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# Observations of two new species of *Navicula* : *N. exiloides* and *N. delicatilineolata*

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# *Navicula* 属 2 新種 *N. exiloides* と *N. delicatilineolata* の観察

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**Abstract**

Two *Navicula* species are newly described from several Japanese rivers and a pond. *Navicula exiloides* nov. sp. resembles *Navicula exilis*, but differs in the size range, apical shape, angle of striation and areola density. Although *Navicula delicatilineolata* nov. sp. bears similarities to *Navicula heimansioides*, they are distinguishable by the shape of both the valve and axial area.

**Key index words :** diatom, *Navicula delicatilineolata*, *Navicula exiloides*, new taxa, taxonomy

## Introduction

In the past ten years, taxonomic studies of *Navicula cryptocephala* Kütz. and its relatives have clearly delimited their circumscriptions based on the confirmation of their types and observations with scanning electron microscopy (e.g. Cox 1995, Lange-Bertalot 1993, 2001). From these studies, it has become clear that one species, which had been observed frequently in Japanese rivers and was considered one of the *N. cryptocephala* complex, was in fact part of a remainder group, and should be newly described. In this paper I undertake a description of this diatom under the name of *Navicula exiloides*. Another species *Navicula delicatilineolata* showing a rhombic-lanceolate valve is also newly described here.

## Material and Methods

The following materials were used for light microscopy (LM) and scanning electron microscopy (SEM) :

K-5384 (Sample no.), Yoshida-gawa (Yoshida River), Kamiyoshida, Yoshida-cho, Saitama (leg. Kobayasi, H., November 1959).

K-5385, Isama-gawa (Isama River), Sawaguchi, Yoshida-cho, Saitama (leg. Kobayasi, H., November 1959).

K-5374, Susuki-gawa (Susuki River), Ohkagura, Ryokami-mura, Saitama (leg. Kobayasi, H., November 1959).

K-2561, A pond at Junshin women's high school, Nagasaki-shi, Nagasaki (leg. Ueno, R., February 1980).

The cleaning methods for diatom cells are given in Mayama & Kobayasi (1984). Cleaned specimens were embedded in Pleurax for LM, and also mounted on the SEM stubs coated with Au-Pa followed by observation with JEOL F15 at an accelerating voltage of 15kV.

## Descriptions

***Navicula exiloides* H.Kobayasi et Mayama, nov. sp.** **Figs 1-10**

*Frustula anguste rectangulata in aspectu cingulari. Valvae late lanceolatae, apicibus obtuse rotundatis, 11-25 μm longae, 5.5-7 μm latae. Raphe filiformis poris centralibus modice distinctis. Area axialis angustissima sed area centralis ampla, plusminusve rotundata aut parum transverse rectangularis. Striae transapicales in media parte val-*

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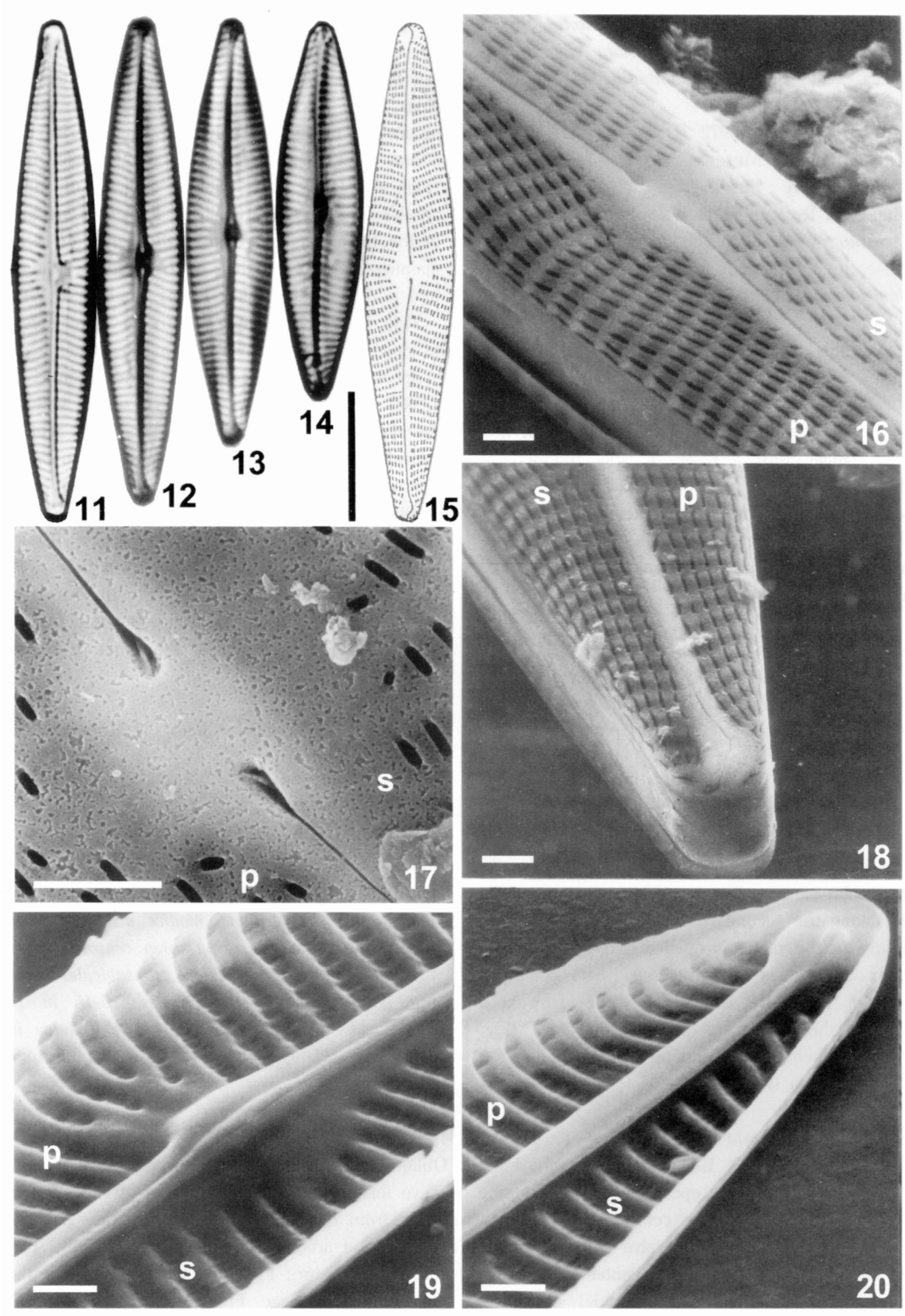
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*varum modice radiantes ad polos versus parallelae vix convergentes, 12-14 in 10 μm, lineolae circiter 30-35 in 10 μm. Cellulae in statu vivo, chloroplastis cuobus elongates et laminalibus.*

**Holotype**: TNS-AL-53972 (Department of Botany, National Science Museum, Tokyo (TNS)).
**Type locality**: Susuki-gawa (Susuki River), Ohkagura, Ryokami-mura, Saitama, Japan
**Etymology**: The epithet *exiloides* was chosen because the morphology slightly resembles that of *Navicula exilis* Kütz.

Frustules narrowly rectangular in girdle view. Valves lanceolate, ends obtusely rounded, 11-25 μm long, 5.5-7 μm wide (Figs 1-5). Raphe filiform with distinct central pores. Axial area narrowly linear with a more or less rounded or slightly laterally expanded central area. Striae weakly radiate in the valve center and parallel or slightly convergent in the ends, 12-14 in 10 μm. Areolae of each stria, 30-35 in 10 μm. Each cell has two plate-like plastids.

SEM observations

Externally raphe branches form central pores at the central endings (Figs 6, 7). Inside of the central pore, a pleat protrudes from the primary side (Fig. 7, arrow), which is the side where the primary side of raphe-sternum is formed in valve ontogeny (e.g. Round *et al.* 1990). Outer fissures hook to the secondary side of the valve formation at both valve ends (Figs 6, 8). Internally, the raphe sternum has a weakly developed axial rib, along the secondary side of which the inner fissure of the raphe is opened (Figs 9, 10). The inner fissure is not discrete but continues through the valve center, at which part both sides of the fissure are distinctly thickened (Fig. 9). The inner fissures end to form helictoglossae at both apices (Fig. 10).

Areolae forming each stria align in a shallow trough of the valve interior (Figs 9, 10), 30-35 in 10 μm. They are occluded by ricae internally but have longitudinal slit-like openings externally (Figs 6, 8). Each apex bears a transverse series of areolae (about 8), which are characteristically denser than those of the striae on the valve face (Figs 6, 8). As each slit-like opening of these areolae is oriented vertically at the apical juncture of the valve face and mantle, the series of these openings resembles that of *Hippodonta*. Cingulum is composed of plain bands (Figs 6, 8, 10).

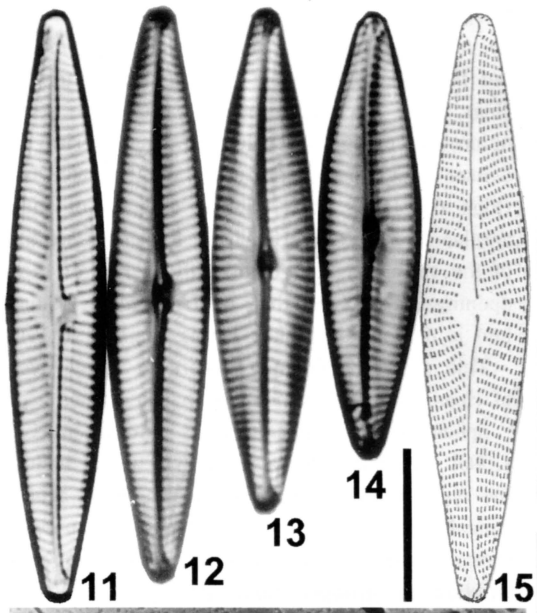
This species frequently occurs in many rivers of clear water but sometimes in lakes also.

Specimens of *Navicula exilis* shown by Cox (1995) and Lange-Bertalot (2001), which include the type population of this species, have acutely cuneate apices in shorter valves and somewhat rostrate apices in longer valves. Their angle of striation is stronger than that of *N. exiloides*. Lange-Bertalot (2001) reported the areola density in its stria to be ca. 40 in 10 μm, but that of *N. exiloides* is not so fine. In addition, the range of valve length reported by Lange-Bertalot for *N. exilis* (20-45 μm) is greater than that of *N. exiloides*.

### *Navicula delicatilineolata* H. Kobayasi et Mayama, nov. sp. Figs 11-20

*Frustula anguste rectangulata in aspectu cingulari. Valvae modice lanceolatae usque ad rhombico-lanceolatae, apicibus obtuse ad paulo latius rotundatae, 29-42 μm longae, 6.5-7.5 μm latae. Raphe filiformis poris centralibus modice distinctis. Area axialis linearis, angustissima, area centralis asymmetrica unilateraliter. Striae transapicales radiantes sub polos satis convergentes, 15-16 in 10 μm, lineolis circiter 30-35 in 10 μm Cellulae in statu vivo, chloroplastis cuobus elongates et laminalibus.*

**Figs 1-10.** *Navicula exiloides*. **Figs 1, 10.** K-5384 (Yoshida-gawa). **Fig. 2.** K-5374 (Susuki-gawa), (Holotype). **Figs 3-9.** K-5385 (Isama-gawa). **Fig. 6.** Oblique view of the theca showing striation composed of slit-like areola openings. p: primary side of valve formation. s: secondary side of valve formation. **Fig. 7.** Detail of the central pore. Note a projection from the wall of the primary side (arrow). **Fig. 8.** Enlargement of the valve end showing the apical row of areolae aligned characteristically. **Fig. 9.** Internal view of the valve center showing indiscrete inner fissure. **Fig. 10.** Oblique view of the valve end with the first band (copula) showing areolae occluded by ricae. **Figs. 1-3.** LM. **Figs 4, 5.** Drawings. **Figs 6-10.** SEM. Scale bars = 10 μm (**Figs 1-5**) or 1 μm (**Figs 6-10**).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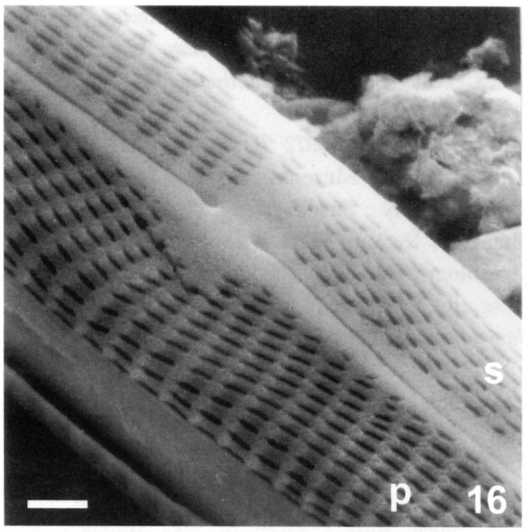
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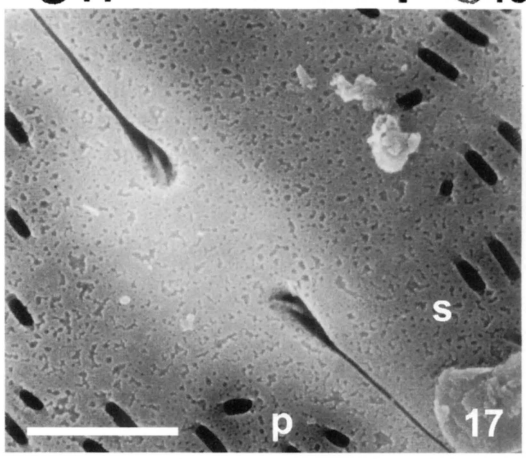
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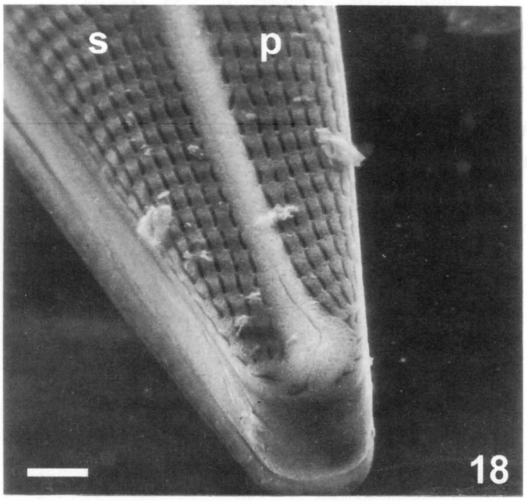
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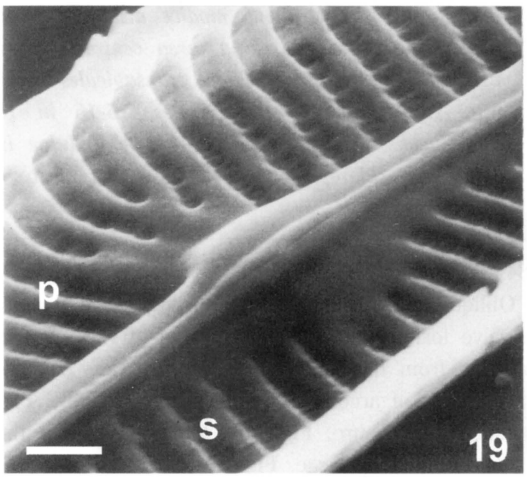
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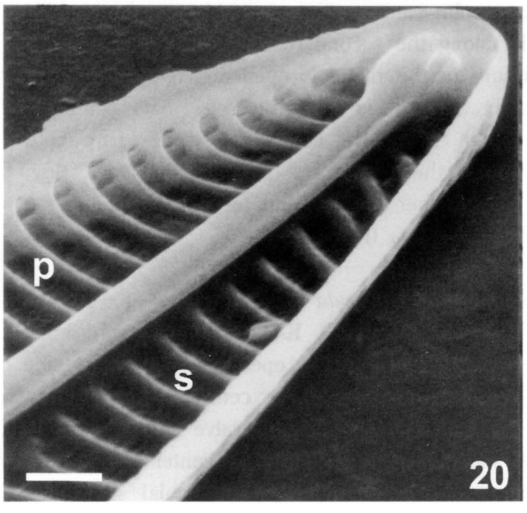
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**Holotype**: TNS-AL-53973 (Department of Botany, National Science Museum, Tokyo (TNS)).
**Type locality**: A pond at Junshin women's high school, Nagasaki-shi, Nagasaki.
**Etymology**: The epithet *delicatilineolata* was chosen because of its delicate shape and striation.

Frustules narrowly rectangular in girdle view. Valves moderately lanceolate to rhombic-lanceolate, ends obtusely or a little widely rounded, 29-42 μm long, 6.5-7.5 μm wide (Figs 11-15). Raphe filiform with distinct central pores. Axial area narrowly linear with a distinct, laterally asymmetrical central area. Striae radiate in the valve center and convergent at both ends, 15-16 in 10 μm. Areolae of each stria, 30-35 in 10 μm. Each living cell has two plate-like plastids.

SEM observations

The central endings of external raphe branches form elongated central pores (Fig. 16), which bear a longitudinally elongated pleat-like projection from the central side of the pore wall (Fig. 17). These branches terminate externally in hooked polar fissures at both apices (Fig. 18). Internally the raphe sternum has a well-developed axial rib on the primary side (Figs 19, 20). The inner fissures of the raphe branches are situated laterally on the axial rib beside the secondary side of the valve (Figs 19, 20). At the valve center the inner fissures end linearly; at that point, both sides of the fissures become thick and the axial rib develops somewhat to the primary side of the valve (Fig. 19). The polar endings of the raphe interior form helictoglossae (Fig. 20).

Each stria is composed of a single row of areolae, which are situated in a shallow trough of the valve interior and occluded by ricae (Figs 19, 20). The areola density is 30-35 in 10 μm. The outer openings of the areolae are longitudinal slits (Figs 16-18) except for several openings, which are oriented horizontally with a slight angle at the apical juncture of the valve face and mantle (Fig. 18).

The cingulum is composed of at least three split bands without areolae (Figs 16, 18).

This species has been recorded only from Japanese lakes or ponds. Recently Tuji (2003) reported this species from the bottom sediments of Lake Biwa, although he also classified different species into the same taxon in part. *N. delicatilineolata* is similar to *Navicula heimansii* Dam and Kooijman. However, *N. heimansii* is smaller and has finer striation (16-18 in 10 μm) and areolation (50 in 10 μm) (Van Dam & Kooyman 1982) than *N. delicatilineolata*. Moreover, a SEM photograph in Van Dam & Kooyman's paper showed round central pores of raphe endings in *N. heimansii*.

Probably *Navicula heimansioides* Lange-Bertalot (1993) shows the closest relationship to *N. delicatilineolata*. Dimensions of both species are quite similar except for valve width, in which dimension *N. heimansioides* is wider. Nevertheless, *N. delicatilineolata* is recognized as a separate taxon, because it shows a somewhat narrow rhombic outline, a remarkably asymmetric central area and outer fissures deflecting toward the primary side of the valve near the center. It is expected that the differences in morphology and distribution areas between the two species will be explained by phylogenetic studies using molecular techniques hereafter.


## 摘　　要

本邦の河川および湖沼から2新種 *Navicula exiloides* H.Kobayasi et Mayama および *Navicula delicatilineolata* H.Kobayasi et Mayama を記載した。*N. exiloides* は *Navicula exilis* に類似するが *N.*


**Figs 11-20.** *Navicula delicatilineolata*. K-2561 (A pond at Junshin women's high school). **Fig. 16.** Oblique view of the valve center showing asymmetrical central area, which is rectangular on the primary side but a longitudinally elongated triangle on the secondary side. **Fig. 17.** Detail of the central pores with the pleat-like projections. **Fig. 18.** Oblique view of the frustule end. Note the slit-like openings oriented horizontally with a slight angle at the apical juncture of the valve face and mantle. **Fig. 19.** Internal view of the valve center showing the discrete inner fissure by the side of the slightly expanded axial rib. **Fig. 20.** Internal view of the valve end showing well-developed interstria as well as axial rib. **Figs 11-14.** LM. **Fig. 15.** Drawing. **Figs 16-20.** SEM. Scale bars = 10 μm (**Figs 11-15**) or 1 μm (**Figs 16-20**).

*exiloides* は殻端が楔状や嘴状に突出せず，広円で終わること，条線の角度がより弱いこと，条線を構成する胞紋密度がより低いこと，変異する殻長の範囲がより短い方にあることから区別ができる。また *N. delicatilineolata* は *N. heimansii* および *N. heimansioides* に類似するが，前者とは *N. delicatilineolata* がより大きく，粗い条線密度および胞紋密度を示すこと，および縦溝の中心孔の形状から区別することができ，後者とは，本種がより菱形に近い皮針形の殻外形をもつこと，および明瞭に左右不相称な形状の中心域をもつことから区別することができる。

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