Jap. J. Phycol. (Sôrui) 27 : 175–181. December 10, 1979

Taxonomic study on *Berkeleya obtusa* (GREV.) GRUNOW (Bacillariophyceae) from Hokkaido, Japan

Makoto MIZUNO

MIZUNO, M. 1979. Taxonomic study on *Berkeleya obtusa* (GREV.) GRUNOW (Bacillariophyceae) from Hokkaido, Japan. Jap. J. Phycol. 27 : 175–181.

Berkeleya obtusa (GREV.) GRUN. collected from Otaru and Muroran, Hokkaido, was studied morphologically and ecologically. Discussion was made on the taxonomy of this species based on morphological and ecological differences between this species and *B. rutilans* (TRENT.) GRUN.

Makoto Mizuno, The Institute of Algological Research, Faculty of Science, Hokkaido University, Muroran, 051 Japan.

During the study of marine littoral diatoms at Oshoro, Hokkaido, the author collected a tube-dwelling diatom having a long central area in December 1973. This diatom was different from *Berkeleya rutilans* (TRENT.) GRUNOW in the tube and valve morphologies and was identified as *B. obtusa* (GREV.) GRUN.

This paper deals with morphological and ecological investigations on *B. obtusa* from two localities in Japan and discussed differences between *B. obtusa* and *B. rutilans*.

Materials and Methods

Materials were collected monthly from May 1973 to April 1974 (except November) at Kabuto-iwa, Oshoro, Otaru City facing the Sea of Japan and in December 1975 at Charatsunai, Muroran City facing the North Pacific Ocean. These samples preserved in 3% formalin seawater were used for observations on tube and valve morphologies. A part of each sample was cleaned by hot concentrated nitric acid and distilled water, and was mounted in Pleurax for the observation of valve structures. The valve length and the distance between the central raphe endings were measured on 50 or more valves in each sample by screw micrometer. The number of striae in the middle part of 50 valves was counted in each sample. For scanning electron microscopy, the acid-treated material collected in Dec. 1973 was used. This was examined using a JXA–50 A X-ray microanalizer (Japan Electron Optics Lab. Co., Ltd.).

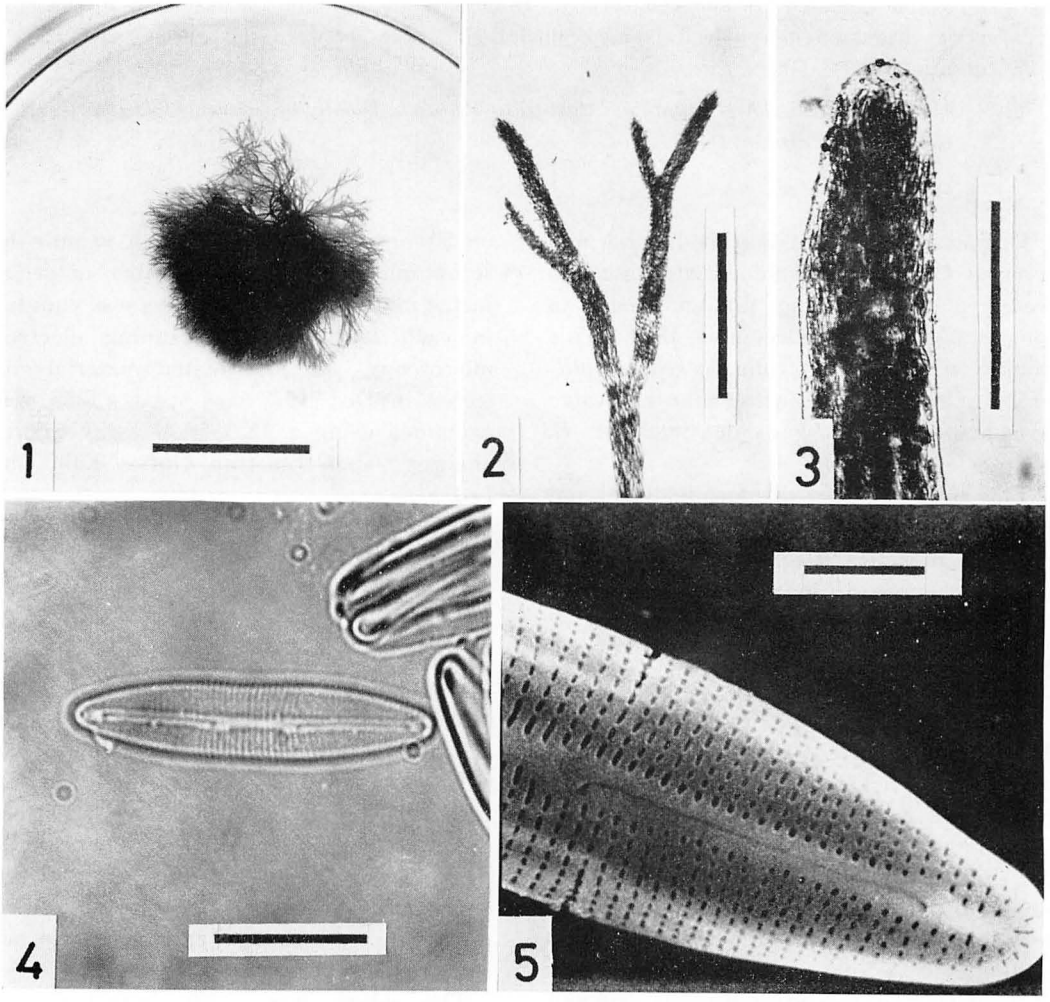
Results

The colonies of this diatom were found epiphytically on *Sargassum confusum*, *S. thunbergii* and *Rhodomela larix* and epizoically on sea mussels in the littoral zone at Oshoro, but at Charatsunai they grew only on seaweeds in the middle-lower littoral zone. This zone was lower than that of *B. rutilans* growing in the upper-middle littoral zone. The colonies grew abundantly from winter to spring, but in April they abruptly decreased and they were not collected in summer and autumn.

The colony was richly branched tuft (Fig. 1) attaining a length of 5 cm and was dark brown in color in fresh materials. A vast number of cells forming the colony was closely packed in files in gelatinous

tubes (Figs. 2, 3). Diameter of gelatinous tubes ranged from 100 μm to 500 μm at the middle portion of the tube and the range from 170 μm to 250 μm was frequently observed. The tube usually branched dichotomously (Fig. 2) and the apices terminated abruptly (Fig. 3). The surface of the gelatinous tube was smooth and the texture of the tube was elastic. There were no seasonal and geographical variations in the tube morphology.

Valves were linear with cuneate ends to narrowly elliptical (Figs. 4, 6). The valves measured 17–36 μm in length and 5–7 μm in width. By light microscopy, axial area expanded in the same direction at the portions of the central raphe endings and resulted in asymmetry (Figs. 4, 6). Scanning electron micrograph of the outer surface showed that the central raphe endings curved to the expanded axial area and also the polar raphe endings curved to the same side (Fig. 5). The central area was elongated in the axial direction (Figs. 4, 6). The ratio value of the distance between the central raphe endings to the



Figs. 1–5. *Berkeleya obtusa* (GREV.) GRUN.

1. A colony. Scale 2 cm. 2. Light micrograph showing the branching of the tube. Scale 1 mm. 3. Light micrograph showing the apex of the tube. Scale 200 μm. 4. Light micrograph of valve view. Scale 10 μm. 5. Scanning electron micrograph of outer surface of the valve. Scale 2 μm.

valve length was shown in Fig. 7. As a result of the comparisons between the material of Dec. 1973 and other samples, the ratio values of other samples approximately accorded with that of the material of Dec. 1973. The ratio values (percentage) of each class of the valve length were as follows; 14–23% in 20 μm valve length, 18–27% in 25 μm, 26–35% in 31 μm, and 31–36% in 35 μm. The ratio value increased in proportion to the valve length. As shown in Fig. 7, the ratio values of this species were distinct from that of *Berkeleya rutilans* from Japan (MIZUNO 1977). In the same class of valve length, the ratio value of this species was smaller than that of *B. rutilans*.

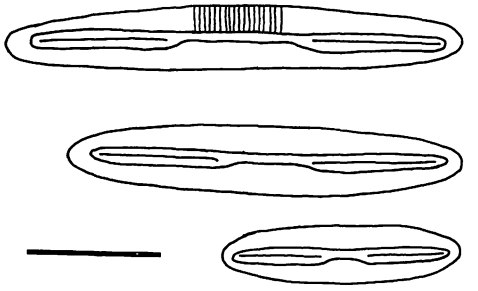


Fig. 6. Camera lucida drawings of cleaned valves of *Berkeleya obtusa*. Scale 10 μm.

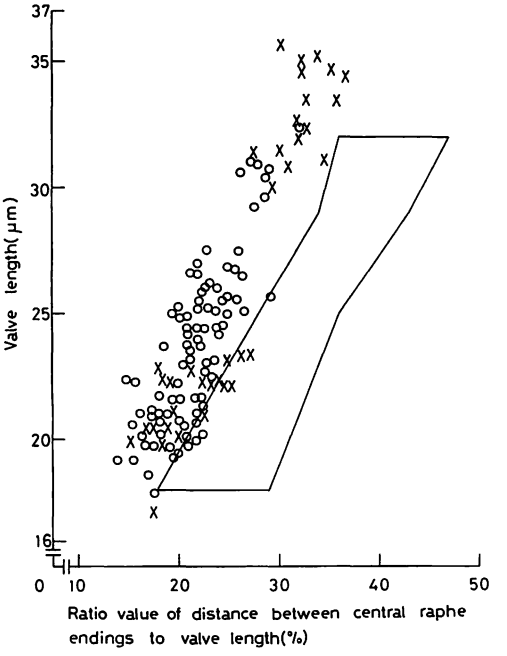


Fig. 7. Correlation between the valve length and the ratio value of the distance between the central raphe endings to the valve length of *Berkeleya obtusa* collected at Oshoro, in Dec. 1973 (○) and at Charatsunai, in Dec. 1975 (×). The area surrounded by solid lines shows that of *B. rutilans* (MIZUNO 1977).

The valve was finely striated (Fig. 4). The striation density was 24–32 in 10 μm in the middle of the valve and 26–32 striae were frequently observed. By scanning electron micrograph, the striae composed of small pores which arranged transversely except the end where the striae arranged radiately over the end (Fig. 5). The pore transversely elongated on either side of the central area (Fig. 5). There was no seasonal and geographical variation in valve morphology.

Discussion

Schizonema obtusum GREV. was transferred by GRUNOW (1880) to the genus *Berkeleya* GREV. emend. GRUN. on the basis of tube-dwelling habit and *Amphipleura*-like structure. According to GRUNOW (1880), *B. obtusa* has obtusely ended frustule, sparingly and dichotomously branched tube, and extremely large tube diameter (150–350 μm) than that of *B. rutilans*. VAN HEURCK's figure (1880–81, Pl. 16, fig. 16) of *B. obtusa* shows that the valve has narrowly elliptical form, 30.7 μm long, 6 μm wide, the distance between the central raphe endings of 9.8 μm (31.9% of valve length) and the striae of 26–28 in 10 μm. SMITH (1856, p. 78, Pl. 58, fig. 368) reported *Schizonema obtusum* (=*B. obtusa*) as follows; "Frond filiform, sparingly branched; apices abrupt; frustules exceedingly numerous, in irregular files; valves elliptical. Length of frond 1 inch (2.54 cm). Length of frustule 0.0011 inch (28 μm). Breadth of valve 0.00025 inch (6.4 μm)." The tube diameter measured from his figure is 200–400 μm. In comparison with two authors' descriptions and figures and the results obtained in the present study, this diatom from

Oshoro and Charatsunai is identified as *B. obtusa*.

This diatom occurs from winter to spring. MIZUNO (1977) reported that *B. rutilans* grew throughout the year except for warmer months at Oshoro. At Charatsunai where a wide tidal range occurs, the growing zone of this diatom is lower than that of *B. rutilans*. SMITH (1856) reported that *B. obtusa* grew epiphytically on algae. At Oshoro, this diatom grows not only epiphytically on seaweeds, but also epizoically on sea mussels. Some workers observed *B. rutilans* growing on rock, concrete, sea mussel and seaweeds (SMITH 1856; ALEEM 1950; HENDEY 1964; MIZUNO 1977). *B. obtusa* and *B. rutilans* show ecological differences in seasonal occurrence, growing zone and substrate (Table 1).

In the present study, it has shown that the ratio values of the distance between the central raphe endings to the valve length of *B. obtusa* is smaller than that of *B. rutilans* (MIZUNO 1977) in the same class of the valve length (Fig. 7). According to the figure given by VAN HEURCK (1880–81, Pl. 16, fig. 16), the ratio value of *B. obtusa* is distributed in the range of that of *B. obtusa* from Japan (Fig. 8). On the other hand, according to the figure given by VAN

Table 1. Diagnostic characters of *Berkeleya rutilans* and *B. obtusa*

Characters \ Species	*B. rutilans*	*B. obtusa*
Gelatinous tube diameter (μm)	10–80[a] 11–183[b]	150–350[a] 200–400[c] 100–500[d]
Mode of branching	irregular[b]	sparingly dichotomous[a] dichotomous[d]
Shape of tube tip	pointed[b]	terminated abruptly[c],[d]
Tube texture	rigid[b]	elastic[d]
Valve size (μm)	18–35×4–6[e] 12–38×3–6[b]	17–36×5–7[d]
Ratio value of distance between central raphe endings to valve length	large[b]	small[d]
Striae number in 10 μm	27[e], 24–36[b]	24–32[d]
Outer raphe ending	curved[e]	curved[d]
Pores on either side of central area	elongated[e]	elongated[d]
Occurrence	Oct.–Jul.[b]	Dec.–Apr.[d]
Growing zone	upper-middle littoral zone[b]	middle-lower littoral zone[d]
Substrate	rock, concrete, algae, sea mussel[b],[c],[f],[g]	algae[c] algae, sea mussel[d]

a) GRUNOW 1880, b) MIZUNO 1977, c) SMITH 1856, d) MIZUNO, present study, e) COX 1975, f) HENDEY 1964, g) ALEEM 1950.

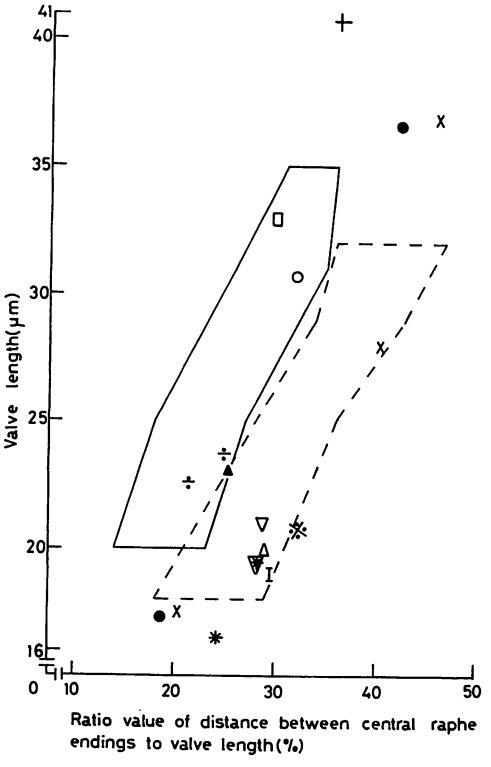


Fig. 8. Correlation between the valve length and the ratio value of the distance between the central raphe endings to the valve length measured from references. (○): *Berkeleya obtusa* (VAN HEURCK 1880–81, Pl. 16, fig. 16), (●): *B. dillwynii* (VAN HEURCK l.c., Pl, 16, fig. 15), (×): *B. obtusa* var. *adriatica* (VAN HEURCK l.c., Pl. 16, figs. 17, 18), (□): *B. rutilans* var. *obtusa* (PERAGALLO and PERAGALLO 1897, Pl. 7, fig. 16), (+): *B. rutilans* (PERAGALLO and PERAGALLO l.c., Pl. 7, fig. 11), (△): *B. rutilans* var. *adriatica* (PERAGALLO and PERAGALLO l.c., Pl. 7, fig. 14), (▲): *B. rutilans* var. *adriatica* (PERAGALLO and PERAGALLO l.c., Pl. 7, fig. 15), (✱): *Amphipleura rutilans* (HUSTEDT 1937, fig. 1093-a, -b), (▽): *A. rutilans* var. *obtusa* (HUSTEDT l.c., fig. 1093-c, -d), (÷): *A. rutilans* (ALEEM 1949, fig. 1-A, -B), (I): *A. rutilans* var. *obtusa* (ALEEM l.c., fig. 1-C) and (※): *B. rutilans* (COX 1975, fig. 8). The area surrounded by solid lines shows the correlation of *B. obtusa* in this study and the area surrounded by dotted lines shows that of *B. rutilans* from Japan (MIZUNO 1977).

HEURCK (1880–81), the ratio values of *B. dillwynii* (AG.) GRUN. (Pl. 16, fig. 15) (=*B. rutilans* by COX, 1975) are distributed in the extent of that of *B. rutilans* from Japan (Fig. 8). From the above descriptions and observations, some differences are recognizable between *B. obtusa* and *B. rutilans* in valve width and the ratio value of the distance between the central raphe endings to the valve length in the same class of the valve length (Table 1).

The author measured the ratio values of the distance between the central raphe endings to the valve length from the figures drawn by some workers and those are shown in Fig. 8. As shown in Fig. 8, those of *Berkeleya rutilans* (PERAGALLO and PERAGALLO 1897, Pl. 7, fig. 11), *B. rutilans* var. *obtusa* (PERAGALLO and PERAGALLO 1897, Pl. 7, fig. 16), *B. rutilans* var. *adriatica* (PERAGALLO and PERAGALLO 1897, Pl. 7, fig. 15) and *Amphipleura rutilans* (ALEEM 1949, fig. 1 A, B) are distributed in the same range or in the extent of that of *B. obtusa* from Japan. On the other hand, the ratio values of *B. obtusa* var. *adriatica** (VAN HEURCK 1880–81, Pl. 16, figs. 17, 18), *B. rutilans* var. *adriatica* (PERAGALLO and PERAGALLO 1897, Pl. 7, fig. 14), *B. rutilans* (COX 1975, fig. 8), *A. rutilans* (HUSTEDT 1937, fig. 1093-a, -b) and *A. rutilans* var. *obtusa* (HUSTEDT 1937, fig. 1093-c, -d; ALEEM 1949, fig. 1-C) are distributed in the same range or in the extent of that of *B. rutilans* from Japan.

CLEVE (1894) treated *B. obtusa* as a synonym of *Amphipleura rutilans* because of the similar values of the valve dimension and the relative fork length to the valve length. Subsequent workers have not given careful consideration to the correlation between the valve length and the distance between the central raphe endings. Moreover, GRUNOW (1880) reported in the description of the section *Monema* that valve shape varied from narrowly elliptical to

* GRUNOW (1880) used the specific epithet *rutilans*. On the other hand, the specific epithet *obtusa* was used in Synopsis des diatomées de Belgique (VAN HEURCK 1880–81). The specific epithet *obtusa* is adopted in this study.

lanceolate with decreasing valve length even in the same sample, and he suggested that the shape of valve had little importance as taxonomic criterion. However, HUSTEDT (1937) attached importance to the shape of valve for classification of variety of *A. rutilans* and treated the diatom showing lanceolate-form with obtuse ends as *A. rutilans* var. *obtusa*, and he placed *B. obtusa* as a synonym of *A. rutilans* var. *obtusa*. That is to say, it seems that *B. obtusa* and *B. rutilans* would be confused.

When CLEVE (1894) transferred the members of the genus *Berkeleya* into the genus *Amphipleura*, he ignored the tube morphology for classification and he treated *B. obtusa* as a synonym of *A. rutilans*. Subsequent workers followed CLEVE's opinion and they rarely reported the tube morphology. In SMITH's figures (1856), however, colonies of *Schizonema obtusum* (=*B. obtusa*) and *S. dillwynii* (=*B. rutilans*) are distinguished each other on the basis of feature of colony, the tube diameter and the shape of the tube apices. GRUNOW (1880) reported that the tube of *B. rutilans* (containing numerous varieties) has 10–80 μm diameter, no dichotomous branching, and length of up to 40 cm. MIZUNO (1977) reported that the tube of *B. rutilans* from Japan has 11–183 μm diameter, no dichotomous branching, and length of up to 5 cm. Judging from the figures and descriptions on the tube morphology, *B. obtusa* clearly differs from *B. rutilans*. The tube morphology of *B. obtusa* from Japan accorded with the figure and the descriptions given by SMITH and GRUNOW, and there was no seasonal and geographical variation. Compared with the tube morphologies of *B. obtusa* and *B. rutilans*, it is reconfirmed that there are differences between them in tube diameter, mode of branching, shape of the tube apices and texture of the tube materials (Table 1), and that the tube morphology is important for the classification of them.

In morphological and ecological comparisons between *B. obtusa* and *B. rutilans*, the former is similar to the latter in valve length, striation density and ultrastructures of the valve, but is different in tube morphology, valve width, the ratio value of the distance between the central raphe endings to the valve length in the same class of the valve length, seasonal occurrence, growing zone and substrate. Recently, COX (1975) treated *B. obtusa* as a synonym of *B. rutilans*. From the above mentioned differences, however, it is concluded that *B. obtusa* and *B. rutilans* belong to distinct taxa at the specific level.

GRUNOW (1880) reported that the tube of *B. obtusa* var. *adriatica* has 20–50 μm diameter, no dichotomous branching, length of up to 60cm. From the tube morphology and the ratio value of the distance between the central raphe endings to the valve length, it seems that *B. obtusa* var. *adriatica* is a synonym of *B. rutilans*.

The author wishes to express his thanks to Prof. Y. SAKAI of Hokkaido University, for reading and commenting on the manuscript, to Prof. M. KUROGI of Hokkaido University, Prof. S. IWAKI of Fuji Women's College, and Dr. T. IORIYA of Tokyo University of Fisheries, for considerable help during the literature search and to Mr. K. SIMADA of Muroran Institute of Technology, for help in operating the scanning electron microscope.

References

ALEEM, A. A. 1949. Distribution and ecology of marine littoral diatoms. Bot. Notiser **102**: 414–440.

ALEEM, A. A. 1950. Distribution and ecology of British marine littoral diatoms. Ecology **38**: 75–106.

CLEVE, P. T. 1894. Synopsis of the naviculoid diatoms. K. Sv. Vet.-Akad. Handl. **26**: 1–194.

COX, E. J. 1975. Further studies on the genus *Berkeleya* GREV. Br. phycol. J. **10**: 205–217.

GRUNOW, A. 1880. Vorläufige Bemerkungen zu einer systematischen Anordnung der *Schizonema*- und *Berkeleya*-Arten, mit Bezug auf die in VAN HEURCK's Diatomeenflora von Belgien veröffentlichten Abbildungen der

Frusteln auf Tafel XV, XVI und XVII. Bot. Centralblatt No. **49/50**, 1585–1598.

HENDEY, N. I. 1964. An introductory account of the smaller algae of British coastal waters. Part V. Bacillariophyceae (Diatoms). HMSO, London.

HUSTEDT, F. 1937. Die Kieselalgen. *In* RABENHORST's Kryptogamen Flora. Vol. VII. 2 Teil. p. 577–736. Akademische Verlagsgesellschaft, Leipzig.

MIZUNO, M. 1977. On the tube-dwelling diatom *Berkeleya rutilans* (TRENTEPOHL) GRUN. Bull. Jap. Soc. Phycol. **25**: 143–149.

PERAGALLO, H. and PERAGALLO, M. 1897. Diatomées marines de France et des districts maritimes voisins. Atlas Pl. 1–24. M. J. Tempère, Grez-sur-Loing.

SMITH, W. 1856. A synopsis of the British diatomaceae. Vol. II. J. v. Voorst, London.

VAN HEURCK, H. 1880–81. Synopsis des diatomées de Belgique. Atlas. Pl. 1–132, privately publ., Anvers.

水野　真：北海道産 *Berkeleya obtusa* (GREV.) GRUNOW (珪藻綱) の分類学的研究

北海道の小樽と室蘭から得られた *Berkeleya obtusa* (GREV.) GRUN. について形態的・生態的研究を行った。この種を *B. rutilans* (TRENT.) GRUN. と比較すると，殻・粘質管の構造と生態に差異がみられ，*B. obtusa* と *B. rutilans* とは異なる分類群である事を確認した。(051 室蘭市母恋南町 1-13　北海道大学理学部附属海藻研究施設)