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EFFECT OF TEMPERATURE ON THE PHOTOSYNTHESIS OF A NATURAL DIATOM POPULATION

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Several suggestions have been made to explain the regular appearance of the characteristic diatom mass-vegetation in early spring and late autumn months on the stony shores of Lake Balaton *(e.g.* G. ENTZ and SEBESTYÉN 1946, 301, FELFÖLDY 1958 etc.).

No definite answer has been hitherto given to the question of seasonal appearance of the diatom belt. It was suggested that it might be attributed to the effect of low temperature but no exact measurements were made to verify this supposition. Moreover in work previously mentioned (FELFÖLDY *l.c.p.* 336), both the results of preliminary experiments and literary data being considered, the role of temperature as a factor did not appear important.

In this paper experiments on the effect of temperature will be discussed in detail.

Materials and methods

The material for photosynthetic measurements was collected on 31st March 1960, on the shore of the Lake from stones yellow with diatom covering. *(Diatoma elongatum var. tenuis*-zone, see FELFÖLDY 1958, 332, 334.) The mass of diatoms was washed from the stone surface with a brush into a larger porcelain dish containing lake water. The suspension obtained in this way was filtered into a beaker through a dense bronze sieve. After a short sedimentation of 1—2 minutes (the heavy inorganic particles sink for the most part to the bottom of the beaker), the reddish-brown diatom suspension was decanted into centrifuge tubes. Thereafter the experimental suspension containing 650 cells pro μl was prepared by washing the diatom cells with fresh lake water by centrifuging at low speed and resuspending them in filtered Balaton-water. (Delta filter paper No 368.) In this suspension *Diatoma elongatum* var. *tenuis* dominates constituting about 95% of total cell number. For associate species see FELFÖLDY 1958, 334.

Photosynthesis was measured manometrically. 10 ml suspension was put into the usual WARBURG vessels and the released O_2 was measured five times at every 30 minute at temperatures 10, 20, 25, $30\pm0{,}1°$ C, and at *c.* 7000 lux light intensity. A fresh sample of cells was used for each run of determinations; the stock cell suspension was kept in water bath at the temperature of the next experiment. An adaptation time of 150 minutes was found sufficient at each temperature. The results are given in μl O_2/1 mg chlorophyll *a*/hour units. The estimation of pigments was performed by the method of Richard and Thompson (Barnes 1959, 242—244).

Aliquots of experimental suspensions were filtered through "Delta" filter paper No 368 with suction. To minimize pheophytin formation, the filter papers with the adherent diatom cells were kept exposed for a short interval (up to three minutes) to hot water vapour (Krey 1939, Gessner 1944). Pigment extraction was made with aqueous acetone (90%) in which the samples were allowed to stand for 12—15 hours, to obtain complete extraction. Thereafter the solutions were carefully filtered, and filled up to known volume. Their transmittancies were measured at 665, 645, 630 millimicrons by Beckman D. U. spectrophotometer.

The concentration of chlorophyll *a* (C_a) is

$$C_a = 15{,}6\ A_{665} - 2{,}0\ A_{645} - 0{,}8\ A_{630}$$

where $A = \log_{10} 1/T$ (absorption at different wave lengths mentioned above)

Table 1

Photosynthetic power of diatom suspension at various temperatures

Temperature °C	μl O_2/1 mg chlorophyll *a* one hour
10	390,0
15	408,1*
20	384,8
30	76,6

Results and discussion

The results of photosynthetic measurements are illustrated in *Table 1*. According to these data a flat optimum can be studied between 10 and 20 °C. On basis of literary data at our disposal it is assumed that a temperature optimum so low is not common for algal photosynthesis. Whereas the cold resistance of bacillariophytes is rather known (Gessner 1955, 171, Fott 1959, 104), results based on experiments with pure cultures show always optima at higher temperatures. Barker (1935) has found optimal photosynthesis at 27—33°C in his study in two *Nitzschia* species. In his work with *Nitzschia putrida*, Richter (1911) demonstrated optimum growth for the species at 24 to 25°C. Wallace (1955) stated that the optimum growth of three species of fresh-water diatoms *(Nitzschia filiformis, N. linearis* and *Gomphonema parvulum)* occurred at 22 to 30°C. For photosynthesis of other unicellular algae temperature optima of about 27—30° or higher was demonstrated experimentally (Lumry *et al.* 1954). Rodhe (1948), working with natural populations, similar to those applied in our investigations, found a growth optimum at 5 to 10°C in *Melosira islandica* ssp. *helvetica* and he concluded that the annual periodicity of this species was due to both temperature and light.

* On basis of 12 measurements only.

The temperature coefficient, that is to say, the ratio of the rate of photosynthesis at a given temperature to the rate thereof at temperature which is 10° lower (Q_{10}), is always greater than 2 between 5—15°C. The Q_{10} of different *Chlorella* strains are: 2,07 (NODDACK and KOPP 1940 *ap.* THOMAS 1955), 4,3—5,0 (WARBURG 1919), 4,4—5,8 (EMERSON 1929, BALY 1940). In our experiments performed at 10—15°C $Q_{10} = 2,1$, but above 15°C Q_{10} was less than 1. The effect of temperature on the photosynthetic process is very complex and some adaptation phenomena should also be taken into consideration (HARDER 1924, GESSNER 1955, 142—146), nevertheless the significant role of lower temperature of water in the development and existence of periphytic diatom mass vegetation might be regarded as established on basis of our experiments. Our earlier statement, therefore (FELFÖLDY 1958), that low temperature is not so important in the life of these plant societies must be abandoned.

Summary

The photosynthesis of the periphytic diatom mass vegetation growing on the stony shores of Lake Balaton was measured by the manometric method of Warburg in filtered Balaton-water, at 10, 15, 20 and 30° C temperatures and at *c.* 7000 lux light intensity. A flat optimum could be observed between 10—20°C.

The importance of low temperature, as an ecological factor, controlling the appearance and existence of these periphytic diatom coverings in early spring and late autumn is supported by these experimental results.

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A HŐMÉRSÉKLET HATÁSA A BALATON-PART KÖVEIN ÉLŐ TERMÉSZETES KOVAMOSZAT-POPULÁCIÓ FOTOSZINTÉZISÉRE

Felföldy Lajos

Összefoglalás

A Balaton eróziós partszakaszainak hullámjárta kövein élő jellegzetes megjelenésű sávban található kovamoszat tömegvegetáció koratavaszi és késő őszi megjelenésének okát kutatva az alacsony hőmérséklet igen kézenfekvő hatását irodalmi adatok és előzetes kísérletek alapján nem tartottuk fontosnak (FELFÖLDY 1958).

A kérdés tüzetes megvizsgálására az 1960 március végén és április elején szépen kialakult kovamoszat sávból március 31-én mintát gyűjtöttünk, melyből 650 sejt/μl sűrűségű szuszpenziót készítettünk szűrt Balaton-vízzel és ennek 10 ml-ében megmértük a fotoszintézis mértékét WARBURG manometriás módszerével 10, 20, 25, 30 $\pm$0,1 C°-on, kb. 7000 lux megvilágítás mellett. Az eredményt μl O^2/1 mg a-klorofill/óra egységben adjuk meg. A pigment meghatározást RICHARD és THOMPSON módszerével végeztük (BARNES 1959). Az acetonos kivonat abszorpcióját BECKMAN D. U. spektrofotométerrel mértük.

Az *1. Táblázat*-ban található eredmények szerint 1—20 C° között a fotoszintézisnek lapos maximuma van. Egysejtű algák esetében ilyen alacsony hőmérsékleti optimumot eddig nem ismertünk. Bár a hőmérséklet hatása a fotoszintézisre nagyon komplikált és bizonyos adaptálódási jelenségek is számításba jöhetnek, kísérleteink alapján az alacsony hőmérséklet fontos szerepe a balatoni kovamoszat öv kialakulásában és fennmaradásában kétségtelen.