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Occurrence of *Phaedactylum tricornutum* in the Great Salt Lake, Utah, USA

Samuel R. Rushforth
Brigham Young University

Jeffrey R. Johansen
Solar Energy Research Institute, Golden, Colorado

Darwin L. Sorensen
Utah State University

OCCURRENCE OF *PHAEDACTYLUM TRICORNUTUM* IN THE GREAT SALT LAKE, UTAH, USA

Samuel R. Rushforth[1], Jeffrey R. Johansen[2], and Darwin L. Sorensen[3]

ABSTRACT.—The diatom *Phaedactylum tricornutum* Bohlin forms blooms in the south arm of the Great Salt Lake, Utah, during cool months. This represents the first report of this taxon from Utah and the first from nonmarine waters in the United States.

Phaedactylum tricornutum Bohlin was first described from coastal waters of Runmarö near Stockholm, Sweden, in 1897. Bohlin (1897) described this organism as being triradiate with each arm being 10–12 um long. Bohlin was not certain of the taxonomic position of this taxon but suggested it was closely related to the diatoms.

In 1907 Allen isolated a diatom culture from Plymouth, England, which he designated but did not describe as *Nitzschia closterium* W.Sm. f. *minutissima* (Allen and Nelson 1910). This diatom was used extensively as food for various marine invertebrate larvae. It was kept for many years at Plymouth and widely distributed to other laboratories in Europe and America. In 1935 Barker noted the occurrence of triradiate and oval cells in his subculture of the organism. Wilson and Lucas (1942) noted that the diatom was polyphasic, producing fusiform, triradiate, and oval cells; and Wilson (1946) later presented considerable detail on the life cycle of the Plymouth strain. Though Wilson drew attention to the fact that the Plymouth culture resembled *P. tricornutum*, he did not recognize *N. closterium* f. *minutissima* as a synonym.

Hendey (1954) reviewed the taxonomic history of *P. tricornutum* and indicated that it was the same organism as *N. closterium* f. *minutissima*. Hendey presented electron micrographs of both triradiate and fusiform cells from the Plymouth culture and noted that he could not determine if the cell was frustular and therefore questioned whether or not it was a diatom. Bourrelly and Dragesco (1955) also were unable to find evidence of valve structure.

Lewin et al. (1958) finally demonstrated that *P. tricornutum* was indeed a diatom by finding siliceous valves associated with the oval cells. Lewin and co-workers discussed the fact that the fusiform and oval cells of *P. tricornutum* dominated their laboratory cultures but triradiate cells were commonly recognized in littoral water samples. Lewin (1958) concluded that *P. tricornutum* was allied with *Cymbella* Ag., a conclusion with which Hendey (1964) concurred.

This diatom was collected from the Great Salt Lake by Felix and Rushforth in 1979, but it was incorrectly identified as *Treubaria triappendiculata* Bernard. We have since observed this taxon frequently in samples collected from the Great Salt Lake.

METHODS

Detailed studies of the Great Salt Lake east of Antelope Island have been conducted during the past two years. These studies were designed to provide data on the biota, nutrients, heavy metals, organics, pathogenic bacteria, and sediments of the lake. As a part of these studies, we established 34 collecting localities for algal studies in the lake east of Antelope and Fremont islands, ranging from Farmington Bay on the south to the Southern Pacific Causeway on the north (Fig. 1).

Collections for algal identification and enumeration started on 25 July 1986 and continued at least monthly (except for November)

[1]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.
[2]Solar Energy Research Institute, 1617 Cole Blvd., Golden, Colorado 80401.
[3]Utah Water Research Laboratory, Utah State University, Logan, Utah 84322-8200.

Fig. 1. Map of the Great Salt Lake showing the position of the three collecting localities for *Phaedactylum tricornutum*.

through 22 December 1986. Plankton samples were collected from surface waters by submerging wide-mouthed plastic bottles directly into the lake.

Samples were returned to our laboratory at Brigham Young University where they were suction filtered using 1.2 μm pore membrane filters. The filters were cleaned in 10 ml distilled water, and the algae were immediately counted using Palmer counting chambers (Palmer and Maloney 1954). Algal numbers were then multiplied by known factors to project numbers of organisms per liter of lake water.

Independent of this project, two Great Salt Lake water samples containing *P. tricornutum* were collected by Johansen from Farmington Bay on 23 October 1986 and 6 March 1987. Two clonal cultures of the triradiate form of this taxon were isolated from enrichment cultures and designated PHAEO3 and PHAEO4. The clones are available from Microalgae Culture Collection at the Solar Energy Research Institute.

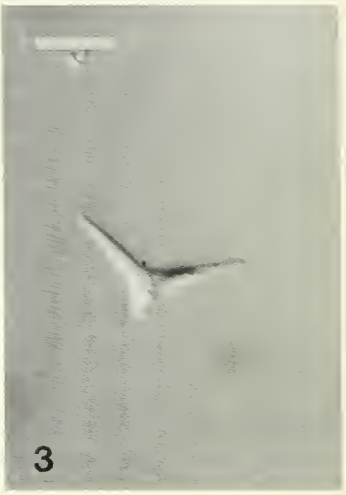
Results and Discussion

Phaedactylum tricornutum is abundant in the Great Salt Lake during months of cool temperature and low light. We collected it from October through March. During December it forms rather large blooms, ranging up to 2×10^7 cells per liter (Table 1). It occurs with the diatoms *Chaetoceros muelleri* var. *subsalsum* Johansen & Rushforth, *Nitzschia acicularis* (Kütz.) Wm.Sm., *Thalassiosira weisflogii* (Grun.) Fryxell & Hasle, the green alga *Oocystis* species, and the cyanophytes *Nodularia spumigena* Mertens and *Oscillatoria* species. *Phaedactylum tricornutum* co-dominates the winter diatom flora with *N. acicularis* and *C. muelleri* var. *subsalsum*.

Phaedactylum tricornutum has previously been found in coastal brackish waters in both Europe and North America. It has been observed both in small bodies of water, such as fishery tanks and rock pools, as well as open waters. It commonly occurs in waters of elevated nutrient content (Wilson 1946, Barclay, personal communication). The south arm of the Great Salt Lake is also of elevated nutrient

Table 1. Abundance of *Phaedactylum tricornutum* and descriptive water data in the Great Salt Lake during the fall of 1986.

Date	Site	Cells per liter	Surface temp.	Dissolved oxygen	pH
10/23/86	Farmington Bay	4.5×10^6	13.4	13.4	9.2
10/23/86	Antelope Island	3.1×10^6	13.7	10.7	9.0
10/23/86	Fremont Island	4.9×10^5	14.3	9.4	9.0
	Mean density of *P. tricornutum*, 10/23/86, = 1.6×10^6 cells/liter.				
12/22/86	Farmington Bay	2.0×10^7	0.3	13.6	8.4
12/22/86	Antelope Island	1.7×10^7	1.3	13.3	8.3
	Mean density of *P. tricornutum*, 12/22/86, = 1.8×10^7 cells/liter.				



Figs. 2–3. Cells of *Phaedactylum tricornutum*: 2, several cells illustrating characteristic triradiate cell shape; 3, cell with two long arms and one shortened arm.

content due to the influence of sewage and industrial effluents from several Wasatch Front cities. *Phaedactylum tricornutum* is most abundant in Farmington Bay (including the inner bay and Antelope Island sites) possibly because these waters are more enriched than other parts of the lake.

Phaedactylum tricornutum seems to occur within the Great Salt Lake when surface water temperatures fall below 15 C. Barker (1935) found the photosynthetic optimum of this species to be between 25 and 30 C. We have noted that a number of species we isolated from cold, inland, saline waters have growth optima at 25–30 C, even though they are abundant in nature only during cool seasons. There are apparently other factors, such as light intensity, that contribute to the abundance of these diatoms during the winter. It is also likely that decreased competition and/or decreased invertebrate grazing pressure modify community structure. Wilson (1946) noted that the triradiate form of *P. tricornutum* could not be ingested easily by marine invertebrate larvae.

Our specimens are primarily triradiate (Fig. 2), although fusiform and oval cells have been observed. Triradiate cells dominate field collections. However, we have observed oval and fusiform cells in culture. This agrees with the observations of Lewin et al. (1958).

To our knowledge, this report is the first for *P. tricornutum* from inland waters. However, it is possible that it does occur in other inland saline waters but has been overlooked. It is easily destroyed and will not survive a typical acid clearing procedure for preparation of diatom-strewn mounts.

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