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THE INFLUENCE OF SOME ENVIRONMENTAL FACTORS ON THE SPECIES DIVERSITY OF THE PREDATOR MITES (ACARI: MESOSTIGMATA) FROM NATURAL FOREST ECOSYSTEMS OF BUCEGI MASSIF (ROMANIA)

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Abstract. The ecological research was made in 2001-2003, in Bucegi Massif, in three natural forest ecosystems with *Picea abies*, *Abies alba* and *Fagus sylvatica*. In order to show the influence of some environmental factors on the species diversity of the investigated soil mites, the following abiotic parameters at soil level were analysed: temperature, humidity and pH. The species diversity (with Shannon-Wiener index) and the equitability were calculated. Taking account of the bio-edaphical conditions, the studied soil mite diversity had a various evolution. In spatial dynamics, the ecosystem with *Abies alba* offered better conditions for a species diversity (78 identified species), in comparison with ecosystem with *Picea abies* (67 identified species), where, due to a high altitude and to the big slope, this parameter had the most decreased values. In the ecosystem with *Fagus sylvatica*, the diversity showed the presence of 71 species. At the soil level, the litter and fermentation layer was a favorable habitat for development of the soil mite populations. In temporal dynamics, these parameters had recorded seasonal fluctuations. All these aspects are due to the different bioedaphical conditions, specific to each studied natural ecosystem.

Résumé. Cette étude écologique a été réalisée au cours de la période 2001-2003, dans le Massif de Bucegi, dans trois écosystèmes naturels avec *Picea abies*, *Abies alba* et *Fagus sylvatica.* Afin de démontrer l'influence de certains facteurs du milieu au niveau du sol sur la diversité spécifique, on a analysé: la température, l'humidité et le pH. On a calculé la diversité spécifique (coefficient Shanon-Wiener) et l'équitabilité. Ces deux paramètres ont eu une évolution différente, en rapport avec les facteurs bio-édaphiques analysés. En dynamique de l'espace, l'écosystème avec *Abies alba* a offert de meilleures conditions d'environnement pour les acariens, car on y a identifié 78 espèces, en comparaison avec l'écosystème caractérisé par *Picea abies*, qui n'a abrité que 67 espèces, fait déterminé par l'altitude plus grande et par la pente plus abrupte. Dans l'écosystème avec *Fagus sylvatica* on a identifié 71 espèces. Au niveau du sol, la couche de litière-fermentation a constitué l'habitat le plus favorable pour le développement des populations des acariens. En dynamique temporelle ces paramètres ont enregistré des fluctuations saisonnières. Tous ces aspects sont dus aux différents facteurs de l'environnement, spécifiques pour chaque écosystème naturel étudié.

Key words: diversity, forest ecosystem soil, mites, population.

INTRODUCTION

Natural ecosystems are characterized by a high stability and complexity, in comparison with anthropic ecosystems. These two characteristics are due to the high species diversity, to the species interrelations and to the undisturbed and continuous energy and matter flow. Soil invertebrates are enormously diverse. According to recent estimations, soil animals may represent as much as 23% of the total diversity of living organisms that has been described to date (Decaëns et al., 2006). Soil invertebrates are key mediators of soil function for the diversity of ecosystem engineering processes in which they partake. The comminuting and incorporation of litter into soil, the building and maintenance of structural porosity and aggregation in soils through burrowing, casting and nesting activities, the control of microbial communities and activities, plant protection against some pests and diseases, acceleration of plant successions are among the many effects they have on other organisms through their activities (Lavellea et al., 2006).

One of the most important soil invertebrates in the structure and functions of the terrestrial ecosystems are mites. Mites were identified in almost all types of ecosystems (terrestrial, aquatic, in trees and as parasites). That is why they are ubiquitous species. Their presence in different habitats is the result of influence of evolutionary, ecological and stochastical factors. The favorable bioedaphical conditions for development of these invertebrate populations determined a reach mite populations, represented more that 80% from the number of individuals of the soil fauna. Among the mites, predatory Mesostigmata are a group which has an important controlling function and which may be used for indication of soil quality and anthropogenic impact. Predatory Mesostigmata do not change soil structure or plant productivity directly. However, as predators, they influence population growth of other organisms and through this have an indirect effect on overall ecosystem performance (Koehler, 1997). The soil, especially that from forest ecosystem, creates favorable development conditions for these mites. The species which lives free in soil depend mostly on its structure, on the detritus and humus content, on water, temperature and pH. Favorable bioedaphical conditions on the soil of forest ecosystems determined appearance of a reach soil mites fauna (Koehler, 1999; Ruf, 2000 a, b; Ruf et al., 2000; Salmane, 2000, 2001, 2003; Manu, 2008).

Studies regarding the mites biodiversity are not so many. In temperate area they were more studied that in tropical and subtropical areas. This fact is due to the small dimensions of the mites, to the increased taxonomical diversity and to the difficulties in their identification. Recently estimations showed that the number of identified predator mites is high (about 97,000 species). One of the causes of this taxonomical diversity is the trophical diversity (Walter & Proctor, 1999).

In Romania, the study of these mites is not so developed. The published papers till present had a systematical approach, the ecology being less studied. There were identified 273 species, representing 42.66% from the total number of species from Romania (Stănescu & Juvara-Balș, 2004).

Starting from these aspects, as a completion of the past studies, we consider necessary a complex research concerning diversity of the soil mites from some forest ecosystems from Bucegi Massif - Romania.

MATERIAL AND METHODS

The researches were made in 2001-2003, in three types of forest ecosystems from the Bucegi Massif with *Picea abies*, *Abies alba* and *Fagus sylvatica* (Tab.1).

The samples of mite fauna were collected with a random stratification method, with a metal core, by 10 x 10 x 10 cm dimensions. The levels were separated in the moment of collecting, taking account of the macro-morphological criterions in: litter and fermentation layer (OLF) and humus layer (OH). The studied layers had variable dimensions and that's why the densities of the populations were reported to the square meter. Through this method it is possible to show the heterogeneity of the biotopes and the ecology of the soil mite populations.

The extraction of the soil mites was made in 10-14 days, by Berlese –Tullgren method, modified by Balogh. The samples have been kept in refrigerator, till next extraction. Totally, 2016 samples were analysed. The counting and identification of the mites were made using a Zeiss binocular and a MC3 microscope. The conservation of the soil mites fauna was made in an alcohol and glycerin mixture.

Table 1

Description of the investigated forest ecosystems from Bucegi Massif.

Ecosystem	Geographical coordinates	Alt.	Exp.	Slope	Soil	Type of forest	Conservative value
Picea abies	45°21'09.15" N; 25°31'10.59" E	1350 m	S	35°	Relatively superficial (30 - 35 cm), with a strong washing of the litter and humus layer. The parenteral matter is made of various resources.	Middle productive spruce forest, with mull-moder, with *Leucanthemum waldsteinii* - R 4209 (Doniță et al., 2005).	Very big
Abies alba	45°23'50.20" N; 25°32'00.07" E	970 m	N	12°	Brown of forest, rich in humus and sandy. The parenteral matter formed of the conglo-merates of Bucegi.	High productive fir forest, with mull (mull-moder), situated on brown, eumesobasic and oligomesobasic soils, with *Oxalis - Pleurozium* - R 4205 (Doniță, op. cit.).	Moderate
Fagus sylvatica	45°20'56.45" N; 25°31'24.9" E	1200 m	S	10°	Brown eumesobasic with clayey-sandy fine texture, of medium depth, with a superior productivity and with the horizon A partially damaged.	High and middle productive beech forest, with mull, on typical brown soils, eu- and mesobasic, with *Oxalis-Dentaria-Asperula* - R 4109 (Doniță, op. cit.).	Big

Alt. = altitude; exp. = exposition; N = north; S = south; E = east.

All identified species are in mite collection of the Institute of Biology – Ecological Stationary of Posada.

Soil samples were collected every month in each ecosystem, in order to measure the abiotical factors. The abiotic factor measurements were made for each layer and the average of these two values was considered in the analysis. To measure the relative humidity of the soil and pH, four samples/month/site were collected. The pH was measured with a C532 Jasco Consort- ABLæE pH-meter. To obtain the air and soil average temperature, maximum and minimum values were recorded monthly in the studied areas. Measurements were made with soil and air thermometers and the standard deviation was calculated for each value.

In study of the soil mites diversity equations derivate from the information theory of Shannon, 1949 were used. The statistical analyse was made in Excell 2007.

Species diversity: $H(S) = - k\ \Sigma\ pi \log p_I$

Equitability: $H_r = H(S) / H(S)_{max}$;

k = 3.321928 constance of transformation of the $\log_{10}$ in $\log_2$;

p_I – probability of "i" species from the unit sample;

S – "species richness" (total number of identified species from the sample units).

RESULTS AND DISCUSSIONS

Analysing the soil temperature evolution, in the ecosystem with *Abies alba* the highest average seasonal values were recorded, followed by those from the ecosystem with *Fagus sylvatica* and by that with *Picea abies*. In all studied areas, the most increased temperatures were obtained in summer (from 4.6°C till 12.44°C), diminishing drastically in winter (till 5.8°C). At the soil level, the litter-fermentation layer was the most favorable habitat (taking account of the temperature), in comparison with humus (Fig. 1). The main factors which determined the temperature increasing on the litter-fermentation layer could be: the more intensive decomposing processes, the more increased level of the microorganism breathing and the big quantity of received solar energy (Chiriță, 1974; Chiriță et al., 1977).

The soil of the ecosystem with *Fagus sylvatica* recorded the most increased humidity (from 39.84% till 58.53%), in comparison with that from the forest with *Abies alba* (from 25.06% till 49.8%) and with that from the forest with *Picea abies* (from 35.8% till 52%). This evolution was due to the litter-fermentation layer tickness, which maintains the soil humidity. This fact is due to the soil topography, which gave to the first layer an insulated structure, allowing to reach a tickness of 10 cm. This layer was almost absent in the ecosystem with *Picea abies*, being often washed by rain or snow, phenomenon favored by steep (35°). In seasonal dynamics, the most increased humidity was recorded in winter (till 58.53% in beech forest and 52% in spruce forest). In fir forest, the most high values were obtained in autumn (56.5%), due to precipitations and to the well developed moss layer (the bryophyta layer representing 95%). The most decresed values of this abiotic factor were recorded in summer (from 25% till 47.25%) (Fig. 2). Often, soil moisture depends on a suite of factors besides precipitation, the most important being probably the temperature (Salmane, op.cit.).

In the ecosystem with *Fagus sylvatica,* the soil was less acid (possible due to the increased calcium content from litter). There are not significant variations between litter-fermentation and humus layers (4.19 – 5.14). In ecosystem with *Abies*

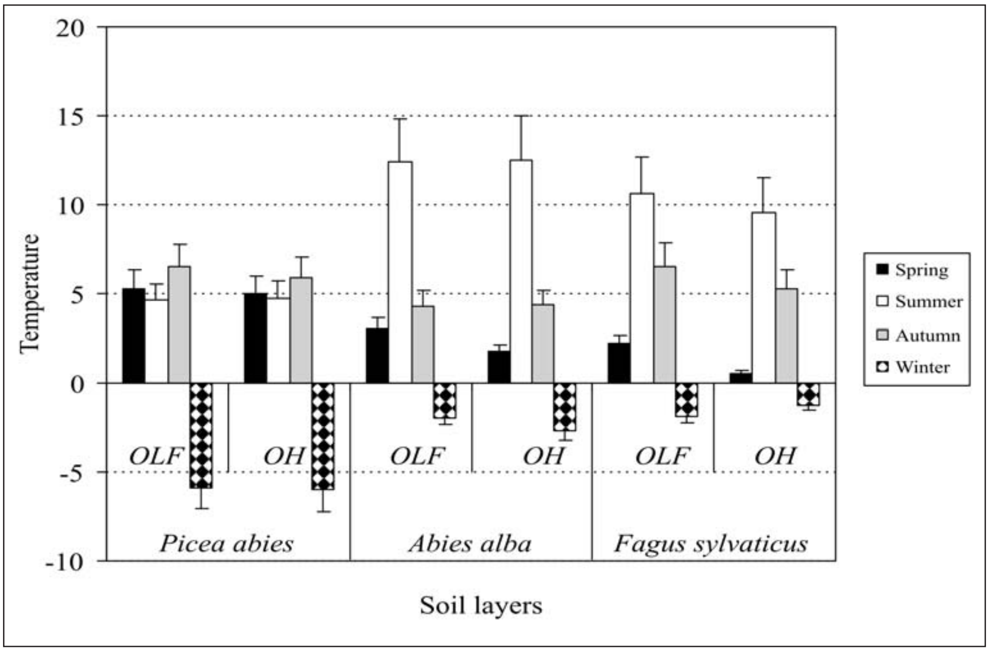

Fig. 1 - Soil temperature in the studied ecosystems from Bucegi Massif.

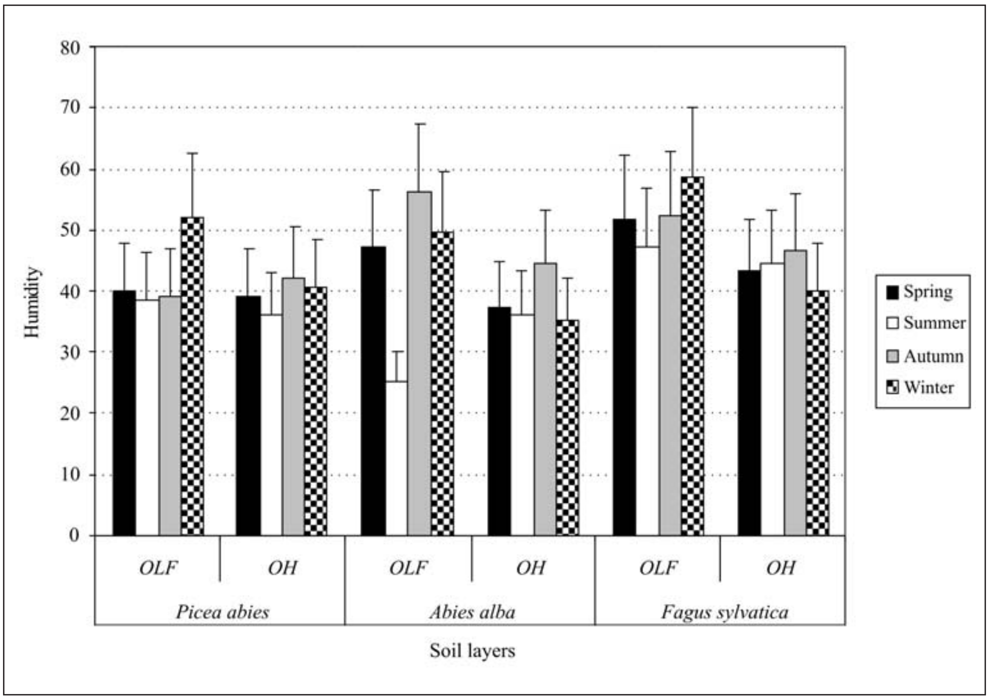

Fig. 2 - Soil humidity in the studied ecosystems from Bucegi Massif.

alba, the soil acidity was lower, in comparison with beech forest, due to the different composition of the plant material (3.96 – 5.08). In the ecosystem with *Picea abies*, the increased acidity of the soil (4.2 – 4.9) could be due to the composition of the plant material (spruce needles), to the increased soil humidity or to the micromycete presence.

Taking into account of the seasonal records, the lowest values were obtained in winter (3.96 – 4.5), and the highest ones in spring (4.28 – 5.14). Litter-fermentation layer presented a higher acidity than the humus, possible due to the vegetal composition, to the micromycete existence, to the increased activity of invertebrates and other groups and due to the higher humidity (Chiriță, op. cit.; Chiriță et al., op. cit.) (Fig. 3).

In the studied forest ecosystems, the taxonomical structure was: 3 suborders with 11 families (Epicriina: Epicriidae and Zerconidae; Parasitina: Parasitidae; Dermanyssina: Rhodacaridae, Veigaiidae, Macrochelidae, Pachylaelapidae, Eviphididae, Ascidae, Ameroseiidae and Laelapidae), 39 genera and 96 species. The maximum number of species was recorded in the ecosystem with A*bies alba* (78), followed by the ecosystem with *Fagus sylvatica* (71) and the minimum in the ecosystem with *Picea abies* (67) (Stănescu & Honciuc, 2006). The species diversity was high in comparison with other types of terrestrial temperate natural or anthropic ecosystems. Species number varied from 15 in undisturbed open grassland sites or shrub ecosystems to 25 in ruderal sites and 90 in forest ecosystems (Georgescu, 1981; Solomon, 1982; Salmane, op. cit.; Stănescu & Gwiazdowicz, 2004; Gwiazdowicz, 2007; Masan & Fenda, 2004; Skorupski, 2001; Stănescu & Honciuc, op. cit.).

In temporal dynamics, the Shannon-Wiener diversity index had not recorded large fluctuations, the most increased values being occurred in spring, summer and autumn, in all three studied ecosystem (HS = 3.45 – 4.24). This fact is due to the abundant precipitations, which determined an increased soil humidity, proper condition for development of other invertebrates, the trophic source for soil mites. The lowest values were obtained in winter (HS=3.67-3.95) in beech and fir forests (excepting the spruce forest), because of the very low temperatures (-9.5°C - 0°C), in comparison with optimal temperature for mites development (12°-16°C) (Salmane, op. cit.). Under these conditions, mites are known to move vertically between mineral soil and organic layers (Metz, 1971) (Fig.4).

Analysing the equitability index, the situation is not similar. The maximum values were obtained in spring and summer for mite species from *Picea abies* forest (86.75% and 78.62%), in winter for species from *Abies alba* forest (78.25%) and in summer for mites from *Fagus sylvatica* ecosystem (77.76%). The minimum values are fluctuating between 75.84% in winter, on *Picea abies* forest, till 71.55% in spring, in *Fagus sylvatica* forest. The mite populations represented by an increased number of individuals found favorable biotic (food source) and abiotic conditions (increased humidity, acid soils, optimal temperature). Under unfavorable conditions, the population decreases or migrates in adjacent ecosystems (Koehler, op. cit.; Walter & Proctor, op. cit.) (Fig. 5).

In the ecosystem with *Abies alba*, the developed layer of moss assured the proper humidity for the soil mites. This fact was reflected by the increased values of the Shannon-Wiener index (HS = 4.14 – 4.32). Usually, humus under the moss cover is relatively moist even during summer drought, as mosses protect soil moisture from evaporation, thereby the mites diversity is increasing, as well as the

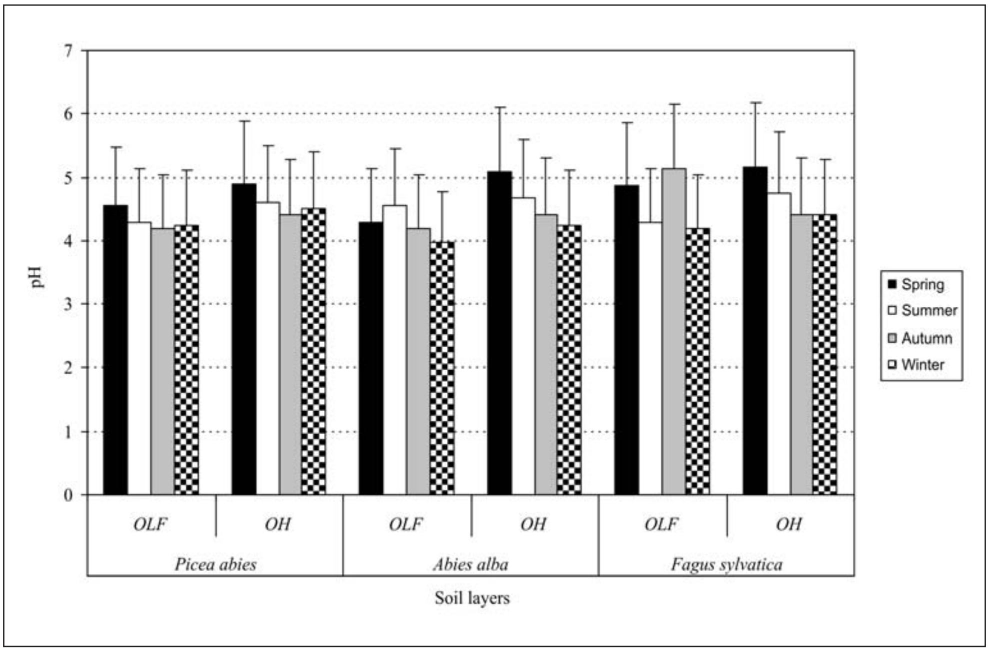

Fig. 3 - Soil pH in the studied ecosystems from Bucegi Massif.

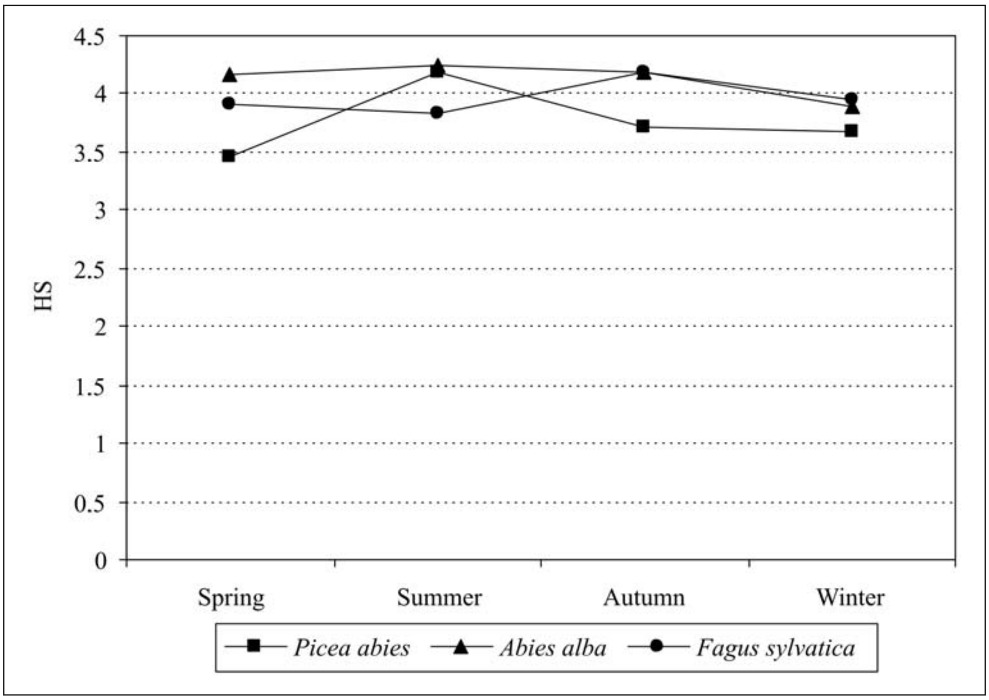

Fig. 4 - Diversity of the soil mite species from the sample of the studied ecosystems from Bucegi Massif.

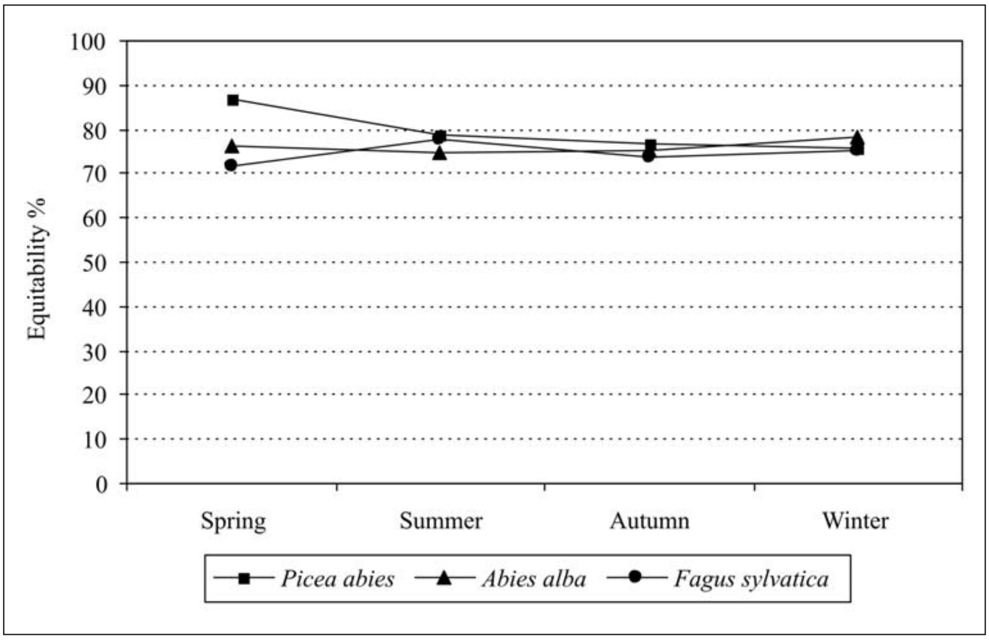

Fig. 5 - Equitability of the soil mite species from the soil sample of the studied ecosystems from Bucegi Massif.

abundance of the soil mites, demonstrated by the high values of equitability index (Salmane & Brumelis, 2008). The mull-moder humus from the soil of fir and beech forests, which had a big content of organic matter, acted as an additional trophic sublayer, determining by its structure proper condition of development. Taking into account the seasonal dynamics, the most favorable conditions were in summer, when due to a higher soil humidity recorded in spring, the increasing of the effectiveness of the other soil invertebrates was possible and thus the diversity of the food source being provided (enchytreids, nematodes, immature of mites, springtails, etc). The species diversity was seriously damaged in winter, especially in the litter-fermentation layer (till 3.63), influenced by the decreased temperatures (-1.95°-2.66°C). The equitability index had an inverse seasonal evolution, the populations of mites being represented by a higher number of individuals in autumn and in winter and lower in spring and summer (Figs 6, 7).

In the ecosystem with *Picea abies*, the minimum values of the Shannon-Wiener index were recorded in spring, when due to the snow melting and to the rain fall on a slope of 35°, litter-fermentation and humus layers were washed, destroying in this way the preferred habitat for soil mites (Fig. 4). Soil mites are mobile species, so that they can avoid unfavorable microclimatic conditions (characteristically for high altitude) and are not restricted to specific microhabitats (Coja & Bruckner, 2003). The maximum value of this index was obtained in summer (HS = 4.6), when on the remained litter-fermentation layer these invertebrates found proper condition for development, including a varied trophical spectrum. In autumn and winter, the values of the species diversity had a constant evolution, in correlation with environmental studied factors. The values of the equitability index had an inverse

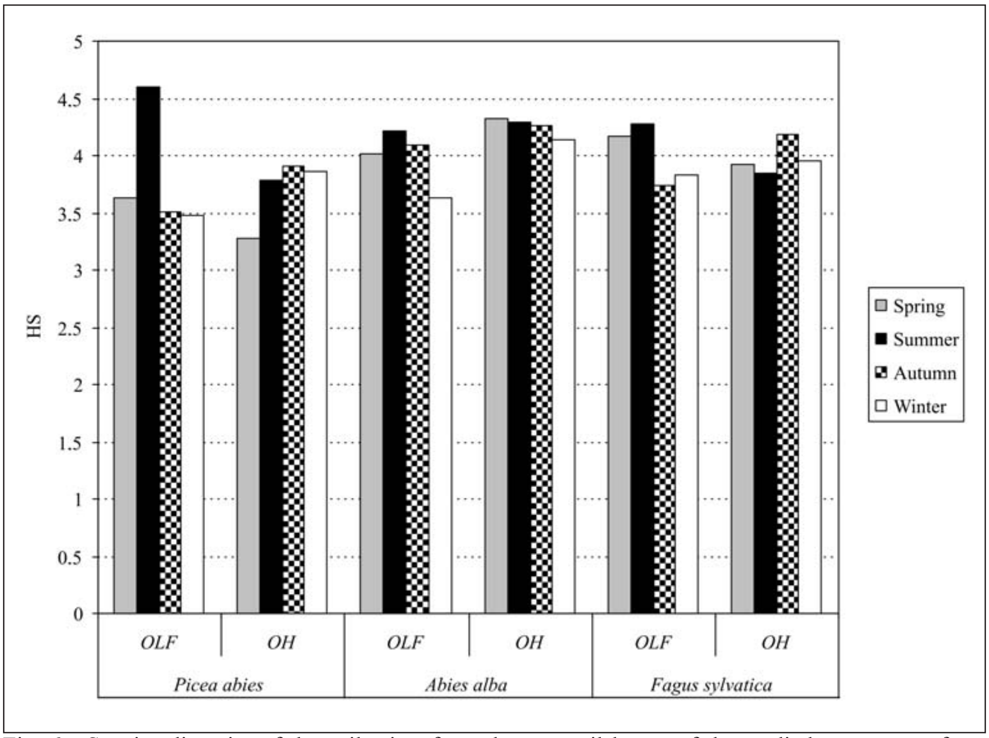

Fig. 6 - Species diversity of the soil mites from the two soil layers of the studied ecosystems from Bucegi Massif.

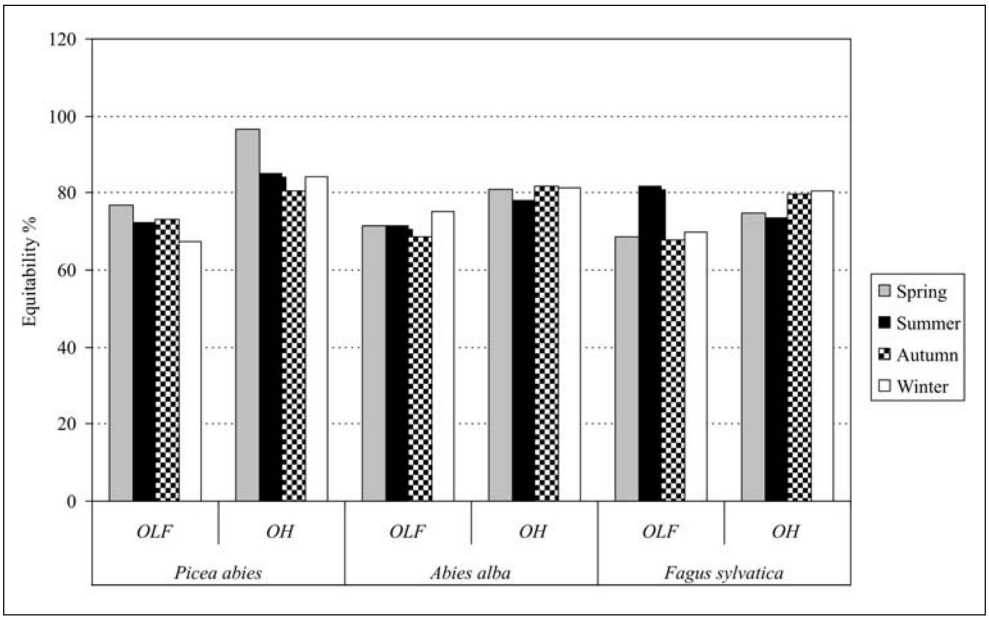

Fig. 7 - Equitability of the soil mite species from the two soil layers of the studied ecosystems from Bucegi Massif.

evolution, comparing with species diversity. This means that the identified species of mites are represented by a larger number of individuals, especially in spring and summer, when it is possible that the environmental factors to create proper conditions for development of other invertebrate groups, which represent the food source for soil mites. This phenomen was observed especially in humus layer (Figs 6, 7).

In the forest with *Fagus sylvatica*, the species diversity has increased values in spring and summer, due to the soil humidity and proper temperature. Although in winter the humidity recorded the most increased values, the negative temperature (due to the high altitude) determined a decreasing of the diversity. Taking account of the soil layers, Shannon-Wiener index has the same evolution at litter-fermentation level, as well as humus level, with a small decreasing at the latter. The equitability index showed that the loss of biological diversity was associated with increased dominance, implied by a lower equitability, especially in autumn and winter, in humus layer. This fact was demonstrated by other specialists from temperate area (Salmane & Brumelis, op. cit.) (Figs 6, 7).

Conclusions

The evolution of the studied environmental factors (as soil temperature, humidity and pH) showed a strong interdependence with other biotical or abiotical factors, as: altitude, slope or the cover level of vegetation.

The values of diversity index (Shannon-Wiener) showed that the recorded environmental factors determined the increasing of species diversity in the ecosystem with *Abies alba*, as well as in the ecosystem with *Fagus sylvatica*. In the ecosystem with *Picea abies*, the distroying of the litter – fermentation layer determined a decreasing of the diversity. In seasonal dynamics, the Shannon – Wienner index had the same evolution as was presented above, with an exception in summer, when the species diversity from forest with *Picea abies* had almost the same values as that recorded in the ecosystem with *Abies alba*. This phenomenon was determined by high temperature and low soil humidity recorded in the forest with *Abies alba*.

In all three studied ecosystems, at the soil level, the litter-fermentation layer provided proper conditions for a high soil mites diversity.

The evolution of the equitability index was different, demonstrating that the soil mites populations from the ecosystem with *Picea abies* were represented by an increased number of individuals in comparison with those from the ecosystem with *Abies alba*. In the forest with *Fagus sylvatica* this index recorded the most decreased values, showing a low numerical representation for the soil mites species. In seasonal dynamics, the equitability had a constant evolution in all three ecosystems, excepting summer, when due to the more increased humidity, the numerical abundances of the soil mites from the ecosystem with *Abies alba* were higher, in comparison with those from the forest with *Fagus sylvatica*. The humus layer was a proper habitat for the development of high number of individuals.

The study of the species diversity and equitability index of soil mites populations showed that from the three studied forest, that with *Picea abies* is a mature ecosystem (represented by a low number of species, but a high number of individuals).

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INFLUENȚA UNOR FACTORI ABIOTICI ASUPRA DIVERSITĂȚII SPECIFICE A ACARIENILOR PRĂDĂTORI (ACARI: MESOSTIGMATA) DIN ECOSISTEME NATURALE FORESTIERE DIN MASIVUL BUCEGI (ROMÂNIA)

REZUMAT

Acest studiu ecologic a fost realizat în perioada 2001-2003, în masivul Bucegi, în trei ecosisteme forestiere naturale cu: *Picea abies*, *Abies alba* şi *Fagus sylvatica*. Pentru a demonstra influența unor factori de mediu de la nivelul solului asupra diversității specifice a acarienilor, au fost analizați: temperatura, umiditatea şi pH-ul. Au fost calculate diversitatea specifică (coeficientul Shannon-Wiener) şi echitabilitatea. Aceşti doi parametri au avut o evoluție diferită, în raport cu factorii bio-edafici analizați. În dinamică spațială, ecosistemul cu *Abies alba* a oferit condiții de mediu mai bune pentru acarieni, fiind identificate 78 de specii, în comparație cu ecosistemul caracterizat de *Picea abies,* unde au fost descrise numai 67 specii, datorită altitudinii mari şi a pantei abrupte. În ecosistemul cu *Fagus sylvatica* au fost identificate 71 specii. La nivelul solului, stratul de litieră-fermentație a constituit habitatul cel mai favorabil pentru dezvoltarea populațiilor de acarieni. În dinamică temporală aceşti parametri au înregistrat fluctuații sezonale. Toate aceste aspecte se datorează factorilor de mediu diferiți, specifici pentru fiecare ecosistem natural studiat.

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