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## *Eunotia nymanniana* Grunow and related taxa

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*Eunotia nymanniana* Grunow とその近縁種

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### Abstract

The type slide of *Eunotia nymanniana* Grun. was observed. On the basis of this observation, *E. nymanniana* collected from Japan was examined in detail. The fine structures of this species and *Eunotia compacta* (Hust.) Mayama nov. stat. were described. They are clearly distinguished by means of the areolae density in addition to the valve shape.

### Key index words

diatom, *Eunotia compacta*, *Eunotia exigua*, *Eunotia nymanniana*, taxonomy.

### Introduction

*Eunotia exigua* (Brébisson ex Kützing) is a cosmopolitan species, occurring in acid waters. This species is known to be a diatom which shows a wide range of morphological variability, as much as is shown in other *Eunotia* species (Mayama & Kobayasi 1991, Mayama 1992, Mayama 1995a, 1995b). As is reviewed by Ko-Bayashi (1994), several varieties and forms of *E. exigua* and several different species akin to *E. exigua* were established and/or discussed by some authors (e.g. Mayer 1918, Hustedt 1930, Cleve-Euler 1953, Patrick & Reimer 1966 and Krammer & Lange-Bertalot 1991), however, these authors differ in their taxonomical recognition of these taxa. *Eunotia nymanniana* Grunow is one of such taxa.

I observed the type slide of *E. nymanniana* at the herbarium of Naturhistorisches Museum Wien. The diatoms collected from an acidic Japanese river were quite similar to the specimens of the type slide in shape and dimension and identifiable as *E. nymanniana*. The fine structures were observed in this taxon as well as in *E. compacta* (Hustedt) Mayama using a scanning electron microscope (SEM).

### Materials and Methods

The samples and slides used in this study are listed as follows:

*E. nymanniana*: Lectotype (desig. by Mayama).

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Ckristiania, Grunow 2020 (W); Epilithic sample from the Susawa River, at Hakone-machi, Kanagawa Pref., Central Japan, on December 12, 1993.

*Eunotia steinecki* Petersen: Isotype. J. C. Kingston's coll., Lyngby Mose, sphagnum bog (C).

*Eunotia elegans* Østrup: Holotype. Denmark, Jylland, Oxboel, Østrup 153 (C).

*Himantidium exiguum* Brébisson ex Kützing: Kützing's coll. BM-17872 (BM).

*E. compacta*: Epiphytic diatom sample from a sphagnum bog at Sugadaira in the Mt. Azuma, Fukushima Pref. Japan, on October 10, 1986, K-6393 (leg. Mayama).

The cleaning methods for the diatom sample and the preparation procedure for the observations are described by Mayama & Kobayasi (1984). JEOL F-15 Scanning Electron Microscope (SEM) was used for the fine structural observations.

A term, valve face and mantle juncture (FMJ), was used with a definition given by Mayama (1992).

### Results and Discussion

*Eunotia nymanniana* Grunow Figs 1-6, 8-17  
Lectotype: Ckristiania, Grunow 2020 (W).

Synonym: *Eunotia steinecki* J. B. Petersen 1950, pl.2. figs 10-15. 1950.

The light micrograms of the specimens from the

Susawa River are shown in Figs 1-5. Valves are narrow and arcuate with ventrally concave and dorsally convex sides, and with slightly protracted and rounded or capitate ends. The valve length is 11-37  $\mu\text{m}$  and the width 3.2-4.0  $\mu\text{m}$ . Transapical striae are parallel and 20-22 in 10  $\mu\text{m}$ . The degree of curvature is nearly the same in both ventral and convex sides.

Grunow illustrated two figures in the original description of *E. nymanniana* (in Van Heurck 1881, pl.14, figs 8 left, right) (= Figs 6, 7). Fig. 6 shows both sides curved moderately, the same as my specimens (Figs 1-5), but Fig. 7 shows the weakly curved dorsal side and the almost straight ventral side.

At Naturhistorisches Museum Wien is "Van Heurck's Synopsis" in which Grunow wrote in, by hand, the localities and slide numbers he used. The slide numbered for Grunow's fig. 8 left contains only specimens quite similar to his drawing (compare Fig. 6 and Figs 8-11). Probably his fig. 8 right (Fig. 7) was illustrated from another slide, but the figure has no index number. Therefore, I designate the slide with the index number 2020 as a lectotype. The specimens in this slide are 21-40  $\mu\text{m}$  long, 2.5-3.5  $\mu\text{m}$  wide and 20-23 striae in 10  $\mu\text{m}$ . The valve shape and dimensions of the Japanese diatoms coincide well with them.

Ultrastructurally the external surface of the valve face is flat in the main part but rounded near the FMJ in both ventral and dorsal sides in Japanese specimens (Figs 12, 13). A pattern center, or a sternum, runs parallel to the FMJ, and does not unite with the FMJ.

In the valve ends, the external raphe branches curve in and slightly back away from the poles and end in circular depressions and from there, the narrow hyaline area is faintly elongated (Figs 12, 13, 17). They are slightly inflated and rounded in the central endings (Fig. 13). The valve mantle is shallow and there is only a single transapical row of areolae between the FMJ and

the raphe branch. Striae are composed of a single row of areolae, apertures of which are located at a slightly lower level than that of the interstriae, and which have pore occlusions as seen in *Eunotia arcus* Ehrenb. (Mayama & Kobayasi 1991) and *Eunotia valida* Hust. (Mayama 1997) (Fig. 14). Since these occlusions are very delicate, most were not intact when they were observed. The areolar density is 50-60 in 10  $\mu\text{m}$ .

Internally, the valve surface is smooth and internal apertures of the areolae are located at the same level (Fig. 15). Each valve has a labiate process. Whenever the valve inside is oriented as in Fig. 15, the labiate process is located at the top of the apical mantle almost on the apical axis (compare with Fig. 16). The helictoglossae tilt slightly and are located at the valve ends (Figs 15, 16). The epicingulum consists of four open bands (Fig. 17). Their open and closed ends are arranged alternately. The epitheca depth is about 4  $\mu\text{m}$ .

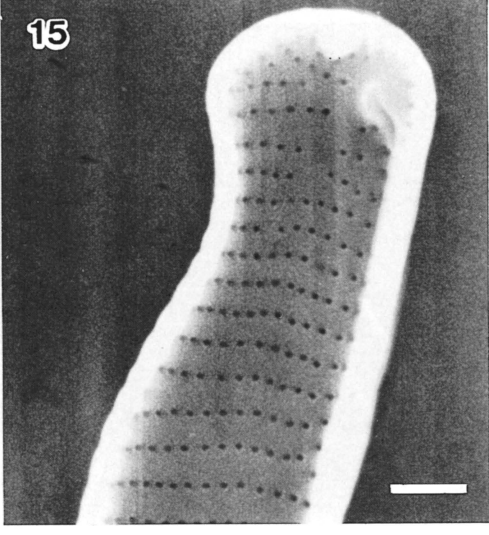
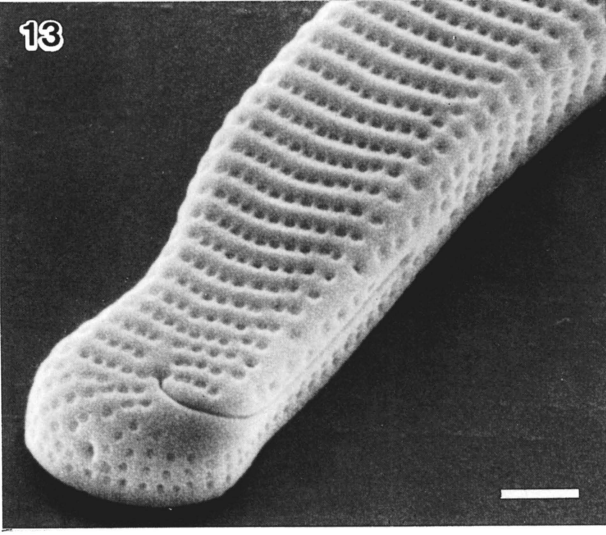
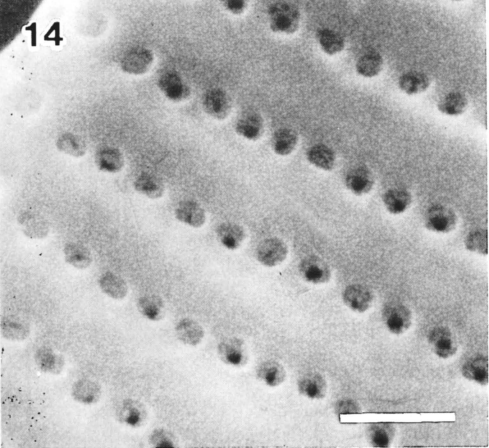
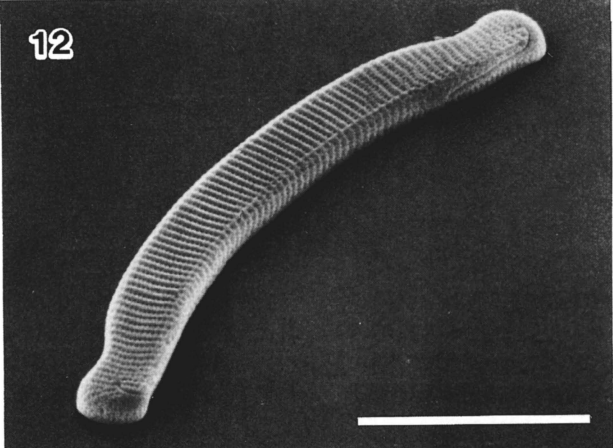
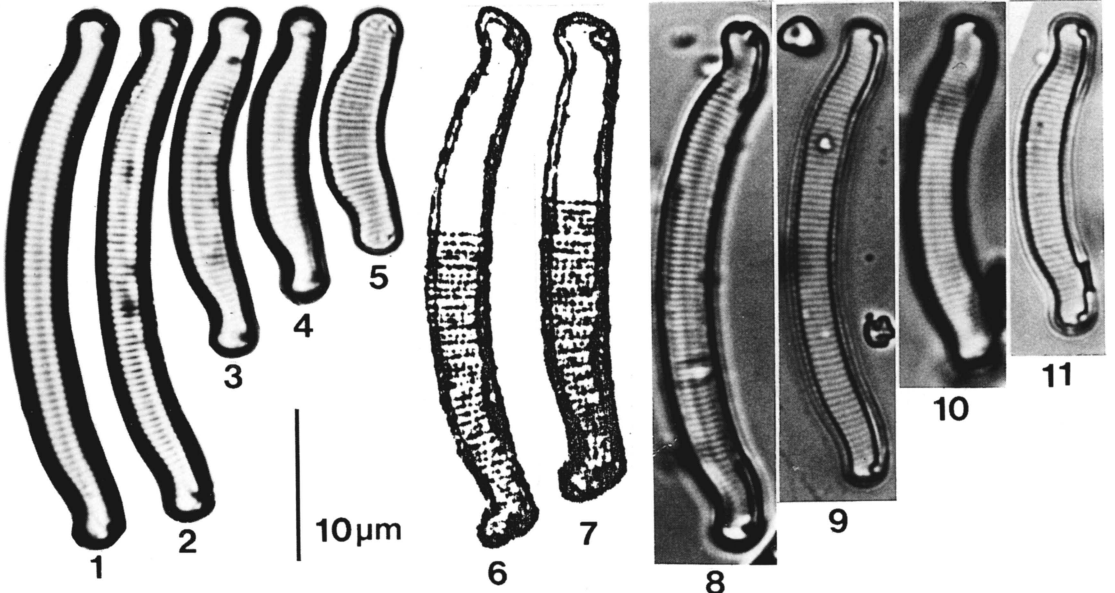
The lectotype slide contains specimens somewhat narrower (e.g. Figs 9, 11) than those from the Susawa River. They are quite similar to the isotype of *E. steinecki* Pet. (Figs 18, 19), so that *E. steinecki* is a later synonym.

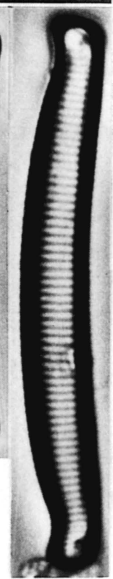
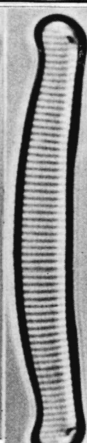
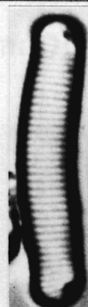
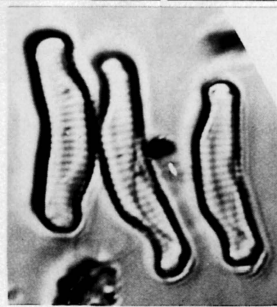
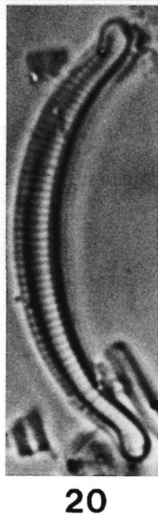
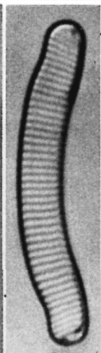
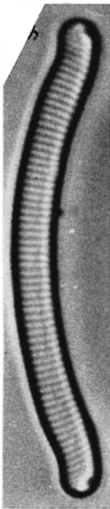
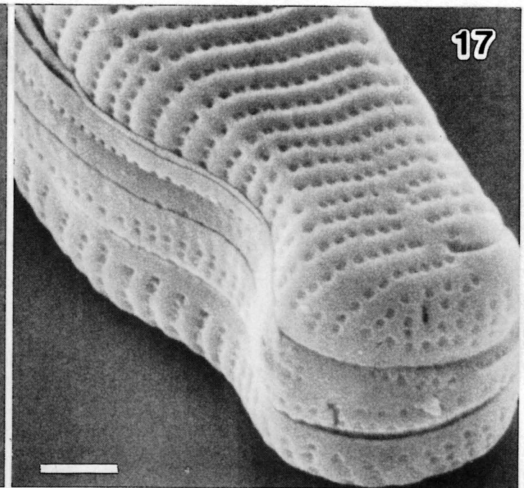
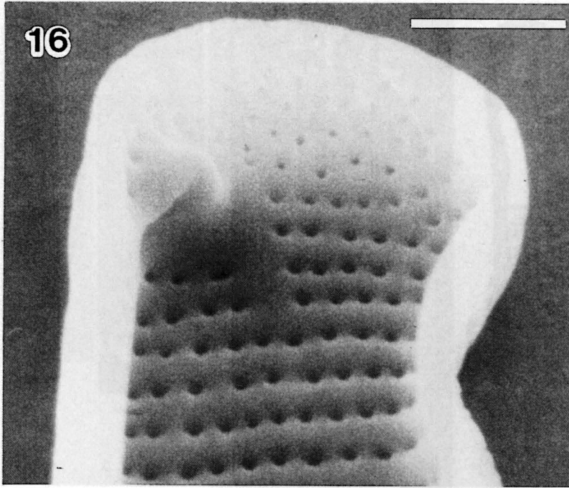
The holotype of *E. elegans* Østr. shares valve characteristics similar to *E. nymanniana* (Fig. 20), however, the degree of curvature is stronger than that of *E. nymanniana*. A complete comparison of the frustules using SEM seems to be necessary for clarifying the taxonomic problem between these species.

Hustedt (1930) pointed out that *E. nymanniana* figured by Grunow (in Van Heurck 1881, pl. 14, fig. 8 left) was conspecific with *E. exigua*. He stressed this again in Kryptogamen-Flora with many figures (Hustedt 1932, fig. 751). Conversely, Krammer & Lange-Bertalot (1991) believed that *E. steinecki* (= *E. nymanniana* in this paper) was distinguishable from *E. exigua*. I tried to find the type slide of the *Himantidium*

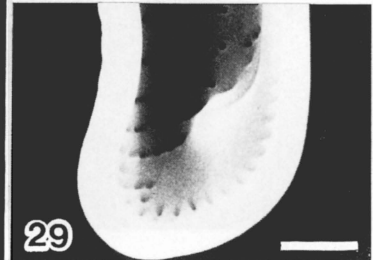
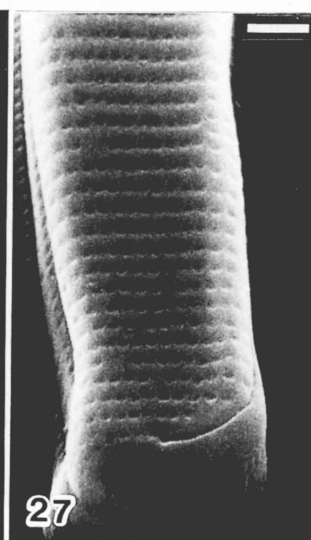
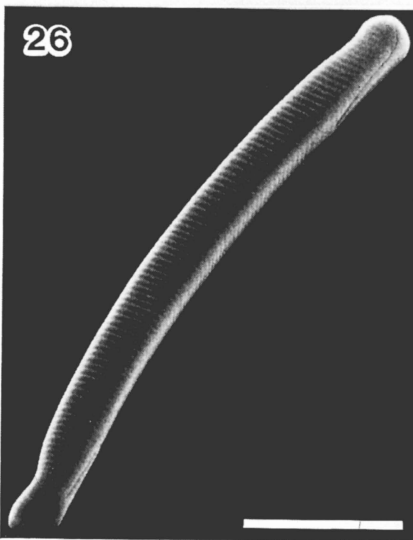
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Figs 1-15. *Eunotia nymanniana*. Figs 1-5. Specimens from the Susawa River. LM. Figs 6, 7. Drawings by Grunow in Van Heurck 1881, pl. 14. Fig. 6. Grunow's fig. 8 left. Fig. 7. Grunow's fig. 8 right. Though it was identified as *E. nymanniana* by him, probably not but *E. compacta*. Figs 8-11. Specimens in lectotype slide. LM. Figs 12-15. SEM. Fig. 12. External oblique view of a whole valve. Fig. 13. Enlargement of the valve end showing the external raphe branch slightly backing away from the pole in the valve face. Fig. 14. Enlargement of the external valve face showing transapical rows of areolae each occluded by a thin siliceous layer, though partly broken. Fig. 15. Internal view of the valve end showing the labiate process and helictoglossa. Figs 1-12, scale bar = 10  $\mu\text{m}$ ; Figs 13, 15, scale bar = 1  $\mu\text{m}$ ; Fig. 14, scale bar = 0.5  $\mu\text{m}$ .





10µm



*exiguum* Bréb. ex Kütz. in Kützing's collection at the Natural History Museum, however, I could find only a slide labeled *H. exiguum* but without locality name. This slide contains many short specimens (Fig. 21) and they are allowed under the circumscription of the taxon which has been accepted by many authors. A population presented as *E. exigua* by Kitazawa (1995) is 11-33  $\mu\text{m}$  in the valve length. The shape of the small valve is quite similar to that of the valve in Kützing's slide and the shape of the long valve to that of Grunow's *E. nymanniana*. In addition, similar specimens are also seen in a population from Misaka Pond (Ko-Bayashi 1994). It is likely that *E. nymanniana* is the name given to longer specimens whose length is close to the length of the initial valve in the life cycle. However, it is necessary to find and examine the type material of *E. exigua* for the ultimate resolution of this taxonomical problem.

***Eunotia compacta* (Hustedt) Mayama nov. stat.**

Figs 22-31

Basionym: *Eunotia exigua* var. *compacta* Hustedt 1930. Bacillariophyta (Süßwasserflora Mitteleuropas. Heft 10), p. 176. fig. 225.

*Eunotia nymanniana* auct. non Grunow: Hustedt 1924, taf. 18, figs 16, 17; Krammer & Lange-Bertalot 1991, taf. 154, figs 31-38.

Lectotype: L1/75. Riesengebirge. Lomnitz. 34. (BRM) (desig. by Simonsen 1987).

The valves collected from a sphagnum bog are weakly arched and have weakly protracted and roundly-truncated ends (Figs 22-25). The degree of the curvature in the ventral side is less than that of the dorsal side and in fact, it is often almost straight. They are 18-57  $\mu\text{m}$  long, 3.5-5.0  $\mu\text{m}$  wide and the striae are

20-22 in 10  $\mu\text{m}$ . Their shape and dimensions are similar to Grunow's other drawing of *E. nymanniana* (in Van Heurck 1881, pl.14, fig.8 right) (Fig. 7).

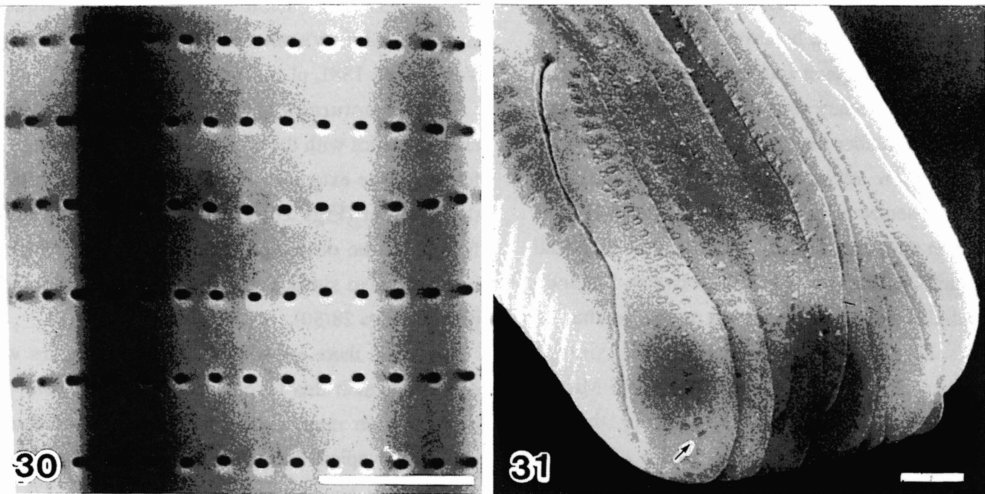
Ultrastructurally the frustules share many characteristics with the "true" *E. nymanniana*, i.e. the feature of the external valve and mantle, the location of the sternum (Figs 26, 27), areolar position and the feature of the occlusion (Fig. 27), the feature of the internal valve surface and the position of the labiate process (Figs 28-30).

However, there are some other characteristics which can distinguish this taxon from *E. nymanniana*. The external polar raphe ending is located at the valve end close to the apices on the apical axis and has no narrow hyaline area backing away from there (Fig. 27). The helictoglossae are located at the valve ends, and though they are only slightly apart from the apices, this distance is a bit longer than that of *E. nymanniana* (compare Figs 28, 29 with Fig. 15). The epicingulum consists of 5-8 open bands and the epitheca depth is 3-5  $\mu\text{m}$  (Fig. 31). In addition, the areola densities of this taxon and *E. nymanniana* are different. It is 40-50 in 10  $\mu\text{m}$  in the former but 50-60 in the latter. The areolae density is very stable throughout the life cycle of *Eunotia* (Mayama & Kobayasi 1991, Mayama 1992) and is sometimes a very important characteristic to distinguish similar taxa (e.g. Mayama 1993, Mayama 1997).

The figure of *E. exigua* var. *compacta* Hustedt (1930) shows larger valve ends than those of my specimens. However, it is obvious that the type material contains specimens with ends of various sizes as seen in Simonsen (1987, pl. 91, figs 18-23) and Krammer & Lange-Bertalot (1991, taf. 154, figs 31-38, as *E. nymanniana*). In addition to Hustedt's specimens, Krammer & Lange-Bertalot also showed a population composed only of specimens with smaller ends (taf.

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Figs 16, 17. *Eunotia nymanniana*. SEM. Fig. 16. Enlargement of the opposite end without labiate process of the valve in Fig. 15. Fig. 17. Frustule showing the epitheca with four bands and hypovalve with the narrow hyaline area elongated from the external polar raphe ending. Figs 18, 19. *Eunotia steinecki*. Specimens in isotype slide. LM. Fig. 20. *Eunotia elegans*. Holotype. Fig. 21. *Eunotia exigua*. Kützing's coll. "*Himantidium exiguum*" BM-17872. LM. Figs 22-29. *Eunotia compacta*. Figs 22-25. Specimens from Sugadaira. LM. Figs 26-29. SEM. Fig. 26. External oblique view of a whole valve. Fig. 27. Details of the external valve end showing the polar raphe ending. Fig. 28. Enlargement of the internal valve end showing the labiate process on the apical mantle. Fig. 29. Enlargement of the opposite end of the valve in Fig. 28 showing the apical mantle without labiate process. Figs 16, 17, 27-29, scale bar = 1  $\mu\text{m}$ ; Figs 18-26, scale bar = 10  $\mu\text{m}$ .



Figs 30, 31. *Eunotia compacta*. SEM. Fig. 30. Enlargement of the internal valve face showing the transapical areolar openings aligned on the same level as the valve surface. Fig. 31. Detail of the end of the frustule showing the epicingulum composed of eight open bands and outer opening of the labiate process (arrow). Figs 30, 31, scale bar = 1  $\mu$  m.

154, figs 39-43). Thus, the range of variability in the end size seems to be fairly wide in this taxon. The specimens with large ends also occurred in Japan but were rare (unpublished data).

Although the type material of *E. exigua* has not been found and examined, in contrast to the definition of *E. exigua* sensu auct. nonnull., *E. exigua* var. *compacta* with valve curvature different from the nominate variety should be established as a species.

#### Acknowledgement

I express my gratitude to the late Prof. Dr. Hiromu Kobayasi of the Tokyo Diatom Institute for his constant encouragement and guidance during this study. My special thanks are due to Dr. Uwe Passauer of Naturhistorisches Museum Wien, Dr. J. B. Hansen of Universitets Botaniske Museum and Ms. P. A. Sims of the Natural History Museum for access to the type slides.

#### 摘 要

*Eunotia nymanniana* Grunow の原記載の絵には殻形の若干異なる 2 個体があり、本種の分類学上の扱いについては研究者によって異なる見解が示されてきた。筆者はウイーン自然史博物館に保存されている Grunow の標本より本種のレクトタイプを

指定した。このスライドの中の個体は殻の腹側と背側の湾曲がほぼ等しくなるもので Grunow の原記載の左側の絵(in Van Heurck, Synopsis, pl.14, fig. 8, left)とよく一致するものであった。これに基づき本邦産の *E. nymanniana* と同定できる個体の被殻を SEM により観察した。条線を構成する胞紋列の密度は大変細かく 10  $\mu$ m 中に 50-60 個あった。縦溝の外裂溝は殻端でわずかに反転し穴状に終わるが、そこから線状の無紋域が短い距離伸長する。

また、*E. nymanniana* に類似する *E. exigua* var. *compacta* の SEM 観察を行った。この珪藻はは光学顕微鏡的には背側と腹側の湾曲が異なる(腹側はほとんど湾曲しない)ことから前出の種類と区別が可能であるが、微細構造的には条線を構成する胞紋列の密度がより粗いこと(40-50/10  $\mu$ m)、および外裂溝が殻端で反転せず殻頂付近で終わることなどの違いがあることがわかった。本分類群に対し、分類学上のランクの変更をおこなった。

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