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GRASSLAND–WOODLAND MOSAICS IN THE KISSZÉNÁS FOREST RESERVE (HUNGARY)

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Phytosociological structure of grassland–woodland mosaics were studied in the Kisszénás Forest Reserve (Hungary) based on 115 relevés. Five groups of relevés were separated by multivariate analyses that represent the typical mosaics. The vegetation was analysed statistically according to phytogeographical area, phytosociological character, social behaviour type and ecological indicator values (preference categories) of the species. Grassland–woodland mosaics may be partly characterised by several types of coenotones and ecotones. With 10 tables and 1 figure.

Key words: coenotone, ecotone, Kisszénás forest reserve, multivariate analysis, phytosociology

INTRODUCTION

Forest reserves are forested areas that serve the purposes of conservation of natural or semi-natural forest communities, maintain undisturbed natural forest dynamics and provide opportunities for scientific research. In these areas all human activities are ultimately stopped so that the natural processes of the forests can prevail and thus become easier to recognise and study. The Hungarian Forest Reserve Network (HFRN) was established with 71 reserves in 1994 (CZÁJLIK and STANDOVÁR 1999).

As a member of the HFRN, the Kisszénás Forest Reserve is situated in the northwestern part of the Buda Mts near Pilisszentiván (Hungary). Total area of this reserve is 111.5 ha (of which the core area and the buffer zone occupy 34.0 ha and 77.5 ha, respectively). The main bedrock of this area is Triassic diplopore dolomite; the average elevation of the dolomite hills is 300–400 m.

VIRÁG (2008) carried out vegetation mapping and study of this reserve, DOBOLYI (2003, 2005, 2008) and DOBOLYI *et al.* (2008) made phyto-

sociological studies of grasslands in this area. According to these works, the vegetation of the Kisszénás Forest Reserve is semi-natural, *i.e.* the original woodlands and grasslands have for a long time been influenced by human activity (first of all forestry and grazing). In its current state the vegetation is characterised by the following forest and grassland plant communities.

Forests:

- *Carici pilosae-Carpinetum* (oak-hornbeam forest),
- *Cotino-Quercetum pubescentis* (Pannonian karst pubescent oak low wood),
- *Daphno laureolae-Fagetum* (Middle European dry-slope limestone beech forests),
- *Fago-Ornetum* (Pannonian mixed karst wood),
- *Primulo veris-Tilietum platyphyllae* (dolomite slope lime wood),
- *Quercetum petraeae-cerris* (Pannonian Turkey oak-sessile oak wood),
- *Veratro nigri-Fraxinetum orni* (dolomite top forest),
- *Vicio sparsiflorae-Quercetum pubescentis* (closed karst pubescent oak wood).

Grasslands:

- *Chrysopogono-Caricetum humilis* (rock steppe),
- *Festuco pallenti-Brometum pannonici* (closed dolomite grassland),
- *Seseli leucospermi-Brometum pannonici* (closed dolomite grassland),
- *Seseli leucospermi-Festucetum pallentis* (open dolomite grassland),
- *Stipo eriocauli-Festucetum pallentis* (open dolomite grassland).

The plant community *Cotino-Quercetum pubescentis* has been described as a grassland–woodland mosaic community, but according to the field experiences the other woodlands and grasslands can also compose mosaics, which cover about 6–8% of the Kisszénás Forest Reserve. The purpose of the recent study is to provide phytosociological information about these mosaic vegetation patches.

MATERIAL AND METHODS

In this study grassland–woodland mosaics are vegetation patches in which the cover value of the tree layer is between 35 and 65%. 115 phytosociological relevés of 5 m × 5 m size were taken so that the full scale of grassland–woodland mosaics of the Kisszénás Forest Reserve can be represented. Cover values of the species were estimated at percentage scale and were transformed to the scale 1 to 9 (VAN DER MAAREL 1979).

Nomenclature of the plant names follows HORVÁTH *et al.* (1995).

Fifty-seven reference relevés of the "COENODATREF" phytosociological database were included in the multivariate analyses, which represent the woodland and grassland communities of the forest reserve area (Table 1) (LÁJER *et al.* 2007). These relevés indicate the place of the relevant plant communities in the abstract ordination space.

The relevés were analysed by the following multivariate methods with SYN-TAX 2000 program packages (PODANI 2001).

1) Hierarchical classification,

– distance optimising procedure: group average (UPGMA);

2) ordinations,

– centered principal component analysis (PCA),

– principal coordinate analysis (metric multidimensional scaling; PCoA).

The applied distance coefficients are: Euclidean distance and Bray–Curtis-index (PODANI 1997).

The separated relevé groups were analysed statistically on the basis of the following species characteristics: phytogeographical area (floral element) (HORVÁTH *et al.* 1995), phytosociological character, social behaviour type and ecological indicator values (preference categories) (BORHIDI 1993). The values of features characterising the groups of relevés were calculated according to percentage pro rata of plant mass, that is, the sum of the transformed cover values concerning one feature has been expressed in percentage of sum of all cover values of all species.

The average naturalness value of the groups was calculated with the following formula:

$$\overline{NV} = \frac{\sum^{sp}\left(\sum^{relevé} M * NV\right)}{\sum^{group} M}$$

Where $\overline{NV}$: average naturalness value of the relevé group,

NV: naturalness value of the species (BORHIDI 1993),

M: cover value of the species (VAN DER MAAREL 1979),

$\sum^{relevé} M$: sum of the cover values of one species (summarising according to the relevés),

$\sum^{sp}$: summarising according to the species,

$\sum^{group} M$: sum of total cover values of the relevé group.

RESULTS

Based on the multivariate analyses and field experiences five groups of relevés were separated (Fig. 1). The groups are characterised with the floristical composition, presence of constant and diagnostic species, phytogeographical and phytosociological spectra, social behaviour type of the species, and environmental and ecological circumstances. Results of the statistical analyses of the groups are given in Tables 2 to 10. The given data were calculated in the same way as in DOBOLYI (2003, 2005 and 2008) and DOBOLYI *et al.* (2008), so they are compatible and comparable with data of the earlier vegetation studies.

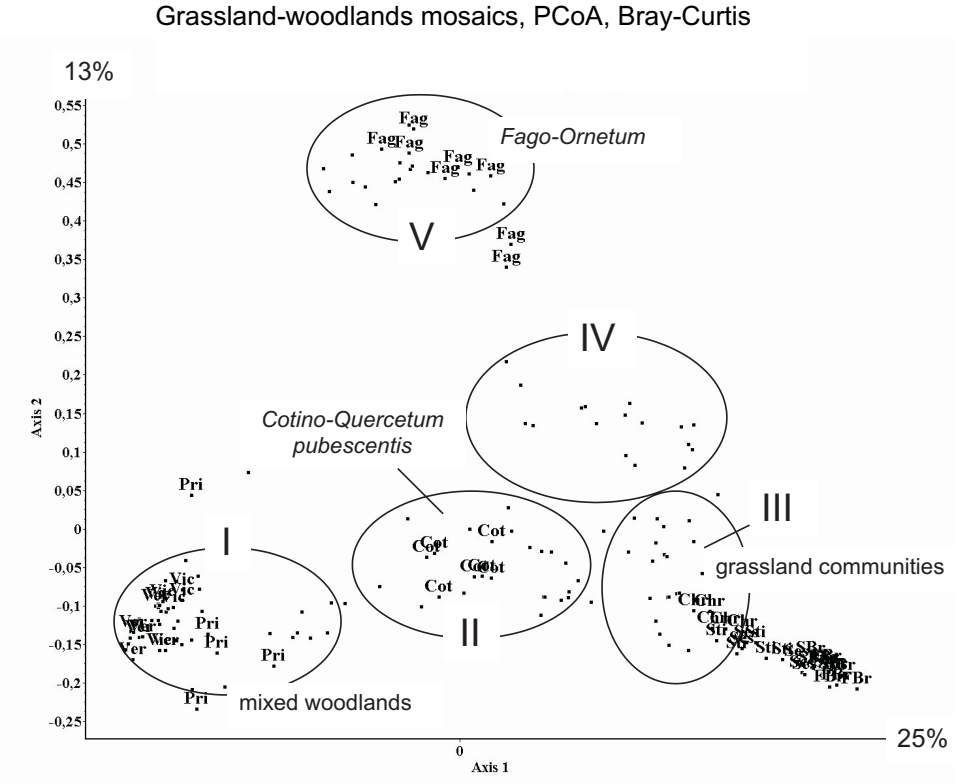


Fig. 1. Principal coordinate analysis (PCoA) of the relevés (I–V: relevé groups)

Table 1. Data of the reference relevés

Code	Plant community	Number of relevés
Ses	*Seseli leucospermi-Festucetum pallentis*	5
Sti	*Stipo eriocauli-Festucetum pallentis*	5
Chr	*Chrysopogono-Caricetum humilis*	5
SBr	*Seseli leucospermi-Brometum pannonici*	5
FBr	*Festuco pallenti-Brometum pannonici*	5
Cot	*Cotino-Quercetum pubescentis*	7
Fag	*Fago-Ornetum*	8
Pri	*Primulo veris-Tilietum platyphyllae*	5
Ver	*Veratro nigri-Fraxinetum orni*	6
Vic	*Vicio sparsiflorae-Quercetum pubescentis*	6

Table 2. The phytogeographical spectrum of the groups of relevés (ranking according to HORVÁTH *et al.* (1995) (expressed in percentage)

	Groups of relevés				
Area	I	II	III	IV	V
?	0.3	–	–	–	–
Adventive	–	0.6	0.8	0.6	–
Cosmopolitan	1.4	–	0.5	–	–
Circumpolar	3.0	2.3	3.5	3.2	6.8
Eurasian	13.5	11.2	7.8	15.7	17.3
Continental	0.3	7.5	10.8	9.0	3.0
European	28.0	12.3	13.7	9.8	13.4
Central European	8.0	10.1	15.1	19.9	26.6
Central European-Alpine	–	0.2	0.2	0.5	–
Sub-Mediterranean	22.9	21.8	12.3	12.4	11.0
East-Sub-Mediterranean	13.9	11.1	8.7	9.0	15.7
Pontic	0.6	1.2	0.6	1.3	4.1
Pontic-sub-Mediterranean	0.8	2.0	3.4	3.1	–
Pontic-Pannonian	0.6	1.9	1.8	1.4	0.7
Atlantic-sub-Mediterranean	4.7	3.8	2.9	3.7	1.5
Sub-Atlantic	0.8	3.6	4.0	3.6	–
Sarmatian	0.2	0.7	1.3	1.4	–
Illyric	–	6.5	7.6	0.7	–
Pannonian-Balkan	0.3	0.4	1.0	1.1	–
Alpine-Balkan	0.5	1.3	1.3	0.3	–
Carpathian endemic	–	0.1	0.1	0.3	–
Pannonian endemic	–	0.7	1.8	1.3	–
Local endemic	–	0.6	0.8	1.7	–

Table 3. Distribution of phytosociological characters (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Phytosociological character	I	II	III	IV	V
Secalietea	0.6	–	–	–	–
Calystegietalia	0.7	–	–	–	–
Glechometalia	1.0	–	–	–	–
Sedo-Scleranthetea	–	–	–	0.1	–
Festuco-Brometea	5.0	9.8	11.4	9.9	7.6
Festucetalia valesiacae	1.6	17.4	23.5	22.3	4.7
Festucion valesiacae	–	–	0.1	0.2	–
Asplenio-Festucion pallentis	–	0.3	1.6	1.2	–
Bromo-Festucion pallentis	0.1	11.8	15.6	6.1	–
Festucetalia vaginatae	–	–	0.1	–	–
Festucion vaginatae	–	0.4	1.3	2.1	–
Molinio-Arrhenatheretea	–	–	0.5	0.2	–
Epilobietea angustifolii	0.8	–	–	–	–
Erico-Pinetea	–	0.6	0.8	0.6	–
Querco-Fagetea	27.0	9.5	6.1	5.3	15.6
Quercetalia pubescentis-petraeae	25.8	17.9	9.5	13.0	9.1
Orno-Ostryon	12.5	14.5	12.9	17.4	25.7
Quercion petraeae-cerris	0.2	–	–	–	–
Fagetalia	5.3	1.0	0.7	1.0	5.8
Fagion sylvaticae	2.1	0.7	1.3	8.3	20.8
Prunetalia spinosae	7.7	4.1	3.9	2.8	–
Indifferent	9.5	12.0	10.6	9.6	10.7

Table 4. Distribution of the social behaviour types (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Social behaviour type	I	II	III	IV	V
Unique specialists	–	–	0.10	0.70	–
Rare specialists	–	0.30	0.40	–	–
Specialists	4.00	10.40	15.10	16.80	10.20
Rare competitors	0.10	–	–	–	0.30
Competitors	41.00	40.30	37.10	37.10	41.30
Unique Generalists	–	0.60	0.70	0.90	–
Generalists	46.10	41.50	39.60	38.50	42.50
Natural pioneers	–	–	–	0.10	1.00
Disturbance tolerants	7.90	6.40	6.10	5.20	4.70
Introduced alien species	–	0.60	0.80	0.60	–
Weeds	0.80	–	–	–	–
Average naturalness value	4.31	4.49	4.49	4.67	4.52

Table 5. Distribution of the temperature preference categories (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Temperature preference categories	I	II	III	IV	V
1–2	–	–	–	–	–
3	0.1	–	–	–	0.3
4	0.2	1.3	3.1	2.6	–
5	32.2	21.0	16.3	27.3	55.0
6	26.7	30.7	36.0	28.5	19.6
7	15.2	15.8	16.9	18.9	9.3
8	25.5	31.3	27.7	22.3	15.7
9	0.1	–	0.1	0.4	–

Categorisation of temperature preference: 1 = subnival or supraboreal belt; 2 = alpine, boreal or tundra belt; 3 = subalpine or subboreal belt; 4 = montane needle-leaved forest or taiga belt; 5 = montane mesophilous broad-leaved forest belt; 6 = submontane broad-leaved forest belt; 7 = thermophilous forest or woodland belt; 8 = sub-Mediterranean woodland and grassland belt; 9 = eu-Mediterranean evergreen belt.

Table 6. Distribution of the water preference categories (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Water preference categories	I	II	III	IV	V
1	0.1	4.8	8.3	10.0	–
2	0.6	9.4	12.5	11.7	–
3	31.0	52.4	50.0	36.1	30.3
4	24.4	19.6	17.4	18.2	14.0
5	34.7	13.2	10.5	22.4	47.2
6	7.9	0.4	1.2	1.0	8.5
7	1.0	–	–	0.3	–
8	0.2	0.2	0.1	0.3	–
9–12	–	–	–	–	–

Categorisation of water preference: 1 = plants of extremely dry habitats or bare rocks; 2 = xero-indicators on habitats with long dry period; 3 = xero-tolerants, but eventually occurring on fresh soils; 4 = plants of semidry habitats; 5 = plants of semihumid habitats, under intermediate conditions; 6 = plants of fresh soils; 7 = plants of moist soils not drying out and well aerated; 8 = plants of moist soils tolerating short floods; 9 = plants of wet, not well aerated soils; 10 = plants of frequently flooded soils; 11 = water plants with floating or partly emergent leaves; 12 = water plants, most wholly submersed in water.

Table 7. Distribution of the reaction preference categories (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Reaction preference categories	I	II	III	IV	V
1–2	–	–	–	–	–
3	–	3.6	4.0	3.6	–
4	–	0.4	–	–	–
5	3.5	2.4	4.0	4.2	3.2
6	18.4	12.5	10.7	11.3	14.7
7	35.5	16.9	16.7	22.3	37.1
8	41.4	49.3	43.3	43.2	42.0
9	1.2	14.9	21.3	15.4	3.0

Categorisation of reaction preference: 1 = plants of extremely acidic, explicitly calcium-free sites; 2 = intermediate type between 1 and 3; 3 = acidifrequent plants, mostly in acidic soils; 4 = plants of moderately acidic soils; 5 = plants of slightly acidic soils; 6 = mostly on neutral soils but also in acidic and basic ones, generally widely tolerant, more or less indifferent plants; 7 = basifrequent plants, mostly on basic soils; 8 = plants of basiphilous sites; 9 = plants of explicitly calcareous sites and ultrabasic specialists.

Table 8. Distribution of the nitrogen preference categories (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Nitrogen preference categories	I	II	III	IV	V
1	1.1	14.3	19.3	19.2	–
2	19.3	28.7	25.4	27.8	17.8
3	19.3	37.1	34.3	26.2	32.8
4	31.9	14.1	15.7	14.9	14.6
5	10.6	4.9	4.6	10.9	33.2
6	2.9	–	–	0.4	1.5
7	8.5	0.3	0.7	0.6	–
8	6.0	0.7	–	0.1	0.2
9	0.3	–	–	–	–

Categorisation of nitrogen preference: 1 = only in soils extremely poor in mineral nitrogen, e. g. peat bog plants; 2 = plants of habitats very poor in nitrogen; 3 = plants of moderately oligotrophic habitats; 4 = plants of submesotrophic habitats; 5 = plants of mesotrophic habitats; 6 = plants of moderately nutrient rich habitats; 7 = plants of soils rich in mineral nitrogen; 8 = N-indicator plants of fertilised soils; 9 = plants only on hyperfertilised soil, extremely rich in mineral nitrogen (indicating pollution, manure deposition).

Table 9. Distribution of the light preference categories (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Light preference categories	I	II	III	IV	V
1	–	–	–	–	–
2	0.2	–	–	–	–
3	5.2	1.6	1.4	8.3	24.4
4	11.5	3.2	3.1	2.1	3.4
5	26.0	15.2	13.4	18.4	37.7
6	29.0	14.6	7.8	9.5	17.9
7	25.1	35.5	32.8	30.2	14.9
8	3.0	19.7	26.5	15.1	0.7
9	–	10.1	14.9	16.4	1.0

Categorisation of light preference: 1 = full shadow plants, often receiving less than 1%, rarely receiving more than 30% of the full day light; 2 = very shadow-tolerant plants; photosynthetic minimum at 1 to 5% of full day light; 3 = shadow plants; photosynthetic minimum under 5% relative light intensity, but survive more illuminated places; 4 = shadow-half shadow plants; photosynthetic minimum between 5 and 10% relative light intensity; 5 = half shadow plants receiving more than 10% but less than 100% relative light intensity; 6 = half shadow-half light plants; photosynthetic minimum between 10 and 40% relative light intensity; 7 = half light plants, mostly living in full light but also shadow tolerants; 8 = light plants; photosynthetic minimum above 40% relative light intensity, less only exceptional cases; 9 = full light plants of open habitats not receiving less than 50% of relative light intensity.

Table 10. Distribution of the continentality preference categories (BORHIDI 1993) (expressed in percentage)

	Groups of relevés				
Continentality preference categories	I	II	III	IV	V
1	–	–	–	–	–
2	9.2	2.2	1.6	8.6	25.4
3	16.3	8.5	5.5	4.2	8.3
4	52.0	60.5	59.5	47.2	38.9
5	14.4	18.7	21.0	20.3	11.8
6	4.4	2.8	4.6	6.1	3.4
7	2.8	6.8	7.4	12.6	10.3
8	0.8	0.5	0.5	1.0	1.9
9	–	–	–	–	–

Categorisation of continentality preference: 1 = eu-oceanic species, reaching Central Europe only in the extreme West, not in Hungary; 2 = oceanic species, mainly in West Europe and western Central Europe; 3 = oceanic-suboceanic species, area in whole Central Europe; 4 = suboceanic species, mainly in Central Europe but reaching to East; 5 = intermediate type with slight suboceanic-subcontinental character; 6 = subcontinental species, main area in eastern Central Europe; 7 = continental-subcontinental species, main area in East Europe; 8 = continental species reaching only eastern part of Central Europe; 9 = eucontinental species, main area in Siberia and East Europe reaching scarcely the eastern part of Central Europe.

Group I

Number of relevés: 38.

Characteristics of the group:

– typical exposure: SE–SW;
– total cover of tree layer: 50–65%;
– vegetation type: mixed woodland close to the following plant communities: *Veratro nigri-Fraxinetum orni*, *Primulo veris-Tilietum platyphyllae* and *Vicio sparsiflorae-Quercetum pubescentis*;
– diagnostic species: *Melica uniflora*, *Brachypodium pinnatum*;
– constant species: *Fraxinus ornus*, *Quercus pubescens*, *Cornus mas*, *Melica uniflora*, *Crataegus monogyna*, *Acer campestre*, *Vincetoxicum hirundinaria*;
– dominant species: *Fraxinus ornus*, *Quercus pubescens*;
– species characteristics: high proportion of sub-Mediterranean (including East-sub-Mediterranean) flora elements, endemic species are absent (Table 2), high proportion of Querco-Fagetea and Quercetalia pubescentis-petraeae species (Table 3).

Group II

Number of relevés: 20.

Characteristics of the group:

– typical exposure: (SW)–W–(NW);
– total cover of tree layer: 40–50%;
– vegetation type: this group is considered a variant of *Cotino-Quercetum pubescentis* (Fig. 1), but *Cotinus coggygria* is absent. The herb layer is close to *Festuco pallenti-Brometum pannonici*;
– diagnostic species: *Phyteuma orbiculare*;
– constant species: *Fraxinus ornus*, *Quercus pubescens*, *Bromus pannonicus*, *Carex humilis*, *Anthericum ramosum*, *Polygonatum odoratum*, *Teucrium chamaedrys*;
– dominant species: *Fraxinus ornus*, *Quercus pubescens*, *Bromus pannonicus*, *Carex humilis*;
– species characteristics: high proportion of sub-Mediterranean and East-sub-Mediterranean flora elements (Table 2);
– phytosociological composition is a transition between group I and group III.

Group III

Number of relevés: 21.

Characteristics of the group:

– typical exposure: SE–SW;

– total cover of tree layer: 35–40%;
– vegetation type: edges between xerotherm oak-woodlands and grassland communities. The herb layer is close *Chrysopogono-Caricetum humilis* and *Festuco pallenti-Brometum pannonici*;
– diagnostic species: *Bromus pannonicus*, *Carex humilis*, *Genista pilosa*,
– constant species: *Fraxinus ornus*, *Quercus pubescens*, *Bromus pannonicus*, *Carex humilis*, *Anthericum ramosum*, *Genista pilosa*, *Berberis vulgaris*;
– dominant species: *Bromus pannonicus*, *Carex humilis*;
– species characteristics: the highest proportion of Illyric flora elements (Table 2), high proportion of specialists (Table 4), the highest proportion of the xero-tolerant species (Table 6), high proportion of light and full light plant species (Table 9);
– phytosociological composition: high proportion of dry grassland elements (Festuco-Brometea, Festucetalia valesiacae, Bromo-Festucion pallentis) (Table 3).

Group IV

Number of relevés: 18.

Characteristics of the group:
– typical exposure: SW–W–(NW);
– total cover of tree layer: 40–50%;
– vegetation type: this group is a transition between *Cotino-Quercetum pubescentis* and *Fago-Ornetum* (Fig. 1). The grassland component and herb layer is close to *Festuco pallenti-Brometum pannonici*;
– diagnostic species: *Carex alba*;
– constant species: *Fraxinus ornus*, *Quercus pubescens*, *Anthericum ramosum*, *Carex alba*, *Fagus sylvatica*;
– dominant species: –;
– species characteristics: no typical flora elements found in these (Table 2); the highest proportion of specialists and the highest average naturalness value are observed (Table 4);
– phytosociological composition is a transition between groups II, III and V (Table 3).

Group V

Number of relevés: 16.

Characteristics of the group:
– typical exposure: W–NW–N;
– total cover of tree layer: 50–65%;
– vegetation type: this group belongs to *Fago-Ornetum* (Fig. 1);
– diagnostic species: *Fagus sylvatica* and *Carex alba*;

– constant species: *Fagus sylvatica*, *Fraxinus ornus*, *Carex alba*;
– dominant species: –;
– species characteristics: rare and special flora elements (*e.g.* Illyric, Balkan, endemic species) are of low proportion or absent (Table 2), the highest proportion of the montane, mesophilous species (Table 5), the highest proportion of shadow plants (Table 9), the highest proportion of oceanic species (Table 10) is observed;
– phytosociological composition: the highest proportion of the Orno-Ostryon, Fagetalia and Fagion sylvaticae species, species of grassland communities are almost absent (Table 3).

DISCUSSION

Shown by the statistical analyses, the grassland–woodland mosaics of the Kisszénás Forest Reserve are heterogenous from the aspect of phytosociology and can be mainly classified into the following three vegetation types.

1) Woodland-dominated mosaics. – This type is essentially a woodland vegetation that belongs to several woodland plant communities represented by the relevé groups I and V (Fig. 1). Grassland elements occur in low proportion in the herb layer (Table 3); full light and light plants are almost absent (Table 9).

2) Grassland-dominated mosaics. – Herb layer is rock steppe or closed dolomite grassland in this vegetation type. Grassland elements are predominant (with a cover value over 40%), and the cover of tree layer is less than 40% (relevé group III and partly IV).

3) Pannonian karst pubescent oak low wood (shrub forest) (*Cotino-Quercetum pubescentis*). – Constant and stable mosaic community developed typically on dolomite hills (relevé group II).

A number of grassland–woodland mosaic patches can be considered as transitions between two (or more) plant communities. According to Zólyomi's coenotone theory, transitional zones between two (or more) habitats of contrasting ecological parameters (ecotone) are covered by special vegetation (coenotone) that offer special environmental circumstances for the species (ZÓLYOMI 1987). These vegetation types play an important role in preserving sensitive plant species (specialist and/or relics).

In the recent study the following vegetation transitions can be considered coenotones:

Cotino-Quercetum pubescentis – Primulo veris-Tilietum platyphyllae,
Cotino-Quercetum pubescentis – Festuco pallenti-Brometum pannonici,
Fago-Ornetum – Festuco pallenti-Brometum pannonici,
Fago-Ornetum – Chrysopogono-Caricetum humilis.

The following specialist and unique specialist species are characteristic for the mentioned coenotones: *Anacamptis pyramidalis*, *Biscutella laevigata*, *Carex alba*, *Coronilla coronata*, *Coronilla vaginalis*, *Daphne cneorum*, *Draba lasiocarpa*, *Gypsophila fastigiata* subsp. *arenaria*, *Jurinea mollis*, *Limodorum abortivum*, *Linum dolomiticum*, *Onosma visianii*, *Paronychia cephalotes*, *Phyteuma orbiculare*, *Poa badensis*, *Polygala amara*, *Pulsatilla grandis*, *Seseli leucospermum*, *Stipa eriocaulis*, *Thalictrum minus* subsp. *pseudominus.*

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