Impact of weather and habitat on the occurrence of centipedes, millipedes and terrestrial isopods in mountain spruce forests

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Abstract

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Microclimatic factors (air temperature, soil temperature and moisture in the Ah and B horizons) were determined using AMET weather stations and VIRRIB sensors on four sites in the Moravian-Silesian Beskids (Czech Republic) in 2007–2014. Simultaneously, pitfall traps were installed to monitor epigeic activity of myriapoda (Diplopoda and Chilopoda) and terrestrial isopods (Oniscidea). No statistically significant relationship was found between the occurrence of epigeic macrofauna and the microclimate of the studied forest stands. A linear curve was fitted to the data, demonstrating an increase in air temperature by 2.9 °C and a decrease in moisture by 4.49% over the eight years of monitoring. In this period, the catch of the studied groups of macrofauna decreased while the diversity of the monitored communities increased. Increasing temperature led to the occurrence of synanthropic species *Porcellio scaber* and the decline of montane centipede species such as *Lithobius tenebrosus* and *Lithobius borealis*.

Keywords

Chilopoda, Diplopoda, forest soil, moisture, Moravian-Silesian Beskids Mts, Oniscidea, temperature

Introduction

In the past few decades, the course of weather has been regarded as a factor of the environment which is undergoing global change affecting the ecosystems. These changes are quantified on the basis of direct measurement of climatic factors and indirectly through the response of fauna and flora. The influence of climate on soil fauna was monitored through myriapods and terrestrial isopods, which are known to react sensitively to developing site conditions – both to changes in temperature and decreasing moisture (Auerbach, 1949; Fründ, 1987; Blower, 1951; Lewis, 1981). The abundance and diversity of edaphic zoocenosis depends on soil moisture content as affected by thickness of the surface humus (Jabin, 2008) or by snow cover depth (Templer et al., 2012). It is presumed that the rising temperature may not only increase the abundance of invertebrates but also extend their distribution area and the ability to reproduce (Rodenhouse et al., 2009; Ladanyi and Horvath, 2010). The influence of snow cover on the centipede community in the permafrost conditions of the northern parts of the USA was described by Templer et al. (2012). Myriapods are confirmed to have a wide temperature tolerance (0–32 °C) (Pfleiderer-Gruber, 1986), allowing the representatives of centipedeto remain at the temperature –3 °C for the period of 7 days (Lavy and Verhoef, 1996). Some species require low temperature limits to develop larval stages (between –6 and +3 °C) (Topp, 1994). Low snow

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depth or late arrival of snow cause freezing of the upper soil layers, which can induce changes in the quantity of edaphic macrofauna (Bale and Hayward, 2010). Changes in the quantity of edaphic macrofauna may be related to deviations in the amount of carbon and its cycle or the nutrient content in forest soils, since the majority of its representatives significantly contribute to the decomposition of organic matter (Templer et al., 2012). Invertebrates increase the degree of decomposition (Seastedt and Crossley, 1983; Hättenschwiler and Gasser, 2005; Wall et al., 2008; Rouifed et al., 2010) and mineralisation (Verhoef and Brussaard, 1990) and stimulate microbial respiration (Hanlon and Anderson, 1979; Kaneda and Kaneko, 2008).

Using long-term measurements of microclimatic data and simultaneous monitoring of the epigeic part of soil macrofauna in four sites located in forest stands with different site conditions, we tested some hypotheses of the effect of weather on soil fauna via statistical methods.

Questions to be solved: (*) Is it possible to use the basic linear trend evident from the climatic data for 2007–2014 for simple determination of increase or decrease in temperature and moisture in the studied soil environment?

(*) Is there any correlation between the catch rate of epigeic macrofauna and the climatic factors?

(*) What impact do climatic factors have on the course of temperature and moisture in the soil environment in complex with other factors of the environment?

Material and methods

Study area and sites

In the northeastern part of the Czech Republic in the Moravian-Silesian Beskids (1,160 km^2), permanent research areas were set up in the Smrk and Kněhyně massifs and along the Čeladenka mountain river. A specific feature of the area is the homogenous, moderately rich bedrock consisting of sandstones and slates of the external flysch and the Magura flysch. On the abnormally thick layer of weathered parent material, there are soils with a trophic range from oligo-basic (Cryptopodsols and Podsols) to eu-mesobasic soils (Cambisols, Ranker) and with a hydric range from soils without hydromorphic influence to soils permanently affected by water (Histosol). Steep slopes (14–15° on average) predominate and the whole area is under the influence of high precipitation (>1,000 mm). The climate and the soil types present strongly affect the hydrological situation of the area (the average outflow rate 20–30 m^3 s^{-1}). The climate is characterised by average annual precipitation of 690–934 mm, mean annual temperature of 2.6 °C, temperature minimum in January (–6.1 °C) and maximum in July (11.7 °C), with absolute temperature minimum –30.9 °C and absolute temperature maximum 29.5 °C (Lysá hora weather station of CHMI, 1,323 m asl).

The Pěkná forest site (49°29´01.9´´N; 18°21´23.0´´E) is characterised by a two-storey forest stand, with the upper layer consisting of Norway spruce of 98 yrs and with 95% canopy closure. The understorey consists of six-year-old beech (80%) and of four-year-old fir (20%). The studied area is located below a forest road on a gentle mountain ridge in the central part of the Smrk massif that reaches the maximum altitude of 1,276 m asl. The soil environment is characterised by Haplic Podsols with mor humus form, the height of the soil profile is 70 cm. The parent rock is flysch fine-grained muscovite sandstone (Table 1).

The Stolová ridge site (49°30´31.7´´N; 18´19´24.3´´E) is located on a steep mountain ridge above the Korabský stream, which continues across the territory of the Malá Stolová mountain (1,009 m asl). The forest stand consists of 88% spruce with admixed beech, larch and birch aged 89 with full canopy closure. The soil environment is characterised by Leptosols with moder humus form, with the soil profile reaching 80 cm in depth. The parent rock is flysch sandstone with 10–30% of the area covered by boulders forming a talus field (Table 1).

The Čeladenka valley site (49°29´55.2´´N; 18°20´26.1´´E) represents the alluvium of the main stream "Čeladenka", where the vegetation consists of single-storey forest stand with spruce aged 70 yrs. The site gets flooded sporadically, after prolonged rainfall (2011). The soil is characterised by Fluvisols with moder humus form, with the soil profile reaching 80 cm in depth. The parent rock consists of alluvial sediment currently reaching up to 4 m above the water level in the stream (Table 1).

The Skalka mound site (49°31´38.5´´N; 18°23´12.9´´E) is located on an isolated conical elevation reaching 613 m asl and situated in the main valley of the mountain massif. The forest stand is formed of spruce monoculture aged 95 yrs. The soil environment is characterised by Leptosols with mor humus form, with the soil profile reaching 60 cm in depth. The parent rock is flysch quartziferous sandstone with 50–70% of the area covered by boulders forming a talus field (Table 1).

Sampling of epigeic macrofauna

Epigeic macrofauna was captured using five pitfall traps per site (4,000 ml glasses, 263 mm height, 93 mm hole diameter, covered by a tin roof, 4% solution of formaldehyde) situated in a line within each stand with 10 m spacing. After installation of the traps (1 May), the catch was monitored at six-week intervals for seven successive seasons (15 June, 31 July, 15 September and 28 October, from 2007 to 2013). On each of the dates, a mixed sample was obtained by combining specimen from all five traps on the site. The sample was preserved

Table 1. Environmental factors characterising the model sites in 2007–2014

Environmental factor		Pěkná forest	Stolová ridge	Čeladenka valley	Skala mound
Temperature air	°C	7.2	7.9	8.2	8.6
Temp. max	°C	30.6	30.4	34.1	32.1
Temp. min	°C	–21.0	–31.5	–15.9	–17.8
Temp. soil 1	°C	6.62	7.07	7.61	8.23
Temp. soil 1_max	°C	17.1	22.5	15.8	16.3
Temp. soil 1_min	°C	–1.4	–3.6	–0.4	–0.3
Temp. soil 2	°C	6.74	7.06	7.86	8.61
Temp. soil 2_max	°C	18.4	16.6	17.0	19.9
Temp. soil 2_min	°C	–2.3	–3.6	–1.6	–2.4
Moisture 1	%	26.85	14.26	26.62	21.35
Moisture 1_max	%	38.1	27.5	49.2	36.4
Moisture 1_min	%	15.2	5.5	12.6	6.1
Moisture 2	%	24.74	20.27	21.16	17.09
Moisture 2_max	%	41.7	25.5	42.6	26.5
Moisture 2_min	%	10.6	6.8	12.9	6.4
Exposition		E	E	NE	SE
Depth of sensors HA	cm	10	15	12	20
Depth of sensors HB	cm	25	40	18	30
Altitude	m	880	800	560	600
Type of soil		Haplic Podzols	Leptosols	Fluvisols	Leptosols
Skeleton	%	29.2	53.7	11.7	54.6
Trees		Norway spruce			

in 75% ethanol. Subsequently, it was processed in a laboratory where the representatives of myriapods and isopods were determined to the species level. For the analysis of the effect of climate, total annual sums of specimen trapped at each site were used.

Seasonal activity of the myriapoda and terrestrial isopod communities was evaluated for each of the seasons studied. The diversity was expressed by the Shannon–Weaver index for individual seasonal phases (spring 1 May–15 June, summer 16 June–31 July, late summer 1 August–15 September, autumn 1 October–31 November).

Microclimatic factors

Air temperature was measured by a PRO V2 temperature sensor placed under a shade and installed onto a shaded side of a tree trunk at the height of 2 m above ground (Fig. 1), at a distance of 20 cm from the trunk. To measure soil temperature, two sensors were used which were inserted into the centre of the monitored soil layer (Ah – horizon 1 and B – horizon 2) after exposing the soil profile. The sensors were covered with sifted soil to eliminate contact with stones (Fig. 1). The depth of the individual sensors ranged between 10 and 50 cm. The sensors (air temp., TEPH1, TEPH2) were connected to a MetoUNI datalogger where the measured values were recorded at hourly intervals.

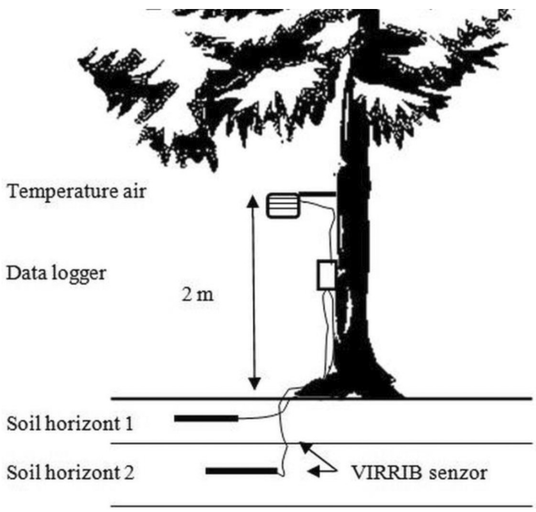

Fig. 1. Technical implementation of installation of AMET weather station with air temperature, soil temperature and soil moisture measurement.

Soil moisture was determined by measuring the resistance of soil by a Virrib sensor (Amet Velké Bílovice) of the weather station. One moisture sensor was located in the centre of the organomineral topsoil (Ah horizon), the other one in the centre of the subsoil layer (B horizon) (Fig. 1). The measurement allows to determine the volumetric soil moisture content in the range 5–50%. The values were recorded by the datalogger at 60 minute intervals (4/2007–10/2014). Volumetric soil moisture represents the ratio between the water content in soil and the total volume of the measured soil.

Average daily values were determined as arithmetic averages from a set of 24 measurements over the course of one day for the measured quantities (air temp., TEPH1, TEPH2, Moist1, Moist2). From a network of 30 stations, four representative areas were selected (based on integrity of measurement and site conditions).

Data analysis

ALA Connect software allowed download of the measured data from the weather station. Daily averages from the individual sensors were processed in Excel. Mutual correlation between the measured temperatures, soil moisture and capture rate of individual representatives of millipedes, centipedes and terrestrial isopods in pitfall traps was tested. To determine the trends in the obtained data, linear regression was used. Statistically significant similarity of the environmental data with the occurrence of macrofauna representatives was sought based on a correlation matrix.

Seasonality of the macrofauna occurrence was evaluated via one-way ANOVA based on the degree of variance. A hypothesis on the inequality of variance in individual monitored sites was expressed via STATISTICA 10.0 software. The Shannon-Weaver diversity index, calculated for each site and season separately, was used to describe the population. Due to the statistically significant variance, a multiple comparison Tukey's HSD test of homogenous groups was performed. The result was estimation of the variability of variance in individual sites and the differentiation of groups with different values of soil moisture.

The significance of the individual environmental factors was compared via principal component analysis (PCA). The basic principle of the analysis is substitution of the original variables by a set of new (hypothetical) variables summarising variance of the original variables. The new variables are called the principal components and are a linear combination of the original variables. The principal components are determined via sequential search for the highest variability with the highest explanation of variance. The result of the PCA is a matrix of covariance coefficients with the determination of eigenvalues and the associated eigenvectors of the matrix (Haruštiaková et al., 2012). We have analysed environmental variables associated with the microclimate of the soil environment (air temp., TEPH1, TEPH2, Moist1, Moist2, exposition, altitude, ToS, Skel., aspect).

The influence of two sets of variables was tested. The matrix of independent variables of ecological data – environmental variables (air temp., TEPH1, TEPH2, Moist1, Moist2, exposition, altitude, ToS, Skel., aspect) and the matrix of dependent variables represented by species captured in pitfall traps. A canonical correspondence analysis (CCA) was applied which uses multidimensional regression to determine the linear combination of variables that best explain the inertia of the ordination scores obtained from the dependent variables (Lepš and Šmilauer, 2003). The testing of hypotheses in CCA was performed using the strength of the permutation test. The statistics were carried out in CANOCO for Windows 4.5 software which allows for the analysis of test strength using the Monte-Carlo permutation test with 999 repetitions. The test strength testing with the individual environmental variables was done using a "forward selection" function, where the first eigenvalue is compared with the appropriate statistic obtained from random permutations of the data. The result of the CCA is an ordination diagram in which the species and samples are indicated by individual points (Haruštiaková et al., 2012).

Abbreviations: Air temp., air temperature measured at 2 m above the ground; TEPH1, soil temperature in the central depth of Ah horizons; TEPH2, soil temperature in the central depth of B horizons; Moist1, volumetric soil moisture in the central depth of Ah horizons; Moist2, volumetric soil moisture in the central depth of B horizons; Exposition, exposition of the research area; Altitude, height above see level; ToS, type of soil according to WRB, 2006 (The World Reference Base for Soil Resources); Skel., percentage content of soil skeleton in the topsoil with particle size of >2 mm; Aspect, seasonal occurrence of the captured species; SW, Shannon-Weaver diversity index.

Results

Climatic factors 2007–2014

During the reporting period, the mean air temperature was 7.97 °C, the difference between the lowest and the highest situated study site being 1.4 °C. The lowest temperature (–31.5 °C) was measured at the Stolová ridge site (20 December 2009, 21:00), after previous eight days of frost with subsequent slight warming. The highest temperature (34.1 °C) was measured at the Čeladenka valley site (8 August 2013, 14:00) during 10 days of warm weather in late July/early August (Table 1). The soil temperature in topsoil (Ah horizon) did not fluctuate as widely when compared to air temperature. The mean soil temperature of 6.62–8.23 °C was 0.6–0.83 °C higher than the average air temperature.

The lowest temperature in the topsoil was measured at the Stolová ridge site along with the lowest air temperature. The highest soil temperature (22.5 °C) was determined at the Stolová ridge site (15 July 2010, 16:00). The mean soil temperature (6.74–8.61 °C) in the subsoil (B horizon) was higher by 0.12–0.38 °C when compared to the topsoil (Ah). The lowest temperature ranged between –3.6 and –1.6 °C [Pěkná forest –2.3 °C (8 March 2011), Stolová ridge –3.6 °C (23 February 2011), Čeladenka valley –1.6 °C (8 March 2011) and Skalka mound –2.4 °C (26 February 2011)]. The highest temperatures in the subsoil (B) were within the range of 19.9 and 16.6 °C.

The sites differed significantly by their maximum values of volumetric soil moisture (27.5–49.2%) from the measured average volumetric soil moisture (14.26–26.85%). The highest value was recorded at the Čeladenka valley site (49.2%, 24 June 2014). During the studied seven-year period, the mean annual air temperature increased by 2.9 °C.

Influence of weather on soil macrofauna

Mutual comparison allowed to calculate a correlation matrix for the individual sites to define the relationship between air temperature, soil temperature, soil moisture and the capture rate of macrofauna in pitfall traps. A correlation between air and soil temperature was confirmed (r = 0.923 to r = 0.991). With increasing temperature, soil moisture decreased. Fitting of the individual curves of weather development and capture rate of macrofauna did not reveal a statistically significant relationship to the course of temperature. Visual comparison revealed a slight similarity in the development of soil moisture and increase in the occurrence of macrofauna, but with a partial time delay after the period of increased moisture. Only at the Čeladenka valley site, there was a correlation between the captured macrofauna and air temperature (r = 0.437, Table 2) and soil temperature in the topsoil (Ah) layer (r = 0.416) and the subsoil (B) layer (r = 0.397).

Seasonality effect

Due to the course of weather throughout the year, when the changing temperature delineates a curve similar to a sinusoid, an influence of the seasonal aspect on the development of soil macrofauna population was found. The variance of occurrence of a species was analysed by one-way ANOVA where the hypothesis of equality of variance in mean values of the basic dataset was rejected by a test criterion (F = 6.3675 and p = 0.00051, Fig. 2). Using a Tukey's HSD test of multiple comparisons, a statistically significant difference was detected in the Summer set. Species diversity was determined in parallel (Shannon-Weaver index) for the population captured in spring (SW = 1.853), summer (SW = 2.213), late summer (SW = 2.113) and autumn (SW = 2.156). The highest species diversity was detected in the summer season.

The effect of environmental variables

The determination of the effect of individual environmental variables was performed via PCA which was explained using four canonical axes. Based on the fact that axis 1 explained 79.33% of the variance in the original data matrix, we can consider only the first component. Axis 2 explained 8.72% of the variance, followed by axis 3 with 7.21% and axis 4 with 4.74% of the variance of the original data. From the values of explained variance from the correlation matrix it follows that the important components are altitude (r = 0.389) and type of soil (r = 0.304). Another significant component was soil moisture, where the moisture in the subsoil (B horizon) was more significant (r = 0.229) than in the topsoil (Ah horizon) (r = 0.153). Soil and air temperature reached only very low values of explained variance.

The relationship between the representation of the captured centipede, millipede and terrestrial isopod species in the samples and the environmental variables was analysed using canonical correspondence analysis. In the ordination space, the first canonical axis explained 12.9% of total variability (Fig. 3), which was statistically significant (F = 2.185, p = 0.001), since the first axis was very well correlated with the environmental data (r = 0.829). In our case, the first canonical axis can be interpreted as a gradient of the site, from eastern exposition (r = 0.608) with skeleton content (r = 0.457) and slightly higher air temperature (r = 0.180) to the site with lower altitude (r = –0.579), more favourable fluvisol conditions (r = –0.518) and higher soil moisture

Table 2. Correlation coefficients between the environmental factors and the occurrence of macrofauna

Variable	Pěkná forest	Stolová ridge	Čeladenka valley	Skala mound
Temperature	–0.0692	0.1906	**0.4372**	0.1326
Temp. soil 1	–0.0337	0.2791	**0.4159**	0.1161
Temp. soil 2	–0.0387	0.3244	**0.3968**	0.1289
Moisture 1	0.0635	–0.2220	–0.0343	0.0892
Moisture 2	0.0289	–0.1006	–0.2089	0.0663

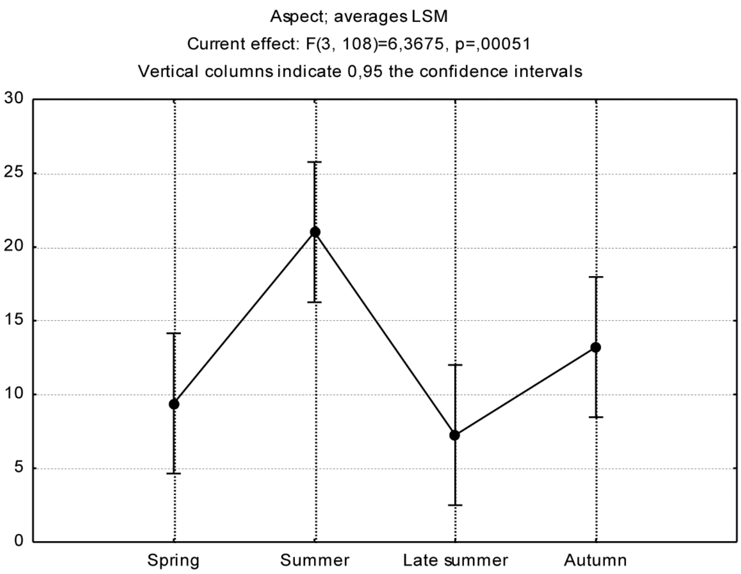

Fig. 2. Significance of congruence of median variance of the basic set of samples expressed via the seasonal aspect factor.

(r = –0.382). The gradient of the second canonical axis best characterises correlations with the soil moisture (r = 0.396) and the type of soil (r = 0.377) variables. The selected environmental variables explain 22.24% of the total inertia of species data. The environmental variables which significantly influence the variability of animal communities were determined via forward selection, the most significant variables being exposition, altitude and type of soil while temperature, moisture and seasonality were of reduced significance (Table 3).

As regards the studied species of the Chilopoda group, they occur more frequently on sites with lower content of skeleton and good hydrologic regime in medium and higher positions (Fig. 3). As regards the relation to temperature, Chilopoda are more resistant to lower temperatures and do not suffer from frost. In contrast, Diplopoda occurred in medium and lower altitudes on soils with higher content of humus and higher temperatures as well as with a good hydric regime (Fig. 3). The Isopoda were more frequent on sites with southeastern exposure with soil type Leptosols and with boulders on the surface. This site was characterized by warm climate but good hydric conditions (Fig. 3).

Discussion

Weather course

Climatic factors were measured under a mature spruce stand. Therefore, the general patterns of temperature and moisture course in a forest ecosystem must

Table 3. Environmental variables driving animal communities: percentages of explained variability, significance and inclusion in manual forward selection (FW). CCA ordination of log-transformed and body size-weighted data

Variable	Variability explained (%)	F	P	FW selection
Exposition	18.34	7.471	0.001	+
Altitude	16.91	6.887	0.001	+
Type of soil	15.36	6.254	0.001	+
Skeleton	11.95	4.867	0.001	+
Moist 2	11.82	4.812	0.001	+
Temp. air	6.63	2.700	0.001	+
Moist 1	6.09	2.482	0.005	+
TEPH2	4.85	1.974	0.008	
Aspect	4.81	1.960	0.117	
TEPH1	3.24	1.319	0.197	

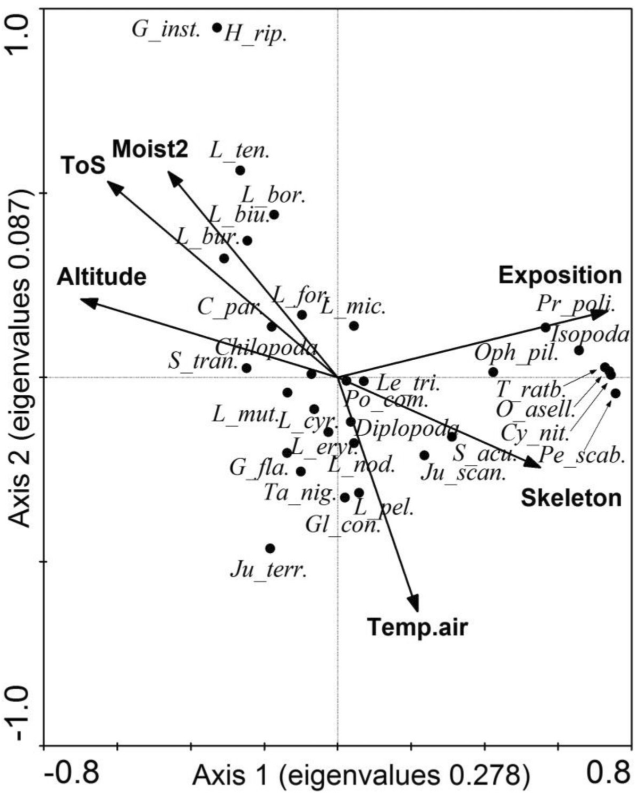

Fig. 3. Effectiveness of environmental variables depending on the capture rate, substantiated by canonical correspondence analysis in the ordinance diagram.

be characterised. Temperature stratification of the atmosphere in the forest stand changes throughout the day and the season. Due to the broken surface of the stand, the effect of air flow is subdued and absorption of photoactive radiation affects the temperature in the stand (Arya, 2001). Total moisture of the stand also increases due to soil moisture as well as moisture released during transpiration of plants when compared to open areas (forest-free areas) (Hayashi, 1983; Hurtalová et al., 2003). Based on the measured climatic factors, we can assert an increase of the average temperature at the local scale by up to 2.9 °C over the period of seven years, which is in accordance with the generally reported global trend of warming (Wardle et al., 2004; Templer et al., 2012). As expected, when comparing the air temperature and soil temperature in both soil horizons, a positive correlation was demonstrated, even though the amplitude in soil temperature was smaller than in air temperature. This was the case especially in winter seasons when the continuous snow layer acts as thermal insulation. Soil moisture content changed inversely proportional to the course of air temperature. Therefore, over the course of the study, an increase in average air temperature was detected, followed logically by a decrease in moisture of the soil environment. The increase in temperature led to a gradual increase in the occurrence of synanthropic species of soil macrofauna *Porcellio scaber*. *Porcellio scaber* is a species with wide ecological valence occurring in sites under anthropogenic influence (Tuf and Tufová, 2008). Simultaneously, a decreased occurrence of the species inhabiting montane and submontane areas (*Lithobius tenebrosus, Lithobius borealis*) was observed. *Lithobius tenebrosus* has been described as a species associated with trunks of coniferous trees (Schatzmann, 1990; Tajovský, 2001; Kula and Lazorík 2014). *Lithobius borealis* is a species typical of montane and submontane spruce stands linked to tree bark (Summers and Uetz, 1979; Spelda, 1999; Blackburn et al., 2002; Kula and Lazorík, 2014).

Effects of microclimatic factors on macrofauna

The effects of weather on the occurrence of macrofauna communities are reported on by Auerbach (1949, 1951) and Fründ (1987). Positive relationship to moisture has been established for representatives of centipedes, millipedes and especially terrestrial isopods based on the understanding of their morphology, mainly their epicuticle structure (Lewis, 1981; Hopkin and Read, 1992; Wirkner and Pass, 2002). If the top wax layer of the epicuticle is noticeably missing (Blower, 1951; Mead-Briggs, 1956) and the breathing spiracula are not sufficiently formed, evaporation increases (Lewis, 1963; Curry, 1974). Our results are in agreement with a number of studies which demonstrate a relationship between invertebrates and sites with increased soil moisture (Albert, 1983; Fründ, 1987; Cloudsley-Thompson and Crawford, 1970; Jabin, 2008).

For centipedes in the temperate zone, a very wide temperature valence and tolerance was reported (Albert, 1983). *Lithobius forficatus* showed activity in a temperature range between 0–32 °C (Pfleiderer-Gruber, 1986), and even survived frost of –3 °C for one week without any damage (Lavy and Verhoef, 1996). Temperature tolerance is confirmed by results of laboratory breeding (Jabin, 2008), where the abundance of centipedes did not correlate with temperature data. Since no temperature threshold of activity has been defined for individual centipede species, a sum of effective temperatures could not be used. Therefore, their activity was assessed only as a sum of the numbers of their occurrences at a site in the reference growing season. The seasonal aspect was observed, which defined the summer period (June–July) as the most appropriate for the activity of centipedes, since it also features the highest rainfall. Extreme temperatures have no effect on the abundance of macroarthropods (Jabin, 2008). It was found out that millipedes (David et al., 1996), isopods (Tanaka and Udagawa, 1993) and rove beetles (Topp, 1978) can survive hypothermia at the temperature between –4 and –5 °C. In our study sites, soil freezing down to a depth of 12 cm was detected only in 2011 when no snow cover formed even at higher elevations. Therefore, an increased mortality in soil arthropods cannot be ruled out, since snow cover fulfils an insulating function (Bale, 1991). Certain limited level of activity of macroarthropods cannot be excluded even under the snow cover.

To demonstrate the impact of climatic factors, we used the principal component analysis (PCA), where the basic environmental factors affecting soil environment were monitored. Based on a correlation matrix with verification of the regression analysis test using the Monte-Carlo test, it was found out that the factor of the type and location of the soil environment has a more significant effect than the climatic factors. We can conclude that microclimatic factors do not have a statistically significant influence on the distribution of the individual soil macrofauna species. Exposition, altitude, type of soil and soil skeleton content, i.e. factors determining the quality of the soil were confirmed to be important factors. It follows from the data that the occurrence of species is closely related to the quality of the environment and not to the temperature or moisture. It should be stressed that the presented results are of a smaller scale i.e. represent a regional assessment. At the global scale, significantly higher abundances were found in warmer areas compared to colder areas (Blackburnn et al., 2002).

Conclusions

A direct effect of microclimatic factors of the soil environment (temperature, moisture) on the dynamics of the communities of centipedes, millipedes and terrestrial isopods in mountain spruce forests has not been proven.

Nevertheless, an indirect effect of environmental factors, such as exposition, altitude and soil skeleton content was found. An increase in average air temperature by +2.9 °C and decrease in soil moisture by –4.49% may be a cause for the decline in montane and submontane species (*Lithobius borealis, Lithobius tenebrosus*) and an increase in the numbers of synanthropes (*Porcellio scaber, Ophyiulus pilosus*) with wide ecological valence at the expense of relict species.

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