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PRELIMINARY RESEARCH ON GAMASID MITE AND THE ACTIVITY OF SELECTED SOIL ENZYMES IN THE KARKONOSZE NATIONAL PARK

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Abstract. The abundance of mites from the order *Gamasida* and the activity of soil enzymes were investigated in relation to altitude, season of the year or distance from the tree trunk. The activity of soil enzymes depended on a season of the year and altitude. The abundance of the *Gamasida* population was higher closer to the tree. Abundance and species composition of the investigated *Gamasida* population changed with season of the year, altitude, and distance from the trunk, however, it was not significantly affected by the activity of the enzymes.

Key words: mites, *Acari*, *Gamasida*, enzymatic activity, Karkonosze National Park

INTRODUCTION

Mites from the order *Gamasida* are used as bioindicators of changes in the natural environment [Gwiazdowicz and Dobies 1999]. Their distribution, abundance, as well as species composition depend on temperature, precipitation, stand reconstruction as part of the silvicultural or conservation operations, as well as direct factors connected with the food resources. In Poland, the order *Gamasida* includes approximately 800 species, and among them predators, saprophages, and mycetophages. A smaller group is composed of parasites of plants and animals. Most of species from the order *Gamasida* inhabit the soil environment, primarily the litter layer.

Organic compounds such as carbohydrates (sugars, cellulose), organic acids, amino acids, protein, lignin, fats, waxes and tannins dominate in the chemical composition of litter. As a result of the activity of soil microorganisms secreting enzymes, a series of processes is initiated which provide nutrients for plants. The activity of enzymes is dependent on the physico-chemical properties of the soil, i.e. the mechanical composition, temperature, moisture, texture, pH, sorption complex, organic matter content and

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mineral composition [Burns 1978, Trojanowski 1973]. In spite of numerous factors modifying the action of soil enzymes (for example soil temperature, humidity, pH) their activity – in the opinion of many authors – is a reliable indicator of the fertility and quality of soils [Balicka 1986, Januszek 1993] and they are sensitive bioindicators of early changes in the soil environment [Olszowska 1998, 2001].

Abundance of mites and activity of soil enzymes depend on soil climate conditions i.e. air temperature and soil humidity. In mountains climate parameters significantly change with the altitude above sea level (a.s.l.) e.g. in the Karkonosze Mts., the value of mean annual temperature increases by 0.7°C and mean annual precipitation by 60 to 70 mm with the growing altitude per each 100 m [Puchalski and Prusinkiewicz 1990]. In the present study we compared abundance and species composition of *Gamasida*, as well as activity of soil enzymes between different altitudes, seasons of the year, and distances from the trunk. We did not find any information about a potential relationship between abundance of *Gamasida*, their species composition and activity of soil enzymes. However, it may be hypothesized that enzymatic activity in soil increased with a growing number of *Gamasida* specimens, which can secret enzymes decomposing forest litter.

MATERIAL AND METHODS

Study area

Four study areas, each of 0.25 ha, were established in the Karkonosze National Park. Two study plots were located at the lower mountainous forest belt at approx. 800 m a.s.l. Acidophylic mountain beech wood with *Picea abies* Karst. dominated in the first storey, with mountain ash *Sorbus aucuparia* L. em. Hedl. in the undercrop and beech *Fagus sylvatica* L. in the understorey. The acid brown soils were the most frequent. Two other study areas were situated at the altitude above 1000 m a.s.l., at the subalpine forest belt. Norway spruce was the dominant species in these areas. The study areas were characterized by low stand density and numerous dead standing trees. Gley-podzolic soils were predominant.

Sampling design

In each area four reference points were chosen, which were trees or stumps. Samples were collected using a probe of 200 cm^3 at the distance of 30 cm and over 100 cm from the fixed point (tree stem). The depth of soil probing was 10 cm from the surface of litter. Samples were collected twice in the late spring (14.06.1999; 12.06.2000) and twice in autumn (7.10.1999; 22.09.2000). 128 soil samples were used for analyses. *Acari* and other invertebrates were driven away from the soil samples with high irradiance provided by Tullgren funnels. Then, the specimens of *Gamasiada* were prepared in lactophenol for microscopic observations.

The used dry soil samples were screened through a sieve with a mesh size of l mm prior to determine the activities of the following enzymes:

– urease, using the colorimetric method, expressing the activity in mg NH_3 per 10 g soil [Gałstjan 1978],

– asparaginase, using the colorimetric method, expressing the activity in mg NH_3 per 10 g soil [Gałstjan 1978],

– acid phosphatase, using the colorimetric method, expressing the activity in mg phenol per l0 g soil [Russel 1972],

– dehydrogenases, using the colorimetric method, expressing the activity in mg TF (triphenylphormasane) per 10 g soil [Gałstjan 1978, Russel 1972]. These enzymes were chosen for analyses because their concentrations are highest compared with other soil enzymes. Total enzymatic activity was calculated as the mean value from activities of four enzymes. The percentage of organic carbon was determined in the SC-132 analyzer by LECO. The reaction of the soil was determined using the potentiometric method – pH in ln KC1 and H_2O.

Data analyses

Linear and non-linear regressions were performed to examine the relationship between enzymatic activity in soil and the number of individuals, and species of *Gamasida*. The effects of the date (the year and the season of the year), the localization of samples (the low mountainous forest belt or the subalpine forest belt, close to tree or in gap) on enzymatic activity in soil as well as the number of individuals and species were evaluated by multivariate analysis of variance (MANOVA according to GLM procedure) followed by Tukey's *a posteriori* tests assuming the results to be statistically significant when $p < 0.05$. All the statistical analyses were carried out with Statistica 5.5.

RESULTS AND DISCUSSION

The structure of *Gamasida* population (number of individuals and species) was statistically independent of enzymatic activity in soil. Only a weak, non-linear relationship was found between the enzymatic activity in gaps and the number of individuals ($R^2 = 0.225$, $p = 0.005$).

Total enzymatic activity in soil related to four enzymes: asparaginase, dehydrogenase, phosphatase and urease did not significantly differ between autumn and spring (Fig. 1 a) but the interaction between a season of the year and activity of the investigated enzymes was statistically significant ($p = 0.0001$). Post-hoc comparison showed that the activity of phosphatase was considerably higher in autumn than in spring ($p = 0.0001$; Fig. 1 b). The activities of the enzymes did not differ when compared the soil samples collected close to tree and in gaps ($p = 0.523$). The activities of phosphatase and urease were higher at the lower mountainous forest belt than at the subalpine forest belt ($p < 0.0001$, $p = 0.035$, respectively; Table 1).

The upper layers of the investigated soils were strongly acid as indicated by pH in KC1 2.81-3.18 and pH in H_2O 3.57-3.89. No significant differences in pH were observed between samples collected at varying distances from the tree.

Organic carbon testing showed that soil samples collected in the subalpine forest belt contained more organic carbon – on average from 38.9 to 44.4% than samples from the low mountainous forest belt – on average 18.9-35.0%. In the subalpine forest belt

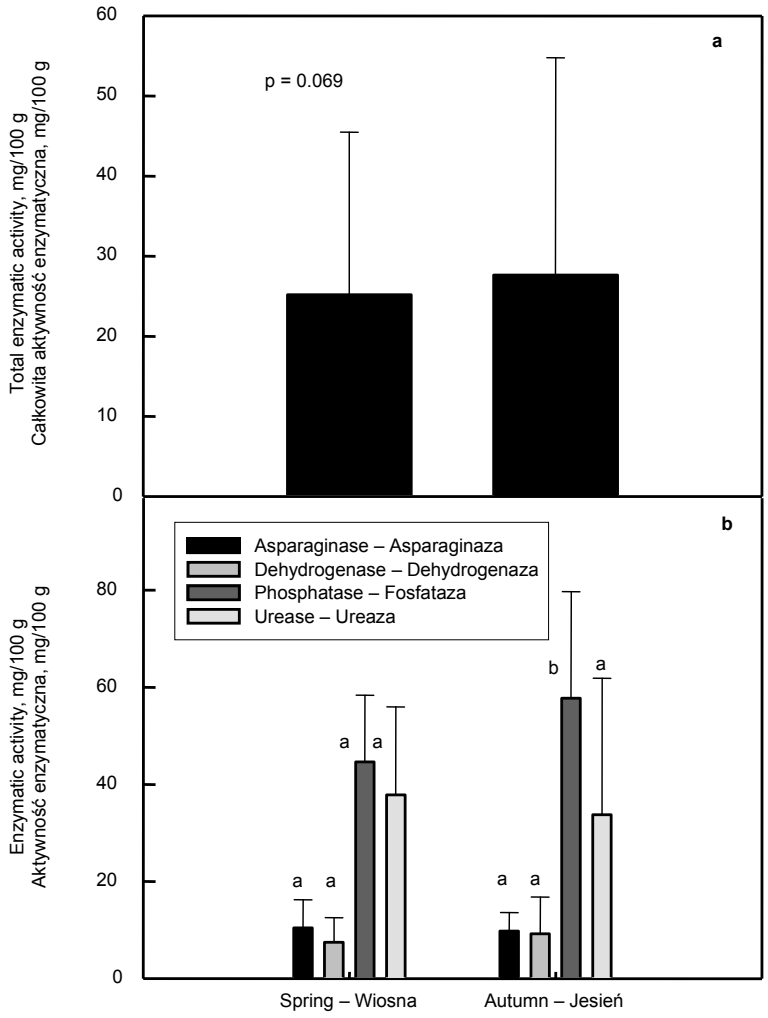

Fig. 1. Total mean values (± SD) of enzymatic activity in soil (**a**) and enzymatic activity of the individual enzymes (**b**) in spring and autumn. The soil samples were collected twice: in 1999 and 2000. MANOVA followed by Tukey's *a posteriori* test at $p < 0.05$ were applied to evaluate the effects of the date and place of samples collection (a distance from the tree) on enzymatic activity in soil. The different letters indicate that the mean values significantly differ according to Tukey's test

Rys. 1. Średnie wartości całkowitej aktywności enzymatycznej gleby (± odchylenie standardowe) (**a**) i aktywność poszczególnych enzymów (**b**) wiosną i jesienią. Za pomocą wieloczynnikowej analizy wariancji i testu Tukeya na poziomie istotności $p < 0{,}05$ oceniono wpływ daty i miejsca zebrania prób (odległości od drzewa) na aktywność enzymatyczną gleby. Różne litery wskazują, że wartości średnie różnią się statystycznie istotnie na podstawie testu Tukeya

Table 1. Mean values (± SD) of enzymes activities at the low mountainous forest belt and at the subalpine forest belt. Two-way ANOVA in general linear model followed by Tukey's *a posteriori* test at $p < 0.05$ were applied to compare the mean values ($n = 64$)
Tabela 1. Średnie wartości (± odchylenie standardowe) aktywności enzymatycznej w reglu dolnym i w reglu górnym. Do porównania średnich zastosowano dwuczynnikową analizę wariancji według ogólnego modelu liniowego i test *a posteriori* Tukeya na poziomie istotności $p < 0,05$ ($n = 64$)

Enzyme Enzym	Low mountainous forest belt Regiel dolny	Subalpine forest belt Regiel górny
Asparaginase – Asparaginaza	8.8 ±4a	11.5 ±5.3a
Dehydrogenase – Dehydrogenaza	9.8 ±7a	7.0 ±5.6a
Phosphatase – Fosfataza	43.9 ±17a	58.5 ±19b
Urease – Ureaza	31.7 ±15a	40.0 ±29b

the distance from the tree trunk did not have a significant effect on the organic carbon content, as it was on average: 30 cm – 44.4%; over 100 cm – 40.8%, respectively. In the low mountainous forest belt more organic carbon was found in the samples collected at the distance of 30 cm – 32.1% than over 100 cm – 21.3%.

Enzymatic activity, organic carbon content and pH may influence the species composition and abundance of *Gamasida* in soil. A total of 973 mite specimens from the order *Gamasida* belonging to 46 species were found in the soil samples. Remarkable differences in the number of species and the size of *Gamasida* population were observed between the altitudes. In the areas located at the low mountainous forest belt in all the soil samples (humus and litter) 577 specimens were found, belonging to 39 species, whereas at the subalpine forest belt – 396 specimens belonging to 31 species (Table 2). The species found most frequently was *Veigaia nemorensis*, of which 203 specimens were found at the low mountainous forest belt and 84 specimens at the subalpine forest belt. At the low mountainous forest belt, the mean total number of individuals of *Gamasida* per 200 cm^3 of humus and litter was 12 close to tree and 6 in gaps compared to the subalpine forest belt – 8 and 4 individuals, respectively. Number of specimens and species composition of *Gamasida* were more abundant in autumn than in spring ($p = 0.005$; Fig. 2 a, b). Moreover, number of individuals of *Gamasida,* in particular number of individuals of *Veigaia nemorensis* attained higher mean values in the soil samples collected close to trees compared to those collected in gaps ($p = 0.003$ and $p < 0.001$, respectively; Fig. 3 a, b). The number of species was greater at the low mountainous forest belt compared to the subalpine forest belt ($p = 0.05$) but did not significantly change with the distance from a tree (Fig. 4 a). The number of *Veigaia nemorensis* individuals was higher at the low mountainous forest belt than at the subalpine forest ($p = 0.003$; Fig. 4 b). Inversely, the activities of phosphatase and urease increased at the higher altitude (Fig. 4 c).

To sum up, our results indicated that the number of *Gamasida* individuals and species composition differed between the seasons of the year, the altitudes and the samples collection places (close to the trunk or in gap). However, the determined parameters of *Gamasida* population were independent of soil enzymatic activity.

Table 2. A list of gamasid mites found in the surface in low mountainous forest belt and subalpine forest belt
Tabela 2. Wykaz roztoczy *Gamasida* stwierdzonych w reglu dolnym i górnym

Species Gatunek	Low mountainous forest belt Regiel dolny		Subalpine forest belt Regiel górny	
	division oddział 104d	division oddział 31j	division oddział 200f	division oddział 71h
Amblyseius sp.		1		
Celaenopsis badius			1	1
Eviphis ostrinus	2	9	2	
Gamasellus montanus	9	24	53	20
Geholaspis longispinosus	3	1	4	1
Geholaspis mandibularis		2		
Geholaspis pauperior		4		1
Holoparasitus calcaratus	17	1		
Holoparasitus sp.	4			
Hypoaspis aculeifer	2	10		
Hypoaspis brevipilis	2		1	
Leioseius magnanalis				2
Leptogamasus obesus	31		9	11
Leptogamasus parvulus	37	12	55	18
Macrocheles glaber	1		1	
Macrocheles montanus		4	1	
Pachylaelaps bellicosus	7	1		
Pachylaelaps furcifer	6	7	4	3
Pachylaelaps longisetis	5	2		
Pachylaelaps suecicus			1	3
Paragamasus crassicornutus	10		5	
Paragamasus homopodoides	10			4
Paragamasus rostriforceps		1		
Paragamasus runcatellus		20		
Paragamasus vagabundus			1	2
Parasitus beta	1			
Parasitus fimetorum	1			
Parazercon radiatus	6	1		1
Pergamasus brevicornis	5	8	4	3
Polyaspinus cylindicus	15	3		
Porrhostaspis lunulata		1	2	
Prozercon kochi		1		
Rhodacarus sp.				1
Trachytes aegrota	9	12	19	17
Trachytes irenae	27		1	
Trachytes pauperior	9	1	4	9
Trichouropoda ovalis				1
Urodiaspis tecta	3			
Uropoda minima	2		2	
Uropoda misella	3	1		
Veigaia cervus	4	2	5	12
Veigaia kochi	3	2	4	1
Veigaia nemorensis	83	120	41	43
Veigaia propinqua	2	1	5	7
Vulgarogamasus kraepelini	2	4	4	4
Zercon triangularis			2	
Numbers of specimens – Liczba osobników	321	256	231	165
Numbers of species – Liczba gatunków	39		31	

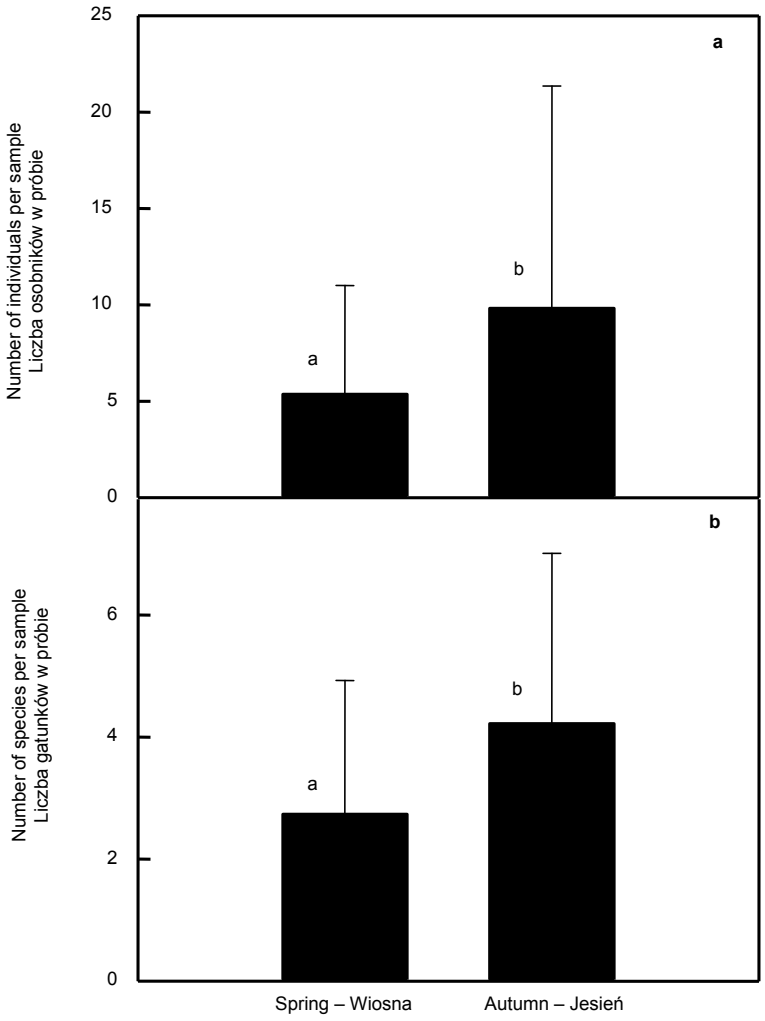

Fig. 2. Mean values (± SD) of the number of individuals (**a**) and the number of *Gamasida* species (**b**) in spring and autumn. MANOVA followed by Tukey's *a posteriori* test were carried out at $p < 0.05$. The different letters indicate that the mean values statistically significantly differ according to Tukey's *a posteriori* test

Rys. 2. Średnie wartości (± odchylenie standardowe) liczby osobników (**a**) i liczby gatunków z grupy *Gamasida* (**b**) wiosną i jesienią. Do porównania średnich zastosowano wieloczynnikową analizę wariancji i test Tukeya na poziomie istotności $p < 0{,}05$. Różne litery wskazują, że wartości średnie różnią się statystycznie istotnie na podstawie testu Tukeya

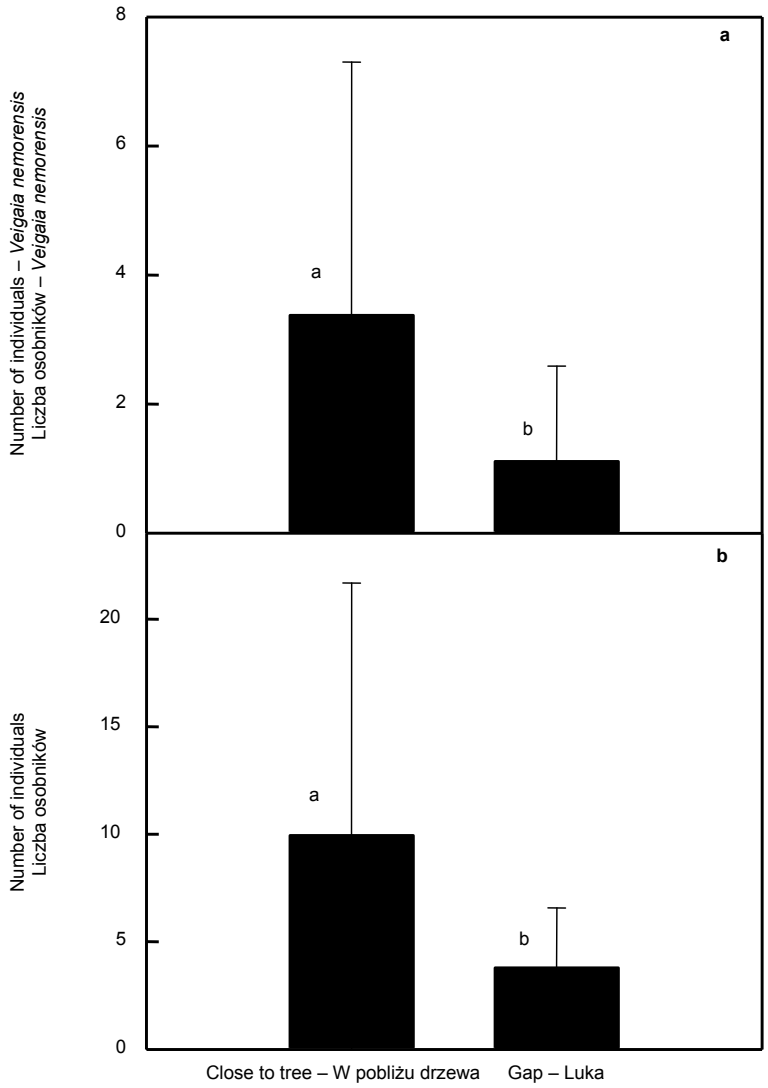

Fig. 3. Mean values (± SD) of the number of *Gamasida* individuals (**a**) and the number of *Veigaia nemorensis*' individuals (**b**) determined in the soil samples (200 cm^3) collected close to trees and in gaps (in distance over 100 cm from a tree). For further explanations see Figure 2

Rys. 3. Średnie wartości (± odchylenie standardowe) liczby osobników z grupy *Gamasida* (**a**) i liczby osobników *Veigaia nemorensis* (**b**) określone w próbach glebowych o objętości 200 cm^3, które zebrano w pobliżu pni drzew i w lukach (w odległości 100 cm od drzew). Pozostałe objaśnienia patrz rysunek 2

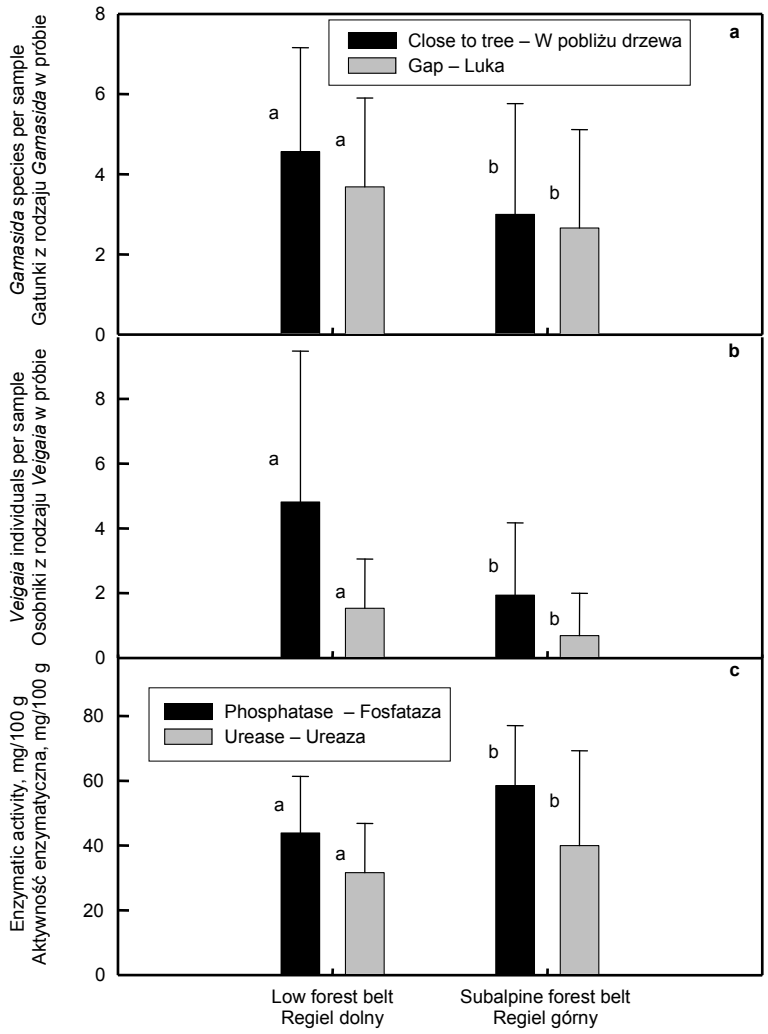

Fig. 4. Comparison of the numbers of *Gamasida* species (**a**), the numbers of *Veigaia nemorensis* individuals per soil sample (200 cm^3) (**b**) and enzymatic activity (**c**) in the soil samples collected at the low mountainous forest and the subalpine forest zone in the Karkonosze Mts. MANOVA (according to GLM procedure) followed by Tukey's *a posteriori* test were applied at $p < 0.05$

Rys. 4. Porównanie liczebności gatunków z grupy *Gamasida* (**a**), liczebności osobników *Veigaia nemorensis* w przeliczeniu na próbę glebową o objętości 200 cm^3 (**b**) i aktywności enzymatycznej (**c**) w próbach glebowych zebranych w reglu dolnym i górnym Karkonoszy. Zastosowano wieloczynnikową analizę wariancji (według ogólnego modelu liniowego „GLM") i test Tukeya na poziomie istotności $p < 0,05$

CONCLUSIONS

1. In autumn the activity of soil enzymes was higher than in spring. The *Gamasida* abundance was greater and more varied as far as species composition is concerned.

2. No statistically significant difference was found between enzymes activity and the distance from the tree trunk but this was shown between the distance from the tree and abundance of *Gamasida*. The closer to the tree trunk, the more specimens were found.

3. At the subalpine forest belt fewer specimens and species from the order *Gamasida* were found than at the low forest belt. The activity of urease, asparaginase, and acid phosphatase was higher at the subalpine forest belt than at the low mountainous forest belt, which may be connected with the higher organic carbon content in the soils at the subalpine forest belt. The activity of dehydrogenase was lower there than at the low mountainous forest belt, which may decrease organic matter decomposition processes.

4. No correlation was found between enzyme activity and the abundance and species composition of *Gamasida*.

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FAUNA ROZTOCZY (*ACARI*, *GAMASIDA*) I AKTYWNOŚĆ WYBRANYCH ENZYMÓW GLEBOWYCH NA TERENIE KARKONOSKIEGO PARKU NARODOWEGO

Streszczenie. Praca jest próbą poszukiwania zależności pomiędzy składem gatunkowym i liczebnością roztoczy glebowych z rzędu *Gamasida* a aktywnością wybranych enzymów glebowych. Ponadto analizowano czynniki wpływające na bogactwo roztoczy i aktywność enzymów, jak np. wysokość nad poziomem morza, pora roku czy odległość od pnia drzewa. W wyniku przeprowadzonych prac nie stwierdzono bezpośredniej zależności między aktywnością enzymów a liczebnością i składem gatunkowym roztoczy. Stwierdzono natomiast zależności pomiędzy porą roku i wysokością nad poziomem morza a akarofauną i aktywnością enzymów glebowych. Zauważono także, że liczebność roztoczy i aktywność dehydrogenaz jest większa bliżej drzewa.

Słowa kluczowe: roztocza, *Acari*, *Gamasida*, aktywność enzymatyczna, Karkonoski Park Narodowy

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