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Characteristics of pigment complex of sphagnum mosses of south-belomorian bogs on example of Ilas bog massif

A K Shtang, V G Tatarintseva, E Yu Churakova, S B Selyanina* and T I Ponomareva

FECIAR UrB RAS, Arkhangelsk, Russian Federation

*E-mail: gumin@fciarctic.ru

Abstract. Sphagnum mosses play a significant role in the plant communities of the south-belomorian bogs. The adaptation of these plants to environmental conditions can be traced through changes in the pigment complex. In this work, the content of chlorophylls a and b and carotenoids was determined in some ridge species (*Sphagnum fuscum, S. rubellum*) and hollow species (*S. lindbergii* and *S. majus*) in June and September. An increase in total pigments in species growing on ridges is observed in autumn and that can be explained by the formation of comfortable conditions for photosynthesis. The growth of algal biomass can cause a decrease in the pigment content in the species of hollows.

1. Introduction

Sphagnum mosses are a key component of the community of the south-belomorian bogs, which are mainly oligotrophic complexes formed by hummocks, hollows and pools. Large systems of this bog type are widespread along the entire coast of the White Sea, occupying up to 70-80% of the territory [1, 2, 3].

The species composition of Sphagnum in the communities of hummocks and hollows is not the same. On the hummocks, the sphagnum mosses are characterized by a low (15-30%) projective cover, the most common species are *Sphagnum capillifolium* and *S. fuscum*, there are *S. angustifolium* and *S. rubellum, S. russowii* [1, 4]. Stripes of *S. papillosum* are often formed on the border of hummocks and hollows [4]. The moss cover of the hollows, that formed by *S. balticum* and *S. lindbergii* , sometimes by *S. majus*, *S. cuspidatum* or *S. papillosum*, rarely by *S. tenellum* , is characterized a high projective cover (90-100%) [3, 4].

Currently, natural ecosystems are exposed to anthropogenic impacts, contributing to climate change. In such conditions, the northern bog ecosystems, including the bogs of the south-belomorian type, are especially vulnerable [6]. The adaptation of a plant organism to new conditions is manifested, first of all, through the activity of the photosynthetic apparatus. The adaptation of sphagnum mosses to growing on different elements of the microrelief of the ridge-hollow complex can also be traced by studying their photosynthetic indicators, for example, the qualitative and quantitative composition of the pigments of the photosynthetic apparatus [11]. Since the process of photosynthesis is inextricably linked with the formation of photosynthetic pigments (chlorophylls a and b and carotenoids) in plant cells, the changes in environmental conditions, such as water, temperature and light conditions, change the content of pigments and their ratios. This makes it expedient to consider in detail the issues related to the peculiarities of the synthesis of pigments by sphagnum mosses, which are a good subject of study due to a rather quick response to changes in environmental conditions, such as water, temperature and light conditions. The study of the seasonal dynamics of the pigment composition can

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make it possible to extrapolate the obtained results to the level of more global changes - climatic changes [2].

The adaptation of *Sphagnum* to growing on different elements of the microrelief of the hummock-hollow complex may be traced by studying their physiological parameters, for example, the qualitative and quantitative composition of the pigments of the photosynthetic apparatus [5]. The process of photosynthesis is inextricably linked with the formation of photosynthetic pigments in plant cells (chlorophylls a and b and carotenoids), hence when environmental conditions (water, temperature and light) change, the content of pigments and their ratios change too [6].

The purpose of this work was to study the species variability and seasonal dynamics of the photosynthetic pigment complex of sphagnum mosses dominating the territory of the Ilas oligotrophic bog, which belongs to the group of south-belomorian bogs.

2. Materials and methods

The research was carried out in the Primorsky district of the Arkhangelsk region in the territory of the Ilas bog. The study subjects were two Sphagnum species of hummocks - *Sphagnum fuscum* and *S. rubellum*, and two hollow species – *S. majus* and *S. lindbergii*. Sampling was carried out in the first and second half of the growing season (June 25 and September 9), in the morning. The moss samples were placed in hermetically sealed bags and light-tight thermal containers.

The content of carotenoids and chlorophylls was determined in a day from the moment of sampling in acetone extract accordance with the spectrophotometric method [6]. For a mixed sample of each sphagnum species, the analysis was carried out in triplicate. The chlorophyll concentration was calculated taking into account the extinction coefficients obtained for 80% acetone. When determining the concentration of carotenoids in the extract, the error due to the presence of chlorophylls was taken into account. The calculation of the quantitative content of pigments was converted to dry weight. Data processing and plotting were performed using Microsoft Excel 2010. The significance of differences at the beginning and at the end of the growing season was assessed using the U Mann-Whitney test at confidence level of p=0.05 in the SPSS Statistics 11.

3. Results and discussion

Figure 1 shows the average content of photosynthetic pigments with standard error detected in *Sphagnum fuscum*, *S. rubellum*, *S. lindbergii*, and *S. majus* in June and September.

In the ridge species *S. rubellum* an increase in the content of pigments is observed in September. The content of chlorophylls increases by 62%, and of carotenoids - by 156%. In *S. fuscum*, which also grows on ridges, the difference in pigment content between June and September is not statistically significant. In the hollow species *S. lindbergii* and *S. majus* the pigment content decreases by September. In *S. lindbergii* the content of chlorophylls decreases by 81%, carotenoids - by 50%, in *S. majus* - by 44% and 50%, respectively.

Sphagnum is characterized by a lower content of photosynthetic pigments even in comparison with other bryophytes, in which it, in turn, is lower than in vascular plants. The reason for such low concentrations of pigments is the structure of the mesophyll of single-layer leaves - large hyaline cells and small chlorophyll cells. So, when studying the content of pigments in mosses on Svalbard, it was found that the range of chlorophyll content in bryophytes was 0.21–5.31 mg/g of dry weight, and carotenoids - 0.10–1.36 mg/g dry weight. In this case, the minimum values are shown by *Sphagnum* [5].

Sphagnum fuscum and *S. rubellum* have similar ecological preferences and optima. Both of these species are part of the plant communities of bog ridges [6]. However, an increase in pigment content can be observed during the growing season in *Sphagnum rubellum*, although this does not occur in *S. fuscum*. This can be explained by the fact that *Sphagnum fuscum* has a lower thickness of the photosynthetic layer due to the formation of denser sods, which provide it with stability and resistance to environmental factors [6]. *S. lindbergii* and *S. majus* are types of hollows - highly waterlogged

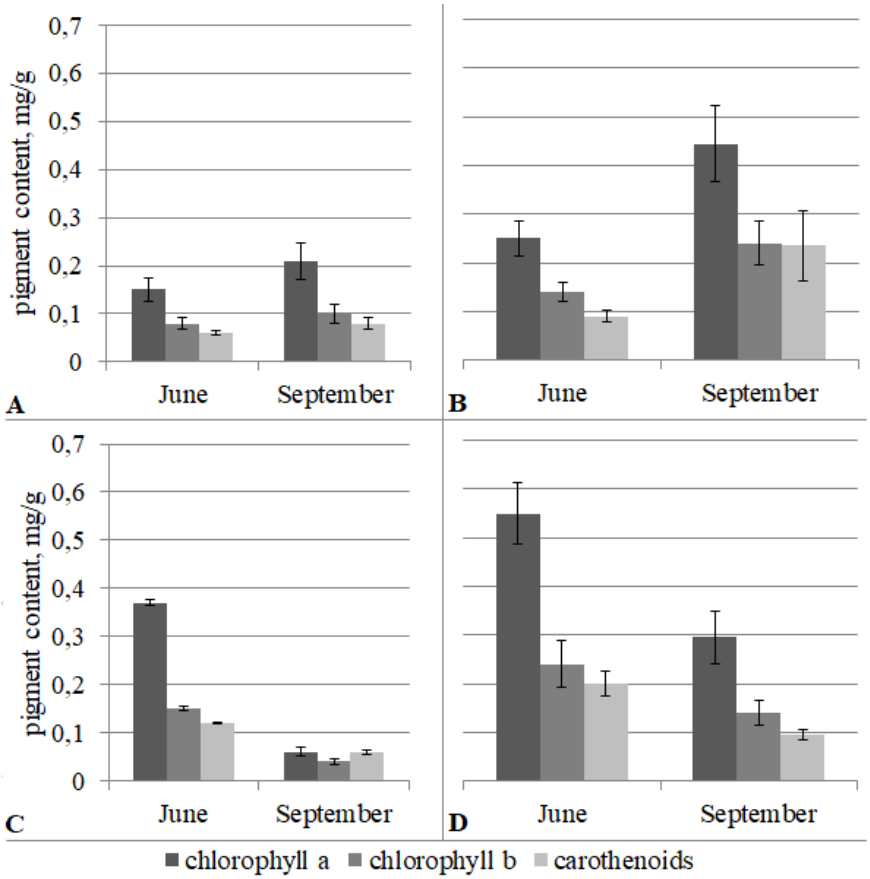


Figure 1. Content of photosynthetic pigments in sphagnum mosses in June and September A – *S. fuscum*, B – *S. rubellum*, C – *S. lindbergii*, D – *S. majus*.

habitats [4]. Their total pigment content in June is several times higher than that of sphagnum mosses growing on ridges. In these species the content of pigments is significantly reduced by autumn.

It is known that there are interspecific differences in the content of pigments associated with the ecology of species [11, 12]. Such factors as temperature, humidity, and light conditions can affect the pigment content as well [13]. When assessing the influence of these factors, it is necessary to pay attention to weather indicators (air temperature, precipitation, cloudiness).

The amount of precipitation for 30 days preceding the day of sampling in September was 81 mm, and it is much more than the amount of precipitation for 30 days preceding the day of sampling in June - 29.4 mm. At the same time, the average daily temperature for this period at the beginning of summer was +13.5 °C, at the end of summer +13.1 °C, and the average cloudiness score was 6.1 and 7.0, respectively (pogodaiklimat.ru). Due to the slight differences in cloudiness and temperature between June and September, the humidity level can be identified as the main factor that could have influenced the increase in pigment content.

Hollow mosses, having a larger volume of chlorophyll cells than hummock mosses, are characterized by a higher content of photosynthetic pigments. The main factors limiting photosynthesis in aquatic forms of mosses growing in hollows may be the limited content of CO_2 in the water and a decrease in the intensity of light when it passes through the water surface, accompanied by scattering of rays from the red part of the spectrum. There is evidence that the accumulation of algal biomass in hollows by the end of summer may increase the negative impact of these factors. Algae absorb quanta of light entering the water and extract carbon dioxide from the aquatic environment. All these limits the intensity of photosynthesis and leads to a decrease in the

content of pigments in the aquatic forms of *Sphagnum* [10]. This can explain the decrease in the pigment content in hollow species in September.

When studying the content of pigments in the sphagnum mosses of the Ilas bog massif in June and September, one of the species growing on the ridges, *Sphagnum rubellum*, revealed a higher content of photosynthetic pigments in September. This change may be due to an increase in precipitation by the end of summer and the formation of more comfortable conditions for photosynthesis. In the second studied ridge species, *S. fuscum*, the pigment content did not change, probably due to the peculiarities of the sod. In hollow sphagnum (*S. lindbergii* and *S. majus*), the highest pigment content is observed in June. In hollow species, the main reason for the lower pigment content in September may be the accumulation of algal biomass in the hollows. To obtain more accurate data on the seasonal dynamics of photosynthetic pigments in sphagnum mosses, it is planned to conduct a study with monthly sampling during the growing season.

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