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Blysmo compressi-Eriophoretum latifoliae ass. nova, a new association of the *Caricion fuscae* alliance from the Sharri Mountains

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Abstract

The sedge-moss vegetation of the moderately to low calcium-rich slightly acidic fens of the *Caricion fuscae* alliance depends on a very specific combination of ecological and climatic conditions to thrive. Until recently, the classification of this vegetation group was complicated by its rarity on the southern edges of its range in Europe. As part of a larger database of phytocenological relevés carried out in Mt. Luboten, we came across an interesting group of 15 relevés on fen vegetation sites. We were curious to know if this plant community was a previously known association or if it might represent something new within this alliance. We compiled a separate dataset at JUICE that includes four plant communities from this alliance, along with our 15 original releves. The classification was based on modified TWINSPAN and beta-flexible clustering as a numerical classification method, with OPTIMCLASS determining the appropriate number of clusters. Five associations were clearly delineated, with the four associations taken from the literature sources clearly grouped individually and a new, fifth association appearing as separate, with completely unique characteristics. This new association: *Blysmo compressi-Eriophoretum latifoliae* occurs at elevations of ~ 1650 m a.s.l. on NE and NW slopes of the mountain. With this work we offer the description of a new high-mountain fen association. These associations may play an important syntaxonomic role as more Balkan data become available on this alliance. The sedge-moss and fen vegetation in the Balkans is particularly rare and characterised by a very diverse and specific vegetation, so it rightly deserves more attention from vegetation scientists and conservation authorities.

Keywords

Biodiversity conservation, Kosovo, phytosociology, plant taxonomy, Supervised vegetation classification

Introduction

Fen plant communities are known to be of great importance for biodiversity, as these natural habitats are among the most endangered in continental Europe. At the same time they act as effective carbon sinks (Nykänen et al. 1995), as important natural archives for storing biological material for millennia (Hájková et al. 2018), and they harbor a variety of sensitive and endangered organisms that cannot survive elsewhere (Juutinen 2011). There are numerous studies and reports on their condition, which is severely threatened by the loss of thousands of hectares due to intensive agriculture and forestry (Rydin et al. 1999; Kotowski et al. 2012; Janssen et al. 2016; Chytrý et al. 2019). Furthermore the loss of character fen plant taxa is expected to continue as a result of global climate change (Essl et al. 2012). Fens are groundwater-fed wetlands with low productivity, characterized by peat formation and limited availability of macronutrients. The plant layer is dominated by the *Cyperaceae* family, while the bryophyte layer is often very well developed. Base-rich fens are protected by the Habitats Directive (Anonymous 1992) under codes 7230 (alpine pioneer formations) and 7420 (alkaline fens), and are classified as type "D4 - Base-rich fens and calcareous spring fens" in the habitat classification of the European Nature Information System – EUNIS (Moss 2008). However, the richness and distribution of these ecosystems in Europe are not well known. Given that these ecosystems are rare in nature and under human pressure, knowledge and understanding of the floristic, and in particular the vegetation patterns of rich fens, remain crucial for their conservation.

From a syntaxonomic point of view, European fens are traditionally assigned to the class *Scheuchzerio palustris-Caricetea fuscae* Tüxen 1937 (Mucina et al. 2016). This term is reasonably comprehensive and includes large fens established on a deep peat layer, as well as young fen meadows, arctic fens, or spring fens with only a shallow peat layer. The class *Scheuchzerio palustris-Caricetea fuscae* Tx. 1937 according to Mucina et al. (2016) includes four orders, while our studied plant community syntaxonomically belongs to the order *Caricetalia fuscae* Koch 1926. The order of sedge-moss vegetation of slightly to strongly acidic fens is further divided into seven alliances (Mucina et al. 2016), of which there are representative plant associations in Kosovo from the following three: *Caricion fuscae* Koch 1926.; *Sphagno-Caricion canescentis* Passarge (1964) 1978 and *Narthecion scardici* Horvat ex Lakušić 1968. Based on the phytosociological data of numerous relevés in the Sharri Mountains (Mt. Luboten) over a period of 4 years of field work, we had in our database a very interesting group belonging to the *Caricion fuscae* alliance. From this alliance, based on the available literature sources (Rajevski 1974; Rexhepi 1994; Ranđelović et al. 1998), there are the following four plant associations occurring in Kosovo: Ass.: *Eriophoro-Caricetum echinatae* V. Randjelović 1998; Ass.: *Carici ferruginei-Eriophoretum angustifoliae* V. Randjelović 1998; Ass.: *Caricetum nigrae scardicum* prov. V. Randjelović 1998; and Ass.: *Carici-Nardetum strictae* prov. V. Ranđelović 1998, with three subassociations: - *caricetosum nigrae*; - *caricetosum macedonicae*; and - *caricetosum flavae*. The main objective of this research was to describe a new plant association, that has derived from the analysis of our original phytosociological data. Specifically, we had three objectives: 1. to demonstrate unequivocally that the newly proposed fen plant association is based on sound data and represents a new addition to the existing phytosociological data on this group; 2. to establish the syntaxonomical position of this new association within the broader plant classification system; and 3. to compare and contrast the ecological relationships of this new association with other closely related plant associations, thereby contributing to a better understanding of the overall dynamics of these fragile plant communities in the region.

Material and methods

The studied site

The investigated area includes subalpine fen vegetation patches in Mt. Luboten, a prominent mountain massif in the Sharri Mountains on the border area between Kosovo and North Macedonia (Figure 1). It is located between 42°11'- 42°13'N and 21°07'-21°09'E with relevés being recorded at an average elevation of ~ 1650 m a.s.l. Annual precipitation ranges between 900 and 1100 mm and is concentrated in the autumn-spring period with a maximum in November and a minimum in August (Çavolli 1997) and an average annual temperature of 7.6 °C, with August being the warmest month in summer. According to its basic morphogenetic features, Mt. Luboten belongs

Figure 1. The red dot (right image) indicates the location of the study area in Mt. Luboten in Kosovo. The small red dots (left image) in the wider map indicate the distance between *Blysmo compressi-Eriophoretum latifoliae* ass. nova in Sharri Mts. and *Blysmus compressus* & J*uncus thomasii* in Skasmada, Greece.

to the Scardo-Pindian mountain system. It represents a marginal part of the Scardo-Pindian mountain system and is itself the last massif of the Sharr Mountains on its northeastern side (Nikolić 1994). Luboten Mt. (2498 m a.s.l.) rises pyramid-shaped above the Kaçanik Gorge and the Tetovo Valley.

Data set

To clarify the syntaxonomic position of this interesting plant community, which consisted of 15 original relevés, we created a working database on JUICE (Tichý 2002) and added there similar relevés of known plant communities from literature sources [with a total of 38 relevés]. The additional relevés we had in our database were from the following plant communities: *Blysmus compressus* & *Juncus thomasii* Quézel 64 (Quézel 1964), *Caricetum macedonicae* Horv. 1936 (Micevski 1994), *Eriophoro-Caricetum flavae* Ranđelović and Radak 94 (Ranđelović and Zlatković 2010) and *Pinguiculo-Narthecietum scardici* Lakušić 68 (Lakušić 1968). Plant species nomenclature follows entirely the Euro-Med Checklist (Euro+Med 2006). Field work of relevé sampling was conducted in 2018 and 2019, with the majority of the plots having a standard plot size of 25 m^2 (Peterka et al. 2020). All vascular plants were recorded using the standard nine-grade Braun-Blanquet scale (Braun-Blanquet 1964) for cover and abundance estimation (r = few individuals covering <1% of the area; + = more individuals covering <1%; 1 = covers up to 10%; 2 = covers 10-25%; 3 = covers 25-50%; 4 = cover 50–75%; 5 = cover 75–100%). The established dataset of 38 relevés is rather small, but to the best of our knowledge included all the rich fens known to occur in Kosovo and the surrounding region. The criteria for including plant communities in the comparative analysis were similarity in terms of taxonomic composition, ecological conditions, to an extent the habitat in which they develop, and certainly their syntaxonomic affiliation.

Classification of vegetation

Using OptimClass analysis (Tichý et al. 2010), we were able to define the most appropriate number of clusters = 5, corresponding to the vegetation groups we had in the established dataset. The modified TWINSPAN (Roleček et al. 2009) method was performed on the whole data set for vegetation classification. This was achieved procedurally by using four different approaches to data transformation, and the following combination was found to be the most reliable by OptimClass: Data transformation = b = (Xi,j) ^ p p = 0.5 was used to estimate percent cover of individual plant taxa (Tichý et al. 2020); distan ce measure = Euclidean (Pythagorean), commonly used in measuring dissimilarity of vegetation data; and group linkage method = Ward's method. For each of the groups, the most diagnostic plant taxa (with the highest phi-coefficient (Tichý & Chytrý 2006); simultaneously with Fisher exact test significance of $p < 0.05$) were calculated.

Indicator values

To assess and compare the site conditions of each of the analyzed plant communities in our dataset, we relied on Ellenberg indicator values (Ellenberg et al. 1991; Hawkes et al 1997; Chytrý et al. 2018) from species composition. Despite certain limitations (Chytrý et al. 2009; Zelený and Schaffers 2012; Berg et al. 2017), this approach remains popular in vegetation analyses, and it was also useful in our study for a clearer comparative analysis.

Results

Classification

Based on OPTIMCLASS analysis, modified TWINSPAN Classification (Roleček et al. 2009) resulted in five clusters in the hierarchical classification of the *Scheuchzerio palustris-Caricetea fuscae* of our dataset (Figure 2). As for the syntaxonomic affiliation of this new plant association from the Mt. Luboten, it was clearly argued that it belongs to the Class: *Scheuchzerio palustris-Caricetea fuscae* Tx. 1937, Order: *Caricetalia fuscae* Koch 1926 and Alliance: *Caricion fuscae* Koch 1926. This was evident in the diagnostic taxa of each syntaxonomic level, and these taxa generally had high constancy values (Table 1). Representative taxa for Class: *Scheuchzerio palustris-Caricetea fuscae* Tx. 1937 were the following: *Parnassia palustris* L. [V], *Gymnadenia frivaldii* Hampe ex Griseb. [IV], *Carex flava* L. [IV], *Pinguicula balcanica* Casper [IV] and *Narthecium scardicum* Košanin [II]. While representative taxa for the Alliance *Caricion fuscae* Koch 1926 were the following ones: *Carex echinata* Murray [IV], *Carex nigra* (L.) Reichard [II] and *Eriophorum angustifolium* Honck. [I]. A compelling fact that provides evidence that our original group of 15 phytosociological relevès represents a new plant association is shown on the obtained hierarchical classification dendrogram (Figure 2). It is clearly evident that (1) they (cluster two) are clearly grouped separately from the others in the dendrogram, and (2) although they are more related to cluster 1 (association *Blysmus compressus* & *Juncus thomasii* Quezel 1964), the differences between them in terms of floristic composition, ecological preferences as well as measured distance (Euclidean) are obvious.

Syntaxonomical notes

Interpretation of the five clusters obtained is straightforward in that four of them (clusters number one, three, four and five, Figure 2) are known plant associations that were included in the dataset from literature sources. Again, our analysis revealed a clear ecological and taxonomic distinction among them. Our research uncovers a new plant association in the classification of fen vegetation in southeastern Europe, making a modest but important contribution to the field of vegetation science. This is also of great importance for biogeography, ecology and conservation efforts in the region. By increasing our knowledge of the plant communities that inhabit fens, this finding contributes to ongoing efforts to classify and understand the unique and complex vegetation types in southeastern Europe. The grouping of our 15 original relevés (cluster number two, Figure 2) from Mt. Luboten clearly stands out from the others and represents a new plant association within this alliance. We further interpret the cluster two as *Blysmo compressi-Eriophoretum latifoliae*, a new plant association for Kosovo. It was recorded growing on rather moist soils, at an average altitude of ~ 1650 m a.s.l., characterized by dense vegetation on the N, NE and NW slopes of the Mt. Luboten with an average slope of 10°. The average cover (in %) was relatively high (from 98 to 100%). The entire data for the new association *Blysmo compressi-Eriophoretum latifoliae* are shown in Table 1. The synoptic table (Table 2) shows the five clearly subdivided associations that resulted from the beta-flexible classification at the level of five clusters.

The syntaxonomic position of the new Association:

Class: *Scheuchzerio palustris-Caricetea fuscae* Tx. 1937

Order: *Caricetalia fuscae* Koch 1926

Alliance: *Caricion fuscae* Koch 1926

Association: *Blysmo compressi-Eriophoretum latifoliae* ass. nova

Nomenclatural note: as explained in the Article 10 (Formation of names of associations and syntaxa of higher ranks) of the Code of Phytosociological Nomenclature (Theurillat et al. 2021), when the name of a syntaxon is formed from the names of two taxa, only one of which belongs to the highest of the dominant strata that determine the community vertical structure, then the name of this taxon comes second. In these studied fens, the herb layer is dominated by *Eriophorum latifolium*, and together with *Blysmus compressus* they form the physiognomy of the plant association. Therefore, *E. latifolium* must appear second in the syntaxon designation, even though it is the dominant species.

The observed differences and the new association

BLYSMO COMPRESSI-ERIOPHORETUM LATIFOLIAE ass. nova

Nomenclatural type: Table 1, Relevé 7 (*holotypus*)

Name giving taxa: *Eriophorum latifolium* and *Blysmus compressus*.

Diagnostic taxa: *Alchemilla hybrida*, *Juncus conglomeratus*, *Epilobium montanum*, *Athyrium filix-femina*, *Saxifraga aizoides*, *Lysimachia atropurpurea*, *Trifolium badium*, *Caltha palustris*, *Ranunculus montanus*, *Neotinea maculata*, *Carex leporina*, *Veratrum album*, *Musci* sp., *Stellaria alsine*, *Veronica beccabunga*, *Pinguicula balcanica* and *Juncus thomasii*.

Constant species (100–55%): *Alchemilla hybrida*, *Athyrium filix-femina*, *Blysmus compressus*, *Caltha palustris*, *Carex echinata*, *Deschampsia cespitosa*, *Epilobium montanum*, *Eriophorum latifolium*, *Geum coccineum*, *Juncus conglomeratus*, *Juncus thomasii*, *Lysimachia atropurpurea*, *Mentha longifolia*, *Parnassia palustris*, *Pinguicula balcanica*, *Prunella vulgaris* and *Saxifraga aizoides*.

As for the floral elements, the Assocation: *Blysmo compressi-Eriophoretum latifoliae* ass. nova. - plant species

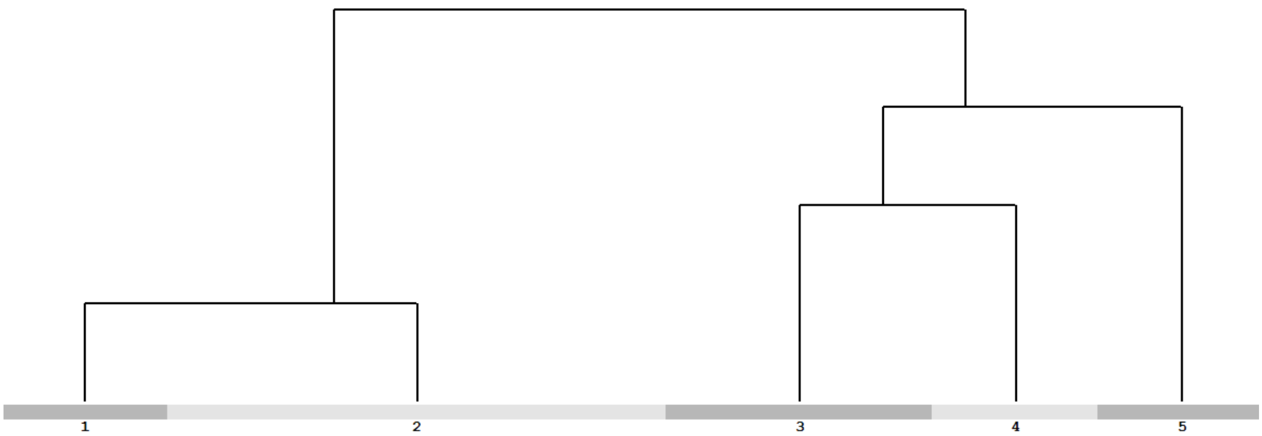

Figure 2. The hierarchial classification of the *Scheuchzerio palustris-Caricetea fuscae* Tx. 1937 – database relevés in a form of dendrogram of the modified TWINSPAN analysis. We were able to finally distinguish five clusters, that derived from 38 relevés. Cluster 1 = 5 relevés from the Association *Blysmus compressus* & *Juncus thomasii* Quezel 1964. Cluster 2 = 15 original relevés from Mt. Luboten (*Blysmo compressi-Eriophoretum latifoliae* ass. nova); Cluster 3 = 8 relevés from *Caricetum macedonicae* (Horv. 36) Micevski 1994; Cluster 4 = 5 relevés from *Eriophoro-Caricetum flavae* Ranđelović & Radak 1994; Cluster 5 = 5 relevés from *Pinguiculo-Narthecietum scardici* Lakušić 1968.

Table 1. Analytical table of the association: *Blysmo compressi-Eriophoretum latifoliae* ass. nova.

Relevé no.	1	2	3	4	5	6	7*	8	9	10	11	12	13	14	15	Constancy level
Original relevé no.	297	298	300	306	311	299	302	309	304	310	301	308	303	305	307	
Relevé area (m2)	25	25	25	25	25	9	25	25	25	25	100	100	25	25	25	
Cover in tot. (%)	98	95	100	95	98	98	98	98	95	95	100	95	98	95	95	
Characteristic and different. species																
Eriophorum latifolium	3	3	3	3	4	4	4	4	3	3	1	2	4	5	5	V
Juncus conglomeratus	1	2	2	2	3	3	2	1	2	2	1	1	1	2	2	V
Caltha palustris	2	2	3	3	1	1	1	2	2	2	2	1	1	1	1	V
Blysmus compressus *	2	+	1	1	2	2	3	3	3	3	4	4	1	+	+	V
Alchemilla hybrida	2	1	2	1	1	1	2	1	2	2	2	1	2	2	1	V
Juncus thomasii	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	V
Cl. *Scheuchzerio palustris-Caricetea fuscae*, Ord. *Caricetalia fuscae*																
Parnassia palustris	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	V
Gymnadenia frivaldii	+	+	.	+	+	+	+	+	+	.	+	.	+	.	.	IV
Carex flava	+	+	+	+	+	+	+	.	.	+	+	+	.	.	.	IV
Pinguicula balcanica	.	+	+	+	+	.	+	+	+	+	.	+	+	+	+	IV
Narthecium scardicum	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	II
All. *Caricion fuscae*																
Carex echinata	.	+	+	+	+	+	+	+	.	+	+	+	+	.	+	IV
Carex nigra	+	+	.	+	+	.	+	.	.	+	.	.	.	.	.	II
Eriophorum angustifolium	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	I
Other species																
Geum coccineum	1	1	1	1	1	1	1	+	1	1	1	+	1	+	+	V
Athyrium filix-femina	+	+	+	+	.	+	+	.	+	+	+	+	+	+	+	V
Epilobium montanum	+	+	+	+	+	+	+	.	+	+	+	.	+	+	+	V
Musci sp.	+	+	+	+	+	+	+	+	.	.	+	+	.	.	.	IV
Saxifraga aizoides	+	+	+	.	.	+	+	+	+	+	+	+	+	+	.	IV
Lysimachia atropurpurea	+	+	+	+	.	+	+	.	+	+	+	+	.	+	.	IV
Trifolium badium	.	.	.	+	+	.	.	+	+	+	+	+	+	+	+	IV
Deschampsia cespitosa	+	+	.	.	.	+	+	+	+	+	+	+	.	+	+	IV
Mentha longifolia	+	+	+	+	+	+	+	.	+	+	+	.	.	.	+	IV
Prunella vulgaris	.	+	.	+	+	+	+	.	+	+	+	.	+	+	+	IV
Ranunculus montanus	+	+	+	+	.	.	+	+	+	+	.	.	.	.	.	III
Neotinea maculata	.	.	.	.	.	.	+	+	+	+	+	.	+	+	+	III
Carex leporina	+	+	+	.	.	.	.	.	+	+	.	.	+	+	+	III
Veratrum album	.	.	+	.	.	+	.	+	.	.	+	+	+	+	+	III
Trifolium repens	+	+	+	+	.	+	.	+	.	.	+	+	.	.	.	III
Stellaria alsine	+	+	.	+	+	.	+	+	.	.	.	.	.	.	+	III
Veronica beccabunga	.	.	.	.	.	.	+	+	+	+	+	+	.	+	.	III
Galium palustre	.	.	.	.	.	.	+	+	.	.	+	.	.	+	+	III
Silene pusilla	.	.	.	+	+	.	.	.	+	+	.	+	+	+	+	III
Stellaria graminea	.	.	.	+	+	.	+	.	.	+	+	+	.	.	.	II
Cardamine carnosa	.	.	.	+	+	.	.	.	.	.	+	+	+	.	.	II

of Balkan and Eur-Asiatic origin clearly predominate (Figure 6A). This proves that a relatively large number of plants of this community is characteristic for the Balkans and equally for the Eurasian chorology. This is followed by, among others, Circumboreal, Eurosiberian and Orophyte- SE-European floral elements. Regarding the composition of life forms (Figure 6B), this association is predominantly composed of Hemicryptophytes (65%), followed by Geophytes (23%), Chamaephytes (9%), and Therophytes (3%). This is reasonably clear knowing that typical herbaceous perennials are strongly represented in these stands. A special feature of this plant community is still the strong occurrence of *Eriophorum latifolium* Hoppe (together with *Blysmus compressus* (L.) Link), which is recognisable from afar by its characteristic white tassel, especially at flowering time (Figure 7).

The newly reported high-mountain fen vegetation association *Blysmo compressi-Eriophoretum latifoliae* occurred at roughly similar elevations compared to the community *Blysmus compressus* & *Juncus thomasii* and the association *Caricetum macedonicae*. However, compared to *Pinguiculo-Narthecietum scardici*, it grew at lower elevations, while at an average of 300 meters it grew higher than *Eriophoro-Caricetum flavae* (Figure 3). In terms of species richness, there were significant differences among the five plant communities in the dataset. We measured the total number of plant taxa per relevé (Figure 4), and it was evident that *Blysmo compressi-Eriophoretum latifoliae* had almost the same number of plant taxa per releve as *Caricetum macedonicae* and *Eriophoro-Caricetum flavae*. Both had higher numbers of plants in the lower and upper quartiles than *Blysmo compressi-Eriophoretum latifoliae*, whose upper quartile never exceeded 28 plant taxa per relevé. The five groups in the data set differed very significantly in their environmental preferences drawn from bioindicators when comparing Ellenberg indicator

Table 2. Synoptic table in percentage frequency. Plant taxa are sorted according to decreasing fidelity (unstandardized phi-coefficient) to an association. Highlighted in grey are taxa with a statistically significant fidelity to a cluster (Fisher exact test < 0.05).

Associations	1	2	3	4	5
No. of relevés	5	15	8	5	5
Alliance diagnostic species (Kojić et al. 1998)					
Plantago lanceolata	100.0	0	0	0	0
Carex flacca subsp. flacca	87.3	0	0	48.0	0
Anthoxanthum odoratum	59.0	0	0	0	0
Parnassia palustris	0	48.0	48.0	0	0
Trifolium repens	0	69.1	0	0	0
Juncus articulatus	0	0	61.8	0	0
Willemetia stipitata subsp. *albanica*	0	0	47.6	0	53.0
Galium palustre	0	0	39.7	0	0
Carex nigra	0	0	0	0	45.8
Carex echinata	0	0	0	49.1	0
Diagnostic species of individual associations					
1. *Blysmus compressus* & *Juncus thomasii* Quézel 1964					
Leontodon hispidus	61.6	0	27.4	0	0
Poa nemoralis	59.0	0	0	0	0
Epilobium parviflorum	59.0	0	0	0	0
Taraxacum laevigatum	59.0	0	0	0	0
Carex appropinquata	59.0	0	0	0	0
Poa trivialis	59.0	0	0	0	0
2. *Blysmo compressi-Eriophoretum latifoliae* ass. nova					
Alchemilla hybrida	0	100.0	0	0	0
Juncus conglomeratus	0	100.0	0	0	0
Epilobium montanum	0	91.6	0	0	0
Athyrium filix-femina	0	91.6	0	0	0
Saxifraga aizoides	0	87.3	0	0	0
Lysimachia atropurpurea	0	82.9	0	0	0
Trifolium badium	0	78.4	0	0	0
Caltha palustris	0	73.7	0	0	0
Ranunculus montanus	0	69.1	0	0	0
Neotinea maculata	0	69.1	0	0	0
Carex leporina	0	69.1	0	0	0
Veratrum album	0	69.1	0	0	0
Musci	0	65.2	0	0	0
Stellaria alsine	0	64.2	0	0	0
Veronica beccabunga	0	64.2	0	0	0
Pinguicula balcanica	0	61.6	0	0	0
Eriophorum latifolium	0	61.2	61.2	0	0
Geum coccineum	0	61.2	61.2	0	0
Juncus thomasii	0	56.4	0	0	0
Cardamine carnosa	0	53.5	0	0	0
Gymnadenia frivaldii	0	50.3	0	0	0
Stellaria graminea	0	48.1	0	0	0
Parnassia palustris	0	48.0	48.0	0	0
Deschampsia cespitosa	0	47.0	0	0	0
Silene pusilla	0	44.5	0	0	0
Blysmus compressus	0	43.9	0	0	0
Prunella vulgaris	0	42.0	0	0	0
Mentha longifolia	0	35.6	0	0	0
3. *Caricetum macedonicae* (Horv. 36) Micevski 1994					
Carex ferruginea	0	0	100.0	0	0
Trifolium hybridum	0	0	92.1	0	0
Alchemilla glabra	0	0	84.0	0	0
Carex lepidocarpa	0	0	75.6	0	0
Equisetum palustre	0	0	72.9	0	0
Juncus alpinoarticulatus	0	0	71.1	0	0
Campanula abietina	0	0	66.7	0	0
Epilobium palustre	0	0	62.0	0	0
Luzula multiflora	0	0	61.8	0	0
Cynosurus cristatus	0	0	61.8	0	0
Cerastium fontanum subsp. *vulgare*	0	0	56.9	0	0
Cardamine raphanifolia	0	0	56.9	0	0
Ranunculus breyninus	0	0	56.9	0	0
Sagina procumbens	0	0	45.9	0	0
Carex paniculata	0	0	45.9	0	0

Table 2. Continuation.

Associations	1	2	3	4	5
No. of relevés	5	15	8	5	5
Euphrasia minima	0	0	45.9	0	0
Agrostis canina	0	0	41.6	0	0
Trifolium pratense	0	0	40.7	0	0
4. Eriophoro-Caricetum flavae Ranđelović & Radak 1994					
Potentilla erecta	0	0	0	100.0	0
Hamatocaulis vernicosus	0	0	0	100.0	0
Crepis paludosa	0	0	0	100.0	0
Ranunculus acris	0	0	0	87.3	0
Drepanocladus exannulatus	0	0	0	87.3	0
Carex rostrata	0	0	0	87.3	0
Equisetum fluviatile	0	0	0	87.3	0
Briza media	0	0	0	73.9	0
Geum rivale	0	0	0	59.0	0
Juncus effusus	0	0	0	59.0	0
Filipendula ulmaria	0	0	0	59.0	0
Vicia cracca	0	0	0	59.0	0
Carex flava	0	0	0	54.9	0
Dactylorhiza cordigera	0	0	33.8	45.9	0
5. Pinguiculo-Narthecietum scardici Lakušić 1968					
Pinguicula leptoceras	0	0	0	0	100.0
Crepis aurea subsp. glabrescens	0	0	0	0	87.3
Narthecium scardicum	0	0	0	0	85.8
Selaginella selaginoides	0	0	0	0	73.9
Nardus stricta	0	0	27.4	0	61.6
Taraxacum palustre	0	0	0	0	59.0
Saxifraga stellaris	0	0	0	0	59.0
Soldanella alpina	0	0	0	0	59.0

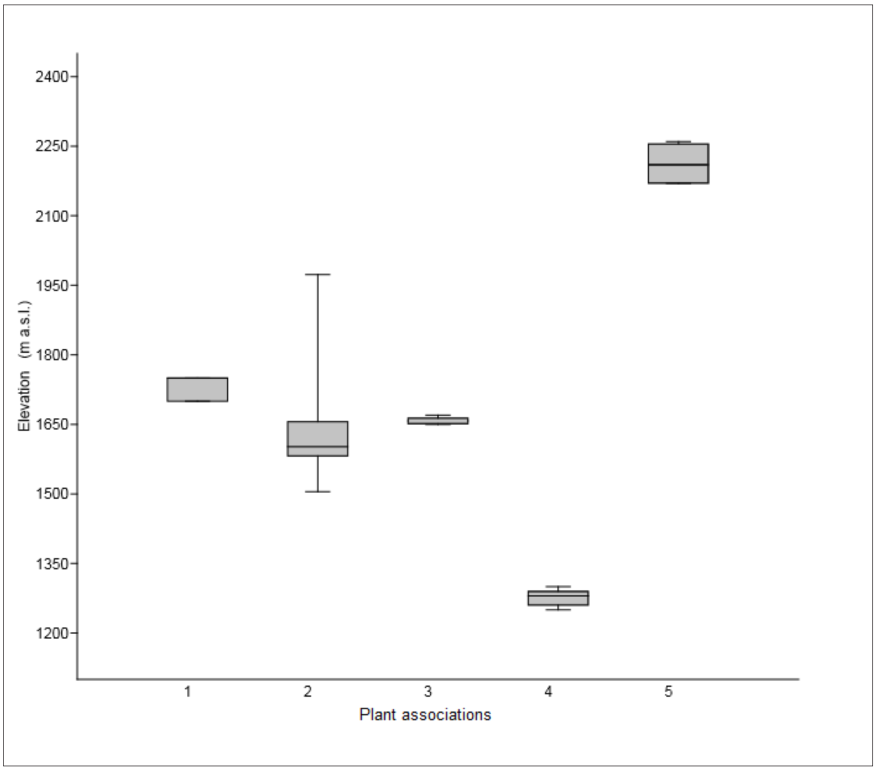

Figure 3. Boxplots showing medians and interquartile ranges of elevation (m a.s.l.) for the five associations in the data set. Explanations: 1 - *Blysmus compressus* & *Juncus thomasii*, 2 - *Blysmo compressi-Eriophoretum latifoliae* ass. nova, 3 - *Caricetum macedonicae*, 4 - *Eriophoro-Caricetum flavae*, 5 - *Pinguiculo-Narthecietum scardici*.

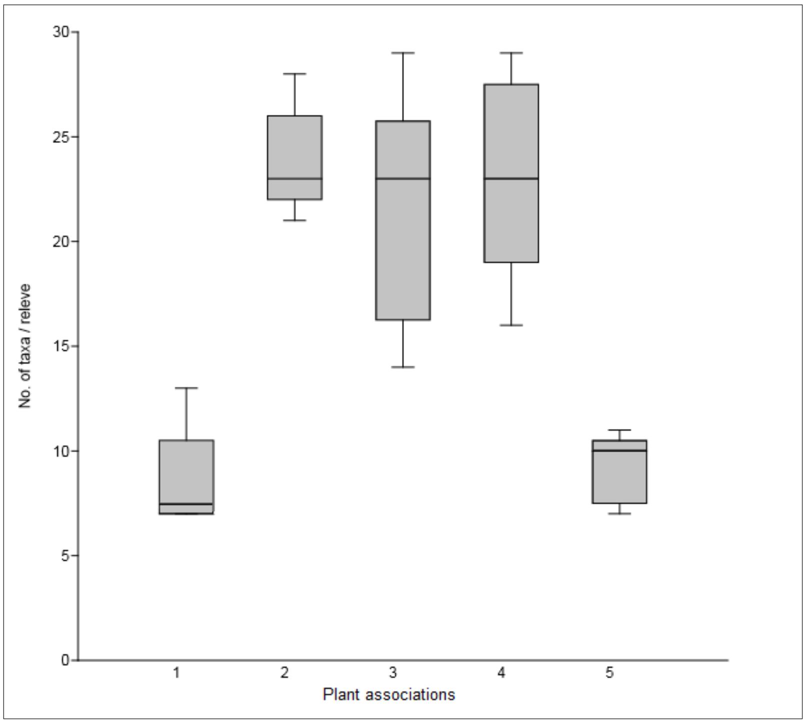

Figure 4. Boxplots showing medians (bold line) and interquartile ranges of plant taxa richness per phytosociological relevé. Explanations: 1 - *Blysmus compressus* & *Juncus thomasii*, 2 - *Blysmo compressi-Eriophoretum latifoliae* ass. nova, 3 - *Caricetum macedonicae*, 4 - *Eriophoro-Caricetum flavae*, 5 - *Pinguiculo-Narthecietum scardici*.

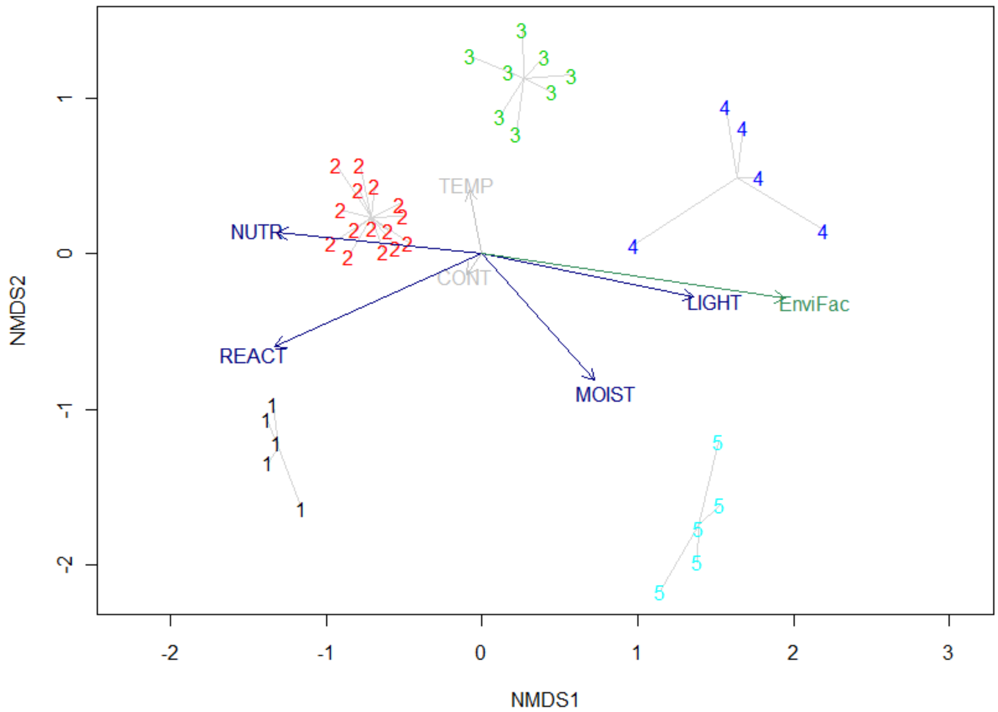

Figure 5. NMDS ordination plot of the five communities with the environmental variables as vectors plotted on the bi-dimensional space. NUTR - Nutrition availability, TEMP - Temperature, EnviFac - Environmental Factor, LIGHT - Light, MOIST - Moisture, REACT - Soil reaction, CONT - Continentality. The grouped numbers indicate plant communities1 - *Blysmus compressus* & *Juncus thomasii*, 2 - *Blysmo compressi-Eriophoretum latifoliae* ass. nova, 3 - *Caricetum macedonicae*, 4 - *Eriophoro-Caricetum flavae*, 5 - *Pinguiculo-Narthecietum scardici*.

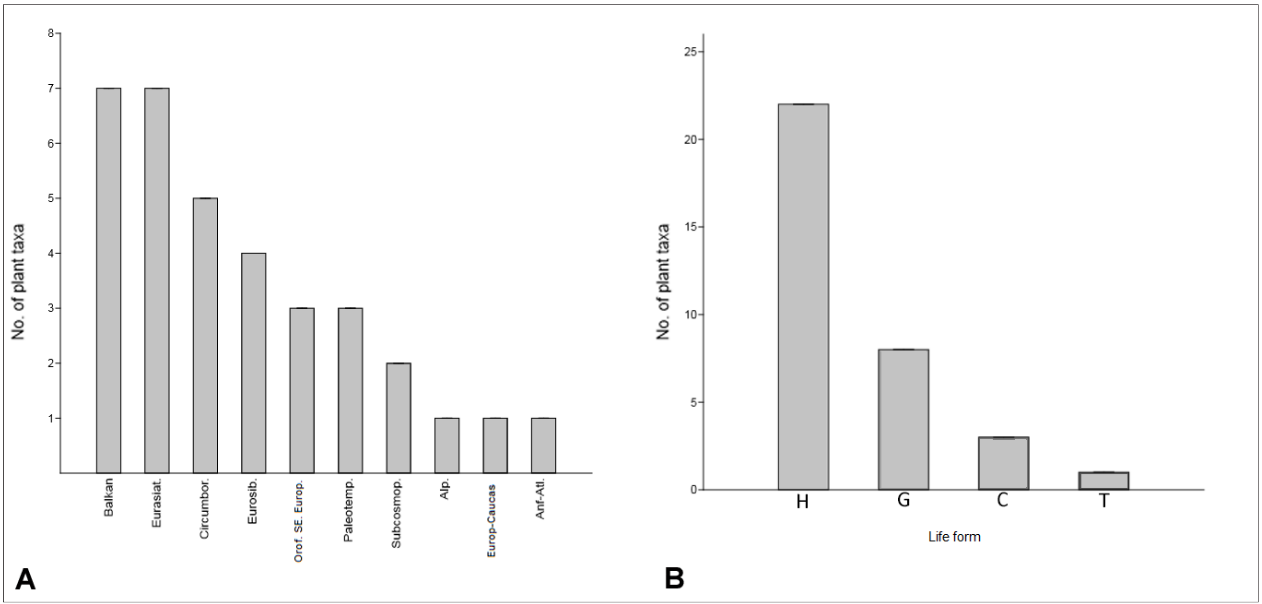

Figure 6. A) The chorological spectrum and B) the life form spectrum of the association *Blysmo compressi-Eriophoretum latifoliae* ass. nova from our relevés on the Mt. Luboten.

values (EIV). In vegetation science, plant ecology, forestry, nature conservation, as well as other scientific fields, Ellenberg's numerical indicator value system for plants is well known (Ellenberg et al. 1991; Hubbell 2001; Jörg 2003). This list system assigns ordinal numbers between 1 and 9 (indicator values) that describe their preferences for a given set of ecological gradients. The EIV NMDS (Figure 5) shows that group one (*Blysmus compressus* & *Juncus thomasii*) appears to be positively associated with soil reaction (REACT), group two (*Blysmo compressi-Eriophoretum latifoliae*), representing the new plant association, appears to be also positively associated with soil reaction (REACT) and also a tendency towards nutrient availability (NUTR). On the other hand, a very clear negative association with light (LIGHT) and moisture (MOIST). Group four (*Eriophoro-Caricetum flavae*) seems positively related to light (LIGHT) and negatively related to soil reaction and nutrient availability. And group five (*Pinguiculo-Narthecietum scardici*) seems to be positively related to moisture (MOIST).

Of the four plant communities in the comparative analysis group, *Blysmo compressi-Eriophoretum latifoliae* has obviousely the greatest similarity to the *Blysmus compressus* & *Juncus thomasii* community. However, the difference between these two communities is also obvious. Almost certainly we are dealing with two distinct plant communities. Quézel (1964) reports that this is a plant community that develops along peat bogs rich in *Cyperaceae* species near streams. And as a particularly species-poor plant community, with fewer than 13 plant species recorded. *Blysmo compressi-Eriophoretum latifoliae* is also considered species-poor, but has a significantly higher number (34) of plant taxa than the aforementioned plant community. In addition to the differences mentioned, there is the geographical distance of the original record of these two plant communities, which belong to the alliance *Caricion fuscae*. One on the Greek island of Skasmada and the other in the Sharri Mountains in Kosovo.

Discussion

The fen and bog vegetation in the Balkans represents the southern limit of distribution for continental Europe. In the syntaxonomic sense, this vegetation group is divided into two main classes: *Oxycocco-Sphagnetea* Br.-Bl. et Tx. ex Westhoff et al. 1946 and *Scheuchzerio palustris-Caricetea fuscae* Tx. 1937 (Mucina et al. 2016). Of these two main vegetation classes, only the occurrence of *Scheuchzerio palustris-Caricetea fuscae* is documented in Kosovo and surrounding countries (Preislerová et al. 2022). The plant communities that syntaxonomically belong to the alliance *Caricion fuscae* Koch 1926, like the one treated in this study, are not characterized by great floristic diversity, but by the presence of rare plant taxa and represent in themselves very sensitive habitat types that are not yet very well known. Furthermore, it is reported that the alliance itself is not yet clearly differentiated in terms of taxa composition, mainly due to the high proportion of pH generalists. And although it occurs throughout Europe, only a few plots are available from Arctic and boreal regions (Peterka et al. 2016). In terms of natural habitats, these plant communities form a unique habitat type referred to as D2.2 Poor fens and soft-water spring mires, D2.2 is classified as vulnerable in Europe (Janssen et al. 2017).

The fen association B*lysmo compressi-Eriophoretum latifoliae* represents a rather unique plant community for Kosovo high-mountain vegetation. Based on various comparisons and analyses, this plant community proved to be different from the known plant communities of the same syntaxonomic alliance. Moreover, its floristic composition, the ecology of the habitat where it was thriving, and its general physiognomy do not resemble any of the plant communities we had in the dataset for direct comparison. If we rely on the hierarchical classification in the form of dendrogram, we can clearly see that this plant community is somewhat close only to *Blysmus compressus* & *Juncus thomasii* Quezel 1964. But again, even with this plant community, the differences are obvious. *Blysmo compressi-Eriophoretum latifoliae* is characterized by a greater altitudinal distribution than *Blysmus compressus* & *Juncus thomasii*. The average number of plant taxa per relevé is much higher than the former and they share only 6 plant taxa in common, out of 34 plant taxa in total. They have shown completely different preferences based on Ellenberg indicator values. For the plant community *Blysmus compressus* & *Juncus thomasii*, Quézel (1964) gives the following two plant species as characteristic ones: Blysmus compressus (L.) Link and *Juncus thomasii* Ten. While *Blysmo compressi-Eriophoretum latifoliae* ass. nova, besides *Blysmus compressus* (L.) Link has other plant species as characteristic ones: *Eriophorum latifolium* Hoppe and *Juncus conglomeratus* L. (Table 1). Moreover, the two geographic locations of these plant communities are more than 390 km apart (Figure 1).

It is generally accepted that accurate and harmonized syntaxonomic classification of vegetation communities is an elementary requirement for proper conservation of endangered and vulnerable natural habitats (De Cáceres et al. 2015). It is well known too that the classification of fen vegetation varies due to the different classification systems used in European countries (Oberdorfer 1998; Kojić et al. 1998; Dítě et al. 2007; Rivas-Martinez 2011; Peterka et al. 2016). The need for a unified classification system in Europe has recently led vegetation scientists to initiate and produce broad-scale syntheses that integrate national classification systems (De Cáceres et al. 2015). This broad continental-scale approach must rely on accurate regional data, especially when dealing with the ecology, syntaxonomy and vegetation composition of priority natural habitats. In addition, the Sharri Mountains are known for their shared high diversity values in particular for vegetation and flora, which has ranked high in numerous biodiversity studies (Rexhepi 1994; Millaku et al. 2013; 2017; Berisha et al. 2020; 2021). Finally, and perhaps more importantly, syntaxonomic studies will serve as powerful evidence of the current state of vegetation and thus of the associated natural habitats. This remains very valuable in the context of the impact that climate change will have in our region (Čarni and Matevski 2015) or even globally (Li et al. 2016).

Figure 7. The view of the newly proposed association: *Blysmo compressi-Eriophoretum latifoliae* ass. nova from the W slope of the Mt. Luboten, at 1811 m a.s.l. (Berisha, N. - 02.07.2017).

Conclusions

The new plant association *Blysmo compressi-Eriophoretum latifoliae*, established in the Mt. Luboten (Sharri Mts.) belongs syntaxonomically to the sedge-moss vegetation of the moderately to low calcium-rich slightly acidic fens of the Alliance: *Caricion fuscae* Koch 1926. Due to the particular characteristics of the natural habitats in which these communities develop, they are rare and very sensitive throughout the Balkan region. As a result of different classification approaches, disagreements about the affiliation of plant communities to corresponding alliances and, moreover, due to the lack of deeper and more comprehensive studies on this vegetation class, additional and detailed studies are urgently needed.

Author contributions

N.B. and R.Ć. planned and implemented the field sampling, data processing and MS writing. In a later stage, N.B., R.Ć., F.M. and V.M. conducted additional field surveys. F.M. and V.M. commented the obtained results and provided further suggestions. All authors critically revised the final version of the manuscript.

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Appendix - Localities of the relevés

Table 1 – Rel. 1: Luboten Mt., just above the beech forests, on the E slope, July 2018, altitude 1505 m., coordinates: 42.220333 21.156867; rel. 2: Luboten Mt., over a pedestrian alley on the E slope, July 2018, altitude 1564 m., coordinates: 42.216700 21.154267; rel. 3: Luboten Mt., in between two rather distant patches of *Juniperus nana* shrubs, Eastern slope, July 2018, altitude 1582 m., coordinates: 42.216867 21.153583; rel. 4: Luboten Mt., a humid and rather steep environment. Somewhere 250 m below the Tre Gurë point. N slope, June 2018, altitude 1601 m., coordinates: 42.22325 21.149633; rel. 5: Luboten Mt., above the Fagus treeline and the mountain bike routes, NW slope, July 2018, altitude 1595 m., coordinates: 42.2233 21.14935; rel. 6: Luboten Mt., over a pedestrian alley on the NW slope, July 2019, altitude 1602 m., coordinates: 42.22305 21.14895; rel. 7: Luboten Mt., a very stable habitat with *Blyssmus compresus* - N slope, July 2018, altitude 1594 m., coordinates: 42.223083 21.14795; rel. 8: Luboten Mt., a humid and rather flat habitat on the NW slope, July 2018, in the straight line with the top of the mountain, altitude 1636 m., coordinates: 42.221033 21.145033; rel. 9: Luboten Mt., a humid and rather steep environment, somewhere 250 m below the shepherd's hut. NW slope,

June 2019, altitude: 1656 m, coordinates: 42.220600 21.144617; rel. 10: Luboten Mt., a humid and rather flat habitat on the NW slope, July 2019, in the direction to Gotovushë village, altitude 1656 m., coordinates: 42.2206 21.144617; rel. 11: Luboten Mt., above the treeline forest - NW slope, July 2019, altitude 1658 m., coordinates: 42.220133 21.136900; rel. 12: Luboten Mt., 300 meters above the shepherds' road on the N slope, july 2018, altitude: 1715 m., coodinates: 42.222583 21.129383; rel. 13: Luboten Mt., above the treeline forest - N slope, July 2018, altitude 1696 m., coordinates: 42.213367 21.11605; rel. 14: Luboten Mt., a humid and rather steep environment, somewhere 265 m below the Tre Gurë point. E slope, July 2019, altitude 1509 m., coordinates: 42.22200 21.155533; rel. 15: Luboten Mt., on a humid environment on rather steep slope, above the treeline, 200 m east from the Tre Gurë point. NE Slope. July 2018, altitude: 1973 m., coordinates: 42.212983 21.115601.