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DIVERSITY ANALYSIS OF PLANT COMMUNITIES WITH *CAREX FLAVA* FROM THE CEAHLĂU MOUNTAIN

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Abstract: The investigated plant communities belong to two phytosociological associations, *Carici flavae-Eriophoretum latifolii*, Soó 1944 and *Carici flavae-Blysmetum compressi*, Coldea 1997. The diversity was estimated through species richness, Shannon Index, relative diversity and evenness. For each association, we calculated the average values of the diversity descriptors, and the differences between the associations were statistically tested. The plant communities of the association *Carici flavae-Eriophoretum latifolii* had 30 – 46% of the maximum potential diversity and contained 13 – 21 species in average. The plant communities of the association *Carici flavae-Blysmetum compressi* had 4 – 9% of maximum potential diversity and contained approximately 11 – 15 species in average. The difference in diversity between the associations was statistically significant. *Carici flavae-Eriophoretum latifolii* is more diverse than *Carici flavae-Blysmetum compressi*. However, the species richness was not significantly different, which suggests that the difference of diversity resides in the dissimilarity of the species evenness. The higher diversity of *Carici flavae-Eriophoretum latifolii* may be the result of the hydrological conditions dynamics, which acts as an intermediate disturbance that reduces the competitive dominant species, allowing the evenness and therefore the diversity to increase.

Key words: mountain grasslands, species richness, evenness, diversity

Introduction

The plant communities with *Carex flava* occur on marshy substrata, around springs, streams, and in small depressions from mountain regions. Generally, the characteristic species are *Carex flava*, *C. lepidocarpa*, *C. nigra* and *Blysmus compresus* in the communities of the association *Carici flavae-Blysmetum compressi,* Coldea 1997, and *Carex flava* and *Eriophorum latifolium* in *Carici flavae-Eriophoretum latifolii,* Soó 1944. Both associations occur in virtually similar conditions except that the communities of *Carici flavae-Eriophoretum latifolii* develop in areas where soil humidity varies greatly during the year [3, 14].

Diversity is an important characteristic given that more diverse communities are generally more resilient to habitat disturbance [13].

We investigated the diversities of the communities with *Carex flava* to see if there is any difference related to the hydrological dynamics of the substratum.

Materials and Methods

Relevés were sampled from the valley of Bistricioara, from an area downstream of the confluence with the Pântec stream, from the right side of the Pântec stream, and form Poiana Stănilelor, from the Ceahlău Mountain, Oriental Carpathians.

For the identification of plant associations, we used phytosociological approach according to the Central-European school [1], and we took into consideration the descriptions by Chifu, Mânzu & Zamfirescu (2006). Reserves were sampled form a $25m^2$ arias.

Prior to numerical calculations and analyses, the Braun-Blanquet scores (+, 1, 2, 3, 4 and 5) were converted to midlle-class cover percentages (0.1%, 5%, 17.5%, 37.5%, 62.5% and 87.5% respectively), after Tüxen et Ellenberg [4].

Diversity was described through the SHE analysis, which implies the computation of species richness (S), Shannon Index (H) and evenness (E). This technique allows the independent and yet simultaneous evaluation of the species richness and evenness contributions to the community diversity [2, 9, 10, 11]. Besides, we also calculated the relative diversity (Hrel). The Shannon index formula is $H = - \Sigma p_i \ln p_i$ where p_i is the decimal fraction of the i^{th} species. Buzas and Gibson's evenness (E) was calculated using the equation $E = e^H/S$ $(0<E\leq1)$ where e is the natural logarithm base. The advantage of this formula is that H can be decomposed as the sum of ln(S) and ln(E) ($e^H = S \times E$ so $H = \ln(S)+\ln(E)$). Further more, because $E \leq 1$, ln(E) will be a negative number. Therefore, H diversity equals its maximum value, ln(S), less the amount of evenness, ln(E) [10]. Using the value of H, one can calculate the relative diversity, which reveals how different the studied community are compared to an ideal equitable community is. The relative diversity formula is Hrel=H/Hmax (Hrel value is between 0 – 1) where Hmax =ln(S) or the value of H calculated with the same number of species, but equal p_i values [6, 13].

For the diversity measures statistical description, we calculated the mean and the confidence interval of the mean with 95% probability [8]. The significance of the differences between diversity related indices was assessed through the Mann-Whithney test [7].

Results and Discussions

The plant communities with *Carex flava*, from the Ceahlău Mountain, belong to two associations: *Carici flavae-Eriophoretum latifolii*, Soó 1944 and *Carici flavae-Blysmetum compressi*, Coldea 1997, both included in the alliance *Caricion davallianae* Klika 1934, order *Caricetalia davallianae* Br.-Bl. 1949, class *Scheuchzerio-Caricetea fuscae* R. Tx. 1937.

The communities of *Carici flavae-Eriophoretum latifolii* are widespread throughout the Ceahlău Mountain, occupying relatively small areas. Relevé altitude was between 750 m and 900 m, on north-western, south-eastern and western slopes, with mild inclination ($0 – 10^o$), and with marshy or bogy, carbonated substrata, where the water table almost permanently reaches the ground surface. Low water temperature favours the development of the circumpolar species, which explains their high constancy (13%).

The floristic composition of this association includes many species that grow on moist soil, of the classes *Scheuchzerio-Caricetea fuscae* and *Phragmiti-Magnocaricetea*, and many species of the neighbouring communities, especially of the class *Molinio-Arrhenatheretea*, order *Molinietalia*. *Carex flava* and *Eriophorum latifolium* are usually co-dominant even though they belong to different herbaceous layers (superior and inferior, respectively). Of the rest of the species, only *Equisetum palustre* displayed high abundance-dominance scores, dominating the median herbaceous layer. Diversity measures analysis (Tab. 1, Fig. 1) shows that the relevé 3 has the highest H value (1.339), comprise 21 species and represent 44% of an ideal community with maximum diversity for the same number of species. The relevé 7 is the least diverse ones (H= 0.501). The diversity of the relevés was not always positively related with the species richness. For instance, relevé 6 was less diverse than relevés 2 and 5, despite the fact that it had higher species richness. On the other hand, although relevés 1 and 7 had the same number of species, the former is more diverse whereas the lattes turned out to be the least diverse of the relevés.

This fact is explained by the SHE analysis result (Fig. 1) – the potential high diversity given by high species richness is lowered by the low evenness. Thus, relevé 6 had the lowest evenness and therefore its diversity was the second from last, despite its high species richness (20 species). Conversely, relevé 1, which together with relevé 7, had the smallest number of species (11 species), had a high evenness value and consequently a higher diversity.

Association *Carici flavae-Blysmetum compressi* communities appear on small areas in the Ceahlău Mountain, along humid, muddy stream deposits or around slope springs, between 600 – 1200 m altitude, on mild slopes (0 – 5°). The plant communities are dominated almost

exclusively by *Blysmus compressus*. The floristic composition reflects the conditions of the abiotic environment – 70% of the species were hygrophilous and mesohygrophilous of the class *Scheuchzerio-Caricetea fuscae*, class *Phragmiti-Magnocaricetea*, and order *Molinietalia*.

The analysis of the diversity measures (Ttab. 2, Fig. 2) shows that the relevé 3 has the highest H value, comprises 15 species and represents more than 9.2% of a maximum diversity community with the same number of species. The relevé 1 has the lowest diversity of all.

Table 1: Diversity measures of Ass. *Carici flavae-Eriophoretum latifolii*

Relevé	H	Hrel	S	E	ln(S)	ln(E)
1	1.101	0.459	11	0.273	2.398	-1.297
2	1.147	0.424	15	0.210	2.708	-1.561
3	1.339	0.440	21	0.182	3.045	-1.706
4	1.242	0.414	20	0.173	2.996	-1.754
5	1.160	0.401	18	0.177	2.890	-1.730
6	1.041	0.347	20	0.142	2.996	-1.955
7	0.501	0.209	11	0.150	2.398	-1.897
Average	1.076	0.385	16.571	0.187	2.776	-1.700
CI (95%)	0.251	0.079	3.955	0.041	0.259	0.203

Legend: H – Sahnnon index, Hrel – relative diversity, E –evenness, S – species richness, CI – confidence interval

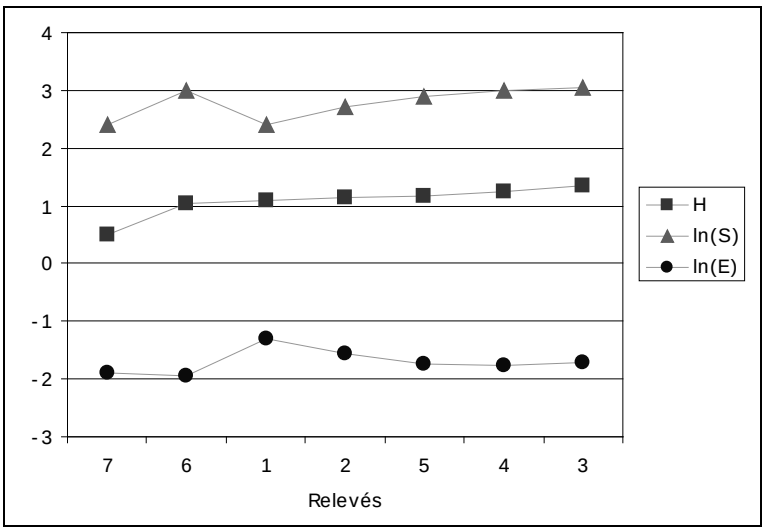

Fig. 1: SHE analysis of Ass. *Carici flavae-Eriophoretum latifolii* (1 – 7 – relevees in H ascending order, H – Sahnnon index, E –evenness, S – species richness)

Table 2: Diversity measures of Ass. *Carici flavae-Blysmetum compressi*

Relevé	H	Hrel	S	E	ln(S)	ln(E)
1	0.117	0.049	11	0.102	2.398	-2.281
2	0.152	0.058	14	0.083	2.639	-2.487
3	0.250	0.092	15	0.086	2.708	-2.458
4	0.129	0.052	12	0.095	2.485	-2.356
5	0.198	0.080	12	0.102	2.485	-2.287
Average	0.169	0.066	12.800	0.093	2.543	-2.374
CI (95%)	0.068	0.023	2.040	0.011	0.157	0.118

Legend: H – Sahnnon index, Hrel – relative diversity, E –evenness, S – species richness, CI – confidence interval

According to the SHE analysis, the diversity of communities is related to species richness, except for the relevé 5 which has a high evenness that compensates the reduced species richness [12].

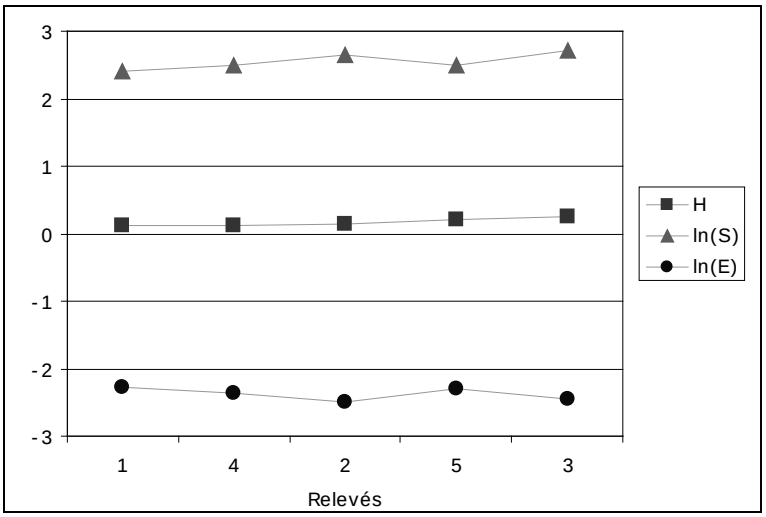

Fig. 2: SHE analysis of Ass. *Carici flavae-Blysmetum compressi* (1 – 5 – relevees in H ascending order, H – Sahnnon index, E –evenness, S – species richness)

The comparison of the diversity measures of the two associations from the investigated area revealed higher values in *Carici flavae-Eriophoretum latifolii* (Tabs. 1; 2; Fig. 3). However, the differences proved to be significant for H, Hrel, and E (Tab. 3).

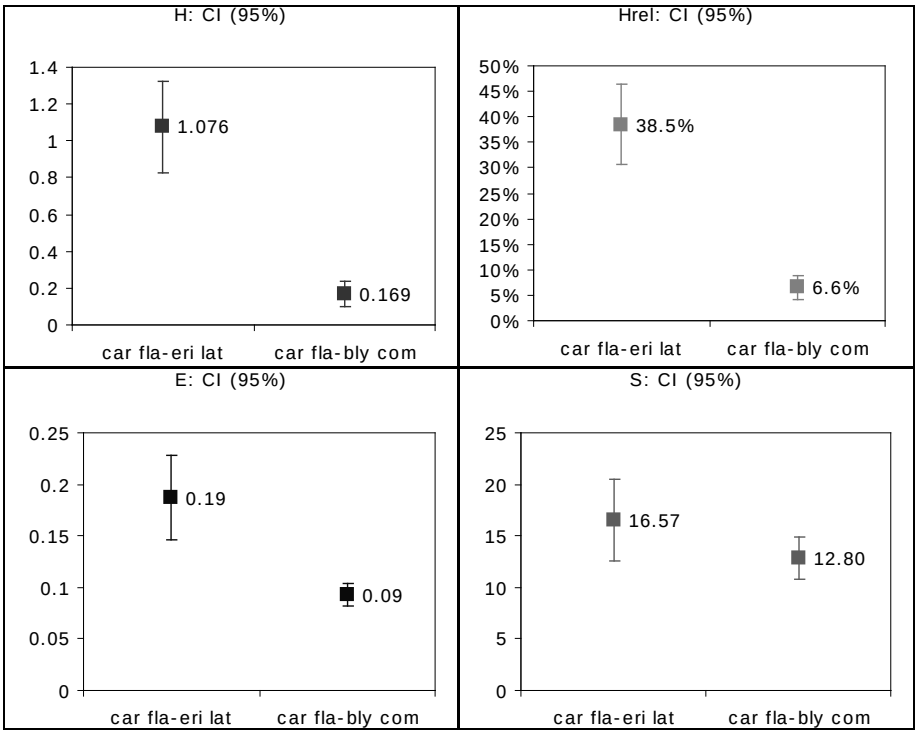

Fig. 3: Comparison of the diversity of *Carici flavae-Eriophoretum latifolii* and *Carici flavae-Blysmetum compressi* (H – Sahnnon index, Hrel – relative diversity, E –evenness, S – species richness, CI – confidence interval)

Thus, there was no significant difference in species richness between *Carici flavae-Eriophoretum latifolii* and *Carici flavae-Blysmetum compressi*. This observation endorses the idea that the difference in diversity is the result of the difference in evenness between the two associations.

Table 3: Mann-Whitney test results regarding the differences in diversity between *Carici flavae-Eriophoretum latifolii* and *Carici flavae-Blysmetum compressi*

Mann-Whitney	H	Hrel	S	E
U	0	0	9.500	0
P	0.0045	0.0045	0.1884	0.0044

Legend: H – Sahnnon index, Hrel – relative diversity, E –evenness, S – species richness

The difference in diversity may be due to the dynamics of the soil humidity, which is main difference in abiotic conditions between the investigated associations. When the water table deepens, the communities of *Carici flavae-Eriophoretum latifolii* are invaded by mesohygrophytes of class *Molinio-Arrhenatheretea*, whereas during flooding periods, the newly arisen conditions allow the species of class *Phragmiti-Magnocaricetea* to grow. It appears, these species are not accountable for diversity difference, as they are also present in the communities of *Carici flavae-Blysmetum compressi* and, as we have already showed, species richness of the communities does not differ significantly between the associations. Therefore, we consider the process of species turnover to be responsible for the *Carici flavae-Eriophoretum latifolii* higher diversity. As soil humidity changes species with different ecological demands replace each others which keeps the communities in a condition far from equilibrium. Such a state favours the species with good colonisation abilities and limits the competitive dominants. Thus, the natural disturbance of the *Carici flavae-Eriophoretum latifolii* hydrological condition suppress the dominant species, resulting in an evenness increase and, consequently, in a diversity augmentation. This mechanism agrees with the intermediate disturbance hypothesis, which basically states that slightly disturbed communities tend to more diverse than stable ones [5].

Conclusions

The communities of *Carici flavae-Eriophoretum latifolii* have 30 – 46% of the maximum potential diversity and contain 13 – 21 species in average.

The communities of *Carici flavae-Blysmetum compressi* have 4 – 9% of maximum potential diversity and contain approximately 11 – 15 species in average.

The difference in diversity between the two associations was statistically significant. *Carici flavae-Eriophoretum latifolii* was more diverse than *Carici flavae-Blysmetum compressi*. However, the species richness was not significantly different, which suggests that the difference of diversity resides in the dissimilarity of the species evenness.

The higher diversity of *Carici flavae-Eriophoretum latifolii* may be the result of the hydrological conditions dynamics, which acts as an intermediate disturbance that reduces the competitive dominant species, allowing the evenness and therefore the diversity to increase.

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DIVERSITATEA FITOCENOZELOR CU *CAREX FLAVA* DIN MASIVUL CEAHLĂU

(Rezumat)

Fitocenozele analizate fac parte din două asociaţii vegetale, şi anume: *Carici flavae-Eriophoretum latifolii*, Soó 1944 şi *Carici flavae-Blysmetum compressi*, Coldea 1997. Diversitatea releveelor celor două asociaţii a fost apreciată cu ajutorul indicelui Shannon, diversităţii relative, bogăţiei specifice şi echitabilităţii speciilor. Pentru fiecare asociaţie s-au calculat valorile medii ale parametrilor diversităţii, iar diferenţele dintre asociaţii au fost testate statistic. Fitocenozele asociaţiei *Carici flavae-Eriophoretum latifolii* au avut o diversitate relativă medie de 30 – 46% din diversitatea potenţială maximă şi o bogăţie specifică medie de 13 – 21 specii. Fitocenozele asociaţiei *Carici flavae-Blysmetum compressi* au avut o diversitate relativă medie de 4 – 9% din diversitatea potenţială maximă şi o bogăţie specifică medie de 11 – 15 specii. Diferenţa dintre diversităţile celor două asociaţii a fost statistic semnificativă. *Carici flavae-Eriophoretum latifolii* a avut o diversitate mai mare decât *Carici flavae-Blysmetum compressi*. Cu toate acestea, bogăţiile specifice ale celor două asociaţii nu au fost semnificativ diferite, ceea ce sugerează că diferenţa de diversitate se datorează deosebirii în privinţa echitabilităţii speciilor. Diversitatea mai mare a asociaţiei *Carici flavae-Eriophoretum latifolii* s-ar putea datora dinamicii condiţiilor hidrologice care acţionează ca un factor perturbator moderat ce reduce speciile dominante competitive, permiţând echitabilităţii şi implicit diversităţii să crească.