ANALÝZA TEPLOTNÍCH POMĚRŮ SMRKOVÉHO POROSTU

ANALYSIS OF TEMPERATURE CONDITIONS OF A SPRUCE STAND

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Abstract

One of the sources for the specification of the effect of various management measures on ecological functions of spruce ecosystems of an upland region is a description of the effect of a young spruce stand on its stand climate. The aim of the paper is, therefore, to characterize changes in the vertical stratification of the air temperature in a young spruce stand (age 24 years) in the Drahany Upland (Czech Republic, altitude about 620m). In the vertical profile of the stand, air temperature was measured by Pt100 platinum thermometers (EMS Brno) at a height of 0.3, 2, 4, 7.5, 10 and 14.5m above the soil surface. Temperature conditions of the spruce stand were evaluated on the example of the period 18 – 21 June, 2002 and 8 – 11 July, 2002. The lowest mean daily air temperatures (Ta_d) in days under evaluation were on the level of measurement 0.3m. The temperature increased with height from the soil surface up to the highest value of Ta_d on the level of measurement 10m above the soil surface. Ta_d values changed with the higher height of measurement (14.5m) only minimally. In days under evaluation, mean daily air temperatures on the surface of crowns were higher than above the tree crowns. The highest amplitude was in the area of crown tops. Different temperature conditions within the stand were formed due to the retention of solar radiation by tree crowns the level of trees being the active surface in forest stands. Thus, a perfectly closed stand showed a marked and mitigating effect on temperature fluctuations.

Key words: vertical profile, air temperature

Introduction

The environment temperature is one of the basic factors of microclimatic conditions for plants and the change of temperature conditions expected in the future can become an important factor affecting trees (Vinš et al. 1996). Therefore, it is necessary to draw attention not only to particular factors the change of which could significantly influence the health condition of forests but also to their extreme values and variability.

The aim of the paper is to characterize changes in the vertical stratification of air temperatures in a young spruce stand in the course of time and thus to obtain data for the specification of the effect of various management measures on ecological functions of spruce ecosystems of an upland region with a climax community of other species.

Material and methods

Air temperature was measured in a permanent trial plot, in the Drahany Upland about 3km west of the village of Němčice. Its position is given by co-ordinates 49°26´ N, 16°41´ E and altitude about 620m. Parent rock is acid granodiorite overlaid by the layer of deluvium. According to the climatological classification of the CR (Quitt 1971), the research plot is situated in the MT7 region. Duration of the main growing season is 140 to 160 days. Mean January temperature is -2 to -3°C, in April 6 to 7°C, in July 16 to 17°C and in October 7 to 8°C. Precipitation total for the growing season amounts to 400 to 450mm, for winter period 250 to 300mm. The mean number of cloudy days is 120 to 150, that of cloudless days 40 to 50.

The measurement was carried out in a spruce stand (25m x 25m) of the second generation (age 24 years) on a site of originally mixed stands. In 1978, 3-year-old seedlings of Norway spruce (*Picea abies* [L.] Karst.) were planted at a spacing of 2.5m x 2m. Since the time, no tending measures were carried out there. In the plot, natural regeneration occurred of spruce, birch, goat willow, European aspen, Scots pine, larch and elder *Sambucus racemosa* (Janíček 1990). In 2002, mean d.b.h. amounted to 7.3cm and the stand was closed.

In the vertical profile of the stand, air temperatures were measured by platinum thermometers Pt100 (EMS Brno) at a height of 0.3, 2, 4, 7.5, 10 and 14.5m above the ground. A ten-minute mean from one-minute readings (Ta) was recorded into the MiniCube (EMS Brno) automatic central. Based on the data, the mean daily temperature of air (Ta_d) was calculated.

Results and discussion

Temperature conditions of the spruce stand were evaluated in the period 18 – 21 June, 2002 and 8 – 11 July, 2002. There were cloudless and cloudy days. Values of global radiation ranged to 1000W.m^{-2}. Mean daily air humidity (RH_d) ranged from 50.0 (19 June, 2002) to 69.7% (11 July, 2002) above the stand at a height of 14.5m.

As for the course of weather between 18 and 21 June, the Czech Hydrometeorological Institute (CHMI) mentions: tropical heats – mean temperatures ranged 5 to 10°C above normal temperatures, maximum temperatures increased largely to 29 - 33°C. He highest temperature was measured on 19 June in Přelouč and in Hradec Králové, viz. 35.5°C. Absolute extremes in Prague (Klementinum) were also exceeded. As for the course of weather on 10 July, the CHMI mentions: tropical temperatures – before the cold front temperatures increased largely to 30 - 34°C. The highest temperature of 34.9°C and 34.8°C was measured in Velichovky and in Brno-Žabovřesky, respectively. A temperature record in Prague (Klementinum) was not exceeded.

Vertical stratification of the mean daily air temperature (Ta_d), daily maximum and minimum temperatures in assessed days is depicted in 1a and 1b diagrams. The lowest Ta_d values were obtained on the level of measurement 0.3m in all days under evaluation (the lowest value of 16.2°C for 11 July). The mean daily air temperature ascended with a height from the soil surface up to the highest

value Ta_d on the level of measurement 10m above the soil surface (the highest temperature of 24.2°C for 10 July). Thus, between a height of 10m and the soil surface a temperature gradient of 2.9°C occurred (for 18 June, 2002). The smallest change in the mean daily air temperature with height was on 11 July 2002, viz. 0.7°C. With the higher height of measurement (14.5m), Ta_d values changed only minimally (maximally to 0.5°C for 21 June and 11 July). As mentioned by Sapožnikovová (1952), Kamlerová, Kučera (2002) etc., mean daily air temperatures on the surface of crowns (10m) were higher than above the tree crowns (14.5m) in days under assessment.

For the purpose of more detailed characteristics of the vertical stratification of Ta_d in a young spruce stand, maximum and minimum air temperatures on particular levels of measurement were plotted into diagrams for days under evaluation. The highest value of the daily maximum of air temperatures was 29.9°C (for 21 June and the height of measurements 10m) and the lowest value of the daily minimum of air temperatures was 11.4°C (for 8 July and the height of measurements 0.3m). On the other hand, Matejka et al. (2000) mention maximum air temperature on the level of 2 m for a 16-year-old spruce stand (mean height about 6m, stand density 2600 trees per ha). With respect to the fact that temperature conditions inside the forest are affected particularly by the canopy density a difference in the level of the occurrence of maximum values can be explained by various degrees of the canopy closure. Petrík et al. (1986) mentions that the highest air temperature occurs mostly on the crown surface whereas under the tree crowns air temperature decreases. Also Sapožnikovová (1952) mentions for an oak forest that maximum temperatures occur in crowns and minimum at a height of 3m.

The largest daily amplitude of air temperatures for the period under assessment was 15.5°C (for 21 June and height 10m), i.e. in the area of crown tops. The finding corresponds also to results obtained by Matejka et al. (2000) who gives for the stand mentioned above that the daily amplitude was higher on the level of a mean height of trees than above the stand. Thus, a perfectly closed stand showed marked and mitigating effects on temperature differences.

As mentioned by Rožnovský, Tomášková (1996), Hurtalová, Rožnovský (1999), Kamlerová (2002) etc. in the vertical profile of a stand the distribution of air temperature markedly changes in relation to particular weather situations, mainly during clear and cloudy days. For days under evaluation, changes in the vertical stratification of air temperatures in the course of time (10-minute interval) are well evident from diagrams with depicted isotherms (differentiation 1.0°C). Changes of Ta in the course of time are of the similar character for assessed days and, therefore, only one example was given (Fig. 2) – 21 June, 2002 (a day with the largest amplitude of air temperature).

After midnight, a zone (up to a height of about 1 m) began to form with a lower temperature than other parts of the vertical profile in the ground layer (0.3m above the soil surface). At about 3:00 CET, also the crown space of a stand began to cool the lowest Ta value being on the level of measurement of 0.3m and the highest one above the stand. After the sunrise at 4:00 CET, air temperature above the stand (14.5m) and in the area of crown tops (10m) began to increase while inside the stand, the air was

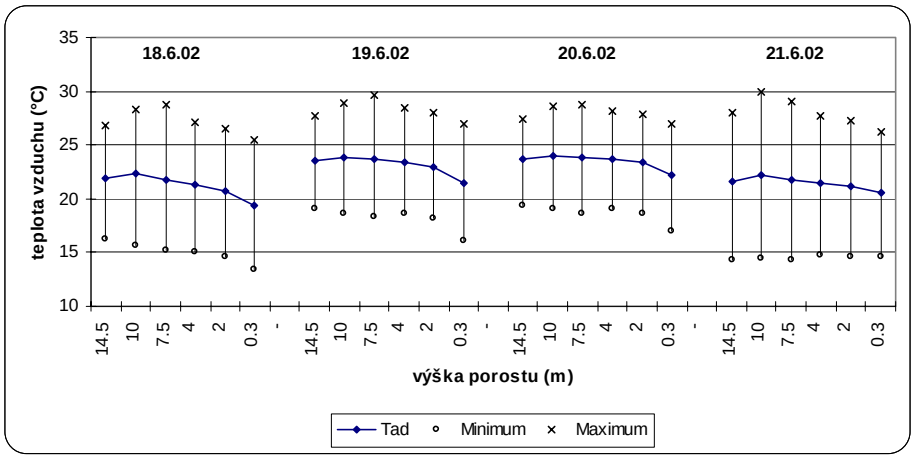

Fig. 1a. Vertical stratification of the mean daily air temperature, daily maxima and minima in the period 18 – 21 June, 2002.

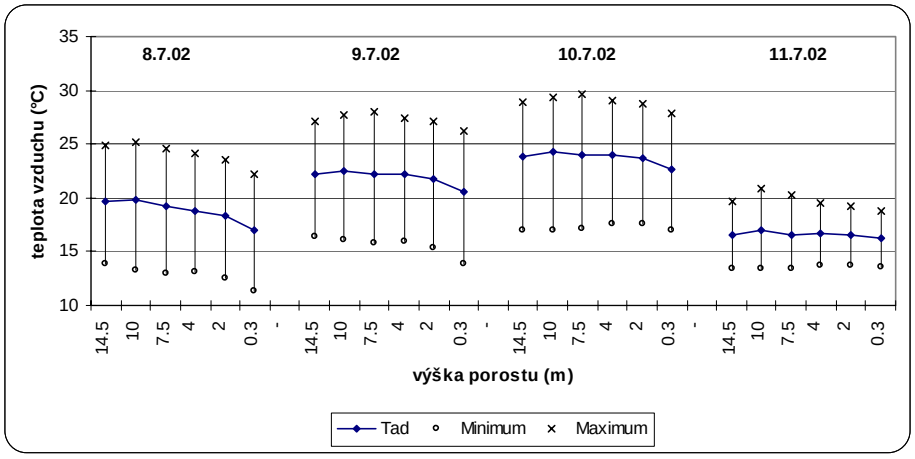

Fig. 1b. Vertical stratification of the mean daily air temperature, daily maxima and minima in the period 8 – 11 July, 2002.

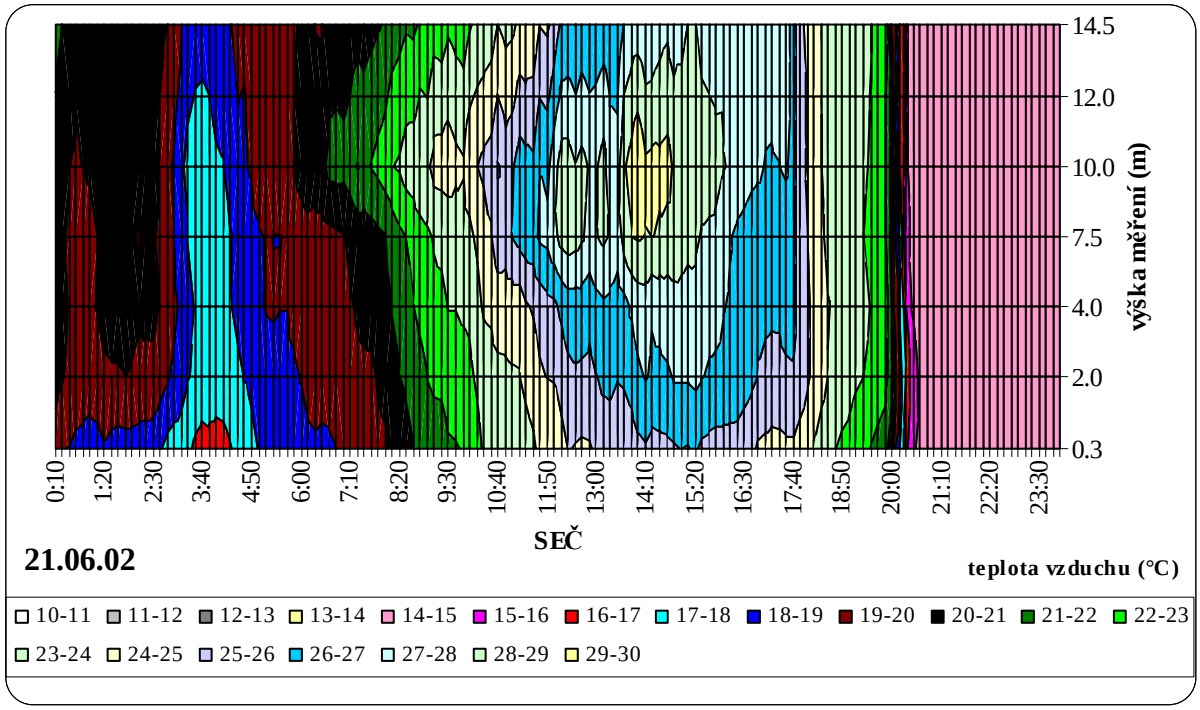

Fig. 2. Changes in the vertical stratification of air temperature in a young spruce stand in the course of time (10-minute interval) – 21 June, 2002.

always cool. From about 8:00, when also the crown space began to be warmed, air temperatures in the zone of crown tops (10m) were even higher than above the stand (14.5m). Thus, in the vertical profile of the stand, the temperature difference was even 4.2°C (at 14:00 CET, the level of measurement was 10m and 0.3m). In the afternoon, air temperatures gradually decreased in the whole vertical profile of the stand and lower temperatures occurred again in the ground layer (0.3m). At 20:20, the first precipitation was noted and in the vertical profile of the stand, inversion temperature stratification was formed. Thus, different temperature conditions inside the stand are created due to the retention of solar radiation by tree crowns (Sapožnikovová 1952, Smolen, Matejka (1982), Grace et al. 1987 etc.), the level of trees being an active surface in forest stands.

The microclimate of forest communities is a result of the interaction of physical meteorological factors and properties of stands (stand structure and physiological properties of forest trees). It is the environment which serves for the live of plants and climatic conditions participate in its formation/modification. The knowledge and thus also a possibility to modify microclimatic conditions of stands is a condition for silvicultural measures in forest stands. However, it is also important for the study of their production processes being a basis for the determination of stand structure and description of the effect of climatic factors on the growth of trees.

Souhrn

Jedním z podkladů pro upřesnění účinků různých hospodářských opatření na ekologické funkce smrkových ekosystémů vrchovinné oblasti je popsání vlivu mladého smrkového porostu na jeho porostní klima. Cílem tohoto příspěvku je proto charakterizovat změny vertikálního zvrstvení teploty vzduchu v mladém smrkovém porostu (24 let) na Drahanské vrchovině (ČR, ca 620m n.m.). Ve vertikálním profilu porostu byla teplota vzduchu měřena platinovými teploměry Pt100 (EMS Brno) ve výškách 0,3m, 2m, 4m, 7,5m, 10m a 14,5m nad povrchem půdy. Teplotní poměry smrkového porostu byly hodnoceny na příkladu dnů 18.-21.6.2002 a 8.-11.7.2002. Nejnižší průměrné denní teploty vzduchu (Ta_d) byly v hodnocených dnech na hladině měření 0,3m, od povrchu půdy teplota s výškou stoupala až k nejvyšší Ta_d na hladině měření 10m nad povrchem půdy. S vyšší výškou měření (14,5m) se Ta_d měnila jen minimálně. Průměrné denní teploty vzduchu na povrchu korun byly v hodnocených dnech vyšší než nad korunami stromů. Největší amplituda byla v oblasti korunových vršků. Odlišné teplotní poměry uvnitř porostu se vytvářely zadržováním slunečního záření korunami stromů, aktivním povrchem v lesních porostech byla úroveň stromů. Dokonale zapojený porost tak měl výrazný a zmírňující účinek na teplotní výkyvy.

Klíčová slova: vertikální profil, teplota vzduchu

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