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NEW MARINE DIATOM (BACILLARIOPHYTA) SPECIES DESCRIBED FROM KERGUELEN ISLANDS COASTAL AREA AND PERTAINING TO *NAVICULA S.S.* WITH SOME REMARKS ON MORPHOLOGICAL VARIATION OF THE GENUS

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DIATOMS
NAVICULA
MORPHOLOGY
NEW SPECIES
MARINE LITTORAL
AUSTRAL ISLANDS
KERGUELEN

ABSTRACT. – Islands far from continental influence or impact represent an interesting field of investigation with regard to species diversity, morphological evolution and speciation. Austral Islands represent such a case, particularly for diatoms (Bacillariophyta). Several light (LM) and electron (SEM) microscopic surveys revealed the presence of more than 20 species, and possibly two genera, new to science. These new species pertain to several genera, most of them belonging to *Navicula s.s.* and *Opephora*, with respectively, eight and four new species. In this paper we describe only the new *Navicula s.s.* taxa, which are: *Navicula australoceanica*, *N. concordia*, *N. criophiliforma*, *N. fabiformis*, *N. hippodontaformis*, *N. irminae*, *N. papilioarea* and *N. szlachetkoi*. If we include historical data, e.g., works of Heiden & Kolbe, and recent data of Le Cohu & Maillard, Riaux-Gobin & Compère and Riaux-Gobin & Romero, the number of species described from Kerguelen Archipelago increases to several dozen. Therefore, it appears that the marine littoral of the Kerguelen Archipelago may represent a biodiversity hot spot. The factors (selection pressure) helping to generate this unique flora may be the geographic isolation of these islands and the unique hydrologic features, including being surrounded by strong hydrologic fronts, e.g., Polar and Sub-Polar Fronts.

INTRODUCTION

Diatom assemblages of the marine littoral of Southern Hemisphere high latitudes have so far received little attention (e.g., Nikolayev 1980, Krebs 1983, Everitt & Thomas 1986). One reason for this situation is that despite the rich diatom assemblages they harbor, the area is not very accessible for collection and research. There are a few causes for this situation. First, the austral archipelagos are usually closely located to latitudes which are impacted by extreme hydrologic and meteorologic/climatic conditions, including low water temperature, extremely strong winds and hydrodynamic factors (waves and currents). This is especially true in the area of the Kerguelen archipelago which is located a short distance northward from one of the strongest hydrologic barriers existing in the oceans i.e., the Polar Front (PF; e.g., Knox 2007). The lack of permanent human settlements and difficult access mean that sampling of this region is very difficult. In the early years of research in the Southern Oceans, cruises or expeditions were used. Several such expeditions were organized in the end of 19th and early 20th centuries. Rich diatomological collections originated and the results were published (e.g., Van Heurck 1909, Peragallo 1921, Heiden & Kolbe 1928, Mann 1937, Manguin 1957, 1960, Hustedt 1958). Despite the fact that accessibility in recent decades of the austral regions is much easier, no significant increase in studies of the marine littoral diatom assemblages has been observed. Many more papers on marine littoral diatoms from high latitudes of the southern Hemisphere, have been published but these focused on either the Kerguelen Islands (Riaux-Gobin 1994, Riaux-Gobin & Compère 1996, 2004, Riaux-Gobin & Romero 2003, Riaux-Gobin *et al*. 2007, 2009) or the Antarctic Peninsula (e.g., Wassell & Håkansson 1992). Some attention was also paid to sea ice diatom assemblages (e.g., Krebs *et al*. 1987). However, most papers have focused on planktonic diatoms of high latitudes (e.g., Medlin & Priddle 1990, Zielinski & Gersonde 1997). Several important studies also dealt with primary production of neritic areas and ecology of algae and of diatoms (e.g., Gilbert 1991, Ahn *et al*. 1997).

An interesting characteristic of such isolated and restricted austral areas, exposed to strong winds, is that the diatom assemblages are more varied (Van de Vijver *et al*. 2002). As a result, species typical for marine littoral can be present in typical inland habitats, e.g., among mosses or in inland ponds. Examples of such a co-occurrence of freshwater and marine diatoms include e.g., *Labellicula subantarctica* Van de Vijver, Frenot, Beyens *et* Lange-Bertalot in Van de Vijver *et al*. (2005), some *Planothidium* (e.g., *P. quadripunctatum* (Oppenheim) Sabbe, *P. densistriatum* Van de Vijver *et* Beyens) and *Navicula* (e.g., *N. ectoris* Van de Vijver) species or some marine planktonic forms (Van de Vijver *et al*. 2002). Among our studies in the Kerguelen marine littoral, we have observed that the opposite phenomenon is much stronger. We have listed a few dozens typical freshwater species, sometimes present in quite high abundance. From marine littoral collections we have identified taxa from diverse freshwater genera such as *Diatomella*, *Eunotia*, *Frankophila*, *Gomphonema*, *Diadesmis* and numerous others (Witkowski *et al*. submitted).

Previous studies and our own reports show that the number of species identified in the marine littoral of austral islands and Antarctica is rather high (e.g., Frenguelli & Orlando 1958, Krebs 1983, Wassell & Håkansson 1992). Usually a few common benthic or epiphytic genera e.g., *Cocconeis*, *Navicula* and *Amphora* may be represented by a few dozen taxa. One example of such species richness may be found in the genus *Cocconeis* in the Kerguelen Islands. Riaux-Gobin & Romero (2003) identified more than 40 *Cocconeis* species, and a few new *Cocconeis* were later described from the Kerguelen, e.g., *C. germainii* Riaux-Gobin, Witkowski *et* Romero (Riaux-Gobin, Witkowski & Romero 2007). New *Cocconeis* species are still also being found on Kerguelen (Witkowski *et al*. submitted). In addition to *Cocconeis,* other benthic genera are represented by an unusually high number of species. A high number of *Navicula* taxa may be found, and next in terms of species richness is, surprisingly, *Opephora*. We estimate the number of *Navicula* species at ca. 50 and of *Opephora* at 14. An interesting point is that the number of newly described taxa is quite high in both genera. As shown in recent publications, the potential for discovering new diatom genera in the area delimited by the Southern Hemisphere Polar Front (PF) is also unique and high (e.g., Hamilton *et al*. 1997, Fernandes *et al*. 2007).

Navicula Bory *sensu stricto* is considered to represent one of the largest diatom genera in terms of species number (e.g., Lange-Bertalot 2001). The best characteristics description is given in Cox (1979) and Lange-Bertalot (2001). In brief, *Navicula* as a genus can be characterized as having cells solitary or tube dwelling (rather low number of species). Valve outline in LM (light microscope) is in general linear elliptic or linear lanceolate. Raphe sternum is located centrally within the valve face and raphe with specific external central endings and the apical endings. The latter are strongly hooked on the same side (geniculate) and best observed in SEM. The most indicative for *Navicula* species are transapical striae, which are composed of apically elongate, slit like areolae (named in LM lineolae) and internal obliquely opening raphe slit, which is observed only under SEM (e.g., Cox 1979, Round *et al*. 1990, Witkowski *et al*. 1998, Lange-Bertalot 2001). The total number of *Navicula s.s.* is hard to estimate, but Lange-Bertalot (2001) calculated it as ca. 250-300 with majority inhabiting inland freshwater. However, our experience from the marine littoral zone of the world ocean suggests the total number of *Navicula* species exceeds 500. Supposedly most species inhabiting inland waters and marine littoral are cosmopolitan in terms of biogeography. In *Navicula* belong species which can be given as examples of world wide distribution in terms of biogeography. Examples included in this group are *Navicula gregaria* Donkin and *Navicula vimineoides* Giffen (e.g., Witkowski *et al*. 2000, Lange-Bertalot 2001).

Definitely, *Navicula* species living in polar regions (sea ice diatom assemblages) are different in the Arctic and in the Antarctic (Krebs 1977, 1983, Poulin 1990, Witkowski *et al*. 2000, Witkowski pers obs). In both areas we can see the occurrence of cosmopolitan taxa. However, both polar regions have the highest potential to host *Navicula* endemic species. The number of the endemic species can be estimated as a few dozen in both Arctic and Antarctic. At this stage of the study, however, it is not possible to give more precise numbers of taxa, this also concerns taxa which we describe as new for science in this paper.

In the present paper we focus on the description of new species of *Navicula s.s*. We have selected 8 species of *Navicula,* though the number of taxa from the region belonging in this genus is distinctly higher. The remaining new species of *Navicula* and of other genera e.g., *Cocconeis*, *Lunella*, *Haslea*, *Staurophora*, *Bacillaria*, *Fallacia*, *Opephora* will be published elsewhere. We also discuss the biogeographic issues/features and factors that are responsible for such a wealth of unknown diatom taxa in an area investigated since the end of 19th century.

MATERIAL AND METHODS

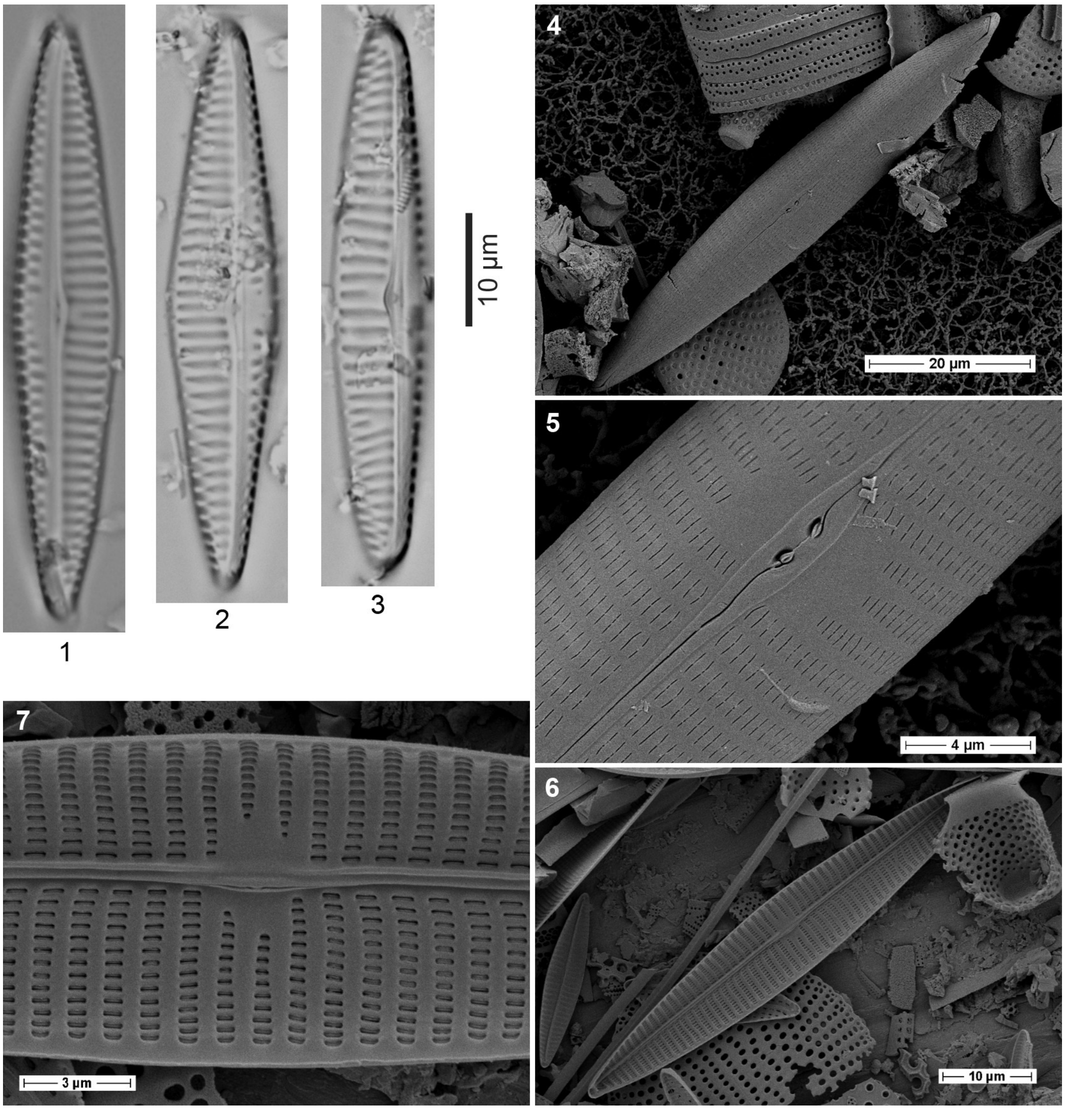
Environmental settings: Kerguelen Archipelago is composed of basaltic islands of complex origin, located in the vicinity of the Polar Front system, between 49° and 50° S (Indian part of the Southern Ocean). Far from continents and other islands (Heard Island being 440 km South), this Archipelago takes place at the north of the “Plateau des Kerguelen”. The main island, highly affected by the last glaciation, is deeply indented and offers a large panel of marine coastal environments, from sheltered/semi enclosed bays to exposed deep fjords (Riaux-Gobin pers obs). During several austral summers, marine diatoms have been collected by C R-G, particularly on intertidal and subtidal sheltered sediments of the main island, and particularly under *Macrocystis pyrifera* (L.) C. Agardh belt.

Material and methods: The material for the present study was collected by one of us (C R-G) during several cruises from 1985 to 1992. Marine intertidal to subtidal sediments were sampled from diversified sites, (see Fig. A and Table II *in* Riaux-Gobin and Romero 2003). Two regularly sampled in the Morbihan Bay: Port-Aux-Français (49°20’ S, 69°50’ E) and Port-Raymond (49°21’ S, 70°12’ E). Samples were formalin preserved (final concentration 10%). Diatom slides were prepared with wet sediment that was treated overnight at room temperature with 10% HCl in order to remove calcium carbonate. The samples were then washed several times with distilled water, boiled in 37% H_2O_2 until the organic matter was completely removed, and washed again several times with distilled water. Permanent slides of cleaned diatom material were mounted using Naphrax®. Permanent slides and raw samples are deposited in the diatom collection of A. Witkowski at the University of Szczecin in Poland (SZCZ).

Permanent slides were examined in LM using a Leica DMLB microscope equipped with oil immersion objective (x100/NA1.4). For SEM, a few drops of cleaned material were air-dried on aluminium stubs, coated with Au and examined at 5 kV in a Hitachi S4500 scanning electron microscope. Measurements of each species' size range and of other diagnostic characters were performed on both scaled LM and SEM images. The number of valves measured ranged from ca. 10 in the largest species to a few dozen in the small ones.

RESULTS

In the sediment samples collected from the marine environments off Kerguelen, we have identified ca. 300 diatom species. With respect to species richness, dominant were *Navicula*, *Amphora*, *Cocconeis*, *Opephora* and *Planothidium*. Light microscopic analysis of diatom species composition revealed an occurrence of numerous taxa that we were unable to assign to existing taxa. These taxa were a subject of further investigation aided by SEM. SEM images supplemented by inspection of accessible literature including old cruise reports (e.g., Castracane 1886, Van Heurck 1909, Peragallo 1921, Heiden & Kolbe 1928, Manguin 1957, 1960) allowed us to select a group



Figs 1-7. – *Navicula australoceanica* sp. nov. Figs 1-3 LM. Scale bar = 10 μm. Figs 4-7 SEM. Figs 4, 5. External valve view. Fig. 4. Valve with the external apical raphe endings. Fig. 5. Close up of the valve middle part, note the elaborate shape of external central raphe endings. Figs 6, 7. Valve internal view. Fig. 6. The whole valve interior. Fig. 7. Close up of the valve middle part showing the internal central raphe endings.

of two dozen to taxa and describe them as new to science. The number of unknown species was highest in *Navicula* and *Opephora*, and we decided to present the taxa pertaining to only *Navicula* in the present paper. The total number of *Navicula* taxa was about 50 including more than a dozen species new to science. The remaining taxa will be described elsewhere. Here we describe the eight *Navicula* for which we have the best photographic documentation.

Navicula australoceanica sp. nov. Figs 1-7

Descriptio :

Valvae lanceolatae-ellipticae, 48-68 µm longae, 8-9 µm latae, cum angustiformibus apicibus rotundatis. Raphe recta filiformis. Area axialis anguste linearis, expansa in media parte in rectangulari area centrali. Area centralis striae mediae abbreviatae facta et occupandum est ½ valvae lata. Externalia extrema centralia raphis distinguibilia, disjuncta et leniter deflecta ad idem latus. Striae transapicales parallelae divergentes prope polos, 7-8 in 10 µm. Lineolae in microscopio photonico non visibiles.

Holotype: slide no. 7354_10_1 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 1.

Isotypi: slide No. KER3 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/23 in Friedrich Hustedt Diatom Collection, Alfred Wegener Institute for Polar and Marine Research, Bremerhaven.

Type locality: Port Raymond, subtidal (12 m), November 1991.

Habitat: in Kerguelen sediments,

Etymology: the epithet of the species refers to its geographic distribution in the Southern Ocean.

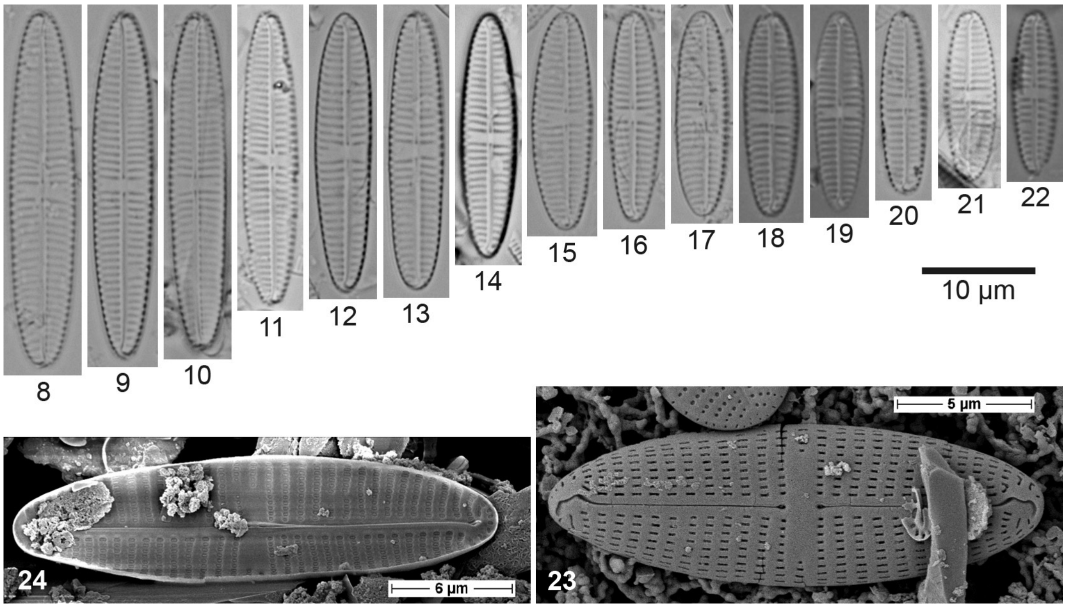
LM: (Figs 1-3)

Valves lanceolate tapering towards apices with obtusely rounded ends, 48-68 µm long, 8-9 µm broad. Raphe straight, filiform, axial area narrow, linear, in the middle expanding into a rectangular central area. Central area originates as a result of shortening of the middle striae and extends to ca. half of the distance between the central nodule and the valve margin. External central raphe endings in LM visible, slightly bent towards one side, distant from each other. Transapical striae parallel becoming divergent near the apices, 7-8 in 10 µm. Lineolae not resolvable in LM.

SEM (Figs 4-7):

Valve surface flat, gradually turning into relatively deep mantle. Raphe-sternum somewhat elevated in the middle of the valve. Raphe straight, external central raphe endings somewhat expanded, elaborate in shape, distant, apical external raphe endings geniculate (Fig. 4). Internally the raphe fissure opens obliquely. Internal central raphe endings slightly undulate, positioned very close to each other. Internal apical raphe endings terminate in a small helictoglossa. Transapical striae composed of apically elongate areolae, ca. 30 in 10 µm (Figs 5-7). Unlike in most *Navicula*, in this new species, the areolae prolong onto the valve mantle.

We did not find in published sources any *Navicula* species resembling *N. australoceanica*. It is unique in its valve ultrastructure, including the high valve mantle coupled with flat valve face. This combination of features is quite unusual in *Navicula s.s.* (cf. *N. hippodontaformis*, this paper).



Figs 8-24. – *Navicula concordia* Riaux-Gobin *et* Witkowski sp. nov. Figs 8-22 LM. Scale bar = 10 µm. Figs 23, 24 SEM. Fig. 23. Valve external view. Fig. 24. Valve internal view.

Navicula concordia Riaux-Gobin *et* Witkowski sp. nov. Figs 8-24

Syn.: *Navicula* sp. nr 2 *sensu* Riaux-Gobin & Chrétiennot-Dinet 1988, Fig. 1: 2

Descriptio :

Valvae lineares ad oblongo-ellipticae apicibus rotundatis, 15-32 longae, 3.8-5.8 latae, striae transapicales modice radiantes 14-15 in 10 µm. Raphe recta. Area axialis angusta et recta. Singularis breviorque stria in media parte valvae. Area centralis rectangularis, marginem valvae non attingens.

Holotype: slide no. 7353_4 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 18.

Isotypi: slide No. KER4 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/24 in Hustedt Collection, Alfred Wegener Institute Bremerhaven.

Type habitat: Port Raymond, intertidal beach, October 1991.

Habitat: in Kerguelen sediments.

Etymology: the specific epithet refers to the French-Italian polar station “Concordia” in Antarctica.

LM (8-22):

Valves linear oblong-elliptic with broadly rounded apices, 14-32 µm long, 3.8-5.8 µm broad. Axial area narrow. Central area rectangular not reaching the margin, due to the presence of one very short stria in middle part of the valve. Raphe straight, external central raphe ends slightly expanded, rather distant from each other. Transapical striae subparallel to very slightly radiate becoming radiate and finally convergent at the apices, 14-15 in 10 µm. Areolae in LM not resolvable.

SEM (23-24):

Valve face slightly arched (except for the middle part where it is flat) gently turning towards the mantle. The contact between valve face and valve mantle is not strongly delimited. Axial area narrow, linear throughout, central area, distinct, narrow, rectangular, in a form of fascia extending almost to the 2/3 of the valve width. Raphe straight, sternum flat not differentiated from valve face. External central raphe ends slightly expanded (drop-like), simple, rather distant, external distal raphe endings strongly geniculate (Fig. 23). The raphe fissure opens internally obliquely (Fig. 24). Transapical striae composed of apically elongate areolae, ca. 35 in 10 µm, subparallel to slightly radiate, becoming radiate and finally convergent at the apices.

The new species slightly resembles *Navicula perminuta* Grun due to its central area. The major difference between the two species is a much larger valve breadth in *N. concordia*. Some degree of similarity also exists between smallest specimens of our species and of *N. bossvikensis* Busse *et* Snoeijs (Busse & Snoeijs 2002). However, *N. bossvikensis* has a distinctly smaller size range than *N. concordia*, which in general has a much more robust valve structure than *N. bossvikensis*. Moreover *N. bossvikensis* has a very a high number of areolae amounting to 47-53 in 10 µm *versus* 35 in 10 µm in *N. concordia*.

Navicula criophiliforma sp. nov. Figs 25-38

Descriptio :

Valvae lineari-lanceolatae, apicibus rotundatis ad acutis. 30-63 µm longae, 6.0-8.5 µm latae, Area axialis angustissima et recta. Area centralis asimmetrica et in forma variabilis, vulgo amplior et regularis ad primum latus, irregularis et parvior ad secondum latus. Raphe filiformis. Externalia extrema centralia raphis notabilia, disjuncta et leniter deflecta ad primum latus. Striae transapicales sub-parallelae ad leniter radiantes, et convergentes ad apicis extremitatem, 11-13 in 10 µm. Areolae in microscopio photonico non visibiles.

Holotype: slide no. 7356_2 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 32

Isotypi: slide No. KER5 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/25 in Hustedt Collection, Alfred Wegener Institute Bremerhaven

Type habitat: Port Raymond, subtidal, January 1992.

Habitat: in Kerguelen sediments

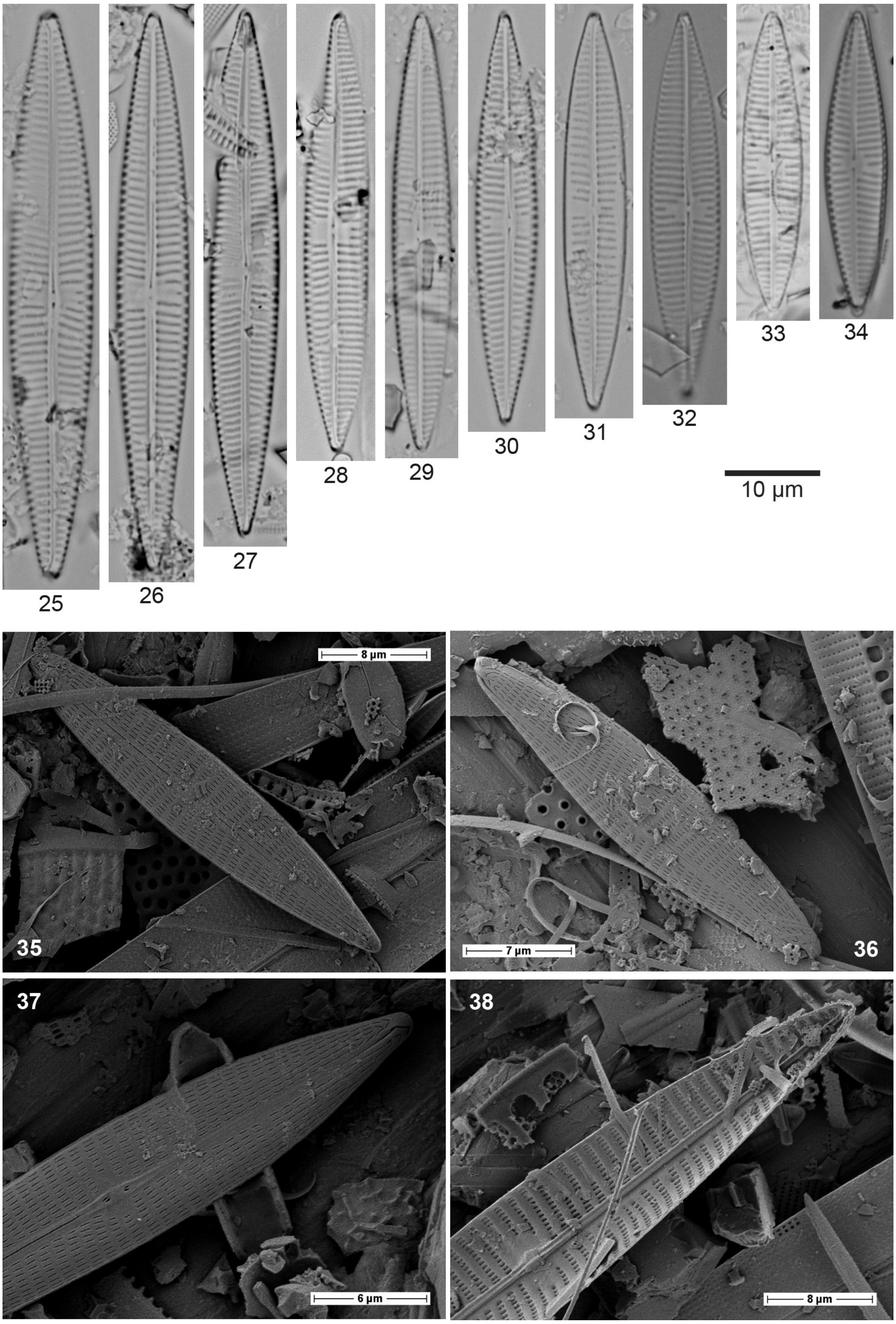
Etymology: the specific epithet refers to the similarity of our new species to *Navicula criophila* (Castracane) de Toni.

LM (Figs 25-34):

Valves linear lanceolate with rather acutely rounded apices, 30-63 µm long, 6.0-8.5 µm broad. Axial area very narrow, linear, central area asymmetric, variable in shape, usually larger and regularly developed (more or less quadrate) at the valve’s primary side, while irregular in shape and smaller at the valve’s secondary side. Raphe filiform, external central ends slightly enlarged, drop-like, distant from each other, deflected towards the valve primary side. Transapical striae subparallel to slightly radiate, becoming convergent very close to the apices, 11-13 in 10 µm. Areolae in LM not resolvable.

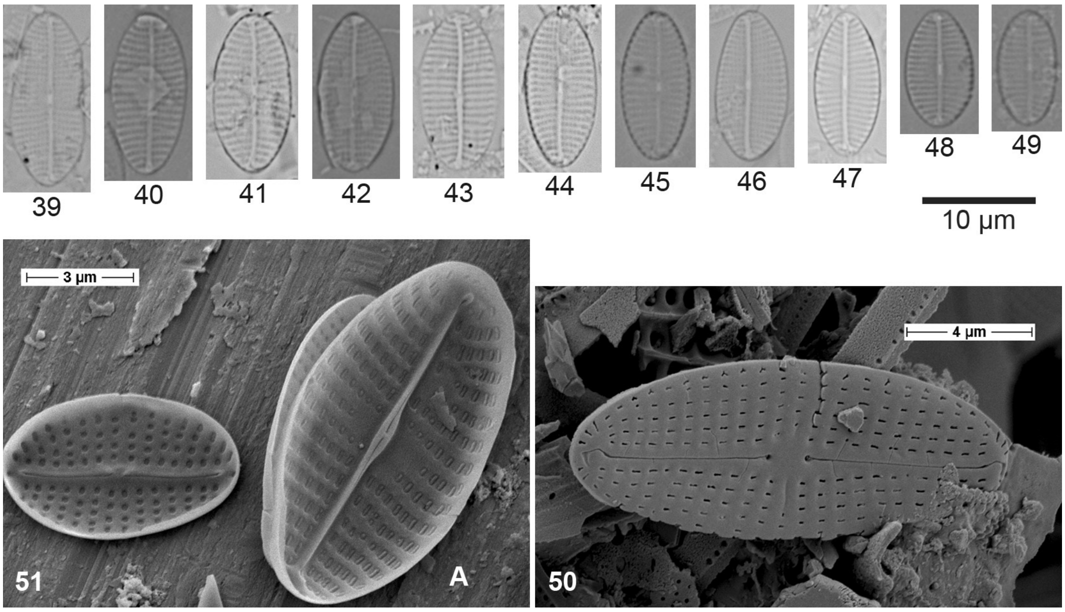
SEM (Figs 35-38):

Valve surface flat with moderately high mantle and slightly elevated sternum in the valve middle. Axial area narrow, central area irregular in shape. Square at the valve primary side, irregular at the valve secondary side. Raphe-sternum bent, external central raphe endings slightly expanded, bent towards the valve primary side, rather distant from each other. Apical raphe endings geniculate (Figs 35-37). The raphe fissure opens internally obliquely. Internal central raphe ends simple, rather distant (Fig. 38). Transapical striae composed of apically oriented slit-like areolae, the number of areolae 35-40 in 10 µm.



Figs 25-38. – *Navicula criophiliphorma* sp. nov. Figs 25-34 LM. Scale bar = 10 μm. Figs 35-38 SEM. Figs 35, 36. Valve external view. Fig. 37. Valve external view at higher magnification showing the central nodule. Fig. 38. Valve internal view, note the robust central nodule.

The new species closely resembles *Navicula criophila* (Castracane) Van Heurck. Both taxa have similar valve outline and size range. They differ, however, in terms of slightly radiate to subparallel striae in *N. criophiliforma* versus strictly parallel in *N. criophila* (Castracane 1886, Hustedt 1958). In addition the newly described species



Figs 39-51. – *Navicula fabiformis* sp. nov. Figs 39-49 LM. Scale bar = 10 μm. Figs 50, 51 SEM. Fig. 50. Valve external view, note that the central area is almost missing. Fig. 51. Valve internal view (specimen marked A), note the size of the central area and the internal central raphe endings.

has 11-13 striae in 10 μm *versus* 10 in 10 μm in *N. criophila*. Finally, external central raphe endings in *N. criophila* are closer to each other than in *N. criophiliforma*.

Navicula fabiformis **sp. nov. Figs 39-51**

Descriptio :

Valvae lineares-ellipticae, 10-14 μm longae, 6-7 μm latae, apicibus rotundatis. Raphe recta. Area axialis et area centralis non discernibiles in microscopio optico (M.O.). Uniseriatae striae parallelae ad leviter radiantes ad apices, interstriae aequidistantes per totam valvam, 17-19 in 10 μm. Lineolae in microscopio photonico visibiles, 25-30 in 10 μm.

Holotype: slide no. 7353_4 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 48.

Isotypi: slide No KER6 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/26 in Hustedt Collection, Alfred Wegener Institute Bremerhaven

Type habitat: Port Raymond, intertidal beach, October 1991.

Habitat: in Kerguelen sediments

Etymology: the specific epithet refers to a similarity of the new species to the bean (Latin faba).

LM (Figs 39-49):

Valves linear elliptic with broadly rounded apices, 10-14 μm long, 6-7 μm broad. Raphe straight, axial and central area practically in LM indistinguishable. External central raphe endings simple, rather distant. Transapical striae parallel throughout, becoming only slightly radiate at apices, 17-19 in 10 μm. Lineolae in LM resolvable, 25-30 in 10 μm.

SEM (Figs 50-51):

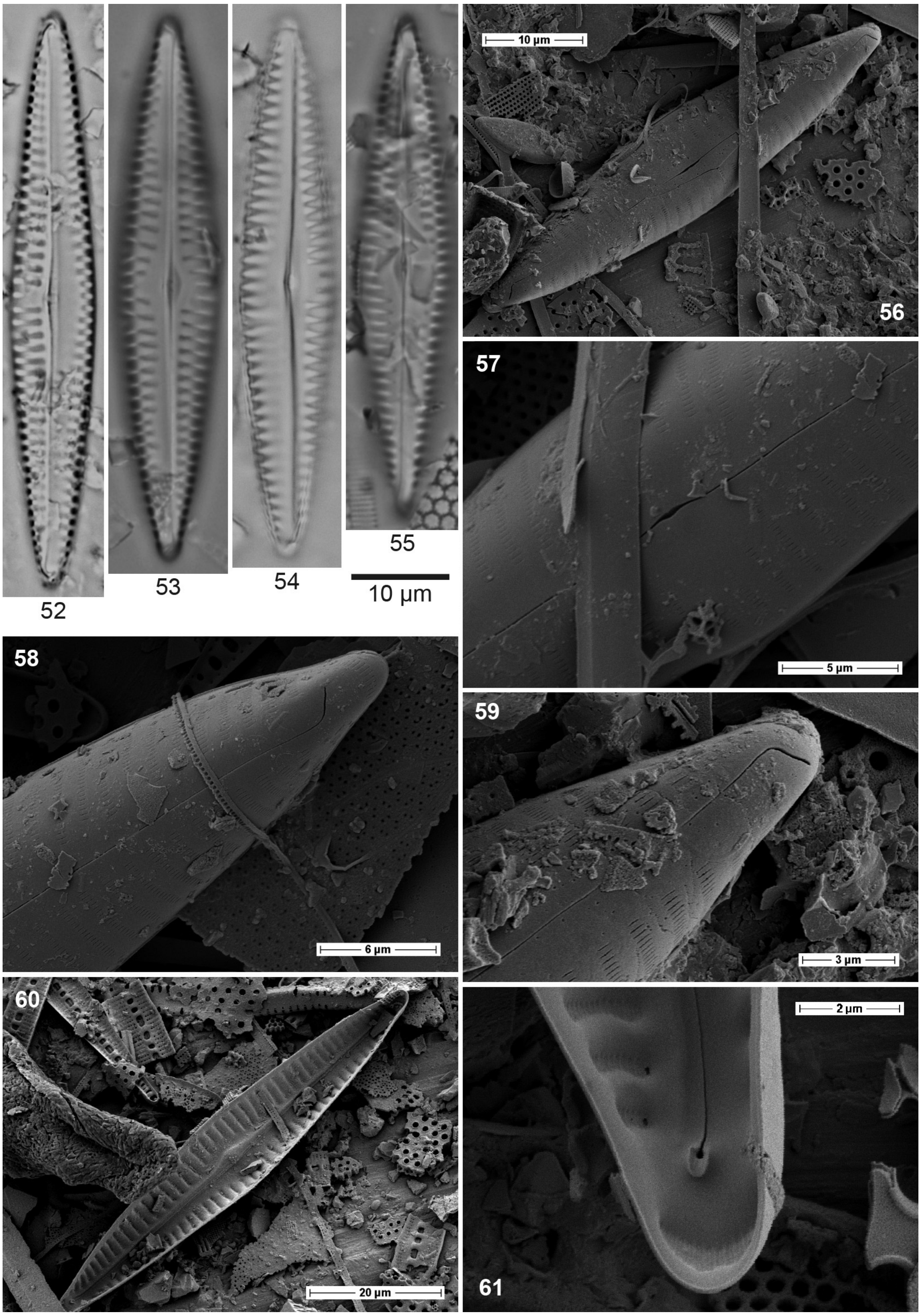
Valve surface flat, gradually turning into the valve mantle. Raphe straight, axial area very narrow, very slightly broadening towards the valve centre to form an indistinct, slightly expanded, square in shape central area (Fig. 50). Central area is much larger internally than externally (Fig. 51). External proximal raphe ends expanded into a drop-like structure, relatively distant from each other. Raphe external distal ends typical for *Navicula s.s.*, hooked towards the valve's secondary side. The raphe fissure opens internally strongly obliquely, internal central raphe ends slightly undulate, very close to each other. Internal distal raphe ends terminate as small helictoglossae. Transapical striae composed of areolae positioned between slightly elevated transapical costae (virgae). The areolae form apically oriented parallel lines 25-30 in 10 μm.

The new species slightly resembles *Navicula tropicoidea* Witkowski, Metzeltin *et* Lange-Bertalot, however, it differs with respect to having a more elliptic shape, and broader valves (up to 5.5 μm in *N. tropicoidea* and 6.0-7.0 in our species).

Navicula hippodontaformis **sp. nov. Figs 52-65**

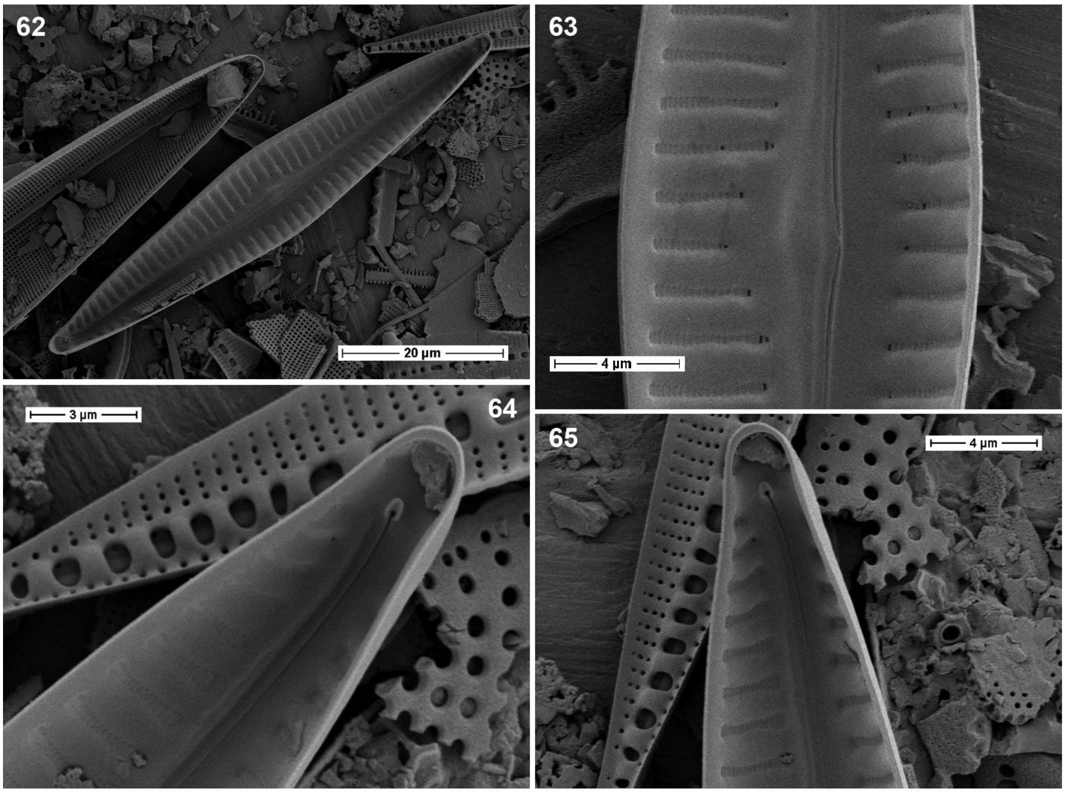
Descriptio :

Valvae lineari-lanceolatae, cum dyssimetrico aspectu, apicibus rotundatis ad acutis, aliquando oblongae, 48-68 μm longae, 8-11 μm latae. Area axialis distincte dyssimetrica, angusta et linearis ad primum latus, lanceolata et amplior ad secundum latus. Area centralis dyssimmetrica,



Figs 52-61. – *Navicula hippodontaformis* sp. nov. Figs 52-55 LM. Scale bar = 10 µm. Figs 56-61 SEM. Figs 56-59. Valve external view. Fig. 57. Close up of the valve middle part. Figs 58, 59. Close up of the valve apical part, note the external apical raphe endings and the apical areolae (Fig. 58). Figs 60, 61. Valve interior. Fig. 61. Close up of the valve apex interior, note the apical areolae occluded with hymenes.

angusto-lanceolata ad primum latus, lanceolata et amplior ad secondum latus. Raphe filiformis, recta, leviter flexa in media parte ad primum latus. Externalia extrema centralia raphis notabilia et approximata, externalia extrema apicalia raphis non observata in microscopio photonico Striae transapicales leviter radiantes per totam valvam et



Figs 62-65. – *Navicula hippodontaformis* sp. nov. Figs 62-65 SEM. Fig. 62. Valve interior. Figs 63-65. Close up of the same specimen. Fig. 63. Valve interior showing the internal central raphe endings. Figs 64, 65. Close up of the apex interior.

convergentes ad apices, 7-8 in 10 μm. Lineolae in microscopio photonico non visibiles.

Holotype: slide no. 7356_3 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 53

Isotypi: slide No. KER7 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/27 in Hustedt Collection, Alfred Wegener Institute Bremerhaven

Type habitat: Port Raymond, subtidal, January 1992.

Habitat: in Kerguelen sediments

Etymology: the specific epithet refers to the fact that the new species shares some features i.e. the valve outline, apical rows of areolae and high mantle (in principle) with genus *Hippodonta* Lange-Bert., Metzeltin *et* Witkowski.

LM (Figs 52-55):

Valves linear lanceolate, apparently asymmetric, with acutely rounded, sometimes slightly protracted apices, 48-68 μm long, 8-11 μm broad. Axial area distinctly asymmetric, at the valve primary side narrower and linear, whilst at the valve secondary side distinctly broader and lanceolate. Central area asymmetric, small, lanceolate at the valve's primary side, and large, lanceolate at the secondary one. Raphe filiform, straight, slightly bent in the middle towards the valve's primary side. External proximal raphe ends slightly expanded, close to one another, distal ends curved (Fig. 53). Transapical striae slightly radiate throughout, becoming convergent at the apices, 7-8 in 10 μm. Lineolae not discernible in LM.

SEM (Figs 56-65):

Valve surface strongly arched with no transition between the valve face and the mantle observed (Figs 56-59). Mantle relatively deep. Apical part of the valve mantle possesses a few rows of areolae. These rows are apically oriented (Figs 58, 61). Raphe straight, slightly bent in the middle towards valve's secondary side; raphe runs asymmetrically along the valve surface and is replaced towards the margin of the valve's secondary side (Figs 56, 57). This causes the valve primary side to be somewhat broader than the secondary one (this is also possible to observe in LM, Figs 52, 53). External central raphe ends approximate, external distal raphe ends curved (not geniculate) in the same direction.

Valve interior (Figs 61-66) with relatively steep slopes, valve asymmetry is easily recognizable with the broader side gently sloped and the narrower one steep (Figs 60, 62, 63). Internally, the raphe sternum structure is typical for *Navicula s.s.*; the raphe sternum opens strongly oblique (Figs 60, 62, 63). Internal proximal raphe ends simple, very close each other (Figs 60, 62, 63). Internal distal raphe ends terminate as small helictoglossae, which are located at a distance from the apices (Figs 62, 64, 65). The central nodule is prominent (Figs 60, 62). Transapical striae composed of apically elongate areolae, 40-45 in 10 μm. Internally, transapical striae are placed in elongated depressions and covered with hymenes typical of *Navicula s.s.* (Figs 63, 64). Apical areolae also occluded by similar hymenes (Fig. 61).

With respect to valve outline and, especially, asymmetry *N. hippodontaformis* resembles a group of taxa represented by e.g. *N. scabriuscula* (Cleve *et* Grove) Mereschk. (Witkowski *et al.* pers obs). There exist, however, distinct differences between these species, as *N. scabriuscula* is characterized by dorsiventral valves and transapical striae with distinct hyaline areas. These features are missing in *N. hippodontaformis*. Also the two groups of species differ with respect to the internal raphe slit. In *Navicula scabriuscula* the internal raphe slit is continuous, whereas *N. hippodontaformis* has two distinct raphe branches, with distinct internal raphe proximal ends that are close to one another.

Navicula irminae sp. nov. Figs 66-76

Descriptio :

Valvae lineari-lanceolatae, apicibus rotundatis ad acutis, 43-67 μm longae, 7.5-9.0 μm latae. Area axialis angusta et recta, perdistincta, area centralis leniter irregularis et rectangularis, tres strias medias abbreviatas facta. Raphe filiformis, externalia extrema centralia raphis rotundata (in forma lacrimae), et moderate disjuncta. Striae transapicales robustae, leviter radiantes ad sub-parallelae, et parallelae prope apicis extremitatem, 9-11in 10 μm. Lineolae in microscopio photonico visibiles.

Holotype: slide no. 7356_2 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 67.

Isotypi: slide No. KER8 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/28 in Hustedt Collection, Alfred Wegener Institute Bremerhaven

Type habitat: Port Raymond, subtidal, January 1992.

Habitat: in Kerguelen sediments

Etymology: the new species is dedicated to Mrs I Wrońska (Kobus) a friend of one of us (AW).

LM (Figs 66-70):

Valves linear lanceolate with acutely rounded apices, 43-67 μm long, 7.5-9.0 μm broad. Axial area linear, narrow, distinct, central area more or less regular in shape, rectangular, developed due to shortening of three striae in the middle of the valve. Raphe filiform, external proximal ends expanded slightly, drop-like, moderately close to each other. Transapical striae rather robust, slightly radiate to subparallel, becoming parallel towards apices, 9-11 in 10 μm. Lineolae in LM resolvable, ca. 30 in 10 μm.

SEM (Figs 71-76):

Valve surface arched, flat only in the centre, mantle relatively shallow (Figs 71-73). Sternum in the valve middle elevated slightly (Fig. 73). External proximal raphe ends expanded slightly, distal ends strongly hooked. Internally the raphe sternum opens very strongly oblique (Fig. 76). Internal proximal raphe ends simple, slightly undulate very close to one another (Figs 74-76). Internal distal raphe ends terminate as small helictoglossae. Striae forming areolae apically elongate, up to 30 in 10 μm.

Navicula irminae does not resemble any established *Navicula* taxa. Similar is *Navicula* spec. depicted in Fig. 47: 12 in A. Schmidt Atlas. The *Navicula* illustrated in Schmidt's Atlas is distinctly larger (80 μm in length, 7 μm in breadth and has seven transapical striae in 10 μm) and a distinctly larger central area. The other potentially similar taxon is *N. longa* (Gregory) Ralfs in Pritchard, but it is also much larger than newly described species (cf. Schmidt *et al.* 1874-1959).

Navicula papilioarea sp. nov. Figs 77-88

Descriptio :

Valvae lanceolatae ad lanceolatae-ellipticae, cum apicibus rotundatis, 13-20 (?27) μm longae, 6-8 μm latae. Area axialis anguste linearis prope apices, ad leniter dilatata in media parte. Area centralis ampla et unilateraliter expansa. Raphe recta filiformis. Externalia extrema centralia raphis notabilia et disjuncta. Striae transapicales radiantes per totam valvam, 18-19 in 10 μm. Lineolae in microscopio photonico non visibiles.

Holotype: slide no. 7353_8_1 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 85.

Isotypi: slide No. KER9 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/29 in Hustedt Collection, Alfred Wegener Institute Bremerhaven.

Type habitat: Port Raymond, intertidal beach, October 1991.

Habitat: in Kerguelen sediments.

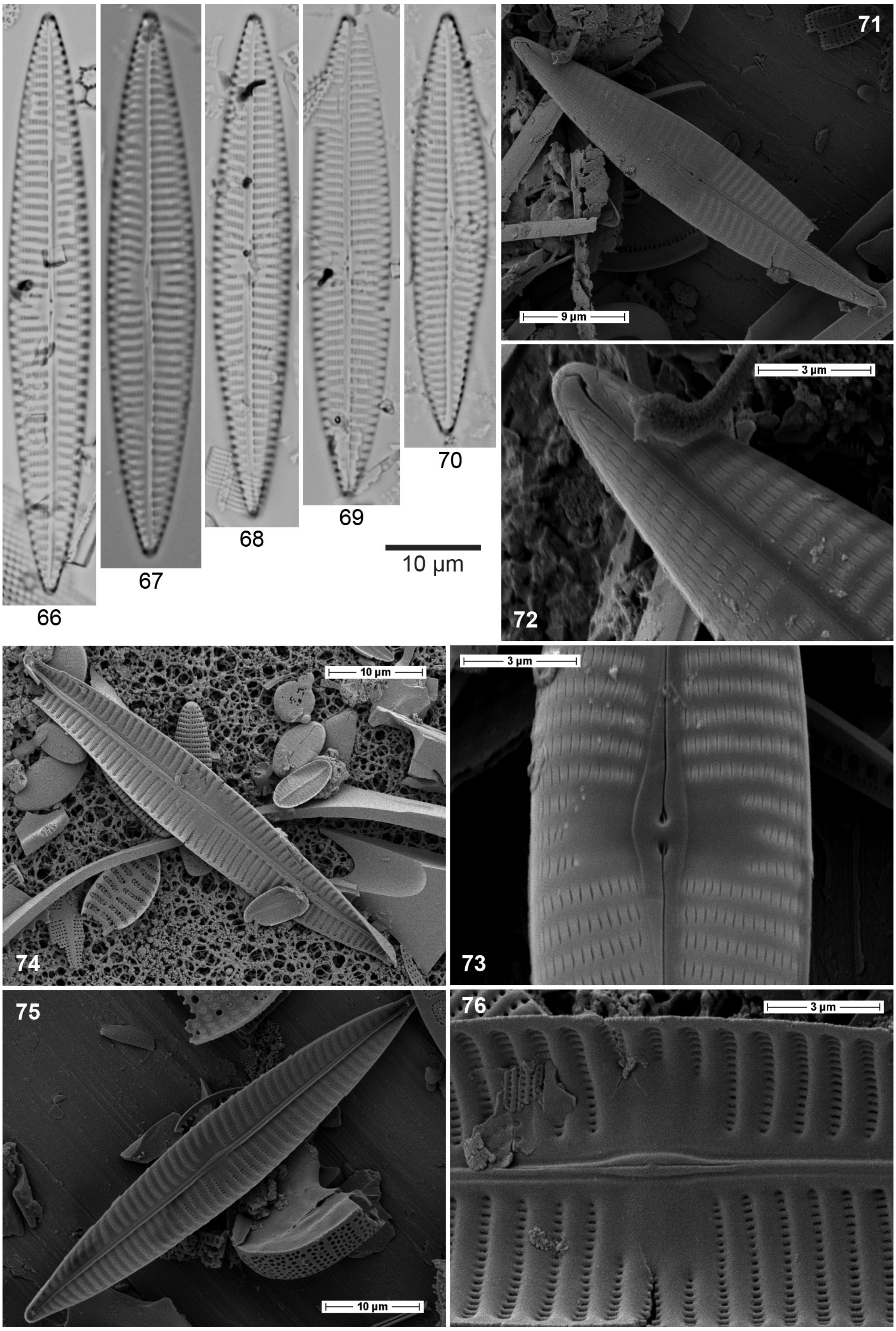
Etymology: the name of this taxon is derived from central area, which resembles a butterfly.

LM (Figs 77-86):

Valves lanceolate to elliptic lanceolate with obtusely rounded apices, 13-20 (?27) μm long, 6-8 μm broad. Axial area linear narrow at apices becoming broader towards the valve middle, finally expanding into relatively large, asymmetric central area. Raphe straight, filiform, external central ending relatively large, distant. Transapical striae radiate throughout, 18-19 in 10 μm. Lineolae in LM unresolvable.

SEM (Figs 87-88):

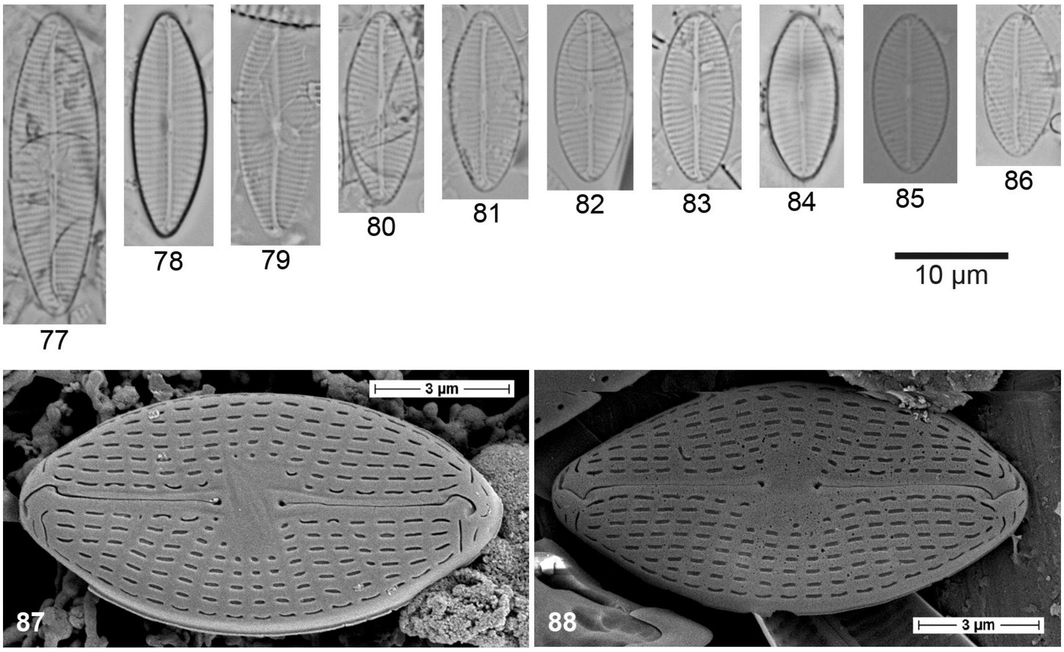
Valve flat turning towards the steep mantle, mantle shallow, devoid of areolae. Axial area very narrow, linear, slightly expanded towards the central area. Central area rather large, asymmetric, but resembling a butterfly. Raphe straight with a somewhat elevated raphe sternum. External proximal raphe ends simple, slightly expanded, indistinctly bent towards the valve primary side, and relatively distant from one another. Transapical striae composed of apically elongate areolae which form rows



Figs 66-76. – *Navicula irminae* sp. nov. Figs 66-70 LM. Scale bar = 10 μm. Figs 71-76 SEM. Figs 71-73. Valve external view. Fig. 72. Close up of the apex. Fig. 73. Close up of the valve middle showing the external central raphe endings. Figs 74-76. Valve internal view. Fig. 76. Close up of the valve interior middle part, note the internal central raphe endings.

almost parallel to the raphe sternum, ca. 35 in 10 μm. Transapical striae radiate throughout.

This species resembles *Navicula ectoris* Van de Vijver in Van de Vijver *et al*. (2002), but is smaller in size and has more obtusely rounded apices. *Navicula ectoris* has acutely rounded apices, transapical striae that are radiate



Figs 77-88. – *Navicula papilioarea* sp. nov. Figs 77-86 LM. Scale bar 10 µm. Figs 87, 88 SEM. Figs 87, 88. Valve external view.

and convergent at apices, 21-24 in 10 µm, denser than our species (Figs 87, 88).

Navicula szlachetkoi **sp. nov. Figs 89-92.**

Descriptio :

Valvae lineares ad rhombico-lanceolatae, cum apicibus rotundatis ad acutis, 62-69 µm longae, 10-12 µm latae. Area axialis recta, leviter undata prope apices. Area centralis moderate ampla, singulam striam mediam abbreviatam facta, et occupans ½ valvae latitudinem. Externalia extrema centralia raphis leviter expansa et disjuncta ; externalia extrema apicalia raphe non observata in microscopio photonico. Striae transapicales robustae, radiantes per totam valvam, 5-6 in 10 µm, Lineolae in microscopio photonico visibiles.

Holotype: slide no. 7356_2 in Coll A Witkowski Institute of Marine Sciences University of Szczecin (SZCZ), leg C Riaux-Gobin. Holotypus Fig. 90.

Isotypi: slide No. KER10 in Collection C Riaux-Gobin, USR 3278 CNRS-EPHE, CRIOBE-Université de Perpignan, France; slide No. ZU7/30 in Hustedt Collection, Alfred Wegener Institute Bremerhaven.

Type habitat: Port Raymond, subtidal, January 1992.

Habitat: in Kerguelen sediments.

Etymology: the new species is dedicated our colleague Professor Dariusz Szlachetko from the University of Gdańsk a distinguished specialist in the taxonomy and biodiversity of orchids.

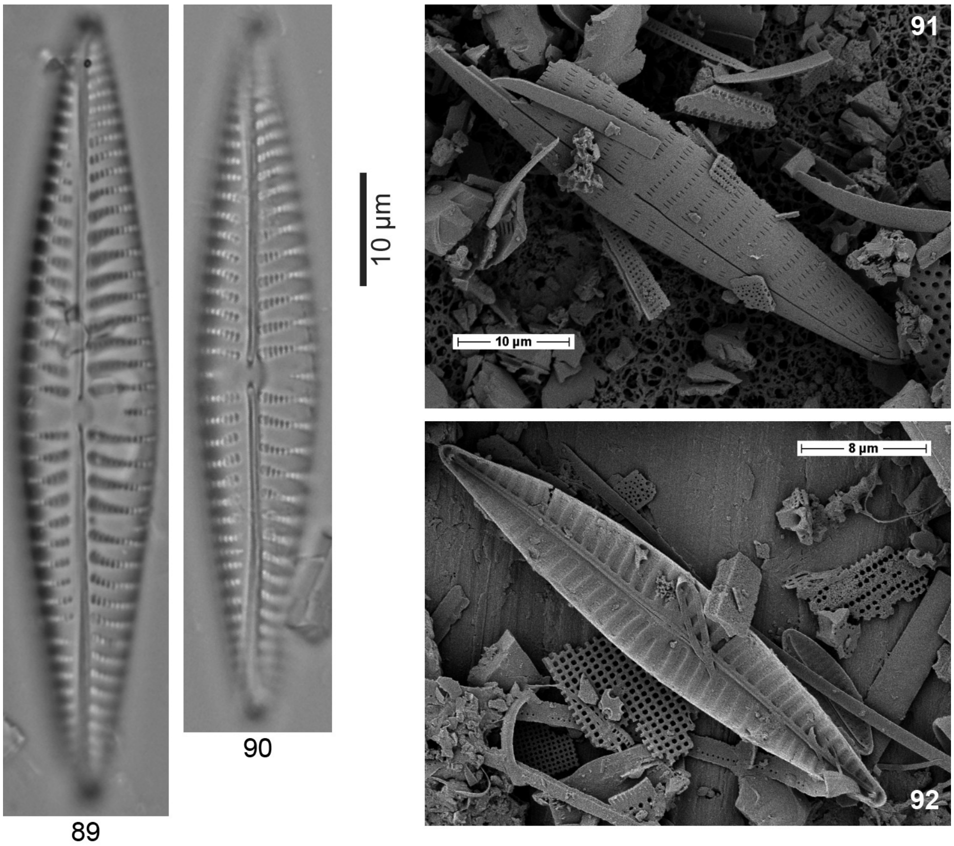
LM (Figs 89, 90):

Valves linear to rhombic lanceolate with acutely rounded apices, 62-69 µm long, 10-12 µm broad. Axial area linear, central area relatively large, formed due to shortening of a single striae in the middle of the valve, extending up to ½ of the valve width. Raphe straight, slightly lateral. External proximal raphe ends very slightly expanded, external distal ends not observed in LM so far. Transapical striae robust, radiate throughout, 5-6 in 10 µm, composed of lineolae, clearly resolvable in LM, ca. 20-22 in 10 µm.

SEM (Figs 91-92):

Valve surface arched in the middle flat with no transition between the valve face and the mantle observed. The mantle shallow, unlike numerous large *Navicula* species. Valve interior with relatively shallow slopes. Raphe sternum flat, not differentiated from the valve surface. Raphe sternum straight, slightly undulate in the middle. External proximal raphe ends very slightly expanded, comma-like, apical external raphe endings strongly hooked (geniculate) in one side (Fig. 91). Internally the raphe sternum structure is typical for *Navicula s.s.*, i.e., it opens very strongly oblique. Internal proximal raphe ends simple, close to each other. Internal distal raphe endings terminate as helictoglossae. The central nodule is well developed. Transapical striae internally placed in elongated depressions and covered with hymenes typical of *Navicula s.s.*

The new species resembles *Navicula pennata* A. Schmidt (Schmidt's Atlas, Pl. 48: 41-43). Both taxa have more or less similar valve outlines and radiate transapical striae, but, central area shape differs. *N. szlachetkoi* has narrow, rectangular central area developed due to the shortening of a single stria in the valve middle, whilst in *N. pennata* central area is relatively large, trapezoid in shape.



Figs 89-92. – *Navicula szlachetkoi* sp. nov. Figs 89, 90 LM. Scale bar = 10 µm. Figs 91, 92 SEM. Fig. 91. Valve external view, note the external apical raphe ending (arrow). Fig. 92. Valve internal view.

DISCUSSION

In this paper we describe eight new diatom species of the genus *Navicula s.s.* All species originate from the marine littoral and sublittoral habitats of the Kerguelen Islands. However, as already pointed out, this is only a small part of the new taxa from these habitats. As further research is carried out, we believe that approximately two dozen new species remain to be described from that area, including representatives of genera such as *Bacillaria*, *Cocconeiopsis*, *Cocconeis*, *Fallacia*, *Haslea*, *Hippodonta*, *Lunella*, *Navicula*, *Nitzschia*, *Opephora*, *Psammothidium*, *Pseudogomphonema* and *Staurophora*. It is quite surprising that, in an area where the diatom assemblages have been studied for nearly 100 years (e.g., Heiden & Kolbe 1928, Manguin 1957, 1960, Riaux-Gobin & Romero 2003, Riaux-Gobin *et al.* 2007, Riaux-Gobin & Witkowski in revision), so many new taxa are still being discovered. In our opinion there are two reasons. First, since the early studies (e.g., Heiden & Kolbe1928) no general floristic investigations have been performed and the research effort was directed mainly towards fouling diatom taxa, in particular species of the genus *Cocconeis*. We would like to point out that from a sample collected in Observatory Bay, Heiden described several species new to science (cf. Heiden & Kolbe 1928, Simonsen 1992). The second reason to account for the high floristic richness is, in our opinion, due to the harsh environmental conditions in the Kerguelen Islands. These conditions have helped to develop an evolutionary hot spot. We postulate here that low temperatures of the marine waters could be an important factor in the evolution of diatom species. Similar floristic richness of marine littoral diatoms has been observed in San Francisco Bay, which is influenced by cold oceanic currents. In San Francisco Bay, Witkowski *et al.* (2009) described 11 *Navicula* species new to science with a few to be described in the future. The total number of *Navicula* species in the Bay is 55. There are about 50 species of *Navicula* in the Kerguelen Islands. In San Francisco Bay, as in Kerguelen, some other diatom genera gave us an opportunity to describe new species. In San Francisco these genera include *Fogedia*, *Hippodonta*, *Nitzschia* and a new genus (Witkowski *et al.* in preparation).

The importance of role of environmental factors, particularly water temperature, in determining the diatom flora of a region seems to be borne out by the distribution of diatom genera present in cold waters. In Kerguelen Islands, in terms of biogeography amongst diatom genera, cosmopolitan forms of world wide distribution e.g., *Cocconeis*, *Hippodonta*, *Melosira*, *Navicula*, *Nitzschia*, *Pteroncola* are dominant. However, in Kerguelen samples representatives of the genera are frequently identified

Table I. – Summary of the diagnostic features of newly described *Navicula* species.

	Navicula australoceanica	*Navicula concordia*	*Navicula criophiliforma*	*Navicula fabiformis*	*Navicula hippodontaformis*	*Navicula irminae*	*Navicula papilioarea*	*Navicula szlachetkoi*
Length (µm)	48-68	15-32	30-63	10-14	46-68	43-67	13-20 (?27)	62-69
Breadth (µm)	8-9	3.8-5.8	6.0-8.5	6-7	8-11	7.5-9.0	6-8	10-12
Striae in 10 µm	7-8	14-15	11-13	17-19	7-8	9-11	18-19	5-6
Lineolae in 10 µm	c. 30	c. 35	35-40	c. 35	40-45	c. 30	ca. 35	20-22
External central endings	expanded, elaborate in shape distant	slightly expanded rather distant	expanded by ligula pincer-like	dot-like rather distant	simple approximate	dot-like by ligula pincer-like approximate	dot-like distant	slightly expanded comma-like
apical raphe endings	geniculate	geniculate	geniculate	geniculate	short bent in the same direction	geniculate	geniculate	geniculate
External sternum	present	absent	present	absent	absent	present	present	absent
Central area	rectangular	distinct narrow rectangular	irregular asymmetric	barely distinguishable square	asymmetric lanceolate	large rectangular	small butterfly-like	large rectangular

which have either a bipolar, discontinuous distribution e.g. *Fragilariopsis*, *Pseudogomphonema*, *Synedropsis,* or are known so far only in the Southern Ocean e.g., *Brandinia* and *Porannulus* (Hamilton *et al.* 1997, Fernandes *et al.* 2007, Witkowski *et al.* submitted). A similar situation is true if we consider species distribution. Actually, of the above mentioned "cold water" genera only two species representing *Fragilariopsis* were identified from the South African coast, which is located northwest of the Kerguelen Islands. These were *Fragilariopsis rhombica* (O'Meara) Hustedt and *F. kerguelensis* (O'Meara) Hust. (e.g., Cholnoky 1968, Witkowski *et al.* 2000, Witkowski unpublished observation). Both *Fragilariopsis* are planktonic species occurring abundantly in the Southern Ocean (Zielinski & Gersonde 1997). Hence, findings of single specimens of this species in South Africa result, in our opinion, from its redeposition with oceanic currents. Analysing the species composition of diatom assemblages from the Kerguelen Islands we have been able to identify numerous species which occur only in the Southern Ocean, some of them representing plankton the others either sea ice or littoral assemblages. These include *Brandinia mossimaniae* Fernandes & Prockopiak, *Thalassiosira antarctica* var. *antarctica* Comber, *Melosira dougetii* Manguin, *Synedropsis fragilis* (Manguin) Hasle, Syversten *et* Medlin and *Achnanthes vicentii* Manguin (e.g. Hendey 1937, Hustedt 1958, Manguin 1957, 1960, Hasle *et al.* 1994, Fernandes *et al.* 2007).

Among the *Navicula* species selected for this manuscript, several taxa conform to the strict circumscription of the genus. The features that diagnose the genus are the raphe-sternum system (raphe apical endings and the raphe internal structure), and transapical striae (lineolate) in particular (see Cox 1979, Round *et al.* 1990, Lange-Bertalot 2001). All new taxa, except *N. hippodontaformis*, conform to the generitype. The latter species possesses the major features of *Navicula*, but also differs in a few aspects. *Navicula hippodontaformis* differs in terms of raphe apical endings, that are just bent on one side instead of forming a double hook (e.g., *Navicula tripunctata* (O.F. Müll.) Bory). Such apical raphe endings are, in general, observed in a group of marine *Navicula* related to *N. cancellata* Donkin (Witkowski *et al.* 1998). Furthermore, *N. hippodontaformis* has apical striae typical for *Hippodonta*, *N. scabriuscula* and *N. cancellata* and missing in most *Navicula s.s.* (Lange-Bertalot 2001). Generally, apical striae appear in some *Navicula* taxa with high valve mantle. Apical striae occur in a group of large *Navicula* which, in our opinion, represent a relic within the genus. Included in this group is *Navicula scabriuscula*. It is interesting that both species show a certain degree of asymmetry about apical axis. In *N. hippodontaformis* this feature is not as strongly developed as in *N. scabriuscula,* but it is distinct enough to observe in the light microscope. Both taxa also have a similar system of transapical striae. Internally transapical striae in both species are placed in elongated depressions and the striae forming areolae are covered with hymenes typical of *Navicula s.s.* Also apical areolae are occluded by similar hymenes. However, *N. scabriuscula* has the striae interrupted internally by lateral hyaline areas. In general, this type of structure of transapical striae positioned in elongate depressions is observed in *Trachyneis*, *Hippodonta*, and in *Navicula cancellata*. *Navicula hippodontaformis* shares a general valve outline with the enumerated species and genera. These features include a strongly arched valve surface that gradually changes from the valve surface to the relatively high mantle. This feature is missing in most of *Navicula s.s.* where the valve surface is flat and the mantle shallow. The transition from the valve surface to the mantle is, in these *Navicula* taxa, rather gradual.

Supporting Witkowski *et al.* (1998), in this manuscript we would like to stress that even despite a rather narrow circumscription of genus *Navicula,* some variation in valve morphology can be pointed out. The only feature that is always consistent is the strongly oblique opening of the raphe sternum in valve internal view. Any groupings distinguished within *Navicula s.s.* possess this feature (Witkowski *et al.* 1998, Lange-Bertalot 2001). Some variation is observed when the following characters are considered: the raphe apical endings, the degree of curvature of the valve face, the height of the valve mantle, areolation of the valve mantle, presence of the apical areolae and valve asymmetry about the apical axis.

Species belonging to *Navicula s.s.* should have external distal raphe ends in a form of a doubly bent strong hook; this condition is termed geniculate. Such appearance of the distal raphe ends is observed in *Navicula tripunctata* (Cox 1979) and in those species which conform with the generitype (Lange-Bertalot 2001). However, as SEM examination reveals in some *Navicula* species which share all remaining aspects of generitype, including plastids, the strongly hooked, geniculate external distal ends are missing. They are either slightly bent (e.g., *N. cancellata*) or strongly bent, but not geniculate (e.g., *Navicula distans*, *N. scabriuscula*). The newly described species *N. hippodontaformis* is such an example, as its distal ends are, however, somewhere between *N. cancellata* and *N. distans* (Metzeltin & Witkowski 1996, Witkowski *et al.* 1998). Surprising that *N. szlachetkoi* despite its close resemblance in morphological robustness, conforms thoroughly to the generitype in terms of the external distal raphe ends.

Regarding the valve face, most *Navicula* species are flat and have a well set off border between the valve face and the mantle (Cox 1979, Lange-Bertalot 2001). In the present study only the very small *Navicula* species described here, i.e., *N. fabiformis* and *N. papilioarea,* and relatively large *N. australoceanica*, show this feature. However, the latter species has a high valve mantle. All the remaining *Navicula* have valves distinctly arched with a varying degrees of flatness around the central nodule. Furthermore, the transition from the valve face to the mantle is gradual and the border between the valve face and the mantle is impossible to delimit. Unlike the two small *Navicula*, in the other species the mantle contains areolae. This feature is different from the generitype, but similar to numerous *Navicula* species conforming to the type e.g., *N. moskalii* Metzeltin, Witkowski *et* Lange-Bert. and in *Navicula* species which show a certain degree of variation when compared to the generitype. Included in this group are e.g., *Navicula cancellata*, *N. distans* and *N. scabriuscula*.

Finally, the species with high valve mantles have one feature that is missing in most of *Navicula* species, conforming to the generitype. These are apical areolae and are best expressed in *N. cancellata*, *N. hippodontaformis*, and *N. scabriuscula*. The two characteristics, i.e., high valve mantle and the apical areolae, point to their close relationship with *Hippodonta*. It looks as if this group of *Navicula* species, bearing the *Navicula* raphe-sternum, still posses some features of its ancestor *Hippodonta*. As the group of *Navicula* species possessing intermediate characters shows some degree of variation, we can speculate that the evolution of *Hippodonta*-like taxa produced several lineages, including *Navicula s.s. Navicula* with arched valves, but missing apical areolae (e.g., *N. irminae*, *N. australoceanica*), could have been one result, whereas the other group that strictly conforms with the generitype arose from another lineage not yet discovered. A close relationship between *Hippodonta* and *Navicula,* where *Hippodonta* may be ancestral to *Navicula,* has been proposed by Mayama & Moriuchi (2000) based on valve ontogenetic studies and by Bruder & Medlin (2008) based on molecular data. Our observations on valve morphology seem to support this relationship between the two genera.

CONCLUSIONS

We present eight new species of the genus *Navicula* from Kerguelen. The newly described *Navicula* taxa present in LM a wide variety of valve outlines and other structural characters. Most of the taxa i.e., *N. concordia*, *N. criophiliformis*, *N. fabiformis*, *N. irminae* and *N. papilioarea,* appear clearly under LM and doubtless they conform to *Navicula tripunctata* as the generitype. As observed in LM the remaining taxa can be thought to represent a group of *Navicula* taxa which upon SEM examination are also similar to *Navicula* in their overall characteristics, but also possess certain differences. Though they have the raphe internal structure typical of *Navicula* i.e. the raphe opens internally strongly oblique, their external distal raphe ends do not possess the prominent double hook, one of the most important characters of *Navicula s.s.* Surprisingly our *N. australoceanica* and *N. szlachetkoi* do conform with *N. tripunctata* overall. The case of *N. szlachetkoi* is especially interesting since it resembles

N. distans which, in terms of raphe structure and its distal raphe ends in particular, is fairly different from *N. tripunctata* though its plastids are typical for *Navicula s.s*.

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