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Humidophila komarekiana sp. nov. (Bacillariophyta), a new limnoterrestrial diatom species from King George Island (Maritime Antarctica)

NATALIA KOCHMAN-KĘDZIORA[1], TERESA NOGA[1], RALITSA ZIDAROVA[2], KATEŘINA KOPALOVÁ[3] & BART VAN DE VIJVER[4,5 *]

[1] *University of Rzeszow, Faculty of Biology and Agriculture, Department of Soil Studies, Environmental, Chemistry and Hydrology, Zelwerowicza 8B, 35-601 Rzeszow, Poland*
[2] *"St. Kliment Ohridski" Univeristy of Sofia, Faculty of Biology, Department of Botany, 8 Dragan Tzankov Blvd., 1164 Sofia, Bulgaria*
[3] *Charles University in Prague, Faculty of Science, Department of Ecology, Viničná 7, 12844 Prague 2, Czech Republic*
[4] *Botanic Garden Meise, Department of Bryophyta & Thallophyta, Nieuwelaan 38, B–1860 Meise, Belgium*
[5] *University of Antwerp, Department of Biology, ECOBE, Universiteitsplein 1, B–2610 Wilrijk, Antwerpen, Belgium*
** Author for correspondence. E-mail: bart.vandevijver@plantentuinmeise.be*

Abstract

During a survey of the non-marine diatom flora of King George Island (South Shetland Islands), an unknown *Humidophila* taxon was recorded. Detailed light and scanning electron microscopy observations indicated that the unknown taxon could not be identified based on the currently available literature. The new species is described as *Humidophila komarekiana sp. nov.* and is characterized in having strictly linear valves with parallel margins and broadly rounded, never protracted apices, a filiform raphe with almost indistinct, straight proximal and distal raphe endings. The striae are composed of one, irregularly shortened areola. The mantle areolae are interrupted at the apices. The new species is compared with similar taxa in the Antarctic Region and worldwide. Notes on the ecology of the new species are added.

Key-words: Antarctica, diatoms, *Humidophila*, new species

Introduction

The genus *Humidophila* R.L.Lowe *et al*. (2014: 352) was established to accommodate taxa originally described in or transferred to the genus *Diadesmis* Kütz. (1844: 109) (Lowe *et al*. 2014). *Humidophila* taxa show small valve dimensions, broadly rounded or weakly protracted apices, striae composed of one usually transapically elongated elliptical to ovoid areola, straight filiform raphe branches with simple, drop-like or anchor-shaped external proximal and distal endings (Lowe *et al*. 2014).

In the Antarctic Region, the genus is widespread in several terrestrial habitats including seepage areas, wet to semi-dry terrestrial moss vegetations, soils and ephemeral pools (Kopalová *et al*. 2012, 2015). The number of *Humidophila* (reported under the genus name *Diadesmis*) taxa in the Antarctic Region is rather low based on literature data prior to 2002 and the list of records merely comprise observations of northern hemisphere taxa, such as *Diadesmis contenta* (Grunow in Van Heurck 1885: 146) D.G. Mann in Round *et al*. (1990: 666) (42 records in Kellogg & Kellogg 2002) or *Diadesmis biceps* Arnott ex Grunow in Van Heurck (1880–1885, pl. 14, fig. 31A) (12 records). Apart from *Humidophila* (*Diadesmis*) *arcuata* (Heiden in Heiden & Kolbe 1928: 628) R.L.Lowe *et al*. (2014: 357), described from the sub-Antarctic Iles Kerguelen, typical Antarctic taxa seemed to be absent. Almost fifteen years ago, a revision of the Antarctic *Humidophila* (*Diadesmis*) taxa started. Le Cohu & Van de Vijver (2002) and Van de Vijver *et al*. (2002a, b) described several new *Humidophila* (*Diadesmis*) taxa from the sub-Antarctic Islands in the southern Indian Ocean. These observations made clear that a lot of old records of cosmopolitan *Humidophila* taxa in fact represented typical Antarctic endemics force-fitted in European relatives (Tyler 1996) due to a too broad species concept (Mann 1999). Recently, seven new taxa have been described from the Maritime Antarctic Region (Kopalová *et al*. 2009, 2015, Van de Vijver *et al*. 2010). Based on these results, it is clear that apart from a few species such as *H. contenta* or *H. arcuata*, the genus *Humidophila* shows a clear biogeographical pattern in the Antarctic Region. At present, twenty *Humidophila* taxa are known from the Antarctic Region (Kopalová *et al*. 2015). Based on the biogeography table in Kopalová *et al*.

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(2015), the highest diversity is reached on the islands in the southern Indian Ocean (12 taxa of which 7 are endemic) and in the Maritime Antarctic Region (11 taxa of which 5 are endemic), probably related to a higher diversity in aerophilic microhabitats compared to the Antarctic Continent which has a very low diatom diversity.

During a recent survey of the non-marine diatom flora of King George Island an unknown *Humidophila* taxon was recorded that could not be identified based on the currently available literature. Comparison with similar taxa worldwide indicated that the taxon presented a unique combination of features necessitating its description as a new species: *Humidophila komarekiana sp. nov*.

Study area

King George Island (61° 54'–62° 16' S / 57° 35'–59° 02' W) is the largest island (1150 km^2) of the South Shetland Archipelago, located approximately 120 km north of the Antarctic Peninsula. The island has a typical maritime climate with small annual variations in air temperature, high relative humidity and constant cloud cover (Rakusa-Suszczewski *et al*. 1993, Wen *et al*. 1994). Most of the island is covered by an ice dome and ice-free areas are scarce. A survey of the limno-terrestrial diatom flora was conducted on two localities. The first locality was Fildes Peninsula, the largest ice-free area on the island (*ca*. 40 km^2) (Schmidt *et al*. 1990), situated on its southwestern tip. The second was the area of Ecology Glacier forefield, south of the Polish H. Arctowski Station at Admiralty Bay, in the territory of Antarctic Specially Protected Area No. 128.

Materials and methods

Samples were obtained from mosses and soils. Mosses were sampled by taking a small piece (approx. 2 cm^3) of moss vegetation whereas a small soil sample (approx. 100 g) was collected on each sampling locality using a spoon. Both kinds of samples were stored without fixation in plastic vials. For mosses obtained on Fildes Peninsula, the F-value of the moss sample was assessed following the classification of Jung (1936). This is a humidity scale, based on the water content of the moss sample as follows: FI = submerged mosses, FII = free floating mosses, FIII = very wet (water drips from the samples without pressure), FIV = wet (water drips with a slight pressure), FV = quasi-wet (water drips after moderate pressure), FVI = moist (little water produced after high pressure), FVII = quasi-dry (only a few drops of water can be squeezed out), FVIII = dry (contains no water). Soil, pH and temperature were measured *in situ* using Hanna® testers. Soil pH for samples from H. Arctowski Station were measured in the laboratory using pH meter with application of suspension of 1:2.5 soil to destilled water ratio.Three samples were selected for analysis of the unknown *Humidophila* taxon:

- KGI29 (Fildes Peninsula, King George Island, leg. R. Zidarova, 03 February 2013) moss vegetation, GPS : 62° 08' 43.3" S/ 58° 54' 45.8" W.
- EcotB1.2015 (near H. Arctowski Station, King George Island, leg. M. Olech, 04 February 2015) soil, GPS: 62° 09' 54.8" S/ 58° 28' 05,0" W.
- EcotB3.2002 (near H. Arctowski Station, King George Island, leg. M. Olech, 02 February 2002) soil, GPS: 62° 09' 56.0" S/ 58° 28' 04,6" W.

Samples were prepared for further analysis following the method described in Van der Werff (1955): small parts of the samples were cleaned by adding 37% H_2O_2 and heating to 80 °C for about 1 h. The reaction was completed by addition of an excessive amount of $KMnO_4$. Following digestion and centrifugation (three times 10 minutes at 3700 × g), cleaned material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides. Cleaned diatom valves were mounted in Naphrax®. Light microscopy (LM) observations were done at Olympus BX51 and Olympus BX53 microscopes, equipped with Differential Interference Contrast (Nomarski) optics and Colorview Soft Imaging Systems. Samples and slides are stored at the BR-collection, property of the Belgian federal government and given in permanent loan to the Botanic Garden Meise (Belgium). For scanning electron microscopy (SEM), parts of the oxidized suspensions were filtered through a 1 µm Isopore™ polycarbonate membrane filter (Merck Millipore). The stubs were sputter-coated with a Gold-Palladium layer of 20 nm and studied in a JEOL JSM-7100F SEM microscope at 5 kV (Botanic Garden Meise, Belgium). Diatom terminology follows Ross *et al*. (1979), Round *et al*. (1990) and Lowe *et al*. (2014). For the new taxon, the number of specimens measured on the type slide is indicated (n).

The new species was compared with similar taxa from the Antarctic Region (Le Cohu & Van de Vijver 2002, Van de Vijver *et al*. 2002a, b, 2010, Kopalová *et al*. 2009, 2015), Europe (Lange-Bertalot & Genkal 1999, Lange-Bertalot & Werum 2001, Werum & Lange-Bertalot 2004), South America (Rumrich *et al*. 2000) and New Caledonia (Moser *et al*. 1998).

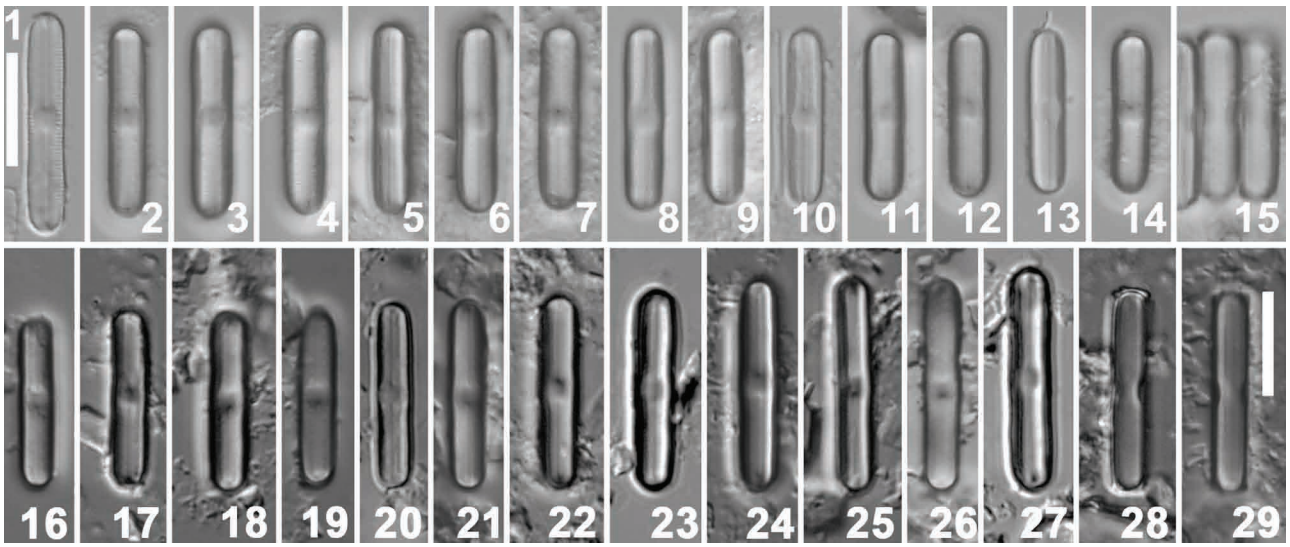
Results

Division **Bacillariophyta**
Class **Bacillariophyceae**
Subclass **Bacillariophycidae**
Order **Naviculales**
Family **incertae sedis**
Genus ***Humidophila***

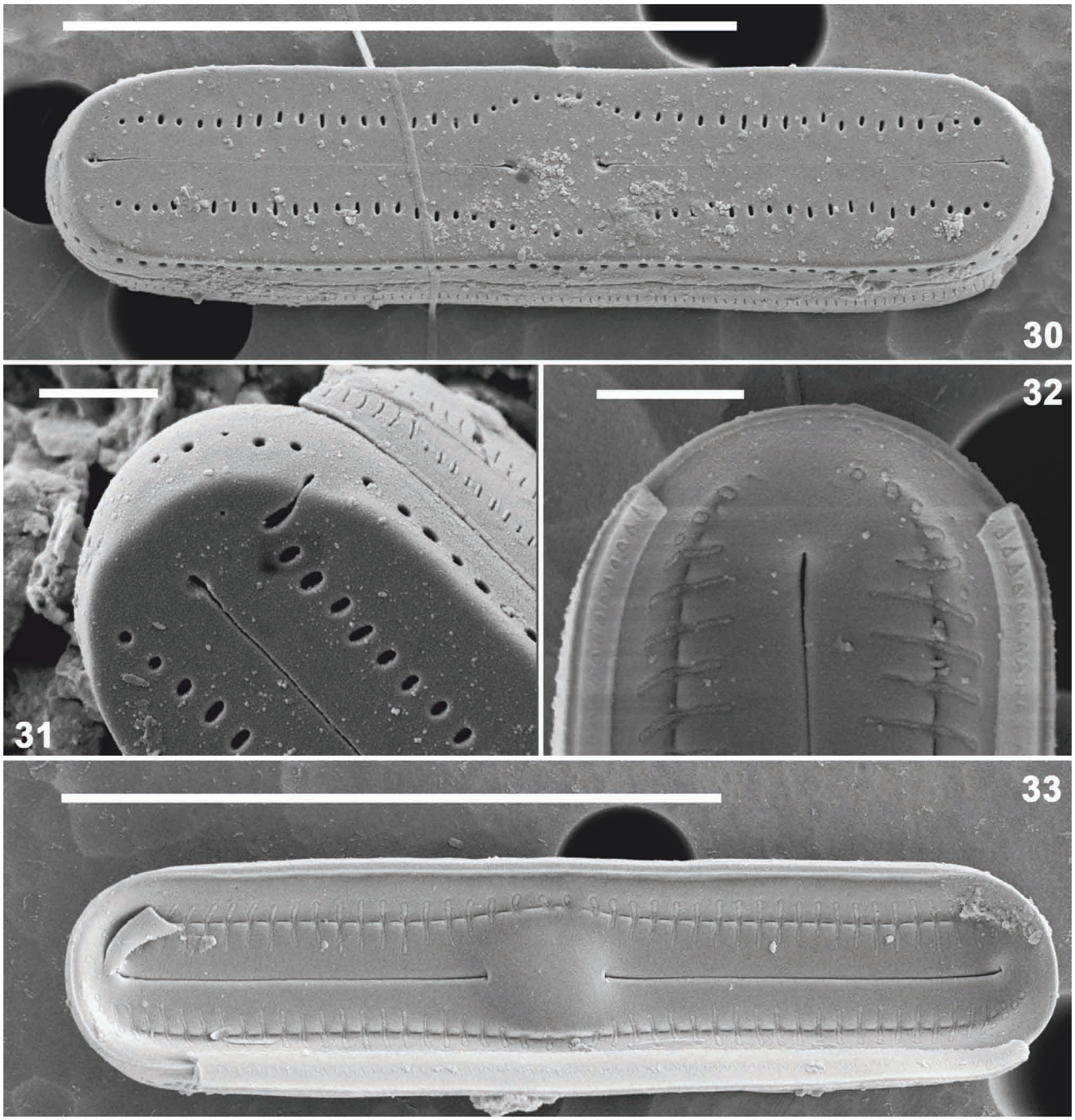
***Humidophila komarekiana sp. nov*. (Figs 1–33)**

LM (Figs 1–29): Frustules rectangular in girdle view (Figs 15, 28–29), often forming short chains (Fig. 15). Valves linear with almost parallel margins, occasionally weakly undulating (*e.g*., Figs 1, 26) in the valve middle. Apices broadly rounded, never protracted (Figs 1–14, 16–27). Valve dimensions (n=20): length 14.0–20.0 µm, width 3.0–4.0 µm. In the Ecology Glacier foreland population, valves up to 21.7 µm in length (n=20) were observed (Figs 16–27). Axial area linear, rather broad, almost 1/3 of the total valve width. Central area formed by a widening axial area, clearly rounded, never forming a fascia. Central nodule well developed and clearly visible in LM (*e.g*., Fig. 1). Raphe filiform, straight with almost indistinct, simple proximal and distal endings. Striae parallel throughout the entire valve, 29–32 (34 in the Ecology Glacier foreland population) in 10 µm. SEM (Figs 30–33): Girdle bands perforated by a series of transapically elongated slits (Figs 30, 31). Axial area broad (Fig. 30), clearly widening near the central area. Towards the valve apices, axial area weakly widening due to irregularly shortening of the last striae (Figs 30, 31). Central area rounded, clearly broadened due to the shortening of the central striae (Fig. 30). Raphe filiform with straight external raphe branches. External proximal and distal endings simple with very weakly expanded pores (Figs 30, 31). Distal endings short terminating near the last striae (Fig. 31). Striae parallel to weakly radiate, forming an undulating series in the middle between the raphe and the valve margins, each composed of a single, short, usually transapically elongated areola (Fig. 30). Mantle areolae short, clearly interrupted near the valve apices (Figs 30–32). Internally, striae occluded by porous hymenes (Figs 32, 33). Internal distal raphe endings simple, terminating on very weakly developed helictoglossae (Figs 32, 33). Central nodule well developed (Fig. 33). Internal proximal raphe endings weakly expanded (Fig. 33).

Type:—ANTARCTICA. South Shetland Islands: King George Island, Fildes Peninsula, sample KGI29 (62° 08’ 43.3” S, 58° 54’ 45.8” W), *R. Zidarova*, *03 February 2013* (holotype BR!, slide no. 4459; isotype PLP!, slide 313).



FIGURES 1–29. *Humidophila komarekiana sp. nov*. Light microscopy views. 1–15. Holotype population from King George Island, South Shetland Islands (sample KGI29). 16–29. Populations near Arctowski Station, King George Island, South Shetland Islands (samples: EcotB1.2015 and Eco.tB3.2002). Scale bar represents 10 µm.



FIGURES 30–33. *Humidophila komarekiana sp. nov*. SEM views taken from the holotype population from King George Island, South Shetland Islands (sample KGI29). 30. SEM of an entire valve, external view. Note the relatively small mantle areolae and the weakly expanded proximal and distal raphe endings. 31. SEM of an external detail of the valve apex with the mantle areolae interrupted at the valve apex. Parts of the perforated girdle bands are likewise visible. 32. SEM of an internal detail of the valve apex with the mantle areolae interrupted at the valve apex. 33. SEM of an entire valve, internal view. Scale bar represents 10 µm, except for figs 31 & 32 where scale bar = 1 µm.

Etymology:—The new species is named in great honour of Prof. Dr. Jiří Komárek (Czech Academy of Sciences, Institute of Botany, Czech Republic) in recognition of his lifetime achievements in Antarctic algological research.

Ecology and Distribution:—*Humidophila komarekiana* was regularly observed in moss and soil samples, but usually in low numbers. The largest population was found on moist mosses (F-value VI) covered with lichens, growing near old skuas' nests (sample KGI29). *Humidophila komarekiana* entirely dominated the sample (75% of the counted valves), accompanied by *Pinnularia borealis* Ehrenberg (1843: 420) *sensu lato*. On Ecology Glacier forefield (samples: EcotB1.2015 and Eco.tB3.2002), the species was observed in soils under lichens, moss and grass vegetation cover. The soil was acid (pH: 4.8–5.6) with low organic matter content (less than 1%). Apart of *Pinnularia borealis s. l.*, other

abundant taxa included *Psammothidium germainii* (Manguin in Bourrelly & Manguin 1954: 20) Sabbe in Sabbe *et al*. (2003: 242) and *Luticola olegsakharovii* Zidarova *et al*. (2014: 164). *Humidophila komarekiana* is (almost) absent in aquatic habitats (Zidarova, pers. obs.).

Due to possible confusion with other *Humidophila* taxa (formerly placed in *Diadesmis*) the exact distribution of this species is not entirely known. So far, the species is present with certainty in terrestrial habitats on several islands of the South Shetland Archipelago, including King George Island, Nelson Island and Livingston Island (Zidarova, pers. obs.).

Discussion

Apart from differences in valve dimensions (length, width, number of striae in 10 µm), the number of morphological features that separate the different taxa in the genus *Humidophila* is rather limited: valve outline, stria length and striation pattern, shape of the proximal and distal raphe endings, mantle areolae continuing or not around the apices, mantle areola positioned in a groove on the mantle or not, shape and size of the central area. The unique combination of these features allows to distinguish the different taxa, even using only LM observations (Lowe *et al*. 2014, Kopalová *et al*. 2015).

Humidophila komarekiana shows a morphological similarity to several other *Humidophila* taxa present in the (Maritime) Antarctic Region. The most similar species is *Humidophila australoshetlandica* Kopalová *et al*. in Kopalová *et al*. (2015: 121). Both taxa have linear valves and broadly rounded, never protracted apices. There are no distinct differences in valve dimensions, however *H. australoshetlandica* is a little bit wider (3.6–4.3 µm *vs*. 3.0–4.0 µm in *H. komarekiana*). The main differences are the longitudinal grooves in which the striae of *H. australoshetlandica* are located (absent in *H. komarekiana*), the mantle areolae that run without interruption around the apices (interrupted in *H. komarekiana*) and the length of the areolae that is very regular and longer in *H. australoshetlandica* compared to *H. komarekiana*. The distal raphe endings of *Humidophila australoshetlandica* terminate before the last striae whereas in *H. komarekiana* the distal endings terminate near the last striae. *Humidophila arcuata* and *H. costei* (Le Cohu & Van de Vijver 2002: 122) R.L.Lowe *et al*. (2014: 357) show a different valve outline with weakly capitate apices and a clear gibbous center. The mantle areolae in both taxa run uninterruptedly around the apices, contrary to *H. komarekiana*. Both taxa have also larger valve dimensions compared to *H. komarekiana*, with valve width exceeding 5.0 µm (Le Cohu & Van de Vijver 2002, Van de Vijver *et al*. 2002b). *Humidophila keilorum* Kopalová in Kopalová *et al*. (2015: 123) has a similar valve outline with almost parallel margins but the mantle areolae are located in a deep groove on the mantle (Kopalová *et al*. 2015: fig. 66) and the valves are longer and wider (width up to 5.2 µm) while *Humidophila deceptionensis* Kopalová *et al*. in Kopalová *et al*. (2015: 125) has shorter, narrower valves with broadened apices and concave margins, an outline never observed in *H. komarekiana* (Kopalová *et al*. 2015). Finally, *H. vojtajarosikii* Kopalová *et al*. in Kopalová *et al*. (2015: 126) has smaller valve dimensions (valve width not exceeding 3.0 µm) and mantle areolae that are positioned in a groove, contrary to *H. komarekiana*.

From all *Humidophila* taxa so far not observed in the Antarctic Region, only *Humidophila brekkaensis* (Petersen 1928: 389) R.L.Lowe *et al*. (2014: 357) bears a slight resemblance to *H. komarekiana*. The former has a comparable valve outline but with a typical gibbous valve center (see Werum & Lange-Bertalot 2004: plate 58). *Humidophila komarekiana* has typical parallel margins lacking the distinctly gibbous valve center. Moreover, in *H. brekkaensis* in SEM, it is clear that the mantle areolae are actually placed on the valve face, separated by a hyaline line from the valve face areolae. This is quite unique within the genus *Humidophila* and only observed in a few species but absent in *H. komarekiana*.

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