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SYNTAXONOMY OF THE OSTRYA CARPINIFOLIA WOODS IN THE SOUTHERN ALPS (N-ITALY) BASED ON NUMERICAL METHODS *

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Abstract
The syntaxonomy of the *Ostrya carpinifolia* woods in the Southern Alps has been studied by means of phytosociological relevés carried out in the area extended from the Trieste Karst westwards to the Lombard Praealps. Syntaxonomic levels have been defined on the basis of similarity measures obtained by application of formal methods of numerical classification. The ecological conditions of the resulting vegetation types have been discussed. Five associations can be distinguished, all belonging to the alliance *Ostryo-Carpinion orientalis* (order: *Quercetalia pubescenti-petraeae,* class. *Querco-Fagetea): Ostryo-Quercetum pubescentis, Buglossoido-Ostryetum, Orno-Ostryetum, Melica uniflora-Ostrya carpinifolia* association, *Seslerio variae-Ostryetum.* Two suballiances, essentially of chorological significance, can be distinguished within *Ostryo-Carpinion orientalis: Ostryo-Carpinenion orientalis* in the Illyric region and *Orno-Ostryenion* in the Praealps.

Introduction

Ostrya carpinifolia woods cover large areas in the climax region of thermophilous oak forests in the Southern Alps, where they constitute an important element of the landscape. In the last thirty years, woods with dominance of *Ostrya carpinifolia* have been described in some regional contributions regarding different parts of the study region and adjacent areas (Knapp, 1953; Eskuche, 1955; Horvat, 1959, 1962; Braun-Blanquet, 1961; Wraber, 1961; Oberdorfer, 1964; Antonietti, 1968, 1979; Ellenberg & Klötzli, 1972; Horvat, Glavać & Ellenberg, 1974; Barbero, 1979; Gerdol & Piccoli, 1979; Köllemann & Clementi, 1979; Poldini, 1979, 1982).

The syntaxonomical and ecological problems connected with the *Ostrya carpinifolia* woods have been recently discussed in two Symposia of the Ostalpin-dinarische Gesellschaft für Vegetationskunde, held in Trieste in the years 1979 and 1981. During the first Symposium, the authors suggested that the syntaxonomy of the *Ostrya* woods could be clarified by a detailed study of the dynamical and

* Nomenclature of species follows Ehrendorfer (1973).

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ecological significance of *Ostrya carpinifolia*, since these woods mainly occur in vegetation complexes formed of secondary woods, wood-edge, fringe communities and grasslands (Lausi, Gerdol & Piccoli, 1979). Important in this sense are the recent works devoted to the wood-edge and fringe communities. The results of these studies allowed a clear definition of the syntaxonomical value of many species involved in the dynamic process of wood regeneration (Müller, 1962; Oberdorfer, 1972; Dierschke, 1974; van Gils, Keysers & Launspach, 1975; van Gils & Keysers, 1978). Therefore, the authors have carried out a survey devoted to the study of all of these vegetation types: a series of phytosociological relevés has been made in the whole area of the Southern Alps, during the years 1979-80 in the transition: closed wood → wood-edge --→ fringe --→ grassland.

The syndynamical role of *Ostrya carpinifolia* in the different phytocoena of this vegetation complex has been discussed in a paper presented at the Symposium of the International Society for Vegetation Science: "Vegetation dynamics in grasslands, heathlands and mediterranean ligneous formations" (Montpellier, 1980). The main conclusions of this dynamical study can be summarized as follows: (i) the wood-edge and fringe communities take part in the successional process of oak wood regeneration; (ii) many species occuring in the deciduous forests region of Eurasia find refuge in these transitional communities; (iii) *Ostrya carpinifolia* is a tree playing an important part in early successional stages of wood regeneration (Lausi, Gerdol & Piccoli, 1982).

The present paper is the contribution presented at the second Symposium of the Ostalpin-dinarische Gesellschaft für Vegetationskunde (Trieste, 1981). It concerns the phytosociological syntaxonomy of the *Ostrya* woods based on the application of numerical methods of classification. Our aim is to present a syntaxonomic scheme consistent with the formal basis of the inclusion principle of set theory (Feoli & Lausi, 1982).

Data and methods

This research is based on relevés carried out, according to the Braun-Blanquet method, in the area extending from the Trieste Karst westwards along the Southern Alps to the Lombard Praealps. Only the relevés of closed woods characterized by the dominance of *Ostrya carpinifolia* in the tree layer have been taken into consideration; special care has been always taken to exclude from the relevés of closed woods the wood-edge and fringe communities that often form a mosaic with *Ostrya* woods. The above mentioned syndynamical study (Lausi, Gerdol & Piccoli, 1982) was performed on the basis of the same data. The relevés have been classified by average linkage clustering (Anderberg, 1973) based on the similarity ratio (Westhoff & van der Maarel, 1978). Cover data matrix was used as input. The original data set has been enlarged with relevés from the Adige Valley (Braun-Blanquet, 1961; rel. 3, 4, 5, 6; table 53).

These data have been synthesized in a synoptic table by calculating a cover index ranging from 0 to 100 (see Lausi, Gerdol & Piccoli, 1982) for each species included in the characteristic species combination of the resulting vegetation types.

The data in this synoptic table have been classified with the same method applied for classifying the original relevés. The synoptic table of association (table 1) is supported by the results of numerical analysis (see dendrogram at top of the table). Since the *Ostrya carpinifolia* woods of Friuli and the Trieste Karst have been studied in detail by Poldini (1982), some new syntaxa are defined in collaboration with this author for nomenclatural uniformity.

Results and discussion

The dendrogram of classification of the types (table 1) shows five clusters at a similarity level of about 0.50. According to literature data (Kortekaas, van der Maarel & Beeftink, 1976; Westhoff & van der Maarel, 1978; Lausi & Feoli, 1979), this value corresponds to the association level in the hierarchical syntaxonomy.

Cluster 1 (column 1 in table 1) includes the relevés from the Trieste Karst and is characterized by the presence of *Paeonia peregrina* and *Frangula rupestris*. *Frangula rupestris* can be considered only a differential species of this phytocoenon since it has the otpimum in the wood-edge communities (order *Prunetalia*). The Illyric *Ostrya* woods were originally ascribed by Horvat & Horvatić (Horvat, 1962) to the association *Seslerio autumnalis-Ostryetum*. Trinajstić (1977) proposed to reserve this name for the *Ostrya* woods derived from the destruction of beech forests, that therefore show an almost complete lack of *Quercus* species, and to assign the submediterranean *Ostrya* woods of the Illyric region to an independent phytocoenon: *Ostryo-Quercetum pubescentis* (Horvat et Horvatić 1950) Trinajstić 1974. This type should therefore be referred to the *Ostryo-Quercetum pubescentis*. This phytocoenon includes thermophilous woods on poor soils. From the dynamical point of view, it can be considered as an initial wood type evolving towards the *Seslerio-Quercetum petraeae* (Illyric oak forest), which is the most mature wood type found in the corresponding region (Lausi, Gerdol & Piccoli, 1982).

Cluster 2 (columns 2-5 in table 1) includes the relevés of dense-canopied mesophilous *Ostrya* woods from the Lombard Praealps (columns 2 and 4), from Berici Hills (column 5) and from the Venetian Praealps (column 3). The caracter species of this phytocoenon are *Buglossoides purpurocaerulea* and *Euphorbia amygdaloides*. Moreover, this wood type is characterized by the presence of several mesophilous species, often transgressive from the alliance *Carpinion*, such as: *Vinca minor, Rosa arvensis, Salvia glutinosa, Acer pseudoplatanus, Knautia drymeia, Carpinus betulus* and *Viburnum opalus*. They can be regarded as differential species of this phytocoenon.

These mesophilous *Ostrya* woods are frequent in the Southern Alps from the Lombard Praealps eastwards to Friuli. A certain chorological differentiation may be observed in some regions, as will be discussed later. The corresponding vegetation type is defined by the relevés presented in this paper (table 2) and by the relevés from Friuli of Poldini (1982). Rel. 16 in table 2 is considered relevé type of the name. This phytocoenon can be called *Buglossoido-Ostryetum* Gerdol, Lausi, Piccoli et Poldini 1982. It is noteworthy that in the study region *Buglossoides purpurocaerulea*, although not being a constant species in this type, occurs only within this

association (table 1). *Buglossoides purpurocaerulea* is considered by Oberdorfer (1979) as characteristic of an oak wood type *(Lithospermo-Quercetum petraeae).* Since it is generally admitted that the climax vegetation in the study area is a mixed oak forest, the presence of *Buglossoides purpurocaerulea* in this phytocoenon may be interpreted as a further proof that the mesophilous *Buglossoido-Ostryetum* has reached a certain degree of maturity from the dynamical point of view (Lausi, Gerdol & Piccoli, 1982). Furthermore, this is confirmed by the presence of many shade tolerant forest species, most of which constitute differential species of *Buglossoido-Ostryetum.*

Buglossoido-Ostryetum shows a geographical differentiation. Several local differential species can be recognized in the relevés of *Buglossoido-Ostryetum* from different regions. Besides the mentioned species (see tables 1 and 2), Poldini (1982) has considerd the following taxa as differential for this association in Friuli: *Acer campestre, Quercus petraea, Prunus avium, Tilia cordata, Fagus sylvatica, Fraxinus excelsior, Ulmus glabra, Euonymus europaea, Pyrus pyraster, Campanula rapunculoides, Melampyrum vulgatum* and *Lathyrus vernus.*

The relevés from the Lombard Praealps (rel. 8-17 in table 2), with constant presence of *Helleborus niger,* correspond to *Helleboro-Ornetum* prov. Antonietti 1968. According to the results of the numerical classification, the *Helleboro-Ornetum* cannot be retained at the association level, since the corresponding types (columns 2 and 4 in table 1) are fused at high similarity levels with those of the Venetian Praealps and Berici Hills. In the Lombard Praealps only a variant (or geographical race), characterized by *Helleborus niger,* can be distinguished within the *Buglossoido-Ostryetum.* Also the relevés from Berici Hills, with the constant presence of *Epimedium alpinum,* may correspond to a peculiar geographical race.

Cluster 3 (column 6 in table 1) includes the relevés of Braun-Blanquet (1961) from the Adige Valley. It is characterized by *Campanula bononiensis, Colutea arborescens, Hypericum montanum, Hieracium laevigatum, Inula conyza, Fragaria viridis* and corresponds to *Orno-Ostryetum* Br.-Bl. 1961. Among the above mentioned species, only *Campanula bononiensis, Colutea arborescens* and perhaps *Hypericum montanum* are specifically linked to the corresponding wood type. *Hieracium laevigatum* shows its optimum in light acidophyticwoods, while *Fragaria viridis* and *Inula conyza* are most frequent in the fringe communities (Oberdorfer, 1979). Therefore, the three last-named species can be considered only as differential for this association. *Orno-Ostryetum* comprehends the *Ostrya* woods of the Adige Valley. This association essentially has a chorological significance but is also conditioned by the arid climate of this inner-alpine valley.

Cluster 4 (column 7 in table 1) includes relevés of closed *Ostrya* woods of Monte Baldo on level relief or on moderately steep slopes with a fairly evolved soil (brown earth). They are characterized by the constant presence of *Melica uniflora* and *Poa nemoralis.* The environmental conditions enhance the evolution of a wood with a dense canopy layer, excluding all of the xerophilous species. Since this wood type has been hitherto recognized only in a very limited zone, and no other data are available about its geographic distribution, we prefer to ascribe it generically to a

Melica uniflora - Ostrya carpinifolia association. The syntaxonomical rank of this type need further research.

Cluster 5 (column 8 in table 1) includes relevés from *Ostrya* woods of the Venetian Praealps on steep calcareous slopes, usually on talus with initial soils, so that they hold several xerophilous species indicating fairly poor soils, generally transgressive from the class *Erico-Pinetea*, such as: *Erica herbacea, Polygala chamaebuxus, Sesleria varia, Amelanchier ovalis, Cotoneaster tomentosus* and *Calamagrostis varia* (table 1). As none of the above mentioned species can be considered characteristic for this syntaxon, the syntaxonomic arrangement of this vegetation type is somewhat problematic, though the phytocoenon is clearly interpretable both from the ecological and the dynamical points of view (Lausi, Gerdol & Piccoli, 1982). The environmental conditions hinder the evolution of these woods which often constitute long lasting stages (*Dauergesellschaften*), blocked in their evolution by edaphic factors. They have a rather loose canopy; this allows the presence of shade tolerant plants linked to light pine woods and xeric grasslands, such as *Erica herbacea, Sesleria varia* and *Polygala chamaebuxus*. It is noteworthy that mesophilous wood species are rare and that species preferentially linked to wood-edge communities are clearly prevailing, such as *Crataegus monogyna, Cornus sanguinea, Viburnum lantana, Ligustrum vulgare, Prunus spinosa, Cotinus coggygria, Prunus mahaleb, Berberis vulgaris* and *Rosa canina*. Among the species mainly occuring in pine woods, only *Erica herbacea, Sesleria varia* and *Polygala chamaebuxus* are constantly present in this phytocoenon with high cover values. This is due to the fact that they are early flowering plants and can complete their life cycle before *Ostrya carpinifolia* comes into leaf.

However, in spite of the absence of true character species, the vegetation type corresponding to cluster 5 can be defined on the basis of the characteristic combination including several transgressive species from *Erico-Pinetea* and *Seslerietea* together with the *Querco-Fagetea* species (tables 1 and 3). Moreover, the presence of typical species of the fringe communities *(Vincetoxicum hirundinaria, Geranium sanguineum, Anthericum ramosum, Peucedanum oreoselinum)* and even of grasslands *(Carex humilis, Brachypodium pinnatum, Teucrium chamaedrys)* is a characteristic feature of the considered phytocoenon. This association can be called, on the basis of the most abundant species in the herbaceous layer, *Seslerio variae-Ostryetum*. This association is defined by the relevés in table 3. Rel. 3 (table 3) can be considered relevé type of the name. *Seslerio variae-Ostryetum* extends along the Southern Alps from Garda Lake eastwards to the Piave Valley.

Several vegetation types more or less rich in *Erico-Pinetea* species and with the dominance of *Ostrya carpinifolia* in the tree layer have been described in the Southern Alps and in the Dinarides. Even the most xerophytic aspects of *Buglossoido-Ostryetum* (see tables 1 and 2) hold some species of the class *Erico-Pinetea*. Other associations showing a remarkable abundance of *Erico-Pinetea* species colonize steep calcareous slopes within the vegetation complex of beech forests and pine woods, i.e. at the border or even out of the climax zone of mixed oak forests. They are: the *"Ostrya carpinifolia-Fraxinus ornus - Assoziation"* (Aichin-

ger, 1933) in Carinthia (Austria), the *Cytisantho-Ostryetum* (Wraber, 1961) on the southern slopes of the Eastern Julian Alps (Yugoslavia) and the *Erico-Ostryetum* (Horvat, 1962) in Gorski Kotar (Yugoslavia). Owing to the ecologically extreme conditions and the geographical position, these associations are floristically very poor in respect to the Praealpine *Seslerio variae-Ostryetum*. Particularly remarkable is the almost complete lack of oaks in the corresponding relevés and the poorness in *Quercetalia pubescenti-petraeae*, and more generally in *Querco-Fagetea*, species. According to Horvat, Glavač & Ellenberg (1974), the *Erico-Ostryetum* and the *"Ostrya carpinifolia-Fraxinus ornus - Assoziation"* should therefore be included in the class *Erico-Pinetea*. It should be noted that the *"Ostrya carpinifolia-Fraxinus ornus - Assoziation"* is to be restricted to a part of the relevés published by Aichinger (rel. 7-10 of table 60; Aichinger, 1933) since the remainder (rel. 1-6 in the same table) corresponds to light pine woods.

There is no doubt that the *Seslerio variae-Ostryetum* belongs to *Querco-Fagetea* since the character species of this class are much more abundant than *Erico-Pinetea* species. However, considering the characteristic combination of species of this type, *Seslerio variae-Ostryetum* can be considered as a transition towards *Erico-Pinetea*.

It should be stressed here that the main aim of the present study is the solution of some syntaxonomical problems regarding woods with dominance of *Ostrya carpinifolia* in the Southern Alps. Therefore, we did not analyze the detailed differentiation of such woods in the different regions of the study area. For this reason, the proposed classification scheme at the association level can be considered as a draft for further regional researches that would take into consideration also the relationships existing between *Ostrya* woods and other wood types (particularly *Fagus sylvatica* and *Carpinus betulus* woods).

The employed approach gives a useful generalizable basis for the syntaxonomic arrangement of *Ostrya* woods at higher hierarchical levels. In fact, it permits us to evaluate, on the basis of a formal method of numerical classification, the syntaxonomic rank of the species considered characteristic of the different syntaxa over a large area. It is however noteworthy that the syntaxonomical scheme arising from our numerical classification of vegetation data regarding the whole area of the Southern Alps is in very good accordance with the results of a detailed regional study carried out by Poldini (1982) in the eastern part of the study area.

In the dendrogram of table 1, the number of clusters drops from 5 to 2 at a similarity level of about 0.44. As this similarity value is a little higher than the threshold (0.30-0.40) proposed for the alliance level (Lausi & Feoli, 1979), the two clusters can be considered as suballiances. This is confirmed by the analysis of the floristic composition of the corresponding types. In fact, the floristic distinction between these two clusters, respectively including the Illyric (column 1) and the Praealpine (column 2-8) *Ostrya* woods, is not very sharp since all of the corresponding wood types contain a series of species considered by Horvat (1962) characteristic of the alliance *Ostryo-Carpinion orientalis: Ostrya carpinifolia, Mercurialis ovata, Celtis australis, Asparagus tenuifolius* and *Dianthus monspes-*

sulanus. The existence of an independent alliance in the Southern Alps, as suggested by Braun-Blanquet (1961), can be hardly supported since this syntaxon is very weakly characterized from the floristic point of view. Braun-Blanquet considered the following species as characteristic both at the alliance *(Orno-Ostryon)* and at the association level *(Orno-Ostryetum): Ostrya carpinifolia, Fraxinus ornus, Celtis australis, Clematis recta* and *Campanula bononiensis. Ostrya carpinifolia* and *Celtis australis* had already been considered as characteristic of the alliance *Ostryo-Carpinion orientalis* (Horvat, 1962); *Fraxinus ornus* is frequent in all of the thermophilous deciduous woods in Southern Europe and should therefore be regarded as a *Quercetalia pubescenti-petraeae* species; *Clematis recta* shows its optimum in the fringe communities and is now considered as character species of the alliance *Geranion sanguinei* (Oberdorfer, 1979), so that it cannot characterize any wood type; finally, *Campanula bononiensis* is found only in the *Ostrya* woods of the Adige Valley and can be used only to characterize the association *Orno-Ostryetum*. For these reasons, the *Orno-Ostryon* Br.-Bl. (non Tomazic 1940) cannot be further retained as an independent alliance. From the numerical analysis, we have clearly defined the character species of the association *Orno-Ostryetum* Br.-Bl. 1961.

According to the inclusion principle, the *Ostrya* woods of both the Balkans and the Praealps belong to one and the same alliance, that is *Ostryo-Carpinion orientalis* Horvat (1954) 1959. This alliance perhaps includes also the *Ostrya* woods of the Appennines. *Ostryo-Carpinion orientalis* therefore extends from Greece and South Bulgaria to the Southern Alps and probably to South Italy. This alliance is characterized by a series of species occuring all over its distribution area. They are, as mentioned above: *Ostrya carpinifolia, Mercurialis ovata, Celtis australis, Asparagus tenuifolius* and *Dianthus monspessulanus*.

As this large area includes several phytogeographic regions showing considerable differences in their flora, it seems possible to distinguish different syntaxa at the suballiance level within the *Ostryo-Carpinion orientalis*. Such an approach is well supported by the results of our numerical classification and has been already followed by Horvat (1959), who distinguished the suballiances *aegeicum* and *illyricum* within *Ostryo-Carpinion orientalis* in the Balkans. However, these geographical names cannot be considered valid according to the nomenclatural rules (Barkman, Moravec & Rauschert, 1976).

The suballiance *Ostryo-Carpinion orientalis "illyricum"*, including the *Ostrya* woods of the Northern Balkans, should be called *Ostryo-Carpinenion orientalis* Horvat (1954) 1959. Character species of this suballiance are, besides *Sesleria autumnalis* and *Coronilla emerus* subsp. *emeroides*, occuring in the relevés of the Trieste Karst considered in our numerical classification (see table 1), *Carpinus orientalis, Pyrus amygdaliformis* and *Helleborus istriacus* (Horvat, 1962). On the contrary, *Acer monspessulanum, Paliurus spina-christi, Pistacia terebinthus, Oenanthe pimpinelloides, Cnidium silaifolium, Melissa officinalis* and *Scutellaria altissima* (Horvat, 1962) can be considered at most as differential species of *Ostryo-Carpinenion orientalis* since they show their optimum in other syntaxa. The Illyric

Ostrya woods are closely related to the Appenninic ones for the common presence of *Carpinus orientalis* and *Acer monspessulanum*. The Appenninic *Ostrya* woods might therefore be also assigned to *Ostryo-Carpinenion orientalis*.

The suballiance *Ostryo-Carpinion orientalis "aegeicum"* of the Southern Balkans is characterized by the presence of several species such as *Syringa vulgaris, Podocytisus caramanicus, Helleborus cyclophyllus, Ajuga laxmannii, Leontodon fasciculatus* (Horvat, Glavać & Ellenberg, 1974). Only further researches in the Southern Balkans will allow us to define the character species and the correct name for the corresponding suballiance.

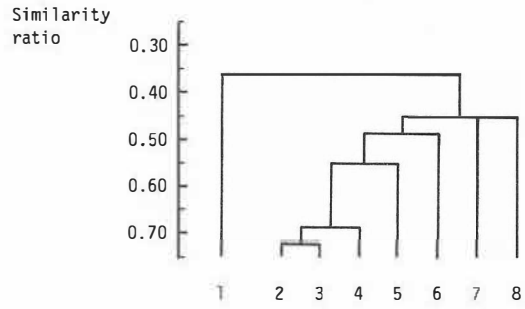
The *Ostrya* woods of the Southern Alps (columns 2-8 in table 1) can be ascribed to an independent suballiance characterized by species with Praealpine character: *Hierochloë australis, Laburnum anagyroides* and *Lilium bulbiferum/croceum* (table 1). *Helleborus odorus,* showing its optimum in the *Carpinus betulus* woods (alliance *Carpinion*), and *Cytisus sessilifolius,* characteristic of *Quercion pubescenti-petraeae,* can be regarded only as differential species for this syntaxon. The Praealpine suballiance does not correspond to the *Orno-Ostryon* Br.-Bl. 1961 (non Tomazić 1940) because all of the species considered by this author as characteristic belong to other syntaxa. This suballiance has been redefined by the authors together with Poldini (1982). It should be called *Orno-Ostryenion* Gerdol, Lausi, Piccoli et Poldini 1982.

Orno-Ostryenion includes thermophilous mixed deciduous woods largely extended in the submediterranean belt of the Southern Alps (200-700 m) from the Lombard Praealps eastwards to Friuli. The distribution area of *Orno-Ostryenion* coincides with that of the "*Orno-Ostryetum* zone" indicated by Mayer (1974, 1977) in his map of the natural forests of the Eastern Alps.

All of the considered types are fused in the classification dendrogram (table 1) at a relatively high similarity value (about 0.35). Therefore, they are to be ascribed to the same order, i.e. *Quercetalia pubescenti-petraeae,* including all of the thermophilous deciduous wood types in Southern Europe. According to Jakucs (1961), the vegetation of the thermophilous woods in South Europe should be referred to an independent class *(Quercetea pubescenti-petraeae)* and the *Ostrya carpinifolia* woods of South-eastern Europe to the order *Orno-Cotinetalia.* However, the suggestion of Jakucs seems to be unfounded since the floristic relationships among the deciduous wood types in Europe do not seem to justify their separation at a hierarchical rank higher than order. On the other hand, the order *Orno-Cotinetalia* appears very weakly characterized since many of the character species indicated by Jakucs (1961) show their optimum in the fringe communities *(Trifolio-Geranietea)* or even in grasslands *(Festuco-Brometea* and *Brachypodio-Chrysopogonetea).*

In the literature, no definite similarity thresholds regarding the distinction of phytosociological syntaxa at the class level have been till now established. However, all of the considered associations clearly belong to *Querco-Fagetea* for the absolute dominance of the character species of this class. As mentioned above, only *Seslerio variae-Ostryetum* has a transition character towards *Erico-Pinetea*, due to the presence of several character species of this class in the characteristic species combination of this association.

Table 1 — Synoptic table and classification dendrogram.



OSTRYO-QUERCETUM PUBESCENTIS								
Paeonia peregrina	28							
Frangula rupestris (D)	28							
OSTRYO-CARPINENION ORIENTALIS								
Sesleria autumnalis	67							
Acer monspessulanum (D)	22							
Coronilla emerus subsp. emeroides	11							
BUGLOSSOIDO-OSTRYETUM								
Vinca minor (D)		28	27	67	11			
Rosa arvensis (D)		8	13	11	22			
Knautia drymeia (D)		19	6	4	11			3
Buglossoides purpurocaerulea		6	3	22	11			
Euphorbia amygdaloides			3	15	22			
Salvia glutinosa (D)		11	5	4	11			
Symphytum tuberosum (D)			3		22			
Carpinus betulus (D)			5		17			
Acer pseudoplatanus (D)		6		4				3
Viburnum opalus (D)		6		7				
ORNO-OSTRYETUM								
Colutea arborescens						25		
Campanula bononiensis						19		
Hypericum montanum			3			17		
Hieracium laevigatum (D)						17		
Inula conyza (D)			2			11		
Fragaria viridis (D)						11		
MELICA UNIFLORA-OSTRYA CARPINIFOLIA ASSOCIATION								
Melica uniflora		8			11		44	
Poa nemoralis					8		39	
SESLERIO VARIAE-OSTRYETUM								
Sesleria varia (D)			13					65
Erica herbacea (D)			8					25
Polygala chamaebuxus (D)				7				25
Calamagrostis varia (D)			11					13
Amelanchier ovalis (D)				7				17
Cotoneaster tomentosus (D)								6

ORNO-OSTRYENION

Helleborus odorus (D)		11	9	4	22			
Hierochloë australis			8			22		10
Cytisus sessilifolius (D)				13				17
Laburnum anagyroides						11		6
Lilium croceum/bulbiferum			3					8

OSTRYO-CARPINION ORIENTALIS

Ostrya carpinifolia	89	89	86	89	81	89	72	78
Mercurialis ovata	11	6	8	11				10
Celtis australis		11	3			17		
Asparagus tenuifolius	11		3	4	6			
Dianthus monspessulanus			6					11

QUERCETALIA PUBESCENTI-PETRAEAE

Fraxinus ornus	55	19	35	52	33	55	28	40
Quercus pubescens	55	28	22	35	28	22	39	21
Cornus mas	28	11	24	22	33	11	28	13
Quercus cerris		25	17	24	33		22	21
Melittis melissophyllum	11	17	16	7	22	17	22	10
Tanacetum corymbosum		14	6	15	11		22	6
Lathyrus niger					22	17		
Sorbus torminalis					19		22	3
Arabis turrita		6	9				11	

QUERCO-FAGETEA

Hedera helix	28	50	44	28	44	25	28	14
Cornus sanguinea		31	38	46	29	25		10
Crataegus monogyna	22	22	22	30	28	17	22	13
Corylus avellana		25	27	31	28		22	14
Carex digitata	17	17	6	17	22	22	28	13
Viburnum lantana		17	13	26	22	17	22	21
Coronilla emerus subsp. emerus		22	22	19	11	33		25
Ligustrum vulgare		17	11	22	22	28	11	13
Tamus communis		11	19	24	33	6	11	16
Hepatica nobilis		14	17	17	28	6	22	16
Primula vulgaris		14	11	9	17		55	8
Acer campestre		6	16	11	33	8	28	6
Festuca heterophylla		28	24	15	11		22	8
Brachypodium sylvaticum	17	14	13	7	28	25		
Viola reichenbachiana		22		11	22	11	28	6
Prunus spinosa		11	16	9	11	17	11	19
Melampyrum velebiticum			27	7			22	36
Cotinus coggygria	44		3			6	11	22
Cephalanthera longifolia	11	17	13	11		8	11	14
Clematis vitalba		11	13	22	11	19		
Campanula trachelium		17	17		11	11	16	
Prunus mahaleb	22		3			33		3
Lonicera xylosteum		11	5	11			22	16
Rhamnus catharticus	6	7	9	15	17			8
Sorbus aria		6	11	7			22	11
Prunus avium		22	11				11	
Lathyrus vernus			6		17	6	11	3
Ulmus minor	11	6	8	7	11			
Euphorbia dulcis		11	3	7	11		11	
Galium laevigatum			9		28			6
Viola mirabilis			3			6	22	10
Rosa canina		6	6	7		6	11	3

Euonymus europaea		17	3	4		11		
Fagus sylvatica		6	5				17	5
Berberis vulgaris				4		11	11	3
Daphne mezereum		6			11		11	
Mercurialis perennis			3	4	11		3	3
Lamiastrum flavidum		11					11	
Sanicula europaea					22			
Tilia cordata		3	3			6		5
Neottia nidus-avis			3				11	3
Tilia platyphyllos	11							
Veronica urticifolia							11	3
Crataegus laevigata							11	
Asarum europaeum			3					
Thalictrum aquilegiifolium			3					
COMPANION SPECIES								
Ruscus aculeatus	22	19	16	22	39			3
Fragaria vesca		22	16		22	14	28	13
Solidago virgaurea		22	16		22	11	22	13
Castanea sativa		39	6		44	6	11	
Cruciata glabra		17	22	20	11		22	6
Rubus fruticosus agg.	11	11	14	13	22		17	8
Vincetoxicum hirundinaria	22	11	19	7	11	14		11
Cyclamen purpurascens	11	11	13	11			22	22
Viola hirta	11	6	16	9	22		22	3
Asplenium trichomanes			13	4	11	17	22	13
Epimedium alpinum					78			
Melica nutans		31	3	20		6	11	3
Carex humilis			16	7		28		22
Carex alba			13	13		22	11	8
Polypodium interjectum			6		11	11	22	16
Juniperus communis	22		16				11	17
Hieracium sylvaticum		6	9			8	22	19
Brachypodium pinnatum	17		11	11				22
Lonicera caprifolium		6	16		28	6		3
Polygonatum odoratum	22	6	3	4		17		
Helleborus niger		22		30				
Teucrium chamaedrys		6	9	7		14		10
Geranium sanguineum							28	13
Silene nutans	11	6	6					13
Betonica officinalis	11	22						
Asplenium adiantum-nigrum		8	5		11	8		
Quercus petraea		11		4		6		8
Asparagus acutifolius	22				6			
Rubus saxatilis							22	6
Calamintha nepetoides			3			14		8
Peucedanum cervaria				11		14		
Anthericum ramosum				7				17
Peucedanum oreoselinum		6	5					6
Molinia altissima			6	7				3
Euphorbia cyparissias						11		3
Phyteuma scheuchzeri								13
Rhamnus saxatilis		6		4				
Campanula persicifolia			6					3
Clematis recta			3					3
Sedum telephium			6					
Lembotropis nigricans								6
Anemone trifolia								3

D = differential species

Table 2 — *Buglossoido-Ostryetum* Gerdol, Lausi, Piccoli et Poldini 1982.

Relevé n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
Elevation m (x 10)	51	65	66	50	46	50	52	52	45	56	42	50	52	75	40	42	42	30	42	
Aspect	SE	SE	SW	SW	W	S	S	SW	SW	NE	SE	S	SE	SW	NW	SE	W	NE	W	
Slope angle (°)	15	20	15	5	25	25	25	35	25	20	20	20	15	15	10	15	25	10	5	
Relevé area m^2 (x10)	20	20	30	20	20	20	20	30	30	30	30	30	25	30	30	25	30	20	20	
Cover (%) tree layer	100	95	95	90	95	90	95	95	90	90	90	90	90	90	90	85	90	90	95	
shrub "	80	50	60	60	80	80	60	20	40	70	20	80	40	70	70	80	70	90	80	
herb. "	60	60	80	80	80	60	40	70	80	70	50	70	70	60	60	60	65	90	70	
N. of species	50	42	41	39	46	47	37	40	41	44	42	33	38	43	35	41	35	53	43	
BUGLOSSOIDO-OSTRYETUM																				
Vinca minor (D)	+			4	2	+		+	2		1	3	2	3	3	2	2		+	14
Rosa arvensis (D)	+	+	+		+					1		+				+	+	+	+	10
Buglossoides purpurocaerulea				+				+				1	2	+		+			+	7
Euphorbia amygdaloides					+							+	+			+	+	+	+	7
Knautia drymeia (D)			1					+	+	1			+					+		6
Salvia glutinosa (D)		+			+			+		+				+				+		6
Carpinus betulus (D)	1																2		1	3
Viburnum opalus (D)										+					+	+				3
Symphytum tuberosum (D)					+													+	+	3
Acer pseudoplatanus (D)											+			+						2
OSTRYO-CARPINION ORIENTALIS																				
Ostrya carpinifolia	4	4	4	3	4	4	5	4	3	4	4	4	4	4	3	4	2	4	3	19
Mercurialis ovata	+					1					+			+	+	+				6
Celtis australis							+		+		+									3
Asparagus tenuifolius						+										+			r	3
Dianthus monspessulanus	+	+																		2
ORNO-OSTRYENION																				
Helleborus odorus (D)	+	+					+	+	+							+		+	+	8
Laburnum anagyroides								+			+						1			3
Cytisus sessilifolius (D)												+		+		1				3
Hierochloë australis		+	1																	2
Lilium croceum/bulbiferum						+														1
QUERCETALIA PUBESCENTI-PETRAEAE																				
Fraxinus ornus	1	1	1	1	2	1	+	+	+	1		2	1	2	3	1	2	1	1	18
Quercus pubescens		1	1	2		1			2	1	+	2	2	1	1	1		1	+	14
Cornus mas	+	1		1	1	+	+		+		+	3	1	+				1	1	13
Melittis melissophyllum	+	+		+	+	+		+		+	+			+		+		+	+	12
Quercus cerris	1	1	+				1	2	+		+	1	+	2			1			11
Tanacetum corymbosum			+		+			1	+			+	+	+			+	+		9
Arabis turrita	+	+	+						+											4
Lathyrus niger																		+	+	2
Sorbus torminalis																			1	1
Hypericum montanum							+													1
QUERCO-FAGETEA																				
Cornus sanguinea	2	1	1	1	1	2	+	1	+	1	1	+	1	2	2	2	2	2	+	19
Corylus avellana	1		1	+	2	+	+	1	+	+	+	1	+	1	2	+	+	+	1	18
Hedera helix	2	2	2	1	1	2	+	2	2	1	2	1	2		+		2	2	1	17
Crataegus monogyna	+	+		2	1		1	+	+	+	+	1	1	1	+	+	1	1	+	7

Presences

Coronilla emerus subsp. emerus	+	+	+	+	+	+	+	+	+	+	+	1	+			+	+	+		16
Tamus communis	+	1	+		+	1		+			+	1	+	+	+	+	+	1	1	15
Viburnum lantana	+			+	+	+			+	+	+	1	+	+	+	1	+	+	+	15
Festuca heterophylla	1	+	1	+		+	1	2	2			1		+	+		2	+		13
Hepatica nobilis	1	+		+	+	+				1	+		+	+	1	+		1	+	13
Ligustrum vulgare		+		1	+			+	+	+		1	+		+	1	+	+	+	13
Clematis vitalba	+				+	+	+	+		+		+	+	+	+	+	+	+		13
Acer campestre	+	+	+	+	+					+		+	+				+	1	1	11
Carex digitata		+			+					1	1	+	1	+	+			+	+	10
Prunus spinosa			+	+	+	+	+			+	+	1	+					+		10
Cephalanthera longifolia		+		+		+	+	+	+	+			+		+	+				10
Campanula trachelium	1	+	+		+	+		+	+	+								+		9
Viola reichenbachiana								+	+	+	+			+	+		+	+	+	9
Primula vulgaris		1	+		+			1	+			+	1					1		8
Brachypodium sylvaticum	+	+	+	+				1	+				+			+				8
Lonicera xylosteum	+				+	+				+	+	+	+		+					8
Melampyrum velebiticum	+	1	3		1	+									+		+			7
Prunus avium	+	1					+		1	1	+									6
Sorbus aria	+		+			1					+			+	+					6
Ulmus minor				1			+	+					+				+		+	6
Galium laevigatum	+			+	+												+	1	+	6
Euphorbia dulcis						+				+	+	+		+					+	6
Euonymus europaea					+				+	+	+						1			5
Rhamnus catharticus		+	+			+							+		+					5
Rosa canina				+			+		+					+	+					5
Melica uniflora										1							+	+		3
Lathyrus vernus	+				+													1		3
Lamiastrum flavidum								+			+						+			3
Epimedium alpinum																		3	3	2
Fagus sylvatica			1								+									2
Tilia cordata	+									+										2
Thalictrum aquilegiifolium					+												+			2
Daphne mezereum										+									+	2
Mercurialis perennis															+			+		2
Sanicula europaea																		+	+	2

COMPANION SPECIES

Cruciata glabra	+	+	+	+	+	+	+	+		+	+	+	+	1	+	+		+		16
Ruscus aculeatus		+		1		1	+	+	1		+	1	+		+	1	+	+	2	14
Fragaria vesca	+	+	+	+	+			+	+	+	+						+	+	+	12
Rubus fruticosus agg.	+	1		+		+		+		+		+	+			1		+	+	11
Vincetoxicum hirundinaria	+		+	+	+	+	+		+	+			+	+					+	11
Solidago virgaurea	+	+	+		+		+	+	+	+	+							+	+	11
Helleborus niger								+	+	+	+	1	1	1	1	+	+			10
Viola hirta		+		+	+	+	+	+				1		+				+	+	10
Cyclamen purpurascens	+				+	+	+			+	+			+	+	+				9
Castanea sativa	+				+			1	1	2	1							1	2	8
Melica nutans	+							1	+	1	1		1	2	1					8
Lonicera caprifolium	+	+		+	+	+			+									1	+	8
Carex humilis			+	+		1	1								+	+				6
Teucrium chamaedrys			+			+	+	+						+		+				6
Asplenium trichomanes	+	+	+	+													+	+		6
Asplenium adiantum-nigrum	r		+						r	+							r	+		6
Carex alba	2				1									+	1	+				5
Brachypodium pinnatum				+		+	1								1	1				5
Juniperus communis		+	+	+		+	+													5
Quercus petraea									+		+		+				1			4
Hieracium sylvaticum	+	+	+								+									4
Carex flacca		+		+										+					+	4

Chamaecytisus hirsutus			+			+	+											+				4
Molinia altissima					+	+	+									+		+				4
Betonica officinalis								+	+	+	+											4
Serratula tinctoria				+						+	+										+	4
Sesleria varia								+														3
Erica herbacea					+					r												3
Silene nutans	+	+									+											3
Polypodium interjectum	+																				+	3
Dactylis glomerata			+			+	+															3
Polygonatum odoratum						+			+									+				3
Pimpinella major			+				+									+						3
Peucedanum cervaria																+	+	+				3
Peucedanum oreselinum						r	+	+														3
Pteridium aquilinum																r		+		+		3

D = differential species

Table 3 — *Sesleria variae-Ostryetum* ass. nova.

Relevé n.	1	2	3	4	5	6	7	
Elevation m (x 10)	28	60	65	79	54	37	50	
Aspect	E	SW	W	NW	NW	W	S	
Slope angle (°)	30	20	25	30	20	35	35	
Relevé area m^2 (x 10)	20	20	40	40	40	40	20	
Cover (%) tree layer	80	95	90	90	50	60	80	
shrub "	40	60	30	20	60	80	70	
herb. "	80	90	10	20	20	25	70	
N. of species	37	49	39	39	47	39	38	
SESLERIO VARIAE-OSTRYETUM								
Sesleria varia (D)	3	2	3	3	1	3	2	7
Polygala chamaebuxus (D)	+	+	+	+	1	+	1	7
Erica herbacea (D)	1	2	+	+	+	+		6
Amelanchier ovalis (D)	+		+	+	+	1		5
Calamagrostis varia (D)	1	2						2
Cotoneaster tomentosus (D)			+	+				2
OSTRYO-CARPINION ORIENTALIS								
Ostrya carpinifolia	3	4	4	3	3	2	3	7
Dianthus monspessulanus	+	1				+		3
Mercurialis ovata	+	+					+	3
ORNO-OSTRYENION								
Cytisus sessilifolius (D)		+	+		+	1	+	5
Hierochloë australis				+	+	+		3
Lilium croceum/bulbiferum		r			+		+	3
Laburnum anagyroides			+			+		2
QUERCETALIA PUBESCENTI-PETRAEAE								
Fraxinus ornus	2	1	1	1	2	1	1	7
Quercus cerris	1	+		+	1		1	5
Quercus pubescens		+	1		2	1		4
Cornus mas			+	1	1			3
Melittis melissophyllum			+	+	+			3
Tanacetum corymbosum				+	+			2
Sorbus torminalis					+			1
QUERCO-FAGETEA								
Coronilla emerus subsp. emerus	+	+	+	+	+	1	1	7
Melampyrum velebiticum	2	3	1	1	+		1	6
Viburnum lantana		+	+	+	+	1	+	6
Prunus spinosa	+	+		+	+	+	+	6
Cotinus coggygria		+	+		+	2	1	5
Tamus communis		+	r		+	+	1	5
Hepatica nobilis	+	+	+	+	+			5
Lonicera xylosteum	+	+	+	+	+			5
Crataegus monogyna		+	+	+	+		+	5
Corylus avellana	1	+		+			+	4
Cephalanthera longifolia		+	+		1	+		4
Hedera helix		2		+		+		3
Carex digitata		+	1	1				3
Sorbus aria		1		+	+			3

presences

Cornus sanguinea					+	+	+	3
Ligustrum vulgare					+	+	+	3
Viola mirabilis			1	1				2
Primula vulgaris		+			1			2
Festuca heterophylla		1				+		2
Acer campestre		+		+				2
Galium laevigatum		+		+				2
Rhamnus catharticus		+					+	2
Viola reichenbachiana			+	+				2
COMPANION SPECIES								
Cyclamen purpurascens	+	+	+	+	+	+	+	7
Brachypodium pinnatum	1	+	+		+	+	1	6
Carex humilis	+	+		+	1	+	1	6
Hieracium sylvaticum	+	+	+	+	+	+		6
Juniperus communis		+	+		+	1	+	5
Polypodium interjectum		+	+	+	+	+		5
Anthericum ramosum	1		+		1	1		4
Phyteuma scheuchzeri	+	+			+		+	4
Fragaria vesca		+	+	+			+	4
Asplenium trichomanes		+	+		+	+		4
Solidago virgaurea		+		+	+		+	4
Geranium sanguineum			+	+		+	+	4
Silene nutans			+		+	+	+	4
Vincetoxicum hirundinaria	1					+	+	3
Teucrium chamaedrys	+				+	+		3
Rubus fruticosus agg.	1	+						2
Quercus petraea	1				+			2
Carex alba	1					+		2
Lembotropis nigricans	+	+						2
Cruciata glabra	+				+			2
Peucedanum oreoselinum	+						+	2
Pimpinella major		+					+	2
Calamintha nepetoides		+	+					2
Rubus saxatilis				+		+		2
Asplenium ruta-muraria			r			+		2
Peucedanum austriacum			r	r				2

D = differential species

Appendix

List of the rare species.

Table 2 *(Buglossoido-Ostryetum)*

In two relevés — Rhamnus saxatilis (9,16); Asplenium ruta-muraria (3,7); Sedum telephium (1,3); Frangula alnus (13,15); Ilex aquifolium (10,17); Primula veris (10,17); Veronica chamaedrys (1,18); Campanula persicifolia (1,3); Calamagrostis varia (2,5); Polygala chamaebuxus (14,16); Amelanchier ovalis (14,16).

In one relevé — Neottia nidus-avis, cl. (1); Cotinus coggygria, cl. (4); Allium pulchellum (4); Calamintha nepetoides (4); Viola mirabilis, cl. (5); Asarum europaeum, cl. (5); Prunus mahaleb, cl. (6); Thesium bavarum (6); Clematis recta (6); Inula conyza (7); Ceterach officinarum (7); Ranunculus nemorosus (8); Anthericum ramosum (9); Peucedanum austriacum (14); Berberis vulgaris, cl. (15); Dictamnus albus (16); Pyrus pyraster, cl. (17); Glechoma hederacea (18); Asparagus acutifolius (18); Mycelis muralis (18); Luzula forsteri (18).

Table 3 *(Seslerio variae-Ostryetum)*

In one relevé — Melica nutans (1); Lonicera caprifolium (1); Anemone trifolia (1); Molinia altissima (1); Campanula persicifolia (1); Frangula alnus (1); Tilia cordata, cl. (2); Epimedium alpinum (2); Chamaecytisus hirsutus (2); Lathyrus vernus, cl. (3); Veronica urticifolia, cl. (3); Fagus sylvatica, cl. (4); Neottia nidus-avis, cl. (4); Acer pseudoplatanus, cl. (4); Rosa canina, cl. (5); Viola hirta (5); Ruscus aculeatus (5); Prunus mahaleb, cl. (6); Mercurialis perennis, cl. (6); Berberis vulgaris, cl. (7); Euphorbia cyparissias (7); Buphtalmum salicifolium (7); Knautia drymeia (7); Clematis recta (7); Helleborus niger (7).

Cl. = character species of the class *Querco-Fagetea*.

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