POLISH POLAR RESEARCH
vol. 39, no. 3, pp. 393–412, 2018 doi: 10.24425/118753

Freshwater diatoms of the Ecology Glacier foreland, King George Island, South Shetland Islands

Natalia KOCHMAN-KĘDZIORA[1*], Teresa NOGA[2],
Maria OLECH[3,4] and Bart VAN DE VIJVER[5,6]

[1] *University of Rzeszów, Faculty of Biology and Agriculture, Podkarpackie Innovative Research Center of Environment, Zelwerowicza 8B, 35–601 Rzeszów, Poland*

[2] *University of Rzeszów, Faculty of Biology and Agriculture, Department of Soil Studies, Environmental, Chemistry and Hydrology, Zelwerowicza 8B, 35-601 Rzeszów, Poland*

[3] *Jagiellonian University, Department of Polar Research and Documentation, Institute of Botany, Kopernika 27, 31-501 Kraków, Poland*

[4] *Polish Academy of Sciences, Institute of Biochemistry and Biophysics, Pawińskiego 5a, 02-106 Warszawa, Poland*

[5] *Botanic Garden Meise, Research Department, Nieuwelaan 38, B–1860 Meise, Belgium*

[6] *University of Antwerp, Department of Biology, ECOBE, Universiteitsplein 1, B–2610 Wilrijk, Antwerpen, Belgium*

[*] *corresponding author <nkochman@ur.edu.pl>*

Abstract. Diatom assemblages from small pools and creeks on the Ecology Glacier forefield have been investigated. It is the first study in the Admiralty Bay region after the thorough taxonomic revision of the non-marine Antarctic diatom flora. A total of 122 diatom taxa, belonging to 35 genera were identified. More than 55% of all observed species have a restricted Antarctic distribution. Another 15% have a marine origin. *Nitzschia gracilis* Hantzsch, *N. homburgiensis* Lange-Bertalot and *Planothidium rostrolanceolatum* Van de Vijver *et al*. dominated the flora. Based on a DCA analysis, samples were subdivided in three groups reflecting ecological differences. Several samples (group 1) showed a mixed freshwater/marine diatom composition and are typical for coastal pools. Two other groups were separated based on the amount of limnoterrestrial taxa indicating the temporary character of some of the pools.

Key words: Antarctic, King George Island, Ecology Glacier, diatoms, freshwater assemblages.

Introduction

Diatoms (Bacillariophyta) are one of the most abundant and productive algal groups in Antarctic and Sub-Antarctic inland waters and terrestrial environments (Jones 1996; Van de Vijver and Beyens 1999; Sabbe *et al*. 2003). In the past 30 years, the freshwater diatom flora of the South Shetland Islands received a fair share of attention from scientists all over the world. Kellogg and Kellogg (2002) listed all publications up to 2002 reporting freshwater diatoms mainly from King George Island and Livingston Island, the two largest islands of the archipelago. Although in most papers a highly diverse diatom flora was reported, a considerable proportion of the recorded species were lumped together as one single, usually morphologically variable species, while many other taxa were force-fitted (Tyler 1996) into European or North American species (Kawecka and Olech 1993; Luścińska and Kyć 1993; Kawecka *et al*. 1998; Teminiskova-Topalova and Chipev 2001; Noga and Olech 2004). This has led to incorrect and incomplete interpretations of the diversity, biogeography and ecology of the Antarctic diatoms (Sabbe *et al*. 2003; Van de Vijver *et al*. 2005). Since 2002 however, significant progress has been made with respect to our knowledge of the diversity and taxonomy of the freshwater diatom flora of the South Shetland Islands. The recent publication of a new freshwater diatom identification guide for the Maritime Antarctic Region (Zidarova *et al*. 2016a) illustrated almost all freshwater and terrestrial diatom taxa reported so far from this region. The guide was based on an extensive revision of all genera that were encountered during a survey of the diatom flora. A large number of new species were described in almost every genus (*e.g*., Van de Vijver *et al*. 2010, 2011, 2013; Zidarova *et al*. 2010, 2012, 2016b; Kopalová *et al*. 2015).

The establishment of the Polish Antarctic Station *Arctowski* on the western coast of Admiralty Bay resulted in the publication of several floristic and ecological diatom studies by Kawecka and Olech (1993), Luścińska and Kyć (1993), Kawecka *et al*. (1996, 1998), Żytkowicz (unpublished data) and Noga and Olech (2004) dealing with the diatom flora in samples collected from streams, creeks and puddles near the station. Luścińska and Kyć (1993) made a general algal survey of the diversity around *Arctowski* station. The paper reported the presence of more than 120 diatom taxa, most of them, however, are typical European taxa such as *Asterionella formosa* Hassall, *Diatoma vulgaris* Bory or *Gomphonema parvulum* (Kützing) Kützing. Kawecka *et al*. (1996) investigated the morphological variability of one of the typical Antarctic diatoms, *Luticola muticopsis* (Van Heurck) D.G. Mann in temporary streams on King George Island. Two years later, the same authors (Kawecka *et al*. 1998) studied diatoms in small waterbodies and defined two groups of communities, indicating different levels of nutrient enrichment. More recently, Noga and Olech (2004) investigated the diatom diversity of a highly eutrophic ephemeral creek close to the Polish base.

They found 95 diatom taxa forming two groups of communities. Despite the unique nature of the diatom flora, none of these studies indicated the presence of endemic, *i.e*. typical Antarctic taxa.

The present study discusses the actual living diatom communities in 14 waterbodies (pools and creeks) on the Ecology Glacier foreland in the vicinity of the Polish Antarctic *Arctowski* Station (King George Island) based on the revised diatom flora according to Zidarova *et al*. (2016a).

Material and methods

Study site. — King George Island (61°54'–62°16'S, 57°35'–59°02'W), the largest island of the South Shetland Archipelago, is 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 (Wen *et al*. 1994; Rakusa-Suszczewski 2002). The mean annual air temperature is about -2.5°C with a mean annual precipitation of around 600–700 mm (Peter *et al*. 2008; Liu *et al*. 2011). Vegetation is composed mainly of mosses, lichens and only two vascular plants, *Deschampsia antarctica* Desv. and *Colobanthus quitensis* (Kunt) Bartl. Human presence on King George Island is intense, as shown by the large number of permanently staffed research stations belonging to Argentina, Brazil, Chile, China, Ecuador, South Korea, Peru, Poland, Russia, Uruguay and the United States.

Most of King George Island is covered by a large ice dome with ice-free areas restricted to only a few percent of the total area of the island. Rapid glacial recession exposed irregular glacial deposits, such as recessional moraine ridges (up to 50 m a.s.l.), separated by depressions in the marginal zone of these forefields. Pools and small, temporary brooks are formed on these newly uncovered areas. One of these forefields, Ecology Glacier forefield (EGF), is located close to the *Arctowski* Station in the northern part of the Antarctic Specially Protected Area 128 (Fig. 1). Part of the forefield, especially close to the recessional moraine ridges, is covered mainly by mosses and lichens (Angiel and Dąbski 2012). Several pools and creeks were formed on this forefield during the previous deglaciation period (1979–2011) (Sobota *et al*. 2015).

Sampling. — A total of 21 samples for diatom analysis were taken in February 2015 from 9 pools and 5 creeks (= small, occasionally drying streams). Geographical coordinates of each sampling location were recorded using a handheld GPS. Both sediment samples and scrapings from submerged boulders were collected. Due to logistic constraints, only a few physical and chemical parameters were measured using a MARTINI PH65 meter and a MARTINI EC59 meter: water temperature, pH and conductivity were measured in situ. Detailed information about all sampling sites is provided in Table 1.

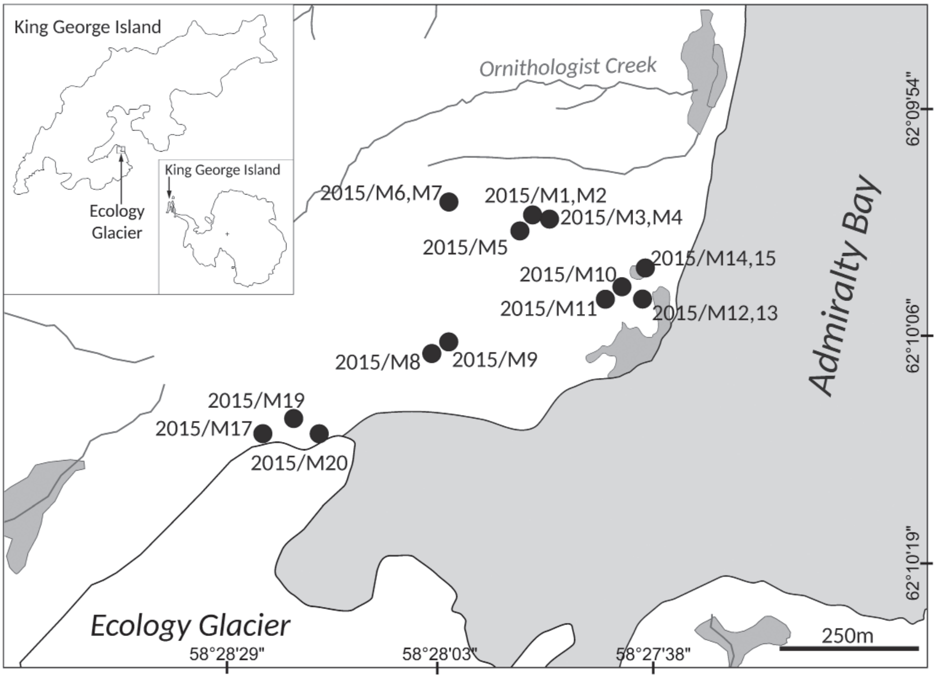

Fig. 1. The Antarctic Region showing the position of King George Island with an inset map of the main sampling area.

Slide preparation and diatom identification. — Samples for diatom analysis were prepared according to the method used by Kawecka *et al*. (1998) and Kawecka (2012). Small subsamples were digested using cleaning mixture, concentrated sulfuric acid and chromic acid. Following digestion and centrifugation, the resulting cleaned material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides, dried on microscope cover slips and mounted in Pleurax (refractive index 1.75). Samples and slides are stored at the Podkarpackie Innovative Research Center of Environment (PIRCE), University of Rzeszów (Poland). In each sample, 400 diatom valves were identified and enumerated on random transects at x1000 magnification under oil immersion using an Olympus BX53 microscope equipped with Differential Interference Contrast (Nomarski) optics and the Olympus UC30 digital camera. After the count, the rest of the slide was scanned for rare species that were not observed during the counting. Freshwater, including limno-terrestrial, diatom identification was based on Zidarova *et al*. (2016a) and references listed therein. Marine taxa were identified using Witkowski *et al*. (2000), Al-Handal and Wulff (2008), Al-Handal *et al*. (2008, 2010) and Riaux-Gobin *et al*. (2009).

Data analysis. — The Shannon-Wiener diversity index (log_{10}-based) and Hill's evenness index were calculated using the statistical package MVSP 3.2 (Kovach Computing Services 1993).

Table 1

List of samples used in this study with detailed physico-chemical information per sample.

sample	sampling date	GPS coordinates	type of the waterbody	substrate	altitude (m asl)	area (sq m)	depth (cm)	distance from the sea (m)	water pH	temperature (°C)	conductivity (µS/cm)
2015/M1	6/02/2015	62°09’55.6”S 58°27’51.0W”	pool	stone	39	25	20–30	430	8.1	5.1	64
2015/M2			pool	sediment							
2015/M3	6/02/2015	62°09’55.4”S 58°27’51.0”W	pool	sediment	30	20	10–50	345	7.6	6.8	147
2015/M4			pool	stone							
2015/M5	6/02/2015	62°09’55.4”S 58°27’51.0”W	pool	sediment with mosses	35	10	20–30	345	7.5	8.2	142
2015/M6	6/02/2015	62°09’55.5”S 58°28’00.4”W	pool	stone	45	35	70	470	7.8	8.0	76
2015/M7			pool	sediment							
2015/M8	6/02/2015	62°10’04.9”S 58°28’03.3”W	pool	sediment	5	40	100	470	7.6	8.5	95
2015/M10	7/02/2015	62°10’03.4”S 58°27’37.4”W	pool	sediment	10	90	100	100	7.7	7.4	231
2015/M11	7/02/2015	62°10’03.6”S 58°27’39.6”W	pool	sediment	10	50	50	125	7.1	3.6	151
2015/M14	9/02/2015	62°10’0.8”S 58°27’36.4”W	pool	stone	10	10	100	95	9.0	3.9	430
2015/M15			pool	sediment							
2015/M17	10/02/2015	62°10’10.9”S 58°28’22.8”W	pool	sediment	10	25	70	800	7.5	2.0	59
2015/M9	6/02/2015	62°10’04.9”S 58°28’02.6”W	creek	sediment	5			470			
2015/M12	7/02/2015	62°10’03.2”S 58°27’37.1”W	creek	stone	10			100	7.5	6.6	144
2015/M13			creek	sediment							
2015/M19	10/02/2015	62°10’10.3”S 58°28’18.0”W	creek	sediment	10			140	6.6	1.9	54
2015/M20	10/02/2015	62°10’11.5”S 58°28’15.0”W	creek	stones	10			85	6.6	2.0	57

The geographic distribution of the taxa was based on Zidarova *et al*. (2016a and references therein). When the identity of a taxon could not be determined with absolute certainty, this was shown using 'cf.' or 'sp.' and, its distribution was listed as unknown (U). For Antarctic species, the geographic distribution was further assigned in MA when the species only occurred in the Maritime Antarctic Region, MA/CA when a species was present in both the Maritime and Continental Antarctic and MA/SA for Maritime Antarctic species also occurring on the sub-Antarctic islands. Antarctic taxa with a wider distribution in the entire Antarctic Region are listed as 'A'. Cosmopolitan species were listed as 'CO'.

Ordination was used to elucidate the principal patterns in species composition in the Ecology Glacier foreland waterbodies. Ln-transformed abundance data with downweighting of rare taxa were used in the ordinations. The statistical and numerical techniques used in this study are described in full detail in Jongman *et al*. (1995). As an initial Correspondence Analysis (CA) revealed a gradient length in standard deviation (SD) units larger than 2 SD, unimodal species response curves could be expected (Ter Braak and Prentice 1988). Detrending by segments was however necessary due to a strong Arch-effect. All ordination analyses were performed using the computer program CANOCO version 4.5 (Ter Braak and Šmilauer 1998).

Results

Species composition and diversity. — A total of 122 diatom taxa (including species, varieties and forms), belonging to 35 genera, were identified during the counts, among them more than 15% (21 taxa) having a marine origin. Three samples (2015/M16, 2015/M18, 2015/M21) contained (almost) no diatoms, even after counting an entire slide, most likely since they were taken from recently arised creeks. Subsequently, these samples have been removed from further analysis. Table 2 provides a full list of all taxa together with their biogeographic distribution.

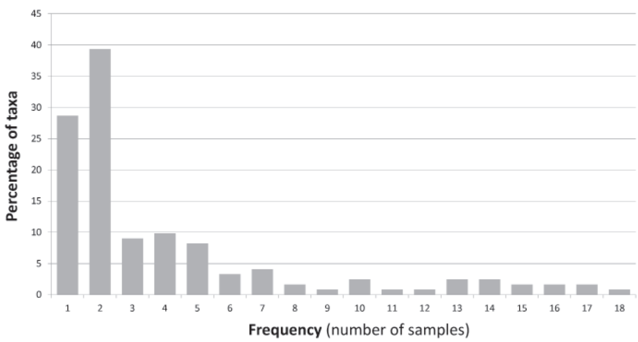

Fig. 2. Frequency distribution of diatom taxa occurrence in the analyzed samples.

Table 2

List of all observed species with their acronyms in the investigated samples from the Ecology Glacier Foreland. Distribution: C, Cosmopolitan; MA, Maritime Antarctic Region; CA, Continental Antarctica; SA, Sub-Antarctic Region; U, Unknown. Marine species are listed at the end of the table.

taxa name	abbreviaton	distribution
Brachysira minor (Krasske) Lange-Bertalot	BRAMIN	C
Caloneis australis Zidarova, Kopalová *et* Van de Vijver	CALAUS	MA
Chamaepinnularia australomediocris (Lange-Bertalot *et* Rol. Schmidt) Van de Vijver	CHAAUS	MA/SA
Chamaepinnularia gerlachei Van de Vijver *et* Sterken	CHAGER	MA
Chamaepinnularia krookiformis (Krammer) Lange-Bertalot *et* Krammer	CHAKRF	C
Chamaepinnularia krookii (Grunow) Lange-Bertalot *et* Krammer	CHAKRO	C
Eunotia pseudopaludosa Van de Vijver, de Haan *et* Lange-Bertalot	EUNPPA	MA
Eunotia ralitsae Van de Vijver, de Haan *et* Lange-Bertalot	EUNRAL	MA
Fistulifera pelliculosa (Brébisson) Lange-Bertalot	FISPEL	C
Fragilaria cf. *parva* Tuji *et* Williams	FRCPAR	U
Gomphonema maritimo-antarcticum Van de Vijver, Kopalová, Zidarova *et* Kociolek	GOMMAN	MA
Hantzschia abundans Lange-Bertalot	HANABU	C
Hantzschia acuticapitata Zidarova *et* Van de Vijver	HANACU	MA
Hantzschia amphioxys (Ehrenberg) Grunow	HANAMP	C
Hantzschia amphioxys f. *muelleri* Ts. Ko-Bayashi	HANAFM	C
Hantzschia hyperaustralis Van de Vijver *et* Zidarova	HANHYP	MA/CA
Hippodonta hungarica (Grunow) Lange-Bertalot, Metzeltin *et* Witkowski	HIPHUN	C
Humidophila australoshetlandica Kopalová, Zidarova *et* Van de Vijver	HUMASH	MA
Humidophila keiliorum Kopalová	HUMKEL	MA
Humidophila sceppacuerciae Kopalová	HUMSCP	MA
Humidophila tabellariaeformis (Krasske) R.L. Lowe, Kociolek, J.R. Johansen, Van de Vijver, Lange-Bertalot *et* Kopalová	HUMTAB	C
Humidophila vojtajarosikii Kopalová, Zidarova *et* Van de Vijver	HUMVOJ	MA
Luticola amoena Van de Vijver, Kopalová, Zidarova *et* Levkov	LUTAMO	MA
Luticola australomutica Van de Vijver	LUTAUM	MA
Luticola austroatlantica Van de Vijver, Kopalová, S.A. Spaulding *et* Esposito	LUTAUA	MA/CA
Luticola contii Zidarova, Levkov *et* Van de Vijver	LUTCON	MA
Luticola higleri Van de Vijver, van Dam *et* Beyens	LUTHIG	MA
Luticola katkae Van de Vijver *et* Zidarova	LUTKAT	MA

Table 2 – continued

taxa name	abbreviaton	distribution
Luticola muticopsis (Van Heurck) D.G. Mann	LUTMUT	A
Luticola olegsakharovii Zidarova, Levkov *et* Van de Vijver	LUTOLG	MA
Luticola pusilla Van de Vijver, Kopalová, Zidarova *et* Levkov	LUTPUS	MA
Luticola quadriscrobiculata Van de Vijver	LUTQUA	MA
Luticola truncata Kopalová *et* Van de Vijver	LUTTRU	MA
Luticola vandevijveri Kopalová, Zidarova *et* Levkov	LUTVDV	MA
Luticola cf. *muticopsis* (Van Heurck) D.G. Mann	LUTCMU	U
Luticola sp.	LUTSP1	U
Mayamaea cf. *atomus* (Hustedt) Bruder *et* Medlin	MACATO	U
Mayamaea cf. *permitis* (Hustedt) Bruder *et* Medlin	MACPER	U
Mayamaea sweetloveana Zidarova, Kopalová *et* Van de Vijver	MAYSWE	MA
Microcostatus australoshetlandicus Van de Vijver, Kopalová, Zidarova *et* Cox	MICASH	MA
Muelleria aequistriata S.A. Spaulding	MUEAEQ	MA
Muelleria australoatlantica S.A. Spaulding	MUEAUA	MA
Muelleria kristinae Van de Vijver	MUEKRI	MA
Muelleria nogae Van de Vijver, Zidarova *et* Kopalová	MUENOG	MA
Muelleria olechiae Kochman-Kędziora, Noga, Van de Vijver *et* Stanek-Tarkowska	MUEOLE	MA
Muelleria pimpireviana Zidarova, Kopalová *et* Van de Vijver	MUEPIM	MA
Muelleria sabbei S.A. Spaulding	MUESAB	MA
Muelleria undulatoides Van de Vijver, Zidarova *et* Kopalová	MUEUND	MA
Muelleria sp.	MUESP1	U
Navicula australoshetlandica Van de Vijver	NAVASH	MA
Navicula cremeri Van de Vijver *et* Zidarova	NAVCRE	MA
Navicula gregaria Donkin	NAVGRE	C
Navicula romanedwardii Zidarova, Kopalová *et* Van de Vijver	NAVROM	MA
Nitzchia gracilis Hantzsch	NITANW	C
Nitzschia annewillemsiana Hamsher, Kopalová, Kociolek, Zidarova *et* Van de Vijver	NITGRA	MA
Nitzschia homburgiensis Lange-Bertalot	NITHOM	C
Nitzschia kleinteichiana Hamsher, Kopalová, Kociolek, Zidarova *et* Van de Vijver	NITKLE	MA
Nitzschia soratensis E. Morales *et* Vis	NITSOR	C
Nitzschia stelmachpessiana Hamsher, Kopalová, Kociolek, Zidarova *et* Van de Vijver	NITSTE	MA

taxa name	abbreviaton	distribution
Orthoseira roeseana (Rabenhorst) O'Meara	ORTROS	C
Pinnularia australoglobiceps Zidarova, Kopalová *et* Van de Vijver	PINAGL	MA/SA
Pinnularia australomicrostauron Zidarova, Kopalová *et* Van de Vijver	PINAMS	MA/CA
Pinnularia australorabenhorstii Van de Vijver	PINARH	MA
Pinnularia australoschoenfelderi Zidarova, Kopalová *et* Van de Vijver	PINASF	MA
Pinnularia austroshetlandica (Carlson) Cleve-Euler	PINASH	MA/SA
Pinnularia borealis Ehrenberg	PINBOR	C
Pinnularia borealis var. *pseudolanceolata* Van de Vijver *et* Zidarova	PINBLA	MA
Pinnularia livingstonensis Zidarova, Kopalová *et* Van de Vijver	PINLIV	MA
Pinnularia magnifica Zidarova, Kopalová *et* Van de Vijver	PINMAG	MA
Pinnularia microstauroides Zidarova, Kopalová *et* Van de Vijver	PINMSI	MA
Pinnularia perlanceolata Van de Vijver *et* Zidarova	PINPER	MA
Pinnularia subaltiplanensis Zidarova, Kopalová *et* Van de Vijver	PINSAP	MA
Pinnularia subantarctica var. *elongata* (Manguin) Van de Vijver *et* Le Cohu	PINSVE	MA/SA
Pinnularia subcatenaborelis Kochman-Kędziora, Pinseel *et* Van de Vijver	PINCCA	U
Pinnularia cf. *strictissima* Manguin	PINCST	U
Pinnularia sp. 1	PINSP1	U
Pinnularia sp. 2	PINSP2	U
Placoneis australis Van de Vijver *et* Zidarova	PLCAUS	MA
Planothidium australe (Manguin) Le Cohu	PLAAUS	C
Planothidium capitatum (O. Müller) Van de Vijver, Kopalová, C.E. Wetzel *et* Ector	PLACAP	C
Planothidium lanceolatum (Brébisson) Lange-Bertalot	PLALAN	C
Planothidium rostrolanceolatum Van de Vijver, Kopalová *et* Zidarova	PLARLA	MA
Psammothidium aretasii (Manguin) Le Cohu	PSAARE	C
Psammothidium germainii (Manguin) Sabbe	PSAGER	MA/SA
Psammothidium germainioides Van de Vijver, Kopalová *et* Zidarova	PSAGEI	MA
Psammothidium incognitum (Krasske) Van de Vijver	PSAINC	MA/SA
Psammothidium papilio (D.E. Kellogg *et al.*) Kopalová *et* Van de Vijver	PSAPAP	MA/SA
Psammothidium rostrogermainii Van de Vijver, Kopalová *et* Zidarova	PSARGE	MA/CA
Psammothidium superpapilio Kopalová, Zidarova *et* Van de Vijver	PSASPA	MA
Sellaphora jamesrossensis (Kopalova *et* Van de Vijver) Van de Vijver *et* C.E. Wetzel	SELJAM	MA

Table 2 – continued

taxa name	abbreviaton	distribution
Sellaphora nana (Hustedt) Lange-Bertalot, Cavacini, Tagliaventi *et* Alfinito	SELNAN	C
Stauroforma inermis Flower, Jones *et* Round	STFINE	MA/SA
Stauroforma cf. *inermis* Flower, Jones *et* Round	STFCIN	U
Stauroneis acidojarensis Zidarova, Kopalová *et* Van de Vijver	STAACI	MA
Stauroneis huskvikensis Van de Vijver *et* Lange-Bertalot	STAHUS	MA
Stauroneis jamesrossensis Zidarova, Kopalová *et* Van de Vijver	STAJAM	MA
Stauroneis latistauros Van de Vijver *et* Lange-Bertalot	STALAT	A
Stauroneis minutula Hustedt	STAMIN	C
Stauroneis pseudomuriella Van de Vijver *et* Lange-Bertalot	STAPMU	MA/SA
Staurosira pottiezii Van de Vijver	STSPOT	MA
Tryblionella debilis Arnott	TRYDEB	C
marine species		
Cocconeis costata W. Gregory group	COCSP1	marine
Cocconeis costata var. *antarctica* Manguin	COCSP2	marine
Cocconeis costata var. *subantarctica* Riaux-Gobin *et* Romero	COCSP3	marine
Cocconeis dallmannii Al-Handal, Riaux-Gobin *et* Wulff	COCCOG	marine
Cocconeis pinnata var. *matsi* Al-Handal, Riaux-Gobin *et* Wulff	COCCVA	marine
Cocconeis schuettii van Heurck	COCCVS	marine
Cocconeis cf. *californica* Grunow	COCDAL	marine
Cocconeis sp. 1	COCPVM	marine
Cocconeis sp. 2	COCSCH	marine
Cocconeis sp. 3	COCCCA	marine
Fallacia marnieri (Manguin) Witkowski, Lange-Bertalot *et* Metzeltin	FALMAR	marine
Fragilariopsis curta (Van Heurck) Hustedt	FRACUR	marine
Fragilariopsis cylindrus (Grunow ex Cleve) Helmcke *et* Krieger	FRACYL	marine
Grammatophora sp.	GRASP1	marine
Licmophora sp.	LICMOP	marine
Navicula perminuta Grunow complex	NAVPER	marine
Navicula salinarum Grunow	NAVSAL	marine
Navicula sp.	NAVSP1	marine
Petroneis sp.	PETRON	marine
Pseudogomphonema sp.	PSEGOM	marine
Thalassiosira gracilis (Karsten) Hustedt	THAGRA	marine

Species richness per sample ranged from 17 to 39 (average: 31 ± 6, median: 31). The highest species richness was observed in samples 2015/M5 (39 taxa), 2015/M7 (38 taxa) and 2015/M11 (37 taxa) whereas samples 2015/M14 (17 taxa) and 2015/M17 (18 taxa) showed the lowest species richness. Diversity analysis revealed a mean Shannon-Wiener diversity index of 2.14 ± 0.39 and a mean evenness measure of 0.6 ± 0.1. Species relative abundance varied considerably. Thirteen freshwater and ten marine taxa were found with only one single valve in all counts together (7200 valves). Forty-one taxa together accounted for 1% of all diatoms counted. A large number of taxa were restricted to only one or two samples. More than 68% of all taxa were recorded in no more than two samples. But only 15.6% of taxa were observed in more than 50% of samples.

The genera *Nitzschia* (40.5% of all counted valves), *Planothidium* (10.2%) and *Pinnularia* (8.9%) dominated the counts when considering the frequencies of counted valves. The most species-rich genus was *Pinnularia* (17 taxa), followed by *Luticola* (14 taxa), *Muelleria* (9 taxa) and *Psammothidium* (7 taxa). The most abundant taxa (% of all counted valves) were *Nitzschia gracilis* (19.6%), *N. homburgiensis* (17.5%), *Planothidium rostrolanceolatum* (7.0%), *Navicula gregaria* (5.9%) and *Staurosira pottiezii* (5.8%). The ten most abundant taxa accounted for almost 70% of all counted valves (Table 3, Fig. 3).

Table 3

Ecological and species characteristics of the three diatom assemblages determined by the community analysis. Species present in number of samples # relative abundance in these samples. Mean values are shown with their standard error.

	group 1	group 2	group 3
number of samples	2	7	9
number of river samples	0	0	5
mean pH	9.0	7.8 ± 0.26	7.2 ± 0.47
mean temperature	3.9	7.0 ± 1.42	4.6 ± 2.85
mean conductivity	430	107 ± 43	113 ± 66
mean diversity	1.67 ± 0.10	2.28 ± 0.31	2.14 ± 0.42
mean evenness	0.54 ± 0.03	0.65 ± 0.08	0.63 ± 0.10
mean number of taxa	23 ± 8.5	34 ± 3.9	29 ± 5.9
Staurosira pottiezii		5 # 14.8	
Nitzschia homburgiensis	2 # 59.9	6 # 19.8	9 # 6.3
Pinnularia borealis	2 # 1.3	7 # 8.5	4 # 0.2
Chamaepinnularia krookiformis	2 # 7.8	7 # 5.1	9 # 2.0
Psammothidium germainii		7 # 3.1	4 # 0.8

Table 3 – continued

	group 1	group 2	group 3
Nitzschia soratensis		2 # 4.7	1 # 0.1
Psammothidium rostrogermainii	1 # 0.4	7 # 3.0	8 # 1.0
Luticola muticopsis	2 # 0.4	7 # 2.1	6 # 0.3
Nitzschia gracilis	1 # 0.5	4 # 9.9	9 # 31.5
Navicula gregaria	2 # 3.6	2 # 0.1	9 # 10.9
Planothidium rostrolanceolatum		4 # 0.4	8 # 13.7
Planothidium australe	1 # 0.4	7 # 1.3	9 # 3.2
Navicula australoshetlandica	2 # 0.6	4 # 0.1	8 # 3.8
Pinnularia australomicrostauron	2 # 5.6	6 # 1.0	8 # 2.6
Licmophora sp.	2 # 4.6		3 # 0.1
Thalassiosira gracilis	2 # 3.6	5 # 0.3	3 # 0.1
Fistulifera pelliculosa	1 # 2.6		
Pinnularia australoglobiceps	2 # 2.6	2 # 0.1	3 # 0.1

More than 55% of all observed species have a restricted Antarctic distribution with a majority of these (44%) endemic to the Maritime Antarctic Region (Fig. 4). Only 18% have a typical cosmopolitan distribution such as *Navicula gregaria* or *Nitzschia gracilis*. For 9% (11 taxa) of all observed taxa, it was impossible to establish their correct taxonomical identity. A fairly large proportion of all observed taxa (21 taxa) belonged to marine species. Most of them were identified as being restricted to the Southern Ocean such as *Cocconeis dallmannii*, *C. pinnata* var. *matsi* and *Fragilariopsis curta*.

Diatom community analysis. — Based on a DCA analysis (Fig. 5), it was possible to subdivide the samples in three groups. The first two DCA axes (λ_1 = 0.413, λ_2 = 0.258) explained 32.5% of the variation in the diatom composition with an additional 8.1% explained on the next two axes. Group 1 (black diamonds) includes samples 2015/M14 and 2015/M15, both taken from the same coastal lake, located very close to the sea and likely influenced by seaspray. The lake had a rather high pH (9.0) and an more elevated conductivity (430 μS/cm) compared to the other two groups. Group 2 (grey up-triangles) on the left side of the diagram is composed of samples taken from pools situated on an elevated ridge (40 m a.s.l.), at almost 500 m from the sea shore. These pools had an average pH of 7.8 ± 0.26 with an average conductivity of 107 ± 43 μS/cm. The samples in this group had the highest diversity (2.28 ± 0.31) and evenness (0.65 ± 0.08) of all three groups. Finally, group 3 (grey squares) consists mostly of samples collected in creeks including some pool samples influenced by inflowing water. The three groups show clear differences in species composition (Table 3,

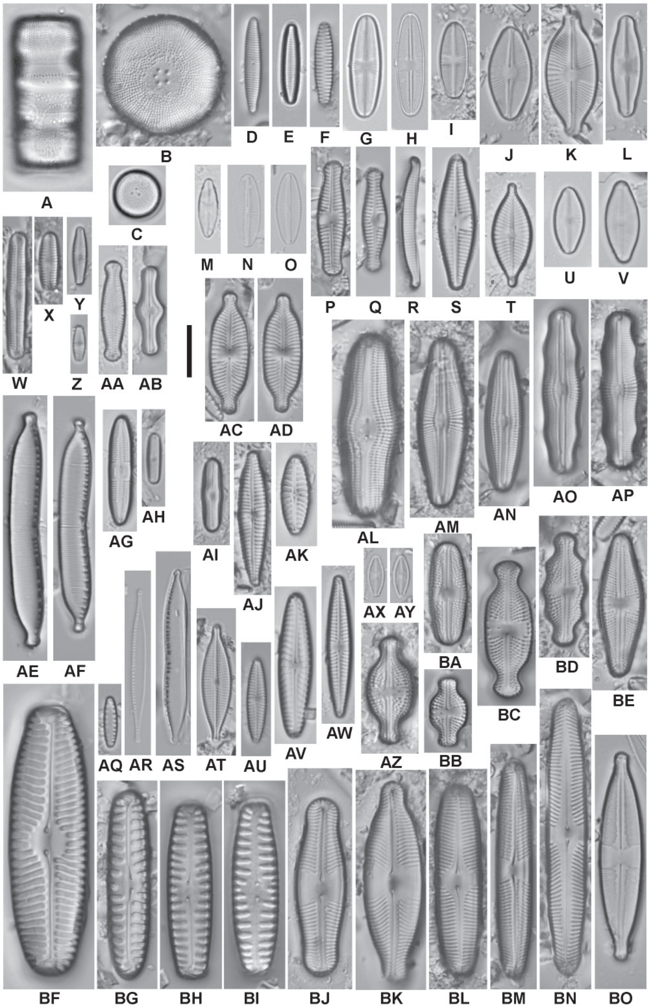

Fig. 3. Light micrographs of selected taxa: A–C, *Orthoseira roeseana*; D–E, *Stauroforma inermis*; F, *Staurosira pottiezii*; G–H, *Psammothidium superpapilio*; I, *P. papilio*; J, *P. germainii*; K, *P. rostrogermainii*; L, *P. aretasii*; M, *Sellaphora nana*; N–O, *S. jamesrossensis*; P–Q, *Planothidium capitatum*; R, *Eunotia pseudopaludosa*; S, *Planothidium rostrolanceolatum*; T, *P. australe*; U–V, *Psammothidium germainioides*; W–X, *Chamaepinnularia gerlachei*; Y–Z – *Ch. australomediocris*; AA, *Ch. krookiformis*; AB, *Humidophila tabellariaeformis*; AC–AD, *Placoneis australis*; AE–AF, *Hantzschia amphioxys*; AG, *Caloneis australis*; AH, *Humidophila vojtajarosikii*; AI, *Brachysira minor*; AJ, *Gomphonema maritimo-antarcticum*; AK, *Hippodonta hungarica*; AL, *Muelleria nogae*; AM, *M. sabbei*; AN, *M. aequistriata*; AO AP, *M. undulatoides*; AQ, *Nitzschia soratensis*; AR, *N. gracilis*; AS, *N. homburgiensis*; AT, *Navicula gregaria*; AU, *N. australoshetlandica*; AV, *N. romanedwardii*; AW, *N. cremeri*; AX–AY, *Microcostatus australoshetlandicus*; AZ, *Luticola katkae*; BA, *L. vandevijveri*; BB–BC, *L. muticopsis*; BD, *L. olegsakharovii*; BE, *L. quadriscrobiculata*; BF, *Pinnularia australorabenhorstii*; BG, *P. borealis*; BH–BI, *P. subcatenaborealis*; BJ, *P. australoglobiceps*; BK, *P. austroshetlandica*; BL, *P. australomicrostauron*; BM, *P. subantarctica* var. *elongata*; BN, *P. microstauroides*; BO, *Stauroneis latistauros*.

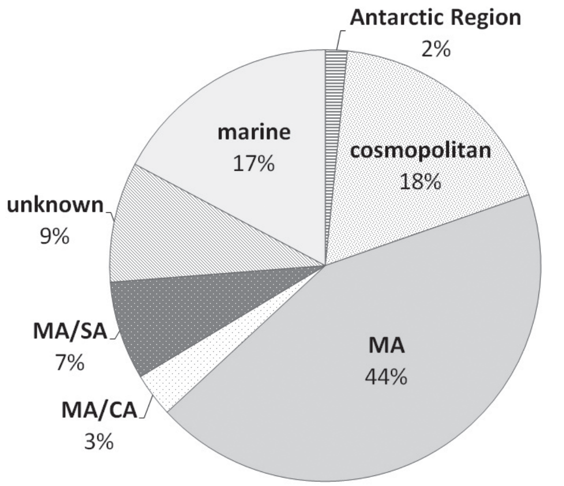

Fig. 4. Biogeographical distribution of the species recorded during this study.

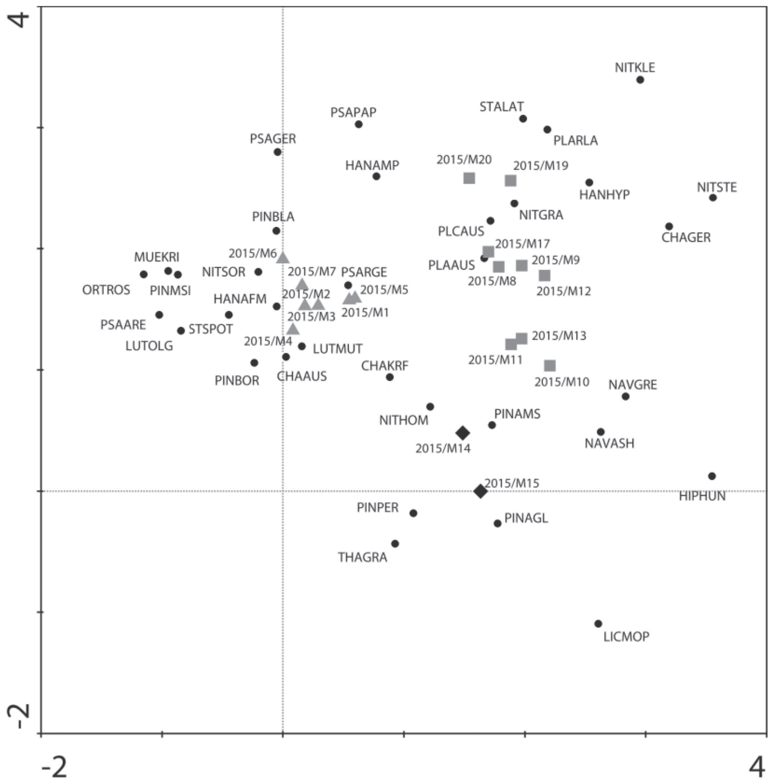

Fig. 5. Detrended Correspondence Analysis (DCA) of the EGF samples. Three assemblages indicated (group 1: black diamonds; group 2: grey up-triangles; group 3: grey squares). Species acronyms are listed in Table 2.

Fig. 5). Table 3 shows the main characteristics of the different groups including the dominant species. Only species with a cumulative fit of >15% are shown (species acronyms added to Table 2). Group 1 contained a rather large amount (up to 15%) of marine taxa such as *Licmophora* sp. or *Thalassiosira gracilis* most likely blown in *via* wind or seaspray. The dominating taxon in the two samples of this group was *N. homburgiensis*, accounting for almost 60% of all counted valves. The samples of group 2 were dominated by *Staurosira pottiezii*, *N. homburgiensis*, *N. gracilis* and *Pinnularia borealis*. Subdominant taxa include *Chamaepinnularia krookiformis*, *Psammothidium germainii*, *P. rostrogermainii*, *N. soratensis* and *Luticola muticopsis*. Finally, the last group is mainly composed of aquatic *Nitzschia* and *Navicula* taxa such as *Nitzschia homburgensis*, *N. gracilis* (31.5% of all counted valves), *Navicula gregaria* and *N. australoshetlandica*, with a considerable share of *Planothidium rostrolanceolatum*.

Discussion

Species composition and distribution. — The diatom composition of the Ecology Glacier forefield waterbodies is quite similar to the flora that was observed in other localities of the Maritime Antarctic Region. Kopalová and Van de Vijver (2013) analysed the freshwater diatom assemblages on the nearby Livingston Island. The dominance of the genus *Nitzschia* was also reported from pools on the largest ice-free area of Livingston Island (31.7% of all counted valves). A typical taxon that is often dominating pools and lakes in many Antarctic localities is *Nitzschia paleacea* Grunow (Kopalová *et al*. 2013; Kopalová and Van de Vijver 2013). Nevertheless, the species was completely absent from the studied waterbodies. This taxon is almost always associated with other *Nitzschia* taxa such as *N. gracilis*, *N. homburgiensis*, *N. kleinteichiana* and *N. annewillemsiana*. In older records of the King George Island diatom flora, the species was also never observed (Żytkowicz (unpublished data), Kellogg and Kellogg 2002).

Contrary however to the Livingston Island diatom flora, the genus *Fragilaria* was only weakly represented in EGF waterbodies with a maximum abundance of 10% in only the creek samples 2015/M19 and 2015/M20, whereas in other samples the genus was entirely absent. The main reason for this difference is most likely the nature of the samples as the genus prefers larger waterbodies and larger rivers. The present study deals mostly with pools including less flowing waterbodies in the dataset. On Livingston Island on the other hand, *Fragilaria* cf. *parva* (reported as *F. capucina* s.l. Desmazières) was present in almost every sample collected from flowing water, often dominating the diatom flora. Previous diatom records from the surroundings of the Polish *Arctowski* Station (Kawecka and Olech 1993; Luścińska and Kyć 1993; Kawecka *et al*. 1998; Noga and Olech 2004) all mention the presence of *Fragilaria* cf. *capucina*, usually in flowing water, but never in high abundances. On James Ross Island (south of the Antarctic Peninsula), another recently investigated island in the Maritime Antarctic Region, the same *Fragilaria* species was reported to be common in streams and seepage areas but less dominant in lakes and pools (Kopalová *et al*. 2013). *Fragilaria* species form an important constituent of lotic waterbodies in the entire Antarctic region (apart from the Antarctic Continent). Van de Vijver and Beyens (1999) reported large populations of *Fragilaria* cf. *capucina* from rivers and brooks on Iles Crozet, a sub-Antarctic archipelago. Kopalová *et al*. (2013) discussed the presence of the genus *Fragilaria* in Antarctic waterbodies, concluding that the genus should be considered as a pioneer species rapidly reflecting changes in water chemistry.

The present study is not the first to be conducted in the vicinity of *Arctowski* Station although it is the first time that the revised taxonomy according to Zidarova *et al*. (2016a) was used. Comparing species compositions with these older records is not always possible when records are not illustrated. One of the largest (historic) analysis was made almost 20 years ago by Kawecka *et al*. (1998) who reported 97 taxa from five small ponds and seven puddles in this area. A similar flora was also recorded in a few creeks in this locality (Kawecka and Olech 1993; Luścińska and Kyć 1993; Noga and Olech 2004). As mentioned earlier, these studies were based on the idea that most diatom taxa have a cosmopolitan distribution (Jones 1996), force-fitting most of the typical Antarctic taxa into European and North-America species based on books and keys available at that time (Tyler 1996). The revisions by Zidarova *et al*. (2016a and references therein) showed that this Ubiquity hypothesis (Finlay and Clarke 1999) should be rejected, indicating the highly specific nature of the Antarctic freshwater diatom flora. The analysis of the Ecology Glacier forefield waterbodies confirms this suggestion. Eleven of all observed taxa were noted using 'cf.' or 'sp.', because of their uncertain taxonomic identification. Despite the recent extensive taxonomic revision of the non-marine Antarctic diatom flora, there are still several taxa in our dataset that could not be identified based on all current available literature. An unknown *Pinnularia* taxon has been split off from the latter and published separately under the name *P. subcatenaborealis* (Kochman-Kędziora et al. 2018) whereas another taxon, *Muelleria olechiae*, was recently described from a soil sample collected in the same area (Kochman-Kędziora *et al*. 2017). The sample containing this new *Pinnularia* species was further characterized by other interesting, rare diatom taxa from the Maritime Antarctic Region, such as *Muelleria undulatoides*, at present only known from a few specimens collected on Livingston Island (Van de Vijver *et al*. 2014b) (Fig. 3).

The high proportion of marine valves in some of the samples are most likely the result of wind activity, biotic influence and sea spray. This is reflected in the habitat preferences of the recorded marine taxa. Several of them exhibit a typical planktonic lifeform, such as the genus *Fragilariopsis*, whereas others are almost exclusively present as epiphytes on marine macro-algae (*e.g.*, *Licmophora* sp.). The two samples in which most of the marine valves were observed, are situated quite close to the seashore and the lake was littered with remains of marine macro-algae, while the presence of marine birds (*Pygoscelis papua* Forster, 1781) and mammals (*Arctocephalos gazella* Peters, 1875) was noted (M. Olech, personal observation).

Diatom assemblages. — Although only 18 samples were used in this study, they present interesting data on the ecology of different pool ecotypes of the Maritime Antarctic Region. The species composition of the three groups reflects the integration of a larger period of habitat characteristics and history. The diatom flora of the pools of Group 2 is composed of two different types of diatoms: typical aquatic taxa such as *Nitzschia homburgiensis* and *N. gracilis*, and limnoterrestrial and aerophilic taxa, such as *Pinnularia borealis*, *Psammothidium germainii*, *P. rostrogermainii*, *Orthoseira roeseana* and *Luticola muticopsis*. One of the dominant taxa, *Staurosira pottiezii*, commonly found in the entire Maritime Antarctic Region (Zidarova *et al*. 2016a), prefers small, shallow, usually temporary pools (Van de Vijver *et al*. 2014a). The results indicate that these pools on the ridge of Ecology Glacier forefield are temporary pools, filled with stagnant water, during early summer and gradually drying out towards the end of the austral summer. This explains the high diversity in aerophilic taxa, although none of them really dominated the flora. Most of these taxa were found on other Maritime Antarctic localities. They often play a dominant role in the diatom flora of seepage areas and wet, terrestrial moss vegetations (Kopalová *et al*. 2012). *Psammothidium germainii* and *P. rostrogermainii* are typical for wet and moist soils and only rarely found in open waterbodies (Van de Vijver *et al*. 2016). On the other hand, the pools on the lower parts of the EGF, are probably also more or less temporary but never seem to dry out, continuously fed by inflowing (melt)water as reflected by several taxa typical for Antarctic lotic environments, such as *Nitzschia gracilis* and *Planothidium rostrolanceolatum*, and the almost total absence of aerophilic taxa. The freshwater flora of the lake corresponds with the composition in the other standing waterbodies in the lower part of the EGF. On Byers Peninsula (Livingston Island), a similar community was observed in coastal lakes, showing comparable pH and conductivity data and a similar diatom flora (Kopalová and Van de Vijver 2013).

Conclusions

It is clear that the revised taxonomy of the Antarctic diatom flora led to a better understanding of the ecology of the small waterbodies on the Ecology Glacier foreland. The obtained results offered a better insight in the nature of these waterbodies. The diatom composition on this part of King George Island containing recently described species as well as taxa, which cannot be identified with currently literature, confirms the unique nature of the Maritime Antarctic diatom flora.

Acknowledgements. — Natalia Kochman-Kędziora benefitted from an Erasmus student grant when visiting the University of Antwerp and the Botanic Garden Meise. This work has been financially supported by the Belspo MICROBIAN project.

References

AL-HANDAL A.Y. and WULFF A. 2008. Marine epiphytic diatoms from the shallow sublittoral zone in Potter Cove, King George Island, Antarctica. *Botanica Marina* 51: 411–435.

AL-HANDAL A.Y., RIAUX-GOBIN C., ROMERO O.E. and WULFF A. 2008. Two new marine species of the diatom genus *Cocconeis* Ehrenberg: *C. melchioroides* sp. nov. and *C. dallmannii* sp. nov., from King George Island, Antarctica. *Diatom Research* 23: 269–281.

AL-HANDAL A.Y., RIAUX-GOBIN C. and WULFF A. 2010. *Cocconeis pottercovei* sp. nov. and *Cocconeis pinnata* var. *matsii* var. nov., two new marine diatom taxa from King George Island, Antarctica. *Diatom Research* 25: 1–11.

ANGIEL P.J. and DĄBSKI M. 2012. Lichenometric ages of the Little Ice Age moraines on King George Island and of the last volcanic activity on Penguin Island (west Antarctica). *Geografiska Annaler, Series A: Physical Geography* 94: 395–412.

FINLAY B.J. and CLARKE K.J. 1999. Ubiquitous dispersal of microbial species. *Nature* 400: 828.

JONES V.J. 1996. The diversity, distribution and ecology of diatoms from Antarctic inland waters. *Biodiversity and Conservation* 5: 1433–1449.

JONGMAN R.H., TER BRAAK C.J.F and VAN TONGEREN O.F.R. 1987. *Data analysis in community and landscape ecology*. Pudoc, Wageningen: 291 pp.

KAWECKA B. 2012. *Diatom diversity in streams of the Tatra National Park (Poland) as indicator of environmental conditions*. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków: 213 pp.

KAWECKA B. and OLECH M. 1993. Diatom communities in the Vanishing and Ornitologist Creek, King George Island, South Shetlands, Antarctica. *Hydrobiologia* 269/270: 327–333.

KAWECKA B., OLECH M. and NOWOGRODZKA-ZAGÓRSKA M. 1996. Morphological variability of the diatom *Luticola muticopsis* (van Heurck) D.G. Mann in the inland waters of King George Island, South Shetland Islands, Antarctic. *Polish Polar Research* 17: 143–150.

KAWECKA B., OLECH M., NOWOGRODZKA-ZAGÓRSKA M. and WOJTUŃ B. 1998. Diatom communities in small water bodies at *H. Arctowski* Polish Antarctic Station (King George Island, South Shetland Islands, Antarctica. *Polar Biology* 19: 183–192.

KELLOGG T.B. and KELLOGG D.E. 2002. Non-Marine and Littoral Diatoms from Antarctic and Subantarctic Regions. Distribution and Updated Taxonomy. *Diatom Monographs* 1: 1–795.

KOCHMAN-KĘDZIORA N., NOGA T., VAN DE VIJVER B. and STANEK-TARKOWSKA J. 2017. A new *Muelleria* species (Bacillariophyta) from the Maritime Antarctic Region. *Fottea, Olomouc* 17: 264–268.

KOCHMAN-KĘDZIORA N., PINSEEL E., RYBAK M., NOGA T., OLECH M. and VAN DE VIJVER B. 2018. *Pinnularia subcatenaborealis* sp. nov. (Bacillariophyta) a new chain-forming diatom species form King George Island (Maritime Antarctica). *Phytotaxa* 364: 259–266.

KOPALOVÁ K., VESELÁ J., ELSTER J., NEDBALOVÁ L., KOMÁREK J. and VAN DE VIJVER B. 2012. Benthic diatoms (Bacillariophyta) from seepages and streams on James Ross Island (NW Weddell Sea, Antarctica). *Plant Ecology and Evolution* 145: 190–208.

KOPALOVÁ K. and VAN DE VIJVER B. 2013. Structure and ecology of freshwater benthic diatom communities from Byers Peninsula (Livingston Island, South Shetland Islands). *Antarctic Science* 25: 239–253.

KOPALOVÁ K., NEDBALOVÁ L., NYVLT D., ELSTER J. and VAN DE VIJVER B. 2013. Freshwater diatom communities from Ulu Peninsula (James Ross Island, NW Weddell Sea) with the construction of a diatom based conductivity transfer function. *Polar Biology* 36: 933–948.

KOPALOVÁ K., KOCIOLEK J.P., LOWE R.L., ZIDAROVA R. and VAN DE VIJVER B. 2015. Five new species of the genus *Humidophila* (Bacillariophyta) from the Maritime Antarctic Region. *Diatom Research* 30: 117–131.

KOVACH COMPUTING SERVICES 2002. *Multivariate statistical package, version 3.1. User's manual*. Kovach Computing Services, Pentraeth, Wales, 137 pp.

LIU X., SUN J., SUN L., LIU W. and WANG Y. 2011. Reflectance spectroscopy: a new approach for reconstructing penguin population size from Antarctic ornithogenic sediments. *Journal of Paleolimnology* 45: 213–222.

LUŚCIŃSKA M. and KYĆ A. 1993. Algae inhabiting creeks of the region of "H. Arctowski" Polish Antarctic Station, King George Island, South Shetlands. *Polish Polar Research* 14: 393–405.

NOGA T. and OLECH M.A. 2004. Diatom communities in Moss Creek (King George Island, South Shetland Islands, Antarctica) in two summer seasons: 1995/96 and 2001/02. *Oceanological and Hydrobiological Studies* 33: 103–120.

PETER H.-U., BÜSSER C., MUSTAFA O. and PFEIFFER S. 2008. *Evaluierung des Gefährdungsgrades der Gebiete Fildes Peninsula und Ardley Island und Entwicklung der Managementpläne zur Ausweisung als besonders geschützte oder verwaltete Gebiete*. Dessau-Roßlau, Umweltbundesamt, Texte19/08: 515.

RAKUSA-SUSZCZEWSKI S. 2002. King George Island – South Shetland Islands, Maritime Antarctic. *In*: Bayer L. and Bölter M. (eds) *Geology of Antarctic Ice–Free Landscapes*. *Ecological Studies*. Springer – Verlag, Berlin, Heidelberg: 23–36.

RIAUX-GOBIN C., ROMERO O.E. and AL-HANDAL A.Y. 2009. *Cocconeis costata* var. *subantarctica* var. nov., a new marine diatom off Kerguelen Archipelago (Southern Ocean, Indian Sector). *Diatom Research* 24: 393–404.

SABBE K., VERLEYEN E., HODGSON D.A., VANHOUTTE K. and VYVERMAN W. 2003. Benthic diatom flora of freshwater and saline lakes in the Larsemann Hills and Rauer Islands, East Antarctica. *Antarctic Science* 15: 227–248.

SOBOTA I., KEJNA M. and ARAŹNY A. 2015. Short-term mass changes and retreat of the Ecology and Sphinx glacier system, King George Island, Antarctic Peninsula. *Antarctic Science* 27: 500–510.

TEMNISKOVA-TOPALOVA D. and CHIPEV N. 2001. Diatoms from Livingston Island, the South-Shetland Islands, Antarctica. *In*: Economou-Amilli A. (ed.) *Proceedings of the 16th International Diatom Symposium*. Athenes & Aegean Islands, Greece: 291–314.

Ter Braak C.J.F. and Prentice I.C. 1988. A theory of gradient analysis. *Advances in Ecological Research* 18: 271–317.

Ter Braak C.J.F. and Šmilauer P. 1998. *CANOCO reference manual and users' guide to CANOCO for Windows*. Centre for Biometry, Wageningen: 352 pp.

Tyler P.A. 1996. Endemism in freshwater algae, with special reference to the Australian region. *Hydrobiologia* 336: 127–135.

Van de Vijver B. and Beyens L. 1999. Biogeography and ecology of freshwater diatoms in Subantarctica: a review. *Journal of Biogeography* 26: 993–1000.

Van de Vijver B., Gremmen N.J.M. and Beyens L. 2005. The genus *Stauroneis* (Bacillariophyceae) in the Antarctic region. *Journal of Biogeography* 32: 1791–1798.

Van de Vijver B., Mataloni G., Stanish L. and Spaulding S.A. 2010. New and interesting species of the genus *Muelleria* (Bacillariophyta) from the Antarctic Region and South Africa. *Phycologia* 49: 22–41.

Van de Vijver B., Zidarova R., Sterken M., Verleyen E., de Haan M., Vyverman W., Hintz F. and Sabbe K. 2011. Revision of the genus *Navicula* s.s. (Bacillariophyceae) in inland waters of the Sub-Antarctic and Antarctic with the description of 5 new species. *Phycologia* 50: 281–297.

Van de Vijver B., Kopalová K., Zidarova R. and Cox E.J. 2013. New and interesting small-celled naviculoid diatoms (Bacillariophyta) from the Maritime Antarctic Region. *Nova Hedwigia* 97: 189–208.

Van de Vijver B., Morales E.A. and Kopalová K. 2014a. Three new araphid diatoms (Bacillariophyta) from the Maritime Antarctic Region. *Phytotaxa* 167: 256–266.

Van de Vijver B., Zidarova R. and Kopalová K. 2014b. New species in the genus *Muelleria* (Bacillariophyta) from the Maritime Antarctic Region. *Fottea, Olomouc* 14: 77–90.

Van de Vijver B., KopalovÁ K. and Zidarova R. 2016. Revision of the *Psammothidium germainii* complex (Bacillariophyta) in the Maritime Antarctic Region. *Fottea, Olomouc* 16: 145–156.

Wen J., Xie Z., Han J. and Lluberas A. 1994. Climate, mass balance and glacial changes on small dome of Collins Ice Cap, King George Island, Antarctica. *Antarctic Research* 5: 52–61.

Witkowski A., Lange-Bertalot H. and Metzeltin D. 2000. Diatom flora of marine coasts I. *Iconographia Diatomologica* 7: 1–925.

Zidarova R., Van de Vijver B., Quesada A. and de Haan M. 2010. Revision of the genus *Hantzschia* (Bacillariophyceae) on Livingston Island (South Shetland Islands, Southern Atlantic Ocean). *Plant Ecology and Evolution* 143: 318–333.

Zidarova R., Kopalová K. and Van de Vijver B. 2012. The genus *Pinnularia* (Bacillariophyta) excluding the section Distantes on Livingston Island (South Shetland Islands) with the description of twelve new taxa. *Phytotaxa* 44: 11–37.

Zidarova R., Kopalová K. and Van de Vijver B. 2016a. Diatoms from the Antarctic Region. Maritime Antarctica. *Iconographia Diatomologica* 24: 1–504.

Zidarova R., Kopalová K. and Van de Vijver B. 2016b. Ten new Bacillariophyta species from James Ross Island and the South Shetland Islands (Maritime Antarctic Region). *Phytotaxa* 272: 37–62.

Received 21 May 2018
Accepted 5 July 2018