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Observations on the Two Rheophilic Species of the Genus *Achnanthes* (Bacillariophyceae), *A. convergens* H. KOB. and *A. japonica* H. KOB.

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好流水性の *Achnanthes* (珪藻綱) の 2 種 *A. covergens* H. KOB. と *A. japonica* H. KOB. について

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Abstract

Two rheophilic diatoms, *Achnanthes convergens* H. KOB. and *A. japonica* H. KOB. described in 1965 from the Ara-Kawa (Ara River) without type citation by one of the present authors, H. KOBAYASI, were re-examined in detail with SEM and TEM using original materials. In addition to the results obtained by careful comparison with the type slides of the related species, morphological differences of these species are confirmed and types are designated, thereby validating these previously invalid names.

Key index words

Achnanthes convergens; *Achnanthes japonica*; diatoms; fine structure; new species.

Achnanthes convergens and *A. japonica* described by one of the present authors (KOBAYASI 1965) without citation of the types, resemble each other morphologically and ecologically, and are found together in many clear mountain rivers in Japan.

Beside these facts, there are some taxa resembling in many aspects to these species.

A. covergens resembles *A. deflexa* Reim. var. *deflexa* (REIMER in PATRICK & REIMER 1966) and var. *alpestris* LOWE & KOCIOLEK (1984), and *A. japonica* resembles *A. minutissima* var. *robusta* HUST. (1937) and *A. crassa* HUST. (1937) In order to clarify the taxonomic position and to fulfill the condition for valid publication of these two species, original materials were reexamined using SEM and TEM and compared with the types of the related taxa.

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Materials and Methods

Two materials were selected from the original materials for TEM and SEM observations The one for *Achnanthes convergens* was collected from the Ara kawa (Ara River) beneath Ochiai Bridge (Station 6 in KOBAYASI 1962 on 1 Feb 1959, wt 3℃ pH 7.1 K 5212) The other for *A japonica* was collected from the Shinno-sawa (Shinno Stream) one of the tributary streams of the Arakawa (Station 21 in KOBAYASI 1962 on 1 April 1959 wt 4℃ pH 7.0 K 5248). Methods of cleaning, washing and preparing objects for light and electron microscopy are given in KOBAYASI & NAGUMO (1985).

The terminology used is that suggest-

ed by the Working Party on Diatom Terminology (ANONYMOUS 1975, Ross *et al.* 1979).

Results and Discussion

Achnanthes convergens H. Kob. (1965, *p. 348, f. 5a-f*)

Figs 1-17, 37-43, 51-54.

This species has been found from rivers (KOBAYASI 1962, 1964, 1972; MAYAMA & KOBAYASI 1982; NEGORO & GOTOH 1983; OSADA & NAGUMO 1985; GOTOH & NEGORO 1986); or from springs (KOBAYASI & HARAGUCHI 1969; NAGUMO & OSADA 1986) in Japan.

A sample from Station 6 (K-5212) in KOBAYASI 1962 was selected as the type material and a frustule was also selected as the holotype (Figs. 1a, 1b).

In LM, valves are linear lanceolate, 10-25 μm in length, 4-4.5 μm in breadth. One of the peculiar features of this species is the densely spaced convergent striae near the ends of the RV (raphid valve) (Figs. 1-4), while the striae of AV (araphid valve) are slightly radiate at the ends (Figs 5, 6). This species rsembles *Achnanthes deflexa* REIM. in valve shape, however, striae of *A. deflexa* are not convergent but parallel to slightly radiate at the ends, evenly spaced at the center and are composed of coarse puncta, being about 24 in 10 μm (Figs. 8-10).

In TEM, the contrast between widely spaced striae at the center and compact ones at the ends of the RV is particularly evident. The striae are about 18 in 10 μm at the center and about 36 (up to 40) in 10 μm at the ends (Figs. 11-13). In the AV, the striae are equidistant at the most part of the valve and only slightly radiate at the ends (Figs. 15-17).

Areolae forming striae in both RV and AV are elongated parallel to the transapical axis and occluded by a hymen with linear perforations arranging in the parallel array type (KOBAYASI & NAGUMO 1985) (Figs. 14, 18).

In SEM, the valve face of the RV is almost flat, concaved along the apical axis and surrounded by a conspicuous marginal hyaline rim between the valve face and valve mantle (Figs. 39, 40). The AV has also marginal hyaline rim (Fig. 53). The raphe branches are straight slits. The central raphe endings form somewhat laterally expanded depressions in the outer surface of the valve, while the terminal fissures are narrow slits bending oppositely to the expansions of the central pores (Figs. 37 39, 40). Internally, the central raphe endings are not dilated but deflected in the opposite directions and terminate in small helictoglossae at the ends (Figs. 38, 41, 42).

The striae are shown to consist of narrowly and transapically elongated areolae, being five in number in the center of the vealve. The outer openings of some of these areolae are constricted in various degrees in both valves (Figs. 14 18 39, 53 arrows). Each areola is occluded internally by a hymen and the row of areolae lies in a trough-like depression. The hymenes are partially join each other in both valves (Figs. 43, 54), namely, the linking bars between interstriae are partially interrupted. Each areola forming a row on the mantle is elongated parallel to the transapical striae in both valves (Figs. 39, 40, 53). It is occluded internally by a hymen (Figs. 39-43, 53, 54). The cingulum of each valve consists of two bands. The valvocopula of both valves is open at one pole of the frustule. The advalver edge of the valvocopula is smooth (Figs. 40 arrow, 41) in RV, while that of the AV is undulate (Fig. 54).

In order to fulfill the last condition for valid publication of this taxon, the holotype is designated in the following, however the possibility still remains uncertain whether the range of morphological variation encompasses other validly published taxa such as *A. deflexa* var.

deflexa REIM. and var. *alpestris* LOWE & KOCIOLEK. Further studies will be necessary to fully define the morphological similarity or differentiation.

Holotype H. K. T-81 in coll. H. KOBAYASI (English finder M41/3, circled), will be haused in the Nat. Hist. Mus Tokyo.

Type material : K-5212, on 1 Feb.1959.

Type locality Ara-kawa beneath Ochiai Bridge (St.6 in KOBAYASI 1962), Saitama Pref., Central Japan.

Achnanthes japonica H. KOB. (1965, *p 347, f. 4a-f*) Figs.19-35, 44-50, 55 58

Though the records of this species is rather scarce in comparison with *A. convergens* (KOBAYASI 1962, 1964, WATANABE 1971, WATANABE & KAMIJO 1973), it is widely found from mostly clear mountain streams.

The remarkable feature of this species is the defferent striation between RV and AV. The RV has strongly radiate, denser striae at the ends and widely spaced median striae, while the AV has equidistantly and more widely spaced striae throughout the valve (Figs. 19-21, 27-29, 31-35). In the RV, the stirae are 16-20 in 10 μm in the center and about 30 in 10 μm at the ends, while in the AV, the striae are about 18 in 10 μm throughout the valve.

The RV with poler dense and radiate striae resembles *A. crassa* HUST. (1937) and *A. minutissima* Kütz. var. *robusta* HUST. (1937) which was transferred to the variety of *A. pusilla* (GRUN.) DE TONI by LANGE-BERTALOT (1980). However, as seen in Figs 24-26, Photomicrographs taken from the type slide haused in the Institute für Meeresforschung, Bremerhaven (BRM, Coll. HUSTEDT, Ma 1/42, Bach am Subangpap, Sumatra, SKB 2c), the striae of *A. crassa* are radiate throughout the valve and the striation of RV and AV is quite identical. Photomicrographs of the specimens of *A minutissima* var. *robusta* taken from the type slide haused in the Institute für Meeresforschung, Bremerhaven (BRM, Coll. HUSTEDT, MO2/48, R.S. Ma 148, Java, Wasserfall, Tjibeureum Tj 2 IIIb, 1933, H.) showed smaller valves and radiate throughout but somewhat denser striae, being about 22-24 in 10 μm at the center and about 24-28 in 10 μm at the ends (Figs. 22, 23). Differences mentioned above seem to be sufficient to regard this taxon as a separate species. The photomicrographs presented by GOTOH & NEGORO (1986, pl. 1, f. 14-19) identified as *A. pusilla* (GRUN.) DE TONI var. *crassa* (HUST.) LANGE-B. seem to be a mixture of *A. covergens* (their figs. 17. 19) and *A. japonica* (their figs. 14-16, 18).

In TEM, the densely and strongly radiate polar striae of the RV are clearly visible. The striae number at this area is about 36 in 10 μm. Contrary, the median striae are strongly distant, being 14-16 in 10 μm (Figs. 27-29). The striae of the AV are almost parallel in the most part of the valve except the slightly radiate polar striae (Figs. 33-35). The openings of the areolae are circular to elliptic and some of them have median constriction (Fig. 30 arrows) in the RV, and almost circular in the AV (Fig. 36). The areolae are occluded by a hymen with linear marginal perforations arranging in a centric array type (MANN 1981).

In SEM, the valve face of the RV is almost flat, concaved along the apical axis and surrounded by a marginal hyaline rim between the valve face and valve mantle (Figs. 44, 46, 47). Inversely, the valve face of the AV is convexed along the apical axis and without the marginal hyaline rim (Figs. 55, 57).

The raphe branches are straight slits. The central raphe endings are dilated to form a round central pores, while the terminal fissures are narrow slits variously curved on the outer surface.

Some are deflected as seen in Fig. 44 and some are variously hooked as seen in Fig. 47. Internally, the central raphe endings are not dilated but deflected in the opposite directions each other and terminate in a small helictoglossa at the ends (Figs. 45, 48-50).

In the RV, the striae are shown to consist of round or elliptic areolae. In the case of elliptic ones, the outer opening is constricted in various ways as seen in Fig. 30 (arrows) but internally they are occluded by a elliptic not constricted hymen separated clearly by the linking bars between intercostae (Fig. 50). In the AV, the row of areolae lies in a deep trough-like depression. Each areola is a round chamber with the circular outer opening and is occluded internally by a circular to elliptic hymen separated clearly by the linking bars between intercostae (Figs. 56, 58).

Each areola forming a row on the mantle is elongated parallel to the pervalvar axis and corresponding in number to the transapical striae in the RV (Figs. 44-47), while in the AV such a row of areolae is lacking (Fig. 57).

The cingulum of each valve consists of three bands (Fig. 56 arrow). The valvocopula of both valves is open at one pole of the frustule and with the undulate advalver edge (Figs. 48, 49, 56).

In order to fulfill the last condition for valid publication of this taxon, the holotype is designated in the following.

Holotype : H. K. T-82 in coll. H. KOBAYASI (English finder 43N／2, circled), will be haused in the Nat. Hist. Mus. Tokyo.

Type material : K-5248, on 1 April 1959.

Type locality : Shinno-sawa (Shinno Stream), one of the tributary streams of Ara-kawa (St. 21 in KOBAYASI 1962), Saitama Pref. Cental Japan.

Acknowledgements

We are greatful to Dr. Reimonsen of the Institute für Meeresforschung, Bremerhaven and Dr. Charles Reimer of the Academy of Natural Sciences of Philadelphia, for access to slide collections.

摘　　要

著者の一人である小林（1965）が荒川産の新種として記載した *Achnanthes convergens* H. KOB. と *A. japonica* H. KOB. の2種について、電顕を用いて詳細な観察を行った。

この2種は電顕的にも明瞭に区別でき、また、これらの近縁の種類のタイプスライドを調べて比較を行ったところ、どちらも独立の種類とするのが妥当と思われた。

しかし、原記載では、国際植物命名規約に規定されているタイプの指定を欠いていたため、正当出版に必要な条件を付加した。

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Plate 1. Figs 1-7, 11-18. *Achnanthes convergens* H. KOB. Ara-kawa, Ochiai Bridge, K-5212. Figs 1a, 1b, RV and AV of the holotype specimen, taken in different planes of focus. Slide no. H. K. T-81. × 2,000. Figs 2-4. RV of isotype specimens. × 2,000. Figs 5-7. AV. of isotype specimens. × 2,000. Figs 11-13. RV in TEM. × 4,000. Fig. 14. Hymenes with perforations of the parallel array type and foramina with median constrictions (arrows) of the RV areolae visible one over ano ther. × 60,000. Figs 15-17. AV in TEM. × 4,000. Fig. 18. Hymenes with perforations of the parallel array type and foramina with medianconstrictions (arrows) of the AV areolaevisible one over another. × 60,000. Figs 8-10. *Achnanthes deflexa* Type slide, PH.-G. C. 1931. × 2,000.

Plate 2. Figs 19-21, 27-36. *Achnanthes japonica* H. KOB. Ara-kawa, Shinno-sawa, K-5248. Figs 19a, 19b. RV and AV of the holotype specimen taken on different planes of focus. Slide no. H. K. T-82. × 2,000. Figs 20, 21, 31, 32, RV and AV of the isotype specimens. × 2,000.

Figs 27-30. RV in TEM. × 4,000. Fig. 30. Hymenes with perforations of the centric array type and foramina with median constriction (arrows) of the RV areolae visible one over another. TEM. × 60,000. Figs 33-35. AV in TEM. × 4,000. Fig. 36. Hymenes with linear marginal perforations arranging in the centric array type and circular foramina visible one over another. TEM. × 60,000. Figs 22, 23. *A. minutissima* var. *robusta*. Hust. Type slides. Fig. 22. BRM Ma1／48. Fig. 23. BRM MO2／48. × 2,000. Figs 24-26. *A. crassa*. Hust. Type slide. BRM Ma 1 ／42. ×2,000.

Plate 3. *A. convergens* H. KOB. Fig. 37. External view of the concaved RV with flat valve face surrounded by a conspicuous marginal hyaline rim. × 7,000. Fig. 38. Internal view of the RV with the valvoc opula. × 7,000. Fig. 39. Enlarged central RV showing the central raphe endings and the linear openings of the areolae. × 17,000. Fig. 40. External RV apex showing the strongly convergent and denselly spaced striae and the open end of the valvocopula (arrow). × 17,000. Fig. 41. Internal RV apex showing the small helictoglossa and the open end of the valvocopula. × 20,000. Fig. 42. Internal view of central RV showing the deflected central raphe endings. ×20,000. Fig. 43. Internal RV areolae showing the partially joined linear occlusions. × 30,000.

Plate 4. Fig. 44. *A. japonica* H. KOB. External view of the slightly concaved frustule with flat face surrounded by a conspicuous marginal hyaline rim. ×7,000. Fig. 45. Internal view of the RV with the remaining valvocopula. × 7,000. Fig. 46. Enlarged external RV center showing the delated central raphe endings and the linear to elliptic openings of the areolae. ×20,000. Fig. 47. External RV apex showing the strongly radiate striae. ×20,000. Fig. 48. Internal RV apex showing the small helictoglossa and the open end of the RV valvocopula. ×17,000. Fig. 49. Internal view of the central RV showing the deflected central raphe endings. ×17,000. Fig. 50. Internal RV areolae showing the circular to elliptic occlusions and the conspicuous linking bars between interstriae. × 30,000.

Plate 5. Figs 51-54. *A. convergens* H. KOB. Fig. 51, 52. External and internal views of the AV with the conspicuous marginal hyaline rim. ×6,000. Fig. 53. External view of the central AV showing linear to ellptic openings with a median constriction (arrows) of the areolae and the marginal hyaline rim. × 30,000. Fig. 54. Internal view of the central AV areolae showing the linear occlusions. × 30,000. Figs. 55-58. *A. japonica* H. KOB. Fig. 55, 56. External and internal views of the AV. Note the three bands at one end (arrow). × 7,000. Fig. 57. External view of the central AV without marginal hyaline rim, showing the round openings of the areolae. × 30,000. Fig. 58. Internal AV showing the circular occlusions and the conspicuous linking bars between interstriae. × 30,000.

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Plate 1

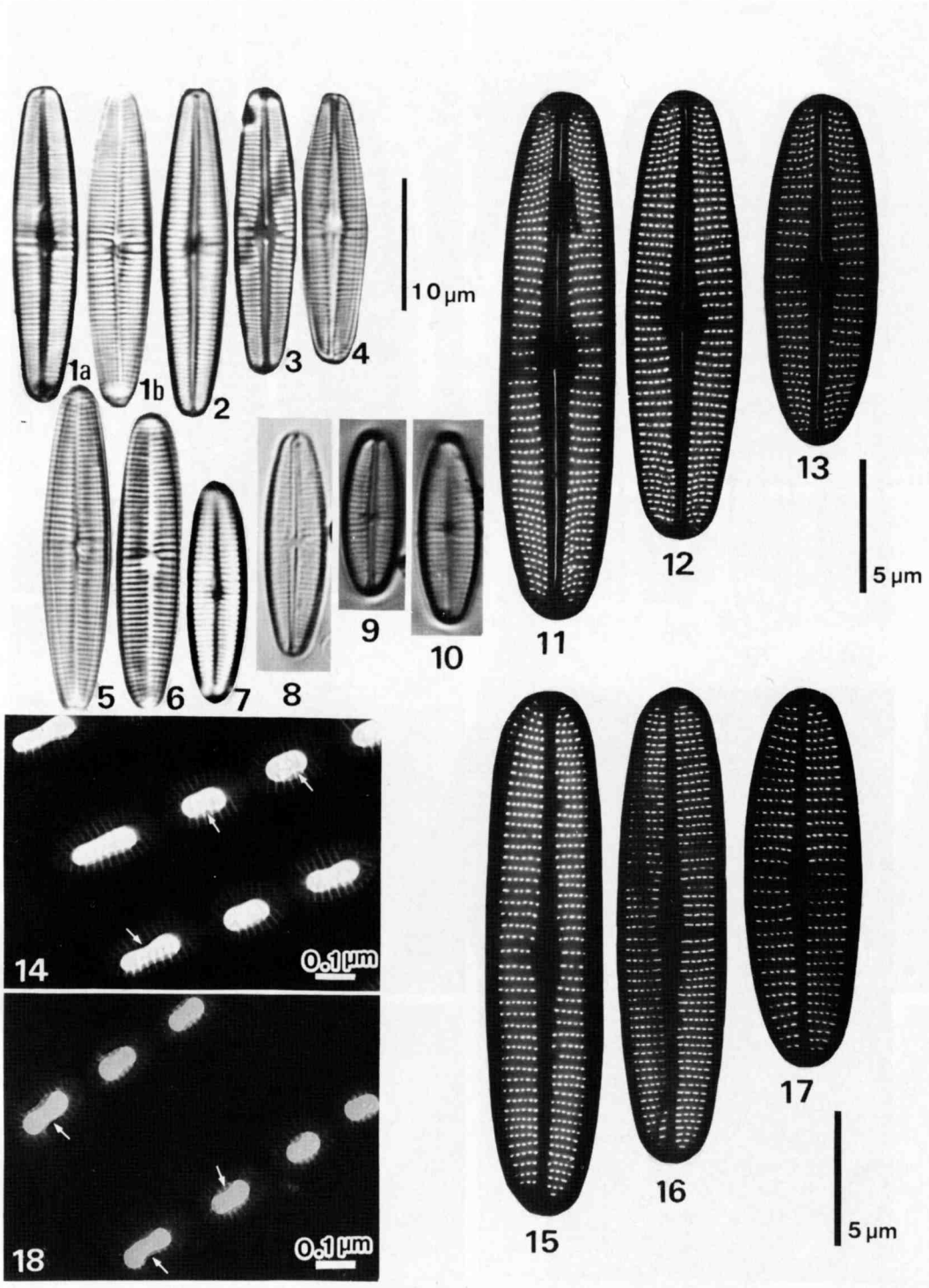

Plate 2

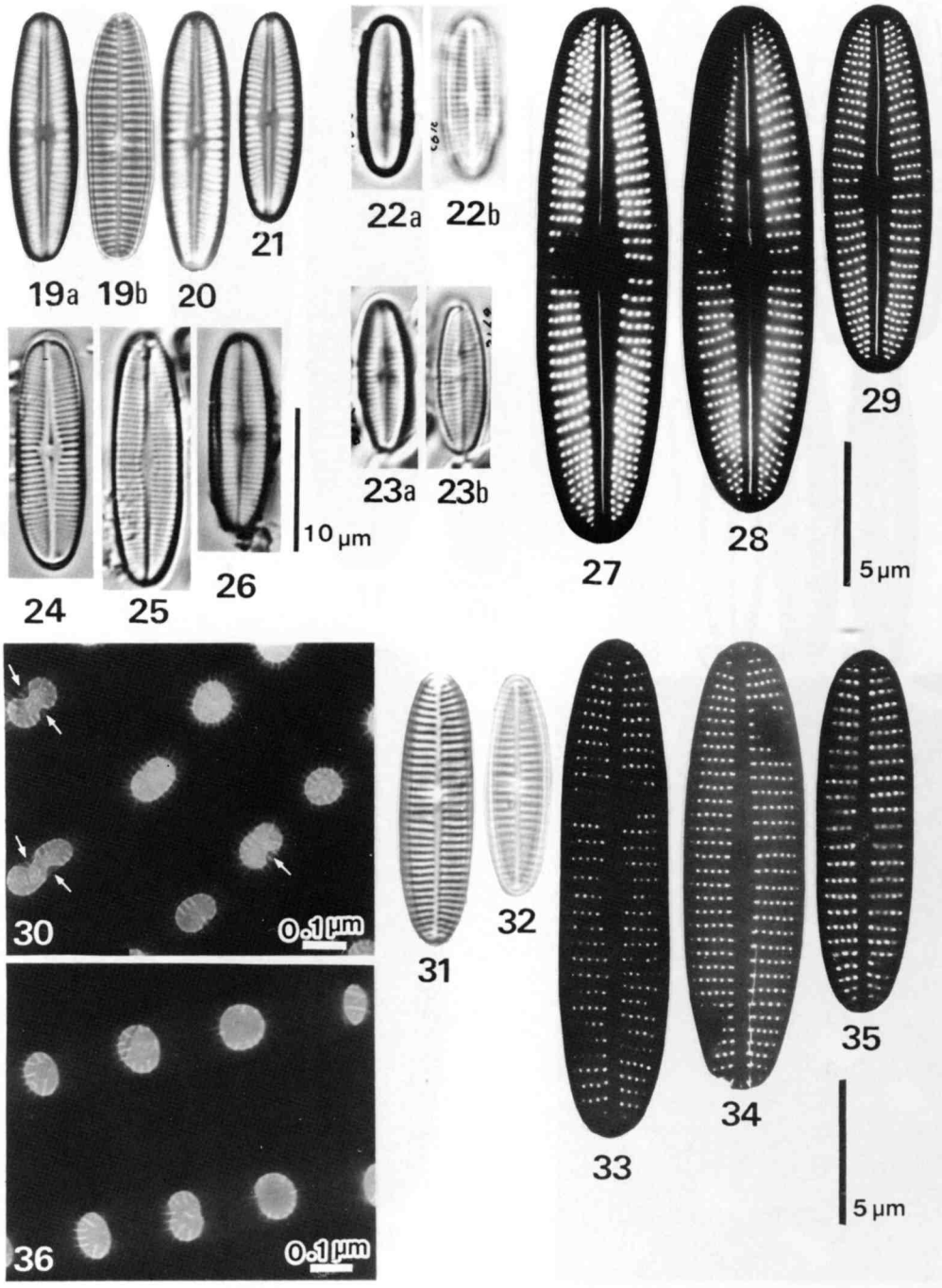
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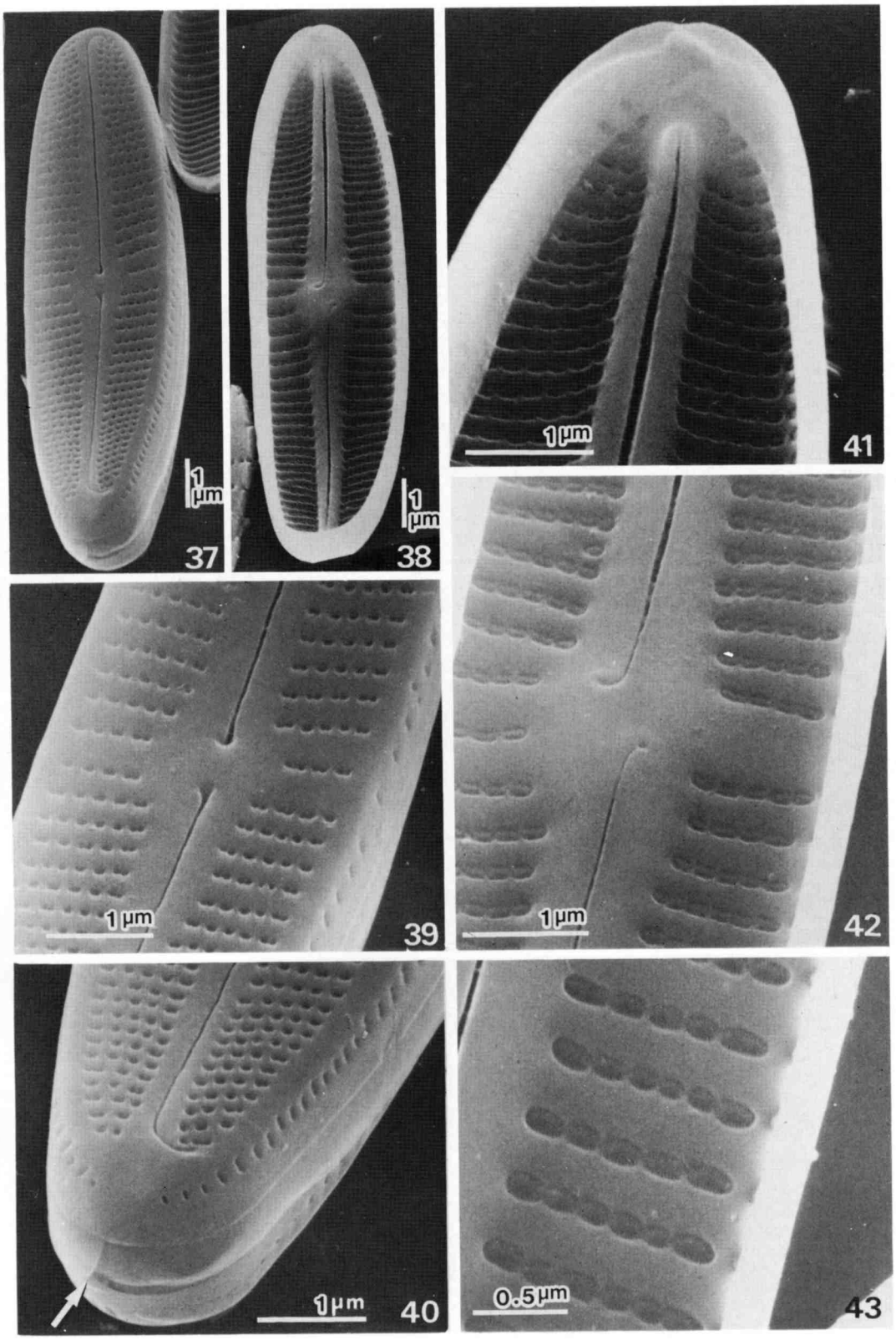
Plate 3



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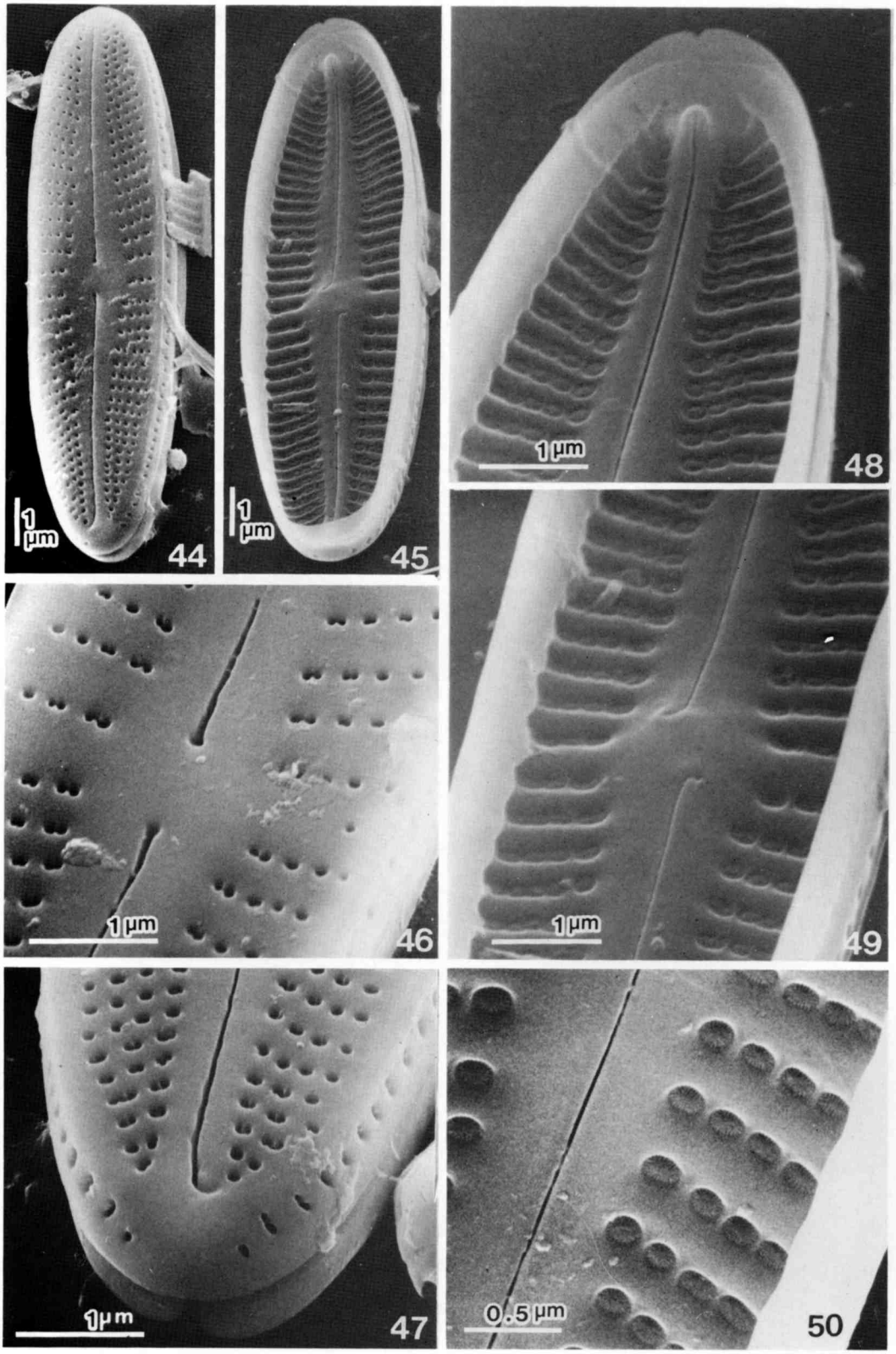

Plate 5