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SELECTED CHARACTERISTICS OF CLIMATE IN BEECH ECOSYSTEMS

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Abstract

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Beech ecosystems (ecosystems with presence of beech) represent 85.3% of the forest fund area in Slovakia. In this contribution we provide selected, up to now not very well recognised, climatic characteristics of beech communities in the Western Carpathians Mts. The research ran on an altitudinal transect covering 350–990 m a.s.l. in groups of forest types (forest type groups) *Fageto-Quercetum* (FQ), *Quereceto-Fagetum* (QF), *Fagetum pauper* (Fp), *Fagetum typicum* (Ft), *Abieto-Fagetum* (AF), *Fraxineto-Aceretum* (FrA). It has been found that the amount of solar radiation (light) reaching the forest ground in Fp group in dormancy period was 40–45% from the total amount reaching open plot under clear sky, in the growing season the range was reduced to 1.5 do 2.5%. The value of 1.5% is the lowest value observed in forest ecosystems with beech presence. In another group of beech forest vegetation tier Ft, illumination under complete foliage ranged from 2 to 4%. In this vegetation tiers is forest soil reached by the highest snowfall percentage from the total – which reveals an immense importance of beech forest stands for water management. Snow cover before frost occurrence in localities situated at above 600 m a.s.l. prevents the soil from freezing: the maximum freezing depth is 5 cm.

Key words: beech ecosystems, solar radiation/light supply, snow cover, soil freezing

Introduction

Beech has the highest dominance from woody plants in forests in Slovakia (29.5%), more than spruce (26.5%). The forest ecosystems with autochtonous beech represented 85.3% of the forest soil fund in the past, and also today, beech forest ecosystems are forming skeleton of Carpathian forests. From the total number of 17 groups of forest types, 11 are present at more than 1%. The most frequent are pure beech stands (*Fagetum pauper, F. dealpinum, F. typicum, F. acidophilum, F. humile*), representing 26.11%, beech-oak stands (*Fageto-Quercetum*) and oak-beech stands (*Querceto-Fagetum*) representing together 23.33%, followed by fir-beech stands (*Abieto-Fagetum*) and beech-fir stands (*Fageto-Abietum*) making 20.7%. Natural ecosystems containing beech have always been the most widespread climax forest

communities. Their high stability is attractive for specialists in forestry seeking to use beech properties as tool supporting homeostasis in forest stands subjected to critical global changes today. Data on microclimate of close-to-natural forest ecosystems have been summarised and published in Petrík et al. (1986); more recent information on the issue can be found in Frič and Škvarenina (2008), Minďáš (2005), Matejka and Hurtálová (2008).

Material and methods

In this work we discuss light supply in beech ecosystems in dependence on their density, more precisely, the density of their crown canopy. Stand canopy, and so also illumination also influence precipitation amounts in the stand. We were focussing on snow, as there has been only a little information about its penetration in stands lacking leaves. We also studied the soil freezing depth directly associated with the snow cover thickness.

The research run in the Kremnické vrchy Mts on an altitudinal transect reaching form 350 m a.s.l. (forest community FQ) to 990 m a.s.l. (community AF) on research plots 25x25 m in size established in natural or close-to-natural beech stands. The plots (35 points) were differentiated in squares (5x5 m) with a grid stabilised with wooden sticks. The stabilisation was especially important for measuring solar radiation (illumination) with using luxmeters. For measurements we used standard lux-meters manufactured by Lange, Germany. The high sensitivity of this appliance is due to adjusting the measurement scale in accord with the illumination intensity. The horizontal positioning is guaranteed with a level attached alongside the photo-cell. Together with illumination measurements in the stand were carried out illumination measurements on the open plot. Illumination values were determined based on measurements repeated at one-hour intervals.

As for stand characteristics, the canopy density interval in associations *Fageto-Quercetum* was 85–90%, in associations *Fagetum pauper* and *Fagetum typicum* 95–100%, with the mean canopy density in *Fageto-Aceretum* 90% and in *Abieto-Fagetum* ca 80%. The stand age ranged 90–95 years, except of AF and FAc reaching 120 years. The FQ associations exhibited dominant oak (90%), with admixed hornbeam (10%), interspersed beech and linden; Fp eclusively beech (100%); Ft dominant beech (70%), admixed fir (15–20%), ash (5%) and maple (5%).

Soil freezing was estimated visually on soil profiles sampled in three replications from each plot. The snow cover thickness was measured on transects established on research plots, with a portable snow-meter with a cm precision. The measurement interval was 14 days. The results have been generalised and evaluated according to the individual forest type groups and forest vegetation tiers.

Results and discussion

In general we can say that the average annual precipitation range in beech ecosystems is 700–1000 mm, and the average mean annual temperature range is 5–8.5 °C, the length of vegetation period is 115–170 days. The soil type until 400 m a.s.l. is Luvisol with lessivation to medium, from 400 m upward are present various forms of Cambisols (saturated, unsaturated, humus etc.).

In the results we present a detailed description of climatopes in the most widespread forest types in beech ecosystems in Slovakia according to the forest vegetation tiers (FVT).

Illumination

The lowest situated forest vegetation tier with beech in the Carpathians is the oak-beech tier represented primarily by the group of forest types *Fageto-Quercetum* (ca 16% of Slovak

forests). The common feature of ecosystems in this tier is extreme values of ecological variables (Petrík, 1971). The average illumination (in % of external illumination under cloudless sky) range in stands without leaves is 50–60%. Illumination in older stands (over 100 years) before foliage development is about 60%; nevertheless, with leaves fully developed, the intensity drops below 10%. The relative light input before leafing is by 47% more than in summer under complete foliage (Petrík, Bublinec, 1972).

Group of forest types *Querceto-Fagetum* representing the oak-beech FVT is in air bioclimate related to the ecosystem *Fageto-Quercetum*, in soil climate to *Fagetum pauper*. Illumination range in dormancy period was 45–50%, in the vegetation period reduced to 5–7 %. Extreme values of ecological variables, similar to the preceding group, are more probable with increasing illumination (Table 1).

T a b l e 1. Penetration of solar radiation in beech ecosystems in period of dormancy and in vegetation period (% of external light under clear sky).

Beech forest vegetation tier	Illumination	
	Leafless stands	Stands with complete foliage
Beech-oak	50–60%	5–10%
Oak-beech	40–50%	5–7%
Beech	Fp: 40–45% Ft: 25–45% At fir presence of 20%	2–3% 2–4%
Fir-beech	15–45% Decrease with fir presence from 10 to 90%	5–12% Decrease with fir presence from 10 to 90%
Spruce-beech-fir	15–30% Decrease with presence of conifers	5–10% Decrease with presence of conifers

In natural communities in the beech vegetation tier itself, which means ecosystems of the group of forest types *F. pauper*, illumination range was 40–45% without foliage, reduced to 1.5–2.5% under full foliage. The value of 1.5% was the lowest one observed for illumination in forest ecosystems with beech presence. The light supply in stands before foliage development was higher by 32% on average than in the full-leaved stands. The corresponding light supply another group of this tier *F. typicum* was 25–40 and 2–4%, respectively. Relative light supply in these stands was by 11 times more in dormancy period than in the summer. Illumination in the fir-beech and beech-fir forest vegetation tiers is dependent on fir proportion, ranging in stands without leaves from 15% (fir dominance 90%) to 40% (fir dominance 10%), reduced to 5–12% in period of fully developed vegetation (Table 1). In communities of the maple order, the illumination under leafless trees was kept within ca 30–50%. In the group *Fageto-Aceretum* (FAc) with fir presence dropped the dormancy value of 70% down to ca 2% in the growing season.

Summarizing, we can say that the most abundant light supply until development of vegetation was recorded in forest ecosystems of the beech-oak forest vegetation tier. Under developed foliage, the lowest amount in percent (2.5%) from the total external radiation in open area under cloudless sky was in the group of forest stands *Fagetum pauper*. Also in communities *F. typicum* and *Fageto-Aceretum* was this value lower than 5%. These values are evidently lower than the value of 5% reported in the literature by several authors as the threshold limiting the development of herb synusia (Bublinec, 1990). Under such illumination, microbial activity in soil is considerably hampered, and there is created moder or raw humus form – significantly supported by the fungus *Mycena sanquinolenta*.

Soil freezing and snow precipitation

The maximum soil freezing depth, ranging 10–25 cm, was recorded in the lowest situated beech ecosystem in the forest type group FQ. It was certain surprise – reflecting a snow-melting episode at the turn of January/February followed by a 14-day black frost period. It is necessary to note that the soil freezing is mainly influenced by snow cover. The amount of snow reaching the forest ground in this group of stands is 40–50% from the amount fallen in the forest-free area. The highest amount of snow reaching forest ground compared to open land was observed in communities at 450 m a.s.l. and more. At a stand density of 70% was this amount over 59%. Data concerning other characteristics such as snow cover thickness in forest stands and open spaces, snow cover duration, and others are given in the publication Petrík (1971).

In the next vegetation tier, forest type group QF, the maximum soil freezing depth is 10–20 cm. The amount of snow reaching the forest soil is 70–80% (Table 2). This amount, in conditions of a relatively low altitude, is guaranteed by simple structure of homogeneous forest stands and shows evident crucial importance of beech forest stands in water management.

Similar to ecosystems of the just discussed group, large snow amounts enter beech ecosystems of the groups Fp and Ft representing optimum growing conditions for beech in

T a b l e 2. Soil freezing and snowfall penetrating forest stands in beech vegetation tiers in % from the total snowfall on open plot.

Beech forest vegetation tier	Soil freezing depth in cm	Snowfall
Beech-oak	10–25 cm	40–50% (decreasing with decreasing stocking value)
Oak-beech	10–20 cm	70–80%
Beech	Fp: 0–15 cm Ft: 0–5 cm	Fp: 60–100% Max. at 600– 700 m a.s.l. Ft: 90–115%
Fir-beech	0–5 cm	70–90%
Spruce-beech-fir	0–5 cm	70–80%

Slovakia. In the group Ft represent these amounts from 90 to 115% compared to open area. Snowfall entering typical beech stands in some cases even exceeds snowfall on open plot. Snow amounts in natural communities in beech forest vegetation tier are primarily dependent on altitude, they are only slightly affected by mensurational variables of the stand. The highest snow amounts enter the stands at about 700 m a.s.l. where are created considerable winter water reserves of a great commercial importance. This zone is at the same time the limit beyond which Cambisols and also soils in open non-stocked enclaves do not freeze over almost the whole winter (Petrík, Bublinec, 1972).

The maximum soil freezing depth in the group Fp is 15 cm. The soils in ecosystems of this group at altitudes above 600 m, as well as all the upper situated groups (Ft, AF, FA, FAc) generally do not freeze at all; if they do, the maximum freezing depth is 5 cm (Table 2). This fact may be explained by relatively early permanent snow cover, since the beginning of November (singularity about November 11), before occurrence of strong frosts. The invasion of cold air in the last November and first December days meets the soil covered with a rather thick snow layer appropriately preventing it from freezing.

The snow amount entering forest communities in the fir-beech fvt and beech-fir fvt (AF, FA and FAc) is 70–90%. This value is lower compared to the lower situated ftg-s due to higher admixture of conifers, primarily fir.

Conclusion

The average illumination range (% of external radiation under clear sky) in leafless stands in FQ is 50–60%, in vegetation period 5–10%, in the group of forest types QF 45–50%, and 5–7%, respectively. In fully foliated stands, the lowest percentage of external solar radiation is in the stand group *Fagetum pauper* (Fp), making less than 2.5% compared to the radiation in open area. Also in communities of Ft and FAc is this value lower than 5%. The deepest and strongest soil freezing was observed in the lowest situated beech ecosystem belonging in the group of forest types FQ (10–25 cm). The amount of snowfall reaching forest soil in this group is 40–50% of the amount fallen on non-stocked land. The soil freezing depth in the ftg QF is 10–20 cm, the average percentage of snowfall in the stand 70–80% compared to the open area. The highest amounts of total fallen snow enter beech forest stands situated at about 700 m a.s.l. The maximum soil freezing depth in the group Fp is 15 cm; in ecosystems of this group situated at above 600 m, similar to the other higher situated groups, practically no soil freezing occurs. In summary we can conclude that the maximum amounts of snowfall in the beech fvt enter forest stands situated mostly at 700–950 m a.s.l. In these localities are created considerable reserves of winter water of a crucial commercial importance. This zone represents also the soil freezing boundary beyond which occurs practically no freezing of cambisols and soils in non-stocked enclaves over the whole winter.

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References

Bublinec, E., 1990: Soil and climate in beech stands (in Slovak). Zprávy Lesnického Výzkumu, 35, 1: 8–12.

Frič, M., Škvarenina, J., 2008: Influence of microclimate on properties of lysimetric waters on gale-disaster plots in the Tatra National Park (in Slovak). Bioklimatologické aspekty hodnocení procesů v krajině, p. 98–107.

Matejka, F., Hurtalová, T., 2008: Microclimatic conditions across the gale-disater area in the Tatra National Park (in Slovak). In Fleischer, P., Matejka, F. (eds), Pokalamitný výskum v TANAPe. CD ROM. GFÚ SAV a US TANAPu, p. 148–156.

Minďáš, J., 1999: Quantitative and qualitative description of precipitation paterns in a fir-beech ecosystem (in Slovak). Dizertačná práca. LVÚ Zvolen, 153 pp.

Petrík, M., 1971: Microclimate of forest types on volcanic rocks in Central Slovakia (in Slovak). Biologické Práce, 17, 6: 161 pp.

Petrík, M., Bublinec, E., 1972: Site conditions in forest communities on rich-in-nutrients rocks. Lesnícke Štúdie, 15: 111 pp.

Petrík, M., Havlíček, V., Uhrecký, J., 1986: Forest bioclimatology (in Slovak). Príroda, Bratislava, 321 pp.