

Entomoneis aequabilis sp. nov. (Bacillariophyceae), a brackish species without junction-lines

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A new brackish *Entomoneis* species without junction-lines in the winged keel is described as *Entomoneis aequabilis* Osada & H. Kob. sp. nov. from Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island), Kagoshima Pref., Japan. The species is mainly characterized by frustules with a quarter twist, a sigmoid keel without junction-lines, denser striation in the valve body, longitudinal costa on one side of the raphe canal, and paired short projections on the interareolar costae of the bands.

Key Index Words: Bacillariophyceae—brackish diatom—*Entomoneis*—*Entomoneis aequabilis*—fine structure—morphology—new species.

The genus *Entomoneis* has been mainly characterized by the sigmoid keel elevated from the valve body, the junction-lines and the complex girdle (Cleve 1894 using the incorrect genus name *Amphiprora*, Reimer in Patrick and Reimer 1975). Though most species of the genus have the junction-lines which separate the winged keel from the valve body, there are some species which have no junction-lines such as *Amphiprora dusenii* Cl. (1894), *A. perplexa* Giffen (1963) and our new species. *E. aequabilis* is more similar to *A. perplexa* than *A. dusenii* in having denser striation. However, the striae of *A. aequabilis* (32–37 in 10 μm) are denser than those of *A. perplexa* (23–27 in 10 μm).

Ross *et al.* (1979) have defined the term “wing” as a kind of keel in which fenestrae alternate with alar canals as seen in *Surirella robusta* Ehr. *E. aequabilis* has only the raphe fibulae and has neither the fenestrae nor the alar canals, however, it has a well developed, wing-like structure as seen in Figs. 3 and 28. Therefore, we also use “wing” for this species as an exceptional case in the genus *Entomoneis*. All the species examined by us using SEM have a genuine wing; *E. alata* var.

japonica (Cl.) Osada & H. Kobayasi (1985), *E. paludosa* (W. Smith) Reimer var. *paludosa*, *E. punctulata* (Grun.) Osada & H. Kobayasi, *E. pseudoduplex* Osada & H. Kobayasi (1990a), *E. decussata* (Grun.) Osada & H. Kobayasi (1990b), and *E. centrospinosa* Osada & Kobayasi (1990c). They have three kinds of fibulae in the wing in which solid parts composed of costae and fibulae alternate with canals or canal-like structures, passages between the interior of valve and the raphe canal. The longitudinal costa on one side of the raphe canal and the paired short projections on the external surface of the interareolar costae of the bands are the additional characteristics of *E. aequabilis*.

Material and methods

Materials were collected from the bottom mud of Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island), Kagoshima Pref., on October 9, 1986 (OS-368). Salinity of the habitat was measured to be 17‰ when collecting the materials. Since individuals of the species were very rare in the materials, their clonal culture was carried out

in test tubes containing a modified PES medium (Osada and Kobayasi 1990a). Other culture conditions and methods of cleaning, washing and preparing objects for light and electron microscopy are given in Osada and Kobayasi (1985, 1990b).

The terminology used is that suggested by Anonymous (1975), Ross *et al.* (1979) and Paddock and Sims (1977, 1981).

Observations and discussion

Entomoneis aequabilis sp. nov. (Figs. 1-3, 5)

Cellulae singulares. Frustula in aspectu cingulari valde constricta et longitudinaliter torta. Valvae leviter sigmoideae, lineares, apicibus late scalpelliformibus, 47-57 μm longae, 7-9 μm latae. Carina alata sigmoidea, valdissime elevata et sine juncturi-lineis. Parietes rapho-canalii striati, costa longitudinali asymmetrica in latere uno. Striae corporis valvae continuae ex margine carinae ad marginem valvae et densissimae, 32-37 in 10 μm , et decussate superpositae in aspectu cingulari.

Cells solitary. Frustules strongly constricted in girdle view and longitudinally twisted. Valves slightly sigmoid, linear with broad scalpelliform ends, 47-57 μm long, 7-9 μm wide. Winged keel strongly sigmoid, elevated and without junction-lines. Walls of the raphe canal striated and with longitudinal costa asymmetrically on one side. Striae on the valve body continuous from the keel margin to the valve margin and extremely dense, 32-37 in 10 μm and appearing decussately to overlap in girdle view.

Holotypus: H. K. T-94. in coll. H. Kobayasi (will be housed in the Nat. Sci. Mus. Tokyo).

Type material: OS-368, coll. by K. Osada on 9 October 1986.

Type locality: Bottom mud of Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island), Kagoshima Pref., Japan.

Etymology: Specific epithet is Latin, adjective *aequabilis*, meaning "uniform" in reference to the uniform structure of the valve body and the keel without junction-lines.

This species closely resembles *Amphiprora perplexa* Giffen described from South Africa (Giffen 1963, 1967) in having a sigmoid winged keel without junction-lines, a line of large puncta near the raphe canal and a densely striated valve body. However, according to the original description and illustration of *A. perplexa* (Giffen 1963), Giffen's species has the transapically symmetrical striation in girdle view. The striae are roughly parallel in the middle portion and radiate near apices of the valve and are slightly sparse, being 23-25 (27) in 10 μm . *E. aequabilis*, therefore, is clearly distinguished from *A. perplexa* by having denser striae, being 32-37 in 10 μm , and by the oblique striation on the valve body, and consequently, appearing decussately to overlap in girdle view (Figs. 1-3, 5, 6).

In the SEM, the frustules have a longitudinal quarter or 90° twist (Fig. 4) but represent a panduriform outline in girdle view, depending on the setup of specimens or the angle

Plate 1. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. Scale bars=10 μm . Figs. 1, 2. Frustule in girdle view. 1. KE-1216. 2. Suguchi-ike (Suguchi Pond), Kamikoshiki-jima (Kamikoshiki Island). Fig. 3. Valve view. KE-1216. Fig. 4. Oblique view of a whole frustule showing its quarter-twisted form. KE-1216. SEM. Figs. 5, 6. Girdle view of valve. KE-1216. 5. LM. 6. TEM (Scale bar with dot).

Plate 2. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars=5 μm (Figs. 7, 8), 1 μm (Figs. 9-11), 0.1 μm (Figs. 12, 13). Fig. 7 External view of half valve showing the transapical costae arranged in parallel slanting toward the valve center but changing direction radially at the sub-terminal valve, and numerous warts on the costae. Fig. 8. The other half of the same valve as Fig. 7, showing the costae arranged in parallel slanting toward the valve apex. Fig. 9. Enlarged internal valve showing the smooth surface of the costae and intercostae (striae). Fig. 10. External sub-terminal valve showing the changeover portion of the costae arrangement, bifurcations and insertions of costae and longitudinal costa running along the keel margin. Fig. 11. Enlarged external valve showing warts arranged in two rows on each costa. Fig. 12. Hymenes occluding areolae on the raphe canal showing perforations forming lines arranged in parallel and densely. TEM. Fig. 13. Hymenes on the valve margin of the same valve as Fig. 12. TEM.

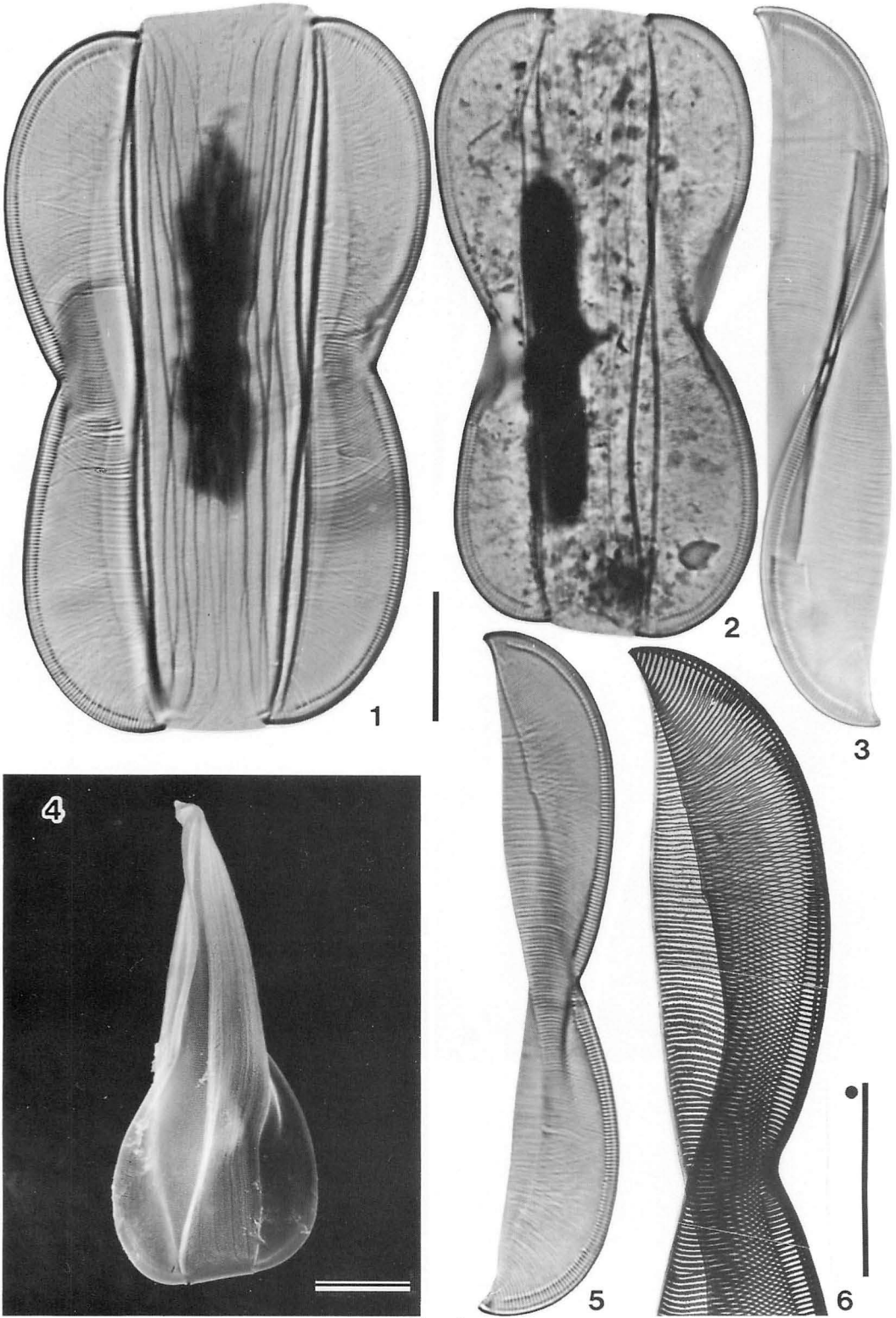


Plate 1.

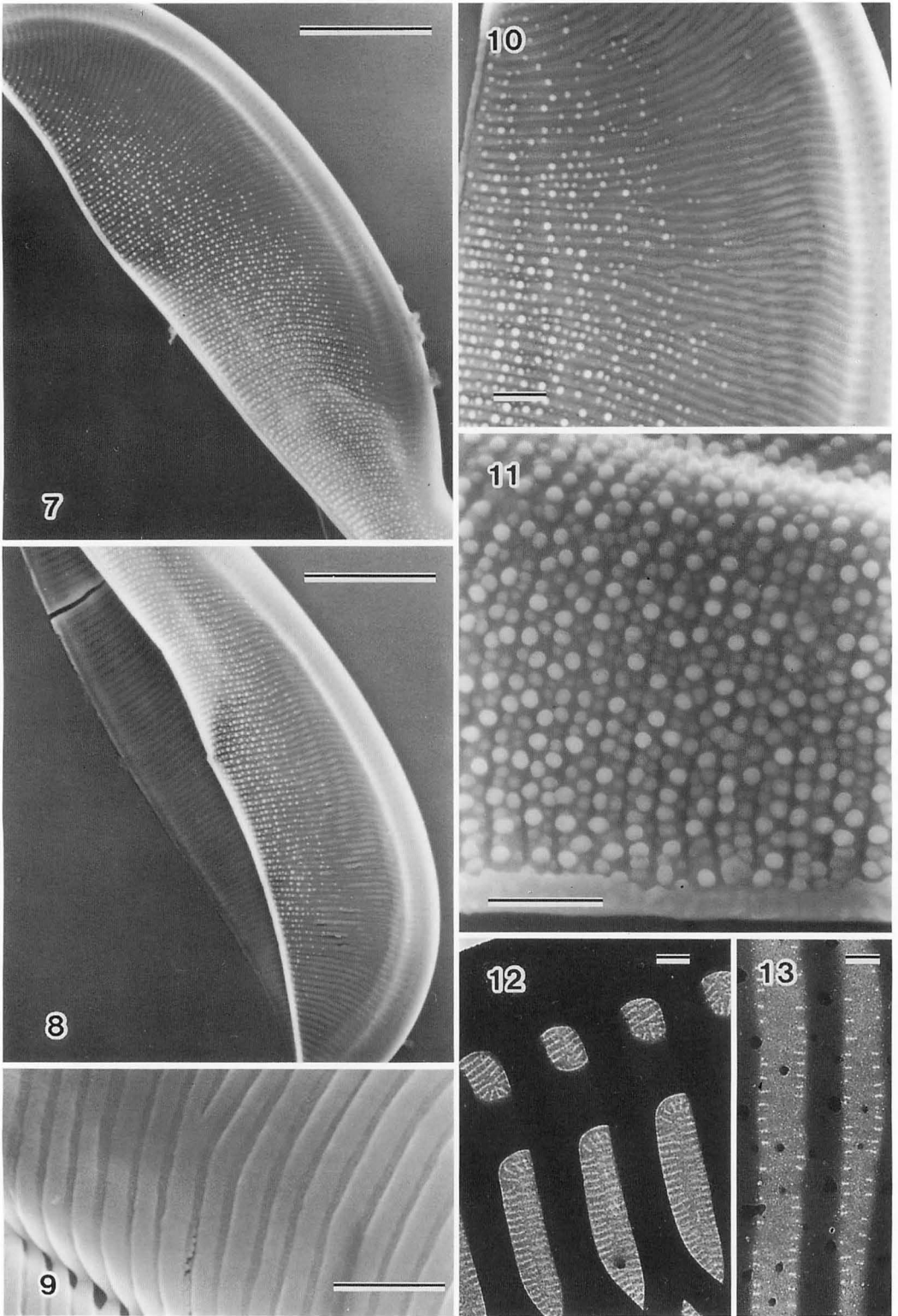


Plate 2.

from which the specimen is viewed (Fig. 20).

The transapical costae continue from the valve margin onto the raphe canal. Those of the valve body have externally numerous warts which vary in size and are arranged more or less in two rows on each costa, while internally their surfaces are smooth (Figs. 7-9, 11). Most costae of the valve body seem to be decussate in girdle view in LM and TEM (Figs. 1, 2, 5, 6) are actually arranged obliquely in the same direction on both sides of the valve. Namely, the decussating appearance in girdle view is caused by the overlapping of the costae of one side and the other side of a valve, as is seen in the wings of *E. pseudoduplex* (Osada and Kobayasi 1990a), *E. decussata* (Osada and Kobayasi 1990b) and *E. centrospinosa* (Osada and Kobayasi 1990c). The costae on one half of the valve are arranged obliquely and in parallel, slanting toward the apex (Fig. 8), while on the other half of the valve the costae are arranged curving slightly in the same direction as the former for about two-thirds of the way between the center and the apex but those in the remaining one-third change their direction radially (Fig. 7). The changeover portion of the costae arrangement, particularly, tend to have frequent bifurcations of the costae and also frequent insertions of the costae from the keel margin (Fig. 10). On the other hand, the costae on the raphe canal have no warts. As seen in Fig. 6, the striations on both sides of the raphe canal overlap exactly in the girdle view. Their arrangement is almost radial in each half of the keel (Figs. 7, 8).

Each intercosta or stria is also continuous from the valve margin onto the wall of the raphe canal on one side of the valve (Fig. 30), but on the other side of the same valve it is interrupted on the wall of the raphe canal, and divided into one distal short areola and one remaining intercosta by the longitudinal narrow costa (Figs. 6-8, 29). The distal areolae are seen as a row of marginal puncta along the edge of the wings in LM (Figs. 1, 2, 5). The longitudinal costa is narrow and continuous lengthwise and seems to have the same structure as that of the transapical costae (Fig.

19). The distal areolae and the longitudinal costa are observed to lie on the same side of the frustule, that is, the epi- and hypovalve have them on the same side (Fig. 31). The stria as well as the distal areola is closed externally by a hymen with perforations forming short lines. The perforated lines are arranged parallel to each other but perpendicular to the margin (Figs. 12, 13, 32, 33). Such structure of the striae is similar to that of *E. punctulata* (Osada and Kobayasi 1990a) and of *Auricula amphitritis* (Paddock and Sims 1980). In this species, however, the arrangement and density of the perforated lines are clearly different near the keel margin and near the valve margin. The perforated lines are longer and denser, being 40-45 in 1 μm , near the keel margin (Fig. 12) and shorter and sparser, 20-25 in 1 μm , near the valve margin (Fig. 13).

The raphe canal is proximally separated from the valve cavity by a row of raphe fibulae and has a central large inner opening (Figs. 15, 17, 18), and distally has a plicate raphe slit (Figs. 19, 32, 33). The fibulae seen as small dash-like puncta along the keel margin in LM link the costae on opposite walls of the keel (Figs. 17, 18). The raphe fissure is extremely narrow throughout, and has the central endings terminating simply on both the external and internal surfaces (Figs. 14, 15 arrows). The terminal fissures also terminate simply and straight (Fig. 16). In the transapical section of the valve, the raphe is a plicate type (Krammer 1982) (Fig. 19). The valve side with key costa, which may correspond to the primary side (Mann 1983), is observed to occur on the side possessing the longitudinal costa (Figs. 19, 32, 33).

The cingulum is composed of five to six open bands, i.e. one open valvocopula and four to five open bands. They open and close alternately at each pole of a frustule (Fig. 22), and all have similar structure except for the sixth band which is usually narrower (Fig. 21). Each band has two rows of oblong areolae, i.e. one advalvar and one abvalvar row, on the pars exterior and has a smooth edge both on the pars exterior and on the pars in-

terior even in the valvocopula (Figs. 21, 23 arrows, 26). The advalvar row is composed of elliptical or round areolae, while those forming the abvalvar row are considerably elongated (Figs. 23, 26, 27). The band areolae, being 46–57 in 10 μm , are occluded by a hymen with perforations forming marginal short rows arranged roughly in parallel and with randomly scattered perforations in the remaining space (Fig. 27). The I or Y shaped projections protruding from the side wall of the areolae in Fig. 27 are shadows of the paired short projections on the interareolar costae (arrows). Most of the hymenes occlude the areolae internally, but those of the advalvar areolae of the valvocopula are near to the external surface of the band (Figs. 23–25). Externally, each interareolar costa of the bands has a row of paired short projections (Figs. 26, 27 arrows) and an abvalvar terminal spine (Fig. 26 arrows), and numerous warts are on the surface between the two areolar rows (Figs. 21, 23, 26). Internally, the band surface is almost flat (Fig. 23). The valvocopula is

clearly distinguished from other bands by the round areolae forming the advalvar row and the wider warty area between the two areolar rows. The cingulum of this species is quite similar to that of *E. pseudoduplex* (Osada and Kobayasi 1990a), *E. decussata* (Osada and Kobayasi 1990b) and *E. centrospinosa* (Osada and Kobayasi 1990c) in having the oblong areolae, in the shape and arrangement of perforations of the areolar occlusion and in having numerous warts on the band surface, but differs, apparently, in the presence of the paired short projections.

Consequently, the following features are considered to be characteristic of this species: 1) Strongly and longitudinally twisted frustule: 2) Strongly elevated sigmoid keel without junction-lines: 3) Seeming decussately overlapping striation on both sides of the valve in girdle view: 4) Denser striae, being 32–37 in 10 μm : 5) Narrow longitudinal costa separating the marginal puncta from the striae on one side of the raphe canal: 6) Extremely dense band areolae forming rows,

Plate 3. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars = 1 μm (Figs. 14–16, 18, 19), 5 μm (Fig. 17). Fig. 14. External view of valve center showing central raphe fissures terminating simply and the smooth surface of raphe canal. Fig. 15. Internal view of valve center showing the central raphe canal opening and central raphe endings (arrows). Fig. 16. External valve end showing a straight terminal fissure. Fig. 17. Internal view of valve showing the smooth surface of the transapical, costa, the central opening of raphe canal (arrow) and a row of the raphe fibulae. Fig. 18. Enlarged internal valve center showing the central opening of the raphe canal and raphe fibulae linking opposite transapical costae. Fig. 19. Transapical section of valve showing the raphe slit on top of the keel, a longitudinal costa (arrow) on one wall of the raphe canal (rc), and raphe fibula on the border between the valve body and raphe canal.

Plate 4. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars = 10 μm (Fig. 20), 5 μm (Fig. 21), 1 μm (Figs. 22–26), 0.5 μm (Fig. 27). Fig. 20. External girdle view of a whole frustule. Fig. 21. External view of frustule pole showing the epicingulum composed of six bands; one valvocopula (B1), four bands (B2, B3, B4, B5) and one narrow band (B6). Fig. 22. Broken frustule pole showing the closed ends of the valvocopula (B1) and two bands (B3, B5), arranged alternately with the open ends (arrows) of the other two bands (B2, B4). V = valve. Fig. 23. Enlargement of internal valvocopula (left) and of other external valvocopula (right) showing the advalvar row of round areolae and the abvalvar row of elongated areolae, smooth pars interior edges (arrows), external paired short projections on the interareolar costa and numerous warts scattered between the two areolar rows. Figs. 24, 25. Cross section of the epicingulum and its drawing (V, valve; B1, valvocopula; B2, B3) showing the hymenes of the advalvar areolae (arrow-head) and those of abvalvar areolae (double arrow-heads), and the interareolar costae (arrows). TEM. Fig. 26. External advalvar cingulum end showing paired short projections and terminal spines (arrows) on the interareolar costae, and numerous warts between the two rows of band areolae. Note a wider warty area between the two areolar rows of the valvocopula (B1) than between the abvalvar bands (B2, B3). Fig. 27. Enlargement of a band showing both the elliptical and elongate areolar occlusions with perforations forming short rows arranged roughly in parallel, and the paired short projections on the interareolar costae (arrows). TEM.

Plate 5. *Entomoneis aequabilis* Osada & H. Kob. sp. nov. KE-1216. Scale bars = 10 μm (Fig. 28), 5 μm (Fig. 31), 1 μm (Figs. 29, 30, 32, 33). Fig. 28. External valve view of a whole valve showing the sigmoid keel. Figs. 29, 30. Enlargement of the external raphe canal of Fig. 28 showing one side with narrow longitudinal costa and the other side without longitudinal costa of the same raphe canal. Fig. 31. External girdle view of a frustule pole showing longitudinal costa (arrows) lying on the same side of the frustule. Figs. 32, 33. Transapical section of one valve (Fig. 32) and of the other valve (Fig. 33) of the same frustule showing longitudinal costa (arrow) and plicate raphe slit. TEM.

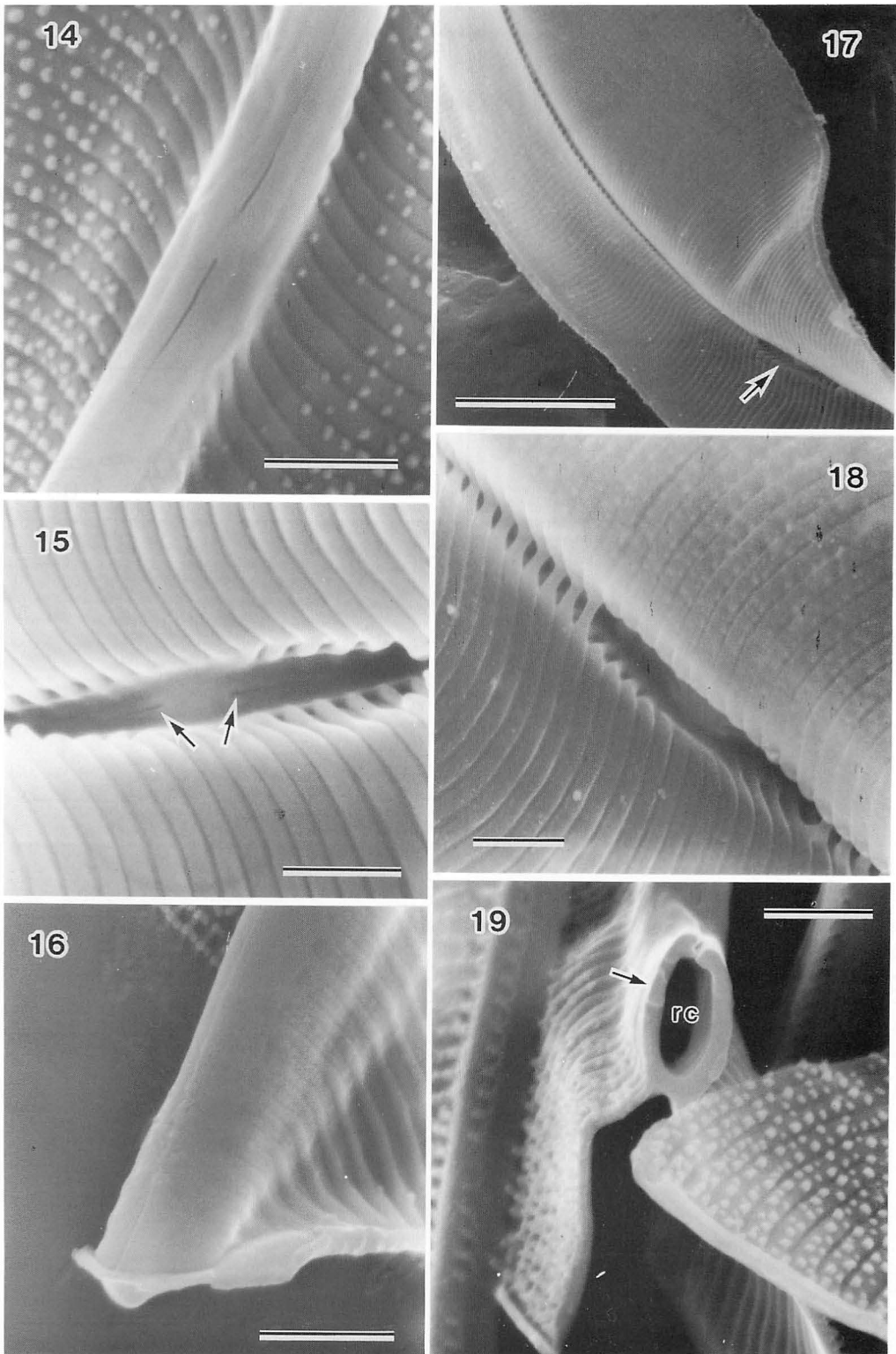


Plate 3.

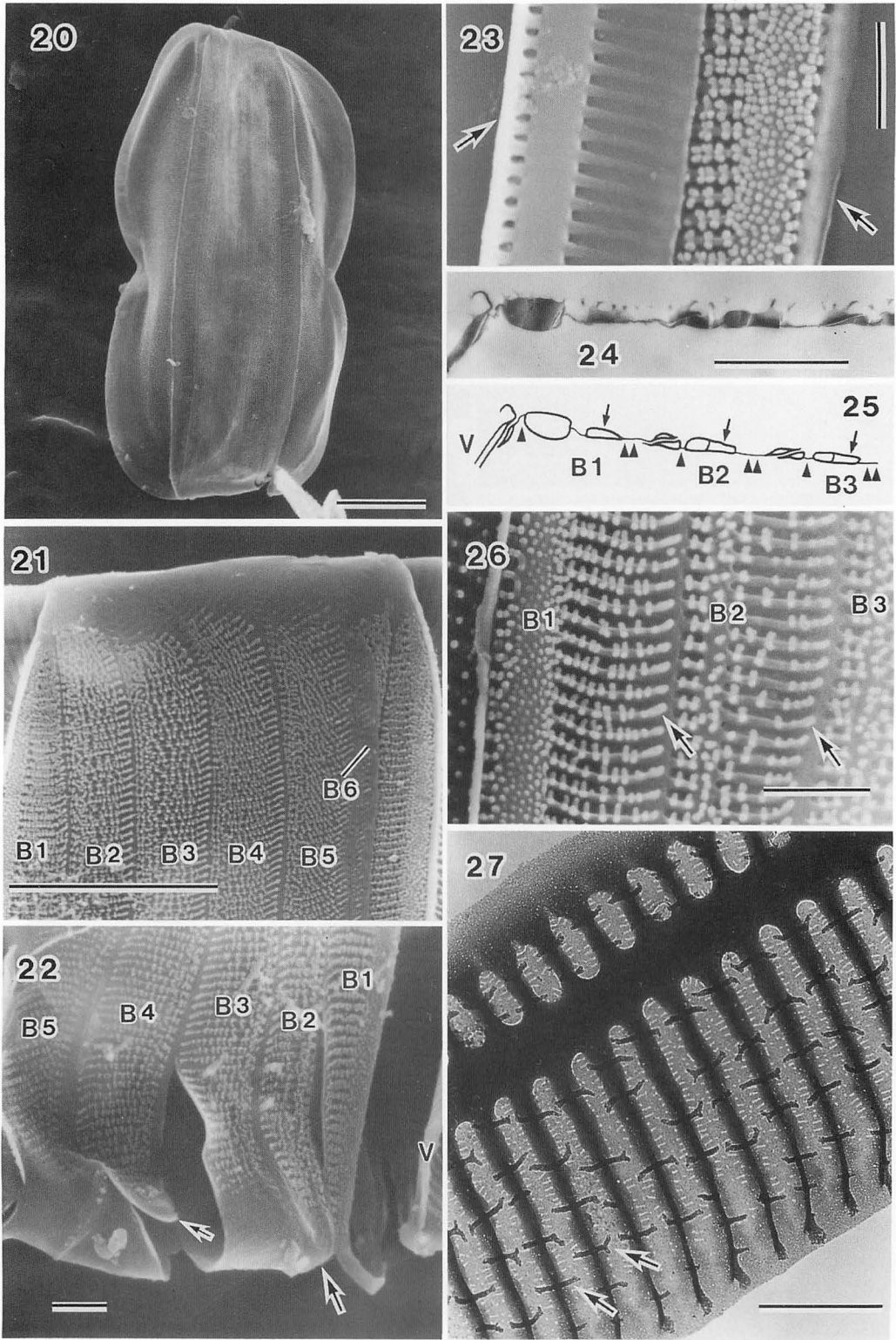
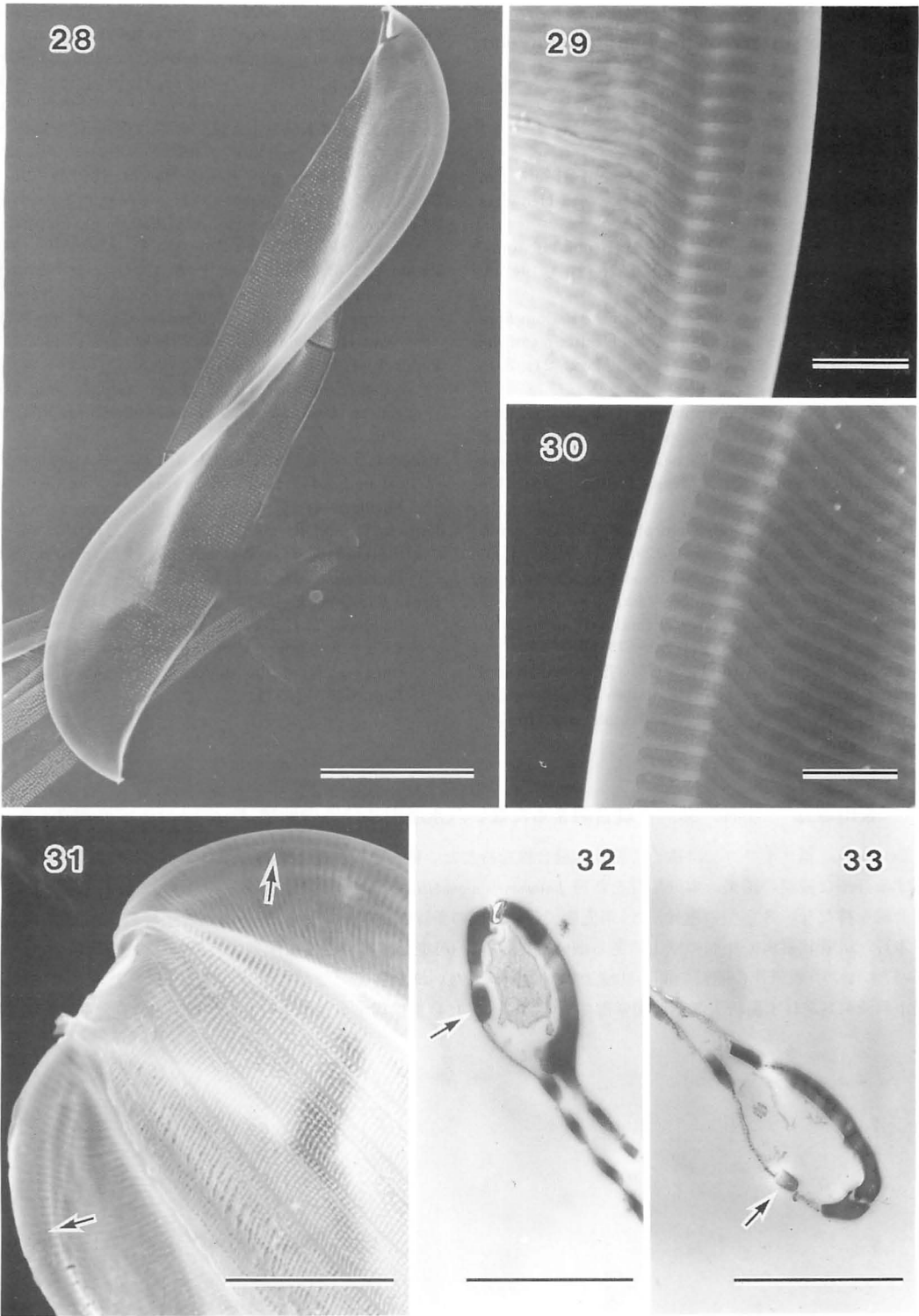


Plate 4.



being 46–57 in 10 μm : 7) Paired short projections on the surface of the band interareolar costae.

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長田敬五*・小林 弘**：縫合線をもたない汽水産羽状珪藻の新種 *Entomoneis aequabilis*

Entomoneis 属ケイソウでは極めて希れな縫合線を持たない種を鹿児島県上甕島の須口池から得た。被殻構造に関する詳細な観察の結果、本分類群を新種 *Entomoneis aequabilis* として記載した。本種は 1) 強く捻れる被殻, 2) 縫合線を持たない S 字型の竜骨, 3) 帯面観で殻の両側の条線は交差して見える, 4) 密な条線数 (10 μm に 32–37 本), 5) 管状縦溝の片側の壁にある細い縦走肋線, 6) 極めて高い密度で配列する殻帯片の胞紋 (10 μm に 46–57 本), 7) 殻帯片の胞紋の間の肋線上に対生配列したほぼ状突起, などによって特徴づけられる。(*951 新潟市浜浦町1–8 日本歯科大学新潟歯学部生物学教室 **184 東京都小金井市本町3–8–9–813 東京珪藻研究所)