

Numerical revision of the *Fagion illyricum* alliance

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Abstract

Cluster analysis and multidimensional scaling are used to revise the syntaxonomy of the *Fagion illyricum* alliance based on presence/absence data. The operational syntaxonomical units are associations and subassociations as suggested in the literature. The results of principal coordinates analysis and nonmetric multidimensional scaling are fairly congruent, whereas some differences occur between the dendrograms obtained by complete linkage and incremental sum of squares clustering. However, a joint evaluation of ordinations and the consensus classification derived from the cluster analysis results facilitates a meaningful revision of the formerly accepted division of the alliance. New low-level syntaxa, and some new names, including *Aremonio-Fagion* to replace the invalid alliance name of *Fagion illyricum*, are proposed and the removal of four associations from the alliance is suggested.

Nomenclature: Ehrendorfer, F. 1973. Liste der Gefässpflanzen Mitteleuropas. G. Fischer, Stuttgart.

Introduction

The *Fagion illyricum* alliance was proposed by Horvat (1938) to include three associations, an oak-hornbeam wood, a beechwood and a maple-ash gorge forest community simultaneously described from the Croatian mountains and colline regions. In this paper numerical methods of classification and ordination are used to revise the within-alliance syntaxonomy of the *Fagion illyricum* established earlier on the basis of traditional phytosociological methods. A new grouping of 36 associations into suballiances is suggested based on analyses of presence/absence data. This paper is not the first attempt for a numerical syntaxonomical revision within the Fagitalia; see Feoli & Lagonegro (1982; see Lausi & Feoli, 1979 for a pioneer attempt with salt marsh communities).

The communities of the *Fagion illyricum* alliance share groups of south European, southeastern European and western Balkan (Illyrian) species which do not occur in the mesophilous forests of central and western Europe. This group comprises ca 30 character-species ('Kennarten') and differential species ('Trennarten', both sensu Braun-Blanquet 1951), of the *Fagion illyricum*. In fact, it was the first instance in phytosociology that a higher syntaxonomic unit was distinguished on the basis of a phytogeographically significant group of character-species. In his monograph of the forest communities of Yugoslavia, Horvat (1950) distinguished as many as 9 associations within the *Fagion illyricum*. Further work in the 1950's and the early 1960's provided more detailed information on these forests (see Borhidi 1963, 1965, 1984, Horvat *et al.* 1974, and references therein), permitting a comparison with

other Fagetalia communities and a more elaborated syntaxonomy of the Illyrian beechwoods.

The relationship of the *Fagion illyricum* to other Fagetalia alliances is shown in Soó's (1964) phytogeographic system, which is primarily based on earlier works by Horvat (1938), Oberdorfer (1957), Soó & Borhidi (in Soó 1962), Borhidi (1963) and Vida (1963):

Fagetalia silvaticae Pawlowski 1928

Scillo-Fagion Oberdorfer 1957 – W. Europe

Fagion austro-italicum Soó 1962 – central and southern Italy

Fagion medioeuropaeum Soó (1960) – central Europe (with several ecologically distinct suballiances such as *Carpinion*, *Cephalanthero-Fagion*, *Eu-Fagion*, *Luzulo-Fagion*, *Abieti-Fagion*, and *Acerion*).

Fagion illyricum Horvat 1938 – SE Alps, SW Hungary, Yugoslavia, Albania, Greece.

Fagion dacicum Soó 1962 – eastern and southern Carpathians, eastern Balkan.

Fagetalia orientalis Soó 1962 – Caucasus, Crimea, northern Asia Minor, SE Balkan.

It is noted that the mesophilous forests of the eastern Balkan were subsequently assigned to a separate alliance (*Fagion moesiicum*; see Horvat *et al.* 1974).

A tentative syntaxonomical division of the *Fagion illyricum* was developed by Borhidi (1963, 1965, 1968; see also Soó 1964) based on the evaluation of 848 relevés most of which were compiled from the literature. Thirty-six community types (associations), divided into four suballiances, are comprised in this system (see Appendix 1). There was a considerable debate among phytosociologists over its validity. Gams (1964, pers. comm.), Soó (1964), and Ozenda (1979) accepted Borhidi's classification, whereas Glavač (1969) and Horvat *et al.* (1974) had several critical comments. Major objections include:

- the oak-hornbeam wood and the submontane beechwood cannot be placed in the same suballiance. The name *Carpinio-Fagion illyricum* (Borhidi 1963) is invalid and should be replaced by *Carpinion illyricum* (Horvat 1963);
- some associations classified into the *Fagion illyricum* should not belong to this alliance; and
- available phytosociological data and evidence are

insufficient to construct a 'correct' classification.

Another problem concerns the selection of species groups to be used in the classification. The question is whether ecological species groups of geographically distinct groups of character- and differential species should receive more emphasis in syntaxonomy. Moor (1952, 1960) and Tüxen (1960) are of the opinion that higher syntaxonomic units must be delimited using ecological species rather than geographically 'significant' species. However, it has been suggested over and over again that species with similar ecological requirements but occurring in different geographical regions are equally applicable, and the classifications thus obtained are of more general purpose than those considering ecological differences only. It is implicitly emphasized in numerical approaches to syntaxonomy in which no arbitrary species weights are useful in the analysis.

Material and methods

Ecology of the Fagion illyricum

Communities belonging to this alliance represent a wide ecological range. Oak-hornbeam forests occur on the alluvial terrains of the Drava River at an elevation of 120–150 m, whereas subalpine beechwoods form the timberline in Albania, Macedonia, and eastern Serbia at 1800 m. Within the distributional range of the *Fagion illyricum*, the annual precipitation ranges between 650 and 2000 mm (occasionally up to 4000 mm). The wettest are the Croatian Karst and the central Dinaric Alps. Precipitation decreases and temperature increases towards the east and south, therefore the same vegetation zone develops in higher and higher elevation. These areas belong to the climatic types VI(V), VI(VII) and X (see the bioclimatic map No. 1.1.9 of Bertović *et al.* in Walter & Lieth 1964).

Operational syntaxonomic units

As a starting point in this study the classification of Illyrian beechwoods into 36 associations and geographical variants (Borhidi 1963) is accepted.

Thus, an object in the multivariate analyses, i.e., the operational syntaxonomic unit (OSU; termed on the analogy of operational taxonomic units, OTUs, extensively used in numerical taxonomy, cf. Sneath & Sokal 1973) is any association or geographical variant. Each association is represented by the list of species present, the list being compiled from published data (see Appendix). A rationale for using presence/absence data for the analyses is that due to differences in conditions of sampling and data treatment by various authors, quantitative scores would provide a much less reliable basis. Nevertheless, some unavoidable imbalance is still present in the data, because the number of relevés comprising the OSUs varies greatly (see Appendix, column 4). The total number of species recorded is 644; only vascular plants are considered. The full data matrix is not presented here (but available on request); instead, Appendix 2 provides constancy values for the most important character and differential species.

Multivariate analyses

The 644 by 36 data matrix was analyzed by cluster analysis and multidimensional scaling to reveal an inherent data structure. A 36 by 36 Euclidean distance matrix, an element of which being the square root of the number of species present in only one of the two OSUs compared, served as the starting point in every case. Two cluster analysis procedures were used, complete linkage (CL) and incremental sum of squares agglomeration (SSQ; see Orlóci 1978 for details). Ordination diagrams were obtained by principal coordinates analysis (PCoA; Gower 1966), a metric method, and nonmetric multidimensional scaling (NMDS; Kruskal 1964; Minchin 1987). In the latter case, a random starting configuration of 36 points in two dimensions was improved by the iterations. CL, SSQ and PCoA were performed using the SYN-TAX III package (Podani 1988), while the NMDS ordination was generated by a version of the Brambilla & Salzano (1981) program described in Orlóci & Kenkel (1985). All computations were done on an IBM370 mainframe computer of the Hungarian Academy of Sciences.

Results and discussion

Classification

The dendrogram obtained by SSQ (Fig. 1) provides an answer with respect to the controversy over ecologic vs geographic species groups. The four main clusters recognized on the dendrogram are formed according to geographic separation, i.e., associations from different vegetation zones of the same area rather than the vicarious associations became clustered (see the positions of OSUs 2 and 13, 3 and 14, 4 and 15, 5 and 16, 29 and 32, and 17, 27 and 31). It must be noted, however, that this is not necessarily the case in other high-level syntaxa. In the explanation of this result one must consider that the Balkan Peninsula is a relic-preserving centre with a high tendency to develop diverse floras and that the local diversity of these floras is much higher than in the central European beechwood zone. Therefore, it is not surprising that species shared by vicarious associations are apparently outnumbered by locally distributed species.

Cluster SSQ-1 includes the oak-hornbeam and submontane beechwood communities from Croatia, southern Hungary and Serbia, justifying Borhidi's (1963) view that the oak-hornbeam woods and the submontane beechwoods should not be separated at the level of alliance or suballiance. This is especially

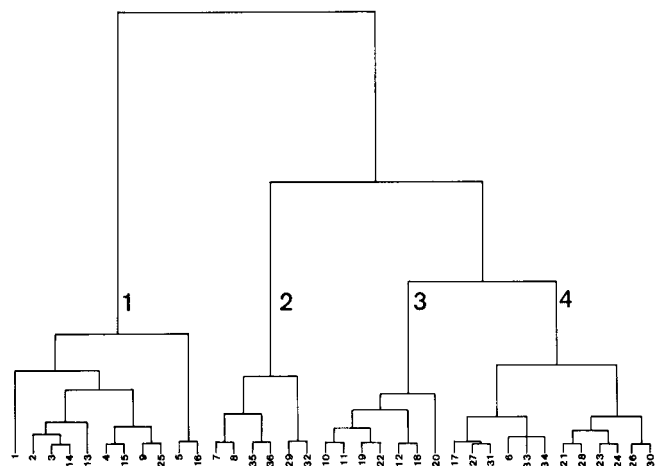


Fig. 1. Incremental sum of squares clustering (SSQ) of associations in *Fagion illyricum*. See text.

true for hilly areas and low mountains where montane and subalpine zones are lacking. Consequently, the suballiance named *Primulo–Fagenion* (Borhidi 1963) should be maintained instead of *Carpinion illyricum* (Horvat 1963).

Cluster SSQ-3 is composed partly of submontane and partly of montane beechwoods which are separated from the oak-hornbeam woods, and the fir-beech forest communities. These communities occur in the submontane region of high mountains, where the montane species descend into the submontane beechwoods primarily through intrazonal gorge forests. Glavač's (1969) observation that they are clearly separated from the oak-hornbeam woods is thus substantiated. From the viewpoint of syntaxonomy, these communities are the most typical representatives of the *Fagenion illyricum*, and it seems straightforward to include them in a new suballiance, *Lamio orvalae–Fagenion* with the *Lamio orvalae–Fagetum* as a typical association.

The above proposal necessitates two other nomenclatural changes: a) *Enneaphyllo–Fagetum* (Košir 1962) is an invalid name and for associations 11 and 12 a new name, *Epimedio alpino–Fagetum* is to be used, and b) the name *Vicio oroboidi–Fagetum* should be applied exclusively to the colline beechwoods of SW Hungary.

Cluster SSQ-2 includes some azonal rocky beechwoods (35, 36) and some zonal forests with a transitional syntaxonomic position (7, 8, 29, 32). All are rich in xero–thermophilous species for edaphic or geographic/climatic reasons, and all are strongly influenced by the species from the *Quercetalia pubescentis* zone.

The dendrogram of Fig. 2 is in a closer agreement with the starting hypothetical syntaxonomic division of the alliance (Borhidi 1963). Cluster CL-1 contains oak-hornbeam woods and submontane forests, whereas CL-4 comprises the montane and subalpine beechwoods. Cluster CL-2 contains an oak-hornbeam and a submontane beechwood community from central and eastern Serbia; their position indicates a transitional situation towards the *Fagenion moesiicum* from the eastern Balkan. Group CL-3 is more heterogeneous syntaxonomically; the OSUs of this cluster are similar to one another in that the species of the *Quercus petraea–Q. cerris* zone pre-

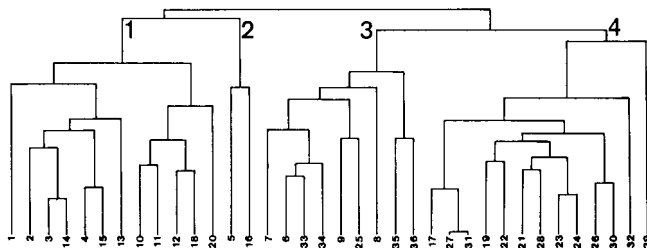


Fig. 2. Complete linkage clustering (CL) of associations and subassociations in *Fagenion illyricum*. See text.

dominate. The results of complete linkage sorting suggest the following conclusions:

- The west Illyrian rocky beechwoods (*Ostryo–Fagenion*) and the Turkish hazel-mixed relic beechwoods of eastern Serbia are separated from the zonal beechwood and oak-hornbeam communities. It seems reasonable to treat these associations in a separate group.

- The oak-hornbeam woods of the south Illyrian and central Balkan distribution differ considerably from the remaining *Carpinio–Fagenion illyricum* associations. Therefore, the oak-hornbeam woods of Montenegro, Macedonia and Albania (OSUs 6, 7, and 8) are replaced from the *Asperulo taurinae–Carpinetum* association into a new syntaxon, the *Aremonio–Carpinetum*, which has three geographic variants. The nomenclatural type of this association is relevé No. 5 of the *Querceto–Carpinetum montenegrinum* (in Blečić 1958).

Ordination

The first three axes of the PCoA ordination of 36 OSUs explain 19, 10 and 7% of the total variance, respectively. The first axis (Fig. 3) arranges OSUs according to altitude and humidity: the associations from wet, high-mountain areas are grouped on the negative pole, whereas the forests from drier, hilly regions are positioned at the opposite end. The submontane beechwoods are in a transitional situation. The interpretation of axis 2 is not straightforward, yet there is a slightly obscured NW–SE geographic gradient along this component. Axis 3 (not illustrated) produces a clear distinction between three associations from E Serbia (16, 29, 32), with high positive

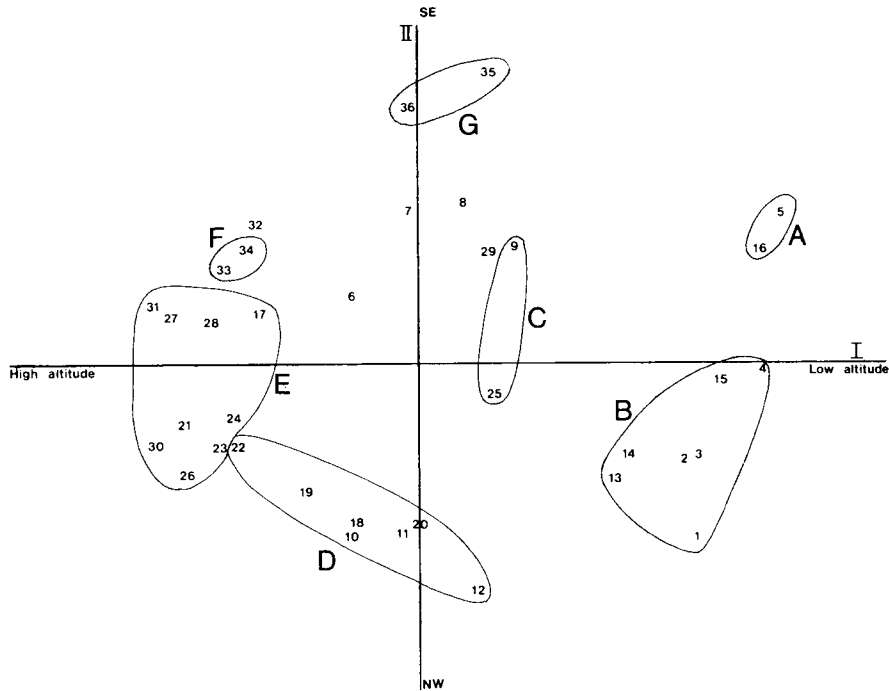


Fig. 3. Principal co-ordinates ordination of the *Fagion illyricum* alliance. Consensus groups used in the revision are outlined (see text for explanation).

loadings, and the other OSUs. These three associations are poor in Illyrian elements while rich in Dacic species, so they represent an obvious transition towards the beechwoods of Transylvania.

The two-dimensional NMDS solution (Fig. 4) is in close agreement with the PCoA ordination along axes 1–2. Its rotation with -90° would result in a configuration that is essentially similar to the PCoA ordination.

Comparative evaluation of results

Whereas the two scaling techniques produced similar configurations in two dimensions, the CL and SSQ dendrograms do not imply the same partition of OSUs at the four-cluster level. Agreements and disagreements between the two classifications are best illustrated by a cross-classification table (cf. Kortekaas *et al.* 1976), see Fig. 5. OSUs occurring in the same cell of this table were classified together by both SSQ and CL at the four-cluster level, and therefore the non-empty cells of the table represent

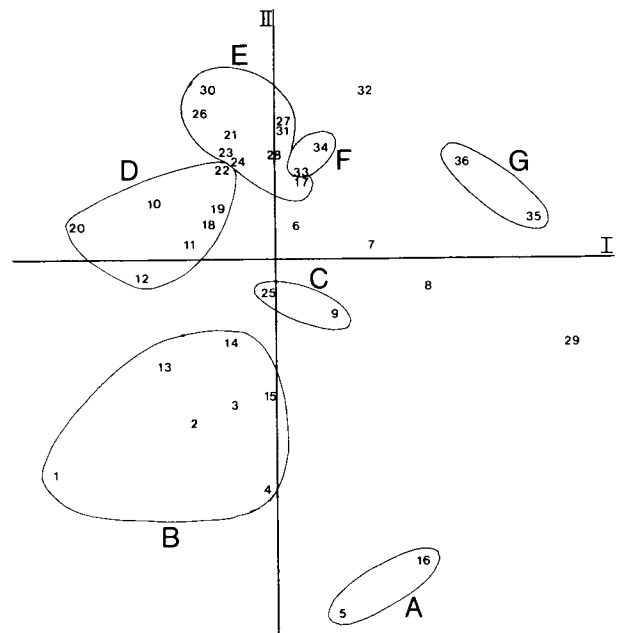


Fig. 4. Nonmetric multidimensional scaling of the *Fagion illyricum* alliance. Consensus groups are superimposed onto the scattergram.

	CL-1	CL-2	CL-3	CL-4
SSQ-1	1,2,3,4, 13,14,15 ^B	5,16 ^A	9,25 ^G	-
SSQ-2	-	-	7,8 ^G 35,36 ^G	29,32 ^H
SSQ-3	10,11,12, 18,20 ^D	-	-	19,22
SSQ-4	-	-	6 ^F 33,34 ^F	17,21,23, 24,26,28, 28,30,31 ^E

Fig. 5. Cross-classification table illustrating the strict consensus partition of 36 OSUs derived from the four-cluster partitions implied by SSQ and CL. Outlined groups are used in the revision (see text).

groups of the strict consensus partition (cf. Podani in press) defined for the two alternative classifications. The consensus groups may be identified in the ordination scattergrams, allowing the simultaneous interpretation of two classifications and the ordinations.

Consensus group A (Figs 3–5) includes two associations from Serbia, group B comprises submontane beechwoods and oak-hornbeam woods from Croatia and southern Hungary, and group C contains two intrazonal associations, a rocky and a gorge forest, from the Mecsek Mountains, Hungary. These groups form cluster SSQ-1 and they fall onto the positive side of the PCoA ordination along axis 1. Their inclusion into the same alliance seems straightforward according to our recent knowledge, even though the CL dendrogram is somewhat contradictory.

Group D includes the inframontane beechwoods and gorge forests from Croatia and Slovenia. Their treatment as a separate suballiance was already suggested above. Group E corresponds to the *Lonicero–Fagenion* suballiance. Two communities from Slovenia, the *Lamio orvalae–Fagetum slovenicum* (OSU #19) and the *Arunco–Fagetum* (OSU #22) represent a somewhat transitional situation between the two suballiances.

Two OSUs (#33 and 34) are assigned to group F which corresponds to the *Ostryo–Fagenion* suballiance of rocky beechwoods from the western Balkan. According to the two ordinations and SSQ, its separation from the *Lonicero–Fagenion* is less clear-cut, however.

Group G (35 and 36) contains the *Corylus colurna–Fagus moesiaca* mixed rocky beechwoods of SE Serbia. It is situated relatively far from the other OSUs in the ordinations, suggesting that its more adequate syntaxonomical position is in the *Quercetalia pubescentis* rather than in the *Fagetalia*, similarly to the Pannonian karstic beechwoods (*Orno–Fagetum*). This group may be treated as a separate alliance.

Consensus group H (29 and 32) includes two montane beechwoods from SE Serbia. It is not recognized in the first two dimensions of the ordinations, but both OSUs involved have high positive loadings on the 3rd PCoA axis. It was already mentioned that these are close to the Transylvanian *Fagetalia* communities and may belong to the *Fagion moesiaca*.

There are three remaining OSUs (6, 7, 8) representing southern Illyrian communities, whose class membership is doubtful. Their inclusion in a separate association, as proposed above, is perhaps the best temporary solution as long as no more data are obtained.

A new syntaxonomy of the *Fagion illyricum*

As several authors note (see Gauch 1982: pp. 33–34), community ecology is partially an art even though multivariate methods themselves offer an objective way of analyzing data. The interpretation of numerical syntaxonomic analyses is in a similar situation, especially if different objective methods suggest contradictory solutions for the same syntaxonomic problem. In the present study, there was a considerable agreement among the results, and 'subjective' expectations were rarely contrasting with the ordinations and numerical classifications. The ordination results and the consensus groups created by synthesizing two four-cluster classifications facilitate the construction of a new syntaxonomic system of the *Fagion illyricum* (Appendix 3). The table also suggests a number of nomenclatural corrections of illegitimate or invalid names (according to the Phytosociological Code, Barkman *et al.* 1986) applied by the former authors. The application of the new name *Aremonio–Fagion* for the alliance *Fagion illyricum* is also justified. The name is based on the East-Submediterranean 'Trennart' *Aremonia agrimonioides* occurring with high frequency values

in nearly all *Fagion illyricum* communities. The geographic epithetons used under the binomials of the associations indicate geographic races.

The classification suggested here is subject to future refinement. Intensive research is needed to create an improved data base for the Illyrian beechwoods, so that differences in sampling conditions will be less influential on the results. The next step towards a better understanding of the syntaxonomy of European beechwoods is perhaps an extended numerical analysis of all Fagetalia associations.

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Appendix 1 Origin of the 36 units described within the *Fagion illyricum* alliance (Borhidi 1963).

OSU number	Syntaxonomical unit	Localities	Nr of relevés	Authors
	PRIMULO – FAGION OR CARPINO – FAGION ILLYRICUM SUBALLIANCE: <i>Oak-hornbeam woods</i>			
1.	Epimedio – Carpinetum	Croatia, Bosnia, Herzegovina	57	Horvat (1938, 1949); Wraber (1962)
2.	Fraxino angustifoliae – Carpinetum	SW Hungary	35	Soó & Borhidi in Soó (1962), Borhidi & Járjai-Komlódi (1959)
3.	Helleboro dumetorum – Carpinetum	SW Hungary	50	Soó & Borhidi in Soó (1962)
4.	Asperulo taurinae – Carpinetum – mecsekense	S Hungary and NE Serbia	72	Horvat (1958); Soó & Borhidi in Soó (1962); Borhidi ined., Janković & Mišić (1960)
5.	– serbicum	Middle and E. Serbia	31	Rudski & Černjavski (1949); Borisavljević, Jovanović-Dunjić & Mišić (1955), Jovanović (1955a), Rajevski & Borisavljević (1956)
6.	– montenegrinum	Piva valley, Montenegro	7	Blečić (1958)
7.	– macedonicum	W Macedonia	5	Em (1952)
8.	– albanicum	Albania	6	Markgraf (1927, 1932)
9.	Tilio argenteae – Fraxinetum	Mecsek hills, S Hungary	5	Horvat (1961)
	<i>Submontane beechwoods</i>			
10.	Hacquetio – Fagetum	Slovenia	28	Košir (1962)
11.	Victo oroboidi – Fagetum – subpannonicum	E Slovenia	37	Košir (1962)
12.	– croaticum	E Slovenia	18	Horvat (1938)
13.	– saladiense	SW Hungary	40	Soó & Borhidi in Soó (1962)
14.	– somogyicum	SW Hungary	50	Soó & Borhidi in Soó (1962)
15.	Hellebro odoro – Fagetum – mecsekense	Mecsek hills, S Hungary and NE Yugoslavia	69	Horvat (1959); Soó & Borhidi in Soó (1962); Janković & Mišić (1960)
16.	– serbicum	Middle and E. Serbia	66	Rudski & Černjavski (1949); Jovanović & Dunjić (1951); Jovanović (1955a); Mišić (1956); Grebensčikov (1950); Knapp (1944a)
17.	Erythronio-Fagetum	Montenegro	9	Blečić (1958)
25.	Scutellario – Aceretum	Mecsek hills, S Hungary and E. Serbia	5	Borhidi ined.; Knapp (1944a)
	LONICERO – FAGION SUBALLIANCE: <i>Montane beechwoods</i>			
18.	Lamio orvalae – Fagetum – croaticum	Croatia	10	Horvat (1938)
19.	– slovenicum	Slovenia	23	Košir (1962)
20.	Anemoni trifoliae – Fagetum – subcarinthiacum	Lower Carinthia	18	Knapp (1944b)
21.	– austroalpinum	SE Austria	10	Aichinger (1933)
22.	Arunco – Fagetum	Slovenia	26	Košir (1962)
23.	Isopyro – Fagetum	Slovenia	26	Košir (1962)
24.	Chrysanthemo macrophylo – Aceretum	Croatia	1	Horvat (1938)

Appendix 1. Continued.

OSU number	Syntaxonomical unit	Localities	Nr of relevés	Authors
	<i>Mixed fir-beechwoods</i>			
26.	Calamintho grandiflorae – Abietetum – dinaricum – montenegri-	Croatia, Dinarian Alps	15	Horvat (1938)
27.	num			
28.	– albanicum	Piva valley, Montenegro	9	Blečić (1958)
29.	Doronico columnae (Abieti) – Fagetum	Albania SE Serbia	5 53	Markgraf (1927) Jovanović (1955a, b); Grebensčičikov (1950)
	<i>Subalpin or elfin beechwoods</i>			
30.	Homogyni – Fagetum	Croatia	15	Horvat (1938)
31.	Pancicio – Fagetum	Montenegro	8	Blečić (1958)
32.	Hyperico umbellato – Fagetum	Suva Planina, SE Serbia	12	Jovanović (1955a)
	<i>OSTRYO – FAGION SUBALLIANCE</i>			
33.	Seslerio autumnali – Fagetum	Piva valley, Montenegro	5	Blečić (1958)
34.	Colurno – Ostryetum carpinifoliae	Piva valley, Montenegro	10	Blečić (1958)
	<i>FAGO – COLURNION SUBALLIANCE</i>			
35.	Fago – Hyrcano – Colurnetum	Suva Planina, SE Serbia	7	Jovanović (1955a)
36.	Colurno – Fagetum	Rtanj hills, SE Serbia	5	Jovanović (1955b)

<i>Sorbus graeca</i>								6	9	4	2		
<i>Doronicum columnae</i>		+ 7		+		1			5	5	2	5	
<i>Geranium macrorrhizum</i>		+		+				1	1	8	5	9	9
<i>Euphorbia polychroma</i>		+		++								4	3
<i>Origanum vulgare</i>		+		1 1		+						5	9
<i>Syringa vulgaris</i>								+				4	9
<i>Teucrium chamaedrys</i>				1								4	3
<i>Helleborus atrorubens</i>		3	+			2 1							
<i>Fraxinus angustifolia</i>		5	+			1							
<i>Dianthus barbatus</i>		+ 3											
<i>Helleborus dumetorum</i>		+ 4				+		1					
<i>Doronicum orientale</i>				2		5							
<i>Trifolium pignatti</i>				2									
<i>Acer obtusatum</i>				4 5 5		1		2	1	7			
<i>Crocus neapolitanus</i>		6		9		+ 1 2 1							
<i>Helleborus cyclophyllus</i>				9									
<i>Anemone appennina</i>				7									
<i>Scrophularia vernalis</i>			+	7		1 2 +		2					
<i>Melandrium rubrum</i>		+				2		+					
<i>Daphne laureola</i>						++ 4 3 4							
<i>Polygala chamaebuxus</i>													
<i>Melampyrum velebeticum</i>													
<i>Dentaria pentaphyllos</i>		+				+		8					
<i>Saxifraga rotundifolia</i>						+		8					
<i>Chrysanthemum macrophyllum</i>						+		1				+	
<i>Galium rotundifolium</i>		+							5 6 1				
<i>Geranium nodosum</i>									3				
<i>Myrrhis odorata</i>								+	3				
<i>Podanthum trichocalycinum</i>									3				
<i>Adenostyles glabra</i>								+	2				
<i>Paniccia serbica</i>										7			
<i>Ranunculus platanifolius</i>									6 6			+	
<i>Anthericum ramosum</i>										7			
<i>Rhamnus rupestris</i>										5			
<i>Senecio rupester</i>												2	
<i>Daphne oleoides</i>												2	
<i>Acer hyrcanum</i>			++			+						+	9
<i>Galium purpureum</i>													4
<i>Acer monspessulanum</i>			++			+				+			5

Appendix 3.

Suggested syntaxonomic system of the *Fagion illyricum* and the related associations. OSU numbers as used in this paper are in brackets.

- Order: *Fagetalia silvaticae* Pawlowski 1928
- Alliance: *Aremonio-Fagion* Borhidi nom. nov. hoc loco (*Fagion illyricum* I. Horvat 1938)
- Suballiance: *Primulio vulgaris-Fagenion* Borhidi 1963 (*Carpino-Fagenion illyricum* Borhidi 1963, *Carpinion illyricum* I. Horvat 1963)
- Associations: *Epimedio-Carpinetum* (I. Horvat 1938) Borhidi 1963 (*Querceto-Carpinetum croaticum* I. Horvat 1938); 57 relevés (1)
- Fraxino panonicae-Carpinetum* Soó & Borhidi in Soó 1962; 35 relevés (2)
- Helleboro dumetorum-Carpinetum* Soó & Borhidi in Soó 1962; 50 relevés (3)
- Asperulo taurinae-Carpinetum* Soó & Borhidi in Soó 1962
- mecsekense* (A.O. Horvát 1958) Soó & Borhidi in Soó 1962 (*Querceto-Carpinetum mecsekense* A.O. Horvát 1958); 72 relevés (4)
- serbicum* (Rudski 1949) Soó & Borhidi in Soó 1962 (*Querceto-Carpinetum serbicum* Rudski 1949); 31 relevés (5)
- Aremonio-Carpinetum* Borhidi nom. novum hoc loco (*Asperulo taurinae-Carpinetum* Soó & Borhidi 62 p.p.)
- montenegrinum* (Blečić 1958) Borhidi hoc loco (*Querceto-Carpinetum montenegrinum* Blečić 1958); 7 relevés (6)
- macedonicum* (Em 1950) Borhidi hoc loco (*Querceto-Carpinetum macedonicum* Em 1950); 5 relevés (7)
- albanicum* (Soó 1962) Borhidi hoc loco (*Asperulo taurinae-Carpinetum albanicum* Soó 1962); 6 relevés (8)
- Tilio tomentosae-Fraxinetum* (A.O. Horvát 1961) Soó & Borhidi in Soó 1962 (*Tilio-Fraxinetum mecsekense* A.O. Horvát 1961); 5 relevés (9)
- Vicio oroboidi-Fagetum* Pócs & Borhidi 1960 em. Borhidi hoc loco
- saladiense* Borhidi & Pócs 1960; 40 relevés (13)
- somogyicum* Borhidi & Pócs 1960; 50 relevés (14)
- Helleboro odoro-Fagetum* Soó & Borhidi in Soó 1962
- mecsekense* (A.O. Horvát 1959) Soó & Borhidi in Soó 1962 (*Fagetum mecsekense* A.O. Horvát 1959); 69 relevés (15)
- serbicum* (Rudski 1949) Borhidi 1963 (*Fagetum serbicum montanum* Rudski 1949); 67 relevés (16)
- Scutellario-Aceretum* Soó & Borhidi in Soó 1962; 5 relevés (25)
- Suballiance: *Lamio orvalae-Fagenion* Borhidi suball. nova
- Associations: *Hacquetio-Fagetum* Košir 1962; 28 relevés (10)
- Epimedio-Fagetum* Borhidi nom. novum hoc loco (*Querceto-Fagetum* Košir p.p., *Enneaphyllo-Fagetum* Košir p.p.)
- slovenicum* (Košir 1962) Borhidi hoc loco (*Querceto-Fagetum* Košir 1962 non Tx. 1937); 37 relevés (11)
- croaticum* (I. Horvat 1938) Borhidi hoc loco (*Fagetum croaticum boreale lathyretosum* I. Horvat 1938); 18 relevés (12)
- Lamio orvalae-Fagetum* I. Horvat 1938 em. Borhidi 1963
- croaticum* I. Horvat 1938; 10 relevés (18)
- slovenicum* (Košir 1962) Borhidi 1965 (*Enneaphyllo-Fagetum* Košir 1962); 23 relevés (19)
- Anemoni trifoliae-Fagetum* Tregubov 1957
- subcarinthiacum* (Knapp 1944) Borhidi 1965 (*Fagetum subcarinthiacum* Knapp 1944); 18 relevés (20)
- Arunco-Fagetum* Košir 1962; 26 relevés (22)
- Suballiance: *Lonicero-Fagenion* Borhidi 1963
- Associations: *Erythronio-Fagetum* (Blečić 1958) Borhidi 1963 (*Fagetum silvaticae montenegrinum montanum* Blečić 1958); 9 relevés (17)
- Anemoni trifoliae-Fagetum* Tregubov 1957
- austro-alpinum* (Aichinger 1933) Borhidi 1963 (*Fagetum austro-alpinum* Aichinger 1933); 10 relevés (21)
- Isopyro-Fagetum* Košir 1962; 26 relevés (23)
- Chrysanthemo macrophylo-Fagetum* (I. Horvat 1938) Borhidi 1963 (*Acereto-Fraxinetum croaticum* I. Horvat 1938); 1 relevé (24)
- Calamintho grandiflorae-Abietetum* Borhidi nom. nov. (*Calamintho grandiflorae-Abieti-Fagetum* Borhidi 1963 nom. invalid.)
- croaticum* (I. Horvat 1938) Borhidi 1963 (*Fagetum croaticum montanum abietetosum* I. Horvat 1938);
- Abieti-Fagetum dinaricum* Tregubov 1957); 15 relevés (26)
- montenegrinum* (Blečić 1958) Borhidi 1963 (*Fagetum montenegrinum abietetosum* Blečić 1958); 9 relevés (27)
- albanicum* Borhidi 1963; 5 relevés (28)
- Homogyne silvestris-Fagetum* (I. Horvat 1938) Borhidi 1963 (*Fagetum croaticum australe subalpinum* I. Horvat 1938); 15 relevés (30)
- Pancicio-Fagetum* (Blečić 1958) Borhidi 1963 (*Fagetum montenegrinum subalpinum* Blečić 1958); 8 relevés (31)
- Suballiance: *Ostryo-Fagenion* Borhidi 1963
- Associations: *Seslerio autumnali-Fagetum* (I. Horvat 1950) Wraber 1960 (*Fagetum croaticum seslerietosum* I. Horvat 1950); 8 relevés (33)
- Corylo colurnae-Ostryetum* Blečić 1958; 10 relevés (34)
- Alliance: *Fagion moesiaca* Horvat, Glavač & Ellenberg 1974
- Associations: *Doronico colurnae-Abietetum* (Jovanović 1955) Borhidi nom. novum (*Abieti-Fagetum serbicum* Jovanović 1955); 53 relevés (29)
- Hyperico umbellatae-Fagetum* (Jovanović 1955) Borhidi 1963 (*Piceo-Fagetum serbicum* Jovanović 1955); 12 relevés (32)
- Order: *Quercetalia pubescentis-petraeae* Br.-Bl. 1931
- Alliance: *Fago-Corylion colurnae* Borhidi 1963 stat. novus
- Associations: *Aceri hyrcano-Fagetum moesiaca* (Jovanović 1955) Borhidi nom. nov. (*Fago-Hyrcano-Colurnetum* Jovanović 1955); 7 relevés (35)
- Corylo colurnae-Fagetum* (Jovanović 1955) Borhidi 1963 (*Fagetum serbicum colurnetosum* Jovanović 1955); 5 relevés (36)