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Notes on Diatoms V. : Epilithic Diatom Biomass in the Des Moines River

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NOTES ON IOWA DIATOMS

V. Epilithic Diatom Biomass in the Des Moines River[1]

Ryan W. Drum[2]

Abstract. Luxuriant epilithic growths of the diatom, *Gomphonema olivaceum* (Lyngbye) Kutz., were observed to be growing throughout a 320 km section of the Des Moines River. Flat rocks covered with the diatom growth were collected and the live weight of the diatom biomass per square centimeter was determined to be 0.7 gm. This included 0.021 gm dry weight of organic matter. Using these values, the standing epilithic diatom biomass in one 6 km section of the river was estimated to be 1260 metric tons (live weight) containing 37.6 metric tons dry weight of organic matter. The bulk of the growth consisted of polysaccharide material secreted as tubular stalks by *G. olivaceum.* Extensive growths were usually limited to rocky shoals and riffle areas, composed of either cobbles and boulders of glacial origin, or of rock rubble of local origin.

For several weeks in the fall of 1962, conditions in the Des Moines River were optimal for the epilithic growth of the diatom, *Gomphonema olivaceum* (Lyngbye) Kutz. Uniformly low temperatures (4-8°C), clear water, a nearly stable water level, abundant nutrients (see Table 1), and the absence of significant grazing populations all contributed to the favorable environment. Vast quantities of *G. olivaceum* flourished in the Des Moines River from October 20 to December 12 and continued to flourish in areas of open water throughout the winter months.

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Table 1. Chemical data from the Des Moines River at the Fraser Dam, collected onNovember 28, 1962, at 1:30 p.m.

Oxygen	12 ppm	Sulfate	95 ppm
Iron	0.02	Chloride	19
Phosphate	0.30	Calcium Hardness	200
Silica	22.0	Total Hardness	460
Nitrate	4.0	Methyl Orange Alkalinity	270
Nitrite	0.011		
		pH	8.3

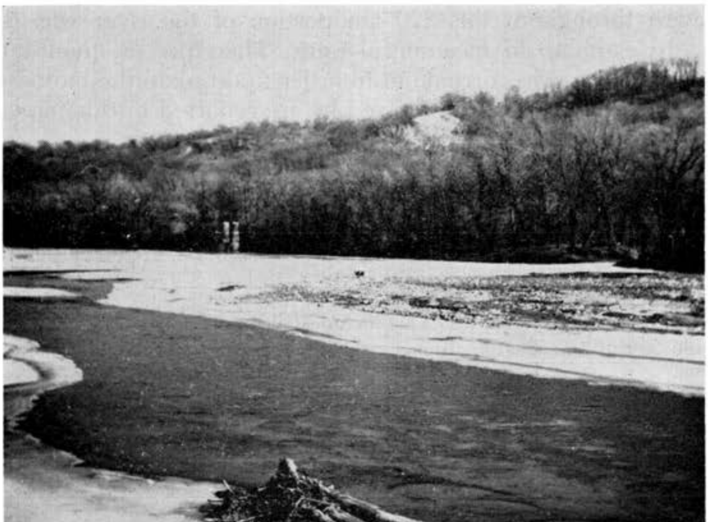


Figure 1. Large rock shoal in Des Moines River, cmoposed mainly of cobbles and boulders. (Boone Co., Iowa)
Figure 2. West Fork of the Des Moines River dowstream from the Highway 169 bridge at Humboldt, Iowa, showing a rock rubble riffle area

In late November, 1962, during the course of a three-day survey of the Des Moines River basin, from its headwaters at Lake Shetek, Minn., to its confluence with the Mississippi River south of Keokuk, Iowa, I observed and collected samples from extremely luxuriant epilithic diatom growths on rocky shoals and riffle areas (Figures 1 and 2). Such growths were common at all sampling stations between Estherville, Iowa, and the Center Street Dam in Des Moines, Iowa. The magnitude of the diatom growth throughout this 320 km portion of the river was difficult to estimate in meaningful units. Therefore, a quantitative determination was carried out in order to estimate the biomass of epilithic diatom growth. The results are reported in this paper.

Results

Table 2. Water, ash[1], and organic matter composition of the epilithic diatom growths collected on November 28, 1962.

Water	Ash	Organic Matter
81%	16%	3%

[1] The high ash percentage is due to the particulate matter trapped within the colonies sampled. This includes silt and fine sand.

Table 3. Epilithic Diatom Biomass, Des Moines River, November 28, 1962

	Measured gm/cm^2	Converted metric tons/ hectare	U.S. tons/acre
Wet (Live) Weight	0.7	70	28
Organic Matter (ash-free dry weight)	0.021	2.1	0:85

Materials and Methods

On November 28, 1962, three nearly flat rocks were collected from an extensive rock shoal, comprised mainly of cobbles and boulders of glacial origin, at the YWCA bend in the Des Moines River in Boone Co. (T-85N, R-27W, Sec. 36). The diatom growth from the top surface of each rock was carefully removed, placed in a separate beaker and allowed to drain for 1 hour. The samples were then placed in porcelain crucibles, weighed on an analytical balance, and put in an oven at 45°C for 48 hours. They were weighed again and then kept at 60°C until constant weight was achieved. Higher temperatures were not used since such treatment might result in the loss of volatile cellular components. The samples were next ignited to ash at 800°C until constant weight was reached. From the data obtained in the above manner, the percentages of water, organic matter, and ash in the diatom growths were calculated (Table 2). The choice of rocks with flat surfaces permitted measurement of their respective areas with a planimeter and the calculation of weight per unit area (Table 3). The amount of live (wet) weight and the amount of organic matter are expressed both in metric tons per hectare and in U. S. tons per acre. Additional material was sampled for light microscopic examination. Some of this material was vitally stained with ruthenium red. The remainder was cleaned with concentrated H_2O_2 and $K_2Cr_2O_7$, and used for taxonomic determinations and electron microscopy. No algal forms other than diatoms were observed in the material collected.

Discussion

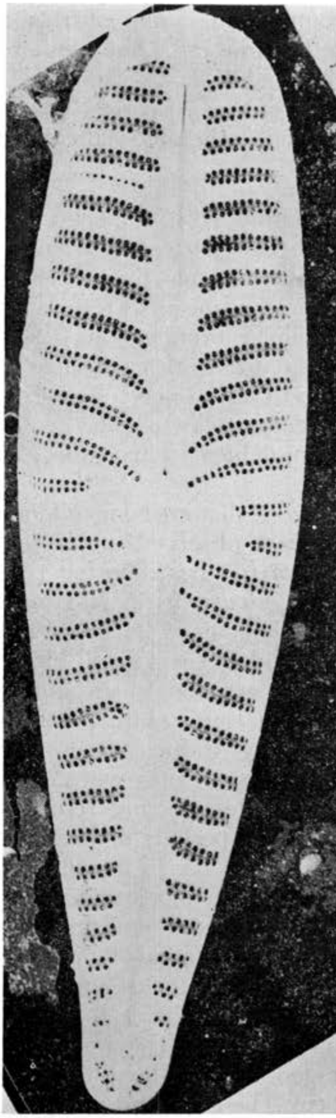
As noted above, the dominant diatom with respect to both numbers and biomass was *Gomphonema olivaceum* (Lyngbye) Kutz. An electron micrograph of the siliceous frustule of this organism is furnished in Figure 3. This organism secretes a polysaccaride in the form of an extracellular tubular stalk, as seen in Figures 4 and 5. The stalks dichotomize with each vegetative cell division and reach lengths of up to 5 mm per cell. The bulk of the colonial mass consists of these stalks which are filled with water. The structure of the *Gomphonema olivaceum* colony has been discussed by Cholnoky (1).

Extensive growths of members of the diatom genus *Gomphonema* in Iowa streams and rivers were observed and reported by Meyers (2) as early as 1898. Blum (3) has reported the occurrence of luxuriant growths of *G. olivaceum* in streams and rivers in the vicinity of Ann Arbor, Michigan.

When the water level drops as it did in the fall of 1962, the diatom-covered rock surfaces become exposed to air and sunshine and the colonies dry down to a thin, white flaky layer. This same phenomenon was observed by Abdin (4) to occur in the Aswan Dam Reservoir when diatom colonies were exposed by a drop in the water level. This white covering remains on the rocks until it is washed away during periods of high water.

Cobbles, boulders, and rock rubble that lay in flowing water, water that is either open or covered by no more than 5 cm of ice, have been observed to maintain extensive epilithic diatom growths throughout the winter months. An area of open water in the upper reaches of the Des Moines River, just south of the junction of the East and West Forks in Humboldt Co. (T-89N, R-28W), was visited on February 21, 1963. The open section was roughly 6 km long, and averaged 30 m in breadth, with an almost uniform depth of about 50 cm. The river bottom appeared to be composed entirely of rock rubble of local origin. The water was very clear, and (with the aid of the midday sun) the entire bottom of the river was observed to be covered with a 1-2 cm blanket of *Gomphonema olivaceum* colonies. Large spheroidal colonies frequently broke loose from the rocks and floated to the surface of the river. Each of them contained a large gas bubble trapped within.

If one assumes that the growth observed was fairly uniform throughout the 6 km section, then the values given in Table 3



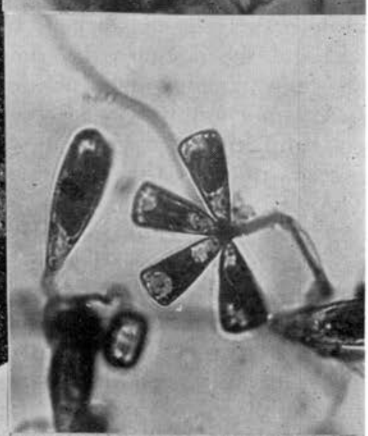


Figure 3. Election micrograph of *Gomphonema olivaceum* (Lyngbye) Kutz. (X5500)
Figure 4. Light micrograph of *G. olivaceum* after staining the stalks with ruthenium red. (X550).
Figure 5. Figure 5. Light micrograph of two pairs of daughter cells of *G. olivaceum* prior to their respective formation of new stalk material.

can be used to estimate the standing biomass of this segment of the Des Moines River. These values yield an estimate of 1260 metric tons of live weight, and 37.8 metric tons dry weight of organic matter (Respectively, these values convert to 1386 U. S. tons, and 41.6 U. S. tons.).

How important such vast quantities of epilithic diatoms may be in terms of primary production is difficult to evaluate. It has been shown, however, that diatoms make up the bulk of the food of some insect larvae (5) and of several species of minnows in the Des Moines River (6). The colonies provide a suitable habitat for many types of protozooans, rotifers, and aquatic worms. Many other diatom taxa are also found thriving among the stalks of *G. olivaceum.*

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A Study of Photosynthesis in Clear Lake, Iowa[1]

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Abstract. The oxygen and carbon-14 methods were used to measure photosynthesis in Clear Lake, Iowa during 1958 and 1959. Differences in the rates of photosynthesis at widely separated stations were generally small. Daily variations in the rate of photosynthesis were not greater than two-fold. The correlation between the rate of photosynthesis and the incident illumination was 0.81, and the efficiency of utilization of incident light energy was 0.72 per cent. The net gain of organic matter at the phytoplankton level during the period May 1 to November 1 was equivalent to 3480 pounds of glucose per acre.

Despite the basic position of planktonic algae in the food chain of aquatic environments there have been few extensive studies of food production by phytoplankton in well-defined ecosystems, and little has been done to follow quantitatively the flow of organic matter from one level in the food chain to the next. A knowledge of the total food budget available at the primary level would contribute much to an understanding of fish population dynamics even though the food relationships between fish and phytoplankton are complex and generally obscure. This study of photosynthesis was undertaken to supplement studies of fish population dynamics that have been carried on in Clear Lake since 1941.

Clear Lake has an area of approximately 1500 hectares and a

[1] This study was conducted in the Department of Botany and Plant Pathology as a part of Project 11 of the Atomic Energy Commission under contract AT(11-1)59, ministere dthrough the Institute for Atomic Research, Iowa State University, Ames, Iowa.

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