

# Morphological Variation of *Gomphoneis quadripunctatum* (Østrup) R.Ross et P.A.Sims (Bacillariophyceae) in Lake Huvsgul, Mongolia

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**Abstract.** The morphological variation of *Gomphoneis quadripunctatum* from Lake Huvsgul, Mongolia, was examined. The morphological variations of the outline and the central area of frustles varied widely, indicating that they are unstable characters for identification of this taxon. Most of the ultrastructural characters on frustles obtained by scanning electron microscopy examinations were common among *Gomphoneis* taxa, and thus may not be useful for the identification for individual *Gomphoneis* taxa.

**Key words:** *Gomphoneis hastata*, pseudo-septum, ultrastructure.

## Introduction

*Gomphoneis* species with four stigmas are commonly found in east Asian water bodies (Kocielek & Stoermer, 1988; Tuji, 2005). *Gomphoneis quadripunctatum* (Østrup) P.A. Dawson ex R.Ross et P.A.Sims have been described as *Gomphonema olivaceum* var. *quadripunctatum* Østrup from Kossogol (Lake Huvsgul), Mongolia. Type examinations using original-type slides were performed by several diatomists (Foged, 1971; Kocielek & Stoermer, 1988; Tuji 2005). Tuji (2005) also designated the lectotype using an individual in slide 4368 in the Østrup collection in the Botanical Museum and Library, University of Copenhagen (C).

However, the differences in these similar taxa consist only of the size and form of the outline of the frustules; differences in ultrastructure have not been examined by scanning electron microscopy (SEM).

In this paper, we examined the morphological variation of *Gomphoneis quadripunctatum* (Østrup) R.Ross et P.A.Sims in Mongolia, and the differences in ultrastructures using SEM.

## Materials and Methods

Specimens were collected from Lake Huvsgul from 27th to 29th September, 2008, from stones, water grasses, sediments and artificial substrates at depths of 0 m to 1.5 m. Specimens from Lake Baikal collected from 28th August to 6th September, 2006, were also used for comparison. These specimens are kept in TNS (Department of Botany, National Museum of Nature and Science) and Botany Department, National University of Mongolia.

Specimens were oxidized with concentrate nitric acid, and mounted onto glass slides with Zrax (Microlife services, Somerset, U.K.). These permanent slides are observed using a microscope (Axiophot, Zeiss, Germany). Photographs were taken using a CCD camera (Lu-135M, Lunera Corp., Ottawa, Canada) and printed after image processing. Scanning electron microscopy (SEM) analysis was done using a scanning electron microscope (JEOL-6390LV, JEOL, Japan) equipped with lanthanum hexaboride cathode.

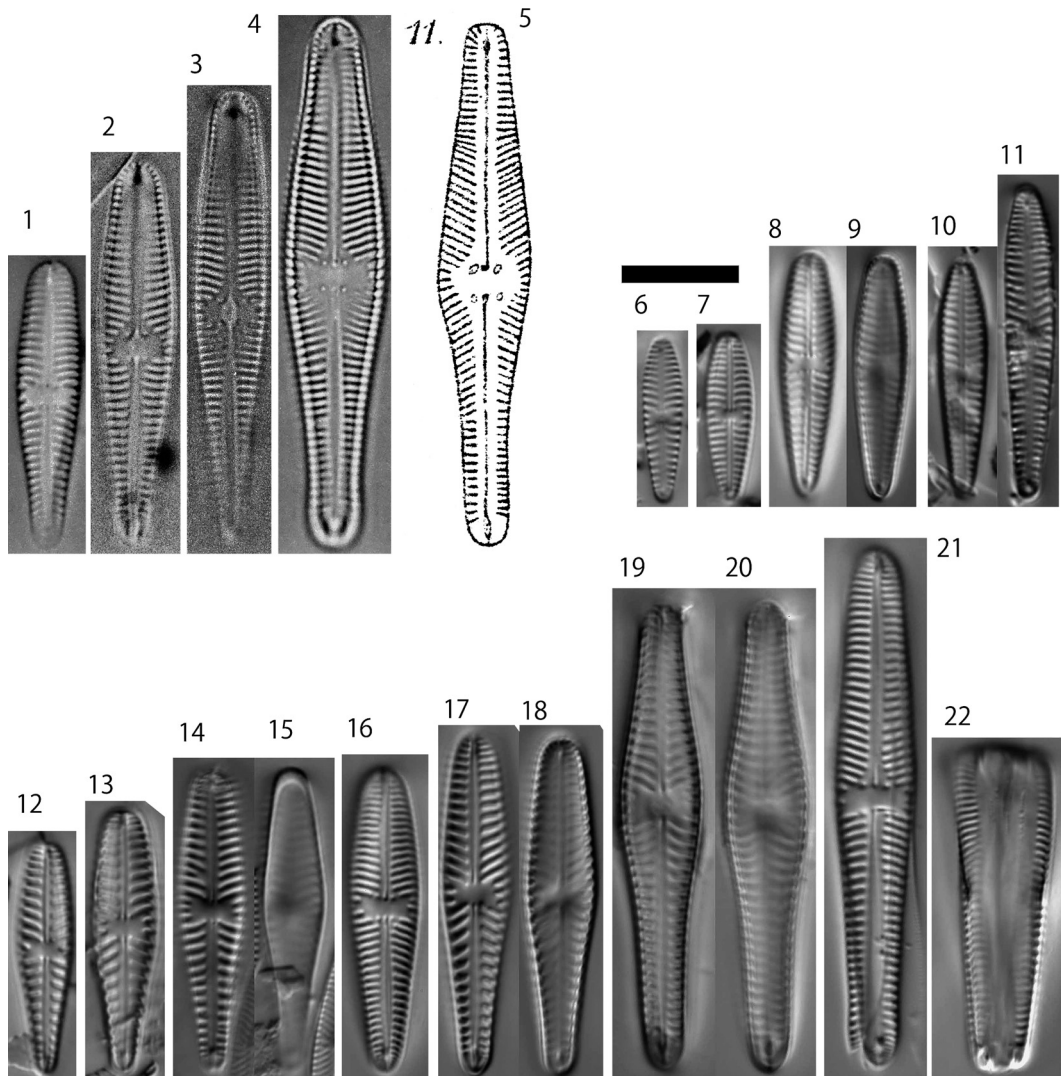
### Results and Discussion

The individuals in the slide numbered 4368 from the Østrup collection in C, the holotype *Gomphonema olivaceum* var. *quadripunctata* ( $\equiv$  *Gomphoneis quadripunctatum*), are presented in Figs. 1–4 (after Tuji, 2005). The original illustration in Østrup (1908) is presented in Fig. 5.

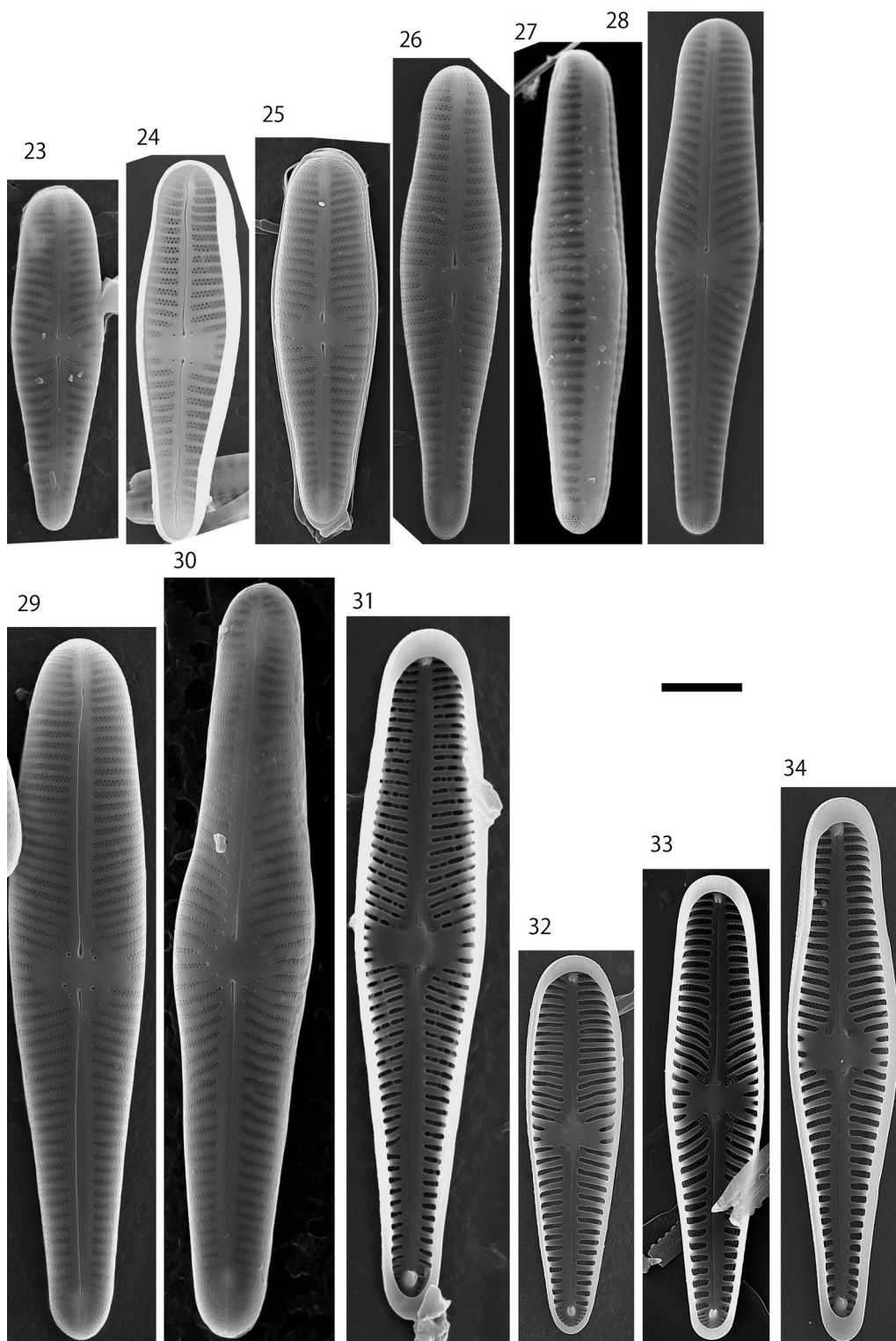
The morphological variation of the *Gomphoneis quadripunctatum* species complex in

these samples is very wide, and it is very similar to that of the specimens from Lake Baikal described by Kociolek & Stormer (1988).

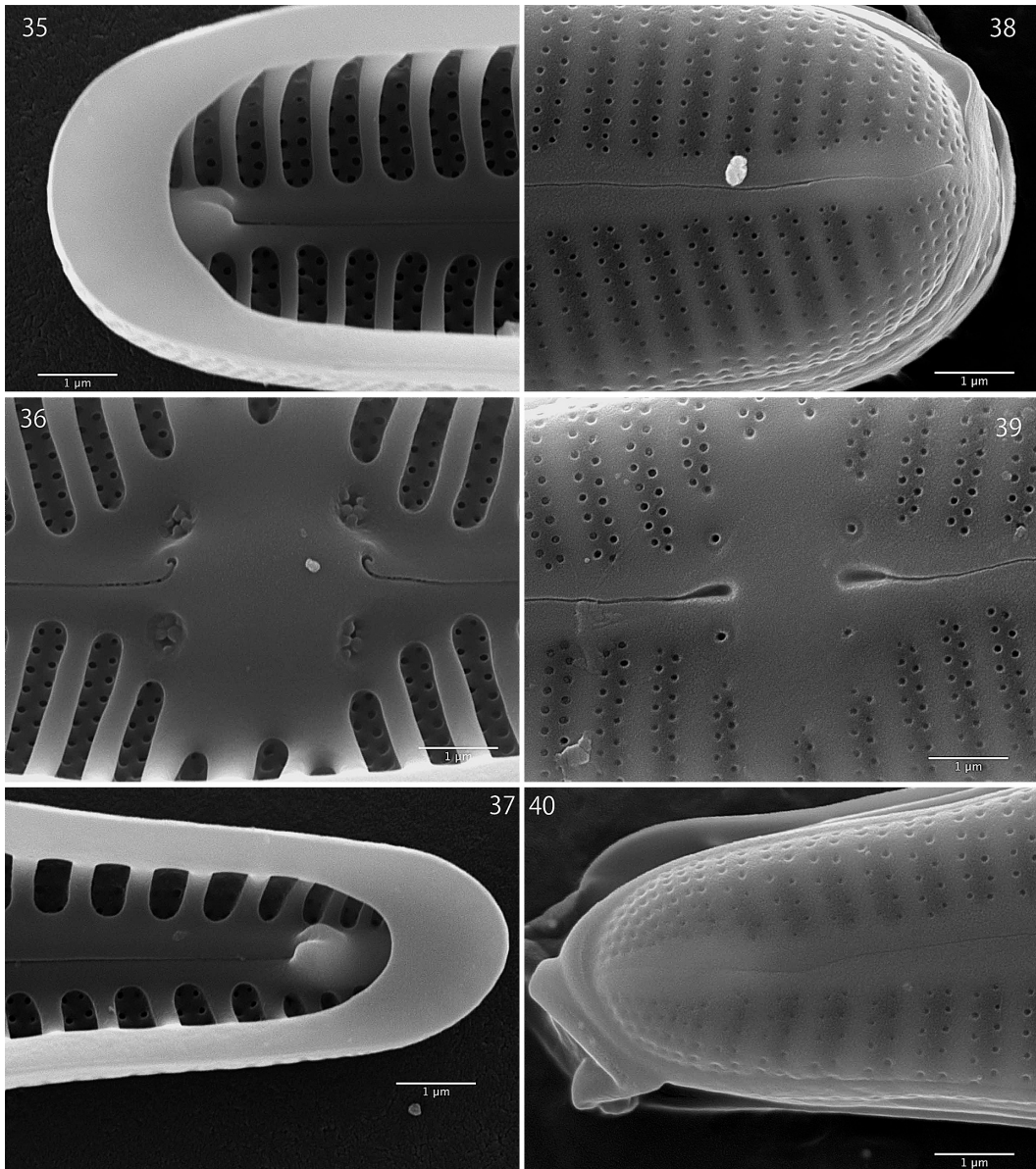
We found three morphological groups in Lake Huvsgul specimens for *Gomphoneis* individuals with four stigmas. The first group is presented in Figs. 6–11. These specimens have a narrow width (3–4  $\mu$ m) and fine striae (14–17 str per 10  $\mu$ m). The central areas are not clear. Striae become parallel and fine at the end of the frustules.



Figs. 1–22. *Gomphoneis quadripunctatum* (Østrup) R.Ross et P.A.Sims species complex from Lake Huvsgul, Mongolia. Bar=10  $\mu$ m. 1–4. Individuals in the slide numbered 4368 from the Østrup collection in C, the holotype *Gomphonema olivaceum* var. *quadripunctata* ( $\equiv$  *Gomphoneis quadripunctatum*). LM. 5. The original illustrations in Østrup (1908). 6–22. Individuals found in Lake Huvsgul, Mongolia. LM.



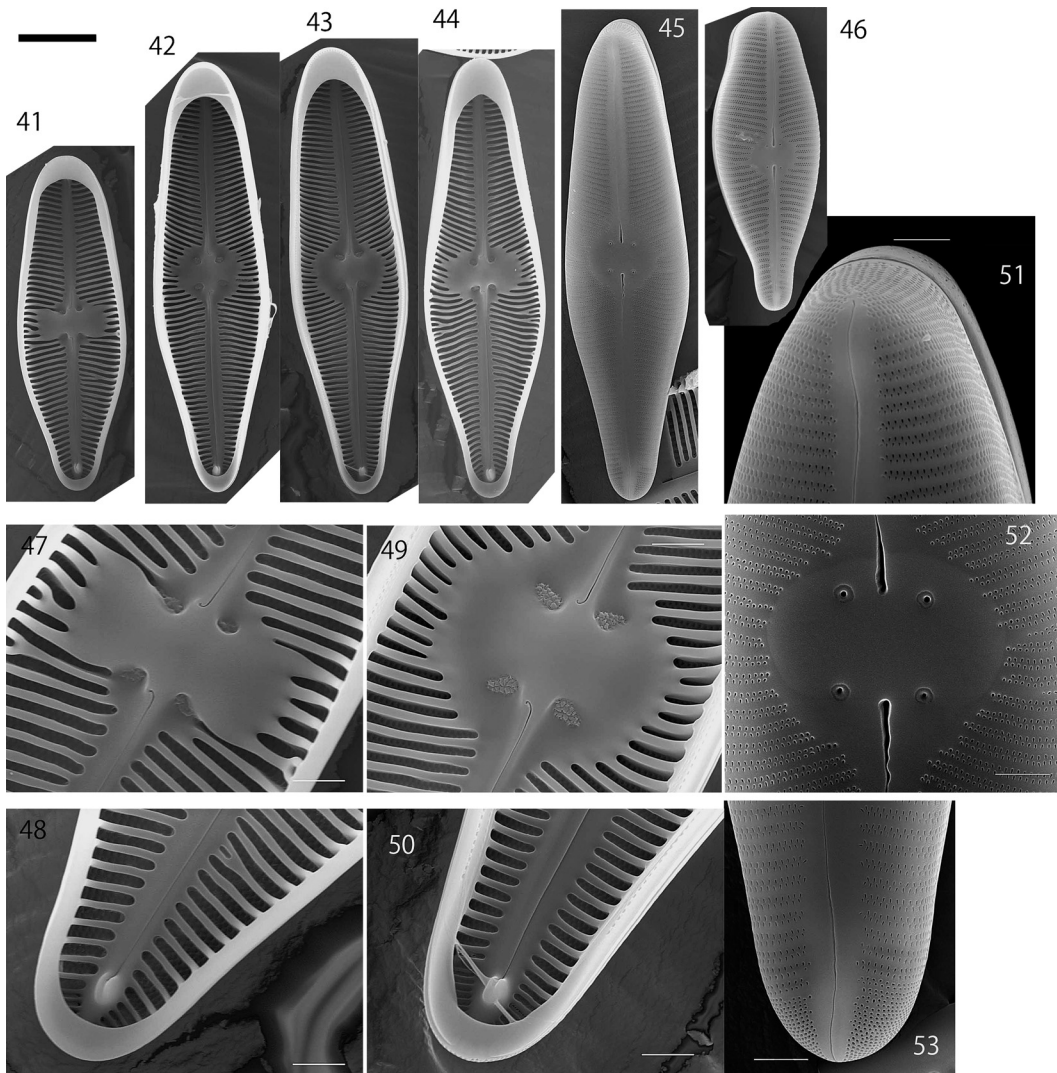
Figs. 23–34. *G. quadripunctatum* species complex from Lake Huvsgul, Mongolia. SEM. Bar=2  $\mu$ m. 23–30. Outer surfaces of frustules. 31–34. Inner surfaces of frustules.



Figs. 35–40. *G. quadripunctatum* species complex from Lake Huvsgul, Mongolia. SEM. Bar=1 µm. 35–37. Enlargements of Fig. 34, showing head pole (Fig. 35), central area and four stigma (Fig. 36), and foot pole (Fig. 37). 38–40. Enlargements of Fig. 25, showing head pole (Fig. 38), central area and four stigma (Fig. 39), and foot pole (Fig. 40).

Four stigmata are present, but are not clear in light microscopy (LM). Based on the lack of a central area, small frustule size and difference of outlines, this group should not belong to *G. quadripunctatum*. This group can be identified as

*Gomphoneis calcifuga* (Lange-Bert. et E. Reichardt) Tuji. However, the individual of Fig. 7 may not fit in the morphological variation presented by Tuji (2005). *Gomphoneis calcifuga* has been reported widely from the Northern Hemi-



Figs. 41–53. *Gomphoneis hastata* (Wislouch) Kociolek et Stoermer. Lake Baikal. TNS-AL-56162. SEM. 41–46. Bar=10  $\mu$ m. 47–53. Bar=2  $\mu$ m.

sphere. Foged (1971) discussed the wide morphological variation for this taxon. Several cryptic taxa might exist in this species.

The second morphological group among Lake Huvsgul specimens is presented in Figs. 12–20 and 22. Their characteristics include a clavate valve, a head pole more broadly rounded-obtuse than the foot pole, length of 18–35  $\mu$ m, and breadth of 4–7  $\mu$ m. Striae gently radiate to become parallel at the head valve ends. There is a central area with circular to acute-angled sub-fas-

cia, four pores in the central area, and polar terminals near to the valve ends. This group agrees with the individual illustrated in Fig. 1 in the holotype slide. The forms of the central areas are different from the original illustration and individuals illustrated in Figs. 2–5. However, Tuji (2005) demonstrated the wide morphological variation of central areas in *G. tetrastigmata*, *G. okunoi* and *G. pseudookunoi*, and the form of central area may be an unstable character for the identification of *Gomphoneis* species. Watanabe

*et al.* (2005) also presented the wide morphological variation of the central area in Japanese *Gomphoneis* taxa.

The third morphological group among the Lake Huvsgul specimens is presented in Fig. 21. It is very similar to the second morphological group, but differs in its outline. This third group corresponds with the individuals illustrated Figs. 2 and 3 in the holotype slide. The morphological variation of the outlines of *G. quadripunctatum* is problematic. Very wide morphological variation of outlines is found in the individuals in the holotype slide. The same very wide morphological variation of *G. quadripunctatum* is also found in Lake Baikal (Kociolek & Stoermer, 1988). Since this taxon appears to have wide morphological variation, we judged that the third group should belong to the second group, and both groups should be identified as *G. quadripunctatum*.

Since Lake Huvsgul is a type locality for *G. quadripunctatum*, the wide morphological variation found in this study should be important knowledge for the identification of this taxon.

The scanning electron microscopy (SEM) photographs of *G. quadripunctatum* specimens from Lake Huvsgul are presented in Figs. 23–40. SEM photographs of *Gomphoneis hastata* (Wislouch) Kociolek & Stoermer from Lake Baikal are presented in Figs. 41–53 for comparison with *G. quadripunctatum*.

The striae of *G. quadripunctatum* are doubly punctate, which supports it belonging to the

genus *Gomphoneis*. The polar head terminals are slightly separated away from the valve ends and there are long terminal raphe fissures. A pseudo-septum has developed and covers the long terminal fissures. The existence of a pseudo-septum is one difference from the Japanese *Gomphoneis* taxa, *G. okunoi* Tuji and *G. pseudookunoi* Tuji, described in Tuji (2005).

The morphological variation of the central area of *G. hastata* is also very wide, like *G. quadripunctatum* and other *Gomphoneis* taxa discussed above. The existence of a pseudo-septum may suggest the similarity of *G. hastata* and *G. quadripunctatum*. The ultrastructures of *G. hastata* and *G. quadripunctatum* are very similar; it is difficult to distinguish the taxa based on their ultrastructures. Most of the ultrastructural characters obtained by SEM examination are common among *Gomphoneis* taxa, and may not be useful for the identification of *Gomphoneis* taxa.

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モンゴル・フブスグル湖の *Gomphoneis quadripunctatum* (Østrup) R. Ross et P.A. Sims の形態変異

辻 彰洋・Soninkhishig Nergui

*Gomphoneis quadripunctatum* (Østrup) R. Ross et P. A. Sims の形態変異について、同種の模式産地であるモンゴル・フブスグル湖の個体について調査した。本種の被殻の中心域および輪郭の形態変異は非常に幅広く、分類形質としては不安定であると考えられた。SEM観察による微細構造は、*Gomphoneis* 属内で共通しており、*Gomphoneis* 属の種の分類形質としては使えないことが明らかになった。