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NET PHOTOSYNTHESIS AND PRODUCTION OF *FURCELLARIA LUMBRICALIS* IN KASSARI BAY, ESTONIA

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Abstract. Net photosynthesis and respiration of *Furcellaria lumbricalis* in Kassari Bay were studied. *F. lumbricalis* showed low photosynthetic activity and accordingly low primary production values. The main environmental factor controlling the production of *F. lumbricalis* is the amount of light available for it.

Key words: Kassari Bay, *Furcellaria lumbricalis*, net photosynthesis, respiration, primary production.

INTRODUCTION

In 1988—90 *in situ* experiments with *Furcellaria lumbricalis* were carried out in Kassari Bay. Together with *Phyllophora truncata* it forms a loose-lying red algal community covering most of the bay's surface at depths of 5—9 m there (Trei, 1978). The species is of great commercial importance, being the basic raw material for the production of the so-called estagar.

The purpose of these experiments was to investigate the photosynthesis and respiration of *F. lumbricalis* in its natural habitat during the vegetation period (except 1990, when the experiments were carried out only in April). Effects of environmental factors, including natural variations in light conditions and temperature, on the above-mentioned processes were also studied with the aim of obtaining data applicable in production estimations.

MATERIAL AND METHODS

Net photosynthesis and respiration of *F. lumbricalis* were determined in the plants growing in natural conditions at a depth of 8 m. For this purpose, changes in dissolved oxygen concentration in light and dark bottles were measured using the Winkler titration method. About 0.5 g (dry weight) of algal material was added to the 300 ml experimental bottles (dark ones were wrapped in aluminium foil) for an incubation period ranging from 3 to 4 hours at noon. The obtained oxygen values were converted to mg C·g dry $wt^{-1} \cdot h^{-1}$, assuming a photosynthetic quotient (PQ)) of 1.2 and respiratory quotient of 1.0 (each of the results is a mean of three replicates).

Dry weight was determined at a temperature of 60°C, and ash-free dry weight at a temperature of 450°C (Dybern et al., 1976).

At the time of the experiments solar radiance ($kW \cdot m^{-2}$) above the water surface and water temperature at 8 m depth were measured. Water transparency was estimated by Secchi disc.

RESULTS AND DISCUSSION

According to our experimental data (Fig. 1) obtained in 1988—89 the highest net photosynthetic rates for *F. lumbricalis* in Kassari Bay were measured from the end of May through July: 0.16—0.25 mg $C \cdot g$ dry $wt^{-1} \cdot h^{-1}$. However, our studies in spring 1990 showed that under more favourable light conditions (Secchi disc transparency 5 m, clear sky) the net photosynthesis of *F. lumbricalis* may reach the maximal rates already at the end of April (data not shown).

Our results are in agreement with the data available in literature. In a field experiment Leskinen et al. (1992) measured using the ^{14}C technique the maximal production rate for *F. lumbricalis* at 3.5 m depth to be 0.23 mg $C \cdot g$ dry $wt^{-1} \cdot h^{-1}$ (converted from μmol photons$\cdot m^{-2} \cdot s^{-1}$ presuming the C content in dry weight to be about 32.7% — our data). In laboratory experiments the values obtained were somewhat higher: 0.26—0.35 mg $C \cdot g$ dry $wt^{-1} \cdot h^{-1}$. King & Schramm (1976) reported a net productivity in laboratory experiments of 3.2 mg $O_2 \cdot g$ dry $wt^{-1} \cdot h^{-1}$ in spring and 1.8 in autumn (corresponding to *c* 1.0 mg C and 0.56 mg C, respectively, if PQ=1.2). Wallentinus (1978) measured with the ^{14}C technique in the field the productivity of *F. lumbricalis* to be 0.36—0.54 mg $C \cdot g$ dry $wt^{-1} \cdot h^{-1}$, while in the laboratory a range of 0.23—0.94 mg $C \cdot g$ dry $wt^{-1} \cdot h^{-1}$ was measured. Inconsistent results obtained by different authors are evidently due to a variety of both techniques and experimental conditions used.

Relatively high net photosynthetic rates of *F. lumbricalis* in Kassari Bay were measured also in August and September, but the primary production was lower than in June—July. This could be due to the shortened length of the day with sufficient light for photosynthesis (in June the day light is about 6 hours longer than in September and maximal solar radiance measured at noon is in September about 60% of that measured in June) and decreasing part of photosynthetically active radiation in solar radiance.

The primary production was at its highest (3.3 mg $C \cdot g$ dry $wt^{-1} \cdot day^{-1}$) in June. But it must be pointed out that due to the lack of up-to-date equipment for long-term measurements (a continuous flow-through system as described for instance by Kautsky (1984) and Lindblad et al. (1986)) only a rough estimate of primary production was possible.

For measuring the diurnal changes in net photosynthetic rates a 24 hour experiment was carried out on 21—22 July 1988. At the time of the experiment the water temperature was about 22°C and transparency 3.5 m. The obtained results with the corresponding diurnal course of radiance presented in Figs. 2 and 3 demonstrate a good correlation ($k=0.97$) between changes in the diurnal light conditions and the net photosynthesis of *F. lumbricalis*. The latter exhibited an increase with increasing radiance up to maximum at noon when the highest solar radiance values were measured. Contrary to the results of Leskinen et al. (1992) we did not find bimodality in the photosynthetic activity of *F. lumbricalis* during the day, most probably due to different experimental conditions.

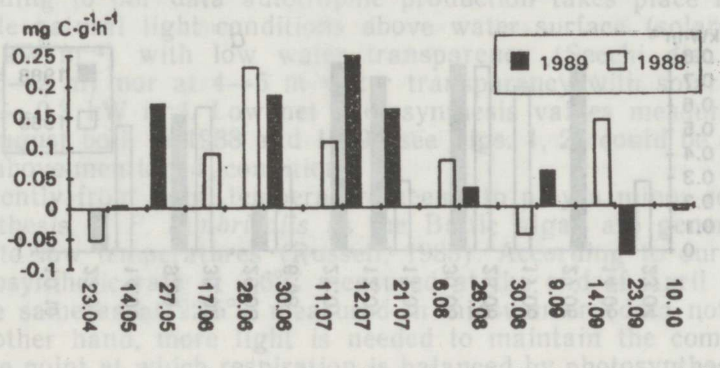

Fig. 1. Net photosynthesis of *Furcellaria lumbricalis* in 1988 and 1989.

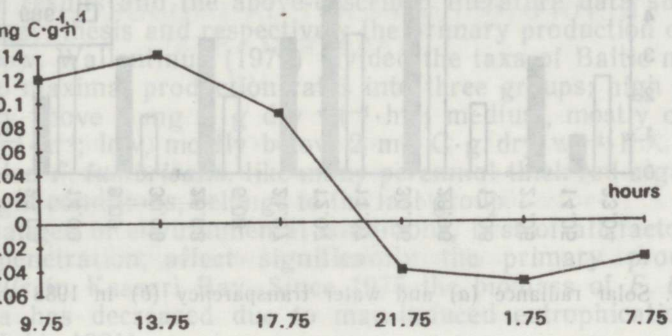

Fig. 2. A 24-hour experiment; net photosynthesis.

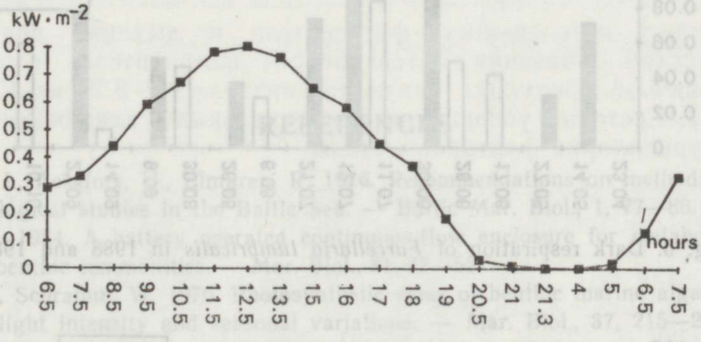

Fig. 3. A 24-hour experiment; solar radiance.

It is obvious that the major factor controlling the production of *F. lumbricalis* at its natural habitat is the amount of light available for algae, dependent both on light conditions above the water surface and water transparency. In Kassari Bay where soft bottoms of chiefly clay and sandy clay prevail (Trei, 1978) the water transparency is low — it varied from less than 1 m to 5 m during our experiments (Fig. 4). Decreased light penetration through the water column could be caused also by phytoplankton blooms.

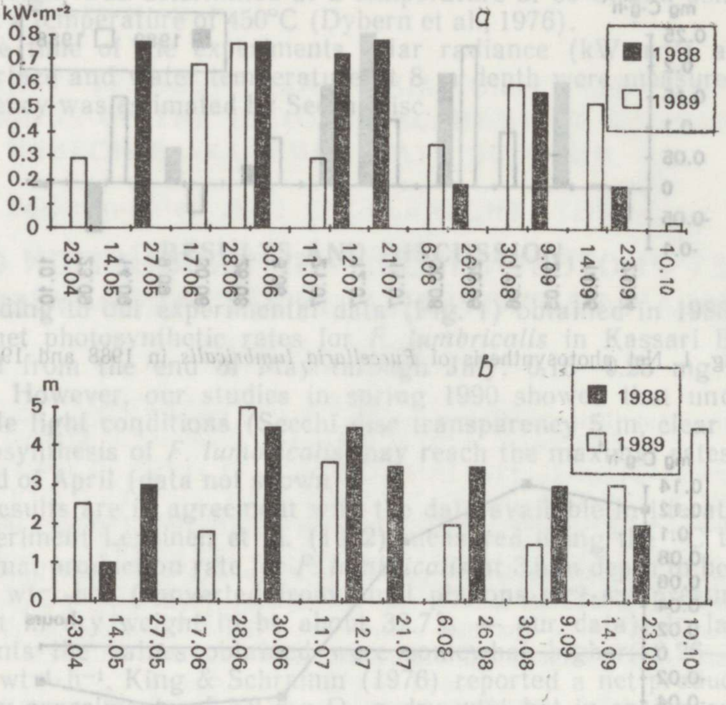

Fig. 4. Solar radiance (*a*) and water transparency (*b*) in 1988 and 1989.

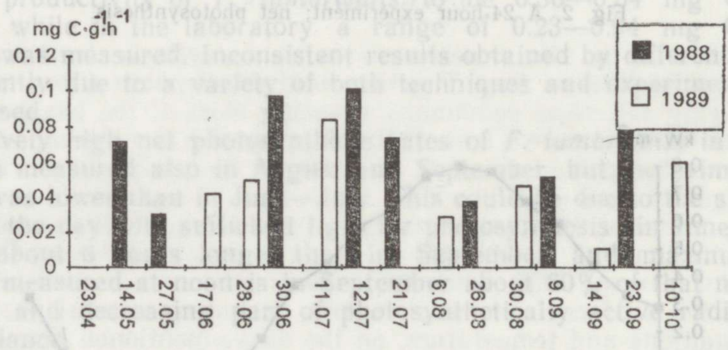

Fig. 5. Dark respiration of *Furcellaria lumbricalis* in 1988 and 1989.

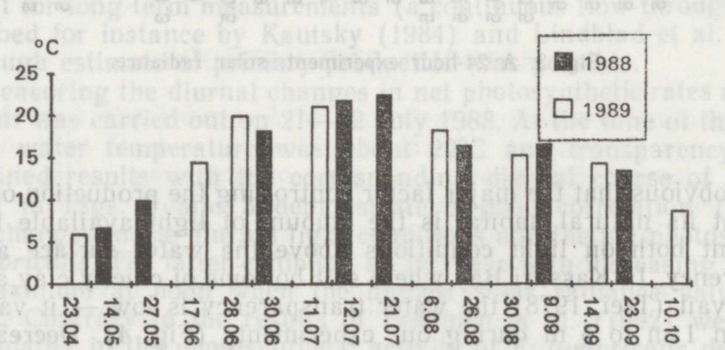

Fig. 6. Water temperature in 1988 and 1989.

According to our data autotrophic production takes place neither at favourable natural light conditions above water surface (solar radiance 0.6—0.8 kW·m^{-2}) with low water transparency (Secchi disc readings below 1.5—2 m) nor at 4—5 m water transparency with solar radiance below 0.2—0.3 kW·m^{-2}. Low net photosynthesis values measured at the end of August both in 1988 and 1989 (see Figs. 1, 2) could be explained by the above-mentioned conditions.

Differently from light, temperature seems to play a minor role in the photosynthesis of *F. lumbricalis* as the Baltic algae are generally well adapted to low temperatures (Russell, 1985). According to our data the net photosynthetic rate at 7.6°C measured at the end of April 1990 was about the same as at 22.5°C measured in midsummer (data not shown). On the other hand, more light is needed to maintain the compensation point (the point at which respiration is balanced by photosynthesis) when the temperature rises (Prescott, 1968). The rates of respiration are more likely to be influenced by temperature (Figs. 5, 6).

Both our results and the above-described literature data suggest that the net photosynthesis and respectively the primary production of *F. lumbricalis* are low. Wallentinus (1979) divided the taxa of Baltic macroalgae according to maximal production rates into three groups: high production rates, mostly above 5 mg C·g dry wt^{-1}·h^{-1}; medium, mostly c. 1—5 mg C·g dry wt^{-1}·h^{-1}; low, mostly below 2 mg C·g dry wt^{-1}·h^{-1}. According to this division *F. lumbricalis,* like many perennial thick red algae adapted to limited light conditions, belongs to the last group.

Thus, changes in environmental conditions, first of all factors decreasing light penetration, affect significantly the primary production of *F. lumbricalis* in Kassari Bay. Since 1975 the biomass of *F. lumbricalis* in this area has decreased due to man-induced eutrophication and oil pollution (Kukk, 1981).

The assemblage of algae in Kassari Bay is in many respects unique. For this reason, much more attention should be paid to protecting *F. lumbricalis* from human impact endangering the species in this area.

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AGARIKU *FURCELLARIA LUMBRICALIS* NETOFOTOSÜNTEESIST JA PRODUKTSIOONIST KASSARI LAHES

Tiina PAALME

On uuritud tööndusliku punavetika *Furcellaria lumbricalis* netofotosünteesi ja pimehingamise intensiivsust vetika looduslikus kasvukohas Kassari lahes. *F. lumbricalis*'e fotosünteetiline aktiivsus ja produktsiooni väärtused osutusid madalaks (alla 0,25 mg C·g kuivkaal^{-1}·h^{-1}). Peamiseks agariku produktsiooni kontrollivaks keskkonnateguriks olid valgustingimused.

ФОТОСИНТЕЗ И ПРОДУКЦИЯ ФУРЦЕЛЛЯРИИ (*FURCELLARIA LUMBRICALIS*) БУХТЫ КАССАРИ

Тийна ПААЛМЕ

Измерялась интенсивность фотосинтеза и дыхания фурцеллярии бухты Кассари. Значения интенсивности фотосинтеза и соответственно первичной продукции оказались низкими (>0,25 мг С·г сухого веса$^{-1}$·ч$^{-1}$). Световые условия являются главными влияющими на продукцию фурцеллярии факторами среды.