CEST 2017

15th International Conference on Environmental Science and Technology

Rhodes, Greece, 31 August to 2 September 2017

Functional diversity and ecosystem resilience in some forests "Natura 2000" sites in Northeastern Romania

Acatrinei L.[1*], **Huţanu M.**[2], **Ivan O.**[1] **And Călugăr A.**[1]

[1] Institute of Biological Research, 47, Lascăr Catargi Street, Iaşi, Romania

[2] "Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine, 3 Mihail Sadoveanu Alley, Iaşi, Romania

*corresponding author: e-mail ligia.acatrinei@icbiasi.ro

Abstract: Capacity for resilience and ecosystem stability of natural systems based on their biodiversity is required to maintain essential ecosystem goods and services over space and time. Loss of resilience may be caused by the loss of functional groups. Based on this perspective three natural forest ecosystems from "Natura 2000" Network situated in Northeastern part of Romania were studied. Central Moldavian Plateau is situated at confluence of two bioregions, steppic and continental, thus many species and habitats occur at the limit of their areal. Investigated stands are represented mainly by forest - steppe vegetation with mixed tree species of oaks and hornbeam.

Leaf functional traits (gas-exchange parameters, relative water content) were analysed in order to evaluate functional pattern of different trees stands in relation with environmental change, climatic extremes and soil type. For the purpose of the study two groups of soil mites with bioindicator value, Mesostigmata and Oribatida were investigated from both qualitative and quantitative points of view. Dynamics of oribatid and gamasid communities during the two years with different climatic conditions showed significant changes in coenoses structure and spatial distribution of these mites, but also a remarkable stability illustrated by the composition of edifying groups and high specific diversity level.

Keywords: "Natura 2000", functional diversity, forest - steppe, leaf traits, soil mites

1. Introduction

Resilience is an important property of ecosystems which is provided by genes, species, functional groups of species and processes within the system. Maintaining or restoring forest resilience is often important to evaluate the particular characteristics of forest ecosystems and the environment, including human-caused disturbances, and respectively, climate change (Thomson *et al.* 2009). Correlation between aboveground and belowground diversity, despite of some lack of knowledge is recognized as an important challenge for the current ecological approaches. Also, both policies and scientific literature attest the linkage between soil biodiversity and soil quality and health, that influences ecosystem functioning and services (Hooper *et al.* 2000; Cluzeau *et al.* 2012). A long-term response of an ecosystem to climate change depends in a great extent on soil subsystem and its inhabitants' reactions (Kardol *et al.* 2010)

The current research is a continuation of a previous one and represents multi-disciplinary investigations (floristic and phytocoenological, ecophysiological and acarological) of the structure and functioning of protected forest ecosystems (Natura 2000 sites) representative for Central Moldavian Plateau and an impact assessment of natural and anthropogenic factors. The studied area, Central Moldavian Plateau is important because it is at the interference of two bioregions, the mainland and the steppe, thus some habitats and species are here at the limit of their areal. The rugged and hilly relief with chernozem (on moderate slopes), regosols and also, erodisoil (steep slopes), marshy clay (wet meadow), in this region is critically affected by the climatic changes (drought, climatic extremes) with consequences over time.

2. Material and methods

2.1 Study sites

Three representative natural forests from "Natura 2000" Network were selected from the geographical area, Moldavian Central Plateau situated in the Northeastern Romania:

1. ROSCI0158 Hârboanca Forest - 46°42′44″N 27°35′34″E, 40.4 ha (Vaslui County) with the Dacian forests of oak and hornbeam on molic vertic stagnic soil.

2. ROSCI0158 Bălteni Forest - 46°40′30″N 27°39′52″E, 18.8 ha (Vaslui County) represented by floodplain forests mixed with oak, elm and ash on preluvosol vertic stagnic soil. Harboanca (1) and Balteni (2) forests belong together in the same community site.

3. ROSPA0096 Micleşti Forest - 46°51′24″N 27°53′12″E 8631 ha (Iasi and Vaslui County), a bird protection zone, a typical forest steppe with hilly mixed oaks on eutricambosol molic vertic stagnic soil.

2.2 Sampling and extraction

Based on field research, a floristic list was elaborated which permitted flora analysis and ecological indices calculation. The vegetation analysis was made after Braun-Blanquet method, being included in three phytoassociations. The cormophytes nomenclature followed Ciocârlan (2009).

Gas-exchange parameters were measured *in situ* by a photosynthesis portable system (LCi ADC Bioscientific, UK). Plant material consisted of branches with leaves, fully sun-exposed of representative trees from investigated sites.

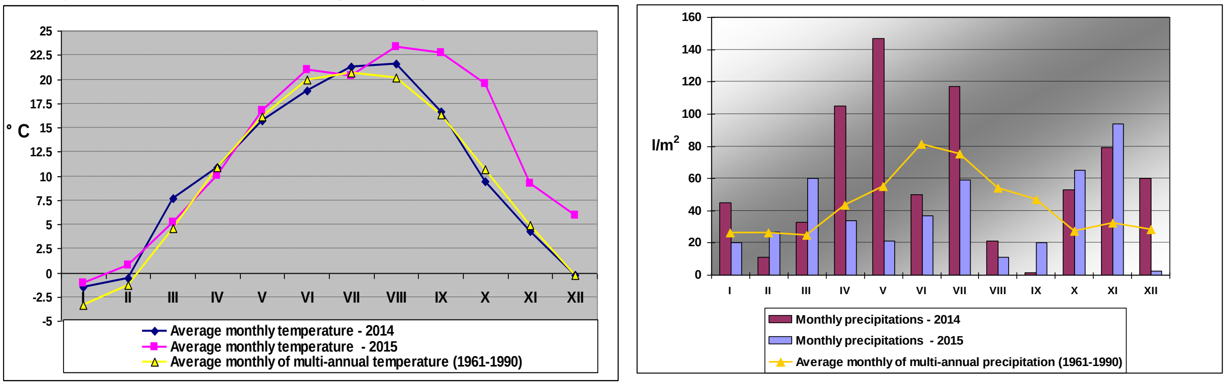
For investigation of soil mites series of 100 cm^2 litter and soil samples have been taken from each forest stand in June 2014 and May 2015. Edaphic mesofauna has been extracted from samples through the Tullgren - Berlese method and sorted by systematic groups. Oribatida and Gamasina mites have been submitted to microscopic study, in order to identify the species; it has been also noted the abundance of each species, on samples and ecological stands.

2.3 Data analysis

Primary data referring to edaphic mites have been processed by means of some analytic and synthetic ecological indices: average abundance of each species (ā) and global average abundance (Ā), expressed as individuals/100 cm^2 and, respectively, m^2; standard deviation and Pearson coefficient of variation (%); number of species (S); frequency (C) of each species; relative density (D.r.); index of ecological significance (Dziuba, 1968) (W), expressed as classes: V and IV-edifying species, III-influential species, II and I-accompanying species; specific diversity (H(s)max, H(s), H.r.), estimated by the Shannon - Wiener equation; the adults/immatures ratio.

2.4 Climatic data

Study sites are characterized by a typical continental climate, characterized by dry, hot summers and cold winters. The investigated period during 2014 - 2015 differed in the level of rainfall thus, 2014 recorded an excess (with 92.2 mm - May, with 42 mm in July) and respectively, in 2015 a deficit in rainfall (with 33.8 mm in May and 16 mm in July) in comparison with multi-annual average. In July it was recorded a pluvial deficit in both studied years (by 31.4 mm for 2014 and by 44.4 mm for 2015) (Fig. 1B). In 2014, monthly temperatures were overall higher in May (with 1.25 °C), in June (with 1.15 °C) and also, in July (with 2.06 °C). In 2015, monthly temperatures were lower in May (by 0.35 °C), higher in June (with 2.05 °C) and lower in July (by 2.15 °C) than average monthly of multi-annual temperature (Fig. 1A). The primary climatic data were provided by Romanian National Agency of Meteorology.



A **B**

Figure 1 Annual and multi-annual temperatures (A) and precipitations (B) graphs in the studied area

3. Results

Flora analysis: During our research we identified in the studied sites 93 species (including 2 hybrids) and 2 subspecies.

Hârboanca forest (ROSCI0158) is a hybridogen genetic center for the genus Quercus, 10 hybrids being found by Dobrescu 1969. Two hybrids were confirmed in 2014: Quercus x budensis and Q. x corcyrensis (Huţanu M., unpublished data).

Bioforms: The majority of species (40%) are hemicryptophytes and hemitherophytes (herbaceous perennial species). The next categories are phanerophytes (with 27%) and geophytes (about 10%), proportion considered as normal for the analysed forests phytocoenosis.

Phytogeographical elements: Eurasian and European species represent about 54% as a characteristic for this geographical area. The relatively high percentage of Mediterranean and Continental species (about 15%) is significant for the increased continentalism of the flora. The small number of adventive species (0.9%) is significant for the good conservation of the floristic diversity in analysed phytocoenosis.

Analysis of indicator species for soil humidity (U), air temperature (T) and soil reaction (R) (after Popescu and Sanda, 1998): According to the ecological indices values, most of species are mesophilous (U3+U3.5 - about 49%) and mesothermophilous (T3+T3.5 - about 70%). Concerning the soil pH, the majority of species are weakly acidophilous (R4+R4.5 - about 37%), mesophilous (R3+R3.5 - about 32.5%) and eurytopic (R0 - about 15%). Important percentages of xeromesophilous species (U2+U2.5 – 32.5%), and also thermophilous species (T4+T5 – 8.3 %) were found.

Analysis of vegetation: The identified phytocoenosis belong to three associations that are included in the following coenosystem (after Chifu et al. 2006):

- Dentario quinquefoliae-Carpinetum (Dobrescu et Kovács 1973) Täuber 1992 (Micleşti), Aro orientalis – Carpinenion (Dobrescu et Kovács 1973) Täuber 1992

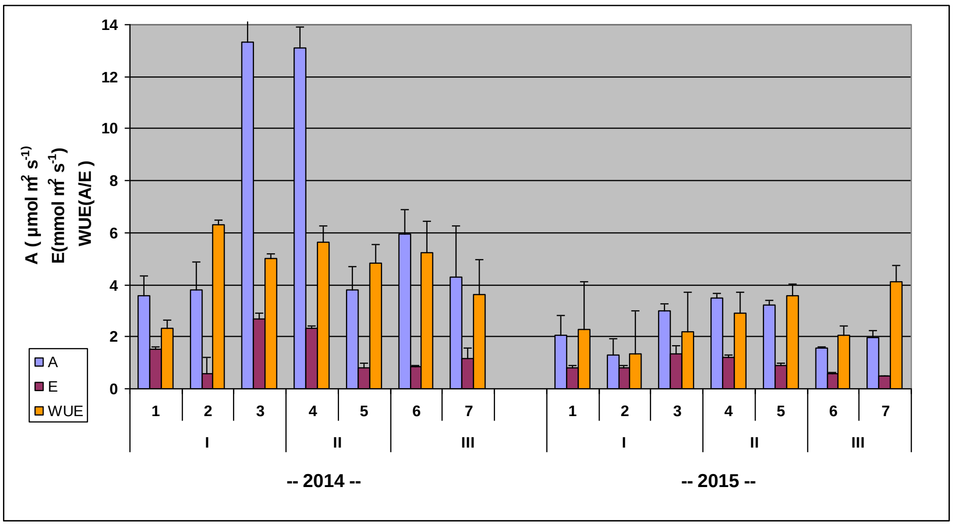


Figure 2. Graphic representation of some gas-exchange parameters in "Natura 2000 " sites

Legend: I - III ("Natura 2000" sites, see § Material and method), A-photosynthesis rate, E - tranpiration rate, WUE - instantaneous water - use efficiency. 1- *Quercus pubescens*, 2- *Q.* x *corcyrensis*, 3- *Q.* x *budensis*, 4- *Q. robur*, 5- *Acer platanoides*, 6- *Q. petraea*, 7- *Q. dalechampii*(mean ± standard error-represented by barrs)

- Euonymo nanae-Carpinetum Seghedin et al. 1977 (Bălteni), Galio schultesii – Carpinenion Täuber 1992, Lathyro hallersteinii – Carpinion Boşcaiu et al. 1982, Fagetalia sylvaticae Pawlowski in Pawl. et al. 1928, Querco – Fagetea Br.-Bl. et Vlieger in Vlieg. 1937;
- Aceri tatarico-Quercetum roboris Zolyomi 1957 (Hârboanca), Aceri tatarico – Quercion Zolyomi 1957, Quercetalia pubescentis Klika 1933, Quercetea pubescentis Doing-Kraft ex Scamoni et Passarge 1959.

Field analysis included two surveys at Micleşti (3) (characteristic species: Quercus dalechampii, Carpinus betulus, Tilia tomentosa, Fraxinus excelsior, Crataegus monogyna, Euonymus europaeus, E. verrucosus, Melica uniflora, Poa nemoralis, Galium schultesii, Arum orientale etc.); one survey at Bălteni (2) (characteristic species: Quercus robur, Carpinus betulus, Fraxinus excelsior, Cornus mas, C. sanguinea, Crataegus monogyna, Euonymus europaeus, Aegopodium podagraria, Dactylis polygama, Brachypodium sylvaticum, Arum orientale, Chaerophyllum temulentum etc.); one survey at Hârboanca (1) (characteristic species: Quercus pubescens, Q. robur, Acer tataricum, A. campestre, Crataegus monogyna, Prunus spinosa, Ulmus minor, Buglossoides purpureocaerulea, Brachypodium sylvaticum, Dactylis polygama, Viola reichenbachiana etc.).

Gas-exchange parameters evaluated on total species per year showed a decreasing values in 2015, being lower in average than in 2014 by 2.87 times at photosynthesis rate, 1.6 times at respiration rate and 1.7 times in water - use efficiency. A comparative perspective between years on each plot revealed that highest decrease of photosynthesis (3.24 times lower) and also, highest decrease of water-use efficiency (2.33 times lower) occurred both in leaf trees species of Hârboanca forest (I) and respectively, highest decrease of respiration (2 times lower) was recorded in species of Micleşti forest (II) (Fig. 2). In 2015, due to the drought and to plot condition (altitude, steep slope etc.) the photosythetic activity recorded the lowest values (*Q. pubescens* and respectively, *Q. x corcyrensis*) in site I (Fig. 2). Carbohydrates analysis in relation with soil type showed increase in the polysaccharids leaf fraction in forests and plantations from Central Moldavian Plateau (Acatrinei *et al*. 2015).

Oribatid mites hold an important numerical share within edaphic mesofauna assembly, backed by a remarkable richness and taxonomic diversity in all investigated sites (Tables 1, 2). Such a situation is common in forest ecosystems and shows that Oribatida represents a key group within the decomposers subsystem, as the main group of detritophages alongside collembolans (Cluzeau *et al*. 2012). The average abundance values are relatively high, but comparable to those recorded in other forests in this part of the country, with large seasonal/annual variations (Table 1). The influence of climatic factors is obvious especially on the vertical distribution of oribatid mites. Thus, in conditions of increased soil moisture due to excessive rainfall in spring 2014 (Fig. 1), 95-97% of individuals were found in the surface layer (Olf) in all investigated forests. The following year, with low precipitation in April – May period, the vertical distribution is reversed, only 16-43% of oribatids being identified in Olf.

The edifying species groups include silvicolous species or that prefer forest soils (*Chamobates voigtsi*, *Steganacarus carinatus*, *Atropacarus serratus*, *Achipteria nitens*, *Minunthozetes pseudofusiger*) along with some less demanding, eurytopic ones (*Tectocepheus velatus*, *Suctobelbella subcornigera*, *Scheloribates laevigatus*, *Protoribates capucinus*) (Weigmann 2006). Noteworthy is that in each of the sites some of these species have high values of W index in both years, indicating stability of edifying groups and of oribatid communities they belong.

Species richness (S) and diversity (H) vary in the same way as average abundance, with no proportionality between these parameters (Table 2). The analysed communities are particularly complex, consisting of a large number of species, whose relative density leads to high values of specific diversity. In addition, immature instars are well represented in the demographic structure of communities, thus the adult / immature ratio has relatively low values in both years and in all three sites. All particulars as referred indicate stability of oribatid

Table 1. Quantitative and structural parameters of Oribatida and Gamasina communities

Sites	Taxonomic group	Year	Ā±cv	Adults/ immatures	% individuals in Olf	Edifying species*
1	**Oribatida**	2014	8,820±16.98	3.2	96.8	*Chamobates voigtsi, Steganacarus carinatus, Metabelba pulverulenta, Suctobelbella subcornigera, Tectocepheus velatus*
		2015	24,200±56.55	4.5	16.86	*Damaeolus ornatissimus, T. velatus, S. subcornigera, Licnodamaeus pulcherrimus, Suctobelbella acutidens*
	Gamasina	2014	3,140±46.39	5.8	83.43	*Veigaia nemorensis, Prozercon carsticus, Paragamasus sp. 1, Prozercon plumosus Hypoaspis sp. 1*
		2015	2,520±38.01	2.6	12.69	*V. nemorensis, P. carsticus, Zercon vacuus*
2	**Oribatida**	2014	15,380±29.58	3.6	95	*Ch. voigtsi, M. pulverulenta, Anomaloppia differens, D. ornatissimus, Minunthozetes pseudofusiger, S. carinatus, Zetorchestes micronychus, Scheloribates laevigatus*
		2015	32,500±63.24	5.8	43.2	*M. pseudofusiger, D. ornatissimus, S. subcornigera, A. differens, Atropacarus serratus*
	Gamasina	2014	3,980±17.45	3.9	91.45	*Z. vacuus* *P.carsticus* *V. nemorensis* *Pergamasus cf. primorellus*
		2015	7,440±66.52	1.0	34.67	*Z.vacuus, Leitneria granulata*
3	**Oribatida**	2014	17,640±72.57	2.6	95.1	*T. velatus, Achipteria nitens, A. serratus, S. carinatus*
		2015	22,940±24.13	2.5	16.04	*Protoribates capucinus, D. ornatissimus, A. serratus, A. nitens, Ch. voigtsi, S. carinatus*
	Gamasina	2014	1,680±60.39	4.3	85	*V. nemorensis, Hypoaspis. aculeife*r
		2015	2,980±29.89	0.9	5.36	*V. nemorensis, Pachyseius humeralis, Olopachys suecicus*

Legend: Ā - global average abundance (individuals/m^2); c.v.- Pearson's coefficient of variation (%); Olf - litter and fermentation layer; *(see § Material and method)

communities, which contribute to a normal dynamics of organic matter decomposition and nutrient cycling, and thus, to the overall functioning of ecosystem. Analysis of the gamasid communities, an important predator group of mites (Krantz, 2009), evidenced differences of their structural parameters (global average abundance, number of species, adult/immature ratio, specific diversity etc.) and vertical/horizontal distribution from one stand to another and also, from one year to another (Table 1). In the conditions of sampling period of 2015 which is characterized by a low amount of precipitation, comparatively with 2014 - year with enough humidity (Fig. 1), gamasid mites fauna responds in a way which assure their resistance. Generally, reported at 2014, the densities and the number of species are higher in 2015 and even the immature stages are less abundant, they are still present. The vertical distribution indicates a massive migration in the deeper humiferous layer of soil (65-95% of the total Gamasina) in the drought year 2015, meanwhile in 2014 the great majority was found in the surface Olf layer (83-96%). Among the edifying species that have been identified in both sequences of time some silvicolous elements (*Zercon vacuus, Prozercon carsticus*) are found, as well as eurytopic (*Veigaia nemorensis*) and eury-hygrophilous ones (*Prozercon carsticus*), all of these conferring stability to respective communities.

Table 2. Species richness and diversity in Oribatida and Gamasina communities

Natura 2000 site	Taxonomic group	Year	S	Specific diversity		
				H(s)max	**H(s)**	**H. r.**
ROSCI0158-1	**Oribatida**	2014	34	5.0874	4.2397	83.34
		2015	49	5.6147	4.3636	77.72
	Gamasina	2014	15	3.9068	0.9714	24.86
		2015	19	4.24	2.9794	70.26
ROSCI0158-2	**Oribatida**	2014	47	5.5546	5.1848	93.34
		2015	59	5.8826	4.2627	72.46
	Gamasina	2014	17	4.087	0.9397	22.99
		2015	21	4,3923	0.8438	19.21
ROSPA009-3	**Oribatida**	2014	35	5.1293	3.9062	76.15
		2015	52	5.7004	4.1986	73.65
	Gamasina	2014	19	4,24	1,0863	25,62
		2015	20	4.32	1.0001	23.14

Legend: S – number of species; H(s)max - maximal specific diversity; H(s) - real specific diversity; H.r. – relative diversity(%).

4. Conclusions

Overall, these phytocoenosis biodiversity conservation is well preserved with a regenerating layer which allows their perpetuation. Also, a very small percentage of alien species was found. Despite that, human impact determined by neighbouring localities, crops, grazing or trees cutting etc. in synergistic action with the extreme climatic factors can affect some functional groups reducing their activity. Changing climatic conditions and especially its fluctuation, reduces soil nutrients availability (cambic soils with higher amount of clay) limiting the forest resilience.

Investigation of the two representative groups of soil mites (Oribatida and Gamasina) showed their similar response to changing habitat conditions, in terms of global abundance dynamics, species richness, and vertical distribution, although they belong to different functional groups.

Acknowledgements – We are thankful to dr. Bireescu L. from Institute of Biological Research, Iaşi for providing data on soils.

References

Acatrinei L., Bireescu G., Călugăr A. and Ivan O. (2015), Integrated quality assessment of forest soils from Central Moldavian Plateau (Romania). Proceedings of International Conference on Land Quality and Landscape Processes, Keszthely (Hungary), Hermann T. *et al*. (Eds.); DOI: 10.2788/8694

Ciocârlan, V. (2009), Illustrated Flora of Romania, Ed. Ceres, Bucureşti (in Romanian).

Chifu T., Mânzu C. and Zamfirescu O. (2006), Flora and vegetation of Moldova (Romania), vol. I-II, Ed. Univ. "Al. I. Cuza", Iaşi (in Romanian).

Cluzeau D., Guernion M., Chaussod R., Martin-Laurent F., Villenave C., Cortet J., Ruiz-Camacho N., Pernin C., Mateille T., Philippot L., Bellido A., Rougé L., Arrouays D., Bispo A. and Pérès G. (2012), Integration of biodiversity in soil quality monitoring: Baselines for microbial and soil fauna parameters for different land-use types, *European Journal of Soil Biology*, **49**, 63-72.

Dobrescu C. (1969), Floristic and geobotanical research in nature reserve Hârboanca-Brăhăşăoaia forest (Vaslui county), *Ocrotirea. Naturii*, **13**(**1**), 19-30 (in Romanian).

Hooper D.U., Bignell D.E., Brown V.K., Brussaard L., Dangerfield J.M., Wall D.H., Wardle D.A., Coleman D.C., Giller K.E., Lavelle P., Van Der Putten W.H., De Ruiter P.C., Rusek J., W. L. Silver W.L., Tiedje J.M. and Wolters V. (2000), Interactions between aboveground and belowground biodiversity in terrestrial ecosystems: Patterns, mechanisms, and feedbacks, *BioScience*, 50(12), 1049-1061.

Kardola P., Reynolds W. N., Norby R. J. and Classen A. T. (2011), Climate change effects on soil microarthropod abundance and community structure, *Applied Soil Ecology*, **47**, 37–44.

Krantz G.W. and Walter D.E. (2009), A manual of Acarology, third ed., Texas Tech University Press.

Popescu A. and Sanda V. (1998), The list of spontaneous flora of cormophytes of Romania, *Acta Bot. Horti Buc. (Suplim.)*, Ed. Univ. Bucureşti, 1-336 (in Romanian).

Thompson I., Mackey B., McNulty S. and Mosseler A. (2009), Forest Resilience, Biodiversity, and Climate Change. A synthesis of the biodiversity/ resilience/ stability relationship in forest ecosystems. Secretariat of the Convention on Biological Diversity, Montreal. Technical Series no. 43.

Weigmann G. (2006), Acari, Actinochaetida. Hornmilben (Oribatida), Goecke&Evers, Keltern.