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PENSOFT

Geographic distribution of epilithic diatoms (Bacillariophyceae) in Antarctic lakes, South Shetland Islands, Maritime Antarctica Region

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Abstract
Organisms adapt to the environment by establishing themselves in suitable locations. Adaptation to the harsh Antarctic environment is no different. In this work the communities of epilithic diatoms in ice-free areas of water systems of five Antarctic islands are studied. The samples were oxidized, and permanent sheets were later prepared for analysis of the material. They were examined using an optical microscope and mounted on stubs for identification of the taxon in an electron microscope. Fifty-nine species distributed in 28 genera were collected. Only four species were observed in all study areas. Deception Island had unique species in comparison with those on other islands. Knowing the diatom community is a first step in understanding the systems that they inhabit. The polar environment is challenging due to the difficulty of sampling and low diversity and abundance.

Keywords
Aquatic systems, biogeography, conservation, environment, microalgae.

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Introduction

Owing to the harsh climatic conditions in Antarctica, microbial organisms dominate most ecosystems. Microscopic algae are the primary producers in most freshwater bodies, such as inland lakes and meltwater streams (Larsen et al. 2014).

Diatoms are among the peripheral organisms of greatest richness and distribution, and tolerate a wide range of environmental conditions, making them suitable bioindicators (Rimet and Bouchez 2012). They can live in a wide variety of habitats, including in extreme conditions such as at the poles (Round et al. 1990). Diatoms represent one of the most common groups of algae in terms of wealth and number of individuals in the Antarctic region (Jones 1996; Sabbe et al. 2003; Van de Vijver and Beyens, 1999). Algae are abundant in the Antarctic meltwater system, with the general trend of decreasing diversity towards the south (Jones 1996). Although the Antarctic diatom community is generally reported to be

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mainly made up of cosmopolitan taxa (Van de Vijver and Beyens 1999), there are several papers that support the importance of endemism, for example, Kopalová (2014), Kopalová et al. (2013), Sabbe et al. (2003), and Spaulding et al. (1997). Moreover, the actual specific richness and the existing endemic taxa are not clear owing to an underestimation of taxa (Kopalová and Van de Vijver 2013; Kopalova et al. 2009). This is demonstrated by the growing publications reporting new species.

The vast majority of studies are related to the description of new taxa and are focused on King George Island (Van de Vijver and Beyens 1996; Kawecka et al. 1998; Lobo et al. 1998; Procopiak and Fernandes 2003; Vinocur and Maidana 2010; Luo et al. 2016; Kochman-Kędziora et al. 2018), Peninsula Antarctica (Vinocur and Izaguirre 1994; Van de Vijver and Beyens 1996; Pizarro and Vinocur 2000; Mataloni et al. 2005; Bonaventura et al. 2006), Prince Edward Islands (Van de Vijver et al. 2008, 2018), Deception Island (Van de Vijver and Mataloni 2008; Kopalová et al. 2015), Livingston Island (Van de Vijver et al. 2009, 2013; Zidarova 2010; Van de Vijver and Zidarova 2011; Zidarova et al. 2012; Van de Vijver and Kopalová 2014; Kopalová et al. 2015), and James Ross Island (Esposito et al. 2008; Kopalová et al. 2011; Van de Vijver et al. 2011, 2015; Kopalová 2012; Kopalová et al. 2013, 2015; Van de Vijver and Kopalová 2014; Hamsher et al. 2016).

The more recent studies have led to the general conclusion that not all the islands of the Antarctic Maritime share similar flora. In addition, the richness of the flora is more limited than that in more temperate or tropical localities (Hamsher et al. 2016). In this context, the aim of the present work was to study the richness, taxonomy and similarity of epilithic diatom communities in lentic systems of the South Shetland Islands.

Methods

Study area. The archipelago of the South Shetlands is part of the Maritime Zone, north of the Antarctic Peninsula. Elephant, King George, Nelson, Robert, Greenwich, Livingston, and Deception islands are the largest of the group. Of these, Elephant Island is farthest to the north, located at 61°10′S, 055°14′W and about 800 km southeast of Cape Horn (South America) and about 265 km from the northern end of the Antarctic Peninsula (Putzke and Pereira 2001).

Sampling design and laboratory methods. During the expedition of the Brazilian Antarctic Program (PROANTAR) in 2012–2017, lentic systems of King George, Halfmoon, Deception, Elephant, and Nelson islands were sampled (Fig. 1). A total of 78 epilithic diatom samples in ice-free areas of water systems of the five Antarctic islands were collected (Table 1). At each sample site, epilithic material was obtained from pebbles by scraping with brushes. Samples were stored in flasks and fixed with 4% formaldehyde.

Slides preparation and counting. The materials were prepared according to Kelly et al. (1998), and permanent slides were mounted using Naphrax® (Refraction index = 1.74, Brunel Microscopes Ltd, Chippenham, Wiltshire, United Kingdom). Diatoms were identified under light microscopy (LM) with a 100× oil immersion objective, and light photographs were taken with a Leica DM750. Samples selected for scanning electron microscopic (SEM) analysis were filtered through Isopore™ polycarbonate membrane filters (Merck Millipore) with a pore diameter of 3 µm, with additional deionized water. They were mounted on aluminum stubs and sputtered with platinum using a BAL–TEC MED 020 Modular High Vacuum Coating System for 30 s at 100 mA. SEM images were taken using the lower (SE-L) detector signal and an ultra-high-resolution analytical field emission (FE) SEM Hitachi SU–70 (Hitachi High-Technologies Corporation, Tokyo, Japan) operated at 5 kV at a distance of 10 mm. The quantitative analysis was performed with approximately 400 valves for each sample. The specimens examined were deposited in the diatom collection of the Laboratory of Ficology at Universidade Federal de Santa Maria (Table 2). The taxonomy follows the system of Round et al. (1990). Specialized works were used for identification, including Bonaventura et al. (2006), Esposito et al. (2008), Kawecka et al. (1998), Kochman-Kędziora et al. (2018), Kopalová (2012), Kopalová et al. (2011, 2013, 2015), Lobo et al. (1998), Luo et al. (2016), Mataloni et al. (2005), Pizarro and Vinocur (2000) Procopiak and Fernandes (2003), Van de Vijver et al. (2008, 2009, 2011, 2013, 2015, 2018), Van de Vijver and Beyens (1996), Van de Vijver and Kopalová (2014), Van de Vijver and Mataloni (2008), Van de Vijver and Zidarova (2011), Vinocur and Izaguirre (1994), Vinocur and Maidana (2010), Zidarova (2010), Zidarova et al. (2012) and Hamsher et al. (2016).

Results

A total of 5598 individuals, belonging to 28 genera and 59 subgeneric level taxa of diatom algae (including subspecies and varieties) (Table 2; Figs 2–5), were recorded in this study. The greatest number of species, subspecies or varieties included in the following numbers was observed in genera *Psammothidium* L.Buhtkiyarova & Round (8), *Nitzschia* Hassall (7), *Navicula* Bory (6) and *Planothidium* Round & L. Bukhtiyarova (4). These genera are usually well represented in Antarctic diatom survey work (Trobajo et al. 2013; Hamsher et al. 2016; Van de Vijver et al. 2013, 2016, 2018, Van de Vijver 2014). Five species, *Chamaepinnularia krookiformis* (Krammer) Lange-Bertalot & Krammer, *Gomphonema maritimo-antarcticum* Van de Vijver, Kopalová, Zidarova & Kociolek, *Luticola multicopsis* (Van Heurck) Mann, *Psammothidium abundans* (Manguin) Bukhtiyarova & Round, and *Planothidium austral* (Manguin) Le Cohu, were observed on all islands. In contrast, 18 species occurred only on Deception Island, nine species on King

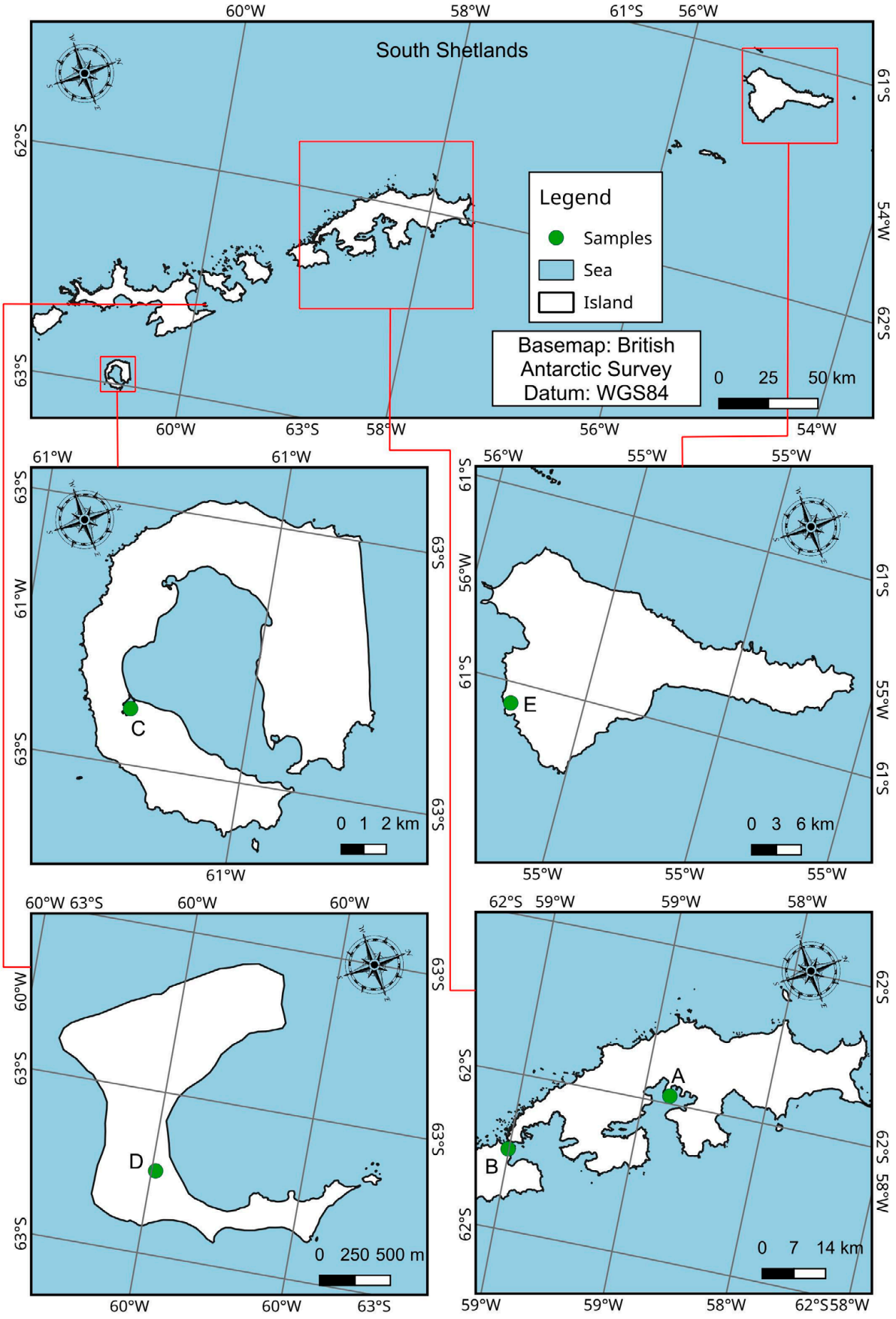

Figure 1. Sample points of the islands. **A.** King George. **B.** Nelson. **C.** Deception. **D.** Halfmoon. **E.** Elephant.

Table 1. Geographic coordinates from the sampling sites in the South Shetland Islands, Antarctica Maritime Region.

Island	Geographic coordinates	Altitude (m)
King George	62°05′07″S, 058°23′39″W	34
Elephant	61°13′19″S, 055°21′19″W	30
Nelson	62°14′45″S, 059°0′15,5″W	38
Deception	62°58′41″S, 060°42′08″W	55
Halfmoon	62°35′41″ S, 059°55′10″W	25

George Island, three species on Halfmoon Island, two species on Nelson Island, and one species on Elephant Island.

Taxonomic composition

***Achnanthes* sp.**
Figures 2(1, 2), 4(1)

Morphometric information: length: 23–34.2 µm; width: 4.7–5.4 µm; striae in 10 µm: 17–22.

***Achnanthidium maritime-antarcticum* Van de Vijver & Kopalová**
Figure 2(3, 4)

Morphometric information: length: 12–16 µm; width: 2–3.7 µm; striae in 10 µm: 30–31

***Berkeleya rutilans* (Trentepho ex Roth) Grunow**
Figures 2(5–7), 4(2)

Morphometric information: length: 28–36 µm; width: 2.3–3.3 µm; striae in 10 µm: 31–42

***Brachysira* aff. *minor* (Krasske) Lange-Bertalot in Lange-Bertalot & Moser**
Figure 2(7)

Morphometric information: length: 12–16.5 µm; width: 3.5–4.3 µm; striae in 10 µm: impossible to resolve in light microscopy (light microscopy)

***Caloneis australis* Zidarova, Kopalová & Van de Vijver**
Figure 2(8)

Morphometric information: length: 16.8–43.1 µm; width: 4–6.2 µm; striae in 10 µm: 21–28

***Chamaepinnularia australomediocris* (Lange-Bertalot & Schmidt) Van de Vijver**
Figures 2(9), 4(3)

Morphometric information: length: 8.9–15.5 µm; width: 2–3.7 µm; striae in 10 µm: 20–25

***Chamaepinnularia krookiformis* (Krammer) Lange-Bertalot & Krammer**
Figures 2(10), 4(4)

Morphometric information: length: 10.6–22.1 µm; width: 4–5.4 µm; striae in 10 µm: 21–23

Comments: *Chamaepinnularia krookiformis* is commonly found associated abundantly with mosses and small bodies of water near the coast in places with high salinity and nutrients (Zidarova et al. 2016).

***Fragilaria* cf. *parva* Tuji & Williams**
Figures 2(11, 12), 4(5)

Morphometric information: length: 15–52 µm; width: 2.5–4.8 µm; striae in 10 µm: 16–18

***Fragilaria labei* Witkowski et Metzeltin in Metzeltin & Witkowski**
Figure 3(13)

Morphometric information: length: 6–12 µm; width: 1.5–2.5 µm; striae in 10 µm: impossible to resolve in light microscopy.

***Fragilariopsis aff. humboldtianorum* Witkowski, Metzeltin et Lange-Bertalot in Metzeltin & Witkowski**
Figures 2(14), 4(6)

Morphometric information: length: 10.2–38.5 µm; width: 3–4.2 µm; striae in 10 µm: 25–32

***Gomphonema maritimo-antarcticum* Van de Vijver, Kopalová, Zidarova & Kociolek**
Figure 2(15, 16)

Morphometric information: length: 20.1– 50 µm; width: 4.3–7.1 µm; striae in 10 µm:10–15

Comments: *Gomphonema maritimo-antarcticum* is a very common diatom in lakes and lagoons (Zidarova et al. 2016).

***Halamphora acutiuscula* (Kützing) Levkov**
Figures 2(17, 18), 4(7)

Morphometric information: length: 24–32 µm; width: 3.9–4.7 µm; striae in 10 µm: 25–35

***Halamphora exigua* (Gregory) Levkov**
Figure 2(19)

Morphometric information: length: 15–32 µm; width: 2.6–4 µm; striae in 10 µm: 15–18

***Halamphora oligotraphenta* (Lange-Bertalot) Levkov**
Figure 2(20)

Morphometric information: length: 16–31 µm; width: 3.3–5 µm; striae in 10 µm: 25–30

***Hantzschia hyperaustralis* Zidarova & Van de Vijver**
Figures 2(21), 4(8)

Morphometric information: length: 67–122 µm; width: 11–16 µm; striae in 10 µm: 50–60

***Hantzschia virgata* (Roper) Grunow in Cleve & Grunow**
Figure 2(22)

Morphometric information: length: 110–140 µm; width: 7–9 µm; striae in 10 µm: 15–20

***Humidophila deceptionensis* Kopalová Zidarova & Van de Vijver**
Figure 2(23)

Morphometric information: length: 8–12 µm; width: 2–4 µm; striae in 10 µm: 27–32.6

***Humidophila keiliorum* Kopalová**
Figures 2(24), 4(9)

Morphometric information: length: 7.7–25.1 µm; width: 3–5 µm; striae in 10 µm: 25–33

Table 2. List of the epilithic diatoms collected during the austral summer season from 2012 to 2017, with catalog numbers of voucher specimens. Islands: King George (KG), Elephant (E), Nelson (N), Deception (D), and Halfmoon (H) islands.

Taxon	Island					Catalog number
	KG	E	N	D	H	
Achnanthes sp.				X		LF127
Achnanthidium maritime-antarcticum Van de Vijver & Kopalová		X	X			LF125, LF126
Berkeleya rutilans (Trentepohl ex Roth) Grunow				X		LF127
Brachysira aff. *minor* (Krasske) Lange-Bertalot in Lange-Bertalot & G.Moser	X					LF124
Caloneis australis Zidarova, Kopalová & Van de Vijver	X					LF124
Chamaepinnularia australomediocris (Lange-Bertalot & Rol.Schmidt) Van de Vijver	X	X		X		LF124, LF125, LF128
Chamaepinnularia krookiformis (Krammer) Lange-Bertalot & Krammer in Lange-Bertalot & Genkal	X	X	X	X	X	LF124, LF125, LF126, LF127, LF128
Fragilaria cf. *parva* Tuji & Williams	X		X		X	LF124, LF126, LF128
Fragilaria labei Witkowski et Metzeltin in Metzeltin & Witkowski				X		LF127
Fragilariopsis humboldtianorum Witkowski, Metzeltin et Lange-Bertalot in Metzeltin & Witkowski				X		LF127
Gomphonema maritimo-antarcticum Van de Vijver, Kopalová, Zidarova & Kociolek	X	X	X	X	X	LF124, LF125, LF126, LF127, LF128
Halamphora acutiuscula (Kützing) Z. Levkov				X		LF127
Halamphora exigua (Gregory) Z. Levkov				X		LF127
Halamphora oligotraphenta (Lange- Bertaloot) Luvkov		X	X			LF125, LF126
Hantzschia hyperaustralis Van de Vijver & Zidarova					X	LF128
Hantzschia virgate (Roper) Grunow				X		LF127
Humidophila deceptionensis Kopalová Zidarova & Van de Vijver	X					LF124
Humidophila keiliorum Kopalová	X					LF124
Humidophila vojtajarosikii Kopalová Zidarova & Van de Vijver			X			LF126
Luticola multicopsis (Van Heurck) Mann	X	X	X	X	X	LF124, LF125, LF126, LF127, LF128
Melosira moniliformis (O.F. Muller) Agardh	X			X		LF124, LF127
Navicula australoshetlandica Van de Vijver	X	X				LF124, LF125
Navicula cremeri Van de Vijver & Zidarova	X					LF124
Navicula cryptotenella Lange-Bertalot				X		LF127
Navicula gregaria Donkin	X			X		LF124, LF127
Navicula perminuta Grunow				X		LF127
Navicula venetiformis Van de Vijver & Beyens in Van de Vijver, Frenot & Beyens	X			X		LF124, LF127
Nitzschia annewillemsiana Hamsher, Kopalová, Kociolek, Zidarova & Van de Vijver	X		X	X		LF124, LF126, LF127
Nitzschia archibaldii Lange-Bertalot				X		LF127
Nitzschia bergii Cleve-Euler				X		LF127
Nitzschia gracilis Hantzsch	X				X	LF124, LF128
Nitzschia homburgiensis Lange-Bertalot	X		X		X	LF124, LF126, LF128
Nitzschia kleinteichiana Hamsher, Kopalová, Kociolek, Zidarova & Van de Vijver	X	X	X			LF124, LF125, LF126
Nitzschia paleacea Grunow	X					LF124
Pinnularia australomicrostauron Zidarova, Kopalová & Van de Vijver		X			X	LF125, LF128
Pinnularia microstauron (Ehrenberg) Cleve		X				LF125
Pinnularia subantarctica var. *elongata* (Manguin) Van de Vijver & Le cohu		X			X	LF125, LF128
Pinnunavis elegans (W. Smith) H. Okuno				X		LF127
Placoneis australis Van de Vijver & Zidarova	X				X	LF124, LF128
*Planothidium austra*l (Manguin) Le Cohu	X	X	X		X	LF124, LF125, LF126, LF128
Planothidium capitatum (O. Müller) Van de Vijver, Kopalová, C.E. Wetzel & Ector	X					LF124
Planothidium rostrolanceolatum Van de Vijver, Kopalová & Zidarova	X		X		X	LF124, LF126, LF128
Planothidium sp.				X		LF127
Psammothidium abundans (Manguin) Bukhtiyarova & Round	X	X	X	X	X	LF124, LF125, LF126, LF127, LF128
Psammothidium aretassi (Manguin) Le Cohu		X			X	LF125, LF128
Psammothidium germanii (Manguin) Sabbe		X			X	LG125, LF128
Psammothidium incognitum (Krasske) Van de Vijver			X			LF126
Psammothidium papilio (D.E. Kellogg, M. Stuiver, T.B. Kellogg & G.H. Denton) Kopalová & Van de Vijver	X				X	LF124, LF128
Psammothidium rostrogermainii Van de Vijver, kopalová & Zidarova					X	LF128
Psammothidium sp.				X		LF127
Psammothidium subatomoides (Hustedt) Bukhtiyarova et Round		X			X	LF125, LF128
Pseudogomphonema kamtschaticum (Grunow) Medlin in Medlin & Round				X		LF127
Sellaphora antarctica Zidarova, Kopalová & Van de Vijver	X					LF124
Sellaphora nana (Hustedt) Lange-Bertalot, Cavacini, Tagliaventi & Alfinito	X					LF124
Sieminskia zeta (Cleve) Metzeltin & Lange-Bertalot				X		LF127
Stauroneis latistauros Van de Vijver & Lange-Bertalot					X	LF128
Stauronella indubitabilis H. Lange-Bertalot & S.I. Genkal				X		LF127
Staurosirella frigida Van de Vijver & E. Morales	X		X			LF124, LF126
Thalassiosira gracilis var. *expecta* G. Fryxell & Hasle				X		LF127

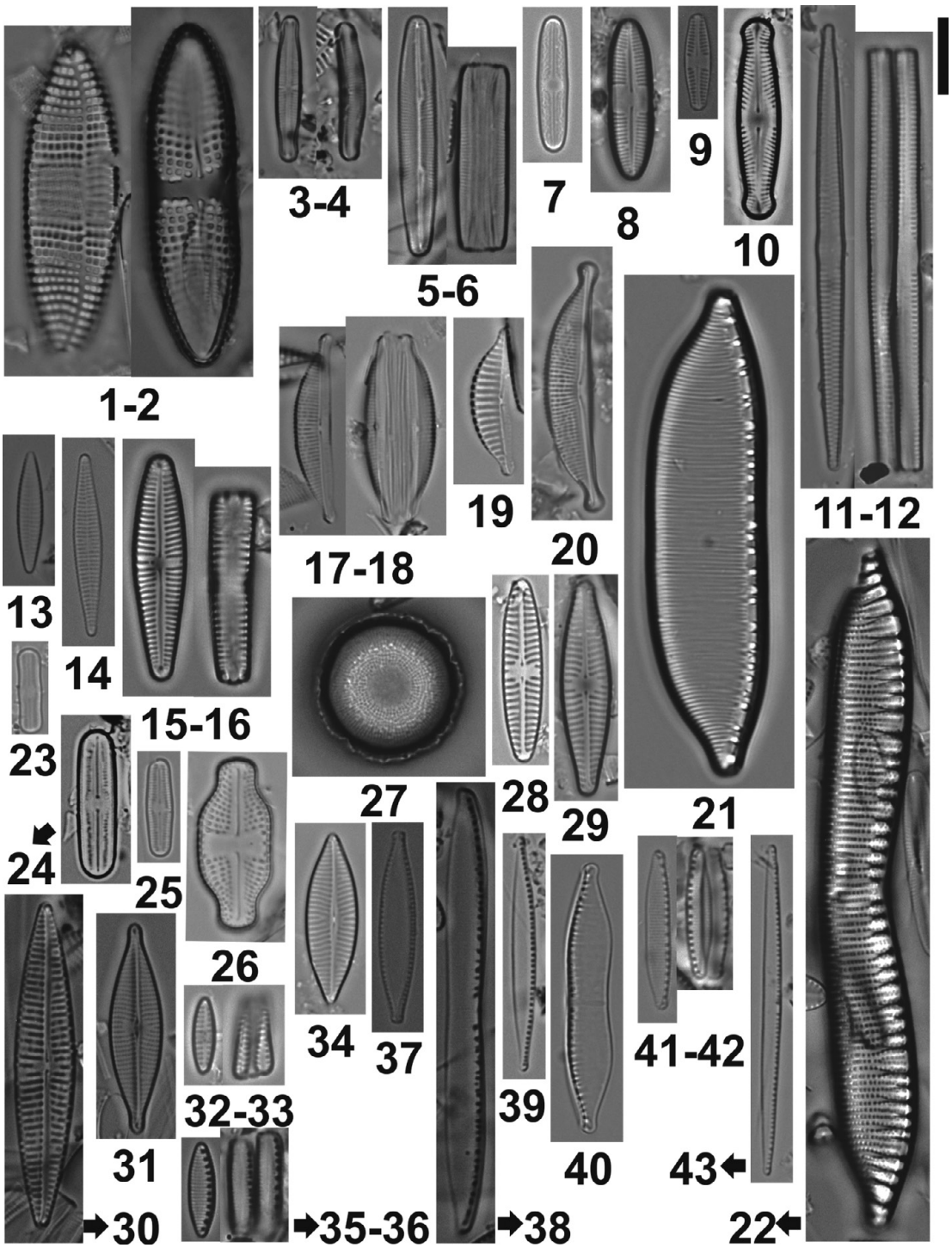

Figure 2. Taxa of diatoms in light microscopy. **1, 2.** *Achnanthes* sp. **3, 4.** *Achnanthidium maritime-antarcticum*. **5,6.** *Berkeleya rutilans*. **7.** *Brachysira aff. minor*. **8.** *Caloneis australis*. **9.** *Chamaepinnularia australomediocris*. **10.** *Chamaepinnularia krookiformis*. **11, 12.** *Fragilaria* cf. *Parva*. **13.** *Fragilaria labei*. **14.** *Fragilariopsis humboldtianorum*. **15,16.** *Gomphonema maritimo-antarcticum*. **17, 18.** *Halamphora acutiúscula*. **19.** *Halamphora exígua*. **20.** *Halamphora oligotraphenta*. **21.** *Hantzschia hyperaustralis*. **22.** *Hantzschia virgata*. **23.** *Humidophila deceptionensis*. **24.** *Humidophila keiliorum*. **25.** *Humidophila vojtajarosikii*. **26.** *Luticola multicopsis*. **27.** *Melosira moniliformis*. **28.** *Navicula australoshetlandica*. **29.** *Navicula cremeri*. **30.** *Navicula cryptotenella*. **31.** *Navicula gregaria*. **32, 33.** *Navicula perminuta*. **34.** *Navicula venetiformis*. **35, 36.** *Nitzschia annewillemsiana*. **37.** *Nitzschia archibaldii*. **38.** *Nitzschia bergii*. **39.** *Nitzschia gracilis*. **40.** *Nitzschia homburgiensis*. **41, 42.** *Nitzschia kleinteichiana*. **43.** *Nitzschia paleacea*.

***Humidophila vojtajarosikii* Kopalová Zidarova & Van de Vijver**

Figures 2(25), 4(10)

Morphometric information: length: 6–15 µm; width: 2.2–3,6 µm; striae in 10 µm: 27–32

***Luticola multicopsis* (Van Heurck) Mann**

Figures 2(26), 4(11)

Morphometric information: length: 20–30.1 µm; width: 8.3–10 µm; striae in 10 µm: 15–17

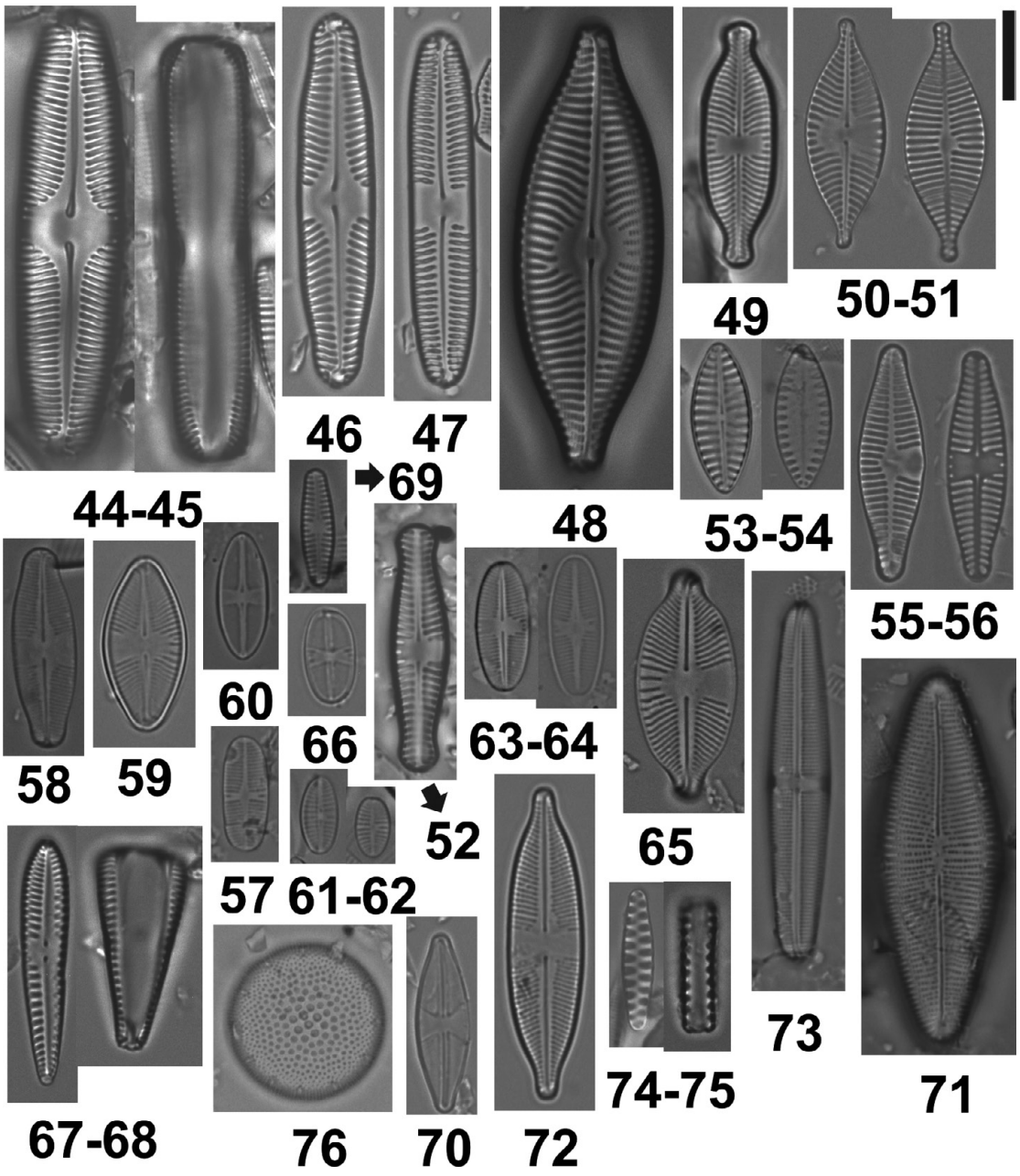

Figure 3. Taxa of diatoms in light microscopy. **44, 45.** *Pinnularia australomicrostauron*. **46.** *Pinnularia microstauron*. **47.** *Pinnularia subantarctica* var. *elongata*. **48.** *Pinnunavis elegans*. **49.** *Placoneis australis*. **50, 51.** *Planothidium australe*. **52.** *Planothidium capitatum*. **53, 54.** *Planothidium* sp. **55, 56.** *Planothidium rostrolanceolatum*. **57.** *Psammothidium abundans*. **58.** *Psammothidium aretassi*. **59.** *Psammothidium germanii*. **60.** *Psammothidium incognitum*. **61, 62.** *Psammothidium* sp. **63, 64.** *Psammothidium papilio*. **65.** *Psammothidium rostrogermainii*. **66.** *Psammothidium subatomoides*. **67, 68.** *Pseudogomphonema kamtschaticum*. **69.** *Sellaphora antarctica*. **70.** *Sellaphora nana*. **71.** *Sieminskia zeta*. **72.** *Stauroneis latistauros*. **73.** *Stauronella indubitabilis*. **74, 75.** *Staurosirella frigida*. **76.** *Thalassiosira gracilis* var. *expecta*.

***Melosira moniliformis* C.Agardh**
Figures 2(27), 4(12)

Morphometric information: diameter (μm): 8–12 × 20–25

***Navicula australoshetlandica* Van de Vijver**
Figure 2(28)

Morphometric information: length: 15–25 μm; width: 4–5 μm; striae in 10 μm: 12–15

***Navicula cremeri* Van de Vijver & Zidarova**
Figures 2(29), 4(13)

Morphometric information: length: 27–33 μm; width: 5.2–7 μm; striae in 10 μm: 14–15

***Navicula cryptotenella* Lange-Bertalot**
Figures 2(20), 4(14)

Morphometric information: length: 39–51.2 μm; width: 5.8–7.3 μm; striae in 10 μm: 16–20

***Navicula gregaria* Donkin**
Figure 2(31)

Morphometric information: length: 20–41.3 μm; width: 5.4–10 μm; striae in 10 μm: 20–30

***Navicula perminuta* Østrup**
Figures 2(32, 33), 4(17)

Morphometric information: length: 4.6–12 μm; width: 1.3–2 μm; striae in 10 μm: 9–11

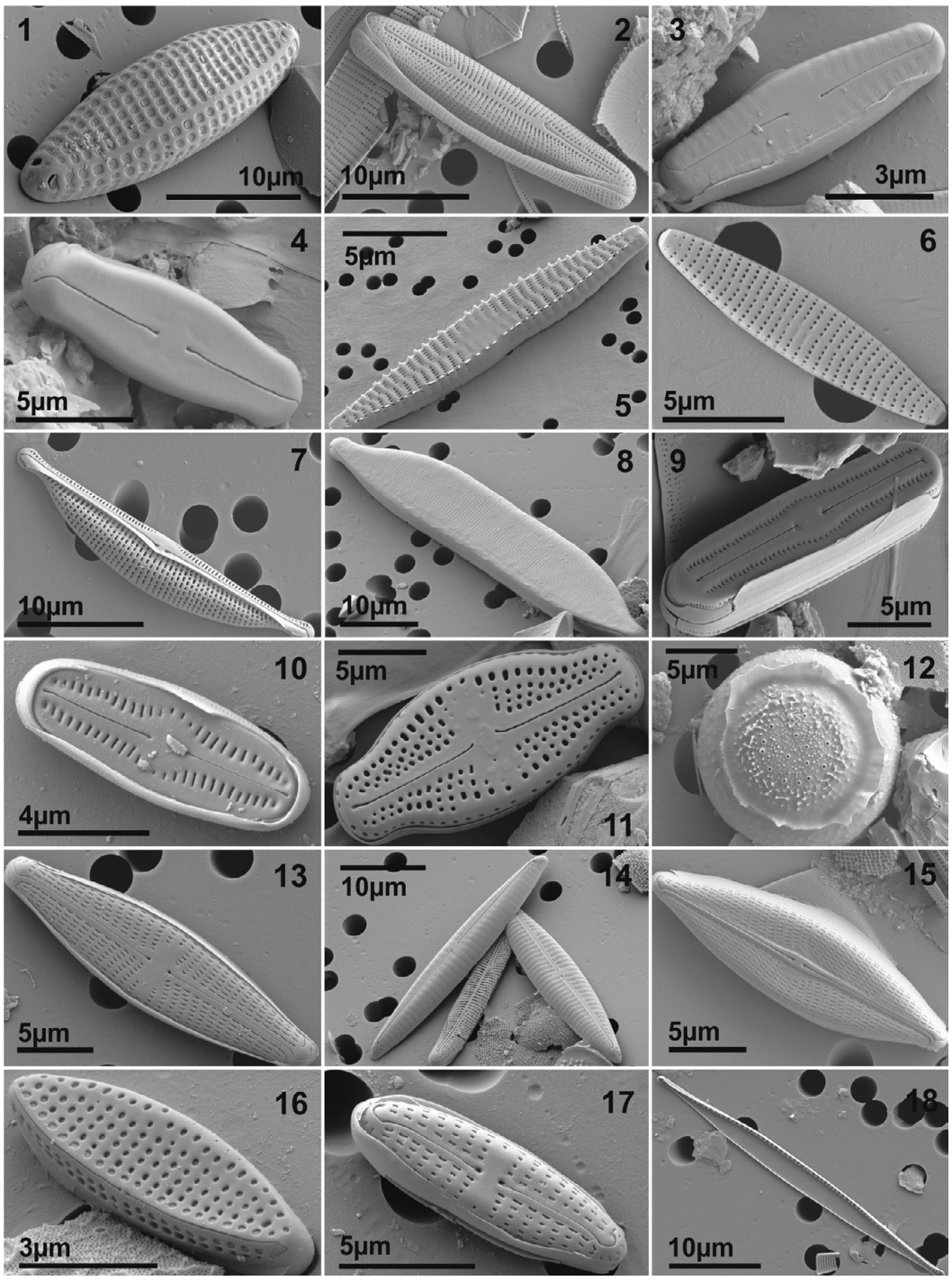

Figure 4. Taxa of diatoms in scanning electron microscopy. **1.** *Achnanthes* sp. **2.** *Berkeleya rutilans*. **3.** *Chamaepinnularia australomediocris*. **4.** *Chamaepinnularia krookiformis*. **5.** *Fragilaria* cf. *parva*. **6.** *Fragilariopsis humboldtianorum*. **7.** *Halamphora acutiuscula*. **8.** *Hantzschia hyperaustralis*. **9.** *Humidophila keiliorum*. **10.** *Humidophila vojtajarosikii*. **11.** *Luticola multicopsis*. **12.** *Melosira moniliformis*. **13.** *Navicula cremeri*. **14.** *Navicula cryptotenella*. **15.** *Navicula venetiformis*. **16.** *Nitzschia annewillemsiana*. **17.** *Navicula perminuta*. **18.** *Nitzschia gracilis*.

***Navicula venetiformis* Van de Vijver & Beyens in Van de Vijver, Frenot & Beyens**

Figures 2(34), 4(15)

Morphometric information: length: 14.8–22 µm; width: 8.7–9.5 µm; striae in 10 µm: 16–19

***Nitzschia annewillemsiana* Hamsher, Kopalová, Kociolek, Zidarova & Van de Vijver**

Figures 2(35, 36), 4(16)

Morphometric information: length: 9–21 µm; width: 3–4 µm; striae in 10 µm: 24–27

***Nitzschia archibaldii* Lange-Bertalot**

Figure 2(37)

Morphometric information: length: 14–39.5 µm; width: 2.1–2.8 µm; striae in 10 µm: impossible to resolve in light microscopy.

***Nitzschia bergii* Cleve-Euler**

Figure 2(38)

Morphometric information: length: 61.1–72 µm; width: 2.9–3.4 µm; striae in 10 µm: impossible to resolve in light microscopy.

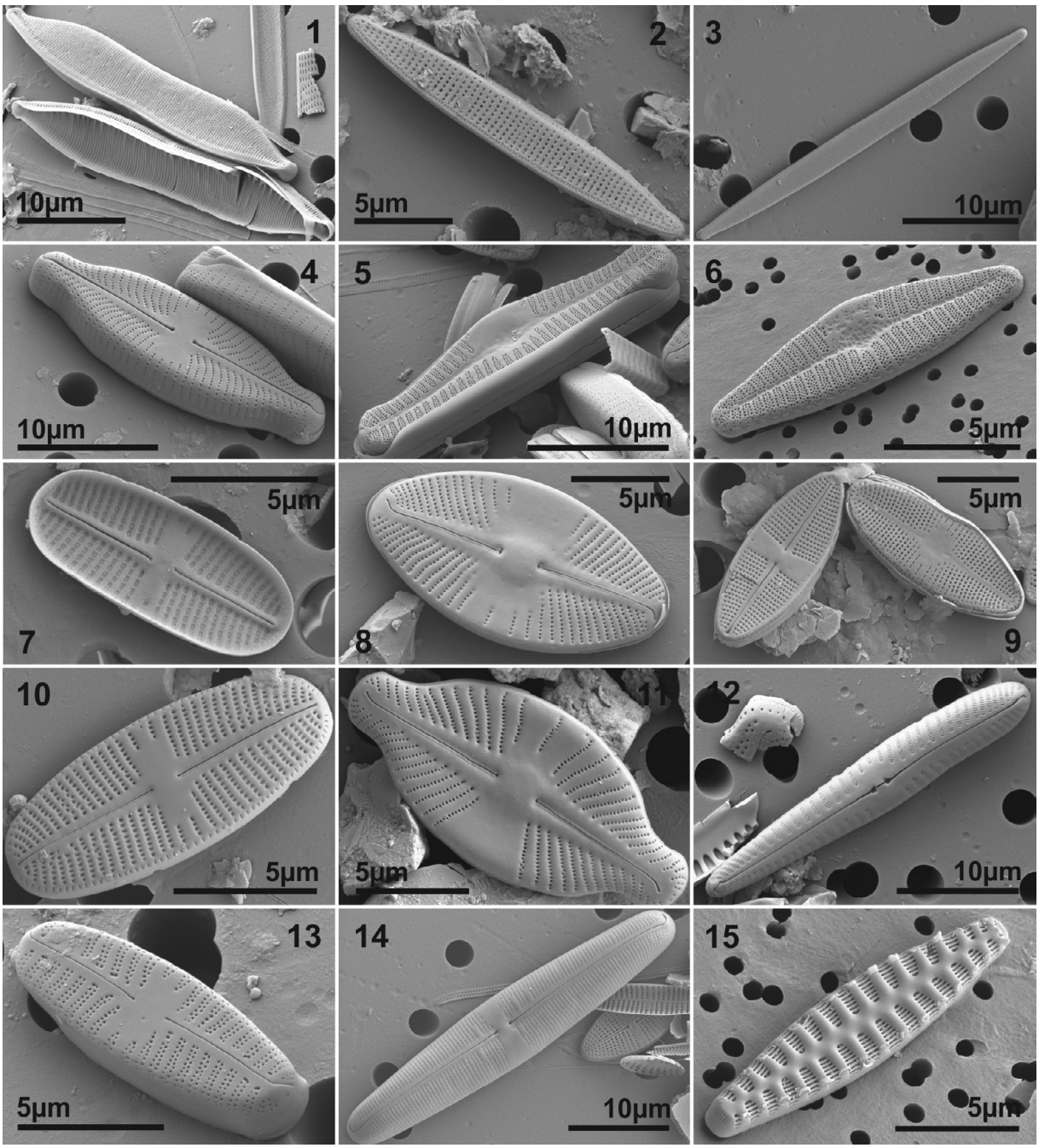

Figure 5. Taxa of diatoms in scanning electron microscopy. **1.** *Nitzschia homburgiensis*. **2.** *Nitzschia kleinteichiana*. **3.** *Nitzschia paleacea*. **4.** *Placoneis australis*. **5.** *Planothidium capitatum*. **6.** *Planothidium rostrolanceolatum*. **7.** *Psammothidium abundans*. **8.** *Psammothidium germanii*. **9.** *Psammothidium incognitum*. **10.** *Psammothidium papilio*. **11.** *Psammothidium rostrogermainii*. **12.** *Pseudogomphonema kamtschaticum*. **13.** *Sellaphora antarctica*. **14.** *Stauronella indubitabilis*. **15.** *Staurosirella frigida*.

***Nitzschia gracilis* Hantzsch**
Figures 2(39), 4(18)

Morphometric information: length: 13.8–73.5 µm; width: 2–3 µm; striae in 10 µm: 15–20

***Nitzschia homburgiensis* Lange-Bertalot**
Figures 2(40), 5(1)

Morphometric information: length: 17.5–38.2 µm; width: 4–5.7 µm; striae in 10 µm: 10–15

***Nitzschia kleinteichiana* Hamsher, Kopalová, Kociolek, Zidarova & Van de Vijver**
Figures 2(41, 42), 5(2)

Morphometric information: length: 12.5–25.9 µm; width: 2-3.3 µm; striae in 10 µm: 10–13

***Nitzschia paleacea* Grunow**
Figures 2(43), 5(3)

Morphometric information: length: 16–40.6 µm; width: 1.4–3 µm; striae in 10 µm: 15–20

***Pinnularia australomicrostauron* Zidarova, Kopalová & Van de Vijver**
Figure 3(44, 45)

Morphometric information: length: 28-87.5 µm; width: 8–15; striae in 10 µm: 12–15

***Pinnularia microstauron* (Ehrenberg) Cleve**
Figure 3(46)

Morphometric information: length: 33.4–60,2 µm; width: 2.9–3.9 µm; striae in 10 µm: 15–17

***Pinnularia subantarctica* var. *elongata* (Manguin) Van de Vijver & Le cohu**
Figure 3(47)

Morphometric information: length: 25.7–59.3 µm; width: 5–8.1 µm; striae in 10 µm: 13–15

***Pinnunavis elegans* (W. Smith) Okuno**
Figure 3(48)

Morphometric information: length: 36.3–57 µm; width: 12–13.6 µm; striae in 10 µm: 13–14

***Placoneis australis* Van de Vijver & Zidarova**
Figures 3(49), 5(4)

Morphometric information: length: 21–31.1 µm; width: 5.9–8; striae in 10 µm: 15–20

***Planothidium australe* (Manguin) Le Cohu**
Figure 3(50, 51)

Morphometric information: length: 21–32 µm; width: 6–8; striae in 10 µm: 15–20

***Planothidium capitatum* (O. Muller) Van de Vijver, Kopalová, Wetzel & Ector**
Figures 3(52), 5(5)

Morphometric information: length: 15–22 µm; width: 4.3–5 µm; striae in 10 µm: 14–15

***Planothidium rostrolanceolatum* Van de Vijver, Kopalová & Zidarova**
Figures 3(55, 56), 5(6)

Morphometric information: length: 15.2–23 µm; width: 6–8 µm; striae in 10 µm: 13–15

***Planothidium* sp.**
Figure 3(53, 54)

Morphometric information: length: 5–14.5 µm; width: 3.8–5.5 µm; striae in 10 µm: 12–15

***Psammothidium abundans* (Manguin) Bukhtiyarova & Round**
Figures 3(57), 5(7)

Morphometric information: length: 7.5–12 µm; width: 3–5 µm; striae in 10 µm: 20–30

Comments: *Psammothidium abundans* was considered a typical species of Antarctica (Van de Vijver et al. 2008). Since its description, *P. abundans* has been reported in Antarctic and sub-Antarctic regions.

***Psammothidium aretassi* (Manguin) Le Cohu**
Figure 3(58)

Morphometric information: length: 12.9–21.2 µm; width: 4.8–6.7 µm; striae in 10 µm: 25–30

***Psammothidium germanii* (Manguini) Sabbe**
Figures 3(59), 5(8)

Morphometric information: length: 12–38.3 µm; width: 5.9–14 µm; striae in 10 µm: 20–24

***Psammothidium incognitum* (Krasske) Van de Vijver**
Figures 3(60), 5(9)

Morphometric information: length: 10–16.7 µm; width: 5–6 µm; striae in 10 µm: impossible to resolve in light microscopy.

***Psammothidium papilio* (Kellogg, Stuiver, Kellogg & Denton) Kopalová & Van de Vijver**
Figures 3(63, 64), 5(10)

Morphometric information: length: 7.6–14 µm; width: 3.7–5.2 µm; striae in 10 µm: impossible to resolve in light microscopy

***Psammothidium rostrogermainii* Van de Vijver, kopalová & Zidarova**
Figures 3(65), 5(11)

Morphometric information: length: 7.5–22 µm; width: 5.1–8.5 µm; striae in 10 µm: 17–22

***Psammothidium* sp.**
Figure 3(61, 62)

Morphometric information: length: 4.2–8.5 µm; width: 3–3.5 µm; striae in 10 µm: impossible to resolve in light microscopy

***Psammothidium subatomoides* (Hustedt) Bukhtiyarova et Round**
Figure 3(66)

Morphometric information: length: 6.9–9 µm; width: 4.2–6 µm; striae in 10 µm: impossible to resolve in light microscopy

***Pseudogomphonema kamtschaticum* (Grunow) Medlin in Medlin & Round**
Figures 3(67-68), 5(12)

Morphometric information: length: 11.2–36.5 µm; width: 2–2.4 µm; striae in 10 µm: 11–13

***Sellaphora antarctica* Zidarova, Kopalová & Van de Vijver**
Figures 3(69), 5(13)

Morphometric information: length: 7–17.2 µm; width: 2.2–3.5 µm; striae in 10 µm: 18–22

***Sellaphora nana* (Hustedt) Lange-Bertalot, Cavacini, Tagliaventi & Alfinito**
Figure 3(70)

Morphometric information: length: 8–20.2 µm; width: 3–6 µm; striae in 10 µm: impossible to resolve in light microscopy

***Sieminskia zeta* (Cleve) Metzeltin & Lange-Bertalot**
Figure 3(71)

Morphometric information: length: 32.1–45.8 µm; width: 10.1–12.3 µm; striae in 10 µm: 24–26

***Stauroneis latistauros* Van de Vijver & Lange-Bertalot**
Figure 3(72)

Morphometric information: length: 26.9–49.4 µm; width: 6.8–10 µm; striae in 10 µm: 20–25

***Stauronella indubitabilis* Lange-Bertalot & Genkal**
Figures 3(73), 5(14)

Morphometric information: length: 36.2–40.7 µm; width: 2.5–3.1 µm; striae in 10 µm: impossible to resolve in light microscopy

***Staurosirella frigida* Van de Vijver & E. Morales**
Figures 3(74, 75), 5(15)

Morphometric information: length: 10–15.3 µm; width: 2.8–4.5 µm; striae in 10 µm: 9–10

***Thalassiosira gracilis* var. *expecta* Fryxell & Hasle**
Figure 3(76)

Morphometric information: diameter (µm): 5.9–14.1; areolae in 10 µm valve: 16–18

Discussion

The species richness observed in this study was much lower than that observed by Kopalová et al. (2013), who found 123 species of diatoms on James Ross Island. However, the number of samplings and sample stations in their study was greater. The most abundant species in that study was *Fragillaria capucina*, *Luticola muticopsis*, *Nitzschia gracilis*, *N. homburgiensis*, and *Psammonthidium papilio*. Lobo et al. (1998) observed 25 species of epilithic diatoms in a survey of two lakes on King George Island, with a sampling number similar to the numbers presented here. In the lakes observed by Lobo et al. (1998), *Gomphonema angustatum* and *Fragillaria capucina* were also present. The southern tip of the American continent is the most likely source of diatom dispersion.

When analyzing the diatom species in a transect of Patagonia to Antarctica, Maidana et al. (2005) observed a decrease in specific richness with the increase of latitude, confirming the theory of insular biogeography. This area–species relationship is another basic principle of island biogeography, in that the number of species found in an area increases with the size of the island (Morin 2005). The number of species on an island is also a consequence of the dynamic balance and interrelationship between rates of colonization and extinction on the island, and it is presumed that in a larger area there would be more interference from such processes.

Deception Island is an active volcano located on a rift along the Bransfield Strait. It is a horseshoe-shaped island belonging to the South Shetland Islands, a mountainous archipelago located in the southern Atlantic Ocean within the Maritime Antarctica biogeographical region (Smith 2005). The volcanic characteristics may be a factor in the selection of unique species because 18 species occurred only on Deception Island. Deception Island had the greatest number of unique species, with nine.

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Authors' Contributions

JFS, MAP, and ABP conceived and designed the project. JFS, RPA, and ABP collected the samples. RRA and EPS carried out the preparation of the material for identification. JFS identified all samples and registered microscopy images. ALS built the maps. All authors wrote and corrected the text.

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