Cryptogamie, Algol., 2002, 23 (4): 333-341

Three new species of *Diadesmis* from soils of Ile de la Possession (Crozet Archipelago, Subantarctic)

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(Received 11 March 2002, accepted 2 July 2002)

Abstract – During an extensive survey of the terrestrial diatom flora of soils on Ile de la Possession (Crozet Archipelago, Subantarctica), three new species belonging to the diatom genus *Diadesmis* have been discovered: *D. ingeae* Van de Vijver sp. nov., *D. vidalii* Van de Vijver et Ledeganck sp. nov. and *D. latestriata* Van de Vijver, Ledeganck et Beyens sp. nov. The detailed morphology of the three new taxa has been examined in detail using Light (LM) and Scanning Electron Microscopy (SEM). Comparisons are made with similar *Diadesmis* species. Ecological data is provided for each species.

***Diadesmis* / diatoms / morphology / Subantarctica**

Résumé – Trois nouvelles espèces de *Diadesmis* des sols de l'Ile de la Possession (Archipel Crozet, Subantarctique). Durant une étude extensive de la flore diatomique terrestre de l'Ile de la Possession (Archipel de Crozet, Subantarctique), trois nouvelles espèces du genre *Diadesmis* ont été trouvées*: D. ingeae* Van de Vijver sp. nov., *D. vidalii* Van de Vijver & Ledeganck sp. nov. et *D. latestriata* Van de Vijver, Ledeganck & Beyens sp. nov. La morphologie détaillée de ces trois nouvelles espèces est examinée avec la microscopie optique (LM) et le microscope en balayage (SEM). Des comparaisons et des différences entre ces espèces et des espèces similaires du genre *Diadesmis* sont discutées ainsi que l'écologie des nouvelles espèces.

***Diadesmis* / diatomées / morphologie / subantarctique**

INTRODUCTION

Diatoms (Bacillariophyceae) are one of the most abundant algal groups in the Antarctic and Subantarctic Regions (Jones, 1996 ; Van de Vijver & Beyens, 1999). During an extensive study of the freshwater and terrestrial diatom flora of Ile de la Possession, the major island of the Crozet Archipelago (Subantarctic), a large number of new species were discovered, many belonging to the genus *Diadesmis*. Several of these are currently being described by Le Cohu & Van de Vijver (in press) since they are shared by both Crozet and nearby Kerguelen Archipelago (research done by R. Le Cohu, University of Toulouse). Three addi-

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tional new species seem to be endemic to Crozet and will be described separately in this paper.

The genus *Diadesmis* Kützing was re-established by Round *et al.* (1990) to accommodate all taxa related to *Navicula confervacea* Kützing and *Navicula contenta* Grunow. In 1978, Schoeman & Archibald published a very detailed study on the morphology and variability of *Navicula contenta*, now placed within the genus *Diadesmis*, indicating that it is an 'extremely polymorphic taxon'. Prior to 1998, the diversity within the genus *Diadesmis* was severely underestimated, since all specimens showing some features of *D. contenta* were included within that species. A survey of the aerophilic diatom flora of New Caledonia (Moser *et al.,* 1998) resulted in the publication of several new species for taxa that were formerly included within *D. contenta*, and at the same time *D. contenta* was more precisely defined. It was apparent, as Moser *et al.* (1998) stated in their work, that *Diadesmis* has many more species than previously thought. Our work on Ile de la Possession confirms this statement and it is highly likely that further investigations on this island and other Subantarctic islands (such as Heard Island, Macquarie Island and Marion Island) will lead to the discovery of additional new species of *Diadesmis*.

This paper describes the morphology and the taxonomic status of three new species of *Diadesmis*: *D. vidalii* Van de Vijver et Ledeganck sp. nov., *D. ingeae* Van de Vijver sp. nov. and *D. latestriata* Van de Vijver, Ledeganck et Beyens sp. nov. Ecological data are provided for each species.

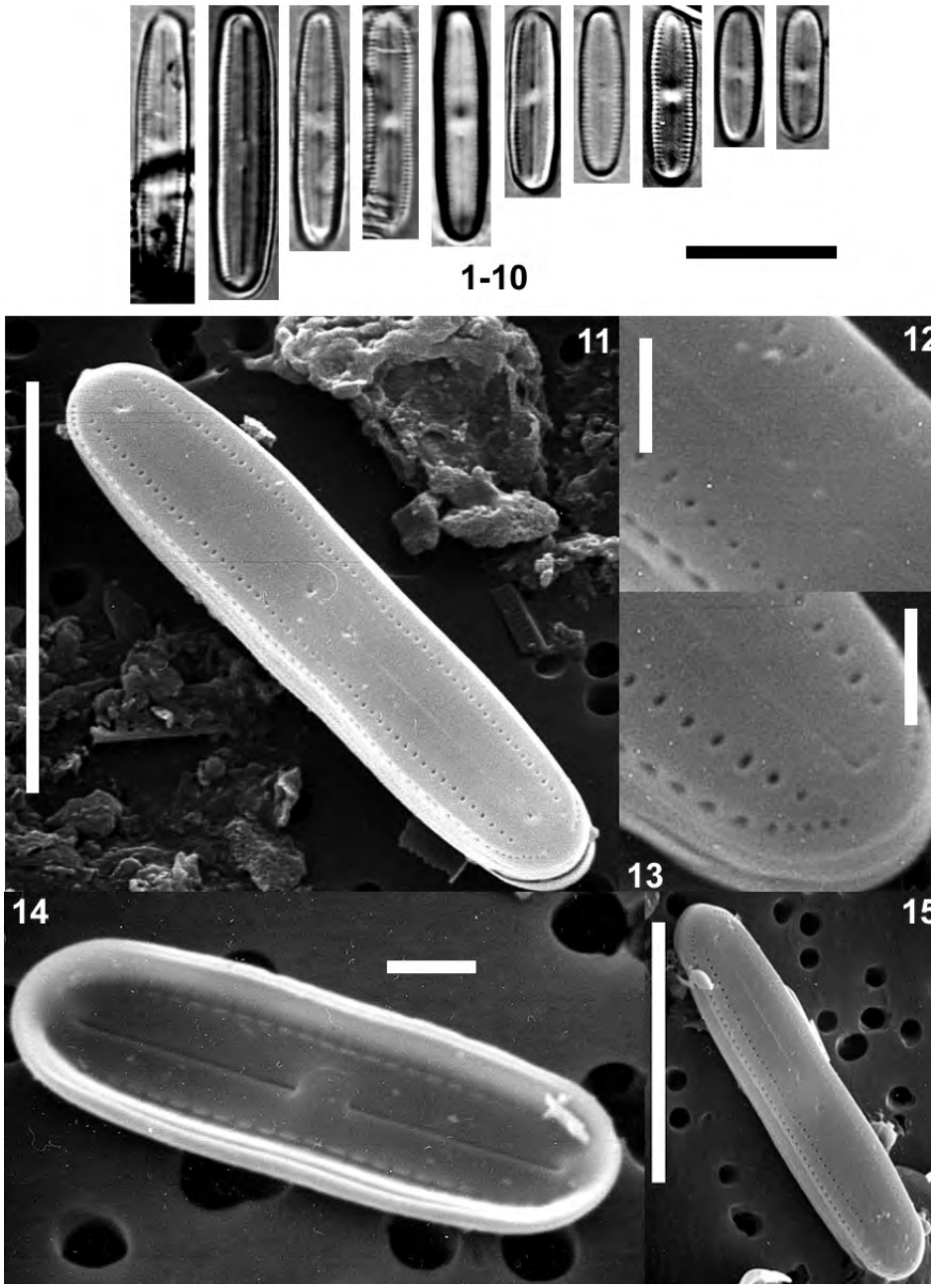
MATERIAL & METHODS

During the austral summer of 1999-2000, more than 100 samples from different soil types were collected on Ile de la Possession. Samples were fixed in the field with 3% formaldehyde. For microscopical analysis, samples were prepared following the method by Van der Werff (1955): samples were treated with 37% H_2O_2 and saturated $KMnO_4$ in order to remove all organic material. To speed up the reaction, samples were heated on a heating plate for a short period. Following digestion and centrifugation, slides for light microscopy (LM) were prepared by mounting cleaned diatom valves in Naphrax®. For scanning electron microscopy (SEM), part of the suspension was filtered through polycarbonate membrane filters with a pore diameter of 3 µm, of which parts were affixed to aluminium stubs after air-drying. The stubs were sputter-coated with 20-50 nm of gold, and studied with a Philips SEM 515 at 20kV. Relative diatom abundance data are based on LM counts of at least 500 valves. Morphological descriptions follow the format of Round *et al.* (1990).

RESULTS

Diadesmis vidalii Van de Vijver et Ledeganck sp. nov.

Diagnosis: Valvae semper lineares apicibus late rotundatis, numquam protractis. Longitudo 8-20 µm, latitudo 2-3.5 µm. Valvae maiores marginibus claro concavis. Area axialis linearis, lata, leviter decrescens ad polos. Raphe filiformis, recta extremis externis ramorum utrimque cum poris distinctis depressis centralibus et terminalibus, fissurae in forma litterae T vacant. Foramina areolarum maxime



Figs 1-15. *Diadesmis vidalii* Van de Vijver & Ledeganck sp. nov. Figs 1-10 in the LM. Fig. 11. SEM, Valve face view showing clearly the broad axial area and the small foramina of the striae. Fig. 12. SEM, Detail of the central raphe endings with slightly depressed pores. Fig. 13. SEM, detail of the terminal raphe endings and the second row of poroids on the valve margin. Fig. 14. SEM, internal valve view. Fig. 15. SEM, entire valve showing clearly the second row of poroids on the valve mantle. Scale bars = 10 µm except for Figs 12-14 where scale bars represent 1 µm.

curta, fere rotundata, prope margines sita, 32-37 in 10 µm. Ita area centralis separata abest. Areolae in limbo aequidistantes ut in fronte valvae, ad polos magis approximatae.

Holotype: CAS-220055 (Californian Academy of Sciences)

Isotypes: PLP-005 (University of Antwerp), BR-4049 (National Botanical Garden, Meise)

Valves always linear with broadly rounded, never protracted ends. Length 8-20 µm, width 2-3.5 µm. Larger valves with clear concave margins. Axial area linear, broad, slightly narrowing towards the poles. Raphe straight, filiform with clearly depressed terminal and central pores. T-shaped endings lacking. Foramina of the areolae very short, almost circular, located close to the valve margins, 32-37 in 10 µm. Separate central area lacking. Areolae on the mantle equidistant as on the valve face, towards the poles closer together.

Type Locality: Vallée des Branloires, Ile de la Possession, Crozet Archipelago sample BA096 (coll. date 30/11/1999)

Etymology: this taxon is dedicated to our colleague Prof. Dr. Eric Vidal (Université de Marseille), whose help during the sampling campaign on Ile de la Possession (1999) was most appreciated.

Valve morphology: Valves clearly linear. Larger valves have concave margins (Figs 1-10, 11). Valve face consists of a large axial area, leaving only small foramina of the areolae (Figs 11, 15). The series of foramina is not completely linear and shows, due to the concave margins, a more undulating line. Axial area slightly narrowing towards the poles (Fig. 13). The last foramina are situated next to or just beyond the terminal raphe pores (Fig. 13). On the mantle, just under the valve margins, a second row of poroids is visible (Fig. 11). They appear evenly spaced and are equidistant to the foramina on the valve face. Towards the valve apices, 4-8 poroids are placed much closer together (Fig. 13). The raphe is filiform and possesses distinct, slightly expanded and clearly depressed central and terminal pores. No T-shaped terminal nor central endings have been observed (Fig. 12).

The valve interior is quite featureless and shows the same broad axial area and the short foramina, closed by hymenes (Fig. 14).

***Diadesmis latestriata* Van de Vijver, Ledeganck et Beyens sp. nov.**

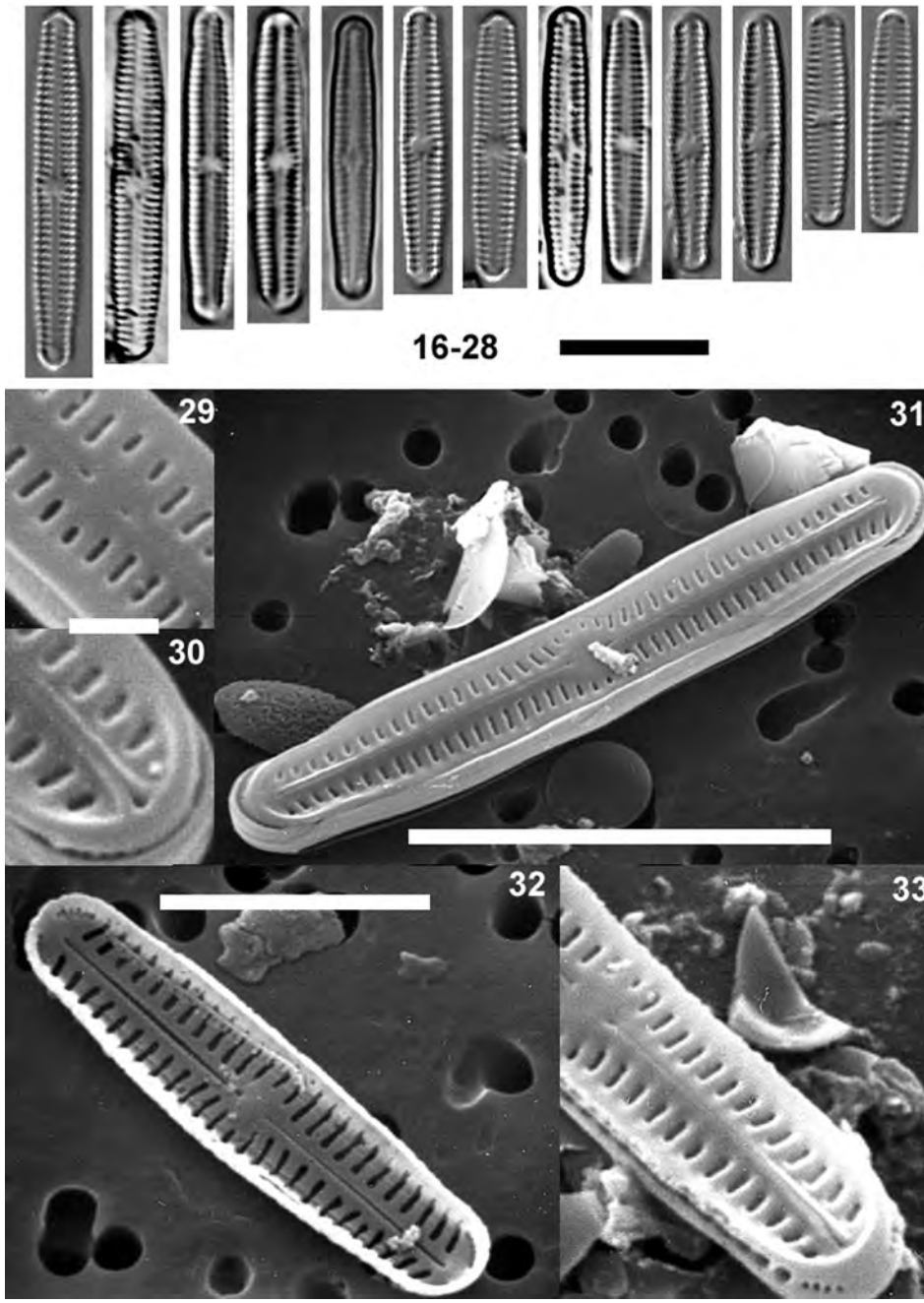
Diagnosis: Valvae lineares marginibus leviter undulatis apicibusque protrusis rotundatis. Longitudo 13-22 µm, latitudo 2-3.5 µm. Area axialis angusta, linearis clare elevataque. Area centralis elliptica, transapicaliter elongata. Raphe filiformis poris centralibus terminalibusque leviter expansis. Striae transapicales parallellae ad leviter radiatas, positae in duabus areis depressis inter margines valvarum elevatas et aream axialis elavatam, constantes ex foraminibus elongatis, 24-26 in 10 µm.

Holotype: CAS-220054 (Californian Academy of Sciences)

Isotypes: PLP-006 (University of Antwerp), BR-4048 (National Botanical Garden, Meise)

Valves linear with weakly undulating margins and protracted ends. Length 11-22 µm, width 2-3.5 µm. Axial area narrow, linear and clearly raised. Central area elliptical, transapically elongated. Raphe filiform with weakly expanded central and terminal pores. Transapical striae parallel to slightly radiate, located in two depressed areas between raised valve margins and raised axial area, consisting of elongated foramina, 24-30 striae in 10 µm.

Type Locality: Vallée des Branloires, Ile de la Possession, Crozet Archipelago, sample BA096 (coll. date 30/11/1999)



Figs 16-33. *Diadesmis latestriata* Van de Vijver, Ledeganck & Beyens sp. nov. Figs. 16-28 valves in LM. Fig. 29. SEM, detail of the central raphe pores. Fig. 30. SEM, detail of the terminal raphe endings with the raised rims next to the axial area. Fig. 31. SEM, entire valve face. Fig. 32. SEM, internal valve view. Fig. 33. SEM, detail showing clearly the second row of poroids on the valve mantle. Scale bars = 10 μm except for Figs 29 and 30 where scale bars represent 1 μm.

Valve morphology : Valves linear and irregularly undulating margins in larger valves (Figs 16-28). Smaller valves have a more convex outline but can also produce several undulations. The valve margins are clearly raised, showing two rims (Fig. 31). The axial area is also raised, but appears much lower than the valve margins. Towards the poles, the filiform raphe runs through two raised divergent rims (Fig. 30) that melt with the valve margins at the poles. Both the central and terminal pores of the raphe are slightly expanded (Figs 29-30). The terminal pores run just beyond the last striae (Fig. 30). No T-shaped pores or fissures present. Due to the raised margins and axial area, the transapical striae are placed within two depressed longitudinal areas (Figs 30, 31). The foramina of the areolae are elongated and situated between slightly raised interstriae. On the mantle, another row of rounded poroids can be observed (Figs 31, 33). The poroids are located next to the foramina on the valve face. The last 4-6 poroids, towards the poles, are much closer together (Fig. 33).

The valve interior shows the same structure as the exterior with transapically elongated foramina (Fig. 32). The central area is slightly raised. The interior raphe produces simple endings.

Diadesmis ingeae **Van de Vijver sp. nov.**

Diagnosis: Valvae lineares marginibus undulatis apicibusque subcapitatis late rotundatis. Longitudo 8-18 µm, latitudo 2-4 µm. Area axialis lata, linearis. Area centralis elliptica. Raphe filiformis poris centralibus leviter depressis. Pori terminales simplices, terminantes juxta vel modo post strias transapicales extremas, fissurae in forma litterae T vacant. Foramina striarum transapicalium modo leviter elongata, parva et rotundata in medio valvae. Striae transapicales parallellae, aliquando convergentes ad polos, non interruptae in medio, curvatae convexe circum nodulum centralem, 31-35 in 10 µm.

Holotype: CAS-220053 (Californian Academy of Sciences)

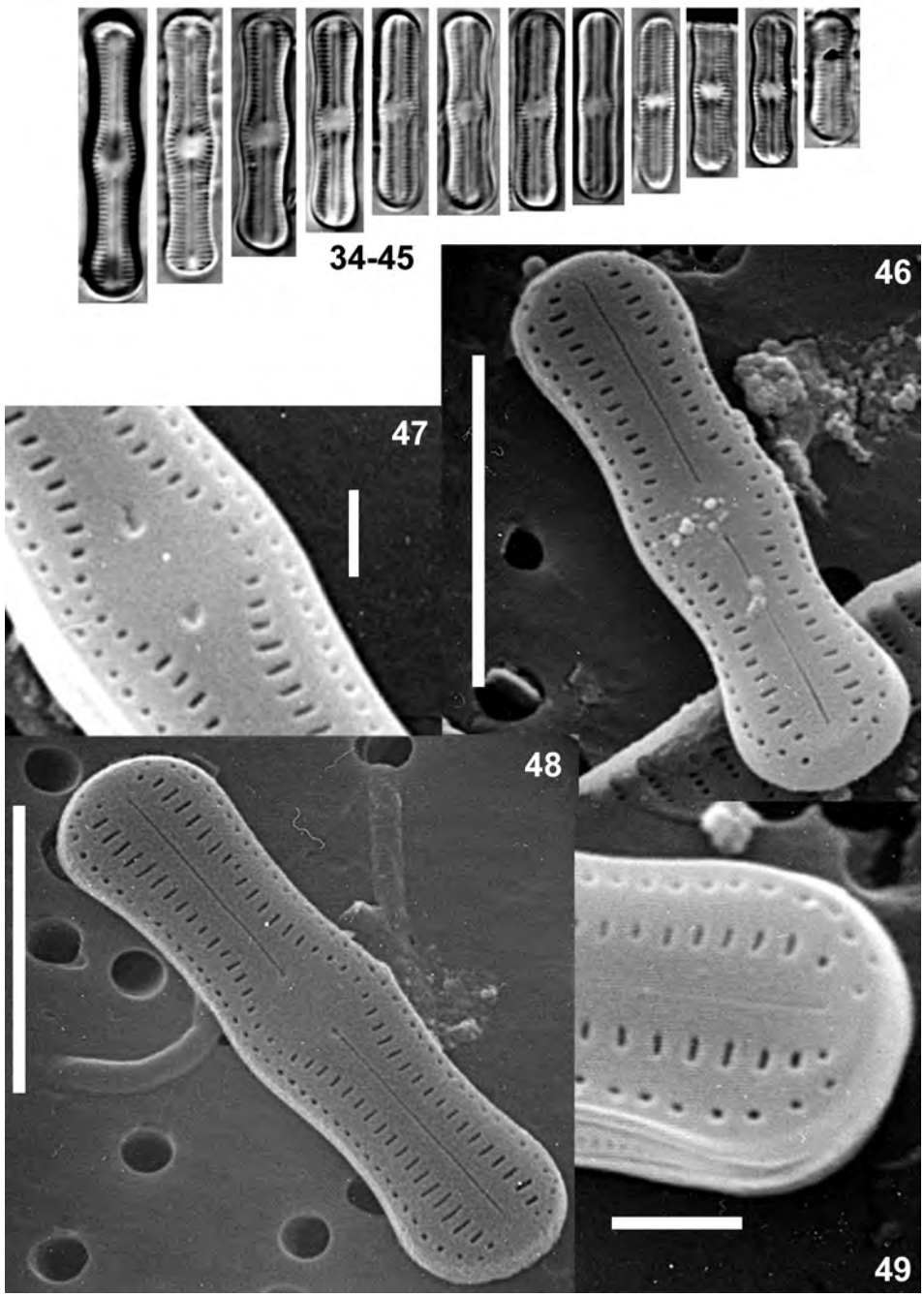
Isotypes : PLP-007 (University of Antwerp), BR-4047 (National Botanical Garden, Meise)

Type locality: Pointe Basse, Ile de la Possession, Crozet Archipelago, sample BA057 (coll. date 18/11/99)

Valves linear with undulating margins and broadly rounded subcapitate apices. Length 8-18 µm, width 2-4 µm. Axial area broad, linear. Central area elliptical. Raphe filiform with slightly depressed central pores. Terminal pores simple, ending next to or just distal from the last transapical striae. T-shaped endings lacking. Foramina of the transapical striae only slightly elongated, in the middle small and rounded. Striae parallel, sometimes convergent towards the poles, not interrupted in the middle, convexely curved around the central nodule, 31-35 in 10 µm.

Etymology: the specific epithet refers to our colleague, Mrs. Inge Van Dyck to thank her for all the professional help she gave us during the last few years.

Valve morphology: Valves linear, in the middle clearly convex giving this taxon an undulated valve outline. Ends broadly rounded, usually not wider than the middle of the valve (Figs 34-45). Axial area linear, fairly wide. Central area enlarged, almost elliptical due to the shortening of the striae in the middle and the convex curve of the striae around the central raphe pores (Figs 46-48). External raphe branches filiform, straight with depressed central endings (Fig. 47). Terminal endings indistinct, ending next to or just before the last pair of striae (Fig. 48). T-shaped endings have not been observed. The foramina of the areolae are transapically elongated except in the middle where they are very short to almost circular in outline (Figs 47, 48). The striae are almost parallel, not inter-



Figs 34-49. *Diadesmis ingeae* Van de Vijver sp. nov. Figs 34-46. Valves in LM. Fig. 46. SEM, entire valve face. Fig. 47. SEM, detail of the central raphe pores. Fig. 48. SEM, entire valve face. Fig. 49. SEM, detail of the terminal raphe endings and the second row of poroids on the valve mantle. Scale bars = 10 μm except for Figs 47 and 49 where scale bars represent 1 μm.

rupted near the central raphe pores but curving convexely around the central nodule (Figs 46, 48). Striae are usually resolvable in LM. On the mantle, close to the valve margins, a second row of rounded poroids can be observed. They are placed at the same distance as the striae on the valve face (Fig. 46). Towards the poles, they appear more widely spaced. They usually do not continue completely around the poles. Internally, the foramina appear much larger than externally. The raphe slits are straight with unmarked pores, both central as terminal pores.

Ecology and associated diatom species

Diadesmis ingeae is very common on Ile de la Possession in soils and temporarily dry moss vegetations. It is probably one of the most common freshwater diatoms on the island and has a preference for relatively dry, acid soils (moisture content <40%) with variable nutrient and salinity conditions. The accompanying taxa, such as several *Diadesmis* taxa, especially *D. crozetikerguelensis* Le Cohu et Van de Vijver (*in press*), *Pinnularia borealis* var. *scalaris* (Ehrenberg) Rabenhorst and *Adlafia bryophila* (Petersen) Lange-Bertalot, all prefer the same drier environment.

Diadesmis vidalii and *D. latestriata* are less common. The highest abundance of both taxa (resp. 60% and 18%) was reached in a small, shallow cave in the Vallée des Branloires. Taxa that are common in the same samples include *Pinnularia crozetii* Van de Vijver et Beyens, *P. acidicola* Van de Vijver et Beyens and *P. microstauron* (Ehrenberg) Cleve, *D. ingeae*, *D. crozetikerguelensis*, and *Luticola mutica* (Kützing) Mann.

DISCUSSION

The three new species clearly belong to the genus *Diadesmis*, based on their overall valve shape, the presence of uniseriate striae with rounded or elongated areolae and a rather simple raphe system with simple central and terminal endings (Round *et al.,* 1990). A comparison of the new species with morphologically similar species shows marked differences. *Diadesmis vidalii* bears some similarities with *Diadesmis aerophila* (Krasske) Reichardt, which also possesses only very short, almost circular foramina, but *D. vidalii* is much larger and less concave in the middle. Smaller individuals even have parallel margins, while in *D. aerophila* the concave valve outline is one of the diagnostic features. Due to the very short and rounded areolae, *D. vidalii* is unmistakable in LM and cannot be confused with other *Diadesmis* species.

Diadesmis ingeae, however, could potentially be confused with several species (Table I). It is similar to *Diadesmis corrugata* Moser, Lange-Bertalot & Metzeltin, but that species always has T-shaped raphe endings, which never occur in *D. ingeae*. The shape and valve outline of *D. implicata* Moser, Lange-Bertalot & Metzeltin are similar to *D. ingeae,* but *D. implicata* never shows the subcapitate endings found in *D. ingeae*. Moreover, the central raphe endings in *D. implicata* lack depressed central pores. *Diadesmis arcuata* (Heiden) Lange-Bertalot and taxa that resemble *D. arcuata* [e.g. *D. costei* Le Cohu et Van de Vijver (in press)] are always much larger, with different raphe endings and a different striation pattern: the foramina are longer forming a narrow axial and central area. Two other taxa, also described from Ile de la Possession, *D. comperei* Le Cohu et Van de Vijver

and *D. crozetikerguelensis* Le Cohu et Van de Vijver (in press), have a different valve outline and can easily be separated from *D. ingeae*, even when they are occurring in the same samples (which is frequently the case with *D. crozetikerguelensis*). *Diadesmis brekkaensis* (Petersen) Mann should also be taken into consideration. It possesses the same uncommon areolae arrangement but can be differentiated by the non-subcapitate valve outline. *Diadesmis paracontenta* Lange-Bertalot et Werum, on the other hand, shares the outline with *D. ingeae*, but lacks the typical areolae arrangement of the latter species.

Diadesmis latestriata is also unmistakable in both LM and SEM due to the broad foramina, the narrow valve shape and (in SEM) the two raised rims.

The genus *Diadesmis* is growing rapidly, with new taxa from worldwide locations continually being described (e.g. New Caledonia: Moser *et al.,* 1998 ; Andes: Rumrich *et al*., 2000). In a recent paper dealing with *Diadesmis* living on mosses and in freshwater habitats from the Crozet and the nearby Kerguelen Archipelago, several new species were described (Le Cohu & Van de Vijver, in press). With a total of almost 10 new taxa, this means that a unique, possibly endemic *Diadesmis* flora exists on the Subantarctic Islands, especially since the more commonly known species (such as *D. contenta* (Grunow) Mann) are present in only very low abundances.

Acknowledgements. This survey has been made possible with the logistic and financial support of the 'Institut Français pour la Recherche et les Technologies Polaires' (France) in the frame of the Terrestrial Ecology Programme 136 (Dr. Y. Frenot). Additional funding was provided by the Science Foundation, Flanders (FWO). The Department TEWO provided the necessary SEM facilities. Prof. Em. Dr. R. Le Cohu and Prof. Em. Dr. H. Lange-Bertalot are thanked for their stimulating discussions. The review has been done by Prof. Dr. Dr. h.c. Horst Lange-Bertalot. Bart Van de Vijver is a post-doctoral researcher at the FWO, Flanders.

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