Benthic diatom flora of freshwater and saline lakes in the Larsemann Hills and Rauer Islands, East Antarctica

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Abstract: A floristic and taxonomic survey was made of the diatom communities of sediments and microbial mats in 66 freshwater and saline lakes and pools in the Larsemann Hills, Rauer Islands and Bølingen Islands (continental eastern Antarctica). A total of 31 taxa were distinguished, 10 of which could not be identified to species (nine) or even generic (one) level, either because they have most probably not yet been described or because they belong to species complexes that are in need of revision. Four new combinations are proposed; three species are reported for the first time from continental Antarctica, while another three are confirmed for eastern Antarctica for the first time. Analysis of literature data on Antarctic lacustrine diatoms shows that taxonomic practice has a profound influence on the assessment of distribution patterns. Force-fitting of European and North American names to Antarctic taxa and erroneous identifications have contributed to an underestimation of endemism in the diatom flora of Antarctic inland waters. In addition, changing concepts on species boundaries during the last decade influence the interpretation of biogeographic patterns. The application of a more fine grained taxonomy will almost certainly reveal a higher degree of endemism in Antarctica, and especially continental Antarctica. The present case study shows that in the Larsemann Hills Antarctic endemics account for about 40% of all freshwater and brackish taxa, while the biogeographic distribution of about 26% is unknown, mainly due to their uncertain taxonomic identity. This contradicts the view that cosmopolitanism prevails in Antarctic diatoms.

Introduction

Diatoms form an important component of benthic freshwater microbial communities in the Antarctic and sub-Antarctic (Spaulding & McKnight 1999). They have been used successfully as proxies to reconstruct changes in lake salinity, ice cover, and sea level, phenomena indicative of climatic change (Spaulding & McKnight 1999 and references therein). The communities, and especially those of continental Antarctica, are usually characterized by low diversity (Jones 1996). It is therefore imperative that identifications, which are the key to ecological and physiological information in the literature, are unambiguous and verifiable (i.e. clear illustrations and descriptions, and preferably references to voucher materials, should be provided, cf. Jones 1996, Stoermer 2001). Regional transfer functions based on the statistical analysis of diatom communities can circumvent identification problems as autecological information is based on weighted averaging regression modelling of a present-day training set. Their application in stratigraphical studies, however, relies on the assumption that the same taxa are present throughout sediment cores. In addition, without intercalibration and careful taxonomic documentation efforts, regional models cannot be applied in other geographic areas and remain of limited use.

In the last decade, diatom taxonomy and classification have undergone a number of drastic changes, resulting in a trend towards a more finely grained classification at both the species and generic level (Round *et al.* 1990, Mann 1999). Until the late 1980s many widely-used diatom floras (such as the '*Süßwasserflora of Mitteleuropa, Bacillariophyceae 1–4*' by Krammer & Lange-Bertalot 1986–91) had advocated broad species concepts, dismissing much morphological variation between and within populations of morphologically similar diatoms as phenotypic plasticity (caused by the diatom cell size reduction cycle or the environment), and therefore unworthy of taxonomic recognition. Outside Europe and North America, this resulted in the force-fitting (Tyler 1996) of European and North American names to specimens from other continents (Sabbe *et al.* 2001). As a consequence, most diatom taxa were considered to be cosmopolitan.

However, there is a growing body of evidence which suggests that minor morphological variation can be significant and that the morphological boundaries of many species have therefore been drawn too broadly (for a review of species concepts see Mann 1999). As a result of this, the taxonomy of many species complexes has been revised,

Table I. List and location of lakes sampled. Labels refer to slides present in the BAS diatom collection (Lxx = Larsemann Hills, Bxx = Bølingen Islands). Brackish lakes are marked with an asterisk. Names given in quote marks are unofficial.

Lake label	Lake Name	Location
L72	Lake Nella	76°22'E 69°24'S
L35	Crater Lake	76°11'E 69°23'S
L34	Kirisjes Pond	76°09'E 69°22'S
L12	Long Lake	76°07'E 69°24'S
LBU	Lake Burgess	76°07'E 69°25'S
L36	-	76°13'E 69°25'S
BBA	Barrtangen	76°05'E 69°27'S
L57	Progress Lake	76°24'E 69°24'S
L51	Lake Cameron	76°21'E 69°24'S
L71 (*)	Sarah Tarn	76°23'E 69°23'S
L59	Moore Lake	76°21'E 69°24'S
L67	-	76°21'E 69°23'S
L74	Discussion Lake	76°22'E 69°23'S
L63	-	76°18'E 69°23'S
L60	-	76°20'E 69°23'S
L8	-	76°05'E 69°09'S
L7	-	76°05'E 69°09'S
L10	Lake Heidi	76°06'E 69°24'S
L13	-	76°07'E 69°24'S
L14	-	76°07'E 69°24'S
L23	Pup Lagoon	76°03'E 69°25'S
LGR	"Lake Grovness"	76°11'E 69°24'S
L49	-	76°16'E 69°24'S
L44	-	76°17'E 69°24'S
L43	-	76°15'E 69°23'S
L69	"No Worry Lake"	76°23'E 69°22'S
L70 (*)	Lake Reid	76°23'E 69°23'S
L68	Heart Lake	76°23'E 69°23'S
BAL	Lake Alanna	75°55'E 69°28'S
LJA	Lake Jack	76°06'E 69°25'S
L18	Lake Spate	76°07'E 69°25'S
L1 (*)	Lake Anna	76°17'E 69°23'S
L73	-	76°23'E 69°24'S
LSP	"South Priddy"	76°02'E 69°25'S
L42	-	76°15'E 69°23'S
BST	-	75°50'E 69°27'S
LPR	Progress 2 pond	76°23'E 69°23'S
BFI (*)	Firelight Lake	75°45'E 69°31'S
L53b	-	76°23'E 69°24'S
LPS	Prog-Shan pond	76°23'E 69°23'S
L52	Lake Bruehwiler	76°21'E 69°24'S
L52b	None	76°21'E 69°24'S
L66	-	76°20'E 69°24'S
L65	-	76°19'E 69°24'S
LG2	Gentner 2	76°19'E 69°23'S
L64	-	76°18'E 69°23'S
LSN	Snowbowl	76°18'E 69°23'S
L61	-	76°19'E 69°22'S
BSU	Sunset Lake	75°45'E 69°31'S
L58	Lake Sibthorpe	76°21'E 69°24'S
LFO	Fold Lake	76°20'E 69°21'S
LMA	Manning Lake	76°19'E 69°21'S
L59b	-	76°21'E 69°24'S
LG1	Gentner 1	76°19'E 69°23'S
LG4	Gentner 4	76°19'E 69°23'S
L64b	-	76°18'E 69°23'S

leading to the description of new species, or the resurrection of older taxon names. It is of paramount importance, not only for the sake of systematic and phylogenetic studies, but also for applied diatom studies, that these revisions are based on sound taxonomic practice, i.e. on critical, comparative and verifiable analyses of numerous populations and published data (descriptions and illustrations, preferably including the type materials). This has unfortunately not always been the case (see for example the critical book reviews by Kociolek (2000) and Sabbe (2002)). The trend towards a more fine-grained taxonomy has also resulted in a reconsideration of biogeographies, indicating that at least in some groups, geographic distributions are more restricted than previously thought (Mann & Droop 1996, Kociolek & Spaulding 2000, Sabbe *et al.* 2001 and references therein).

While this recent 'splitting' trend has led to considerable confusion and discouragement amongst (palaeo)ecologists (Stoermer 2001), it also offers unique possibilities for refining existing models about the relationships between diatoms and their environment. This will enhance resolution in palaeolimnological reconstructions and will also ultimately lead to a better understanding of diatom biogeographies and the underlying causes of restricted distribution patterns.

The present study forms part of several interdisciplinary research projects aimed at reconstructing late Pleistocene and Holocene environmental and climatic conditions in the Larsemann Hills oasis (East Antarctica) (Hodgson *et al.* 2001b). While analysing fossil diatom assemblages from lakes in the Larsemann Hills oasis we came across numerous inconsistencies and misidentifications in the Antarctic diatom literature, apparently caused by the application of diatom literature from the Northern Hemisphere to Antarctic environments (see also Jones 1996, Spaulding & McKnight 1999). This not only jeopardises the use of palaeoecological inference models, but has also led to the notion that cosmopolitanism prevails in the Antarctic region (Pankow *et al.* 1991, Jones 1996, Van de Vijver & Beyens 1999a). We therefore performed a detailed analysis of the taxonomic composition of the diatom communities. In addition, we provide concise information on the geographic distribution and autecologies of the observed taxa. This dataset is then used as a case study to demonstrate that endemism in Antarctic diatoms has been underestimated.

More detailed information on the exact distribution of the species in relation to the abiotic environment in the Larsemann Hills oasis will be given in forthcoming papers on the Larsemann Hills diatom flora. The limnology and biology of the lakes in the Rauer Islands, with detailed information on the distribution of the diatom taxa, have been treated in a recent paper by Hodgson *et al.* (2001a).

Table II. List of Larsemann Hills and Bølingen Islands lakes showing % abundance of the diatom taxa present. Labels refer to slides present in the BAS diatom collection (Lxx = Larsemann Hills, Bxx = Bølingen Islands). Full lake names can be found in Table I; full generic names can be found in the text. Note that *Luticola murrayi, Navicula incertata* and *N.* sp. 1 are not listed as they only occur in the Rauer Islands.

| Lake	*A. taylorensis*	*A. veneta*	*C. laevissimus*	*C.* cf. *molesta*	*D.* cf. *perpusilla*	*D. gallica*	*G.* sp.	*H. virgata*	*H.* cf. *amphyoxis*	*L. muticopsis*	*M. peraustralis*	*N. shiloi*	*N. phyllepta*	*N.* cf. *shackletoni*	*N.* (?) sp. 2	*N. commutata*	*P. borealis*	*P. cymatopleura*	*P. microstauron*	*P. quadripunctatum*	*P. abundans*	*P. germainii*	*P. metakryophilum*	*P. stauroneioides*	*P.* sp.1	*S. inermis*	*S. anceps*	Centric diatom sp.1
L72	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99.8	-	-	0.2	-	-	-	-
L35	-	55.3	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29.3	0.5	13.0	-	-	-	-	1.0	-	-
L34	-	1.0	-	-	1.1	-	-	-	-	-	-	-	-	-	-	-	-	-	4.7	-	87.3	-	-	1.0	-	4.9	-	-
L12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	96.4	-	-	0.2	-	2.6	0.2	-
LBU	-	-	-	-	2.9	-	-	-	-	-	-	-	-	-	-	-	-	-	11.9	-	61.5	-	13.4	2.9	-	7.5	-	-
L36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7	-	96.5	-	-	-	-	2.8	-	-
BBA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	89.9	-	8.3	0.9	-	0.9	-	-
L57	-	6.2	-	-	0.2	-	-	-	-	-	-	-	-	-	-	2.5	-	-	0.6	-	87.5	-	0.2	1.4	-	1.4	-	-
L51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	99.1	-	0.7	-	-	-	-	-
L71	-	23.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39.4	-	-	-	-	-	-	36.7	0.3	-
L59	-	0.2	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	76.6	-	-	0.4	-	22.1	-	-
L67	-	2.4	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	-	93.0	-	-	-	-	2.7	-	-
L74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	37.5	-	-	-	-	62.3	-	-
L63	-	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	39.9	-	-	-	-	59.4	-	-
L60	-	0.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.9	71.9	-	-	-	-	25.6	-	-
L8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98.7	-	-	-	-	1.3	-	-
L7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.4	73.6	-	-	-	-	23.0	-	-
L10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	99.4	-	-	-	-	0.2	-	-
L13	-	10.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	84.5	-	-	2.4	-	1.7	-	-
L14	-	20.8	-	72.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.7	-	0.4	-	-	0.4	-	-	-	0.8
L23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.3	-	0.5	-	-	-	-	98.2	-	-
LGR	-	46.2	-	5.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	13.2	-	-	-	-	0.2	-	34.4
L49	-	-	-	-	71.7	-	-	-	-	-	8.7	-	-	-	-	-	-	-	0	-	16.9	0.7	-	-	-	-	1.9	-
L44	-	60.4	-	7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	23.4	-	5.4	-	-	-	-	0.9	-	2.7
L43	-	-	-	0.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-	91.6	-	-	-	-	7.9	-	-
L69	-	2.5	-	39.9	-	-	-	-	-	0.2	-	-	-	-	-	2.7	-	-	3.2	1.5	33.9	-	1.2	-	-	14.7	-	-
L70	-	33.3	-	29.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10.9	-	-	-	-	0.5	-	25.5	-	-
L68	-	4.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	8.1	15.8	-	-	0.4	-	71.2	-	-
BAL	-	0.3	-	1.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.6	-	1.6	-	-	-	-	87.9	-	-
LJA	-	-	-	-	43.3	38.5	0.4	-	-	-	-	-	-	-	-	0.4	-	-	-	-	0.7	-	8.1	4.5	-	4.0	-	-
L18	-	64.5	-	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9.4	-	21.3	-	-	0.6	-	-	3.0	-
L1	-	76.6	-	16.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.9	-	4.3	-	-	-	-	1.4	-	-
L73	-	-	-	-	0.4	-	-	-	-	-	-	-	-	-	-	-	-	-	1.7	-	71.9	-	-	-	-	25.8	-	-
LSP	-	1.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	98.3	-	-	-	-	-	-	-
L42	-	69.5	-	29.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.8	-	-	-	-	-	-	0.4	-	-
BST	-	-	-	20.3	-	-	-	-	-	-	0.9	-	-	-	-	-	-	-	-	-	29.1	-	9.8	39.2	-	-	0.6	-
LPR	-	-	-	40.3	-	-	-	-	-	10.6	-	-	-	-	-	-	-	11.5	23.5	-	-	0.9	0.3	-	-	12.6	0.3	-
BFI	-	-	84.4	1.1	-	-	-	-	-	-	-	1.1	-	-	-	-	-	-	4.4	-	-	-	-	-	1.1	7.8	-	-
L53b	-	-	-	12.6	-	-	-	-	-	-	-	-	-	-	0.2	-	1.2	-	0.9	-	1.2	-	-	83.0	-	0.2	0.2	0.2
LPS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	99.8	-	0.2	-	-
L52	-	-	-	67.5	-	-	-	-	-	3.0	-	-	-	-	-	-	-	-	3.2	-	-	-	0.3	21.3	-	3.6	1.0	-
L52b	-	-	-	33.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	33.3	-	-	33.3	-	-	-	-
L66	-	9.5	-	1.4	1.4	-	-	-	-	16.2	-	-	-	-	-	-	-	-	68.9	-	-	-	-	1.4	-	1.4	-	-
L65	4.3	-	-	-	7.8	-	-	-	1.4	27.8	-	-	-	-	-	-	-	-	55.1	-	-	-	-	-	-	-	3.2	0.3
LG2	-	-	-	-	6.7	-	-	10.0	-	-	-	-	-	-	-	-	-	-	30	-	-	-	-	3.3	-	-	50.0	-
L64	-	-	-	-	36.4	-	-	-	-	-	-	-	-	-	-	-	9.1	9.1	-	9.1	18.2	-	-	18.2	-	-	-	-
LSN	-	-	-	-	33.2	-	-	-	-	0.5	-	-	-	-	-	-	0.3	-	0.2	-	-	0.8	4.4	60.0	-	0.3	0.3	-
L61	-	-	-	-	14.3	-	-	-	-	1.0	-	-	-	-	-	-	8.6	-	-	-	0.2	2.9	1.7	70.5	-	0.2	0.7	-
BSU	-	-	-	-	52.5	-	-	-	-	0.0	-	-	-	-	-	-	-	-	46.5	-	-	-	-	-	-	0.7	0.4	-
L58	-	-	-	-	39.7	-	-	-	-	0.8	-	-	-	-	-	-	7.9	-	-	-	9.1	-	5.0	26.9	-	8.3	0.4	2.1
LFO	-	-	-	-	5.2	-	-	-	-	78.2	-	-	-	-	-	-	0.5	15	-	-	-	-	-	-	-	-	1.0	-
LMA	-	-	-	-	4.1	-	-	-	-	1.7	-	-	5.0	-	-	-	4.1	35.3	-	-	-	-	-	5.4	-	44.4	-	-
L59b	-	2.2	-	0.7	-	-	-	-	-	10.1	-	-	-	-	-	-	12.3	-	-	-	-	-	-	-	-	-	-	74.6
LG1	-	2.0	-	-	-	-	-	-	-	8.0	-	-	-	-	-	-	6	-	-	-	-	-	-	82.0	-	-	2.0	-
LG4	-	-	-	-	-	-	-	-	-	1.2	-	-	-	-	-	-	-	-	-	-	-	-	-	98.8	-	-	-	-
L64b	-	6.0	-	-	-	-	-	9.0	23.9	-	-	-	-	1.5	16.4	-	-	-	-	-	1.5	-	-	1.5	-	-	40.3	-
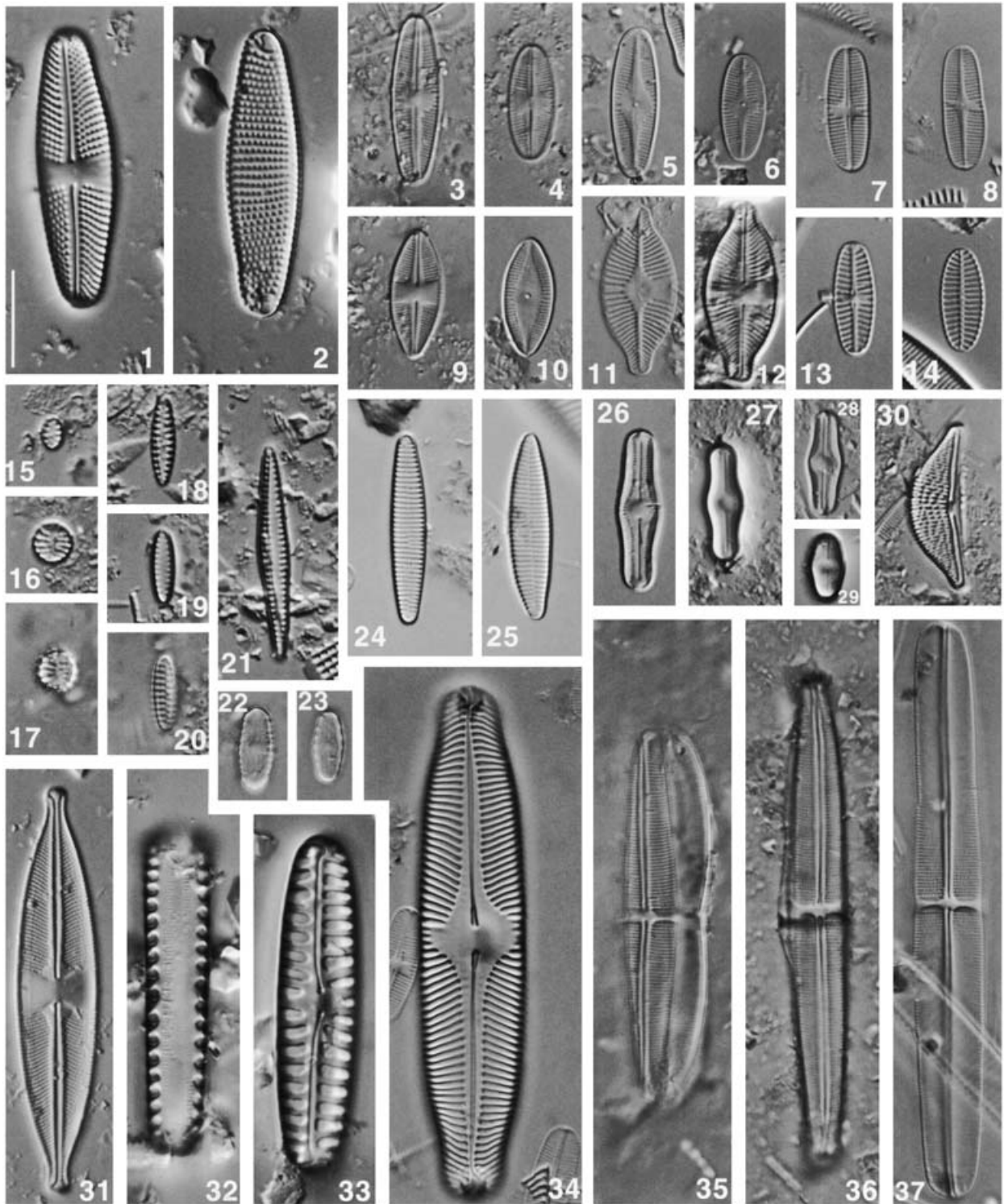
Figs 1–37. LM photographs of diatom taxa from Larsemann Hills and Rauer Islands, all in valve view except Fig. 32. **Fig. 1.** *Achnanthes taylorensis*, RV, **Fig. 2.** *A. taylorensis*, RLV, **Figs 3 & 4.** *Psammothidium metakryophilum*, RV, **Figs 5 & 6.** *P. metakryophilum*, RLV, **Fig. 7.** *P. abundans*, RV, **Fig. 8.** *P. abundans*, RLV, **Fig. 9.** *P. stauroneioides*, RV, **Fig. 10.** *P. stauroneioides*, RLV, **Fig. 11.** *P. germainii*, RLV, **Fig. 12.** *P. germainii*, RV, **Fig. 13.** *Planothidium quadripunctatum*, RV, **Fig. 14.** *P. quadripunctatum*, RLV, **Figs 15, 18–21.** *Pseudostaurosira* sp. 1, **Figs 16 & 17.** *Nanofrustulum shiloi*, **Figs 22 & 23.** *Diadesmis gallica*, **Figs 24 & 25.** *Stauroforma inermis*, **Figs 26–29.** *D.* cf. *perpusilla*, **Fig. 30.** *Amphora veneta*, **Fig. 31.** *Stauroneis anceps*, **Fig. 32.** *Pinnularia borealis*, girdle view, **Fig. 33.** *P. borealis*, **Fig. 34.** *P. microstauron*, **Fig. 35–37.** *Craspedostauros laevissimus*. Scale bar = 10 μm.
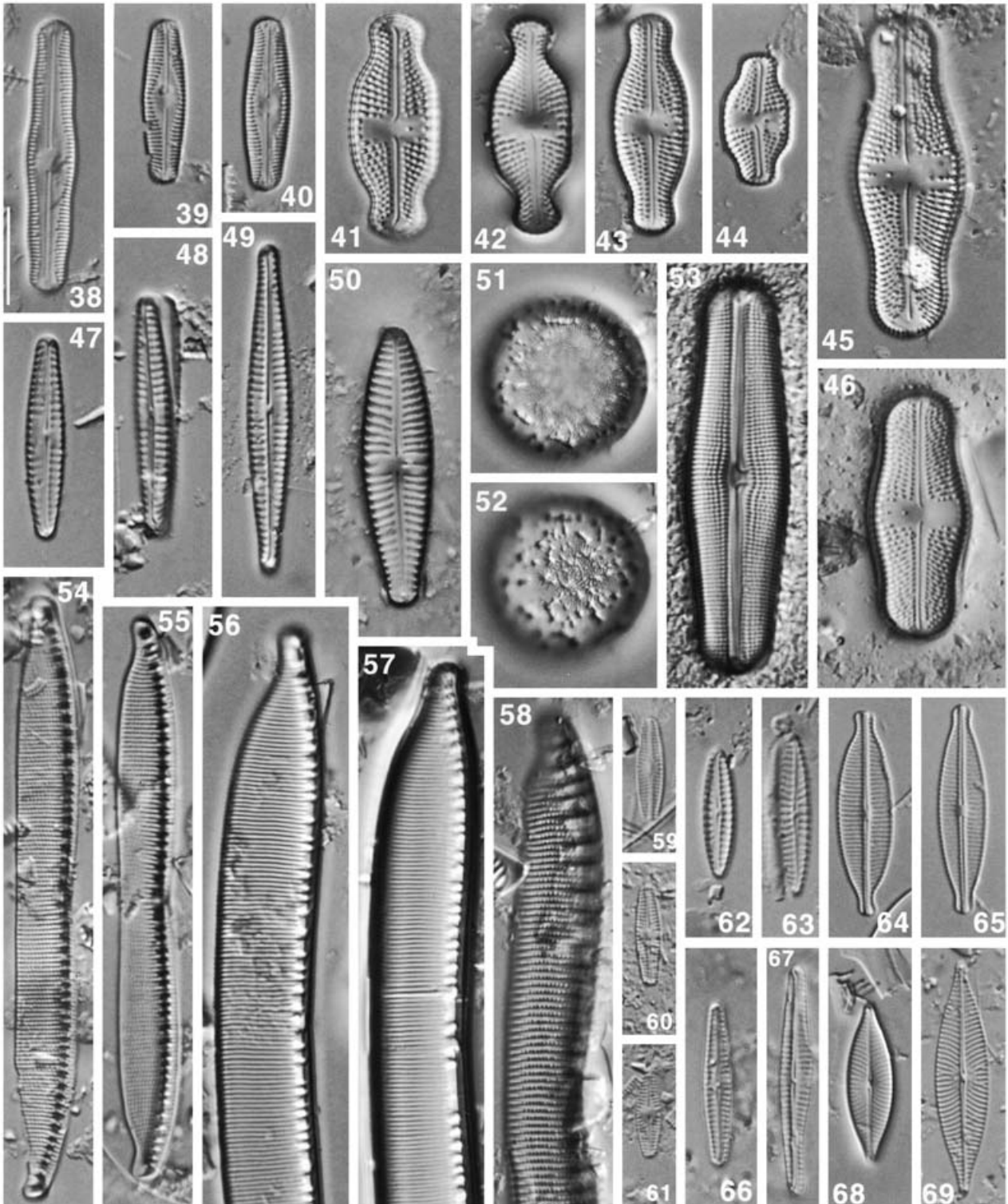
Figs 38–69. LM photographs of diatom taxa from Larsemann Hills and Rauer Islands, all in valve view. **Figs 38–40.** *Pinnularia cymatopleura*, **Figs 41–44.** *Luticola muticopsis*, **Figs 45 & 46.** *L. murrayi*, **Figs 47–49.** *Navicula* cf. *shackletoni*, **Fig. 50.** *Gomphonema* sp., **Figs 51 & 52.** incertae sedis – centric diatom sp., at two different foci, **Fig. 53.** *Muelleria peraustralis*, **Figs 54 & 55.** *Nitzschia commutata*, **Figs 56 & 57.** *Hantzschia* cf. *amphioxys*, **Fig. 58.** *H. virgata*, **Figs 59–61.** *Navicula* (?) sp. 2, **Figs 62 & 63.** *N. incertata*, **Figs 64 & 65.** *Craticula* cf. *molesta*, **Figs 66 & 67,** *Navicula* sp. 1, **Figs 68 & 69.** *N. phyllepta*. Scale bar = 10 µm.
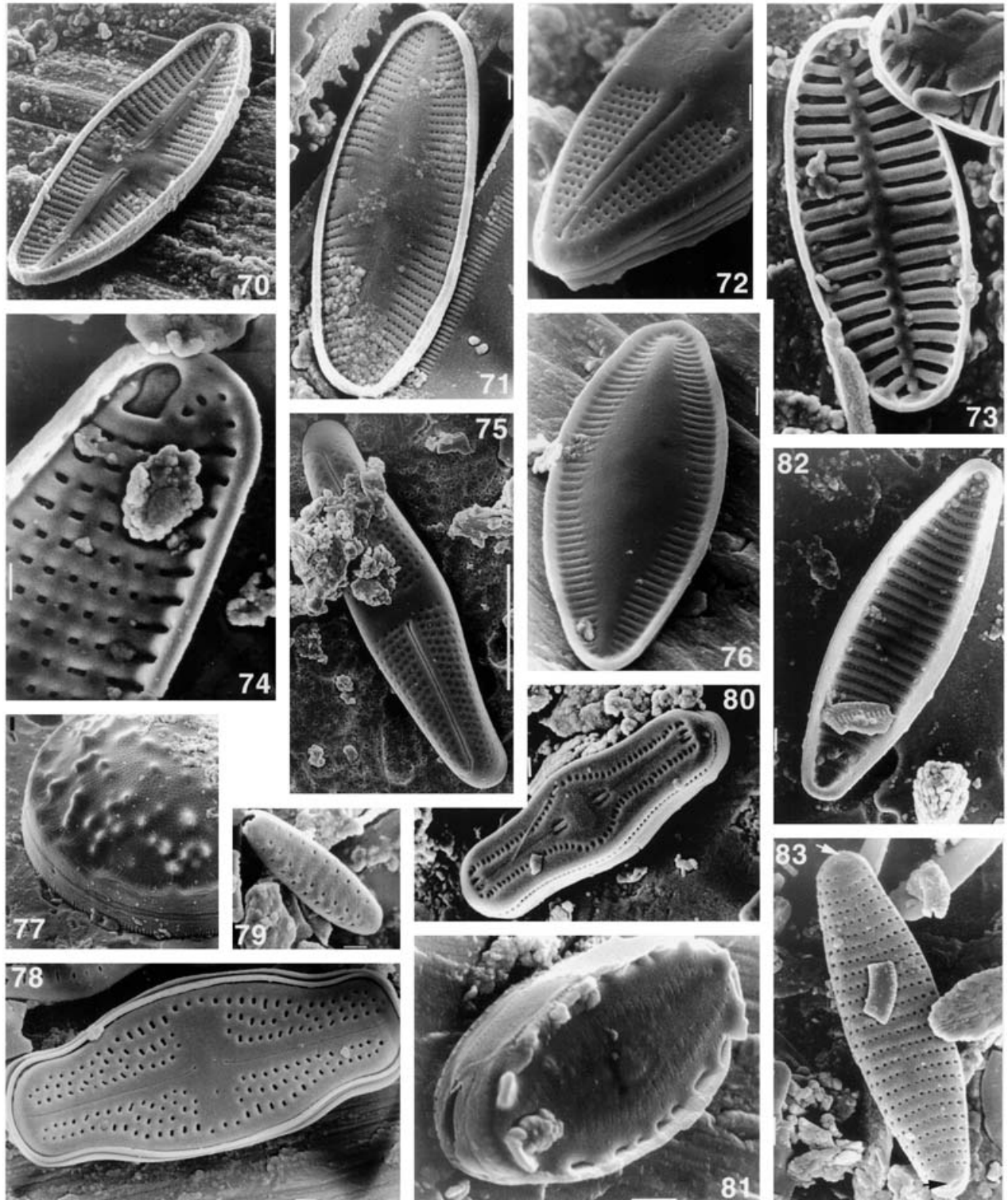
Figs 70–83. SEM photographs of diatom taxa from Larsemann Hills and Rauer Islands, all in valve view. **Fig. 70.** *Psammothidium metakryophilum*, RV, internal view, **Fig. 71.** *P. metakryophilum*, RLV, internal view, **Fig. 72.** *P. stauroneioides*, RV, external view, **Fig. 73.** *Planothidium quadripunctatum*, internal view, **Fig. 74.** *Achnanthes taylorensis*, RLV, internal view, note the distinct orbiculus near the valve apex, **Fig. 75.** *A. taylorensis*, RV, external view, **Fig. 76.** *Psammothidium stauroneioides*, RLV, internal view, **Fig. 77.** incertae sedis – centric diatom sp., external view, **Fig. 78.** *Luticola muticopsis*, external view, **Fig. 79.** *Pseudostaurosira* sp. 1, external view, **Fig. 80.** *Diadesmis* cf. *perpusilla*, external view, **Fig. 81.** *D. gallica*, **Fig. 82.** *Stauroforma inermis*, internal view, **Fig. 83.** *S. inermis*, external view. The small apical pore fields are arrowed. Scale bar = 1 µm in all figures except in Fig. 75 where it is 10 µm.
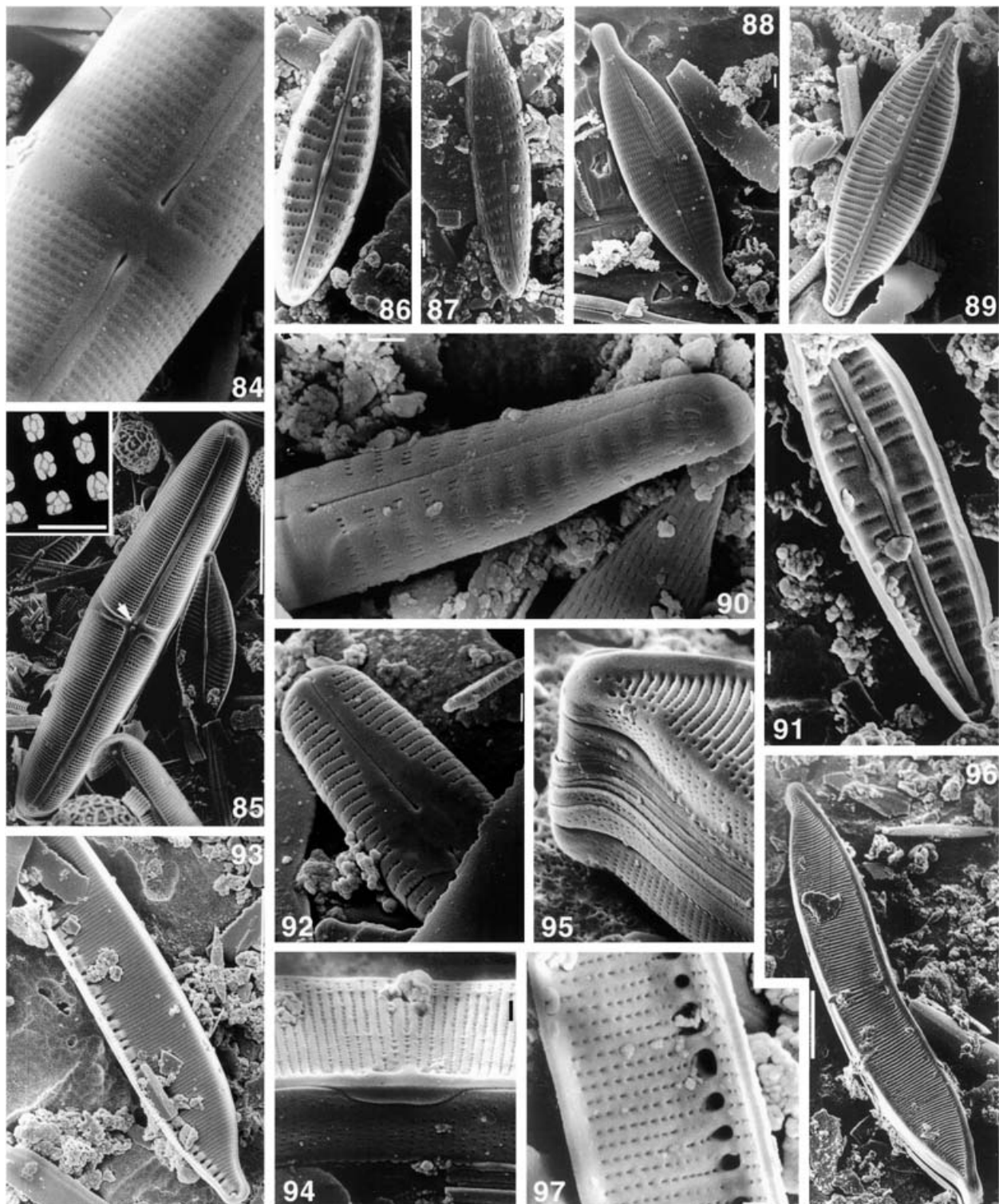
Figs 84–97. SEM and TEM photographs of diatom taxa from Larsemann Hills and Rauer Islands, all in valve view except Fig. 95.
Fig. 84. *Craspedostauros laevissimus*, external view, **Fig. 85.** *C. laevissimus*, internal view showing double helictoglossa (arrow), inset TEM detail of areolae, **Fig. 86.** *Navicula incertata*, internal view, **Fig. 87.** *N. incertata*, external view, **Fig. 88.** *Craticula* cf. *molesta*, external view, **Fig. 89.** *C.* cf. *molesta*, internal view, **Fig. 90.** *Navicula* cf. *shackletoni*, external view, **Fig. 91.** *N.* cf. *shackletoni*, internal view, **Fig. 92.** *Pinnularia cymatopleura*, external view, **Fig. 93.** *Hantzschia* cf. *amphioxys*, internal view, **Fig. 94.** *H.* cf. *amphioxys*, external view of central area and valve mantle, **Fig. 95.** *H.* cf. *amphioxys*, external girdle view of apex, **Fig. 96.** *H.* cf. *amphioxys*, external view, **Fig. 97.** *Nitzschia commutata*, internal view of central area. Scale bar = 1 µm in all figures except in Figs 85, 93 and 96 (= 10 µm) and the inset of Fig. 85 (= 500 nm).

Methods

Study area

The Larsemann Hills oasis (69°23'S, 76°53'E), Prydz Bay, is an ice-free area on the Ingrid Christensen Coast, Princess Elizabeth Land (eastern Antarctica) located approximately midway between the eastern extremity of the Amery Ice Shelf and the southern boundary of the Vestfold Hills. The region consists of two main peninsulas, the western named Stornes and the eastern Broknes/Mirror, and a number of scattered offshore islands. The Bølingen Islands lie 25 km to the west-south-west and the Rauer Islands 60 km to the north-east (for maps showing the locations of these regions see Hodgson *et al.* 2001a). Both island groups are also largely ice-free. An extensive description of the geology, physiography and climate of these regions is given in Gillieson *et al.* (1990), Stüwe *et al.* (1989) and Hodgson *et al.* (2001a, 2001b). Most of the lakes sampled in the Larsemann Hills oasis are freshwater, with the exception of a few brackish lakes (Table I). In the Rauer Island group, six hypersaline, two brackish and two freshwater lakes were sampled (Hodgson *et al.* 2001a).

Collection and analysis of materials

Surface sediment cores were extracted from the deepest part of selected lakes (for a list see Hodgson *et al.* 2001b, table I) using a Glew gravity corer (Glew 1991). Diatom samples were collected from the uppermost 5 mm. In shallow lakes (which have no or only little ice cover around the edges) sediment samples were collected between 0.5–1 m depth in the littoral zone. A complete list of the 56 lakes in the Larsemann Hills and Bølingen Islands is given in Table I. Detailed information on their water chemistry will be published elsewhere (Sabbe *et al.* unpublished). A list of the 10 lakes sampled in the Rauer Islands and details on their water chemistry can be found in Hodgson *et al.* (2001a).

Subsamples for diatom analysis were digested with H_2O_2 (30%) and CH_3COOH (95%) following a slightly modified protocol by Renberg (1990). For light microscopy (LM), part of the sample was dried onto a glass cover slip, mounted in Naphrax and studied using a Leitz Diaplan equipped with differential interference contrast (DIC). For scanning electron microscopy (SEM), sample material was directly air-dried onto specimen stubs and sputter-coated. SEM was performed with a Jeol JSM-840 operated at 15 kV. For transmission electron microscopy (TEM), 10 µl aliquots of oxidized material were placed on formvar-coated copper slot grids. Grids were examined with a Jeol JEM 1010, operating at 60 kV. Valve dimensions (length (L), width (W) and stria density) were determined on *n* valves. For each dimension, the minimum and maximum values are given. Striae densities were measured along the raphe branches between the central and terminal raphe endings (as shown in Schoeman & Archibald 1976).

Terminology used in the descriptions of the valve structures is based on Hendey (1964, valve outlines), Anonymous (1975), Ross *et al.* (1979) and Round *et al.* (1990, cingulum and raphe structures).

Biogeographic and autoecological notes are based on literature data provided with unambiguous illustrations and/or descriptions and our own observations from the Larsemann Hills and Rauer Islands (Hodgson *et al.* 2001a). When the identity of a taxon could not be determined with certainty, its distribution is listed as unknown. Distribution of the taxa within the Larsemann Hills and Bølingen Islands regions is given in Table II (relative abundances of the diatom taxa present in the lakes). A similar table for the lakes of the Rauer Islands is given in Hodgson *et al.* (2001a, table VI). All materials examined have been deposited in the diatom collection of the British Antarctic Survey (see Table I for slide labels).

In addition to the abbreviations listed above, the following abbreviations were used: RLV (rapheless valve) and RV (raphe valve), both for monoraphid diatoms, CRE = central raphe endings, TRE = terminal raphe endings, UVR = ultraviolet radiation, CA (Continental Antarctic), MA (Maritime Antarctic) and SA (sub-Antarctic). Definitions of CA, MA and SA are as in Vincent (1988).

Results

Achnanthes taylorensis Kellogg, D.E., Stuiver, M., Kellogg, T.B. & Denton, G.H. 1980
Figs 1, 2, 74, 75

Description. 30–31 µm L, 8.3–8.5 µm W (*n* = 10), 12.5–15 striae in 10 µm. Valves linear-elliptical, apices rounded. RV with distinct rectangular fascia (Figs 1 & 75). Striae uniseriate, radiate throughout the valve (RV) or parallel in the centre to radiate near the apices (RLV). Areolae large, rounded, sometimes transapically elongate in the RLV; external occlusions cribrate with volae (Figs 74 & 75). Raphe straight, CRE expanded, TRE strongly hooked onto the mantle (Fig. 75). Sternum on RLV usually situated on the valve face margin (and hence not visible in LM or REM), but sometimes only slightly displaced towards the valve face margin (not shown but see Kobayashi 1963); sternum ends in an eccentric orbiculus (cf. Krammer & Lange-Bertalot 1986–91). This orbiculus consists of a large areola-like opening occluded by an unperforated plate (Fig. 74). Cingulum structure unknown.

Remarks. Kobayashi (1963) made a detailed morphometric analysis of this species (as *A. brevipes* Agardh var. *intermedia* (Kützing) Cleve). *Achnanthes taylorensis* is often reported under the names *A. brevipes* var. *intermedia* (e.g. West & West 1911, Kobayashi 1963, Baker 1967, Watanuki 1979) or *A. coarctata* (Brébisson) Grunow var. *elliptica* Krasske (Le Cohu & Maillard 1983, figs 115–118). However, *A. taylorensis* differs from *A. brevipes* var.

intermedia in stria density (13–15 versus 10 striae in 10 µm, Cleve 1895). *Achnanthes taylorensis* is reminiscent of *A. coarctata* var. *elliptica* but the latter has a slight central valve constriction while an orbiculus is either inconspicuous or absent (none can be seen in the lectotype specimens of *A. coarctata* var. *elliptica* illustrated in Lange-Bertalot *et al.* 1996, pl. 7, figs 3 & 5). Carlson (1913) described a similar diatom, *A. muelleri* Carlson, from South Georgia and the Falkland Islands. This species however has a lower stria density (9–10 striae in 10 µm), appears to have no orbiculus (cf. Carlson 1913, pl. III, fig. 5 and Fukushima 1965, pl. 1, figs 12–13) and has an elliptical not rectangular central area. *Achnanthes muscorum*, described from Antarctic moss vegetations by Peragallo (1921), is possibly synonymous with *A. muelleri*.

Distribution. Antarctic endemic. *Achnanthes taylorensis* was described from Taylor Valley (McMurdo Dry Valleys, Kellogg *et al.* 1980) and is widespread in CA (West & West 1911, Kobayashi 1963, Baker 1967, Roberts & McMinn 1999 as *Nitzschia* sp. b). It is also present in SA (Kerguelen, Le Cohu & Maillard 1983), and possibly also MA (Horseshoe Island, Wasell & Håkansson 1992), although here *A. muelleri* appears to be more common (Carlson 1913, Van de Vijver & Beyens 1997).

Autoecology. In the Rauer Islands and Vestfold Hills *A. taylorensis* is relatively rare in brackish lakes (Roberts & McMinn 1999, Hodgson *et al.* 2001a). Most probably, the diatom studied by Watanuki (1979) and referred to as *A. brevipes* var. *intermedia*, also concerns *A. taylorensis*. This diatom grew well in both freshwater and brackish water cultures, but does not appear to tolerate higher (> 20‰) salinities.

Amphora veneta Kützing 1844 *sensu* Schoeman & Archibald (1978)
Fig. 30

Description. 9–48.5 µm L, 5–12 µm W, 22–28 striae in 10 µm near the apices, 14–22 striae in 10 µm in the centre (*n* = 250). Since the type material of this species has never been examined (Schoeman & Archibald 1978) and the original description does not allow unambiguous identification, we follow the concept of this species as given by Schoeman & Archibald (1978) and Krammer & Lange-Bertalot (1986). Our specimens fully match these descriptions. A detailed morphometric analysis of 250 valves (Sabbe *et al.* unpublished) revealed no discontinuities in valve morphology, despite large variations in width, length and stria density.

Distribution. Cosmopolitan. *Amphora veneta* is widespread and common in CA, MA and SA (e.g. Fukushima 1965, Håkansson & Jones 1994, Roberts & McMinn 1999).

Autoecology. In Europe, *A. veneta* occurs in electrolyte-rich

waters (Krammer & Lange-Bertalot 1986–91). In Antarctica, it is found in brackish lakes (Roberts & McMinn 1999, Hodgson *et al.* 2001a). In the Larsemann Hills, it is common in both freshwater and brackish lakes.

Craspedostauros laevissimus (West & West 1911) Sabbe K. comb. nov.
Figs 35–37, 84, 85

Basionym. *Tropidoneis laevissima* W. & G.S. West 1911, Freshwater Algae. In *Biology*, Vol. 1, Reports on the Scientific Investigations, British Antarctic Expedition 1907–1909, ed. J. Murray: 281, pl. XXVI, figs 115–120. London, Heinemann.

Description. 37–66 µm L, 5.5–7.8 µm W, 24–27.5 striae in 10 µm (*n* = 16). Detailed descriptions of this species can be found in West & West (1911, type description) and Kobayashi (1963), who studied the range of morphological variation within this species. Specimens from the Larsemann Hills (Figs 35 & 36) and Rauer lakes had linear to linear-lanceolate valves with cuneate to rounded apices. Valve face more or less curved in transapical section, with a very gradual transition into a deep mantle (Figs 84 & 85), often slightly biarcuate in girdle view (Fig. 35). Stauros distinct, narrow; internal thickenings lying in a slightly wider fascia (Fig. 85). Striae parallel to radiate in the centre, to convergent near the apices. The striae are composed of round areolae occluded by cribra (Fig. 84), mostly with four corner and one small central pore. However, cribra with only two corner pores or with four corner and two central pores also occur (Fig. 85, inset). Raphe straight to slightly biarcuate, lying in a narrow raphe sternum (Figs 35–37). CRE expanded, drop-like, slightly deflected in the same direction (Fig. 84). Internally, the CRE end in a distinct double helictoglossa (Fig. 85). Terminal fissures bent in the same direction (not shown). Internal CRE end in small helictoglossae (Fig. 85). Copulae numerous, narrow, each with two rows of areolae (not shown).

Remarks. This species displays all characteristics of the genus *Craspedostauros*, viz. cribrate areolae, a stauros that is narrower than the fascia, numerous girdle bands with double rows of areolae (Cox 1999) and was therefore transferred. *Craspedostauros laevissimus* shows some resemblance to *C. britannicus* Cox but differs in being wider, on average, and has a higher stria density (Cox 1999). *Craspedostauros laevissimus* might be conspecific with *C. indubitabilis* (Lange-Bertalot & Genkal Cox) which was recently described from the Arctic (Lange-Bertalot & Genkal 1999) and which has similar dimensions. However, as details on the fine structure of the areolar occlusions, helictoglossae and stauros, all crucial for identification (cf. Cox 1999), are not illustrated it is impossible to assess the true identity of *C. indubitabilis*.

Roberts & McMinn (1999) reported a similar

Craspedostauros species (as *Stauroneis* sp. A) from the Vestfold Hills but their specimens reportedly have a higher stria density (about 30 striae in 10 μm). Further study is required to assess whether this is significant or not.

Distribution. Antarctic endemic (unless conspecific with *C. indubitabilis*, cf. above). *Craspedostauros laevissimus* was originally described from the McMurdo Dry Valleys region (West & West 1911), and was subsequently reported from localities in East Antarctica (Fukushima 1962, Kobayashi 1963, Watanuki 1979) and MA (Priddle & Belcher 1981). It has so far not been reported from SA.

Autoecology. *Craspedostauros laevissimus* is a truly brackish water diatom that grows optimally in a salinity range of 10–15‰ and does not tolerate freshwater or marine conditions (Watanuki 1979), which is in accordance with its occurrence in the Larsemann Hills (one single brackish lake) and Rauer Islands (Hodgson *et al.* 2001a, as *Craspedostauros* sp. 1). So far, it is the only *Craspedostauros* species that solely occurs in saline lakes and not in the marine littoral.

Craticula cf. *molesta* (Krasske) Lange-Bertalot & Willmann 1996
Figs 64, 65, 88, 89

Description. 21–24 μm L, 4.9–6.2 μm W, 22 striae in 10 μm ($n = 6$). A detailed morphometric analysis of *C.* cf. *molesta* (as *Navicula molesta* Krasske) was given by Kobayashi (1965). Our specimens closely match his description. The Antarctic specimens differ from the holotype valves of *C. molesta* (illustrated in Lange-Bertalot *et al.* 1996) in dimensions (both length and width are significantly smaller in the holotype specimens). The species complex around this taxon (including species such as *C. vixnegligenda* Lange-Bertalot and *C. molestiformis* (Hustedt) Lange-Bertalot) is in need of revision (see Lange-Bertalot 1993, Lange-Bertalot *et al.* 1996).

Distribution. Unknown. *Craticula molesta* was originally described from Spitzbergen (Krasske 1938). *Craticula* cf. *molesta* has been reported from several localities in CA (Vestfold Hills, Roberts & McMinn 1999, as *Navicula* sp. I, pl. 5, fig. 12, not 13, Kasumi Iwa, Kobayashi 1965, as *N. molesta*). It is not possible to assess whether the numerous reports of *C. molesta* (usually as *Navicula molesta*) from other Antarctic localities (e.g. MA: Håkansson & Jones 1994, Schirmacher Oasis: Pankow *et al.* 1991, McMurdo Dry Valleys: Spaulding *et al.* 1997, SA: Van de Vijver & Beyens 1999b) also concern *C.* cf. *molesta* as no illustrations were provided.

Autoecology. In the Rauer Islands *C.* cf. *molesta* (as *C. molesta*) only occurs in a slightly brackish lake (Hogdson *et al.* 2001a). In the Larsemann Hills, it is common in both freshwater and brackish lakes.

Diadesmis gallica W. Smith 1857
Figs 22, 23, 81

Description. 6.6–9.1 μm L, 3.1–3.9 μm W ($n = 10$). This species is uniquely characterized by its indistinct appearance in LM (Figs 22 & 23) due to the filled in raphe slits and the presence of spines and/or short ridges along the valve face margin (Fig. 81). Type material of this species was studied by Krammer & Lange-Bertalot (1985).

Distribution. Cosmopolitan (Krammer & Lange-Bertalot 1986). *Diadesmis gallica* has been reported from CA (Schirmacher Oasis, Pankow *et al.* 1991) as *Navicula contenta* Grunow. Given the taxonomic and nomenclatural confusion in the *D. contenta* species complex, it is as yet impossible to assess the distribution of *D. gallica* in Antarctica.

Autoecology. *Diadesmis gallica* is a typical aerial diatom (Johansen 1999). Common in one freshwater lake of the Larsemann Hills.

Diadesmis cf. *perpusilla* (Grunow) D. G. Mann 1990
Figs 26–29, 80

Description. 6.5–18 μm L, 3.5–4.9 μm W, ± 29–32 striae in 10 μm ($n = 12$). Valves elliptical (smaller specimens) to linear (larger specimens), centrally inflated. Valve face flat, at sharp angles with the mantle. Valve face with broad raphe sternum, and two rows of transapically elongate areolae; these are often not or only partly visible in LM (Figs 27–29). A longitudinal row of areolae runs on the mantle along the valve margin, interrupted at the apices. Raphe branches straight, CRE and TRE simple, straight. Small apically elongate depressions are present on both sides of the external CRE and TRE (Fig. 80).

Remarks. The species complex around *Diadesmis contenta* s. l. (Grunow) Mann was partly revised by Moser *et al.* (1998). Our specimens most closely resemble *D. perpusilla* as illustrated in Krammer & Lange-Bertalot (1986, as *Navicula gallica* var. *perpusilla* (Grunow) Lange-Bertalot). Given the recent splitting of the species complexes around *Diadesmis contenta* and *D. perpusilla/gallica* examination of the type material of *D. perpusilla* is imperative; we therefore hesitate to make a positive identification of our Antarctic taxon. It also resembles *D. implicata* Moser, Lange-Bertalot & Metzeltin (Moser *et al.* 1998) but this species has a lower stria density and lacks the depressions alongside the raphe endings. *D. arcuata*, described from SA (Heiden & Kolbe 1928, Simonsen 1992) differs from our taxon in its typically rectangular valve shape. This species needs to be examined in SEM.

Distribution. Unknown. *Diadesmis perpusilla* has been reported from MA (Håkansson & Jones 1994) and CA (Pankow *et al.* 1991, cf. also Aleshinskaya & Bardin 1965,

as *Navicula seminulum* Grunow var. *tenuis* Schirschow). *D.* cf. *perpusilla* is probably often reported as *Diadesmis* (*Navicula*) *contenta* (e.g. Kellogg *et al.* 1980).

Autoecology. The freshwater genus *Diadesmis* is typically restricted to subaerial habitats (Round *et al.* 1990). *Diadesmis perpusilla* is often found in slightly brackish habitats (Johansen 1999). In the Larsemann Hills, *D.* cf. *perpusilla* is commonly found in freshwater lakes and is completely absent from brackish lakes.

Gomphonema sp.
Fig. 50

Description. 30 µm L, 7.8 µm W, 11–12 striae in 10 µm ($n = 1$).

Remarks. This species belongs to the species complex around *Gomphonema angustatum* (Kützing) Rabenhorst and closely resembles this species but also *G. micropus* Kützing (Reichardt 1999). However, SEM studies, which are necessary for a positive identification of this taxon, were not possible due to its rarity. Our taxon closely resembles a *Gomphonema* species illustrated in Wasell & Håkansson (1992) as *Gomphonema angustatum/parvulum* (Kützing) Kützing.

Distribution. Unknown.

Autoecology. A few specimens in a freshwater lake in the Larsemann Hills.

Hantzschia cf. *amphioxys* (Ehrenberg 1843)
Grunow 1880
Figs 56, 57, 93, 96

Description. 78–88 µm L, 9.6–11 µm W, 17.5–21.5 striae in 10 µm, 7–9 fibulae in 10 µm ($n = 10$). Valves linear/semi-arcuate, asymmetrical, apices rostrate to capitate. Dorsal margin convex, sometimes more or less straight in the central part, ventral margin concave (Figs 56 & 57). Valve face flat, at right angles with the deep valve mantle. Raphe situated on the ventral valve face-mantle transition, in a distinct sternum (Figs 94 & 96). In the centre, the raphe curves onto the mantle. Whether the raphe is actually continuous across the centre is hard to assess as the CRE may be close together and hidden under the thickened central part of the valve face/mantle margin (Fig. 94). The terminal fissures are strongly curved to the dorsal side (Fig. 95). Internally, the TRE lie in a distinct helictoglossa (Fig. 93). A marginal ridge is usually present on the dorsal valve face/mantle transition (Figs 95 & 96). Striae slightly radiate and more widely spaced in the centre, becoming parallel to convergent towards the valve apices. They consist of small round areolae, externally usually lying in transapical grooves sunk beneath the valve face but not the mantle (Figs 94 & 95). Internally, the areolae open into

narrow slits which extend inbetween the fibulae (Fig. 93). The latter are variable in width (spanning up to five or more striae) and spacing, often (but not always) being more widely spaced in the centre of the valve (cf. Figs 56 & 57). The cingulum is composed of 7–8 porous copulae (Fig. 95).

Remarks. *Hantzschia amphioxys* and a large number of infraspecific taxa are commonly reported from CA, MA and SA (e.g. Prescott 1979, Håkansson & Jones 1994, Van de Vijver & Beyens 1999b). The species complex is characterized by a high degree of morphological variability (e.g. Kobayashi 1965). Many of the *H. amphioxys* reports (e.g. Baker 1967, Kobayashi 1965, Seaburg *et al.* 1979) concern diatoms that are similar (with respect to valve shape, dimensions and stria and fibula densities) to *H.* cf. *amphioxys* from the Larsemann Hills. However, as Lange-Bertalot (1993) pointed out, the exact identity of *Hantzschia amphioxys* is unclear. According to this author (cf. also VanLandingham 1971), a specimen described by Ehrenberg (1843) from the Falkland Islands should be selected as lectotype. Unfortunately, not enough detail is provided in the original protologue and illustration to allow unambiguous delimitation of this species (Lange-Bertalot 1993). He therefore adopts the concept of Mann (1977) for *Hantzschia amphioxys* s.s. (Lange-Bertalot 1993).

Our specimens correspond well with *H. amphioxys* sensu Mann (1977) but not with *H. amphioxys* s. s. (= *sensu* Mann 1977?) depicted in Lange-Bertalot (1993): the valves are significantly wider (9.6–11 µm vs 5–7 µm), internally the striae do not continue inbetween the fibulae and the central fibulae are not consistently more widely spaced. As the true identity of *H. amphioxys* is as yet uncertain, we refrain from making a positive identification of our taxon.

Our specimens also do not fully correspond to any of the recently described or recombined *Hantzschia* species (see a.o. Lange-Bertalot 1993, Metzeltin & Lange-Bertalot 1998, Lange-Bertalot & Genkal 1999) except for *Hantzschia hyperborea* (Grunow) Lange-Bertalot, which was originally described from the Arctic (Lange-Bertalot 1993). *Hantzschia hyperborea*, as illustrated in cf. Lange-Bertalot (1993, t. 96) appears to be much larger than our specimens.

It is clear that the genus *Hantzschia* is in need of revision using SEM in order to verify whether the Antarctic taxa (including ours) indeed belong to currently known *Hantzschia* spp.

Distribution. Unknown. In the absence of detailed morphometric and SEM studies it is as yet impossible to assess whether our specimens are conspecific with the ones from the numerous reports from other Antarctic localities (cf. above) or with *H. amphioxys* reports from other continents (cf. also Johansen 1999).

Autoecology. *Hantzschia amphioxys* and its forms, varieties and related species are typical components of aerial, slightly

brackish habitats worldwide (Johansen 1999), including Antarctica (Prescott 1979, Kawecka & Olech 1993, Broady 1996). Rare in two freshwater lakes of the Larsemann Hills.

Hantzschia virgata (Roper 1858) Grunow 1880
Fig. 58

Description. 80–86 µm L, 8.2–10 µmW, 13–14 striae in 10 µm, 5.5–6 fibulae in 10 µm (*n* = 3). Our specimens fully correspond to *H. virgata* as described in Mann (1977) and Krammer & Lange-Bertalot (1988). To our knowledge, the type of this species has not yet been investigated.

Distribution. Cosmopolitan. *Hantzschia virgata* was reported from CA (Vestfold Hills) by Roberts & McMinn (1999).

Autoecology. In the Vestfold Hills and Rauer Islands *H. virgata* is characteristic of hypersaline waters (Roberts & McMinn 1999, Hodgson *et al.* 2001a).

Luticola murrayi (West &West) D.G. Mann 1990
Figs 45 & 46

Description. 27–37 µm L, 11–13 µm W, 17–19.5 striae in 10 µm (*n* = 10). Valves lanceolate with broadly rostrate to rostrate-capitate apices. Striae radiate throughout the valve, areolae transapically elongate to round (Fig. 45). Raphe branches straight, CRE and TRE slightly deflected in the same direction. One isolated punctum is present in the rectangular to elliptical central area.

Remarks. *Luticola murrayi* differs from *L. muticopsis* in valve shape, stria density and dimensions (both are on average higher in *L. murrayi*). Our specimens agree well with those described by Kobayashi (1963) and Hustedt (1966), except with respect to stria density which appears to be clearly lower in Kobayashi's specimens (12–17, mostly 13–16 striae in 10 µm). However, this could be due to differences in the exact place along the valve where the striae were measured: following our method of counting stria densities we measured between (16–)18–19 striae in 10 µm in his specimens on pl. 4. As *L. muticopsis*, this species needs to be further investigated, and especially the type materials.

Distribution. Antarctic endemic. *Luticola murrayi* occurs in CA (West & West 1911, Kobayashi 1963, Hustedt 1966), and possibly also in MA and SA (cf. Hustedt 1966).

Autoecology. This species was only found in slightly brackish lakes in the Rauer Islands (Hodgson *et al.* 2001a, as *L.* cf. *murrayi*) and was absent from the Larsemann Hills.

Luticola muticopsis (Van Heurck 1909) D.G. Mann 1990
Figs 41–44, 78

Description. 14–28 µm L, 7.8–10 µm W, 15–19 striae in 10 µm (*n* = 17). Valves rectangular to broadly elliptic with rostrate to capitate apices. Valve face flat, at sharp angles with the mantle. Striae more or less radiate throughout the valve, areolae transapically elongate to round (Fig. 78). Raphe branches straight, CRE and TRE slightly deflected in the same direction. One isolated punctum is present in the rectangular to elliptical central area.

Remarks. *Luticola muticopsis* was described by van Heurck (1909) from marine sea ice, and as apparently only a single specimen (with about 10 striae in 10 µm) was seen, it probably was a specimen blown in from the continent. Subsequent reports of this species (e.g. West & West 1911) depict specimens with a higher stria density (13–14 striae in 10 µm), and an extensive morphological analysis by Kobayashi (1965) showed a striae density range of 10–22 (mostly 14–18) in 10 µm. Our specimens clearly correspond to his, and exhibit a similar range in dimensions. The morphological variation in this species (including that of the type material), and especially its varieties and forms, and their relationship with similar species such as *Navicula muticopsiforme* West & West needs to be further investigated. At present, we therefore refrain from distinguishing any subspecific taxa.

Distribution. Antarctic endemic. *Luticola muticopsis* is one of the most common forms in Antarctic lakes (Kobayashi 1965, Fukushima 1967) and has been reported from CA (West & West 1911, Kobayashi 1965), MA (Håkansson & Jones 1994) and SA (Fukushima 1967). The last locality, South Georgia, is the northern limit for this species when confirmed. *L. muticopsis* is the only diatom present at far south locations such as the La Gorce mountains (Broady & Weinstein 1998).

Autoecology. *Luticola muticopsis* prefers freshwater to slightly brackish conditions (up to 5–10‰, Watanuki 1979) and is often associated with sea spray (Oppenheim 1990). It is common in Antarctic terrestrial habitats (Broady 1996). Often dominant in freshwater lakes in the Larsemann Hills; rare in the Rauer Islands (Hodgson *et al.* 2001a, as *L.* cf. *muticopsis*).

Muelleria peraustralis (West & West) Spaulding &
Stoermer 1997
Fig. 53

Dimensions. 40–70 µm L, 10–14 µm W, 19–22 striae in 10 µm (*n* = 6). A detailed description of this species is given by Spaulding *et al.* (1999).

Distribution. Antarctic endemic. *Muelleria peraustralis* has so far only been reported with certainty from the McMurdo Dry Valleys (Spaulding *et al.* 1999). However, our observations corroborate a misidentified record from East Antarctica (Prince Olav Coast, Fukushima 1962 - as *Diploneis* sp., see also Spaulding & McKnight 1999) and

confirm the presence of this species outside the McMurdo Dry Valleys region. Reports of *Muelleria gibbula* (Cleve) Spaulding & Stoermer (as *Navicula gibbula*) from the Thala Hills oasis (Opalinski 1972) may also concern *M. peraustralis*.

Autoecology. *Muelleria peraustralis* occurs across a wide range of salinities and is one of the first colonizers of new surfaces in shallow waters (Spaulding *et al.* 1999). It is only present in two freshwater lakes of the Larsemann Hills.

Nanofrustulum shiloi (Lee, Reimer & McEnery) Round, Hallsteinsen & Paasche 1999
Figs 16 & 17

Synonyms. *Fragilaria shiloi* Lee, Reimer & McEnery 1980, *Pseudostaurosira shiloi* (Lee *et al.*) Hallegraeff & Burford 1996, *Fragilaria sopotensis* Witkowski 1994, *Opephora krumbeinii* Witkowski, Witak & Stachura 1999

Dimensions. 4.2–5.6 µm L, 3.8–5.1 µm W, ± 19 striae in 10 µm (*n* = 4). Cells very small, elliptical to round. Sternum narrow, striae radiate throughout the valve.

Remarks. Due to its rarity, we were unable to study this diatom in SEM or TEM.

Distribution. *Nanofrustulum shiloi* is a cosmopolitan species that has been isolated from coastal and littoral environments across the world (Round *et al.* 1999). It has also been found in the Vestfold Hills (E–CA, Roberts & McMinn 1999, pl. 3, fig. 4, not fig. 5) as *Fragilaria construens* (Ehrenberg) Grunow var. *venter* (Ehrenberg) Grunow.

Autoecology. *N. shiloi* isolates grow optimally at brackish salinities (± 15‰) but can also grow in freshwater media (Hargraves & Guillard 1974) and can thus be considered as a euryhaline species. In the Vestfold Hills, it is also widespread in brackish lakes and saline lakes (Roberts & McMinn 1999). In the Rauer Islands (Hodgson *et al.* 2001a, as *Fragilaria* sp. 1) and Larsemann Hills it is present in a single hypersaline and brackish lake respectively.

Navicula incertata Lange-Bertalot 1985 *sensu* Krammer & Lange-Bertalot 1986
Figs 62, 63, 86, 87

Description. 14–21 µm L, 2.9–4.3 µm W, 13–16.5 striae in 10 µm (*n* = 9). Valves lanceolate with cuneate, slightly produced apices. Striae slightly radiate in the centre to convergent near the apices, composed of lineolate areolae (Figs 86 & 87). Striae more widely spaced and slightly shorter in the centre, leaving a narrowly lanceolate central area. Raphe branches slightly curved, CRE straight, terminal fissures hooked in the same direction (Figs 62, 63, 87). Internally, the TRE end in small, slightly deflected helictoglossae. CRE lie in a distinct central nodule,

accessory rib present. Virgae strongly silicified internally (Fig. 86). Cingulum structure unknown.

Remarks. Our specimens correspond well to the description of *Navicula incertata* in Krammer & Lange-Bertalot (1986). However, the type of this species has never been investigated and therefore its true identity remains uncertain.

Distribution. Cosmopolitan. Single valves belonging to this species were found in a slightly brackish lake in the Larsemann Hills, but it was common in hypersaline lakes in the Rauer Island group (Hogdson *et al.* 2001a, as *Navicula* sp. 2). *Navicula incertata* is characteristic of coastal waters and inland saline waters (Krammer & Lange-Bertalot 1986).

Navicula phyllepta Kützing 1844
Figs 68 & 69

Dimensions. 16–29 µm L, 5.2–6 µm W, 18–18.5 striae in 10 µm (*n* = 6)

Remarks. A detailed morphometric analysis of this species (as *Navicula cryptocephala* Kützing var. *intermedia* Grunow, which is a synonym of *N. capitatoradiata* Germain, Lange-Bertalot 2001) was given by Kobayashi (1965). Our specimens closely match this description but are on average slightly narrower (5.2–6 µm vs 5–8 µm) and have, on average, a slightly lower stria density (18–18.5 vs 17–22 striae in 10 µm). *Navicula phylleptosoma* Lange-Bertalot was recently removed from *Navicula phyllepta* (Lange-Bertalot & Genkal 1999, Lange-Bertalot 2001). According to its protologue, *N. phylleptosoma* is smaller (15–26 vs 25–46 µm), narrower (4.7–6.6 vs 6.6–8.5 µm) and has a higher stria density (17–20 vs 14–15 striae in 10 µm). However, specimens shown in Lange-Bertalot (1993, t. 56, figs 19 & 20) display intermediate features. We therefore adopt the old concept of *N. phyllepta* (see lectotype in Krammer & Lange-Bertalot 1986) until the distinction between the two taxa is further clarified.

Distribution. Cosmopolitan. *Navicula phyllepta* is commonly reported from Antarctica (CA, MA and SA) but usually erroneously as *N. cryptocephala* var. *intermedia* (Fukushima 1962, Kobayashi 1965, Priddle & Belcher 1981).

Autecology. *Navicula phyllepta* occurs in electrolyte-rich freshwaters and brackish waters, both inland and coastal (Krammer & Lange-Bertalot 1986). In the Rauer Islands, it is dominant in two brackish lakes (Hodgson *et al.* 2001a). In the Larsemann Hills it is present in two freshwater lakes.

Navicula cf. *shackletoni* West & West 1911
Figs 47–49, 90, 91

Description. 21–35 µm L, 3.6–4.6 µm W, 13–13.5 striae in

10 µm (n = 8). Valves elliptical to lanceolate with substrate to rostrate apices. Striae slightly radiate in the centre to convergent near the apices; areolae lineolate. Central area rectangular; 2–3 central striae shortened. Raphe branches more or less straight, TRE slightly deflected to the same side, opposite to the one of the hooked terminal fissures (Figs 49 & 90). CRE close together, pore-like. Internally, a distinct accessory rib is present (Fig. 91). Virgae strongly silicified internally.

Remarks. Our specimens closely correspond to the type description of *Navicula shackletoni* in West & West (1911). However, our specimens have a slightly higher stria density (13–13.5 vs 10–12 striae in 10 µm in *N. shackletoni*). Alfinito & Cavacini (2000) described a similar species, *N. skuae*, from northern Victoria Land (CA). The only difference between *N. skuae* and *N. shackletoni* would lie in stria density, which according to the protologue, is 16–20 striae in 10 µm in *N. skuae*. However, all illustrated specimens in Alfinito & Cavacini (2000) have about 14–15 (–16) striae in 10 µm. Examination of the type material is necessary to assess the identity of *N. shackletoni*, its morphological variability and its relationship with *N. skuae* and other species such as *N. wunsamiae* Witkowski, Lange-Bertalot & Metzeltin (Witkowski *et al.* 2000) (possible synonym *N. heidenii* var. *pulchella* (Heiden) Simonsen, Simonsen 1992).

Distribution. Unknown. *Navicula shackletoni* is endemic to Antarctica.

Autoecology. *Navicula shackletoni* is characteristic of saline ponds on Ross Island, the type locality (Broady 1989). *Navicula skuae* is listed as a freshwater species, but as no salinity data are given for the type locality, this is hard to verify. On Inexpressible Island (CA) it occurs in a brackish lake (Lake D) (Fumanti *et al.* 1997). In the Rauer Islands, *N.* cf. *shackletoni* (as *Navicula* sp. 1) is the dominant diatom in the hypersaline lakes. Clearly, the taxonomy of this taxon needs to be clarified before its exact autecological characteristics can be determined.

Navicula sp. 1
Figs 66 & 67

Description. 18–25 µm L, 3–3.9 µm W, 17–19 striae in 10 µm (n = 5). This species resembles *Navicula incertata* but has a different valve shape (lanceolate with distinctly produced apices), is on average larger and has a significantly higher stria density. In addition, the central striae are often less distinct, which gives the central area of the valve a slightly stauroid appearance (Fig. 67).

Remarks. Apart from the resemblance to *N. incertata*, this species also shows some similarity to *Navicula* cf. *shackletoni*, from which it differs in width and stria density. SEM is needed to assess the identity of this species.

Distribution. Unknown.

Autoecology. *Navicula* sp. 1 was common in hypersaline lakes of the Rauer Island group.

Navicula (?) sp. 2
Figs 59–61

Description. 9.1–12 µm L, 2.6–3 µm W, 25–27 striae in 10 µm (n = 10). Valves elliptic with broadly rounded apices. Striae slightly radiate in the centre to convergent near the apices. Raphe straight, CRE distinct and pore-like, rather widely separated. This species is characterized by the presence of a distinct round central area (Figs 59–61).

Remarks. Due to its rarity, we were unable to obtain SEM illustrations of this species. It superficially resembles *N. bremensis* Hustedt but the latter has a significantly lower stria density. There is also a slight resemblance to *Navicula evanida* Hustedt (Simonsen 1987) but this species has a lower length-width ratio. It also resembles a diatom illustrated in Lange-Bertalot *et al.* (1996, t. 19, fig. 20) as *Navicula aliena* Krasske. This specimen, however, does not correspond to the type of that species (Lange-Bertalot *et al.* 1996, t. 19, figs 19, 19') and therefore its identity remains uncertain.

Distribution. Unknown.

Autoecology. *Navicula* (?) sp. 2 is also present in hypersaline lakes of the Rauer Islands.

Nitzschia commutata Grunow in Cleve & Grunow 1880
Figs 54, 55, 97

Description. 60–66 µm L, 5.9–7.8 µm W, 20.5–22 striae in 10 µm, 8–10.5 fibulae in 10 µm (n = 10). Our specimens fully correspond to the specimens (including the lectotype) illustrated in Krammer & Lange-Bertalot (1988).

Distribution. Cosmopolitan (Krammer & Lange-Bertalot 1988). *Navicula commutata* has also been reported from the Schirmacher Oasis in East Antarctica (Pankow *et al.* 1991).

Autoecology. *Nitzschia commutata* occurs in brackish inland and coastal waters, but also in electrolyte-rich freshwaters (Krammer & Lange-Bertalot 1988). It is only present in a single lake in the Larsemann Hills.

Pinnularia borealis Ehrenberg 1843
Figs 32–33

Descriptions. 31–37 µm L, 7.5–9.5 µm W, 5.5–6.5 striae in 10 µm (n = 6), 23 punctae in 10 µm on cingulum. Our specimens agree with the descriptions given by Krammer & Lange-Bertalot (1986) and Krammer (2000).

Distribution. Cosmopolitan. *Pinnularia borealis* is common in SA (Fukushima 1965), CA (Aleshinskaya & Bardin 1965,

Pankow *et al.* 1991) and MA (Priddle & Belcher 1981 and references therein).

Autoecology. Pinnularia borealis is a typical aerial diatom, often found in slightly brackish habitats (Johansen 1999), which is in accordance with culture experiments (Watanuki 1979). It is common in Antarctic terrestrial habitats (Broady 1996). *Pinnularia borealis* is present in a few freshwater lakes in the Larsemann Hills.

Pinnularia cymatopleura West & West 1911
Figs 38–40, 92

Synonyms. Navicula deltaica Kellogg, D.E., Stuiver, M., Kellogg, T.B. & Denton, G.H. 1980, *Navicula quaternaria* Kellogg, D.E., Stuiver, M., Kellogg, T.B. & Denton, G.H. 1980

Description. 17–28.6 µm L, 4.7–5.8 µm W, 22–24 striae in 10 µm (*n* = 9). Valves elliptical with broadly rounded apices; larger specimens sometimes with triundulate valve margins. Striae convergent in the centre to radiate near the apices. They consist of narrow alveoli with serrated margins (Fig. 92). Central area lanceolate to elliptic, wide; axial area variable, narrow (Fig. 39) to wide (Figs 38 & 40). Central nodule distinctly roundish, thickened. Raphe straight, terminal fissures curved.

Distribution. Antarctic endemic. *Pinnularia cymatopleura* has been reported from several localities in western and eastern CA (Broady 1989 and references therein, Roberts & McMinn 1999), often under other names (e.g. *Navicula seminulum* Grunow, Hirano 1959, or *Pinnularia krookei* (Grunow) Cleve, Priddle & Belcher 1981). *Navicula seminulum* has all characteristics of the genus *Sellaphora* (Mann 1989, hence *S. seminulum* (Grunow) Mann) whereas *P. cymatopleura* does not; *P. krookii* (now *Chamaepinnularia krookii* (Grunow) Lange-Bertalot & Krammer) has a much lower stria density (15–17 striae in 10 µm, see type in Krammer & Lange-Bertalot 1986, Krammer 1992).

Autoecology. Pinnularia cymatopleura is very common in both freshwater and brackish Antarctic lakes (Fukushima 1967, Roberts & McMinn 1999). Present in a few freshwater lakes in the Larsemann Hills.

Pinnularia microstauron (Ehrenberg 1843) Cleve 1891
Fig. 34

Description. 20–100 µm L, 7–15 µm W, 9–14 striae in 10 µm. Detailed descriptions of this species can be found in Krammer & Lange-Bertalot (1986) and Krammer (2000).

Distribution. Cosmopolitan. Common throughout Antarctica (SA, MA and CA, Roberts & McMinn 1999 and references therein).

Autoecology. In the Rauer Island lakes (Hodgson *et al.* 2001a), the Vestfold Hills (Roberts & McMinn 1999) and Larsemann Hills *P. microstauron* is one of the most common diatoms in freshwater and brackish lakes.

Planothidium quadripunctatum (Oppenheim) Sabbe K. comb. nov.
Figs 13,14, 73

Basionym. Achnanthes quadripunctata Oppenheim 1994 in Oppenheim (1994), Taxonomic studies of *Achnanthes* (Bacillariophyta) in freshwater maritime antarctic lakes, *Canadian Journal of Botany*, 72: 1742, figs 26–29, 63–66.

Description. 9.1–12 µm L, 3.9–5.5 µm W, 17–19 striae in 10 µm (R, *n* = 8), 17.5–20 striae in 10 µm (RL, *n* = 10). This species is described in detail in the protologue (Oppenheim 1994), where it is compared to similar species. Our specimens fully correspond to the original description. SEM illustrations in Oppenheim (1994) show that this species belongs in *Planothidium*: the striae are multiseriate, composed of 3–4 rows of areolae, and the RV is plane rather than convex (Round & Bukthiyarova 1996).

Distribution. Antarctic endemic. Kerguelen (Le Cohu & Maillard 1983), Signy Island (Oppenheim 1994). This species has so far only been reported from SA and MA, but given its recent description, small size and high abundancy it is to be expected that it is more widespread than previously thought.

Autoecology. Planothidium quadripunctatum was described from mesotrophic freshwater lakes on Signy island (Oppenheim 1994). It is rare in the freshwater Larsemann Hills lakes.

Psammothidium abundans (Manguin 1954) Bukhtiyarova & Round 1996
Figs 7 & 8

Dimensions. 11–15 µm L, 4.3–5.5 µm W, 26–30 striae in 10 µm (*n* = 6)

Description. Detailed descriptions of this species are given by Bourrelly & Manguin (1954), Le Cohu & Maillard (1983) and Oppenheim (1994). Our specimens fully correspond to the type description. However, stria density is often lower in the centre of the valve, hence the slightly lower stria densities in our specimens.

Remarks. The illustrations of the lectotype material of *Achnanthes mollis* Krasske (note that this species does not belong in *Achnanthes* s.s.) in Lange-Bertalot *et al.* (1996) confirm the findings of Oppenheim (1994) that this species is not a synonym of *P. abundans* (as incorrectly claimed in Schmidt *et al.* 1990). *Achnanthes mollis* has distinctly punctate striae and a stauros-like structure in the centre of the valve without short marginal striae (as in *P. abundans*).

Distribution. Antarctic endemic. *Psammothidium abundans* is particularly common in CA, MA and SA (Oppenheim 1994 and references therein, Roberts & McMinn 1999).

Autoecology. Common in freshwater Antarctic lakes (Roberts & McMinn 1999). In the Larsemann Hills, it is also present in slightly brackish lakes.

Psammothidium germainii (Manguin) Sabbe K. comb. nov.
Figs 11 & 12

Basionym. *Achnanthes germainii* Manguin 1954 in Bourrelly & Manguin (1954), Contribution à la flore algale d'eau douce des Iles Kerguelen, Mémoires de L'Institut Scientifique de Madagascar, Série B, Tome V: 20, pl. II, figs 19a & b.

Description. 18–20 μm L, 7.8–8.5 W, 20–21 striae in 10 μm ($n = 4$). Detailed descriptions of this species can be found in Bourrelly & Manguin (1954) and Oppenheim (1994). SEM figures of *P. germainii* are shown in Chalmers *et al.* (1996, pl. 6, figs g & h): these show that this species has a convex RV, oval-elliptic valve shape (with rostrate apices) and striae that reach the sternum, and that it therefore should be placed in the genus *Psammothidium*. The terminal fissures are distinctly curved in opposite directions (Chalmers *et al.* 1996, pl. 6, fig. h).

Distribution. Antarctic endemic. This species has so far only been reported from SA and MA (Bourrelly & Manguin 1954, Priddle & Belcher 1981, Oppenheim 1994 and references therein, Van de Vijver & Beyens 1999b). *Achnanthes lapidosa* Krasske var.? reported by Lavrenko (1966) from the Schirmacher oasis (E–CA) probably also concerns *P. germainii*. Our report from the Larsemann Hills constitutes the first confirmed report of this species for CA.

Autoecology. *Psammothidium germainii* was described from a peat bog in the Kerguelen. At Rothera Point, it was found in freshwater ponds (Priddle & Belcher 1981). Rare in two freshwater lakes of the Larsemann Hills.

Psammothidium metakryophilum (Lange-Bertalot & Schmidt) Sabbe K. comb. nov.
Figs 3–6, 70, 71

Basionym. *Achnanthes metakryophila* Lange-Bertalot & Schmidt 1990 in Schmidt *et al.* 1990, Holocene diatom flora and stratigraphy from sediment cores of two Antarctic lakes, Journal of Paleolimnology 3: 64, figs 6d–I

Description. 11–18 μm L, 4.3–5.2 μm W ($n = 13$), 25.5–28 striae in 10 μm (R) ($n = 9$), 23–27 striae in 10 μm (RL) ($n = 4$). Valves elliptical to lanceolate, central area transapically expanded, elliptical to rectangular in RV, variably shaped though usually more or less rhombic in RLV. The central area does not reach the valve margin and is delineated by 4–6 shortened striae on the RV. Raphe

sternum distinct. Internally, the CRE are non-coaxial; the TRE end in a small helictoglossa. Striae uniseriate, radiate throughout the valve, both on RV and RLV. Raphe vestiges often distinctly present in the latter. For an external view of the RV, see Schmidt *et al.* 1990 (fig. 6d).

Remarks. *Psammothidium metakryophilum* displays all features that distinguish *Psammothidium* from *Achnanthidium* (oval-elliptic valve shape, convex RV and striae reaching the sternum, Bukhtiyarova & Round 1996) and is therefore transferred to this genus. *Psammothidium metakryophilum* closely resembles a number of other species belonging to *Achnanthes* s.l. (i.e. *sensu* Krammer & Lange-Bertalot 1991). However, *P. abundans* has linear to linear-elliptic valves and a narrower, more or less rectangular central area on the RV. *Achnanthidium kryophilum* (Petersen) Bukhtiyarova is wider, has a lower stria density and a distinctly rectangular (not rhombic) central area on the RLV. *Psammothidium helveticum* (Hustedt) Bukhtiyarova & Round has a distinctly punctate RLV and is wider. *Psammothidium daonense* (Lange-Bertalot) Lange-Bertalot and *P. marginulatum* (Grunow) Bukhtiyarova & Round both have a wide, rhombic sternum on the RLV. *Psammothidium chlidanos* (Hohn & Hellerman) Lange-Bertalot has a higher stria density and a differently shaped central area on the RLV. *Psammothidium subatomoides* (Hustedt) Bukhtiyarova & Round has a rectangular central area on the RLV and a higher stria density. The frustules of *Eucocconeis austriaca* (Hustedt) Lange-Bertalot are curved about the transapical plane.

The RV of *P. metakryophilum* is identical to *Navicula papilio* Kellogg, Stuiver, Kellogg & Denton (Kellogg *et al.* 1980). Examination of the type material of *N. papilio* is needed to assess their relationship. If they appear to be conspecific, the epithet *papilio* has priority over *metakryophilum*.

Distribution. Antarctic endemic. *Psammothidium metakryophilum* has so far only been reported with certainty from its type locality (Mondsee, King George Island, MA). It was reported by Fumanti *et al.* (1997) but no illustration was provided so this record cannot be confirmed. However, it has probably also been reported from other Antarctic localities under the names *Achnanthidium kryophilum* (CA, Pankow *et al.* 1991), *Eucocconeis (Achnanthes) austriaca* (SA, Le Cohu & Maillard 1983) and *Psammothidium marginulatum* (CA, Kawecka & Olech 1993). *Achnanthes* sp. illustrated in Priddle & Belcher (1981, fig. 3a & b) from Adelaide Island (MA) also fully corresponds to the description of *P. metakryophilum*. If these reports are confirmed *P. metakryophilum* is widespread throughout Antarctica.

Autoecology. *Psammothidium metakryophilum* is present in some freshwater lakes from the Larsemann Hills. It was never found in any brackish lakes.

Psammothidium stauroneioides (Manguin) Bukhtiyarova
1996
Figs 9, 10, 72, 76

Description. 12–17 μm L, 4.9–6.2 μm W, 27–31 striae in
10 μm (*n* = 10). Detailed descriptions of this species are
given by Bourrelly & Manguin (1954), Le Cohu & Maillard
(1983), Lange-Bertalot & Krammer (1989) and Oppenheim
(1994). SEM reveals straight raphe branches, uniseriate
striae and a single row of areolae on the valve mantle on the
RV (Figs 72 & 76).

Remarks. This species can be distinguished from
A. incognita Krasske (which has an almost identical RV) in
the structure of the RLV, which has a small, circular (not
rhombic) central area (Oppenheim 1994). Note that the
correct ending of the specific epithet should be
stauroneioides and not *stauroneioideum* as in Bukthiyarova
& Round (1996).

Distribution. Antarctic endemic. *Psammothidium
stauroneioides* was described from the Îles Kerguelen but
was subsequently also found in several localities in MA
(Håkansson & Jones 1994). To our knowledge, our
observations of this species constitute the first report for
CA. However, *A. marginulata* reported by Pankow *et al.*
(1991) from the Schirmacher Oasis might also concern
P. stauroneioides.

Autoecology. *Psammothidium stauroneioides* was described
from a freshwater lake and peat bog on Kerguelen. In the
Larsemann Hills, it is often the dominant component of the
diatom communities of freshwater lakes.

Pseudostaurosira sp. 1
Figs 15, 18–21, 79

Description. 3.2–23 μm L, 1.8–3.5 μm W, 15–19 striae in
10 μm (*n* = 11). Cells elliptic to lanceolate with rounded to
cuneate apices. Striae parallel to radiate near the apices.
Axial area is either narrow (Figs 18 & 20) or wide and
lanceolate (Figs 19 & 21). This characteristic is very
variable, even within a single frustule (cf. Figs 19 & 20
which belong to the same cell) (cf. also Sabbe & Vyverman
1995). In SEM, the striae appear to be composed of small
round areolae, present both on the mantle and the valve face
(Fig. 79). Occlusion type and presence of apical pore fields
is as yet unknown.

Remarks. We have tentatively placed this taxon in the genus
Pseudostaurosira on the basis of overall similarities with
Pseudostaurosira perminuta (Sabbe & Vyverman 1995).
Our taxon closely resembles an unidentified
Pseudostaurosira species illustrated in Wasell & Håkansson
(1992, figs 107, 109–115, 117–120).

Distribution. Unknown. *Pseudostaurosira* sp. 1 has also
been reported from the Vestfold Hills as *Fragilaria* sp. a

(Roberts & McMinn 1999).

Autoecology. In the Vestfold Hills, this taxon is typical of
hypersaline lakes (Roberts & McMinn 1999), which is in
accordance with its occurrence in a hypersaline lake in the
Rauer Islands. Only found in one brackish lake of the
Larsemann Hills.

Stauroforma inermis Flower, Jones & Round 1996
Figs 24, 25, 82, 83

Description. 15–21 μm L, 3.9–4.8 μm W, 19.5–20.5 striae
in 10 μm (*n* = 10). As in the type material of this species
(Flower *et al.* 1996), described from Signy Island (MA),
there are no spines and a small apical pore field (Fig. 83).
The internal occlusions (Fig. 82) appear to be of the volate
type as in e.g. *Pseudostaurosira perminuta* (Grunow) Sabbe
& Vyverman (Sabbe & Vyverman 1995, figs 58 & 60).

Remarks. *Stauroforma inermis* can be distinguished from
S. exiguiformis (Lange-Bertalot) Flower, Jones & Round by
the absence of marginal spines and the presence of an apical
pore field. However, Le Cohu (1999) argues that spininess
is not an appropriate criterion for distinguishing between
species, and also shows that apical pore fields do occur in
S. exiguiformis. Further research is necessary to assess
whether both forms belong to the same species. However,
possible slight differences in ecological preferences (with
respect to pH, Flower *et al.* 1996) and the absence of the
spinose species from CA indicates that we might yet be
dealing with two different taxa.

Distribution. Cosmopolitan. *Stauroforma inermis* is a
cosmopolitan species and has been reported from CA
(Roberts & McMinn 1999), MA (Flower *et al.* 1996) and
SA (Le Cohu 1999). *Stauroforma exiguiformis*, also a
cosmopolitan species, has as yet not been observed in MA
and CA, but does occur in SA (Le Cohu 1999).

Autoecology. *Stauroforma inermis* occurs in freshwater
lakes in the Vestfold Hills and MA (Roberts & McMinn
1999 and references therein). It is one of the most abundant
diatoms in both freshwater and brackish lakes of the
Larsemann Hills.

Stauroneis anceps Ehrenberg 1843
Fig. 31

Dimensions. 34–49 μm L, 7.2–9.1 μm W, 22.5–25.5 striae
in 10 μm (*n* = 7). Our specimens fully correspond to
Ehrenberg's original concept of this species (see Reichardt
1995, lectotype). Numerous varieties and forms of
S. anceps have been described (see VanLandingham 1978).
These need revision in order to clarify biogeographical and
ecological questions within this complex.

Distribution. Cosmopolitan. *Stauroneis anceps* commonly

occurs in the littoral 'of all water types' (Krammer & Lange-Bertalot 1986) and has been reported from numerous localities in CA, MA and SA (Pankow *et al.* 1991, Roberts & McMinn 1999).

Autoecology. Stauroneis anceps is found in a few freshwater lakes of the Larsemann Hills which is in accordance with literature data (Roberts & McMinn 1999)

Incertae sedis – centric diatom sp**.**
Figs 51 & 52, 77

Description. 18.2–32.5 µm (*n* = 21). Valves hemispherical, areolae radially arranged. A distinct annulus can be present in the valve centre (Fig. 52). Valve mantle distinct, with radially arranged rows of areolae, and short, shallow ribs near the valve margin. Spine-like, solid structures are scattered across the valve face (Fig. 77). Cingulum structure unknown.

Remarks. This unknown taxon will be described in detail elsewhere. At present, its generic affiliation is uncertain. *Podosira* Ehrenberg lacks a distinct valve mantle, *Melosira* Agardh does not have the sharp distinction between valve face and mantle, and *Hyalodiscus* Ehrenberg has a hyaline area in the centre of the valve.

Distribution. Antarctic endemic. This taxon was found, sometimes in very high abundance, in a few freshwater and slightly brackish lakes in the Larsemann Hills oasis.

Discussion

A total of 31 taxa were observed in the lakes of the Larsemann Hills oasis and the Rauer Islands. Marine species such as *Fragilariopsis* and *Cocconeis* spp., listed in the species list of the Rauer Island group (Hodgson *et al.* 2001a) have not been included here, as it is uncertain whether these taxa actually form part of the autochthonous diatom flora of the lakes or whether it concerns deposition of dead, airborne marine material. The following new nomenclatural combinations are proposed: *Craspedostauros laevissimus* (West & West) Sabbe comb. nov., *Planothidium quadripunctatum* (Oppenheim) Sabbe comb. nov., *Psammothidium metakryophilum* (Lange-Bertalot & Schmidt) Sabbe comb. nov. and *Psammothidium germainii* (Manguin) Sabbe comb. nov. *Nanofrustulum shiloi*, *Psammothidium stauroneioides* and *Planothidium quadripunctatum* are reported for the first time from continental Antarctica. *Psammothidium germainii*, *Psammothidium metakryophilum* and *Muelleria peraustralis* are confirmed for the first time from eastern Antarctica.

The total number of taxa from the two regions is comparable to the species numbers reported from inland freshwater and saline lakes from other continental Antarctic locations [e.g. 22–42 (Victoria Land), 5–33 (Sôya

Coast/Molodezhnaya Hills), 22–56 (Schirmacher Oasis) and 67 (Vestfold Hills), Jones 1996 and references therein, Roberts & McMinn 1999]. However, it is much lower than the numbers reported from the maritime Antarctic and sub-Antarctic [up to 234 taxa in the South Shetland and South Orkney Islands (Håkansson & Jones 1994), and up to 279 taxa in Îles Kerguelen (Le Cohu & Maillard 1983, 1986)]. This is in accordance with the previously observed trend of decreasing species numbers as one moves southwards in the Antarctic (Hirano 1965, Jones 1996, Van de Vijver & Beyens 1999a). This phenomenon of low species diversity has been attributed to the harshness of the environment and geographic isolation, as well as to factors related to latitude such as period of ice cover and light intensity (Jones 1996).

Taxonomic practice appears to have a profound influence on the perception of distribution patterns of continental Antarctic diatoms: many species have been hidden under other names. This is either the result of force-fitting of European and North American names to Antarctic diatoms, which creates broad species concepts and hence widely distributed species, or erroneous identifications. For example, *Hantzschia amphioxys* is commonly reported from the Antarctic, despite the fact that the Antarctic specimens do not correspond to the generally accepted concept of this species. Moreover, our specimens, which in LM are very similar to the specimens reported from other Antarctic localities, do not correspond to any of the new species described in the *Hantzschia amphioxys* species complex. Similarly, *Diadesmis* cf. *perpusilla* needs further study in order to assess whether the Antarctic specimens are conspecific with *D. perpusilla* from other continents. Given the fact that recently numerous new *Diadesmis* species have been described from the Southern Hemisphere, often with very restricted distribution patterns (Moser *et al.* 1998), it is likely that the Antarctic *D. perpusilla* are species in their own right. Even in the earlier literature it was noted that the Antarctic forms of cosmopolitan species consistently displayed minor morphological differences when compared with supposedly conspecific forms from lower latitudes (Hirano 1965, Lavrenko 1966). However, this variation was dismissed as 'minor and trivial' (Lavrenko 1966), brought about by the 'adaptation to the severe environment of Antarctica' (Hirano 1965). Incorrect identications also distort our perception of diatom biogeographies. For example, the persistent identification of *Achnanthes taylorensis* as *A. brevipes* var. *intermedia* masks the fact that we are dealing with an Antarctic endemic, probably one confined to continental Antarctic lakes. The diatoms *Muelleria peraustralis*, *Psammothidium germainii, P. metakryophilum* and *P. stauroneioides* have previously been reported from eastern continental Antarctica but under other names or as unidentified taxa. In the present study, their presence in this region is confirmed. Other taxa which are commonly misidentified include *Nanofrustulum shiloi*, *Navicula phyllepta* and *Pinnularia cymatopleura*.

Force-fitting and incorrect identifications can also result in the notion that some taxa have bipolar distribution patterns. For example, *Craticula molesta* was originally described from the Arctic and has been reported from several Antarctic localities. However, the specimens from the Larsemann Hills do not fully correspond to the type description. Likewise, *Luticola palaearctica* (Hustedt) Mann, an Arctic species (Hustedt 1966, Lange-Bertalot & Genkal 1999) was reported from the Schirmacher Oasis (Pankow *et al.* 1991), although the specimen illustrated does not correspond to the type specimens (Simonsen 1987, pl. 762, figs 1–6). Moreover, no scale bars are provided in the plates in Pankow *et al.* (1991) and the description on p. 117 is a literal copy of Hustedt's type description. Unless the original Shirmacher materials are studied, it is impossible to verify this report. Care should therefore be taken when using compilations of literature data for floristic or biogeographic purposes if these are not critically annotated. The examples of *Craticula molesta* and *Luticola palaearctica* support the view that the Arctic and Antarctic freshwater diatom floras probably have few species in common (Spaulding & McKnight 1999). In addition, in the absence of critical revisions of the southern South American freshwater diatom floras, the affinities between the Antarctic and South American floras also need to be questioned. For example, *Achanthes mollis* Krasske, reported from King George Island by Schmidt *et al.* (1990), is not synonymous with *Psammothidium abundans* (cf. Oppenheim 1994, Lange-Bertalot *et al.* 1996), but is a species in its own right and has not yet been observed in Antarctica.

Finally, it is worth noticing that the diatom floras of many Antarctic regions are still little known. Under-sampling (Patterson & Lee 2000) of Antarctic freshwater environments can also lead to an erroneous assessment of biogeographies.

In two recent reviews on diversity and biogeography of Antarctic and sub-Antarctic diatoms it is stated that cosmopolitanism is the norm in Antarctica (Jones 1996, Van de Vijver & Beyens 1999a), although it is acknowledged that a more fine-grained morphology might lead to a higher proportion of endemics (Jones 1996). In the present study, 39% of diatom taxa from the Larsemann Hills oasis are shown to be endemics to Antarctica. This number is almost certainly a conservative estimate as, due to taxonomic uncertainties, it is as yet impossible to assess the distribution of a further 26% of the taxa (e.g. *Craticula* cf. *molesta*, *Diadesmis* cf. *perpusilla*, *Hantzschia* cf. *amphioxys*). Previous estimates of endemism in continental Antarctica range from 18–45% for East Antarctica (Sôya region and Shinnan rocks) to 60–81% in the McMurdo Dry Valley region (Fukushima 1967). However, according to Pankow *et al.* (1991) endemics are very rare in the Schirmacher oasis (East Antarctica) and throughout the whole Antarctic region; supposed endemism is attributed to worldwide under-sampling. Likewise, Van de Vijver and Beyens (1999a) conclude that the Antarctic is characterized by a high proportion of cosmopolitan species. As shown in the results section above, it is clear that the large differences between these estimates is mainly due to taxonomic practice and differing opinions on species boundaries.

On the basis of the present study, we believe that endemism has been underestimated in Antarctic lacustrine diatoms. This contradicts recent views which claim that all microbial organisms are ubiquitous, i.e. potentially cosmopolitan, and that restricted distribution patterns merely reflect the limited or fragmented nature of habitats (Finlay & Clarke 1999). In our opinion, this hypothesis does not hold true for diatoms, or at least not for certain diatom taxa (e.g. Sabbe *et al.* 2001). In order to obtain independent evidence for endemism in Antarctic diatoms, molecular studies will be necessary to resolve the relationships between Antarctic and non-Antarctic forms of 'cosmopolitan' species. Similar studies on other groups of microorganisms (i.e. bacteria) have indeed shown that Antarctica appears to contain unusual phylogenetic subsets (Vincent 2000). Preliminary phylogenetic analyses based on SSU rDNA data of Chlorophyta from lakes in the McMurdo Dry Valleys, the Vestfold Hills and Larsemann Hills also reveal subsets which uniquely define Antarctic genotypes (Sabbe *et al.* unpublished). However, these data have to be interpreted with caution, as the molecular databases are still far too incomplete and the resolving power of different molecular markers still needs to be evaluated (Vincent 2000). In this respect, it is worth noticing that diatoms have the additional benefit that even minor morphological variation can be correlated with distinct differences in ecology, physiology, crossing behaviour and genetic data (Mann 1999), and that this 'cryptic' morphological variation can be easily documented using light microscopy. As shown above, many so-called cosmopolitan Antarctic species (such as *Hantzschia amphioxys*) display consistent differences with forms found in other continents; these ought to be taken into account. Critical and detailed microscopic analyses can thus yield important information on the distribution and occurrence of Antarctic diatom taxa; resulting hypotheses on their biogeography can then independently be tested using genetic methods.

Diatoms are unique proxy indicators in high-latitude environments (Lim *et al.* 2001), and especially in the Antarctic where many other proxies are lacking. If, as we argue, endemism is more widespread in Antarctic inland waters than previously thought, the baseline data on ecology and distribution of lacustrine diatoms will need to critically (re-)assessed in order to make correct inferences about past environmental changes. The application of a more fine-grained taxonomy and a rigorous taxonomic practice will also result in a better understanding of the processes shaping diatom floras in the different Antarctic regions.

Acknowledgements

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