

Trigonium curvatus sp. nov. and *Trigonium arcticum* (Bacillariophyceae) from the surface sediments of Prydz Bay, East Antarctica

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ABSTRACT: Here we propose a new species of genus *Trigonium* namely *Trigonium curvatus* described from the surface sediments of coastal Antarctica. A comparative study was done between *Trigonium curvatus* and *Trigonium arcticum* to find out the differential morphological characters. *Trigonium curvatus* is differentiated from the earlier described *Trigonium arcticum* on the basis of valve morphology such as the presence of clustered rimoportulae at centre of the valve, concave sides of the valve, smaller areolae, constricted structure of areolae and fewer pores surrounding areolae. On the contrary in *Trigonium arcticum* rimoportulae are absent or inconspicuous, sides of the frustules are convex/straight and it has larger areolae which appear to be flattened with more pores encircling it. Both species show basic resemblances pertaining to genus *Trigonium* such as triangular valve structure, centrally radiating areolae and valve apices comprised of pseudocelli. Hence, it is proposed that *Trigonium curvatus* is different from the originally described *Trigonium arcticum* and is a new species of genus *Trigonium*.

Key Words: Benthic diatom, epiphyte, sea-ice, taxonomy, Southern Ocean

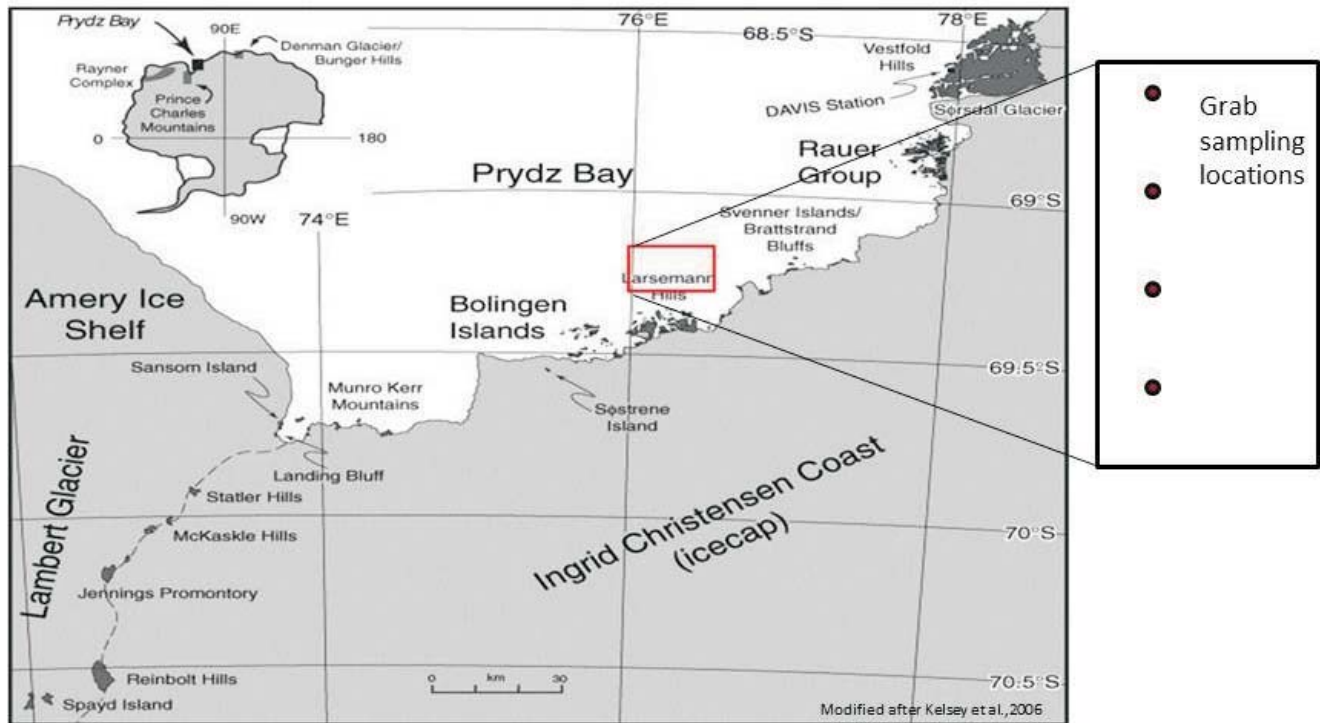
INTRODUCTION

Diatoms are the highest contributors of primary productivity in the Southern Ocean (Treguer et al. 1995) and are abundant in Sea-ice Zone (SIZ) of Coastal Antarctica. SIZ is an important regime, it acts a barrier regulating heat transfer and gas exchange (Bentley 1981; Wu et al. 1997), and it is also known to influence primary, export production and ocean circulation (Budd 1975; Ackley 1980, Abelmann and Gersonde 1991). Antarctic marine diatoms have attracted considerable attention recently as they are good indicators of past oceanographic conditions. Tracking the past climatic changes using diatoms requires good knowledge of taxonomy and autecology of these diatoms. Benthic epiphytic diatoms have high species diversity beneath the Antarctic sea-ice (Everitt and Thomas 1986) and may serve as a good indicator of bottom water conditions in paleoclimatic perspective. Some of the benthic epiphytic diatoms found under the sea-ice are *Trachynesis aspera* (Ehrenberg) Cleve, *Amorpha bongrainii* M. Peragallo, *Achnanthes brevipes* Agardh, *Cocconeis fasciolata*, *Navicula gelida* var *parvula* Heiden and Kolbe and *Trigonium arcticum* (Brightwell) Cleve (Everitt and Thomas 1986). *Trigonium arcticum* is the largest epiphytic benthic diatom (~100- 350µm) found in the sediments under the Antarctic sea-ice and seldom they do get into the water column due to the water circulation (Everitt and Thomas 1986). The survival mechanism and the morphological variation of this diatom in the light limited region beneath the Antarctic sea-ice needs to be studied extensively. The very fact that *Trigonium arcticum* is an epiphytic diatom may suggest an alternate mode of nutrition by this diatom (Thomas 1966). The objective of this study is to identify and describe the *Trigonium* diatom species found in the Prydz Bay, coastal Antarctica.

In 1868 Cleve erected the genus *Trigonium* and placed in it the tripolar species *arcticum* which was originally described by Brightwell (1853) under the genus *Triceratium* (Gibson and Mahoney 1984). The genus *Trigonium* (Cleve 1868) belongs to the Order Centrales and Family Biddulphiaceae (Simonsen 1979). Family Biddulphiaceae is characterised by the absence of ocelli, pseudocelli that may or may not be present, a vertical valve mantle, ribs that when present are in the form of internal costae, and labiate processes that when present are irregularly arranged at the centre of the valve (Simonsen 1979).

Earlier studies by Round et al. (1990) suggested that morphological features such as presence of ocellus or pseudocellus, pseudoloculi, position of rimoportulae, and valve polarity forms the basic criteria for differentiating taxonomic categories within Family Triceratiaceae and Biddulphiaceae. Hence, based on such morphological norms, we propose a new species of *Trigonium curvatus* which earlier was considered as *Trigonium arcticum* (Brightwell) Cleve. Presently, *Trigonium curvatus* is delineated from the originally described *Trigonium arcticum* based on its valve structure, presence of rimoportulae, structure of areolae and number of pores surrounding the areolae.

Trigonium arcticum is described as having a valve with triangular to multiangular structure, radiating areolae with fine granular structure, a septum on the valvocopula, and rimopotulae that are low lying and inconspicuous (Scott and Thomas, 2005). Hence, based on the comparative study of *Trigonium curvatus* and *Trigonium arcticum*, it is evident that there exist significant morphological differences between the two to erect a new species *Trigonium curvatus*.



TEXT-FIGURE 1
Sampling locations in the Prydz Bay, coastal Antarctica.

MATERIALS AND METHODS

Surface sediment samples were collected from the sea-ice regime using van-veen grab from the Prydz Bay region of coastal Antarctica at 4 different points (200m from each point) at 69°23.1'S latitude and 76°10.2'E longitude (text-fig. 1). Both *Trigonium curvatus* and *Trigonium arcticum* were identified in multiple grab samples from the Prydz Bay region. Sample processing was carried out according to Batterby (1986) and Gersonde and Zielinski (2000) for Light microscopy (LM). Sediment samples were treated with hydrogen peroxide and hydrochloric acid in a beaker to get rid of organic and calcareous matter. Furthermore, samples were allowed to settle in distilled water and later decanted. The remnant samples were then used for permanent slide preparation by means of mountant naphrax. For scanning electron microscopy (SEM), diatom species *Trigonium curvatus* and *Trigonium arcticum* were identified using LM technique and placed onto stubs for scanning by a Jeol scanning electron microscope (SEM).

RESULTS

Trigonium curvatus Nair, Mohan, Shetye, Gazi and Jafar sp. nov.

Text-Figures 1-12

Description LM and SEM: Frustules were trihedral, displayed concavity at the sides (text-figs. 2, 3, 12 and 13). Surface of the valve had radial perforations of areolae (text-figs. 2, 3, 12 and 13). Areolae were occluded by vela (projected) and surrounded by 5-8 pores (text-fig. 4, 5, 6 and 8). Corners of the valve were elevated from the valvar plane (text-fig. 7).

Length between apices ~360µm (n = 20); perivalvar axis ~45µm (n = 20) as shown in text-figure 24 a and b. Sizes of the areolae were < 5µm, constricted and elevated from the valvar surface. These projected areolae gave the surface of the valve a rigid look. Frustules had narrow girdle, (text-fig. 7). External surface of the valve showed the presence of 20-24 rimoportulae clustered at the centre (n = 20) (text-fig. 5 and 8). Internally the valve displayed opening of rimoportulae with a fissure and elliptical rim (text-fig. 8). Apices of the frustules were ornamented with pseudocelli (text-figs. 10 and 11), which looked more prominent and covered significant area at the apices of the valve. Essential characters of this species are listed out in Table 1.

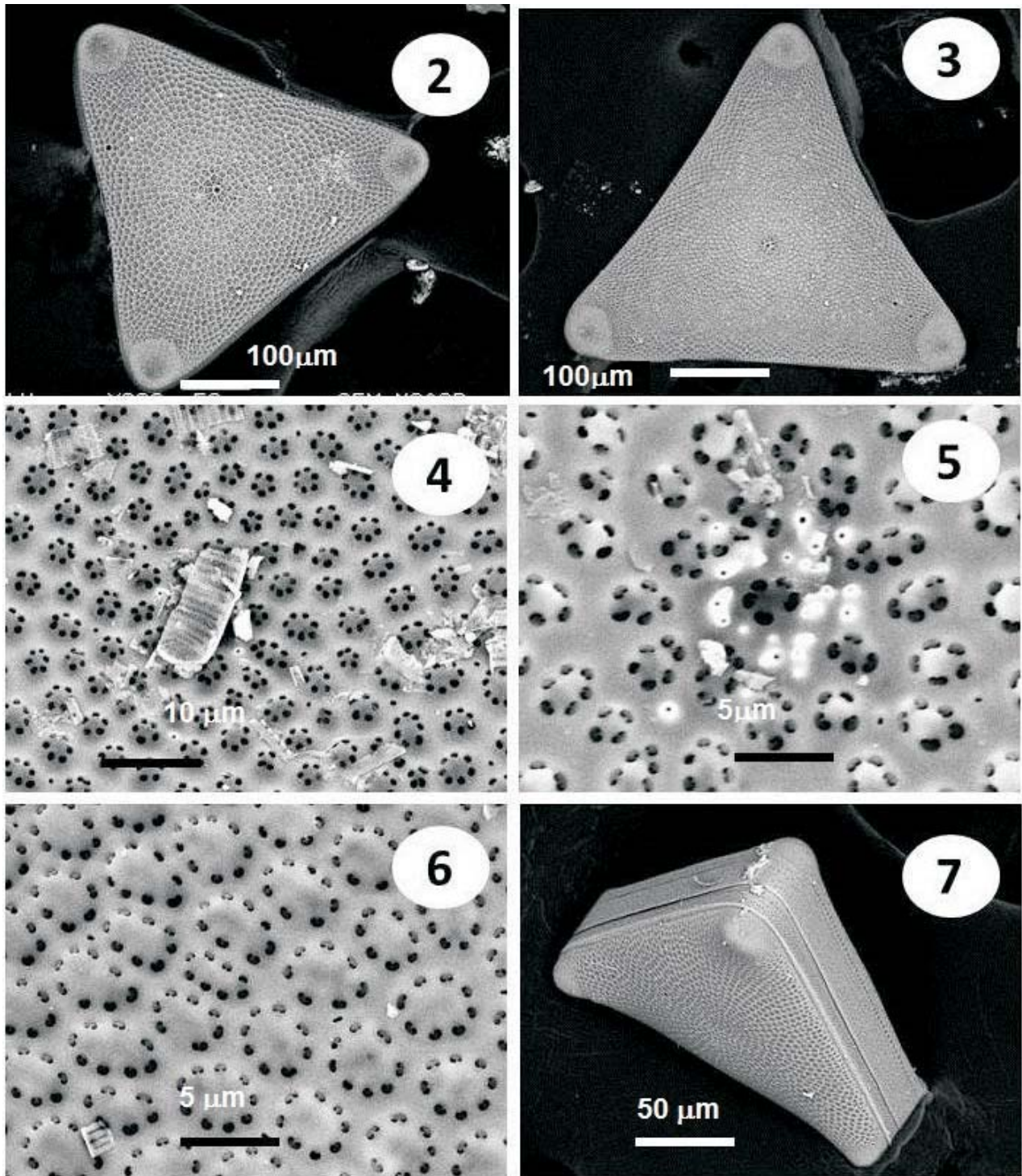
Holotype: Slide no. 1 and stub no. 1; scanning electron microscope (SEM) laboratory, National Centre for Antarctic and Ocean research, Goa, India.

Type Locality: 69°23.1'S and 76°10.2'E; Prydz Bay, coastal Antarctica, surface sediments.

Etymology: *curvatus* (Latin = being curved) refers to valves having curved sides.

***Trigonium arcticum* (Brightwell) Cleve**
Text-figures 13-22

Trigonium arcticum HOBAN 1983, p. 277, figs 37-42. – GIBSON and MAHONEY 1984, figs. 32-37. – EVERITT and THOMAS 1986, p. 9, Fig. 3B. – SCOTT and THOMAS 2005, Figs. 2.6 a-f. – AL-HANDAL and WULFF 2008, Figs. 16-21.

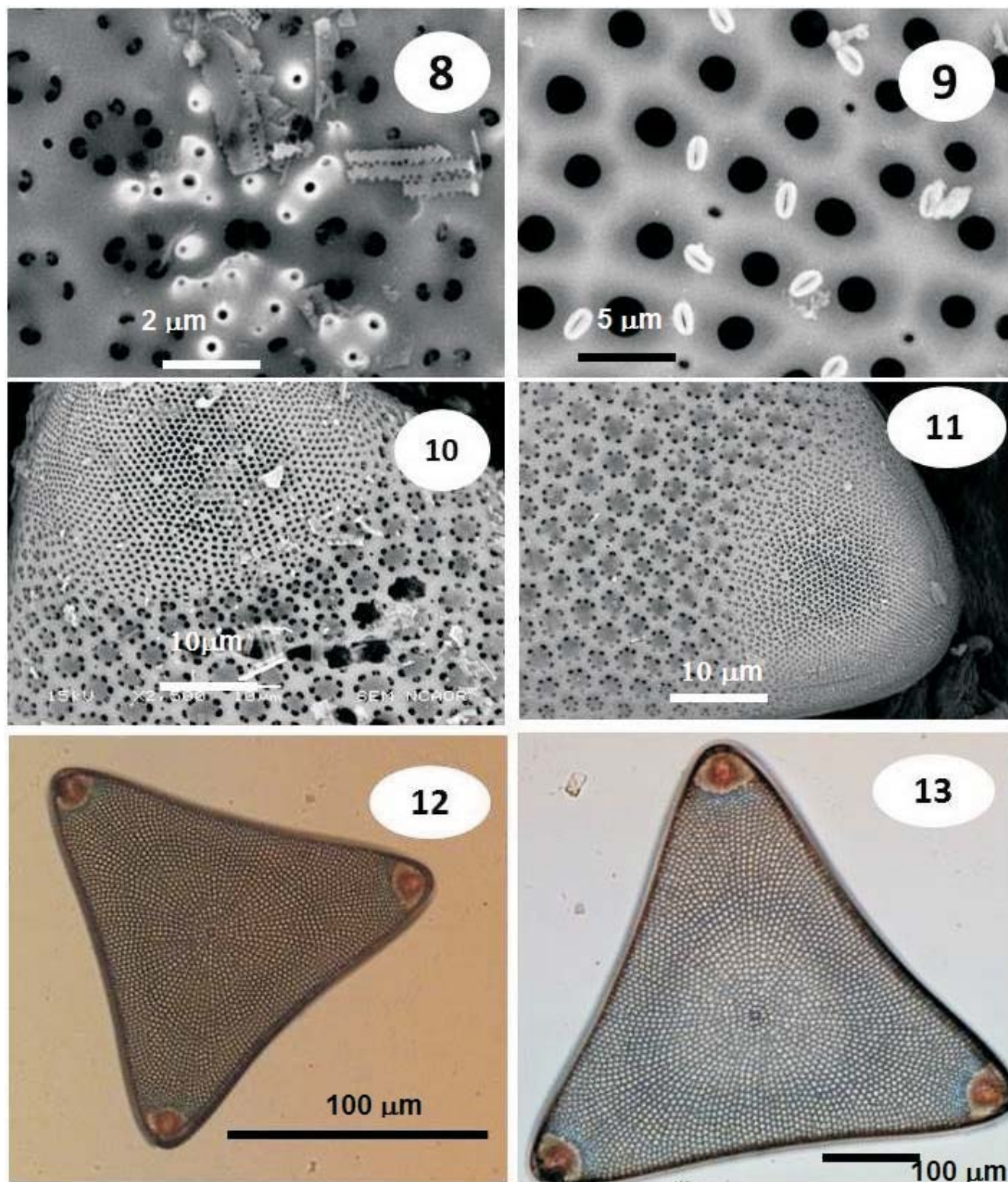


TEXT-FIGURES 2-7

Marine epiphytic diatoms *Trigonium curvatus* from Prydz Bay, Coastal Antarctica.

- 2-3 External view of the frustule showing concavity at the sides. Scale bars = 100 μm
- 4-6 Valve surface showing constricted areolae with rimoportulae at the centre. Scale bars: 4, 10 μm; 5-6, 5 μm

- 7 Girdle view of the frustule with transverse areolae. Scale bar = 50 μm.



TEXT-FIGURES 8-13

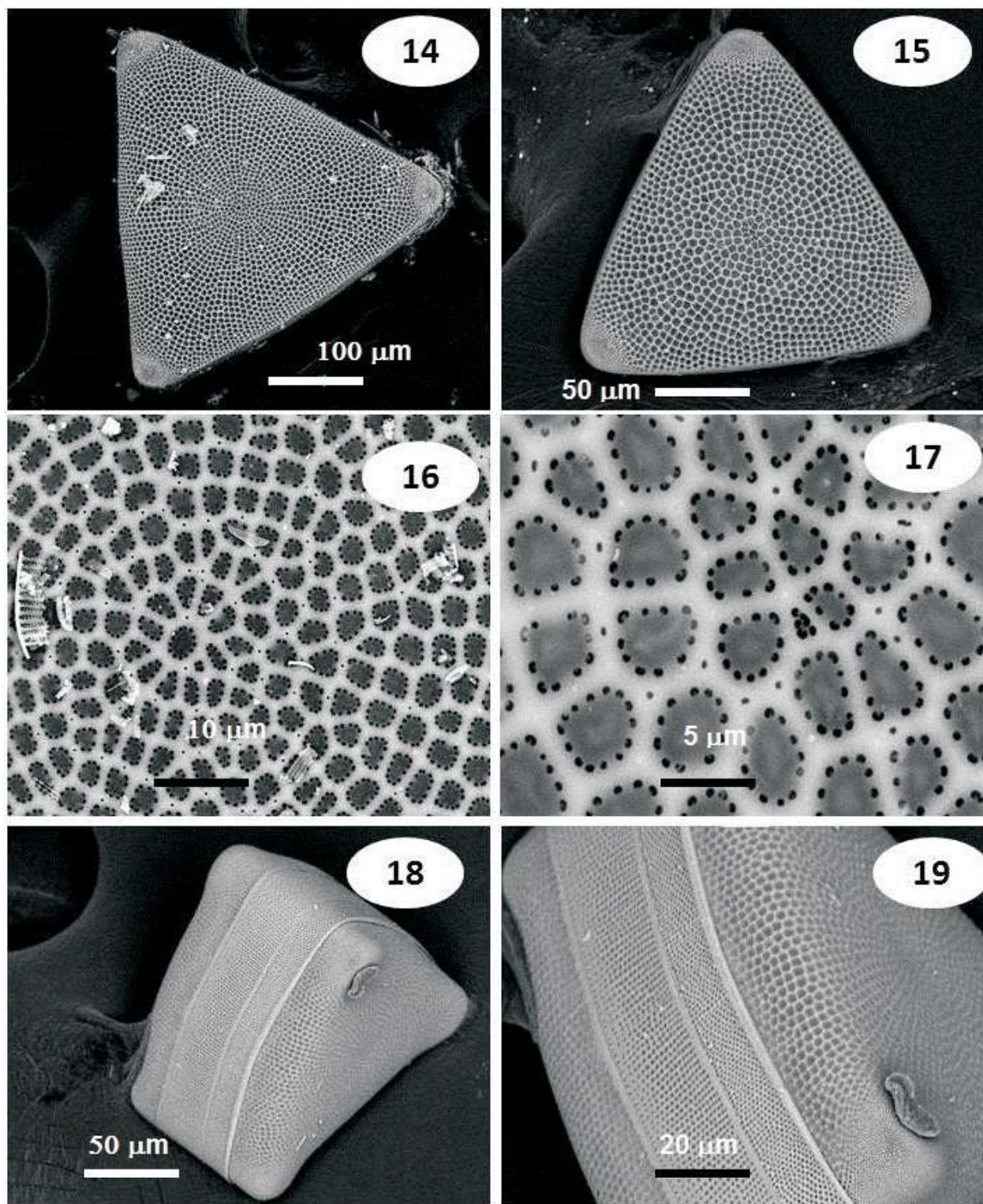
Marine epiphytic diatoms *Trigonium curvatus* from Prydz Bay, Coastal Antarctica.

8 External view of the rimoportulae. Scale bar = 2 μ m.

9 Internal view of rimoportulae. Scale bar = 5 μ m.

10-11 Valve apices showing pseudocelli. Scale bars = 10 μ m.

12-13 Light microscopic view of frustule. Scale bars = 100 μ m.



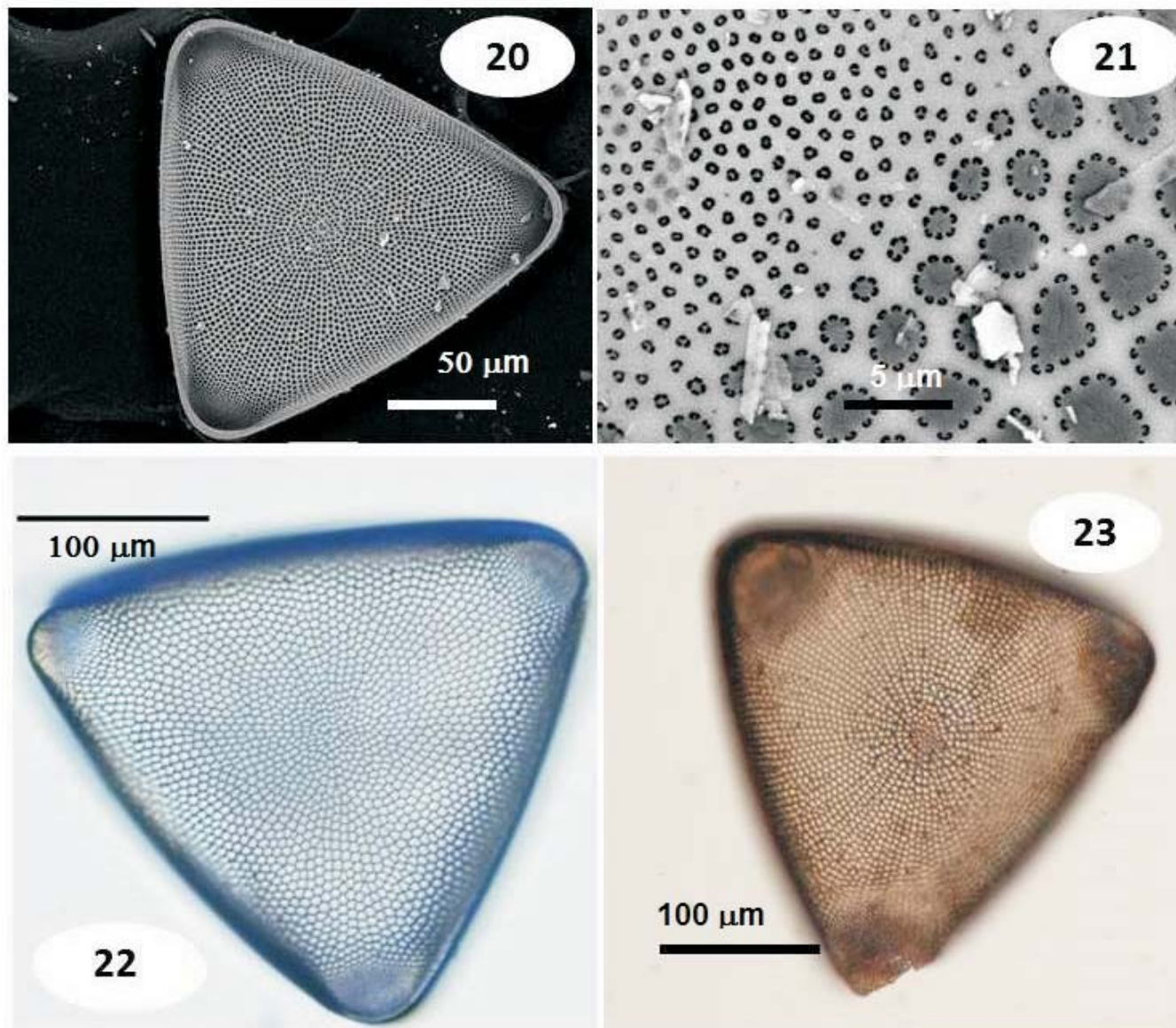
TEXT-FIGURES 14-19

Marine epiphytic diatoms *Trigonium arcticum* from Prydz Bay, Coastal Antarctica.

14-15 External view of the frustule displaying convex to straight edges. Scale bars: 14 = 100 μ m, 15 = 50 μ m

16-17 Valve surface showing radially arranged areolae. Scale bars: 16 = 10 μ m, 17 = 5 μ m

18-19 Girdle view of the frustule having transverse rows of areolae. Scale bars: 18 = 50 μ m, 19 = 20 μ m



TEXT-FIGURES 20-23

Marine epiphytic diatoms *Trigonium arcticum* from Prydz Bay, Coastal Antarctica.

20 Internal view of the frustule. Scale bar = 50μm.

21 Valve apices showing pseudocelli. Scale bar = 5μm.

22-23 Light microscopic view of the external structure of the frustule. Scale bars = 100μm.

Description LM and SEM: Valves were triangular with convex to linear edges (text-figs. 14, 15, 22 and 23). Areolae showed radial arrangement on the valvar surface surrounded by 12-14 granules (text-figs. 14-17). Valves were devoid of rimoportulae (text-figs. 14-17). Corners of the valves were elevated (text-fig. 17). Length between apices ranged from 175-350µm (n = 20) (text-fig. 24 a). Areolae appeared to be flattened covered by vela which were lightly silicified at the centre. Sizes of areolae were greater than 5µm, not showing any kind of elevations, which gave the valvar surface an even look. Pervalvar axis was ~100µm long (n = 20) (text-fig. 24 b). Girdle was broad and had transverse rows of areolae (text-fig. 18 and 19). Areolae were further reduced in size and modified into pseudoceilli at corners (text-fig. 21). Vital morphological features are mentioned in Table 1.

DISCUSSION AND CONCLUSION

Morphological diagnosis of *Trigonium curvatus* and *Trigonium arcticum* revealed significant differences in sizes of the valves and areolae, number of pores per areolae, presence and absence of rimoportulae, convexity and concavity of the frustules sides, and thickness of the girdle (Table 1). The most striking characteristics in *Trigonium curvatus* are the frustules with concave sides, presence of rimoportulae at the centre of the valve and projecting/constricted areolae on the valvar surface.

In the present study *Trigonium curvatus* displayed a narrow size range, and its structure appeared to be flattened for it had a shorter pervalvar axis and a narrower girdle compared to its counterpart. *Trigonium curvatus* has smaller size range compared to its counterpart. *Trigonium curvatus* also displayed smaller sizes of areolae on the valvar surface. Valvar surface of *Trigonium curvatus* appeared rigid because of the constricted/projected areolae, while the plane surface of *Trigonium arcticum* were attributed to flattened distribution of areolae.

These differences in structural characteristics of *Trigonium curvatus* makes it morphologically different from *Trigonium arcticum*. Apart from these differences both the taxa shows similarities in valve polarity, radial arrangement of areolae, position of pseudoceilli and arrangement of girdle bands with transverse areolae, and thus makes it more difficult to differentiate between the two in light microscopy.

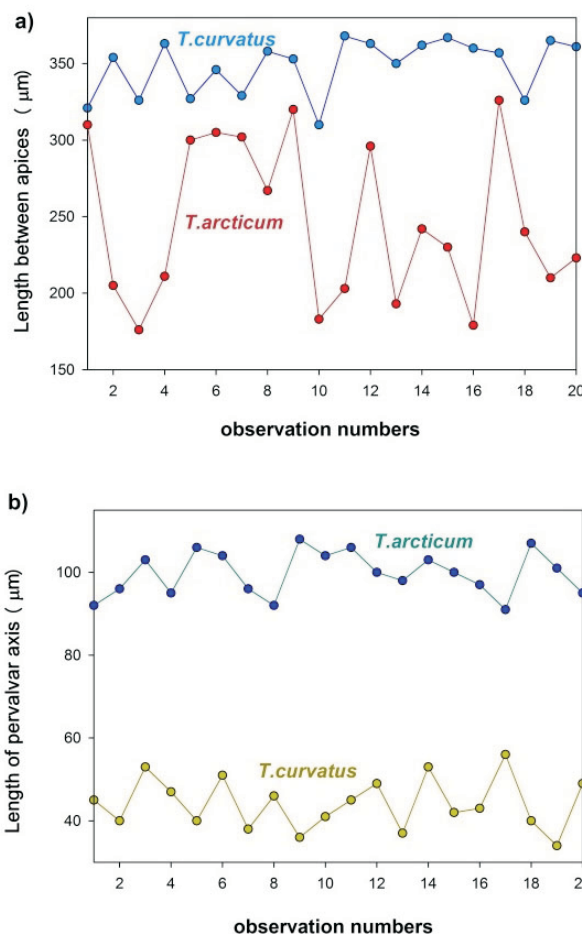
Hence, based on the observations of light microscopy and scanning electron microscopy, there exist significant morphological differences between the two species. It is hereby proposed that *Trigonium curvatus* is a new species of genus *Trigonium* and should be considered as a new record to the epiphytic community of diatom.

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TEXT-FIGURE 24
 (a) Comparison of length between apices of *Trigonium curvatus* and *Trigonium arcticum*.
 (b) Comparison of pervalvar axis length of *Trigonium curvatus* and *Trigonium arcticum*.

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TABLE 1
Differential characteristics of *Trigonium curvatus* and *Trigonium arcticum*.

Morphological features	<i>Trigonium curvatus</i>	<i>Trigonium arcticum</i>
Length of the apical axis (µm)	~360 µm	175-350 µm
Length of the perivalvar axis (µm)	~ 45 µm	~ 100 µm
Areolae	Projected	Flattened
Number of granules per areolae	5-8	12-14
Size of the areolae	< 5 µm	>5 µm
Rimoportulae	Present	Absent
Sides of the frustules	Concave	Convex to straight
Girdle	Narrow	Broad

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