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REGULAR PAPER

Revision of the genus *Eunotia* (Bacillariophyta) in the Antarctic Region

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Background and aims – The past few years, the limnoterrestrial and aquatic diatom flora of the entire Antarctic Region (sub-Antarctic islands, Maritime Antarctic Region, Antarctic Continent) is currently under revision. One of the genera that still needed a revision is the genus *Eunotia*, quite common in wet to semi-wet moss vegetations in the sub-Antarctic and Maritime Antarctic Region.
Methods – Using both Light Microscopical and Scanning Electron Microscopical techniques, the morphology of all *Eunotia* taxa, present in the samples from the Antarctic Region, has been analysed. Each taxon is properly described, illustrated and compared with all other possible similar *Eunotia* taxa, known worldwide.
Key results – A total of nineteen *Eunotia* taxa has been found of which one remains unidentified and is discussed as *Eunotia* sp. 1. Six taxa could be identified using the currently available literature: *Eunotia meisterioides* Lange-Bert., *E. muscicola* Krasske var. *muscicola*, *E. paludosa* Grunow var. *paludosa*, *E. pyramidatoides*, *E. seminulum* Nörpel-Schempp & Lange-Bert. and *E. tecta* Krasske. Ten new *Eunotia* species and two new subspecies are described: *Eunotia amayae* sp. nov., *E. amayae* subsp. *heardensis* subsp. nov., *E. australomaior* sp. nov., *E. clotii* sp. nov., *E. frigida* sp. nov., *E. mcbridei* sp. nov., *E. mourotii* sp. nov., *E. muscicola* subsp. *polyglyphis* subsp. nov., *E. parallelogramma* sp. nov., *E. pseudopaludosa* sp. nov., *E. ralitsae* sp. nov. and *E. subantarctica* sp. nov.
Conclusions – The obtained results confirm the presence of a typical and highly specific limnoterrestrial diatom flora in the Antarctic Region and contradict the generally accepted idea about the worldwide distribution of diatoms.

Key words – Antarctic Region, Bacillariophyta, *Eunotia*, new species, morphology, taxonomy, biogeography.

INTRODUCTION

The Antarctic Region roughly comprises three different parts: the sub-Antarctic Region, the Maritime Antarctic Region and the Antarctic Continent (Chown & Convey 2007), each characterized by its own climatological and environmental features, determining for a large part the specific and structural composition of their ecosystems. Antarctic ecosystems are rather simple and dominated by only a few taxonomic groups of which algae are of prime importance (Sabbe et al. 2004). In particular diatoms (Bacillariophyta), worldwide known as excellent bio-indicators for changes in environmental conditions (Spaulding et al. 2010), are one of the most abundant and diverse groups in Antarctica (Jones 1996, Van de Vijver & Beyens 1999a). For a long time, it was impossible to test biogeographical and biodiversity-related hypotheses for diatom species due to the lack of rigorous up-to-species-level revised and intercalibrated data sets. Recent studies on Antarctic diatoms showed that older data are no longer relevant (e.g. Van de Vijver et al. 2005, 2011). Distinct forms were sometimes lumped together as one single morphologically variable species since based on the application of a broader species concept widely used in the past (Mann 1999), and many taxa were force-fitted into European or North American species (Tyler 1996), which led to incorrect interpretations of the exact diversity and endemism of the Antarctic diatoms, and of their ecology and biogeography, consequently (Sabbe et al. 2003, Van de Vijver et al. 2005, Van de Vijver & Mataloni 2008). Recent investigations of the Antarctic limnoterrestrial and aquatic diatom flora revealed the presence of a highly specific and in many cases even endemic diatom composition, manifested in the high number of newly described species following the thorough revision of several genera such as *Stauroneis* (Van de Vijver

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et al. 2004a), *Luticola* (Van de Vijver & Mataloni 2008, Kopalová et al. 2011), *Muelleria* (Van de Vijver et al. 2010), *Navicula* (Van de Vijver et al. 2011) and *Pinnularia* (Van de Vijver & Zidarova 2011, Van de Vijver et al. 2012, Zidarova et al. 2012). Several other genera, containing a large number of species, such as for instance *Eunotia*, *Gomphonema* and *Nitzschia*, still await a revision of their Antarctic representatives.

The genus *Eunotia* is a well-known diatom genus with species present on all continents of the world. *Eunotia* taxa are characterized in having dorsiventral valves, usually with a convex dorsal and a concave to straight ventral margin. The most striking feature of the genus is the particular raphe system with short, always distinctly curved raphe branches located distally on the valves. In most species, a single rimoportula is present at one pole of each valve although some species, mainly in the northern hemisphere, can possess two rimoportula or lack this feature completely (Round et al. 1990, Lange-Bertalot et al. 2011). In some tropical species, occasionally, more than two rimoportulae can be found. Currently in Europe, more than 150 taxa are known (Lange-Bertalot et al. 2011, Pavlov & Levkov 2013) but worldwide, the diversity is very large, especially in South America where between 300 and 400 taxa are present (e.g. Metzeltin & Lange-Bertalot 1998, 2007).

In this paper, we present the first revised species list of the genus *Eunotia* present in Sub-Antarctic and Antarctic inland waters, compiled on the basis of a critical revision of literature reports (Kellogg & Kellogg 2002) and, where necessary, (re)analysis of slides and samples from our own Antarctic collections (see table 1). Twelve new *Eunotia* taxa are described from aquatic and terrestrial materials from several islands in Southern Ocean. In addition, information is provided for seven other *Eunotia* taxa with notes on their morphology, ecology and biogeography.

MATERIAL AND METHODS

The past fifteen years, aquatic, moss and soil samples were collected during several field campaigns on islands in the Southern Ocean, mostly from the sub-Antarctic Region (Prince Edward Islands, Iles Crozet, Iles Kerguelen, Heard Island, South Georgia and Macquarie Island) but also from the Maritime Antarctic Region (South Shetland Islands). A critically revised list of all *Eunotia* taxa present in the Antarctic Region has been compiled on the basis of listed publications in Kellogg & Kellogg (2002) after a thorough screening of all records. First, their list of *Eunotia* taxa has been screened to remove taxa that were reported from localities outside Antarctic Region (such as southern South America, Tasmania or New Zealand). Secondly, we checked the original *Eunotia* records listed by Kellogg & Kellogg (2002) and only retained those taxa that could unambiguously be confirmed on the basis of illustrations. Finally, new samples and samples from previous studies by the authors were reanalyzed for the presence of *Eunotia* taxa. All sampling localities are indicated on figure 1 whereas all samples and slides used in the present study are listed in table 1.

Diatom samples for light microscopical (LM) observation were prepared following the method described in Van der Werff (1955). Subsamples of the original material were

Table 1 – List of samples used in this study.

Sample ID	Geographic locality	Source
C-BA101	Crozet	Van de Vijver et al. 2002a
C-W523	Crozet	Van de Vijver et al. 2002a
C-W528	Crozet	Van de Vijver et al. 2002a
K-BM368	Kerguelen	Van de Vijver et al. 2001
K-MB07	Kerguelen	unpublished data
K-N20	Kerguelen	Gremmen et al. 2007
K-Q162	Kerguelen	unpublished data
K-Q193	Kerguelen	unpublished data
He-D273	Heard Island	Van de Vijver et al. 2004b
He-H773	Heard Island	Van de Vijver et al. 2004b
PEI-D100	Prince Edward Islands	Van de Vijver et al. 2004b
PEI-D162	Prince Edward Islands	Van de Vijver et al. 2008
MI99-36	Macquarie Island	unpublished data
SG-M321	South Georgia	Van de Vijver & Beyens 1997a
SG-M335	South Georgia	Van de Vijver & Beyens 1997a
SG-M343	South Georgia	Van de Vijver & Beyens 1997a
SG-M347	South Georgia	Van de Vijver & Beyens 1997a
SG-W379	South Georgia	Van de Vijver & Beyens 1996
SG-W399	South Georgia	Van de Vijver & Beyens 1996
SG-W412	South Georgia	Van de Vijver & Beyens 1996
SG-Tonsb15	South Georgia	unpublished data
LIV-BY067	Livingston Island	Kopalová & Van de Vijver 2013

oxidized by adding 37% H_2O_2 and heating to 80°C for about 1h. The reaction was further completed by the addition of saturated $KMnO_4$. Following digestion and centrifugation (three times 10 minutes at 3700 x g), the resulting clean material was diluted with distilled water to avoid excessive concentrations of diatom valves on the slides. Cleaned diatom material was mounted in Naphrax® for diatom assemblage studies. The slides were analysed at BR using an Olympus BX51 microscope, equipped with Differential Interference Contrast (Nomarski) and the Colorview I Soft Imaging System. Samples and slides are stored at the BR-collection, property of the Belgian federal government and given in permanent loan to the Botanic Garden Meise (Belgium). For scanning electron microscopy (SEM), part of the suspension was filtered through polycarbonate membrane filters with a pore diameter of 1 µm, pieces of which were fixed on aluminum stubs after air-drying. The stubs were sputter-coated with 50 nm of Au and studied in a JEOL-5800LV at 25 kV. Morphological terminology follows Lange-Bertalot et al. (2011). Comparisons with other (recently described) Antarctic, South American and northern Hemisphere taxa, are based on Lange-Bertalot et al. (1996, 2011), Metzeltin & Lange-Bertalot (1998, 2007), Rumrich et al. (2000), Van de Vijver et al. (2002a, 2008a) and Furey et al. (2011).

RESULTS

An initial screening of the checklist published by Kellogg & Kellogg (2002) revealed a total number of 78 taxa listed. Fourty-one taxa, reported from localities outside the Antarctic Region such as New Zealand, the Falkland Islands, Tasmania, Patagonia and southern Chile, have been omitted from the initial list. Some taxa appeared to be later synonyms of older taxa, which further reduced the taxon count. Eight records could not yet be verified; these usually concern species that were newly described (such as for instance *E. tridentula* var. *ventricosa* Peragallo described in 1921 from the Maritime Antarctic Booth Wandel Island) at the time but which have never been reported afterwards, and whose type materials should be studied to ascertain their identity. Several taxa, such as *Eunotia tetraodon* Ehrenberg (Fukushima 1965) or *E. incisa* Gregory (Cremer et al. 2004) were reported only once and although the illustrations in the reports allowed for a positive identification, none of these species have ever been found by other authors and proved to be typical taxa from the northern hemisphere. As a result of this revision, at present only twenty *Eunotia* taxa can be confirmed from the Antarctic Region (table 2). Three of these taxa were recently described from cold-temperate sub-Antarctic Ile Amsterdam (Stonehouse 1982), located in the southern Indian Ocean, north of the islands investigated in the present study (Van de Vijver et al. 2008a). Although the island is not always considered to be part of the Antarctic Region, it is part of the TAAF (Terres Australes et Antarctiques Françaises) making the addition of the data sufficiently interesting to complement the revision of the genus *Eunotia*.

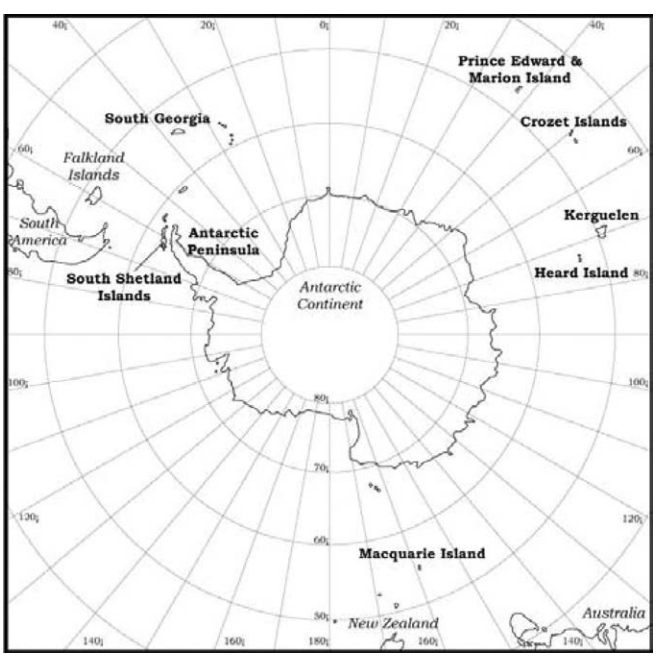

Figure 1 – The Antarctic Region with the location of the different islands and archipelagos discussed in this paper.

A total of nineteen *Eunotia* taxa has been found in the samples collected from the investigated sub-Antarctic and Maritime Antarctic localities (excluding Ile Amsterdam). Six of them could be identified up to species level using the currently available literature. Figure 2 shows LM pictures of all these taxa and some additional notes regarding their observed morphology and ecological preferences are given: *Eunotia meisterioides* Lange-Bert., *E. muscicola* Krasske var. *muscicola*, *E. paludosa* Grunow var. *paludosa*, *E. pyramidatoides* Nörpel-Schempp, *E. seminulum* Nörpel-Schempp & Lange-Bert. and *E. tecta* Krasske. Twelve taxa are described as new for science, ten as a new species and two as a new subspecies: *Eunotia amayae* sp. nov., *E. amayae* subsp. *heardensis* subsp. nov., *E. australomaior* sp. nov., *E. clotii* sp. nov., *E. frigida* sp. nov., *E. mcbridei* sp. nov., *E. mourotii* sp. nov., *E. muscicola* subsp. *polyglyphis* subsp. nov., *E. parallelogramma* sp. nov., *E. pseudopaludosa* sp. nov., *E. ralitsae* sp. nov. and *E. subantarctica* sp. nov. These are described below and compared with similar taxa from the Northern hemisphere and from South America. Finally, one up to now unidentified species (*Eunotia* sp. 1), found in some samples on South Georgia, is illustrated and discussed but due to taxonomical uncertainty, it is still unclear whether it also represents a new species.

Previously described taxa

Eunotia meisterioides Lange-Bert. (fig. 2V–AE)

Morphological remarks – For more details regarding the overall morphology, see Lange-Bertalot et al. (2011: 149). The observed range of dimensions (n=20): length 13–17 µm, width 2.7–3.4 µm, 16–21 striae in 10 µm. The number of striae is slightly higher than in Lange-Bertalot et al. (2011) and seems more consistent with *E. meisteri* Hust. (15–22 in 10 µm).

Distribution and ecology – *Eunotia meisterioides* is so far only found on South Georgia in the southern Atlantic Ocean (table 2) where the species was incorrecty identified as *Eunotia exigua* (Brébisson) Rabenhorst and *Eunotia* sp. 1 by Van

Table 2 – List of *Eunotia* species present in the Antarctic Region.

	South Indian Ocean					South Pacific Ocean	South Atlantic Ocean	
	Ile Amsterdam	Prince Edward Islands	Iles Crozet	Iles Kerguelen	Heard Island	Macquarie	South Georgia	South Shetlands
Eunotia lecohui Van de Vijver	X							
Eunotia pugilistica Van de Vijver	X							
Eunotia cocquytiae Van de Vijver	X							
Eunotia paludosa Grunow	X	X	X	X	X	X	X	
Eunotia muscicola Krasske subsp. *muscicola*	X		X	X	X		X	
Eunotia muscicola subsp. *polyglyphis* subsp. nov.			X					
Eunotia clotii sp. nov.		X	X	X				
Eunotia mourotii sp.nov.		X		X	X			
Eunotia subantarctica sp. nov.		X		X				
Eunotia amayae sp. nov.			X	X				
Eunotia frigida sp. nov.				X				
Eunotia australomaior sp. nov.				X				
Eunotia parallelogramma sp. nov.					X			
Eunotia amayae subsp. *heardensis* subsp. nov.					X			
Eunotia mcbridei sp. nov.						X		
Eunotia meisterioides Lange-Bert.							X	
Eunotia pyramidatoides Nörpel-Schempp							X	
Eunotia seminulum Nörpel-Schempp & Lange-Bert.							X	
Eunotia tecta Krasske							X	
Eunotia sp1							X	
Eunotia ralitsae sp. nov.							X	X
Eunotia pseudopaludosa sp. nov.								X

de Vijver & Beyens (1996, 1997a). The largest populations of this species were found in wet to semi-wet terrestrial moss vegetations (*Tortula robustula* Cardot & *Warnstorfia laculosa* Müll.Hal.) and in a small acid pool with a pH of 5.9 and a specific conductance value of 62 µS/cm.

Eunotia muscicola Krasske **var. *muscicola*** (fig. 2AU–BH)

Morphological remarks – For more details regarding the overall morphology, see Krammer & Lange-Bertalot (1991: 216) and Lange-Bertalot et al. (1996: 72). The observed range of dimensions (n=20): length 14–22 µm, width 3.3–4.0 µm, 18–22 striae in 10 µm. These valve dimensions agree with the original description in Krasske (1939) although the valve width is slightly higher (3.0 µm in Krasske 1939). Valves reported under the name of *E. muscicola* var. *tridentula* Nörpel & Lange-Bert. in Lange-Bertalot (1993) by Van de Vijver & Beyens (1996 , 1997a, South Georgia; 1999b, Iles Crozet) and Van de Vijver et al. (1998, 2001, Iles Kerguelen) proved to be erroneous identifications. The latter species, currently known under the name *E. paratridentula* Lange-Bert. & Kulikovskiy in Kulikovskiy et al. (2010), have a comparable valve width but lower stria density (14–18 vs. 18–22 in 10 µm). *Eunotia perminuta* (Grunow) Patrick has less pronounced dorsal undulations and a lower stria density (12–14 vs. 18–22 in 10 µm).

Distribution and ecology – *Eunotia muscicola* is a widespread taxon in the southern hemisphere. Originally described from Chile, the species is present on almost every sub-Antarctic island including South Georgia, Ile Amsterdam, Iles Crozet, Iles Kerguelen and Heard Island. So far the taxon was not found on the Prince Edward Islands, Macquarie Island and in the Maritime Antarctic Region. The taxon was previously reported under the name of *Eunotia polydentula* (J.Brun) Hust. by Larson (1974), Pierre (1977) and Le Cohu & Maillard (1986). It is at present unclear whether the record from Jenny Island (Peragallo 1921) as *Eunotia tridentula* Ehrenb. represents the same species. Unfortunately, the Peragallo material could not be located in the collection in Bordeaux (M. Coste, pers. comm.). The taxon is a typical constituent of small acid pools and bog ponds with a low specific conductance value (<100 µS/cm), wet terrestrial and aquatic mosses and also fairly common in wet, acid soils.

Eunotia paludosa Grunow (fig. 2AF–AT)

Morphological remarks – For more details regarding the overall morphology, see Lange-Bertalot et al. (2011: 186). The observed range of dimensions (n=40): length 16–70 µm, width 1.7–3.5 µm, 19–21 striae in 10 µm. These data are consistent with the description in Lange-Bertalot et al. (2011) apart from the fact that some of the reported valves from the sub-Antarctic region extend the maximum length range given by Lange-Bertalot et al. (2011: 16–70 vs. 6–53 µm). On Ile Amsterdam, a considerable part of the population had a higher stria density (up to 27 in 10 µm) but all other features seemed to match the description of *E. paludosa* (Van de Vijver et al. 2008a).

Distribution and ecology – *Eunotia paludosa* is a cosmopolitan taxon and quite common in the sub-Antarctic Region, present on all investigated localities: Ile Amsterdam, South Georgia, Prince Edward Islands, Iles Crozet, Iles Kerguelen, Heard Island and Macquarie Island. On the Maritime Antarctic South Shetland Islands, the species is replaced by *E. pseudopaludosa* sp. nov. (see below). The species is absent from the more southern localities in the Maritime Antarctic Region such as James Ross Island and from the Antarctic Continent. The species was also reported from the South Orkney Islands (Frenguelli 1943, Håkansson & Jones 1994) as one of the most common diatoms in small, acid pools (up to pH of 4.0) with low specific conductance values but this record needs to be verified whether these populations do not belong to *E. pseudopaludosa*. It is also present in large number in semi-wet terrestrial mosses, wet acid soils mostly in peat-dominated valleys.

Eunotia pyramidatoides Nörpel-Schempp (fig. 2E–K)

Morphological remarks – For more details regarding the overall morphology, see Lange-Bertalot et al. (1996: 77, under the name of *E. pyramidata* var. *ventralis* Krasske). The observed range of dimensions (n=10): length 18–34 µm, width 6.3–6.9 µm, 13–15 striae in 10 µm. The valve width seems to be a little bit lower than the original description (Krasske 1939: 6.9–8.4 µm) but valve length and stria density are consistent. In some specimens, it was possible to discern some of the areolae in LM, c. 35 in 10 µm.

Distribution and ecology – At present, this taxon, originally described from southern Chile, has only been observed on South Georgia (Van de Vijver & Beyens 1996) and the South Shetland Islands (R. Zidarova, University of Sofia, Bulgaria, pers. comm.). The taxon has never been reported from the southern Indian and the southern Pacific Ocean islands. It is a very rare species, reported on South Georgia in low numbers living on dry to very dry moss vegetations (Van de Vijver & Beyens 1997a) and on Livingston Island in a dry soil sample taken near a former skua nest under vegetation cover close to the Bulgarian base (R. Zidarova, University of Sofia, Bulgaria, pers. comm.).

Eunotia seminulum Nörpel-Schempp & Lange-Bert. (fig. 2L–U)

Morphological remarks – For more details regarding the overall morphology, see Lange-Bertalot et al. (2011: 217). The observed range of dimensions (n=30): length 9–25 µm, width 2.6–3.3 µm, 22–24 striae in 10 µm. These data are consistent with the description in Lange-Bertalot et al. (2011). The ventral margins of valves of the South Georgian populations are less concave compared to the type specimens of this species shown in Lange-Bertalot et al. (2011). *Eunotia subarcuatoides* Alles, Nörpel & Lange-Bert. has a larger valve width (3.0–4.5 vs. 2.6–3.3 µm) and a lower stria density (18–22 vs. 22–24 in 10 µm). The latter also shows more curved dorsal margins, especially in the larger valves.

Distribution and ecology – *Eunotia seminulum* has so far only been observed on South Georgia but was erroneously reported under the name of *E. subarcuatoides* (Van de Vijver & Beyens 1996, 1997a). The taxon seems to be absent on the other investigated Antarctic localities. The largest populations were found in small acid pools with a pH range of 4.2–5.6 and low specific conductance values (<100 µs/cm).

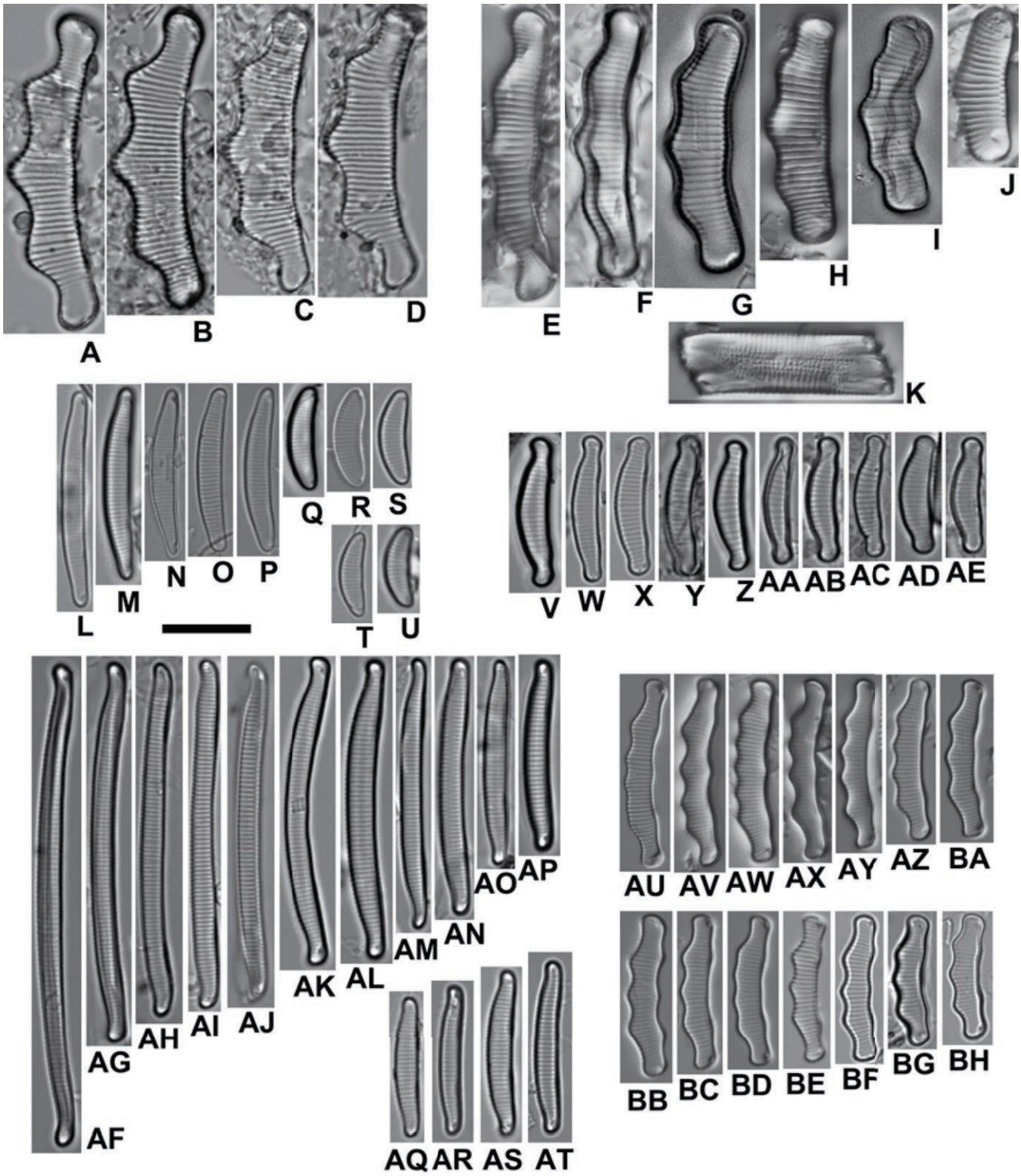

Figure 2 – Light micrographs of several (previously described) *Eunotia* taxa found in the Antarctic Region. A–D, *Eunotia tecta*; E–K, *Eunotia pyramidatoides*; L–U, *Eunotia seminulum*; V–AE, *Eunotia meisterioides*; AF–AT, *Eunotia paludosa* var. *paludosa*; AU–BH, *Eunotia muscicola* subsp. *muscicola*. Scale bar represents 10 µm.

It was also found in high abundances in a wet *Dicranoloma hariotii* (Müll. Hal.) Paris moss vegetation and in lower numbers in semi-wet mixed moss vegetations (Van de Vijver & Beyens 1996, 1997a).

Eunotia tecta Krasske (fig. 2A–D)

Morphological remarks – For more details regarding the overall morphology, see Lange-Bertalot et al. (1996: 80). The observed range of dimensions (n=5): length 32–36 µm, width 7.9–8.5 µm, 14–15 striae in 10 µm. The number of striae is slightly higher than in Krasske (1939: 12–13 in 10 µm).

Distribution and ecology – This taxon was originally described by Krasske (1939) from several localities in southern South America including South-Chile and Patagonia. So far, the species was only found on South Georgia in a subfossil peat core, collected from the Tønsberg Peninsula in the northern part of the island (Van de Vijver et al., unpubl. res.). It has never been reported in the Antarctic literature (Kellogg & Kellogg 2002). The samples in which the taxon was present were dominated by *Aulacoseira principissa* Van de Vijver, *Eunotia ralitsae* sp. nov., *Pinnularia angliciformis* Van de Vijver & Beyens and *Staurosira* cf. *construens* var. *venter* (Ehrenberg) P.B.Hamilton, indicating aquatic circumstances with higher specific conductance and nutrient values, possibly influenced by marine animals (Van de Vijver et al. 2002a).

New taxa

Eunotia amayae Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4332 (Botanic Garden Meise); iso-: PLP-230 (University of Antwerp, Belgium), BRM-ZU9/50 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Vallée des Branloires, Ile de la Possession, Crozet Archipelago, sample W528 (coll. B. Van de Vijver, coll. date 15 Nov. 1997).

Description – **LM**: ventral valve margins of smaller specimens moderately, of larger ones more strongly, concave; dorsal margins parallel or more sharply convex in the shortest cell cycle stages. Apices of the smallest specimens hardly protracted but longer ones being narrowed and obliquely protracted. Valve dimensions (n=20): length 16–54 µm, width 3.5–4.2 µm. Distal raphe nodules terminating close to the poles; fissures forming a short curve from the mantle onto the valve face. Striae evenly spaced, 14–15 in 10 µm. Fig. 3A–U.

SEM (external and internal view): areolae 50–55 in 10 µm. Virgae and series of areolae forming a shallow relief at appropriate oblique view (fig. 3V). Distal raphe fissures ending in a little groove, approximately near the middle of poles (fig. 3W, 3X). Three mantle areolae present between the middle of the raphe branches and the mantle (fig. 3V). One valve end with a small rimoportula (fig. 3Z), lacking on the other end (fig. 3Y). Fig. 3V–Z.

Etymology – The specific epithet refers to Amaya, first daughter (7 Feb. 2013) of Mr. Yann Le Meur (IPEV, France) to thank him for the excellent way he handled the emergency situation in November 2012 after the ship accident with the Marion Dufresne II near the coast of Ile de la Possession.

Distribution and ecology – *Eunotia amayae* was first reported as *Eunotia* sp1 in Van de Vijver et al. (2002a). So far the species has only been found on Ile de la Possession (Crozet Archipelago) and on the neighbouring Iles Kerguelen. It is rather common in small, acid pools with a low specific conductance value (50–70 µs/cm) and low nutrient values. The new taxon was also found in wet terrestrial and floating aquatic mosses and in dry (moisture value 32%), acid soils.

Taxonomical remarks – At present there are hardly any taxa that are so similar that they could be confused with *E. amayae*, in particular none from the Holarctic plant realm. *Eunotia minor* (Kütz.) Grunow is roughly similar but can be mainly distinguished by its distal striae becoming considerably denser spaced (18–25 in 10 µm). *Eunotia tenella* (Grunow) Hust. is much shorter concerning its primary cells whereas *E. pseudogroenlandica* Lange-Bert. & Tagliaventi in Lange-Bertalot et al. (2011) is characterized by a higher stria density (15–18 in 10 µm vs. 14–15 in *E. amayae*) and narrower valves (valve width 2.7–3.6 µm). *Eunotia groenlandica* (Grunow) Nörpel-Schempp & Lange-Bert. differs in having longer polar raphe fissures and narrower valves (valve width 2.7–4.0 µm with distinctly reflected ends (Lange-Bertalot et al. 2011).

Eunotia amayae subsp. ***heardensis*** Van de Vijver, M.de Haan & Lange-Bert., **subsp. nov.**

Type: holo-: BR-4348 (Botanic Garden Meise); iso-: PLP-242 (University of Antwerp, Belgium), BRM- ZU9/51 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Fairchild Beach, Heard Island, sample D24 (coll. N.J.M. Gremmen, coll. date 12 Dec. 2000).

Differential diagnosis vs. *Eunotia amayae* – Main differential characters are the apices: much more clearly set off capitate ends, consistently from long (except for the post-primary stage) to smallest specimens. Apices broadly to flatly rounded (vs. at most subcapitate, becoming gradually narrowed, finally just obtusely rounded). Valve dimensions (n=25): length 17–62 µm, width 3–4.5 µm, 14–16 striae in 10 µm, areolae c. 50 in 10 µm. Minor differential character: sternum at ventral valve side more clearly marked in comparison. A single areola of each one of the ventral mantle striae is more widely spaced from the others (fig. 4X). Fig. 4A–AA.

Etymology – The subspecific epithet refers to Heard Island where the new subspecies was observed.

Distribution and ecology – *Eunotia amayae* subsp. *heardensis* was reported as *Eunotia* sp. 1 in Van de Vijver et al. (2004). So far the species has only been found on Heard Island. It is rare and at present only reported from several wet moss samples in flush areas at low altitude.

Taxonomical remarks – The only taxon that can be confused with the new susbspecies is the nominate taxon *E. amayae*. Both taxa differ consistently in the shape of the apices being always more rounded, less protracted or subcapitate in *E. amayae*. There are hardly any differences in valve dimensions.

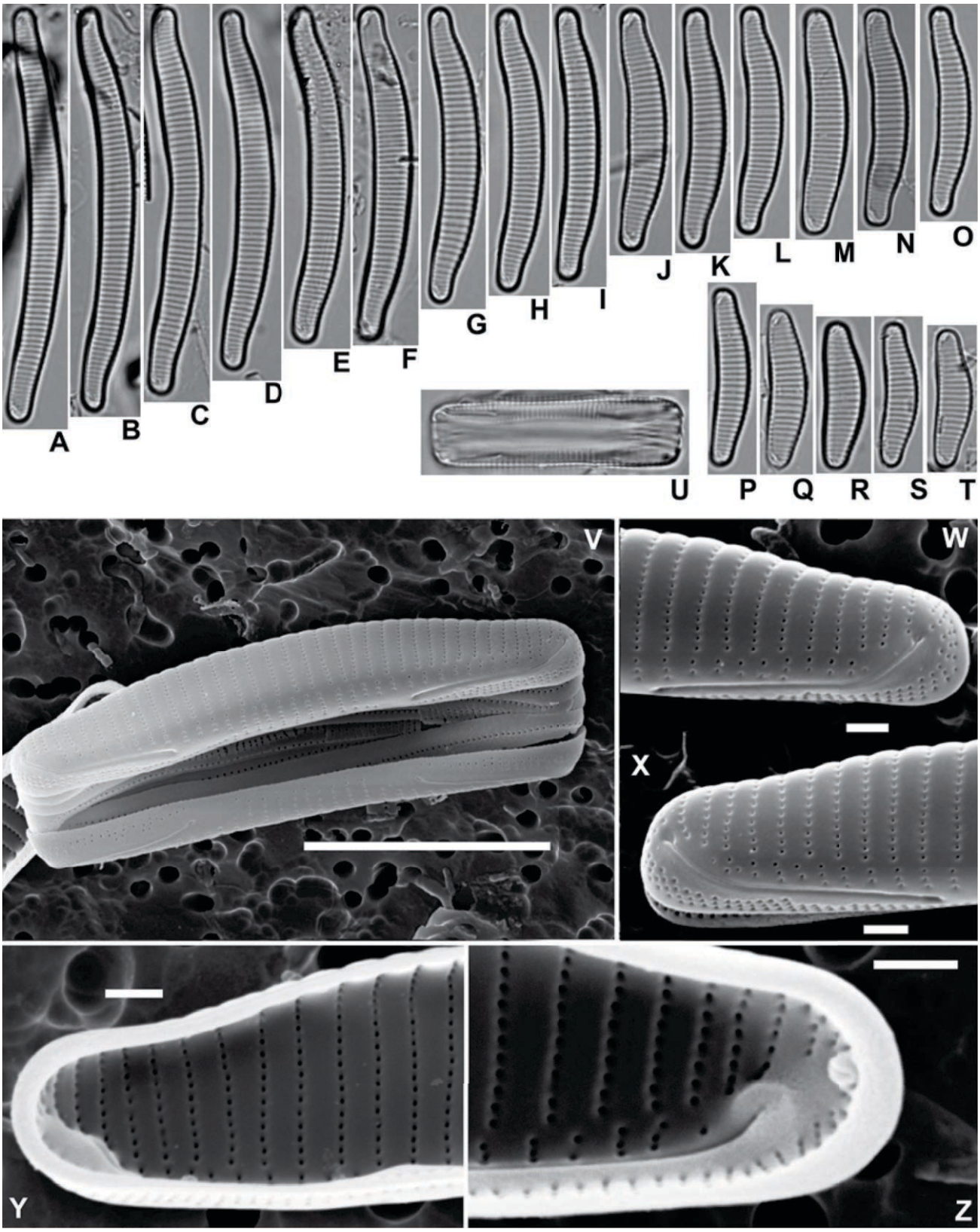

Figure 3 – *Eunotia amayae*: A–U, LM micrographs of the type population on Ile de la Possession (Iles Crozet) (sample W528). U represents a frustule in girdle view; V, Scanning electron micrograph, entire frustule in oblique view showing the valve mantle with the raphe course and the girdle elements; W, X, Scanning electron micrograph, external detail of the both apices of the same valve; Y, Scanning electron micrograph, internal detail of one valve apex lacking the rimoportula; Z, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. Scale bar represents 10 µm except for W–Z where scale bar = 1 µm.

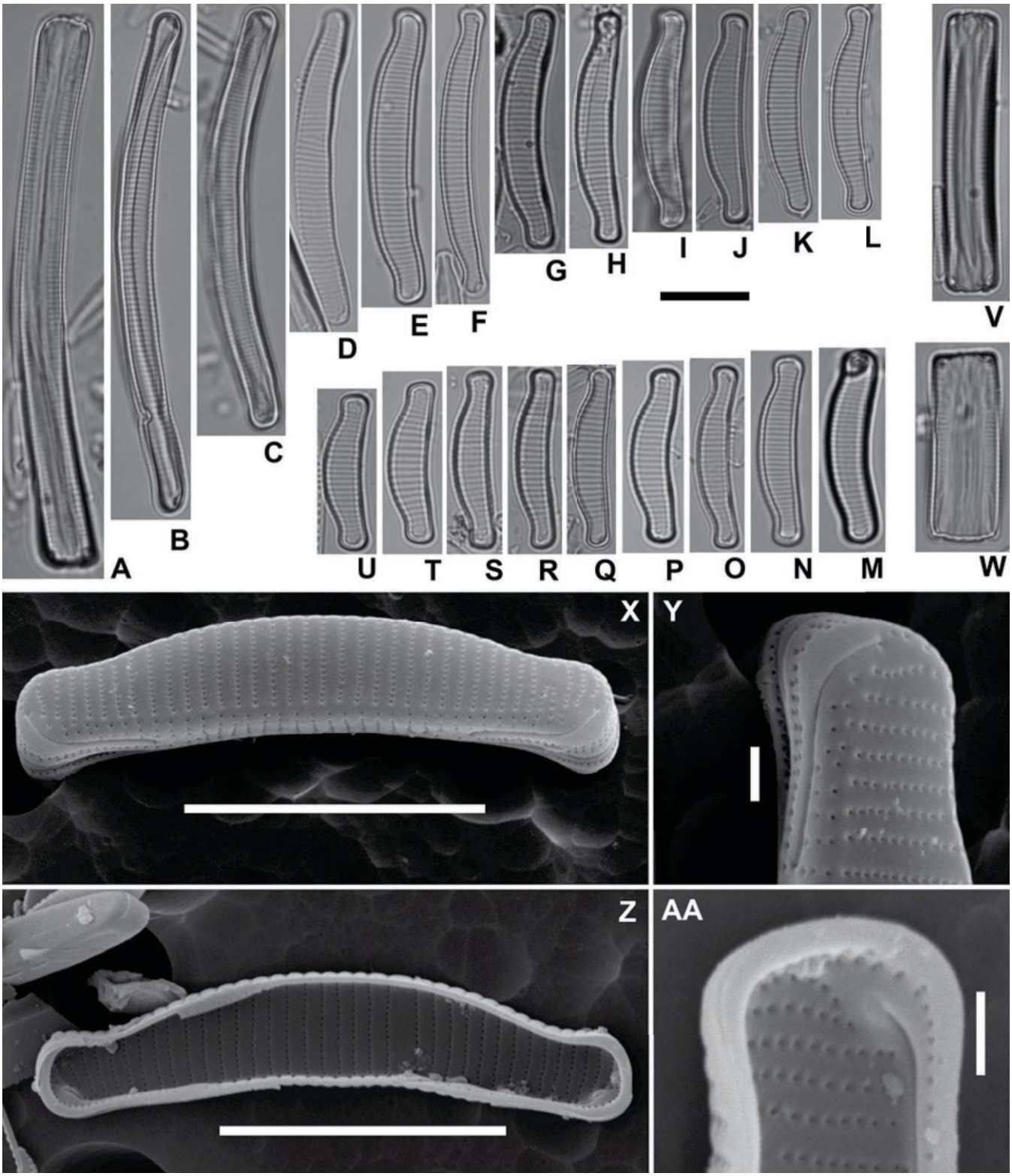

Figure 4 – *Eunotia amayae* subsp. *heardensis*: A–W, LM micrographs of the type population on Heard Island (sample D24). V, W represent frustules in girdle view; X, Scanning electron micrograph, entire frustule in oblique view showing the valve mantle with the raphe course; Y, Scanning electron micrograph, external detail of one valve apex. The arrows indicate the separation of one series of areolae from the other areolae. Z, Scanning electron micrograph, internal view of a complete valve; AA, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. Scale bar represents 10 µm except for Y, AA where scale bar = 1 µm.

Eunotia australomaior Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.** – Type: holo-: BR-4333 (Botanic Garden Meise); iso-: PLP-231 (University of Antwerp, Belgium), BRM- ZU9/52 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Val Studer, Iles Kerguelen, sample BM368 (coll. B. Van de Vijver, coll. date 04 Feb. 1998).

Description – **LM**: valves arcuate, margins almost parallel in the central part or ventral margin slightly less concave than dorsal margin convex. Ends more or less long-protracted, deflected to the central and finally back to the dorsal side. Apices obtusely rounded. Valve dimensions (n=15): length 110–224 µm, width 11–12 µm in proximal parts, length-to-width ratio 9–19. Raphe with long distal fissures extending to the dorsal margins. Striae in a large part of the valve evenly spaced but in some sections several striae irregularly more widely spaced, 9–12 in 10 µm, slightly denser at the ends, up to 14 in 10 µm. Areolae just discernible with light microscopy, 27–30 in 10 µm. Fig. 5A–E.
SEM: (external and internal view) raphe course confirmed, particularly the extremely long distal fissures (fig. 5I). Large number of mantle areolae (7–8) present between the middle of the raphe branches and the mantle (fig. 5J). Distal areas rather large (fig. 5J). Ventral area at the junction of valve face and mantle distinct, narrow. Relief of the virgae in relation to areolated striae moderately high (fig. 5H). No crest at any valve margin. Internally, a rimoportula at one end of the valve in straight polar position (fig. 5F, G). Fig. 5F–J.

Etymology – The specific epithet '*australomaior*' refers to the close resemblance to the northern hemisphere species *E. maior* (W.Smith) Rabenh. and its distribution in the southern hemisphere.

Distribution and ecology – The species was reported so far only from Iles Kerguelen [as *E. monodon* var. *maior* (W.Smith) Hust.] by several authors (Bourrelly & Manguin 1954, Larson 1974, Le Cohu & Maillard 1986 and Van de Vijver et al. 1998). It is a rather rare species, always occurring in low abundances. The largest population was found in wet mosses near a small, almost circumneutral pool in the Val Studer area (pH = 6.6–6.9, spec. cond. = 50–60 µS/cm).

Taxonomical remarks – *Eunotia maior* is the most similar taxon, concerning valve shapes, size dimensions and the distal course of the raphe. It is mainly distinguished in having marginal and polar spines (lacking in *E. australomaior*), consistently the first forming an unperforated ridge with their bases (cf. Lange-Bertalot et al. 2011: plates 215, 216). While stria and areola densities are hardly different, the valve shape differs in details in as much as the ends are less abruptly set off from the main body of the valve. Another, roughly similar taxon is *Eunotia gracilis* f. *maxima* Freng. described in 1933 from Ybera, Argentina, Provincia de Corrientes (Frenguelli 1933). Similarity is restricted to shape and size dimensions: 232 µm long, 10.5 µm wide, 7 striae in 10 µm [if the given magnification of x 600 in Sar et al. (2009) is correct]. This low stria density and the course of the raphe fissure in the line drawing do not match the features of *E. australomaior*. Anyway, the infraspecific taxon has no priority in species rank. Apparently, Frenguelli has followed the concept of Hustedt concerning the identity of *E. gracilis* W.Smith. None of these taxa, however, can actually be valuated as conspecific, neither with Frenguelli's forma nor with the population from Iles Kerguelen.

Eunotia clotii Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4334 (Botanic Garden Meise); iso-: PLP-232 (University of Antwerp, Belgium), BRM- ZU9/53 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Petite Manchotière, Ile de la Possession, Crozet Archipelago, sample BA101 (coll. B. Van de Vijver, coll. date 30 Nov. 1999).

Description – **LM**: frustules in girdle view narrow-rectangular to slightly trapezoid, 3–4 µm broad (fig. 6W, X). Valves slightly to moderately arcuate with almost straight to moderately concave ventral margins and consistently more convex dorsal margins, both parallel only in longest specimens. Ends shortly narrowly protracted and deflected to the dorsal side, resembling in outline *E. paludosa* and to a lesser extent *E. fallax*. Valve dimensions (n=30): length 7–33 µm, width 2.3–3.0 µm. Terminal raphe nodules close to the ends, distal fissures very short, indistinct in light microscopy. Striae rather coarse in relation to the narrow specimens, evenly spaced, 16–18 in 10 µm throughout, never becoming denser near the ends. Areolae not discernible in LM. Fig. 6A–X.
SEM: (external and internal view) course of the raphe almost entirely restricted to the valve mantle, very shortly visible in the valve face (fig. 6Y–Z). Only two-three mantle areolae present between the middle of the raphe branches and the mantle (fig. 6Y). Profile of the virgae moderately low above alternating series of areolae crossed by the narrow ventral area (fig. 6AA). Areolae c. 55 in 10 µm. Internally, a rimoportula lying close to the much larger helictoglossa at one of the valve poles (fig. 6AB–AD). Fig. 6Y–AD.

Etymology – The specific epithet refers to Mr. Thierry Clot (TAAF) to thank him for the excellent way he handled the emergency situation in November 2012 after the ship accident with the Marion Dufresne II near the coast of Ile de la Possession.

Distribution and ecology – *Eunotia clotii* was reported as *Eunotia fallax* Ile de la Possession (Van de Vijver et al. 2002a). So far the species has been found on three islands in the southern Indian Ocean (Prince Edward Islands, Iles Crozet, Iles Kerguelen). Apparently, the species is missing on Heard Island. It is a rare species, usually occurring in small numbers. The largest population (= type population) on Ile de la Possession was collected in the small penguin rookery in the Vallée des Branloires from a dry (soil moisture = 46%), acid (pH = 5.2) soil sample with higher chloride values (Van de Vijver et al. 2002b) due to the presence of several thousands of king penguins (*Aptenodytes patagonicus* Miller).

Taxonomical remarks – Several small-celled *Eunotia* species are more or less similar making misidentification easily possible. *Eunotia paludosa* is widespread with individual-rich populations on all sub-Antarctic and Maritime Antarctic archipelagos including Iles Crozet, the type locality of *E. clotii*. *Eunotia paludosa* differs mainly by a higher stria density (18–25 in 10 µm), whereas the areola density is lower (c. 40 in 10 µm vs. c. 55 for *E. clotii*). *Eunotia fallax* differs by

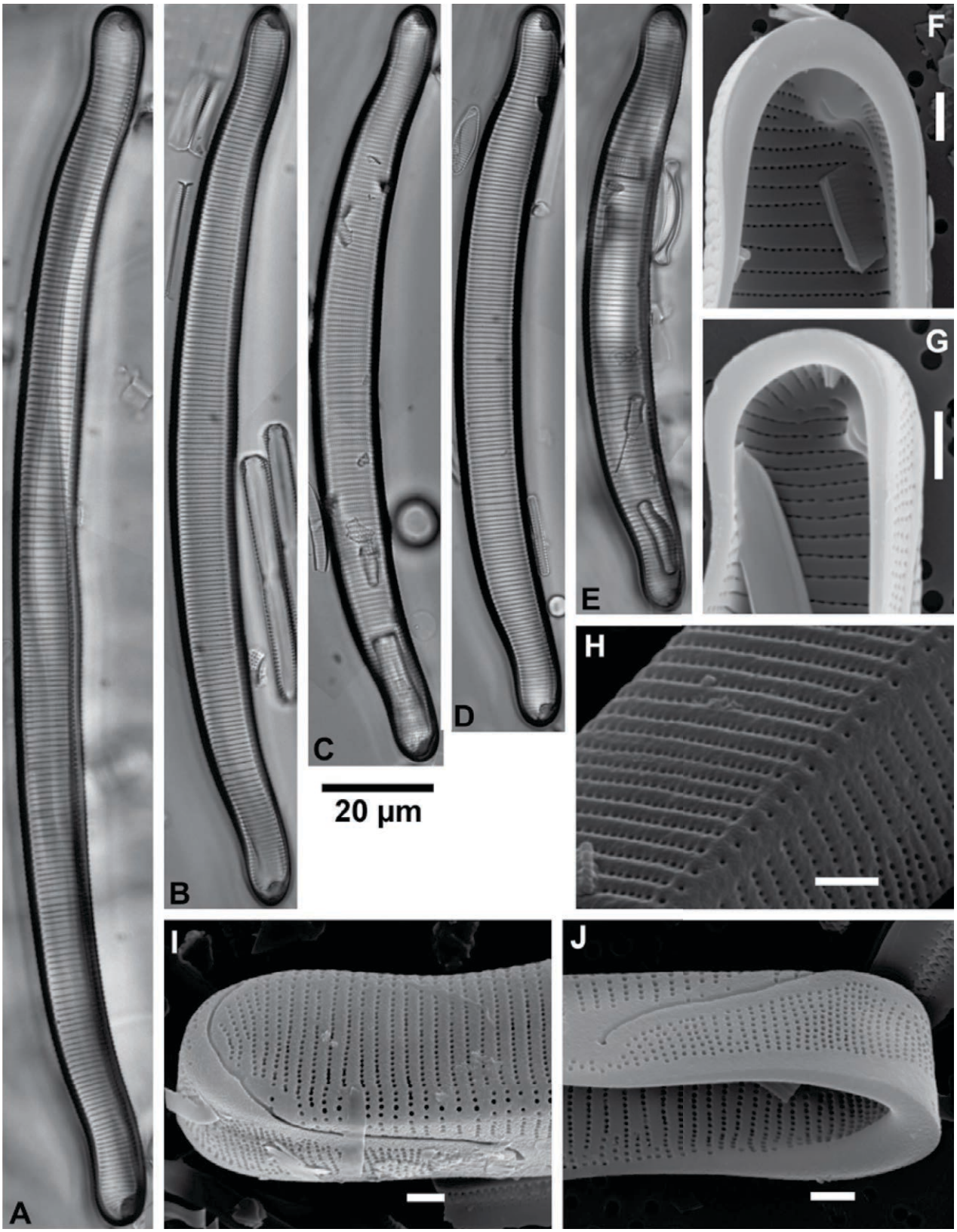

Figure 5 – *Eunotia australomaior*: A–E, LM micrographs of the type population on Iles Kerguelen (sample BM368); F, Scanning electron micrograph, internal detail of one valve apex lacking the rimoportula; G, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. H, Scanning electron micrograph, external detail of the valve relief and the junction with the valve mantle; I, Scanning electron micrograph, external detail of a valve apex. J, Scanning electron micrograph, external detail of valve mantle. Scale bar represents 20 µm except for F–J where scale bar = 1 µm.

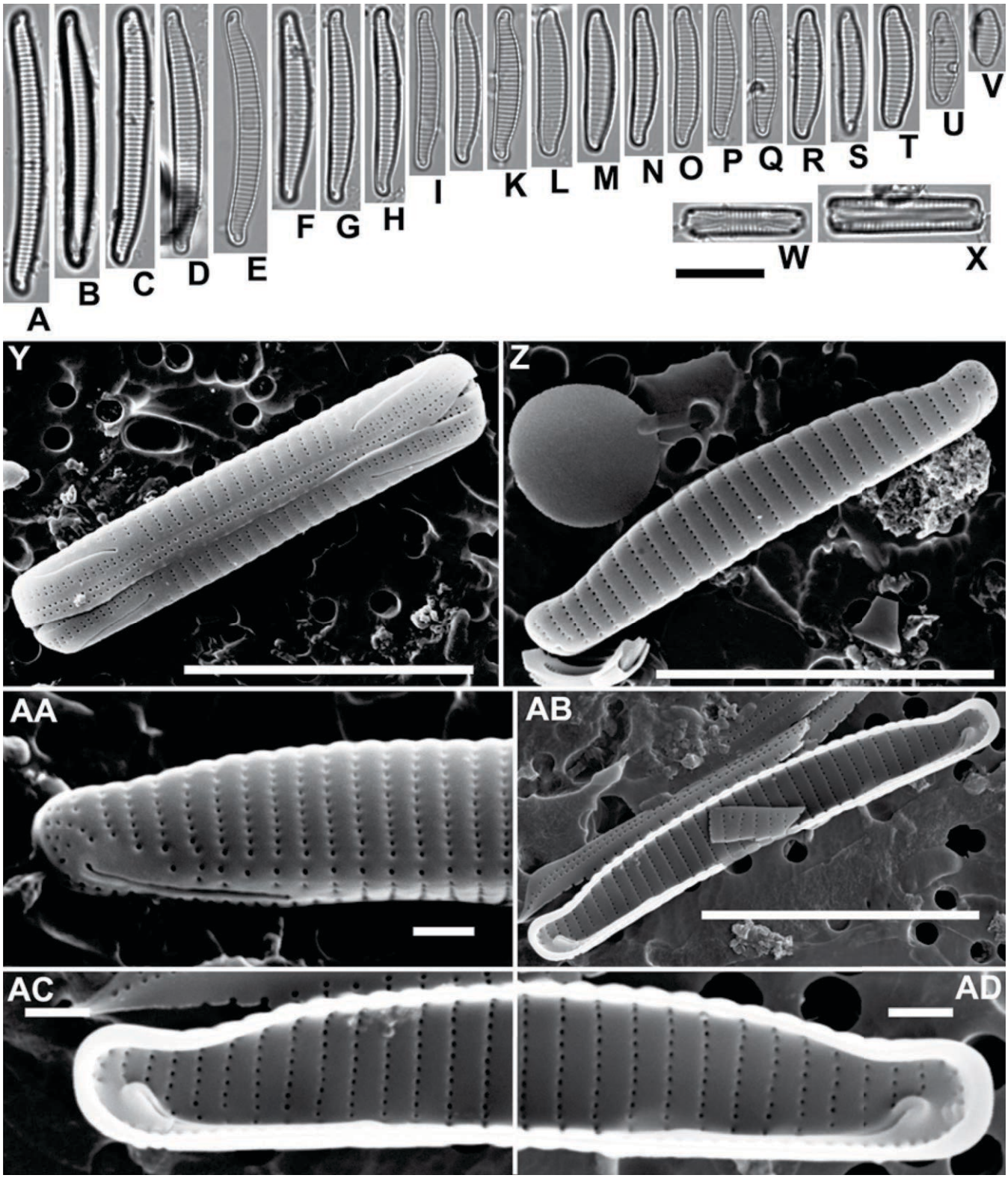

Figure 6 – *Eunotia clotii*: A–W, LM micrographs of the type population on Ile de la Possession (Iles Crozet) (sample BA101). W, X represent frustules in girdle view; Y, Scanning electron micrograph, entire frustule in oblique view showing the valve mantle with the raphe course and the girdle elements; Z, Scanning electron micrograph, entire valve showing the raphe course; AA, Scanning electron micrograph, external detail of one valve apex. AB, Scanning electron micrograph, internal view of entire valve with the helictoglossae at both apices and the rimoportula at one apex; AC, AD Scanning electron micrograph, internal detail of the valve apices, one without (AC) and one with rimoportula (AD). Scale bar represents 10 µm except for AA, AC, AD where scale bar = 1 µm.

a lower stria density (12–17 in 10 µm). The areola density is even much lower (c. 36 in 10 µm), and the distal raphe fissures are considerably longer, approaching the dorsal margins. *Eunotia fallacioides* Lange-Bert. & Cantonati in Cantonati & Lange-Bertalot (2011) is broader on average, 2.7–4.3 µm, and has a lower areola density (35–40 in 10 µm) while short distal raphe fissures and stria density (mostly 16–19 in 10 µm) matching by and large data of *E. clotii*. *Eunotia neofallax* Nörpel-Schempp & Lange-Bert. in Lange-Bertalot et al. (1996) can be easily distinguished by the wider spaced striae (9–14 in 10 µm) and the presence of spines on both apices. *Eunotia nanolusitanica* Lange-Bert. & Novais in Lange-Bertalot et al. (2011) differs by a higher stria density (18–23 in 10 µm), lower areola density (c. 40 in 10 µm) and the ventral valve margin being more strongly concave likewise in larger ad shortest cell cycle stages. Finally, *Eunotia pseudogroenlandica* differs in having longer distal raphe fissures curving onto the valve face and stronger set off, capitate-subcapitate, broader, rounded ends. Morphologically closely related to *E. clotii* is *Eunotia* sp. 1 from South Georgia (see below) but barely conspecific.

Eunotia frigida Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4335 (Botanic Garden Meise); iso-: PLP-233 (University of Antwerp, Belgium), BRM- ZU9/54 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Val Studer, Iles Kerguelen, sample N20 (coll. N.J.M. Gremmen, coll. date 12 Jan. 2004).

Description – **LM**: frustules in girdle view rectangular (fig. 7Q). Valves with slightly to moderately concave ventral and more strongly convex dorsal margin that is not or totally flattened in the proximal part. Ends shortly protracted, obliquely subcapitate with obtusely rounded poles. Valve dimensions (n=20): length 14–45 µm, width 5.5–6.5 µm, length-to-width ratio 2.6–7.8. Distal raphe nodules close to the ends, distal fissures appearing short in the valve face. Striae evenly spaced, 15–16 in 10 µm throughout the entire valve, i.e. not becoming denser near the ends. Areolae not discernible in LM. Fig. 7A–Q.
SEM: (external and internal view): distal raphe fissures short, extended less than halfway to the dorsal margin, ending in a little groove (fig. 7S). Areolae 35–40 in 10 µm. Relief of virgae and areolated striae moderately high (fig. 7R, S). Internally, a rimoportula at one valve pole, much smaller than the adjacent helictoglossa (fig. 7T, U). Fig. 7R–U.

Etymology – The specific epithet '*frigida*' (Latin = cold) makes reference to the cold ecological conditions in which this taxon thrives.

Distribution and ecology – *Eunotia frigida* is at present only reported from Val Studer on Iles Kerguelen as *E. praerupta* (Gremmen et al. 2007). It is possible that older records of *E. praerupta* in fact represent populations of *E. frigida* but without a careful re-analysis of the samples, it is impossible to clarify its actual distribution in the Antarctic Region. The species was only found in one sample, collected from water-saturated mosses on a small (1–5 m^2), isolated seepage area at an altitudinal gradient of 366 m a.s.l.

Taxonomical remarks – The most similar taxon is *E. palatina* Lange-Bert. & Wolfg.Krüger in Werum & Lange-Bertalot (2004), known as yet exclusively from various regions of Europe. The specimens are 16–42 µm long, 4.5–6.6 µm broad; stria density is 15–18 in 10 µm, which means that the numerical characters are not significantly different. However, the latter taxon can be distinguished by its longer protracted ends and coarser areola pattern, easily discernible with light microscopy, 30–35 (vs. 35–40) in 10 µm. Another differentiating character is the sinuous course of the raphe that describes a double curve in the European but a simple curve in the sub-Antarctic taxon (see Lange-Bertalot et al. 2011: plate 155A). The variable populations of *E. minor* (Kütz.) Grunow are clearly distinguished by the striae becoming conspicuously denser spaced at valve ends. *Eunotia compactarcus* Lange-Bert., Pavlov & Levkov in Lange-Bertalot et al. (2011), at present only known from Macedonia, is distinguished mainly by its broader rounded, distinctly set off apices, stronger convex dorsal valve margins and, on average, a lower stria density, 13–15 (vs. 15–16) in 10 µm. Its areolae not discernible with light microscopy but unfortunately, SEM observations are not available at the moment, so differences in raphe structure cannot be verified. The smaller valves of *Eunotia novaisiae* var. *altopyrenaica* Lange-Bert. & Rivera Rondón bear some slight resemblance in being compact but they have a straight ventral margin compared to E. frigida that is always somewhat curved. The larger valves of the latter species have a more curved dorsal margin, entirely in contrast to the almost flattened straight margins of *E. frigida*.

Eunotia mcbridei Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4336 (Botanic Garden Meise); iso-: PLP-234 (University of Antwerp, Belgium), BRM- ZU9/55 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Pyramid lake, Macquarie Island, sample MI99_36 (coll. T.P. McBride, coll. date 22 Nov. 1999).

Description – **LM**: frustules in girdle view narrowly rectangular (fig. 8Q). Valves rather arcuate, becoming continually or somewhat irregularly narrowed towards the more or less pointed ends. Longer specimens having an almost parallel dorsal and ventral margin, smaller ones with a more strongly convex dorsal but less concave ventral margin. Ends rather narrowly rounded, barely protracted or deflected. Valve dimensions (n=20): length 20–60 µm, width 2.8–3.3 µm proximally. Raphe hardly to discern precisely in LM but apparently not recurving from the poles into the valve face. Striae evenly spaced, 20–22 in 10 µm. Areolae not discernible in LM. Fig. 8A–Q.
SEM: (external and internal view): areolae 50–60 in 10 µm. Virgae and series of areolae apparently lying flush on the valve face (fig. 8T, V) but forming a shallow relief after tilting from straight to oblique view seen from the girdle (fig. 8R, U). No mantle areolae present on both sides of the raphe branches (fig. 8U). Distal raphe ends short, terminating in the valve face without any hook in proximal direction. One of the poles bearing a rimoportula, quite prominently present and visible on the valve face (fig. 8T, V–X). Fig. 8R–X.

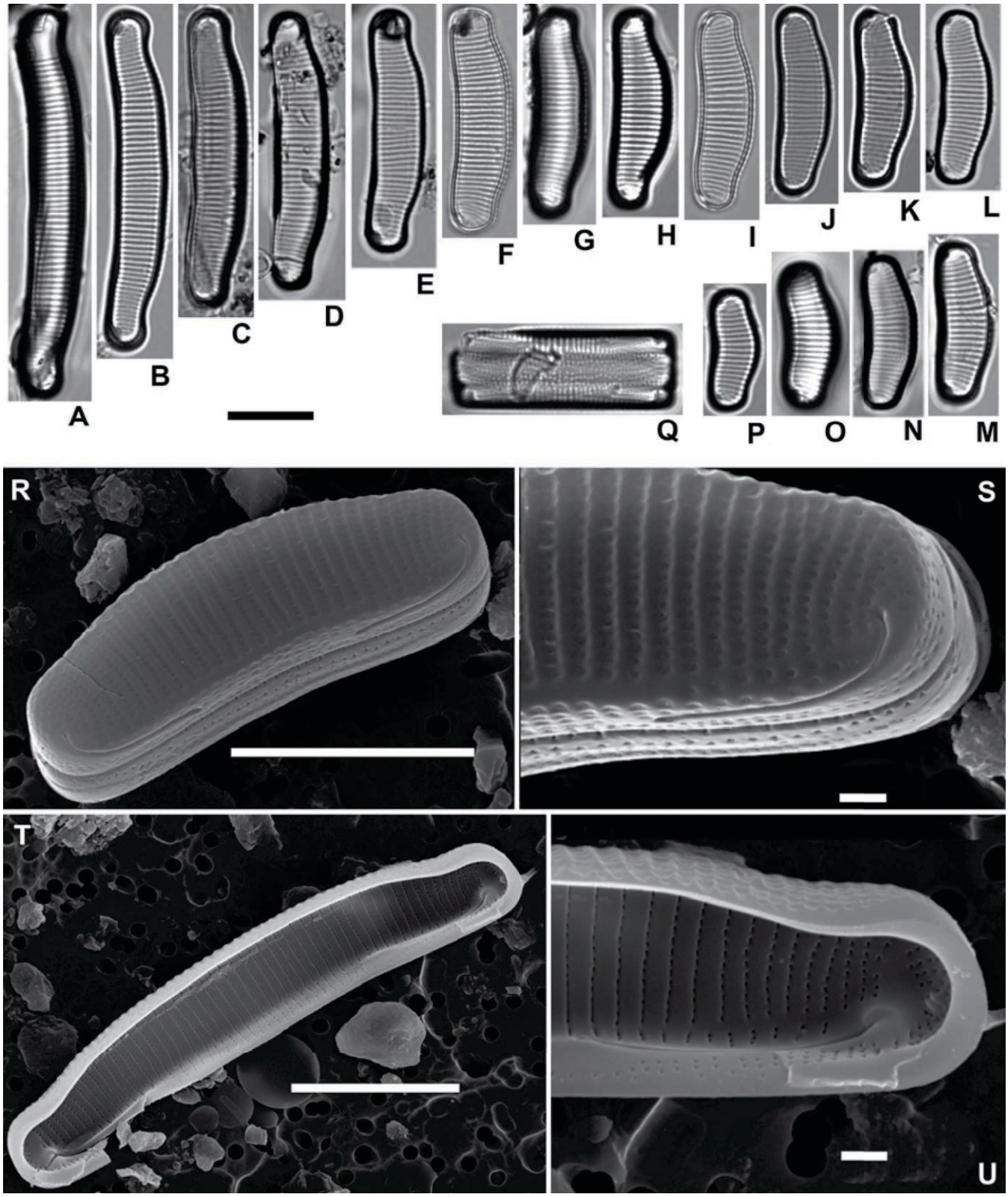

Figure 7 – *Eunotia frigida*: A–Q, LM micrographs of the type population on Iles Kerguelen(sample KN20). Q represents a frustule in girdle view; R, Scanning electron micrograph, entire frustule in oblique view showing the valve mantle with the raphe course and the girdle elements; S, Scanning electron micrograph, external detail of one valve apex; T, Scanning electron micrograph, internal view of entire valve with the helictoglossae at both apices and the rimoportula at one apex; U, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. Scale bar represents 10 µm except for S, U where scale bar = 1 µm.

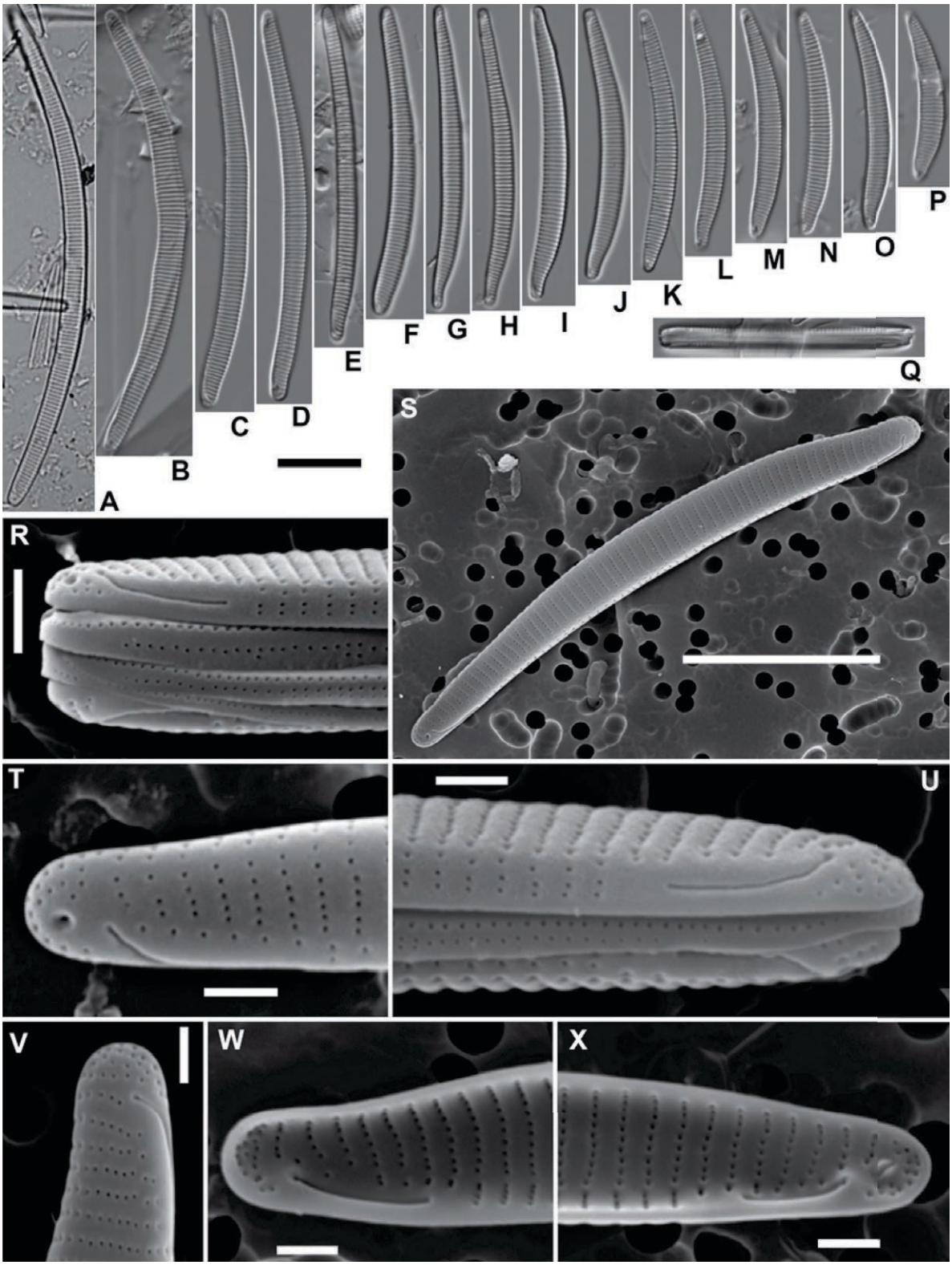

Figure 8 – *Eunotia mcbridei*. A–Q, LM micrographs of the type population on Macquarie Island (sample MI99_36). Q represents a frustule in girdle view; R, Scanning electron micrograph, external detail of a valve apex in oblique view showing the mantle and some girdle elements; S, Scanning electron micrograph, entire valve showing the raphe course and the opening of the rimoportula; T, Scanning electron micrograph, external detail of one valve apex with the opening of the rimoportula; U, Scanning electron micrograph, external detail of the valve apex in oblique view lacking a rimoportula; V Scanning electron micrograph, external detail of the valve apex lacking a rimoportula; W, X, Scanning electron micrograph, internal detail of the valve apices, one lacking rimoportula W) and the other with the rimoportula (X). Scale bar represents 10 µm except for R, T–X where scale bar = 1 µm.

Etymology – The specific epithet refers to our Australian colleague, Dr. Thomas Patrick McBride who provided us with the sample of this new species.

Distribution and ecology – At present, *E. mcbridei* is only found on Macquarie Island, in a sample taken from a submerged *Rhacomitrium crispulum* (Hook.f. & E.H.Wilson) Hook.f. & E.H.Wilson moss vegetation growing in a lake beside the track. Unfortunately, more ecological data were not collected when the sample was taken.

Taxonomical remarks – Based on the valve outline together with the typical course of the raphe, there are hardly any other *Eunotia* taxa that can actually be confused with *E. mcbridei*. All more or less morphologically resembling taxa from the Holarctic realm or elsewhere differ clearly by recurving distal raphe ends as observed in for instance *E. mertensiae* Lange-Bert., *E. monnieri* Lange-Bert. & Tagliaventi, *E. juettnerae* Lange-Bert. and *E. mucophila* (Lange-Bert., Nörpel & Alles) Lange-Bert. (all in Lange-Bertalot et al. 2011) whereas in *E. mcbridei*, the distal raphe endings are short and never recurving (fig. 8T, V). Other long and narrow *Eunotia* taxa, such as *E. naegelii* Migula or *E. cantonatii* Lange-Bert.& Tagliaventi in Lange-Bertalot et al. (2011), differ in having different valve dimensions (usually much longer with valve lengths up to 130 µm), a higher length/width ratio or a higher stria density (up to 27 in 10 µm). The new taxon also shows some affinities with the genus *Actinella* but lacks the complete set of differentiating characters of this genus. A slight heteropolarity, typical for almost all *Actinella* taxa, is present in a few specimens but does not seem to be a constant feature. Marginal spines or vestiges of polar spines are completely missing. Therefore, the entire complex of characters does barely point to the genus *Actinella* but instead agrees more with the genus *Eunotia*, justifying its taxonomic position within the latter (Lange-Bertalot et al. 2011). The position and the external expression of the rimoportula is quite unusual in the genus *Eunotia*. The outer rimoportula opening is rarely so prominently visible on the valve face (Lange-Bertalot et al. 2011).

Eunotia mourotii Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4337 (Botanic Garden Meise); iso-: PLP-235 (University of Antwerp, Belgium), BRM- ZU9/56 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Inland from Albatross Lake, Marion Island, Prince Edward Islands, sample D162 (coll. N.J.M. Gremmen, coll. date 15 Apr. 2003).

Description – **LM**: frustules in girdle view rectangular. Longer valves arcuate with approximately parallel dorsal and ventral margins. Ventral margins becoming less concave during the cell cycle towards smaller specimens. Ends clearly set off and obliquely capitate or subcapitate with flattened dorsally reflexed poles. Valve dimensions (n=25): length 16–55 µm, width 2.6–3.0 µm. Terminal raphe fissures shortly curved onto the valve face. Striae rather evenly spaced, consistently c. 16 in 10 µm. Areolae not discernible in LM. Fig. 9A–Z.

SEM: (external and internal view)polar raphe ends run at most up to the middle of the poles (fig. 9AA, AE). Areolae 40–45 in 10 µm. Internally, a rimoportula at one valve pole, much smaller than the adjacent helictoglossa and somewhat separated from it (fig. 9AC, AD, arrow). Fig. 9AA–AE.

Etymology – The specific epithet refers to Mr. Sébastien Mourot (chief of staff of the Prefect of TAAF) to thank him for the excellent way he handled the emergency situation in November 2012 after the ship accident with the Marion Dufresne II near the coast of Ile de la Possession.

Distribution and ecology – *Eunotia mourotii* has been observed on several sub-Antarctic islands in the southern Indian Ocean but reported under different names. The largest populations were found on the Prince Edward Islands (as *E. fallax*) and Iles Kerguelen [as *E. elegans* Lange-Bert. & Nörpel-Schempp in Lange-Bertalot (1993)] but smaller populations were likewise recorded from Heard Island (as *E. nymanniana* Grunow in Van Heurck). Remarkably, the new taxon has not been observed so far on Ile de la Possession, Crozet Archipelago, despite the thorough survey that was made on the diatom flora of that island (Van de Vijver et al. 2002a). The new taxon prefers wet moss vegetations in mires and mire drainage areas with a slightly acid to circumneutral pH (6.3–7.0) and low specific conductance values (<120 µS/cm).

Taxonomical remarks – The most resembling taxon among the taxa from the Holarctic realm is *E. arculus*, distinguished by its 3.0–4.0 µm broad valves and longer primary cells with a valve length up to 50 µm, 16–20 striae in 10 µm and about 35 areolae in 10 µm. Moreover, its capitate ends are not flatly rounded. *E. neocompacta* Mayama var. *neocompacta* differs in having much broader valves (width: 3.3–5.7 µm) while the var. *vixcompacta* Lange-Bert. in Lange-Bertalot et al. (2011) mainly by distinctly less arcuate valves and 17–18 striae in 10 µm. *Eunotia nymanniana* has a higher stria density (17–21 µm). *Eunotia fallax* has less pronounced apices and a more straight ventral margin compared to *E. mourotii* that has a more curved ventral margin. On the other hand, *E. elegans*, has strongly curved to even sickle-shaped valves, a feature never observed in *E. mourotii* (Lange-Bertalot et al. 2011).

Eunotia muscicola Krasske subsp. ***polyglyphis*** Van de Vijver, M.de Haan & Lange-Bert., **subsp. nov.**

Type: holo-: BR-4338 (Botanic Garden Meise); iso-: PLP-236 (University of Antwerp, Belgium), BRM- ZU9/57 (Hustedt Collection, Brem erhaven, Germany). – Type locality: Vallée des Branloires, Ile de la Possession, Iles Crozet, sample W523 (coll. B. Van de Vijver, coll. date 15 Nov. 1997).

Differential diagnosis vs. subsp. *muscicola* – **LM**: valve outlines in general similar to the nominate subspecies. Valve dimensions (n=15): length 20–33 µm, width 3.0–3.5 µm vs. 9–25 µm and 2.5–3.0 µm respectively; in the protologue 15–17 µm long, 3.0 µm wide. Stria density 18–19 vs. 19–21 in 10 µm but 22 in the protologue. Fig. 10A–P.

SEM: (external and internal views): areolae 45–50 in 10 µm. Polar raphe endings are hooked to approximately the middle of the apices (fig. 10Q). A small rimoportula at one pole is situated close to the helictoglossa (fig. 10R, arrow). Fig. 10Q, R.

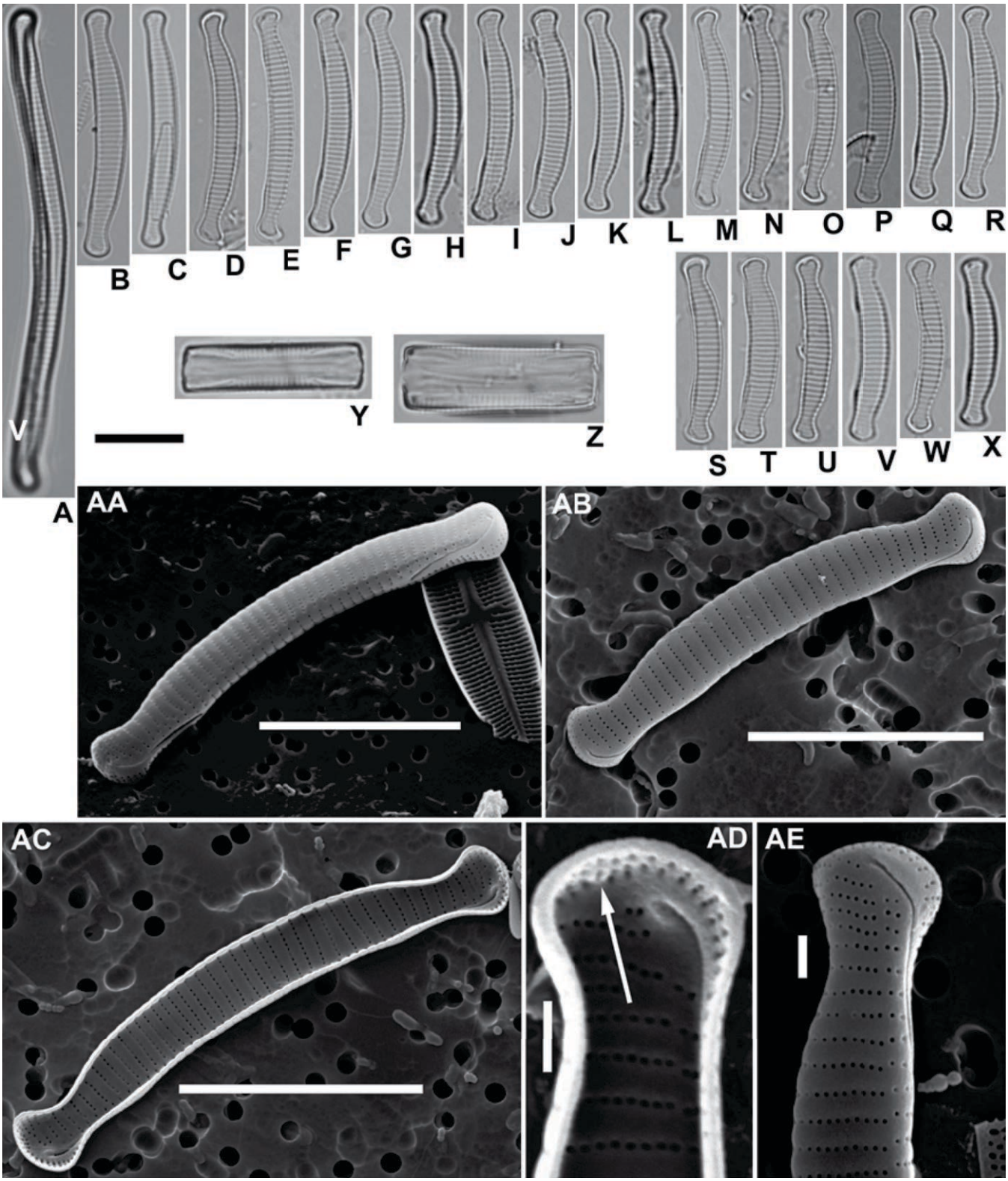

Figure 9 – *Eunotia mourotii*: A–Z, LM micrographs of the type population on Marion Island (Prince Edward Islands (sample D162). A represents an initial cell; Y, Z represent frustules in girdle view; AA, Scanning electron micrograph, external view of a valve in oblique view showing the mantle; AB, Scanning electron micrograph, entire valve showing the raphe course; AC, Scanning electron micrograph, internal view of entire valve with the helictoglossae at both apices and the rimoportula at one apex; AD, Scanning electron micrograph, internal detail of one valve apex with the rimoportula (arrow). AE, Scanning electron micrograph, external detail of one valve apex with the opening of the rimoportula. Scale bar represents 10 µm except for AD, AE where scale bar = 1 µm.

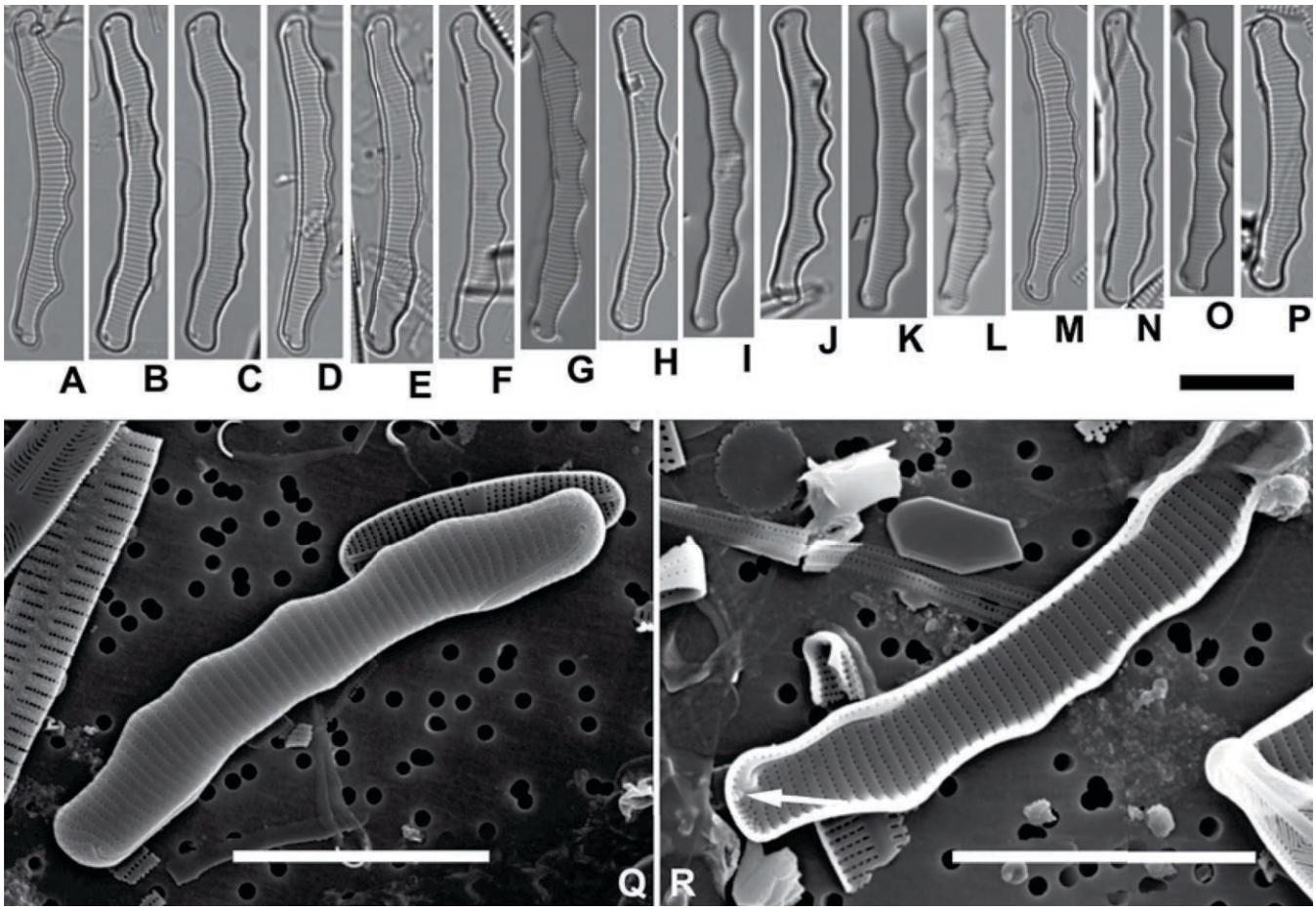

Figure 10 – *Eunotia muscicola* subsp. *polyglyphis*: A–P, LM micrographs of the type population on Ile de la Possession (Iles Crozet) (sample W523); Q, Scanning electron micrograph, entire valve showing the raphe course; R, Scanning electron micrograph, internal view of entire valve with the helictoglossae at both apices and the rimoportula at one apex. Scale bar represents 10 µm.

The main distinguishing characteristics are longer specimens, 33 µm do not represent primary but post-primary cells of the cell cycle, whereas in the lectotype population from continental Chile 25 µm is the maximum length approximately (see Lange-Bertalot et al. 1996: 138, fig. 68). Moreover, the smallest, c. 9 µm long, valves of the lectotype population possess a single gibbosity, all longer ones, two to three waves. The new subspecies possesses a minimum of three waves. While such cells occur rather rarely, the majority has 4–7 waves, often being unevenly shaped.

Etymology – The specific epithet '*polyglyphis'* refers to the large ('*poly*') number of undulations of the valves.

Distribution and ecology – At present, the new subspecies has only been with certainty observed on Ile de la Possession (Iles Crozet) (Van de Vijver et al. 2002a: plate 18, figs 13–24). It is highly likely that within the records of *E. muscicola* subsp. *muscicola* from the sub-Antarctic localities, more populations of the subsp. *polyglyphis* are included but a complete revision of all these populations will be necessary to establish the correct biogeographic distribution of this subspecies. The largest populations of the new subspecies were observed in small lakes in the Vallée des Branloires, the largest valley of Ile de la Possession. The entire area around the lakes is completely built up with peatlands. PH of the lake water ranged from 6.0 to 6.6 with a low specific conductance (80–90 µS/cm) and low nutrient values (PO_4^{2-} = 0.02 mg/l).

Taxonomical remarks – Despite of the differences mentioned above, a close relationship of both subspecies seems obvious. Isolation mechanisms due to the biogeographic situation could be the main reason of a certain discontinuity in this case. There are hardly any *Eunotia* taxa that show a comparable valve outline. *E. variundulata* var. *suecica* Lange-Bert., Van de Vijver & Jarlman in Lange-Bertalot et al. (2011), recently described from Sweden, has weak dorsal undulations but possesses less elongated valves with a lower stria density (17–18 in 10 µm). *Eunotia crista-galli* P.T.Cleve and *E. hexaglyphis* Ehrenb. have wider valves (width up to 11 µm) whereas E. *perminuta* (Grunow) R.M.Patrick has a lower stria density (12–14 in 10 µm). Recently, Krstić et al. (2013) described from the Himalaya two Eunotia taxa that are closely related to *E. muscicola* and that both show a larger number of dorsal undulations. *Eunotia panchpokhariensis* Krstić, Levkov & Pavlov has a higher stria density (20–23 vs. 18–19 in 10 µm) but more important lacks a rimoportula, a feature that is prominently present in the new subspecies. The valves of the Himalayan species are also more dorsiventrally curved compared to the new subspecies. On the other hand, *E. paramuscicola* Krstić, Levkov & Pavlov has

straighter valves with a lower valve width, a higher stria density. As in the previous species, *E. paramuscicola* lacks also a rimoportula. Based on these differences, both Himalayan species can be separated from the new subspecies.

Eunotia parallelogramma Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4339 (Botanic Garden Meise); iso-: PLP-237 (University of Antwerp, Belgium), BRM- ZU9/58 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Scarlet Hill, Heard Island, sample H773 (coll. N.J.M.Gremmen, coll. date 15 Jan. 2001).

Description – **LM**: frustules in girdle view forming a parallelogram, rectilinear outlines were not observed thus far (fig. 11J). Valves with distinctly concave ventral and parallel dorsal margins, sometimes variously arched, e.g. flattened in central parts. Ends set off, more or less broadly capitate with broadly rounded poles, obliquely reflexed to the dorsal side. Valve dimensions (n=10): length 27–35 µm, width 7–8 µm. Terminal raphe fissures short, at most extending to the middle of the poles, finally with a little hook. Striae almost evenly spaced throughout from proximal parts to the ends, 11–14 in 10 µm but with some irregularities occasionally. Areolae not clearly discernible with light microscopy. Fig. 11A–J.
SEM: (external view) only a single specimen could be observed, see: course of the raphe confirmed. Several mantle areolae (4–5) present between the middle of the raphe branches and the mantle (fig. 11L). Areolae c. 35 in 10 µm. Profile of virgae moderately high. Foramen of a rimoportula not detectable, spiny structures or crests missing. Valve interior not observed due to the rarity of the taxon. Fig. 11K, L.

Etymology – The specific epithet '*parallelogramma*' refers to the parallelogram-like shape of the frustules in girdle view, although this is not a unique character within the genus *Eunotia*.

Distribution and ecology – So far, *Eunotia parallelogramma* has only been found in one sample on Heard Island from where it was reported as *E. praerupta* in Van de Vijver et al. (2004b). It is possible that more records, currently reported under *E. curtagrunowii* Nörpel-Schempp & Lange-Bert. in Lange-Bertalot & Metzeltin (1996) exist in the Antarctic literature but since appropriate illustrations are lacking it is unclear whether these records represent small forms of *E. ralitsae* sp. nov. or subantarctica sp. nov. (see below) or *E. parallelogramma*. The sample in which *E. parallelogramma* was found in low numbers (< 2% of all counted valves), was collected from wet *Bucklandiella didyma* (Mont.) Bednarek-Ochyra & Ochyra turfs in a drainage line on a mountain slope. PH of the water squeezed out of the moss turfs was 6.5.

Taxonomical remarks – The morphologically closest related taxon from the northern Hemisphere is *Eunotia curtagrunowii*. It was however never found forming frustules that are parallelogram-like in girdle view. The striae are rarely evenly spaced but being wider spaced proximally, 9–14 in 10 µm, becoming denser near the ends, up to 18 in 10 µm. Moreover, the latter taxon can also be distinguished in having a lower areola density on average, 27–35 in 10 µm. *Eunotia ewa* Lange-Bert. & Witkowski, described from Greenland, is on average larger (width 9.5–13 µm) with a lower stria density (9–12 in 10 µm).

Eunotia pseudopaludosa Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4349 (Botanic Garden Meise); iso-: PLP-243 (University of Antwerp, Belgium), BRM- ZU9/59 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Byers Peninsula, Livingston Island, South Shetland Islands, sample BYM002 (coll. B.Van de Vijver, coll. date 9 Jan. 2009).

Description – **LM**: frustules in girdle view comparatively rather broadly rectangular, c. 6–7 µm broad (fig. 12T, U). Valves slightly arcuate with moderately concave ventral margins and parallel to slightly more convex dorsal margins. Ends more or less clearly set off, reflexed to the dorsal side, resembling *E. paludosa* but more obliquely subcapitate in comparison. Valve dimensions (n=25): length 21–30 µm, width 2.5–3.0 µm. Terminal raphe nodules close to the ends, distal fissures rather long, c. halfway towards the dorsal valve side, often difficult to discern with light microscopy. Striae 18.5–19.5 rather consistently, barely becoming denser spaced at the valve ends (conforming just to the lowest stria densities of E. paludosa). Areolae not discernible in LM. Fig. 12A–U.
SEM: (external and internal view) course of the raphe distinctly prolonged onto the valve face, ending in a little groove c. in the middle of the apex. Three–four mantle areolae present between the middle of the raphe branches and the mantle (fig. 12V). Profile of the virgae above alternating series of areolae with here intact closing membranes (fig. 12Y). Main characteristic features in comparison to *E. paludosa* are (1) high dorsal and ventral valve mantles, particularly in proximal to subdistal parts with 6–7 areolae in every pervalvar row (compare to Lange-Bertalot et al. 2011, fig 146: 30, 31); (2) a somewhat discontinuous but conspicuous ridge at the dorsal junction between valve face and mantle (fig. 12X). Areola density is c. 50 in 10 µm, i.e. moderately denser (vs. 40–45 in *E. paludosa*). Internally a rimoportula lying at one of the valve poles (Fig. 12Z). Fig. 12V–Z.

Etymology – The specific epithet '*pseudopaludosa*' refers to the close resemblance to *E. paludosa* that is often confused in the Antarctic literature.

Distribution and ecology – *Eunotia pseudopaludosa* has with certainty only been found on Byers Peninsula, Livingston Island but was misidentified as *E. paludosa* (see Kopalová & Van de Vijver 2013). It is likely that other reports from the Maritime Antarctic Region refer to this new taxon instead of *E. paludosa* (e.g. Zidarova 2008). Sample BYM002 is dominated by *E. pseudopaludosa*. This moss sample was collected near some coastal pools near Sealers Hill on Byers Peninsula. The mosses were rather wet and showed remains of marine birds (skuas). A smaller population was found in the sediment a small coastal pool with a rather circumneutral pH and low specific conductance value (<100 µS/cm).

Taxonomical remarks – No other taxon than *E. paludosa* will be confused with the new taxon. Except for the distinguishing features given in the description above, the higher

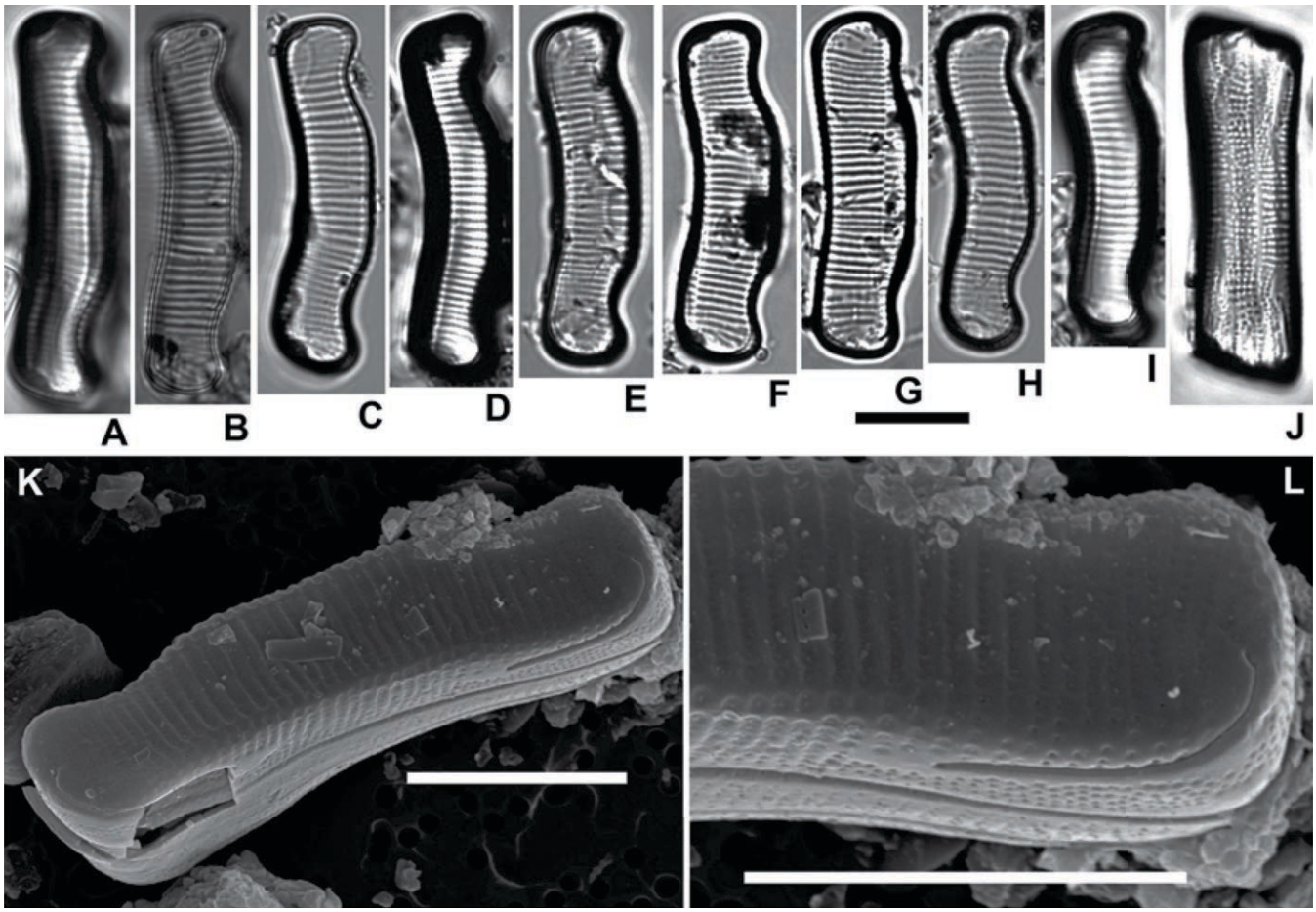

Figure 11 – *Eunotia parallelogramma*: A–J, LM micrographs of the type population on Heard Island (sample H773). J represents a frustule in girdle view; K, Scanning electron micrograph, entire valve showing the raphe course; L, Scanning electron micrograph, external detail of one valve apex. Scale bar represents 10 µm.

breath of the frustules in girdle view seem to be remarkable, 6–7 vs. 3–4 µm, see e.g. Lange-Bertalot et al. (2011), figs 147: 14–17. However, girdle views of correctly identified *E. paludosa* have rather rarely been documented in the literature (see e.g. Germain 1981, figs 31: 22–26 as misidentified *E. tenella*). *Eunotia superpaludosa* Lange-Bert. (Lange-Bertalot 2011) and *E. leptopaludosa* Lange-Bert. (Lange-Bertalot 2011) appear sufficiently distinguished from the new taxon.

Eunotia ralitsae Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4340 (Botanic Garden Meise); iso-: PLP-238 (University of Antwerp, Belgium), BRM- ZU9/60 (Hustedt Collection, Bremerhaven, Germany). – Type locality: Byers Peninsula, Livingston Island, South Shetland Islands, sample BY067 (coll. B. Van de Vijver, coll. date 18 Jan. 2009).

Description – **LM**: frustules in girdle view rectangular (fig. 13I). Valves arcuate, ventral margins much less concave than dorsal margins convex. Ends broadly protracted, almost square, poles broadly rounded, not truncated. Valve dimensions (n=20): length 26–75 µm, width 10–11 µm, including the smallest cell cycle stages. Length-to-width ratio 2.3–7.1. Terminal raphe fissures curved onto the valve face, approaching approximately the middle of the poles. Striae rather evenly spaced in the main body of the valves, becoming conspicuously more densely spaced in the ends of longer stages, 10–11 proximally and 15–18 distally in 10 µm. Fig. 13A–I.

SEM: (external view), see: areolae 30–32 in 10 µm. Four–five mantle areolae present between the middle of the raphe branches and the mantle (fig. 13K). Profile of virgae rather low, alternating with slightly depressed series of areolae. Foramina of rimoportulae barely visible at any pole. Internally, a rimoportula at one valve pole, well developed, somewhat separated from the helictoglossa (fig. 13L, M). Fig. 13J–M.

Etymology – The specific epithet refers to our dear colleague Dr. Ralitsa Zidarova (University of Sofia, Bulgaria) to thank her for the great collaboration during the past eight years.

Distribution and ecology – *Eunotia ralitsae* is a rather rare taxon on the islands in the southern Atlantic Ocean. The taxon was previously reported under the name of *E. praerupta* from South Georgia (Van de Vijver & Beyens 1996, 1997a), South Orkney Islands (Broady 1979 as *E. praerupta* var. *inflata* Grunow) and the South Shetland Islands (Van de Vijver & Beyens 1997b, Zidarova 2008, Kawecka et al. 1998).

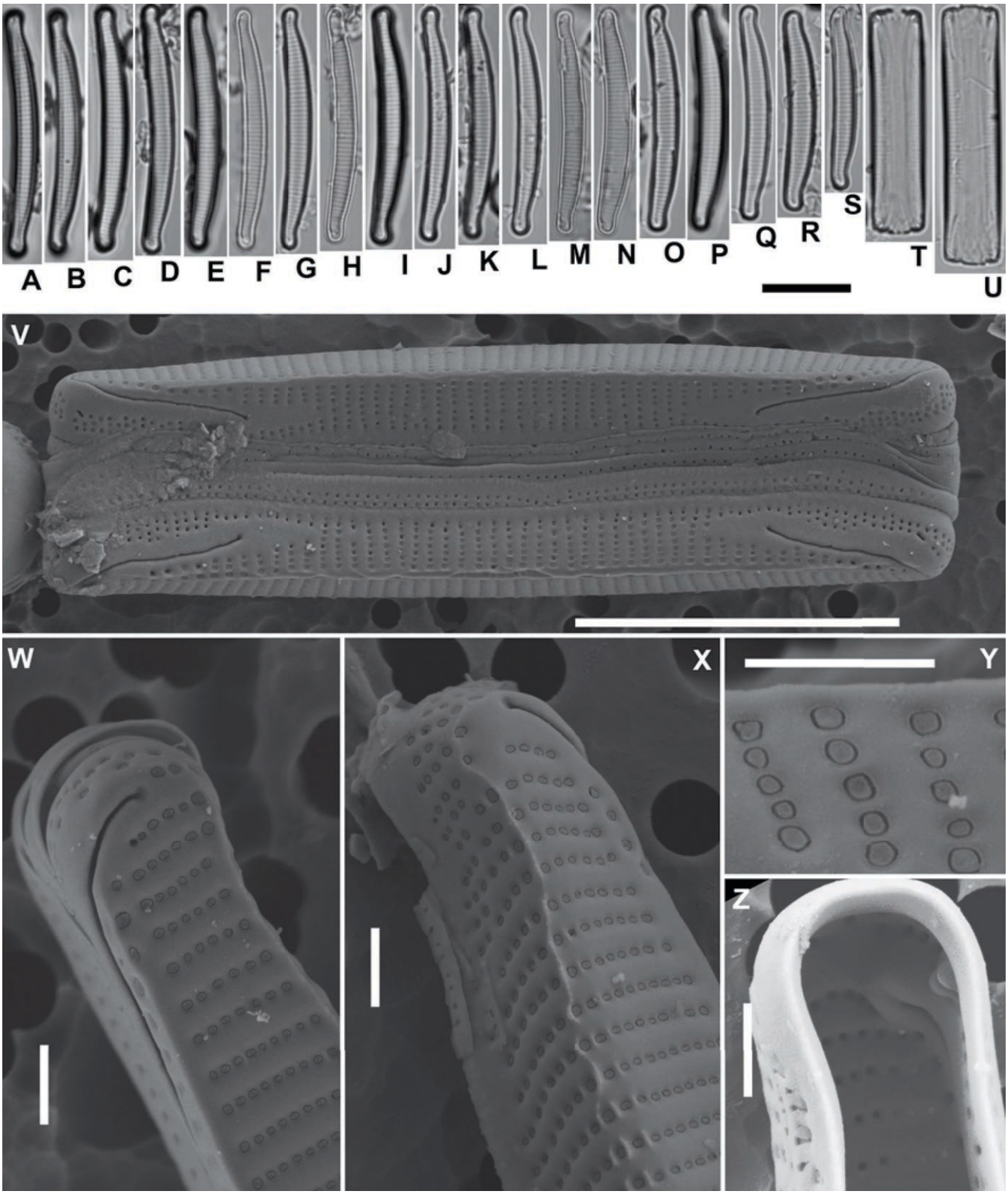

Figure 12 – *Eunotia pseudopaludosa*: A–U, LM micrographs of the type population on Byers Peninsula (Livingston Island, South Shetland Islands (sample BYM002). T,U represent frustules in girdle view; V, Scanning electron micrograph, external view of a frustule in girdle view showing the broad mantle; W, Scanning electron micrograph, external detail of a valve apex showing the course of the raphe and the closing of the areolae; X, Scanning electron micrograph, external detail of the valve margin showing the ridge at the dorsal side; Y, Scanning electron micrograph, external detail of the hymenes covering externally the areolae; Z, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. Scale bar represents 10 µm except for W–Z where scale bar = 1 µm.

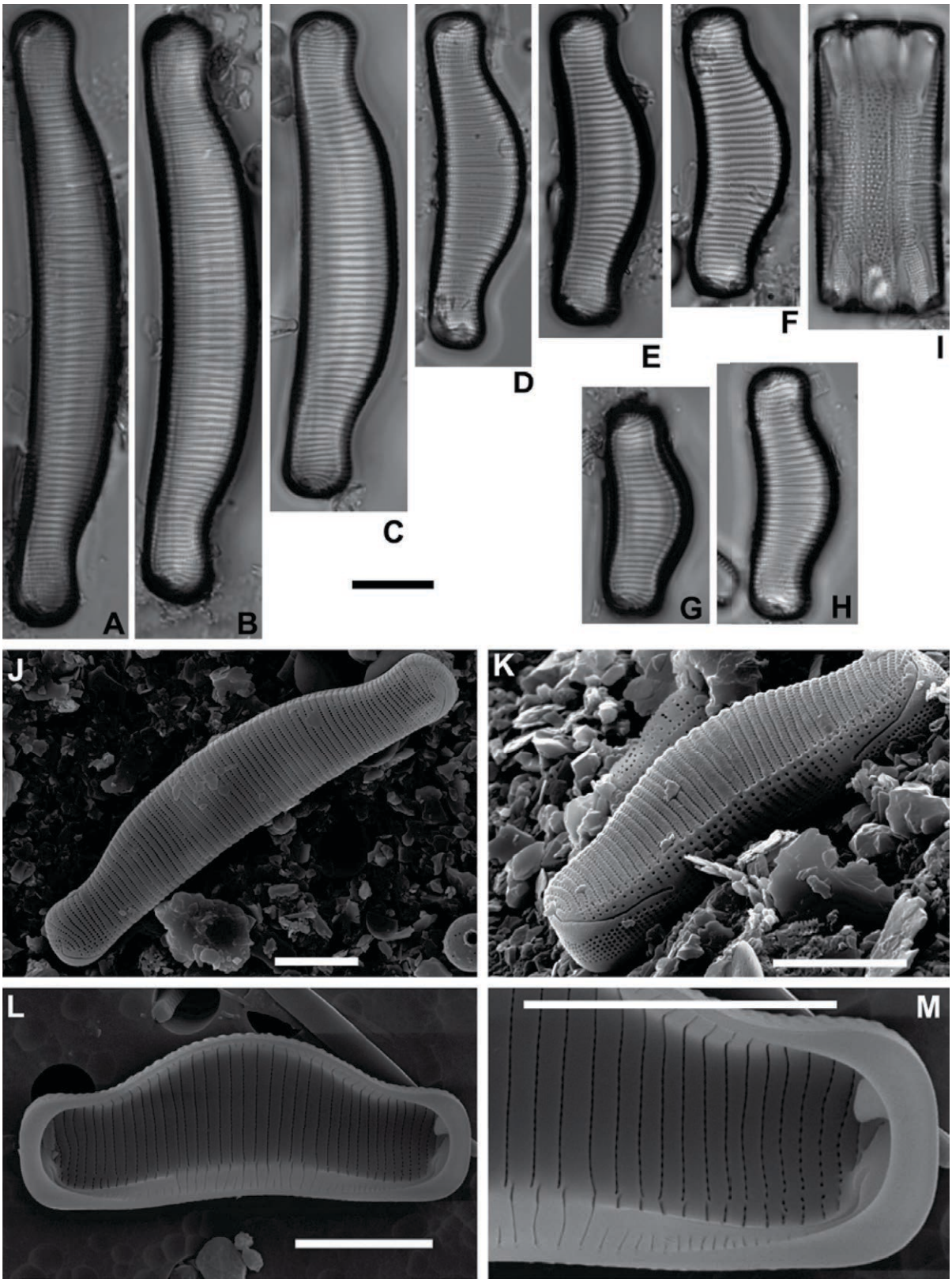

Figure 13 – *Eunotia ralitsae*: A–I, LM micrographs of the type population on Byers Peninsula (Livingston Island, South Shetland Islands (sample BY067). I represents a frustule in girdle view; J, Scanning electron micrograph, external view of a valve in oblique view showing the mantle; K, Scanning electron micrograph, entire valve showing the raphe course; L, Scanning electron micrograph, internal view of entire valve with the helictoglossae at both apices and the rimoportula at one apex; M, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. Scale bar represents 10 µm except for AD, AE where scale bar = 1 µm.

The largest populations were found on South Georgia living in semi-wet to dry moss vegetations. On the South Shetland Islands, the taxon was mostly found in small circumneutral pools with moss-covered shores and in semi-wet moss vegetations.

Taxonomical remarks – *Eunotia praerupta* Ehrenb. is hardly similar because of much wider valves when medium-sized and larger stages are compared (at least 15 µm wide). Length-to-width ratio is 2.5–4.7 compared to 2.3–7.1 in *E. ralitsae*. The striae are unevenly spaced, 5.5–7 in 10 µm proximally, which is much coarser than in *E. ralitsae*. Morphologically closerly related is *Eunotia elena* Lange-Bert. in Lange-Bertalot et al. (2011). It is, however, mainly distinguished by a higher profile of the virgae (SEM) on the valve face and mantle, whereas the apices are less narrowly protracted and the distal striae are less densely spaced, 12–14 in 10 µm. *Eunotia arcus* Ehrenb. s.str. is less broad on average, 6.0–10.6 µm with less narrowly protracted apices and 11–14 striae in 10 µm, becoming only slightly denser near the poles. On the sub-Antarctic islands in the southern Indian Ocean, the species seems to be replaced by *E. subantarctica* sp. nov. (see below). The latter can be separated based on a higher stria density, more elongated, often wider valves and shorter distal raphe endings (see below).

Eunotia subantarctica Van de Vijver, M.de Haan & Lange-Bert., **sp. nov.**

Type: holo-: BR-4341 (Botanic Garden Meise); iso-: PLP-239 (University of Antwerp, Belgium), BRM- ZU9/61 (Hustedt Collection, Bremerhaven, Germany).– Type locality: Tafelberg, Marion Island, Prince Edward Islands, sample D100 (coll. N.J.M. Gremmen, coll. date 10 Apr. 2003).

Description – **LM**: frustules almost rectangular to forming a parallelogram in girdle view (fig. 14H, I). Valves with a slightly to moderately concave ventral margin and a rather highly convex dorsal margin (except for the post-primary stage). Ends small (compared to the *Eunotia praerupta* species complex), protracted obliquely subcapitate, poles obtusely rounded. Valve dimensions (n=25): length 23–90 µm, width 7.8–10.5 µm. Length to width ratio 3.2–9.6. Terminal raphe fissures long (when focusing). Striae of most specimens evenly spaced in the main body of the valve, 12–14 in 10 µm proximally, becoming considerably denser at the ends, 17–21 in 10 µm. Fig. 14A–I.

SEM: (external and internal view): long polar raphe ends particularly remarkable, running parallel to the polar valve margins approaching almost the dorsal side (fig. 14J). Five mantle areolae present between the middle of the raphe branches and the mantle (fig. 14J) Areolae, 28–30 in 10 µm, lying depressed between elevated virgae. One small rimoportula present near the helictoglossa at one pole (fig. 14K). Fig. 14J, K.

Etymology – The specific epithet '*subantarctica*' refers to the biogeographic distributiuon of the species in the sub-Antarctic Region.

Distribution and ecology – *Eunotia subantarctica* has been previously reported from two sub-Antarctic islands in the southern Indian Ocean, but under the name of *E. praerupta* (Van de Vijver et al. 2001, 2008b). The species was not observed on the Iles Crozet (Van de Vijver et al. 2002a) not on Heard Island (Van de Vijver et al. 2004b) despite intensive diatom research. The new taxon is typically found in bog ponds and on rocks in mires and small streams with a rather acid to slightly acid pH (5.8–6.5) and low specific conductance values (<50 µS/cm).

Taxonomical remarks – Resembling taxa are *E. arcus* Ehrenb. and *E. praerupta*. Even more similar than the types or lectotypes respectively are these very often recorded taxa in the inadequate "second-hand' concepts of many authors. *Eunotia subantarctica* is best distinguished by its characteristic outlines together with the long terminal raphe fissures. No taxon from the Holarctic realm or elsewhere possesses such a complex of characters [see Lange-Bertalot et al. (2011), plates 185, 191, 192]. In the Antarctic Region, only *E. ralitsae* seems similar but can be distinguished by the shorter distal raphe fissures and different valve dimension.

***Eunotia* sp. 1**

Eunotia aff. *bertrandii* Lange-Bert. & Tagliaventi in Lange-Bertalot et al. (2011).

Differential diagnosis vs. *E. bertrandii* – **LM**: valves approximately conforming in shape and size dimensions. Length 10–30 µm (vs. 8.7–22 µm), width 2.8–3.3 µm (vs. 2.2–3.0 µm). Raphe barely different. Striae 18–22 (vs. 19–21) in 10 µm. Fig. 15A–X.

SEM: (internal and external view): areolae 50–55 (vs. 45–50) in 10 µm. Valve face appearing moderately relief-like, i.e. virgae elevated above the depressed areolated striae (fig. 15Z). Two mantle areolae present between the middle of the raphe branches and the mantle (fig. 15Z). One rimoportula present at one of both valve ends (fig. 15AA–AC). Fig. 15Y–AC.

Distribution and ecology – This unidentified taxon is so far only reported from South Georgia (as *E. exigua* in Van de Vijver & Beyens 1996, 1997a) where it was found in mosses in a small, very acid (pH = 4.6) pool with low specific conductance values (54 µS/cm).

Taxonomical remarks – The only distinguishing morphological characters as yet recognizable are a slightly higher areola density and relief-like elevated virgae in appropriate view, whereas the valve face appears smooth, i.e. areolae lying flush with the virgae. However, it cannot be excluded that the profile of the virgae may accommodate in both populations in appropriate oblique view, more tilted in case of *E. bertrandii*. Moreover, tilting of the valve could result in a comparable course of the raphe on the ventral valve mantle (compare practically SEM fig. 131: 40 of the protologue of *E. bertrandii* to our fig. 15Z). *Eunotia* (?nov.) sp. cf. *E. bertrandii* from the spring of the Pfrimm River, Germany (see Lange-Bertalot et al. 2011, figs 131: 42–55) is less similar to the South Georgia population because of consistently less concave ventral valve margins. *Eunotia pseudogroenlandica* Lange-Bert. & Tagliaventi in Lange-Bertalot et al. (2011, plates 132, 133) differs by wider spaced striae on average, 15–18 in 10 µm, areola density is 40–50 in 10 µm, however a population of questionable identity from the southern Alps, Italy (loc. cit., figs 133: 12–17) possesses 20–22 striae in 10 µm, conforming to specimens from South Georgia. Without

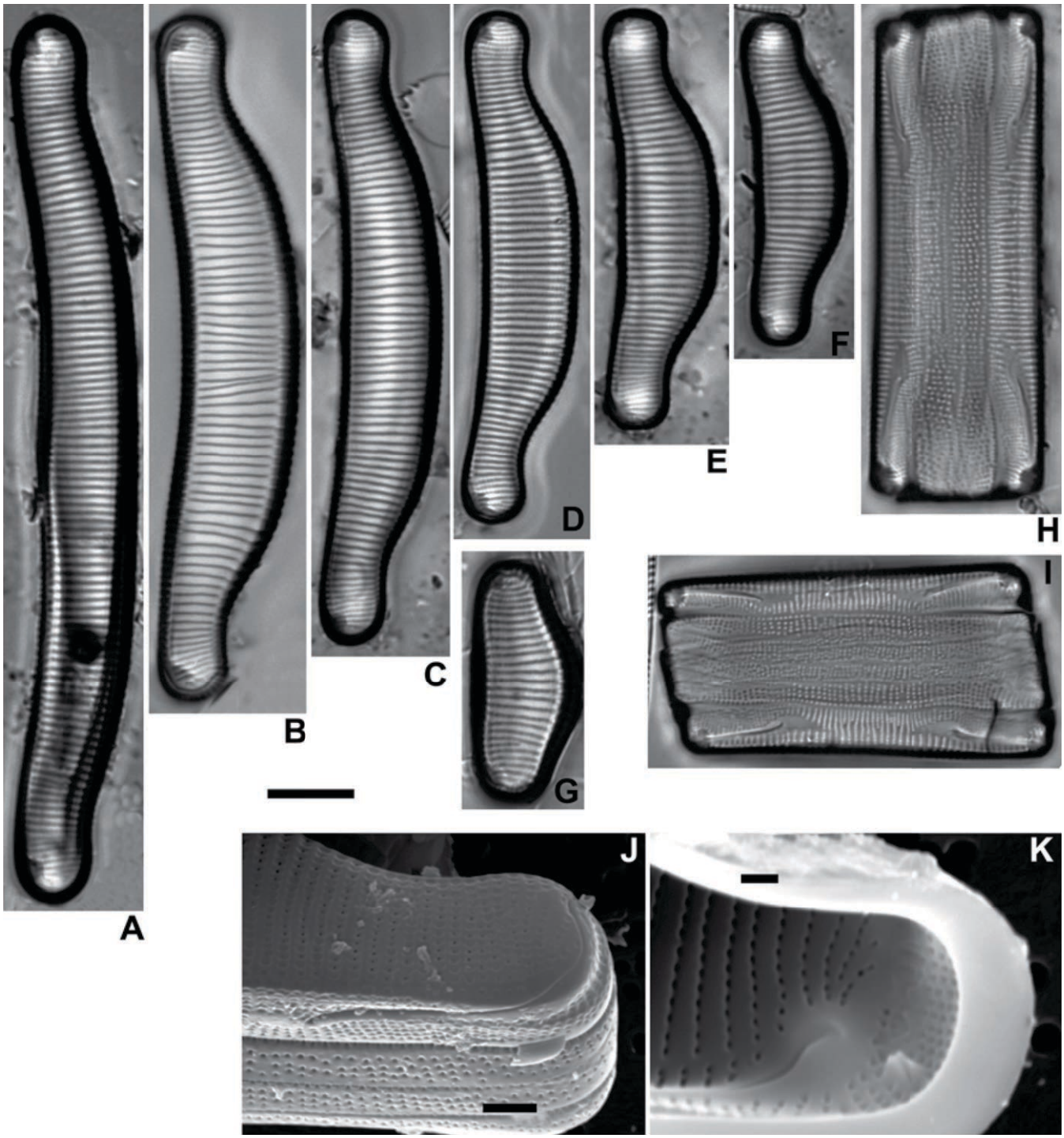

Figure 14 – *Eunotia subantarctica*: A–I, LM micrographs of the type population on Marion Island (Prince Edward Islands (sample D100). H, I represent frustules in girdle view; J, Scanning electron micrograph, external view of a valve apex in oblique view showing the mantle and some girdle elements; K, Scanning electron micrograph, internal detail of one valve apex with the rimoportula. Scale bar represents 10 µm except for J, K where scale bar = 1 µm.

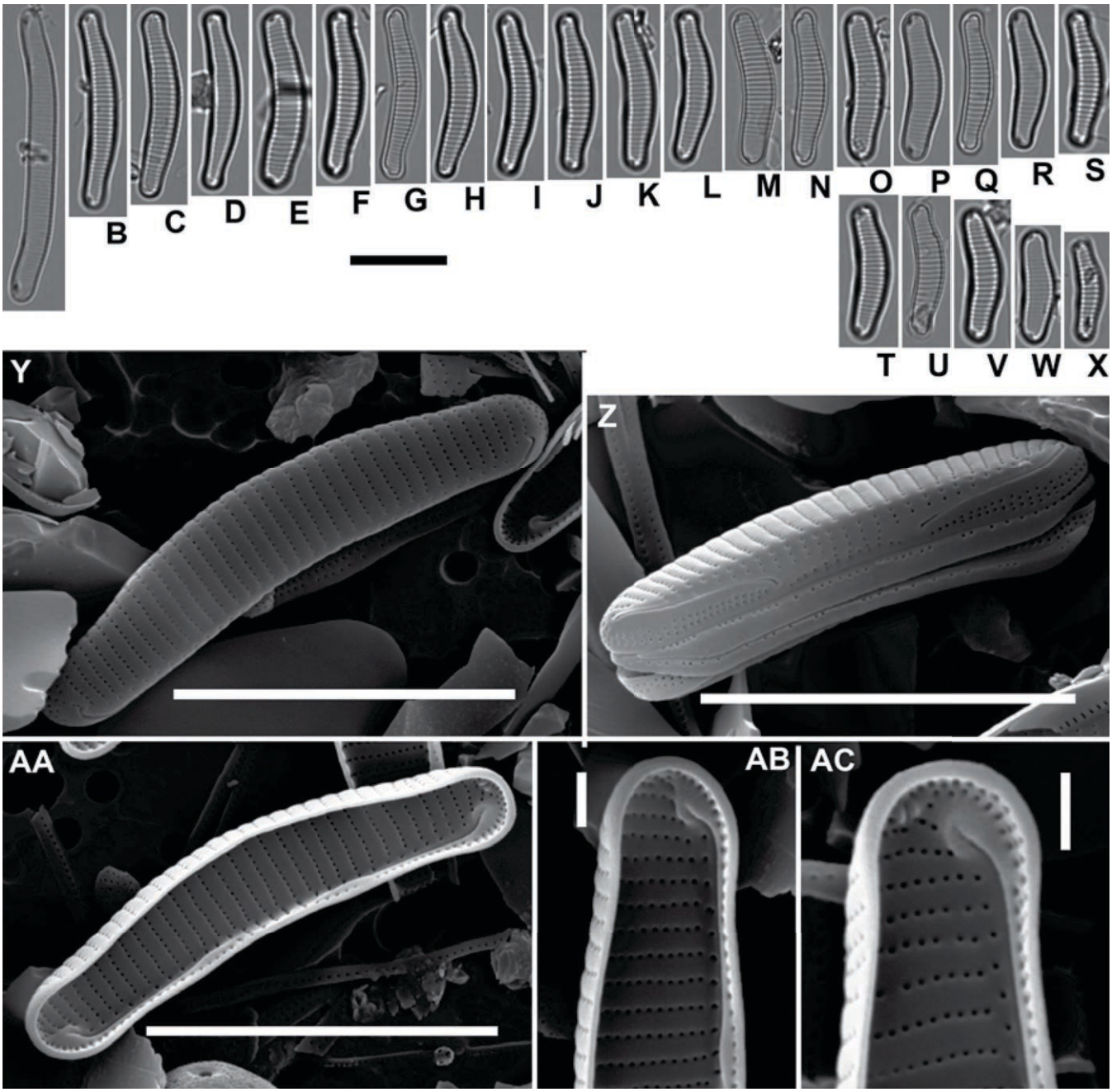

Figure 15 – *Eunotia* sp1: A–X, LM micrographs of the largest population on South Georgia (sample W399); Y, Scanning electron micrograph, entire valve showing the raphe course; Z, Scanning electron micrograph, external view of a valve in oblique view showing the mantle; AA, Scanning electron micrograph, internal view of entire valve with the helictoglossae at both apices and the rimoportula at one apex; AB, AC Scanning electron micrograph, internal detail of the valve apices, one lacking the rimoportula (AB) and one with the rimoportula (AC). Scale bar represents 10 µm except for AB, AC where scale bar = 1 µm.

more information about the fine structure pattern, conspecificity or heterospecificity of at least four taxa (established and non-established) remain as an open question. Therefore, the description of a new taxon with a 'weak' differentiation of maybe variable features is avoided in this case, waiting for more information.

DISCUSSION

The large number of newly described *Eunotia* taxa in the Antarctic Region is hardly surprising considering on one hand the high percentage of new taxa described after previous revisions of other genera [see for instance *Hantzschia* (Zidarova et al. 2010), *Muelleria* (Van de Vijver et al. 2010) or *Stauroneis* (Van de Vijver et al. 2004a)] and on the other hand the result of the recent revision of the genus *Eunotia* in the northern hemisphere where 54 out of 159 taxa appeared to be new (Lange-Bertalot et al. 2011). These new data confirm once more our ideas about the diversity and endemicity of the Antarctic diatom flora and have also serious biogeographical implications. It is clear that based on table 2, the number of *Eunotia* species that are widespread in the entire Antarctic Region is reduced in comparison to the previously accepted data. So-called cosmopolitan taxa such as *Eunotia praerupta*, *E. tenella* or *E. exigua* are no longer on the species list and have been replaced by their Antarctic counterparts. These erroneous identifications are a clear example of either taxonomic drift, enlarging the original description of the taxon to accommodate 'aberrant' populations or force-fitting the Antarctic populations in European or north-American relatives (Tyler 1996). Two taxa still show a broad distribution, *E. paludosa* and *E. muscicola*, present on almost all investigated localities in the sub-Antarctic region but absent from the other parts of the Antarctic Region. However, given the widespread occurrence of (semi) cryptic diversity in diatoms (Mann et al. 2004, Beszteri et al. 2005, Van Elslander et al. 2009, Poulíčková et al. 2010, Souffreau et al. 2013), their species structure and biogeography still remains to be critically assessed using molecular-genetic techniques.

The results in table 2 show a clear regionalism in the *Eunotia* flora of the Antarctic Region. On the Antarctic Continent, the genus is completely absent despite some doubtful records (Fukushima 1965, Cremer 2004). As we never encountered any of these taxa in the hundreds of samples (including those listed in table 1) we have examined from the Antarctic Region, we believe that the original raw materials from which they were reported should be re-examined to verify their identity and confirm whether their presence in the Antarctic region is a result of later post-sampling contamination or represent a true Antarctic record. In the Maritime Antarctic Region, at present only three taxa have been with certainty identified: *E. pseudopaludosa*, *E. ralitsae* and *E. pyramidatoides*. This low diversity is in clear contrast with the relatively higher *Eunotia* diversity in the sub-Antarctic Region where nineteen species have been recorded. This diversity is most likely the result of a higher variation in suitable microhabitats. Most *Eunotia* taxa have very narrow ecological tolerances and prefer oligo- to dystrophic, (usually) acid, aquatic conditions although a lot of species also form a dominant component of the bryophilic diatom flora (Furey et al. 2011, Lange-Bertalot et al. 2011). Mosses represent thus a very suitable habitat. Most of the sub-Antarctic vegetation consists of very large moss tundras composed of large continuous moss carpets whereas in the Maritime Antarctic Region, these large carpets are more scarce and restricted to the wet parts of seepage areas and around lakes and pools. In contrast, the diatom flora of the Maritime Antarctic Region is dominated by typical soil-inhabiting taxa such as *Luticola* and *Hantzschia* (Van de Vijver & Mataloni 2008, Zidarova et al. 2010, Kopalová et al. 2011), genera that show a lower diversity in the sub-Antarctic Region (Van de Vijver et al. 2002a). Within the sub-Antarctic Region, the islands in the southern Indian Ocean such as the Iles Crozet and Heard Island, have a completely different *Eunotia* flora than South Georgia in the southern Atlantic Ocean. None of the newly described taxa is shared by both subregions. Both sub-regions have their own unique taxon that belongs to the *Eunotia praerupta*-complex with *E. subantarctica* on several islands in the southern Indian Ocean and *E. ralitsae* on South Georgia, maybe the result of allopatric speciation. All islands are oceanic islands and have never been connected either to each other or to larger landmasses (Chown et al. 1998).

Compared to the northern hemisphere, the *Eunotia* flora of the Antarctic Region is quite species-poor. Lange-Bertalot et al. (2011) present an example of one Finnish lake where 70 different *Eunotia* taxa were found, almost 4 times higher than the total *Eunotia* diversity in the entire Antarctic Region. In Nova Scotia, 73 *Eunotia* taxa were identified in a single sample (Lange-Bertalot et al. 2011). In tropical South America, the number of *Eunotia* taxa is likewise very high. Metzeltin & Lange-Bertalot (1998, 2007) report a total of 264 taxa in tropical South and Central America. The low number of *Eunotia* taxa in the Antarctic Region is most likely not the result of a lack of suitable habitats since samples from Greenland, taken from comparable habitats, yielded a significant higher number of *Eunotia* taxa (>50 taxa in samples from Queqertarsuaq; Lange-Bertalot, pers. obs.). It can probably be explained by the reduced dispersion possibilities *Eunotia* species have to reach the Antarctic localities. This observation clearly contradicts the Baas Becking statement (1934) "everything is everywhere, but the environment selects", later used by Finlay & Fenchel (2004) to develop their Ubiquity hypothesis. Compared to marine diatoms, limnoterrestrial diatoms seem to represent more patchy distributions especially in the southern hemisphere where the amount of terrestrial biomes is small compared to the marine environment. A good example of this is represented in the *Eunotia* composition of South Georgia, located rather close to the southern tip of South America, on the so-called Scotia Arc, which shows a close, though clearly impoverished, resemblance to the *Eunotia* flora of southern South America (Krasske 1939). Taxa such as *E. tecta*, *E. pyramidatoides* and *E. muscicola* were described from southern Chile and reported now, in low abundances, from South Georgia.

The relationship between the different populations can however only be established using molecular techniques but the results of the present study already offers interesting possibilities to further develop the biogeographical scheme of the Antarctic diatom flora.

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