Aerial algae on spruce needles in the Krušné Hory Mts., Czech Republic

Aerofytické řasy na smrkových jehlicích v Krušných Horách

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Abstract

The aerial algal growths on spruce needles in two localities located in the western and central parts of the Krušné Hory Mts., which were characterized by different levels of damage caused by environmental pollution, were investigated. In total four species of green algae were encountered in algal growths (*Apatococcus lobatus* (CHODAT) PETERSEN, *Pseudococcomyxa* sp., *Chlorella angusto-ellipsoidea* HANAGATA, KARUBE & CHIHARA, *Choricystis minor* (SKUJA) FOTT). In the western locality nearby Přebuz, where the phenomenon of "new forest decline" expressed by enhanced needle yellowing and shedding has been observed since 1999, the growths were more developed than in the central part locality in Kovářská. In addition, the coccal green alga *Pseudococcomyxa* sp. was present only in samples from the Přebuz locality, thus we hypothetize its bio-indicative importance.

Introduction

In recent years the increase of the phenomenon of macroscopic algal growths on spruce needles has been observed in temperate and boreal Europe (PEVELING et al., 1992; BRÅKENHIELM & QINGHONG, 1995; SØCHTING, 1997). The positive correlation of the extent of algal growths on needles and air pollution load (both NO_x and SO_2) has been stated (BRÅKENHIELM & QINGHONG, 1995). However, the influence of other environmental factors as altitude, growing season or geographical position has also been demonstrated. The growths are composed of low-species green algal communities (PEVELING et al., 1992). However, the floristic composition has not been investigated till this time.

The Krušné hory Mts. have been heavily affected by the highest levels of SO_2 pollution loads in Europe between the 1950's and the 1980's. A steep gradient of sulfur deposition corresponding to damage gradient in Norway spruce stands ranged from dying and very heavy (to the east) to light (to the west). The western part due to lower pollution loads has been remaining relatively undamaged. During the 1990's, air pollution loads were gradually decreasing and health status of spruce stands located in the central part has improved remarkably (ALBRECHTOVÁ et al. 2000). The west-located forests remained relatively healthy until 1999 when symptoms of "new type of forest decline" appeared there similar to the ones recorded during 1980's in most of Central and Western Europe (LOMSKÝ et al. 2001). No such symptoms were observed in the central part.

In the presented study the quantitative parameters and species composition of algal growths on two spruce forest localities in the Krušné Hory Mts. with a different life history were investigated.

Localities and methods

In 1998, two study sites were selected in the Krušné hory Mts. in northwestern Bohemia. Site W in the western part of the Krušné hory nearby village Přebuz and the Site C in the central part nearby Kovářská. Both Norway spruce (*Picea abies* L. Karst.) stands were older than 80 years. They were assigned a damage class (DC) based on average crown defoliation and occurrence of needle discoloration. Additional characteristics of stand health status (needle retention and occurrence of chlorosis on needles) followed in 1998 and 2000 are given in Table 1. Both sites had similar aspect, the climatic and soil conditions but they differed greatly in historic and current loads of atmospheric pollution and accordingly they differed in a degree of damage (Table 1).

In October 2000, the samples from 5 representative trees on each investigated locality were taken in sterile plastic bags, placed immediately into a portable cooler (+4°C), in which they were transported to a laboratory and investigated immediately for algal growths. For quantitative evaluation the colonization rate was calculated as $C = 1/r$, where r is the age of youngest annual whorl where algal growth was observed. The growth extent was evaluated on the annual whorl with most extensive algal growth (usually the oldest generation). It as categorised as belonging to one of 5 classes: 0 – none; 1 – little – isolated colonies; 2 – medium; 3- heavy occurrence of continuous algal growths; 4 – heavy occurrence along the whole needle surface.

The species composition was investigated on both natural and cultured material. The semiquantitative evaluation of particular species was as follows: 0 – species absent from the sample; 1 – species present in a very small amount,

encountered only in cultures; 2 – species encountered in smaller amount in a natural sample; 3 – a dominant species in the growth.

The strains were cultivated on both agar-solidified and liquid BBM (BISCHOFF & BOLD, 1963) and in biphasic cultures (PRINGSHEIM, 1954); in the temperatures 13°C and 25°C; under the illumination of about 2,500 lux (light source: Tungsram 36W F33, cool white). The set of standard cytological solutions stains (cotton blue, methylene blue, India ink, nigrosine) was used.

Results and discussion

The algal growths in investigated localities were composed of four chlorophyte species. Sarcinoid species *Apatococcus lobatus* (CHODAT) PETERSEN was the dominant species in growths in all samples. This species is one of the most common aerial algae in temperate ecosystems. It frequently occurs on tree trunks and stems (ETTL & GÄRTNER, 1995). The irregularly globular cells form loose cubic packets and pseudofilaments. The dimensions of the cells are: (5,5-)6,0 – 12,0(-18,0) µm in diameter. The chloroplast is parietal, somewhat separated from the cell wall in some cases. Pyrenoid is not present.

The coccal green alga *Pseudococcomyxa* sp. (Figs. 4-8) occurred in samples from Přebuz locality only. Although this species was never a dominant one, its presence was conspicuous already in natural material in most cases. Species of the genus *Pseudococcomyxa* are frequently occurring in soil and aerial biotopes worldwide. However, regarding the poor knowledge of *Pseudococcomyxa* taxonomy the specific identification is almost impossible for the time being (KOSTIKOV et al., 2002). Consequently, we identified our organism without specific epitheton for the present. The cells are of irregularly elongated ellipsoidal shape. Some cells are attached to the substrate with mucilaginous cap. The dimensions of the cells are (3,3-)4,5 – 7,5(-9,2) x (1,2-)1,7 – 3(-4,5) µm. The width : length ratio is 1: 2,7 – 4,3. Single chloroplast is parietal, without a pyrenoid. The reproduction takes place by means of 2 to 4 elongated autospores.

Coccal green algae *Chlorella angusto-ellipsoidea* HANAGATA, KARUBE & CHIHARA and *Choricystis minor* (SKUJA) FOTT (Figs. 9 – 10) were encountered only in liquid cultures from several samples. In natural specimens these organisms are present in minute amounts without calculable ecological significance.

The considerable differences in extent and composition of algal growths between both investigated localities were apparent. The Přebuz locality with considerable amount of needles yellowing and shedding was considerably more colonised with algae (Figs. 1, 2). In the addition, there has been considerable difference in qualitative species composition with *Pseudococcomyxa* sp. occurring only in this locality (Fig. 3).

The cause of new forest decline observed in spruce forests of the western part of the Krušné hory since 1999 remains uncertain and is supposed to be connected with soil nutrient imbalance of unkown causes (LOMSKÝ et al. 2000). The same applies for the proximate explication of higher incidence of algal growths and their different species composition in the western locality in contrast to the central locality. Based on air quality data (Table 1) differences in algal occurrence cannot be accounted for by higher nitrogen deposition. The coccal green algae on needles have not been found to directly parasite their hosts (PEVELING et al., 1992). Rather, they could contribute to the progress of the phenomenon of "new type of forest decline" by competition for resources with their hosts, such as light or gases. Whether there is a causal or rather correlative (bioindicative) relation between the needle yellowing and shedding and algal growths remains to be questioned in future investigations.

Acknowledgement

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Literature

ALBRECHTOVÁ J.; ROCK B.N.; SOUKUPOVÁ J.; ENTCHEVA P.; ŠOLCOVÁ B. & POLÁK T. (2001): Biochemical, histochemical, structural and reflectance markers of damage in Norway spruce from the Krušné hory used for interpretation of remote sensing data. - Journal of Forest Science, Special Issue 47: 26-33.

BISCHOFF, H. W. & BOLD, H. C. (1963): Some soil algae from Enchanted Rock and related algal species. Phycological Studies IV. – Univ. Texas Publ. 6318: 1-95.

BRÅKENHIELM, S. & QINGHONG, L. (1995): Spatial and temporal variability of algal and lichen epiphytes on trees in relation to pollutant deposition in Sweden. – Water, Air and Soil Pollution 79: 61 – 74.

KOSTIKOV, I.; DARIENKO, T. & HOFFMANN, L. (2002): Taxonomic revision of the genus *Pseudococcomyxa*, with comments on the genus *Coccomyxa*. – Proc. Abstr. Int. Conf. "Biology and Taxonomy of Green Algae IV.", pp. 47 – 48, Smolenice, Slovakia.

LOMSKÝ, B.; ŠRÁMEK V. & PFANZ H. (2001): An introduction to the development of tree and forest damage by air pollution in the Ore Mountains. - Journal of Forest Science, Special Issue 47: 26-33.

PEVELING, E.; BURG, H. & TENBERGE, K.B. (1992): Epiphytic algae and fungi on spruce needles. – Symbiosis 12: 173 – 187.

PRINGSHEIM, E. G. (1954): Algenreinkulturen, ihre Herstellung und Erhaltung. – 109 pp., VEB G. Fischer, Jena.

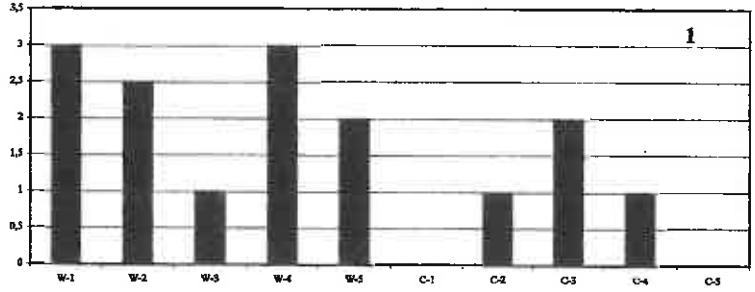
SØCHTING, U. (1997): Epiphyllic cover on spruce needles in Denmark. – Ann. Bot. Fennici 34: 157 – 164.

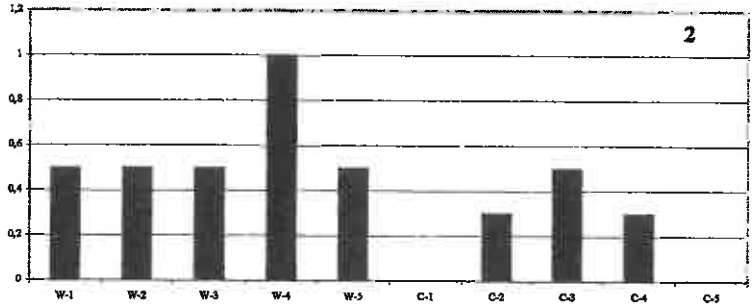
Table 1. Description of two localities in the Krusne hory Mts.

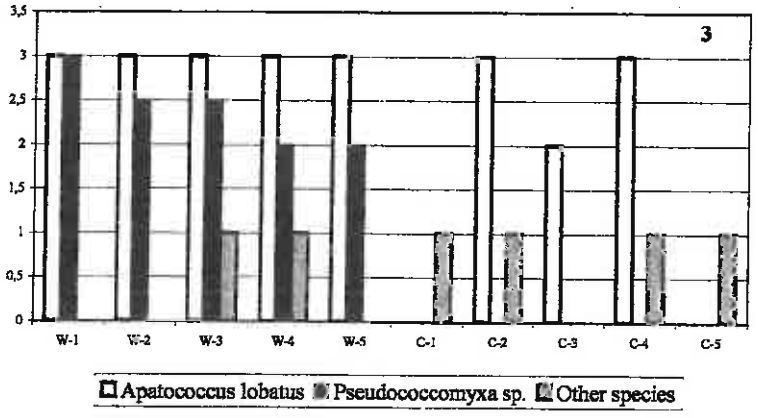
	Sites			
	W		**C**	
Geographical Localization				
Part of the Krušné hory	Western		Central	
Nearby Village	Přebuz		Kovářská	
Localization	50°21'34''N, 12°38'16''E		50°29'53''N, 13°07'20''E	
Altitude [m a.s.l.]	926.51		790.39	
Parameters of health status of Norway spruce stands				
Stand Damage Class				
1998 (Damage)	1 (moderate)		2 (high)	
2000 (Damage)	2 (high)		3 (very high)	
Presence of chlorosis on needles				
1998	Yes		No	
2000	Yes		No	
Average needle retention [years]				
1998	9		6	
2000	9		7	
Air pollution data*				
Location of the nearby monitoring station	Přebuz		Měděnec	
	Year	**Přebuz**	**Year**	**Měděnec**
Monthly average deposition of SO_2 in 1996-1998 [$mg.m^{-3}$]	1996	26	1996	66
	1997	14	1997	37
	1998	6	1998	17
	1999	3	1999	7
	2000	5	2000	10
Monthly average deposition of NO_x in 1996-1998 [$mg.m^{-3}$]	1996	17	1996	27
	1997	15	1997	23
	1998	14	1998	17
	1999	11	1999	17
	2000	12	2000	16

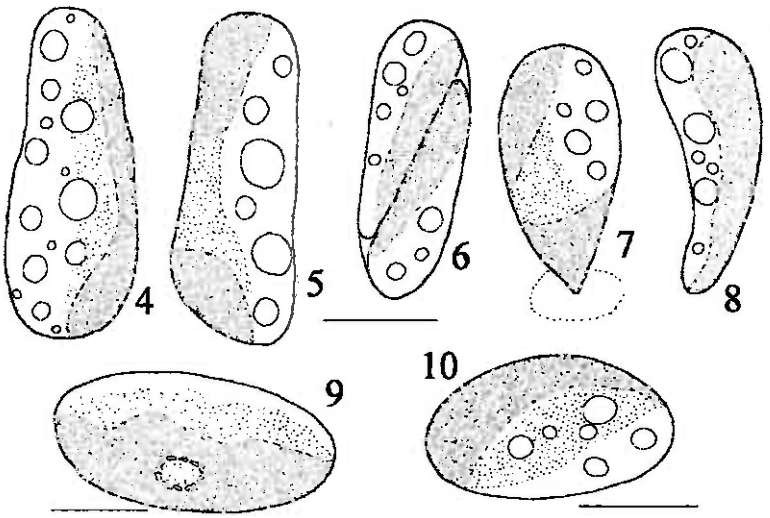
* The pollution data presented were obtained from the Czech Hydrometeorological Institute - http://www.chmi.cz.

Fig. 1: Algae on needles – the growth extent (relative scale 0 – none, 1 – little, 2 – medium, 3 – heavy, 4 – cover the whole surface).
Fig. 2: Algae on needles - colonization rate.
Fig. 3: Algae on needles - species composition (0 – absence, 1 – rare in culture, 2 – rare in nature, 3 - dominant .
(W1-5 – sampling sites in western Přebuz locality, C1-5 – sampling sites in central Kovářská locality.)


1
3,5
3
2,5
2
1,5
1
0,5
0
W-1
W-2
W-3
W-4
W-5
C-1
C-2
C-3
C-4
C-5


2
1,2
1
0,8
0,6
0,4
0,2
0
W-1
W-2
W-3
W-4
W-5
C-1
C-2
C-3
C-4
C-5


3
3,5
3
2,5
2
1,5
1
0,5
0
W-1
W-2
W-3
W-4
W-5
C-1
C-2
C-3
C-4
C-5
Apatococcus lobatus
Pseudococcomyxa sp.
Other species



Figs 4 – 8: *Pseudococcomyxa* sp., bar = 3 μm.
Fig. 9: *Chlorella angusto-ellipsoidea*, bar = 5 μm.
Fig. 10: *Choricystis minor*, bar = 5 μm.