

Micromorphology of Benthic Diatom Species *Achnanthes alteragracillima* Lange-Bert.

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Morphology of *Achnanthes alteragracillima* Lange-Bert. was studied with scanning electron microscopy in epilithic samples from the Kwang River (Kwangchun), Kyungsangbuk-Do, Korea. The species was characterized by the external raphe terminal fissure deflecting up to valve margin, the internal raphe proximal endings slightly deflecting to the opposite direction each other and biased hyaline area at the valve pole. It could be distinguished from *A. minutissima* Kütz., closely related species, in having not straight external raphe terminal fissures, and from *A. convergens* H.Kob. in having a biased hyaline area at the valve pole and not a convergent striae arrangement at the pole of the raphe valve.

Keywords: *Achnanthes alteragracillima*, morphology, raphe, *A. convergens*, the Kwang River

Achnanthes alteragracillima Lange-Bert. was newly established as *Nomen novum* to replace the earlier name *Achnanthes minutissima* var. *gracillima* (F. Meister) Lange-Bert. (Lange-Bertalot, 1993), because the species is not able to be classified as a variety of *A. minutissima* Kütz. any longer on account of a different raphe structure. Hitherto *A. alteragracillima* has been mainly confusedly identified as a variety of *A. minutissima* or *A. microcephala* Kütz. (Lange-Bertalot and Krammer, 1989; Krammer and Lange-Bertalot, 1991; Lange-Bertalot, 1993), therefore there is little information on the morphology and the distribution of the species. Especially, only three SEM photographs existed prior to this study, which were the external observations of raphe valve in whole (Lange-Bertalot, 1993, Fig. 35: 1-3). In the present study, morphological characteristics and distribution of *A. alteragracillima* are discussed in detail.

MATERIALS AND METHODS

Samples containing *Achnanthes alteragracillima* were collected from twelve different stations of the

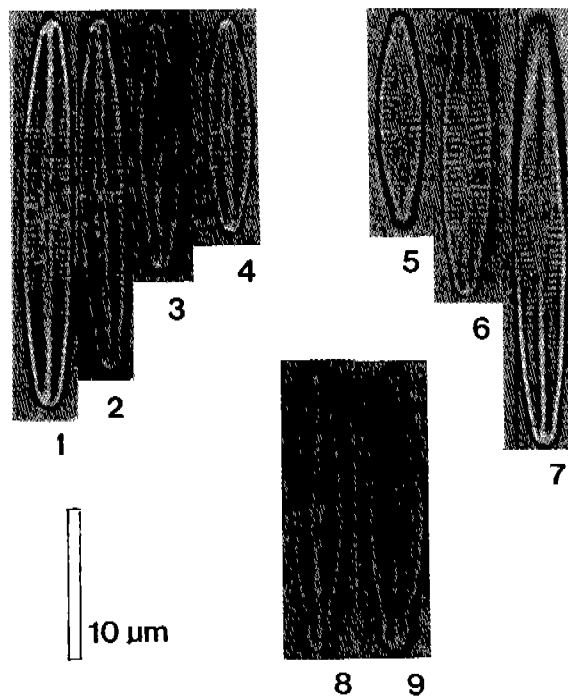
Kwang River (Kwangchun), 37°04'N, 129°09'-129°25'E, Ulchin County, Kyungsangbuk-Do, Korea on May 19, August 2, October 28 in 1991 and January 5 in 1992 (Lee *et al.*, 1994). In addition, one sample from a pond, Tofutsu, Hokkaido in Japan collected on September 13, 1982 by T. Gotoh was examined. The environmental conditions (Lee *et al.*, 1994) and the structure of diatom community (Lee and Chung, 1993) of the river were already discussed.

The samples were collected from stone surfaces at a depth of 30 cm from the free surface of water. The samples were cleaned with the permanganate method (Hendey, 1974) and mounted in Pleurax. Slides were examined with a Nikon Labophoto microscope. For scanning electron microscopy, the cleaned materials were dehydrated in ethanol, then a drop of the suspensions was air-dried on stub, sputter-coated with Au, and examined with a Hitachi S-450 SEM.

RESULTS

The terminology used is that suggested by Anonymous (1975) and Ross *et al.* (1979) and the abbreviated names of original authors of each taxon by Brummitt and Powell (1992).

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Figs. 1-9. *Achnanthes alteragracillima*, LM. Scale bar=10 µm. Figs. 1-7. Representative valves of different sizes of raphe valves (Figs. 1-4) and rapheless valves (Figs. 5-7) from the Kwang River. Figs. 8, 9. Specimens from a pond, Tofutsu, Hokkaido, Japan.

Achnanthes alteragracillima Lange-Bert.

Basionym: *Microneis gracillima* F. Meister

Synonyms:

Achnanthes gracillima (F. Meister) Mills

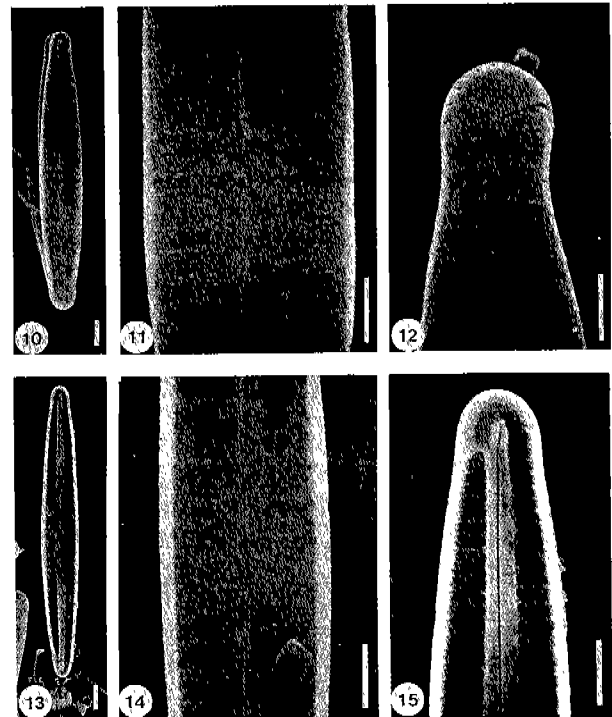
Achnanthes microcephala var. *gracillima*
(F. Meister) Cleve-Euler

Achnanthes microcephala sensu auct. nonnull.

Achnanthes minutissima var. *gracillima*
(F. Meister) Lange-Bert.

Our specimens collected from the Kwang River, located in mountainous region, were identical with the original description and figures of *Achnanthes alteragracillima* (Krammer and Lange-Bertalot, 1991 as *A. minutissima* var. *gracillima*).

The valves are linear or linear lanceolate with mainly rounded subrostrate ends, 13-28 µm in length and 3-3.5 µm in breadth (Figs. 1-9). Both in raphe and rapheless valves striae are almost parallel or slightly radiate, 23-26 in 10 µm in the center, but much denser in the pole. In the raphe valve, raphe is filiform, axial area is moderately narrow



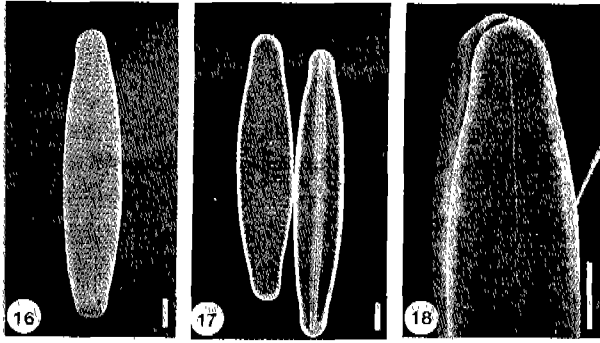
Figs. 10-15. *Achnanthes alteragracillima*, SEM. Scale bars=1 µm (Figs. 10, 13) or 2 µm (Figs. 11, 12, 14, 15). Figs. 10-12. External views of raphe valve. Fig. 10. Whole valve. Fig. 11. Valve centre showing proximal raphe endings. Fig. 12. Valve pole showing raphe terminal fissure deflecting up to valve margin and biased hyaline area. Figs. 13-15. Internal views of rapheless valve. Fig. 13. Whole valve. Fig. 14. Valve centre showing raphe proximal endings slightly deflecting to the opposite direction each other. Fig. 15. Valve pole showing helictoglossa and biased hyaline area.

and linear but somewhat widen in the center (Figs. 1-4).

SEM observations

Raphe valve: Externally, raphe terminal fissures deflect at an angle of about 60 degrees and reach the valve margin (Figs. 10, 12). Hyaline area is biased to the direction of the raphe deflection in the pole area (Figs. 12, 15), and several areolae radially arrange along the terminal margin (Fig. 12). Outer openings of the areolae are simple slit shape elongated parallel to the transapical axis (Fig. 11).

Internally, raphe is straight, terminal fissures are connected with the small elliptical helictoglossae (Figs. 13-15). Both raphe proximal endings shortly deflect in the opposite direction (Fig. 14, 17). Pole area is laterally half covered with the silicified layer



Figs. 16-17. *Achnanthes alteragracillima*. SEM. Scale bars = 1 μm (Figs. 16, 17) or 2 μm (Fig. 18). Fig. 16. External view of rapheless valve. Fig. 17. Internal view of raphe valve and rapheless valve. Fig. 18. *Achnanthes convergens*, note the raphe terminal fissure shortly not reaching the valve margin and the convergent striae arrangement.

(Fig. 15).

Rapheless valve: Externally, pseudoraphe is moderately narrow and slightly deflects laterally around the pole (Fig. 16). Several slits like areolae radially arrange in the margin of the pole (Fig. 16).

DISCUSSION

Achnanthes alteragracillima is separated from *A. minutissima* Kütz. (cf. Lange-Bertalot and Ruppel, 1980, Figs. 274-277) by its not straight but curved raphe terminal fissures externally (Lange-Bertalot, 1993), and the difference enables it to be an independent species from *A. minutissima*. *Achnanthes alteragracillima* can be distinguished from *A. convergens* H. Kob. (Fig. 18; cf. Kobayasi *et al.*, 1986, Figs. 11-13, 37-40), closely similar species to it, in having no convergent striae arrangement, biased hyaline area in the pole of the valve and slenderer valve shape in the raphe valve.

Some important morphological characteristics as well as valve shape of *Achnanthes alteragracillima* are akin to them of *A. biasolettiana* Grun.: internal raphe proximal endings slightly deflecting to opposite direction each other, externally not straight raphe terminal fissures and biased hyaline area in the pole (cf. Lange-Bertalot and Krammer, 1989, Figs. 57: 5-7; Krammer and Lange-Bertalot, 1991, Fig. 35: 5). Only the former can be differentiated from the latter in having somewhat slenderer valve shape, generally

Table 1. Environmental conditions of the three sampling stations: the Kwang River, Lake Imha (from Kim, 1993) and a pond in Tofutsu, Hokkaido, Japan (PTHJ)

	Water temp. ($^{\circ}\text{C}$)	pH	Conductivity ($\mu\text{S}/\text{cm}$)
Kwang R	0.8-23.8	6.8-8.6	44-480
L. Imha	6.1-23.3	6.2-8.3	82-283
PTHJ	15.6	7.0	140

substrate valve pole, narrower ranges of valve length and striae density. Therefore, it is questionable that *A. alteragracillima* can be continuously regarded as an independent species, not a variety of *A. biasolettiana*.

It has been little known of the distribution and the ecology of *Achnanthes alteragracillima*, because it has been commonly confused with another similar taxa such as some varieties of *A. minutissima* Kütz. or *A. microcephala* Kütz. (Lange-Bertalot and Krammer, 1989; Krammer and Lange-Bertalot, 1991). It only appears that the species frequently occurs in oligotrophic and calcareous waters in mountainous region (Krammer and Lange-Bertalot, 1991).

It is confirmed of *Achnanthes alteragracillima* to distribute in Lake Imha (Kim, 1993) and the Kwang River, Korea and a nameless pond, Hokkaido in Japan; in fact, we could find *A. alteragracillima* in the samples from only the sampling sites in our observations on diatom samples from various habitats in Korea and Japan. Especially this study is the first report on distribution of the species in Japan.

As shown in Table 1, in this study it appears that the species has the wide ecological adaptation ranges; in fact, it distributes with an eurythermal condition both in running and standing waters such as the Kwang River and Lake Imha. Especially *Achnanthes alteragracillima* occurs with the high relative abundance even in the estuary of the Kwang River having a somewhat brackish condition (Lee and Chung, 1993; Lee *et al.*, 1994), therefore it can be inferred that the species has a tolerance at least to low contents of salinity.

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底棲性 硅藻類 *Achnanthes alteragracillima* Lange-Bert.의 微細形態

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적 요

Achnanthes alteragracillima Lange-Bertalot의 형태학적 연구를 위하여 경상북도 소재의 光川으로부터 채집된 岩表性 試料를 전자현미경을 이용하여 관찰하였다. 본 종의 주요 특징은 殼의 가장자리까지 굴절된 縱溝의 外側 末端裂과 서로 반대 방향으로 약간 휘 縱溝의 內側 中心末端 그리고 殼의 末端部의 偏在된 透明域 등으로 조사되었다. 본 종은 유사종인 *A. minutissima* Kütz.와는 굴절된 縱溝 外側 末端裂에 의해서, 그리고 *A. convergens* H. Kob.와는 殼 末端部의 偏在된 透明域과 縱溝殼의 末端部의 橫條線의 非逆放射狀 配列에 의해서 구별된다. 본 종 *A. alteragracillima*는 경상북도 소재의 광천과 임하호 그리고 日本 北海島의 無名의 작은 못에 분포하고 있음이 확인되었다.

주요어: *Achnanthes alteragracillima*, 微細形態, 縱溝末端裂, *A. convergens*, 光川

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