Thaiszia - J. Bot., Košice, 24 (1): 1-21, 2014
http://www.bz.upjs.sk/thaiszia

THAISZIA
JOURNAL OF
BOTANY

Comparative analysis of the natural and semi-natural plant communities of Mt Nagy and other parts of the Villány Mts (south Hungary)

LÁSZLÓ ERDŐS[1], CSABA TÖLGYESI[1], ANDREA DÉNES[2], NIKOLETTA DARÁNYI[1], ANETT FODOR[1], ZOLTÁN BÁTORI[1] & DOLLY TOLNAY[1]

[1]Department of Ecology, University of Szeged, H-6726 Szeged, Közép fasor 52., Hungary; erdos.laszlo@bio.u-szeged.hu, Tel.: +36-62-546-951; Fax: +36-62-546-949

[2]Department of Natural History, Janus Pannonius Museum, H-7621 Pécs, Szabadság u. 2, Hungary; denes.andrea@jpm.hu, Tel.: +36-72-213-419

Erdős L., Tölgyesi C., Dénes A., Darányi N., Fodor A., Bátori Z. & Tolnay D. (2014): Comparative analysis of the natural and semi-natural plant communities of Mt Nagy and other parts of the Villány Mts (south Hungary). – Thaiszia – J. Bot. 24 (1): 1-21. – ISSN 1210-0420.

Abstract: The Villány Mts have a great nature conservation importance in Hungary, since large areas are covered with natural and near-natural sub-Mediterranean plant associations, providing habitat for several valuable species. However, the western parts of the Villány Mts, including Mt Nagy, are relatively understudied, though these may also harbour natural values of significant conservation importance. Based on 127 phytosociological relevés, we provide an analysis of the vegetation of Mt Nagy, in comparison with other parts of the Villány Mts. We carried out PCoA ordinations to assess the similarity of the plant communities of Mt Nagy to other parts of the Villány Mts. To characterize the naturalness of the habitats, we calculated social behaviour type spectra. We also calculated and compared the species richness of the communities. Finally, we compiled a list of protected and strictly protected plant species of Mt Nagy, based on a review of all earlier floristic publications as well as on our own observations. We found that the plant communities studied in the present article are in a good natural condition, although the calcareous scrubs and the open calcareous grasslands are degraded to a certain extent. Nevertheless, the social behaviour type spectra suggest that degradation is not too serious: although the proportion of disturbance-tolerants is high, the types indicating severe

degradation (weeds, ruderal competitors and agressive aliens) are scarce or absent. The open calcareous grasslands of Mt Nagy proved to be extremely species rich. Despite its small size, the literature indicates that at least 29 protected and strictly protected plant species occur on Mt Nagy. We conclude that Mt Nagy deserves to be protected at a higher level, and should be regarded as a potential part of the Villány Mts Landscape Protection Area, designation of which is currently in progress.

Keywords: calcareous grassland, calcareous scrub, species richness, protected species, nature conservation.

Introduction

Hosting a great number of protected, rare, endemic and relict species, the Villány Mts of southern Hungary are among the most diverse areas of the country. The Villány Mts are relatively well-known, both from a floristic and a phytosociological point of view. However, most previous studies focused on its central and eastern parts (Mt Szársomlyó, Mt Fekete, Mt Tenkes), whereas the western parts have largely been neglected (cf. DÉNES 2000). Recent floristic results suggest that the western parts, including Mt Nagy, may be important from a nature conservation point of view (ERDŐS et al. 2010a, 2011, 2013). In a rough analysis of the vegetation of the Villány Mts, ERDŐS et al. (2012) listed three natural or semi-natural plant communities from Mt Nagy: the calcareous scrub *Inulo spiraeifoliae-Quercetum pubescentis* (JAKUCS 1961) SOÓ & BORHIDI in SOÓ 1971, the closed calcareous grassland *Festuco rupicolae-Arrhenatheretum* ERDŐS & MORSCHHAUSER in ERDŐS, DÉNES & MORSCHHAUSER 2010 and the open calcareous grassland *Sedo sopianae-Festucetum dalmaticae* SIMON 1964. Although the areas covered by the above communities are relatively small on Mt Nagy, they provide habitat for a large number of protected and rare species, thus there is an urgent need for their detailed analysis to realize efficient conservation measures. In addition, information on these sub-Mediterranean associations contributes to our overall understanding of the vegetation of the SW Carpathian Basin.

The occurrence of the calcareous scrubs in the Villány Mts was first mentioned by HORVÁT (1956, 1963, 1965) from Mt Szársomlyó and Mt Tenkes, but he did not publish any relevés. A comprehensive study of the calcareous scrubs of the Villány Mts was carried out by DÉNES (1995). However, the scrubs of Mt Nagy were not included in the analysis.

The closed calcareous grassland *Festuco rupicolae-Arrhenatheretum* was studied by ERDŐS et al. (2010b), who described every occurrence of this community, except the stands on Mt Nagy, which were unknown at that time.

The open calcareous grassland *Sedo sopianae-Festucetum dalmaticae* was described by SIMON (1964) from Mt Szársomlyó. Later, KUN (1994) published five relevés from Mt Tenkes as well. BORHIDI & DÉNES (1997) and DÉNES (1998) mentioned the occurrence of the open calcareous grassland community on Mt Nagy, but neither relevés nor detailed descriptions were published.

The aim of our study is to characterize the natural and semi-natural plant communities of Mt Nagy, as well as to compare them with the corresponding stands of the rest of the Villány Mts. The second aim is to compile the list of all protected and strictly protected plant species of Mt Nagy, using both own and published data. Our results will be useful for nature conservation activities, possibly contributing to the protection of the natural values of Mt Nagy.

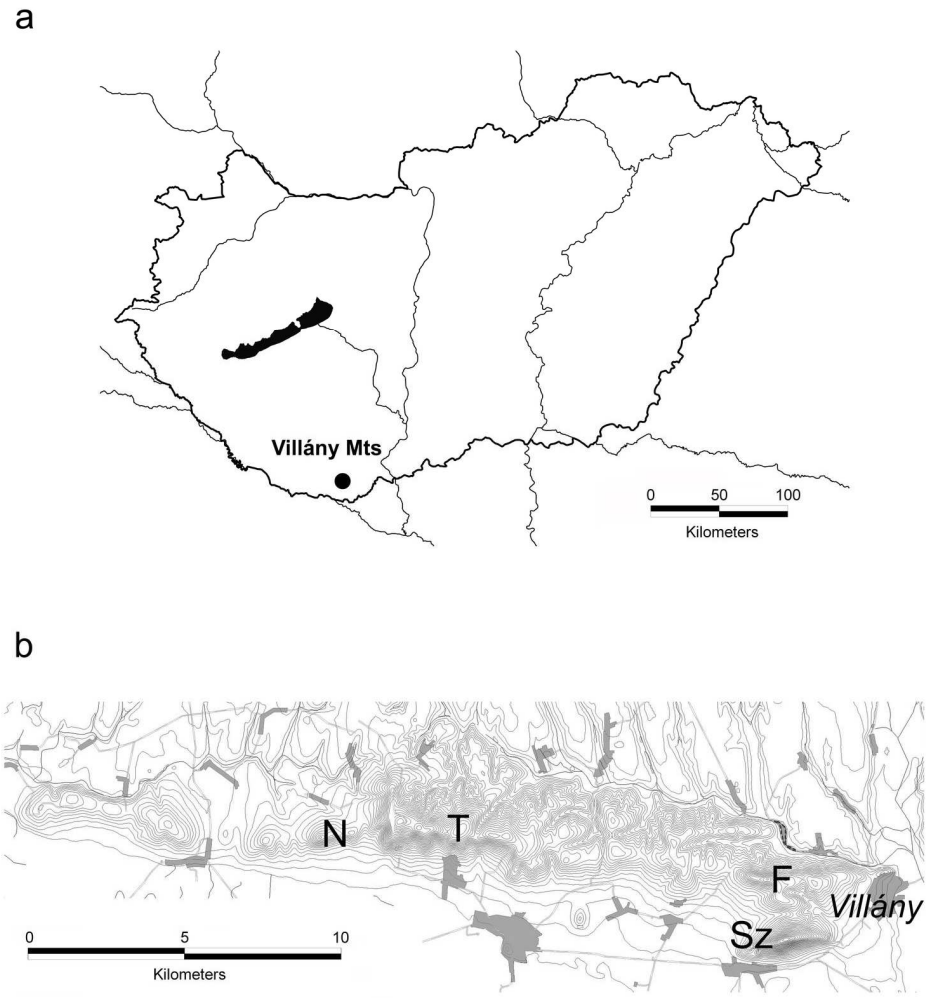

Fig. 1. (a) Location of the Villány Mts in Hungary. (b) Parts of the Villány Mts where vegetation is natural or near-natural. N: Mt Nagy, T: Mt Tenkes, F: Mt Fekete, Sz: Mt Szársomlyó.

Study area

Mt Nagy is located in the Villány Mts, southern Hungary (Fig. 1). The highest point of this low hill reaches 272 m a.s.l. Its bedrock is limestone, which is partly covered by loess; a karrenfield has developed on the plateau. The mean annual temperature is 10.5 °C (FODOR 1977, SZILÁRD 1981); the mean annual precipitation is 680 mm (AMBRÓZY & KOZMA 1990). The north-facing slope is mostly covered by vineyards, arable lands and *Robinia* plantations. Most of the south-facing slope is covered by degraded xeric grasslands and forests, but *Ailanthus* plantations and vineyards also occupy considerable areas. Natural and semi-natural communities have been preserved on and near the plateau: the calcareous scrub *Inulo spiraeifoliae-Quercetum pubescentis*, the closed calcareous grassland *Festuco rupicolae-Arrhenatheretum* and the open calcareous grassland *Sedo sopianae-Festucetum dalmaticae* (ERDŐS et al. 2012).

Material and Methods

Phytosociological relevés were made in 4 m × 4 m plots in the *Inulo spiraeifoliae-Quercetum pubescentis*, *Festuco rupicolae-Arrhenatheretum* and *Sedo sopianae-Festucetum dalmaticae* communities. In scrub communities, usually larger quadrats are used for relevés but in the Villány Mts, and especially on Mt Nagy, the size of the scrub patches is small and does not allow larger quadrat sizes. The three communities were identified by using the description of Hungarian plant communities (BORHIDI et al. 2012) together with the regional literature focusing on the Villány Mts (SIMON 1964, DÉNES 1995, 1998, ERDŐS et al. 2010b) and our earlier studies conducted on Mt Nagy (ERDŐS et al. 2012). Field work was done in May and August 2012, by estimating the percentage cover of all vascular plant species within the quadrat. In each community, five relevés were made so as to represent the stands of the study area. Previous relevés made on the same associations in other parts of the Villány Mts were also used to compare communities of different localities. These included 45 relevés of *Inulo spiraeifoliae-Quercetum pubescentis* (DÉNES 1995), 18 relevés of *Festuco rupicolae-Arrhenatheretum* (ERDŐS et al. 2010b) and 48 relevés of *Sedo sopianae-Festucetum dalmaticae* (DÉNES, unpublished). Thus, the total number of relevés used in the analyses was 127.

PCoA-ordination was carried out with the program package SYN-TAX 2000 (PODANI 2001). This multivariate method suited our data structure and research aim (cf. Podani 1997). In the ordination, presence-absence data were applied. We used the simple matching coefficient as the comparative function.

To characterize the naturalness of the communities, spectra of social behaviour types (BORHIDI 1995) were developed for each stand, using presence-absence data. The social behaviour types of plant species provide an indication on their ability to tolerate disturbance. The nature conservation “values” of the species range from +6, representing the most valuable specialists of undisturbed, intact vegetation, to -3, corresponding to the least valuable

agressive alien competitors of degraded habitats. Summarizing social behaviour types of all species within a stand provides information on how intact the community is.

Stands were also compared according to their species richness. Differences were tested with ANOVA and subsequent Tukey-tests; results were visualized with box-plots. Analyses were carried out with SPSS 11.5 (SPSS Inc.).

We compiled a list of protected and strictly protected plant species of Mt Nagy, using data from both our phytosociological relevés and from extensive field work on the total area of Mt Nagy. Species names and community names follow SIMON (2000) and BORHIDI et al. (2012), respectively. The phytosociological preference of the species in the phytosociological tables was given according to BORHIDI (1995).

Results

The syntaxonomical position of the three associations identified on Mt Nagy can be given as follows:

Quercetea pubescentis-petraeae (OBERDORFER 1948) JAKUCS 1960
Orno-Cotinetalia JAKUCS 1960
Orno-Cotinion SOÓ 1960
Cotino-Quercenion pubescentis KEVEY 2008
Inulo spiraeifoliae-Quercetum pubescentis (JAKUCS 1961) SOÓ & BORHIDI in SOÓ 1971

Festuco-Brometea BRAUN-BLANQUET & TÜXEN ex SOÓ 1947
Festucetalia valesiacae BRAUN-BLANQUET & TÜXEN ex BRAUN-BLANQUET 1949
Festucion valesiacae KLIKA 1931
Festuco rupicolae-Arrhenatheretum ERDŐS & MORSCHHAUSER in ERDŐS, DÉNES & MORSCHHAUSER 2010

Festuco-Brometea BRAUN-BLANQUET & TÜXEN ex SOÓ 1947
Stipo pulcherrimae-Festucetalia pallentis POP 1968
Chrysopogono-Festucion dalmaticae BORHIDI 1996
Sedo sopianae-Festucetum dalmaticae SIMON 1964

Characteristics of the three communities are provided in the following text:

Calcareous scrub *Inulo spiraeifoliae-Quercetum pubescentis* (JAKUCS 1961) SOÓ & BORHIDI in SOÓ 1971

The calcareous scrubs of Mt Nagy are located on the west-facing slope. Scrub patches are usually small, with an average diameter of 5-10 m. The scrub patches are surrounded by calcareous grasslands. Canopy height varies between 4 and 6 m; its cover is 60-90%. The shrub layer is 1-2 m high; its cover is 6-30%. Most plants of the herb layer are 5-10 cm high and there are only a few species reaching 50 cm. The coverage of the herb layer is 20-60%.

The monodominant species of the canopy layer is *Fraxinus ornus*, while *Quercus pubescens* is very rare, found only outside our relevés. Constant and abundant species of the shrub layer are *Fraxinus ornus* and *Ligustrum vulgare*, but *Juniperus communis* can also be found. Constant species of the herb layer include *Euphorbia cyparissias*, *Galium lucidum*, *Polygonatum odoratum*, *Potentilla arenaria*, *Sanguisorba minor* and *Teucrium chamaedrys*. The protected Mediterranean liana *Tamus communis* is also worth mentioning. In some places, *Anthericum ramosum* has a considerable cover. The following protected species have been found in our plots: *Convolvulus cantabrica*, *Dianthus giganteiformis*, *Dictamnus albus*, *Ranunculus illyricus*, *Tamus communis*, *Adonis vernalis* (Tab. 1).

Tab. 1. Phytosociological table of the association *Inulo spiraeifoliae-Quercetum pubescentis* of Mt Nagy.

	1	2	3	4	5	K%	A-D
CANOPY LAYER	85	90	60	60	75		
Orno-Ostryon species							
Fraxinus ornus	85	90	60	60	75	100	60-90
SHRUB LAYER	8	30	6	10	25		
Querco-Fagetea, Quercetalia pubescentis-petraeae and Orno-Ostryon species							
Fraxinus ornus	5	5	4	6	10	100	4-10
Ligustrum vulgare	3	25	2	2	-	80	2-25
Euonymus verrucosus	-	-	-	2	15	40	2-15
Juniperus communis	-	-	-	1	-	20	1
Prunetalia spinosae species							
Rosa canina	-	-	-	1.5	0.5	40	0.5-1.5
Crataegus monogyna	-	-	-	-	0.1	20	0.1
HERB LAYER	60	30	20	40	30		
Festuco-Brometea species							
Botriochloa ischaemum	0.1	0.1	1	0.1	0.1	100	0.1-1
Helianthemum ovatum	2.5	0.1	0.5	0.5	0.1	100	0.1-2.5
Potentilla arenaria	6	1	1	3	1.5	100	1-6
Koeleria cristata	0.5	0.5	-	0.1	0.1	80	0.1-0.5
Sanguisorba minor	-	0.5	5	0.1	0.1	80	0.1-5
Teucrium chamaedrys	3	3	-	3	0.5	80	0.5-3
Taraxacum erythrospermum	-	-	0.1	0.1	0.1	60	0.1
Thymus spp.	0.5	0.1	-	0.1	-	60	0.1-0.5
Elymus hispidus	0.5	0.1	-	-	-	40	0.1-0.5
Fragaria viridis	1	5	-	-	-	40	1-5
Achillea pannonica	0.1	-	-	-	-	20	0.1
Asperula cynanchyca	0.1	-	-	-	-	20	0.1
Filipendula vulgaris	17	-	-	-	-	20	17
Linaria genistifolia	0.1	-	-	-	-	20	0.1
Minuartia verna	-	-	-	0.1	-	20	0.1
Stachys recta	-	-	-	0.5	-	20	0.5
Festucetalia valesiaceae species							
Allium flavum	0.5	0.1	0.1	0.5	0.1	100	0.1-0.5
Festuca valesiaca	0.5	0.1	0.1	0.5	0.5	100	0.1-0.5
Orlaya grandiflora	0.1	0.1	1	0.1	0.1	100	0.1-1
Hieracium bauhinii	0.1	-	0.5	0.5	0.1	80	0.1-0.5

Tab. 1. – cont.

	1	2	3	4	5	K%	A-D
Anthericum ramosum	-	-	1.5	20	25	60	1.5-25
Campanula sibirica	-	-	0.1	0.1	0.1	60	0.1
Verbascum phoeniceum	0.1	0.5	-	0.1	-	60	0.1-0.5
Adonis vernalis	0.1	-	-	-	-	20	0.1
Arabis auriculata	-	0.1	-	-	-	20	0.1
Chamaecytisus austriacus	0.1	-	-	-	-	20	0.1
Melica ciliata	0.1	-	-	-	-	20	0.1
Salvia pratensis	0.5	-	-	-	-	20	0.5
Festucion rupicolae, Asplenio-Festucion pallentis and Saturejon montanae species							
Galium lucidum	1	1	2.5	2	3	100	1-3
Artemisia alba	-	2	3	4	-	60	2-4
Asplenium ruta-muraria	-	-	0.1	0.1	0.1	60	0.1
Convolvulus cantabrica	0.1	-	0.5	0.1	-	60	0.1-0.5
Dianthus giganteiformis	0.1	0.1	-	-	-	40	0.1
Lathyrus sphaericus	0.1	0.1	-	-	-	40	0.1
Ranunculus illyricus	0.1	0.1	-	-	-	40	0.1
Querco-Fagetea, Quercetalia pubescentis-petraeae and Orno-Ostryon species							
Fraxinus ornus	0.1	2	0.1	0.5	1	100	0.1-2
Ligustrum vulgare	1	3	0.1	0.5	0.1	100	0.1-3
Campanula bononiensis	0.1	-	0.5	0.1	1.5	80	0.1-1.5
Polygonatum odoratum	3	1	-	0.1	0.1	80	0.1-3
Quercus cerris	0.1	0.1	0.1	-	0.1	80	0.1
Dictamnus albus	0.1	4	-	-	-	40	0.1-4
Euonymus verrucosus	-	-	-	0.1	2	40	0.1-2
Quercus pubescens	-	-	-	0.1	-	20	0.1
Tamus communis	-	0.1	-	-	-	20	0.1
Viola alba	-	-	-	-	0.5	20	0.5
Prunetalia spinosae species							
Crataegus monogyna	-	0.1	0.1	0.1	0.1	80	0.1
Rosa canina	-	0.1	0.1	-	0.1	60	0.1
Indifferent species							
Euphorbia cyparissias	0.1	1	0.5	7	1	100	0.1-7
Hypericum perforatum	0.1	0.1	0.1	0.1	0.1	100	0.1
Poa angustifolia	5	3	-	0.5	-	60	0.5-5
Vicia angustifolia	0.1	-	-	0.1	0.1	60	0.1
Dactylis glomerata agg.	0.1	0.1	-	-	-	40	0.1
Thlaspi perfoliatum	0.1	0.1	-	-	-	40	0.1
Fallopia convolvulus	0.1	-	-	-	-	20	0.1
Stellaria media	-	0.1	-	-	-	20	0.1
Vicia hirsuta	-	0.1	-	-	-	20	0.1
Other species							
Acinos arvensis	-	0.1	-	0.1	0.1	60	0.1
Sedum sexangulare	0.1	0.1	-	0.1	-	60	0.1
Viola arvensis + kitaibeliana	0.1	0.1	0.1	-	-	60	0.1
Geranium columbinum	-	-	0.1	0.1	-	40	0.1
Polygala comosa	-	-	-	1	0.5	40	0.5-1
Arrhenatherum elatius	0.1	-	-	-	-	20	0.1
Bromus squarrosus	-	-	0.1	-	-	20	0.1
Geum urbanum	-	0.1	-	-	-	20	0.1

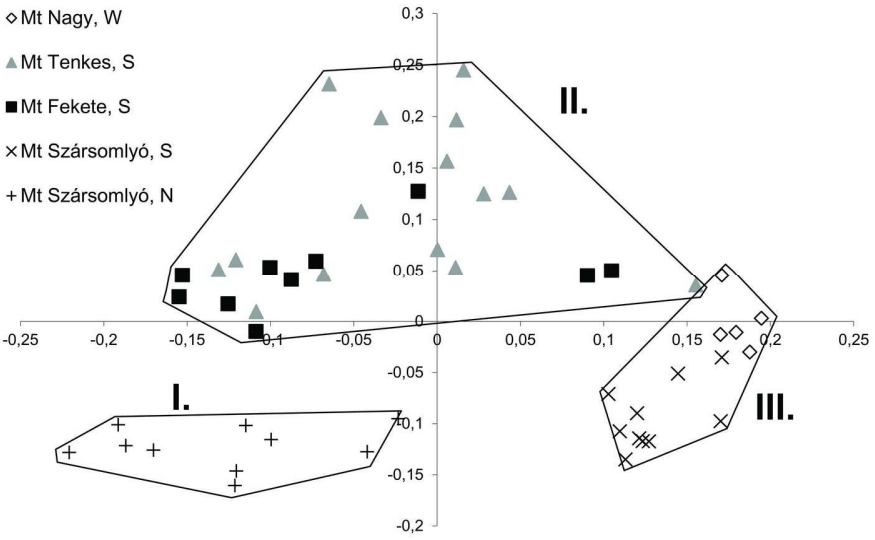

Fig. 2. Ordination scatterplot of 50 calcareous scrub relevés from the Villány Mts. W: west-facing, S: south-facing, N: north-facing.

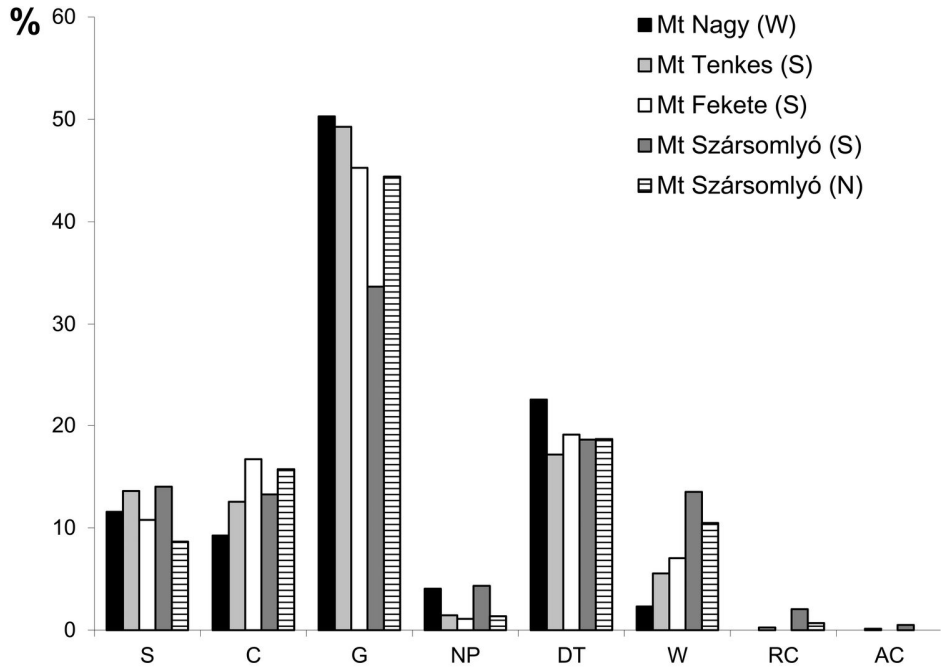

Fig. 3. Spectra of the social behaviour types in five stands of the calcareous scrubs of the Villány Mts. S: specialist (+6), C: competitor (+5), G: generalist (+4), NP: natural pioneer (+3), DT: disturbance tolerant (+2), W: weed (+1), RC: ruderal competitor (-2), AC: aggressive alien competitor (-3).

Results of the ordination show more or less well-defined groups in the scatterplot (Fig. 2). A relatively distinct group (Group I) is formed by the relevés of the northern slope of Mt Szársomlyó (no other stands of the calcareous scrub occur on the north-facing slopes of the Villány Mts). In the second group (Group II), there are relevés from Mt Tenkes and Mt Fekete. Scrubs of Mt Nagy seem to be similar to the stands of Mt Szársomlyó (Group III).

As for the social behaviour types, the variation among the different parts of the Villány mountains appears low (Fig. 3).

Regarding species richness, considerable differences can be seen among the stands of the five locations (Fig. 4). Mt Nagy resembles the southern slope of Mt Szársomlyó, though, compared to the other mountains, the species richness of the scrubs of Mt Nagy is significantly ($p<0.05$) lower.

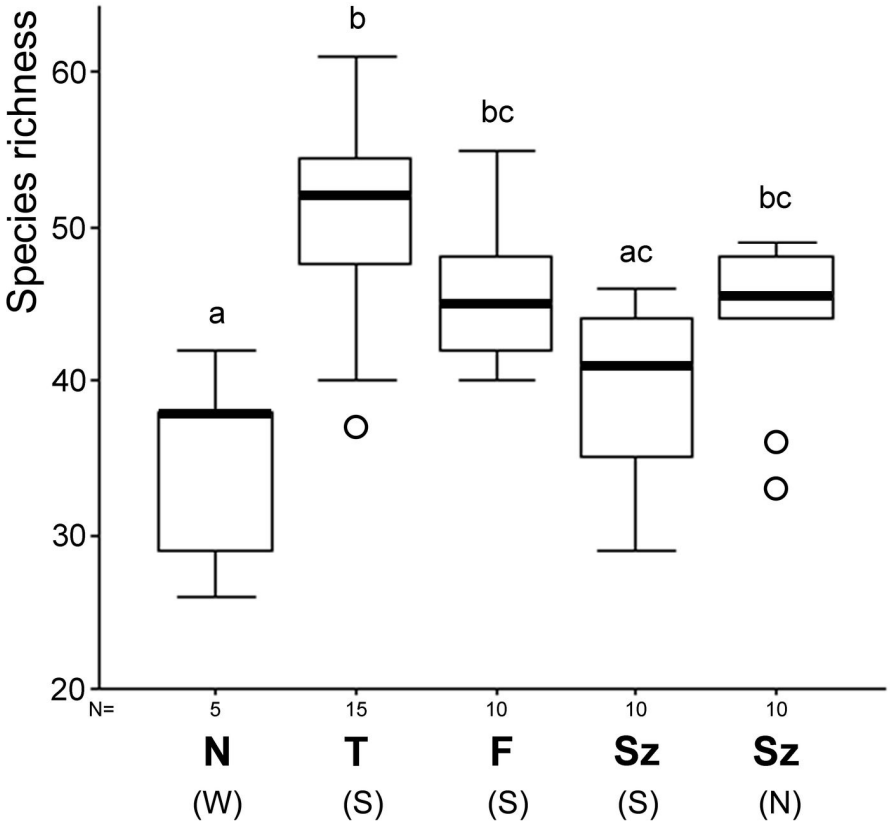

Fig. 4. Species richness of the calcareous scrubs of the Villány Mts. N: Mt Nagy, T: Mt Tenkes, F: Mt Fekete, Sz: Mt Szársomlyó. Letters in parenthesis indicate exposure as follows: W: west-facing, S: south-facing, N: north-facing slope.

Closed calcareous grassland *Festuco rupicolae-Arrhenatheretum* ERDŐS & MORSCHHAUSER in ERDŐS, DÉNES & MORSCHHAUSER 2010

This grassland has evolved on the north-facing slope near the plateau. Neighbouring communities are a patch of a secondary shrubbery *Pruno spinose-Crataegetum* SOÓ (1927) 1931 and a degraded stand of the forest *Asperulo taurinae-Carpinetum* SOÓ & BORHIDI in SOÓ 1962 to the north, and an open calcareous grassland to the south. The closed calcareous grassland *Festuco rupicolae-Arrhenatheretum* has a cover of 80-95%. Higher grasses and herbs reach a height of 50-70 cm, while the lower grass and herb layer is 10-20 cm high.

The constant and dominant species of the closed calcareous grassland are *Festuca rupicola* and *Arrhenatherum elatius*. Further constant and abundant species include species like *Elymus hispidus*, *Euphorbia cyparissias*, *Filipendula vulgaris*, *Fragaria viridis* and *Teucrium chamaedrys*, etc. Occasionally, *Bromus pannonicus* and *Poa angustifolia* can also have high cover values. Protected species recorded in the plots include *Adonis vernalis*, *Dianthus giganteiformis*, *Iris variegata* and *Ranunculus illyricus* (Tab. 2).

Tab. 2. Phytosociological table of the association *Festuco rupicolae-Arrhenatheretum* of Mt Nagy.

	1	2	3	4	5	K%	A-D
Chenopodietea, Polygono-Chenopodietalia, Secalietea, Arction lappae, Calystegietalia and Convolvulo-Agropyrion species							
Geranium columbinum	0.1	0.1	0.1	0.1	0.1	100	0.1
Viola arvensis	0.1	0.1	0.1	0.1	0.1	100	0.1
Convolvulus arvensis	0.1	0.1	-	1	0.1	80	0.1-1
Lamium purpureum	-	-	0.1	-	-	20	0.1
Sedo-Scleranthetea, Alysso-Sedion, Festuco-Sedetalia and Hypno-Polypodietalia species							
Cerastium brachypetalum	0.1	0.1	0.1	0.1	0.1	100	0.1
Myosotis stricta	0.1	0.1	0.1	-	-	60	0.1
Sedum sexangulare	-	1	-	-	0.5	40	0.5-1
Festuco-Brometea species							
Elymus hispidus	0.1	25	2	0.1	1	100	0.1-25
Filipendula vulgaris	5	7	1	5	10	100	1-10
Koeleria cristata	0.1	0.1	0.1	0.1	0.1	100	0.1
Trifolium montanum	4	1	2	0.1	0.5	100	0.1-4
Fragaria viridis	35	10	-	0.1	4	80	0.1-35
Sanguisorba minor	0.1	0.1	-	0.1	0.1	80	0.1
Teucrium chamaedrys	10	4	20	-	6	80	4-20
Achillea pannonica	1	1	5	-	-	60	1-5
Potentilla arenaria	-	1	0.1	0.1	-	60	0.1-1
Pseudolysimachion spicatum	0.5	0.1	-	-	0.1	60	0.1-0.5
Bothriochloa ischaemum	-	-	-	0.1	1.5	40	0.1-1.5
Stachys recta	-	0.5	-	0.5	-	40	0.5
Asperula cynanchica	-	-	-	-	0.1	20	0.1
Brachypodium rupestre	-	2	-	-	-	20	2
Phleum phleoides	-	0.1	-	-	-	20	0.1
Thesium ramosum	-	-	-	-	0.5	20	0.5

Tab. 2. – cont.

	1	2	3	4	5	K%	A-D
Festucetalia valesiacae, Festucion rupicolae, Asplenio-Festucion pallentis, Bromo-Festucion pallentis and Saturejon montanae species							
Dianthus giganteiformis	0.1	2	0.1	0.1	0.1	100	0.1-2
Festuca rupicola	5	8	45	30	25	100	5-45
Galium lucidum	0.1	0.5	0.5	1	0.1	100	0.1-1
Lathyrus sphaericus	0.1	0.1	0.1	0.1	0.1	100	0.1
Orlaya grandiflora	3	0.1	0.1	0.5	5	100	0.1-5
Ranunculus illyricus	0.1	0.1	0.1	0.1	0.1	100	0.1
Adonis vernalis	0.5	0.5	0.1	-	0.5	80	0.1-0.5
Bromus pannonicus	15	1	0.5	-	0.1	80	0.1-15
Thymus praecox	0.1	1.5	-	1	1	80	0.1-1.5
Veronica prostrata	0.1	0.1	0.1	-	0.1	80	0.1
Festuca valesiaca	-	0.5	-	0.1	0.5	60	0.1-0.5
Chamaecytisus austriacus	3	0.5	-	-	-	40	0.5-3
Cruciata pedemontana	-	0.1	0.1	-	-	40	0.1
Salvia pratensis	1	-	-	-	0.5	40	0.5-1
Dorycnium herbaceum	-	-	-	-	0.5	20	0.5
Melica ciliata	-	-	-	-	0.1	20	0.1
Verbascum phoeniceum	-	-	-	-	0.1	20	0.1
Molinio-Arrhenatheretea species							
Arrhenatherum elatius	45	25	35	50	15	100	15-50
Polygala comosa	0.1	-	-	-	0.1	40	0.1
Briza media	-	-	-	-	0.1	20	0.1
Querco-Fagetea, Quercetalia pubescentis-petraeae and Orno-Ostryon species							
Fraxinus ornus	2	0.1	0.1	0.1	0.1	100	0.1-2
Euphorbia epithymoides	-	-	0.1	-	-	20	0.1
Iris variegata	-	-	-	-	20	20	20
Ligustrum vulgare	-	-	0.5	-	-	20	0.5
Peucedanum cervaria	-	0.1	-	-	-	20	0.1
Prunetalia spinosae species							
Crataegus monogyna	-	-	0.1	0.1	0.1	60	0.1
Prunus spinosa	-	-	-	0.1	0.5	40	0.1-0.5
Rosa canina	1	-	-	-	-	20	1
Indifferent species							
Anthoxanthum odoratum	0.1	0.1	0.1	0.1	0.1	100	0.1
Dactylis glomerata	0.1	0.5	0.1	0.1	0.1	100	0.1-0.5
Euphorbia cyparissias	10	12	10	11	13	100	10-13
Hypericum perforatum	0.1	0.5	1	0.5	0.1	100	0.1-1
Poa angustifolia	10	5	1	1	0.5	100	0.5-10
Eryngium campestre	2	2	-	0.5	0.1	80	0.1-2
Vicia angustifolia	0.1	-	0.1	0.1	0.1	80	0.1
Ornithogalum umbellatum	-	-	0.1	0.1	0.1	60	0.1
Stellaria media	0.5	0.1	0.1	-	-	60	0.1-0.5
Thlaspi perfoliatum	0.1	0.1	-	0.1	-	60	0.1
Falcaria vulgaris	-	0.1	-	1	-	40	0.1-1
Muscari comosum	0.1	-	-	0.1	-	40	0.1
Fallopia convolvulus	-	0.1	-	-	-	20	0.1
Potentilla argentea	-	0.1	-	-	-	20	0.1
Securigera varia	-	0.1	-	-	-	20	0.1
Veronica arvensis	-	0.1	-	-	-	20	0.1

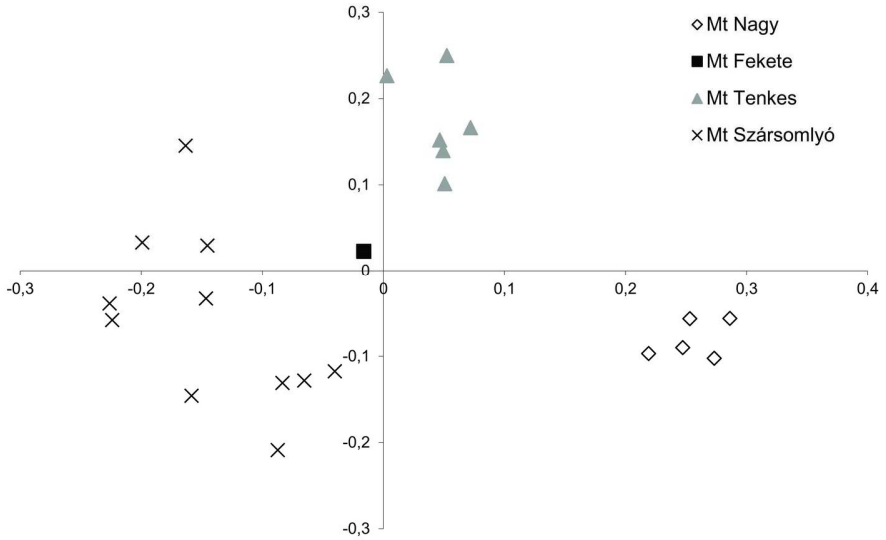

Fig. 5. Ordination scatterplot of 23 closed calcareous grassland relevés from the Villány Mts. All relevés were recorded on north-facing slopes.

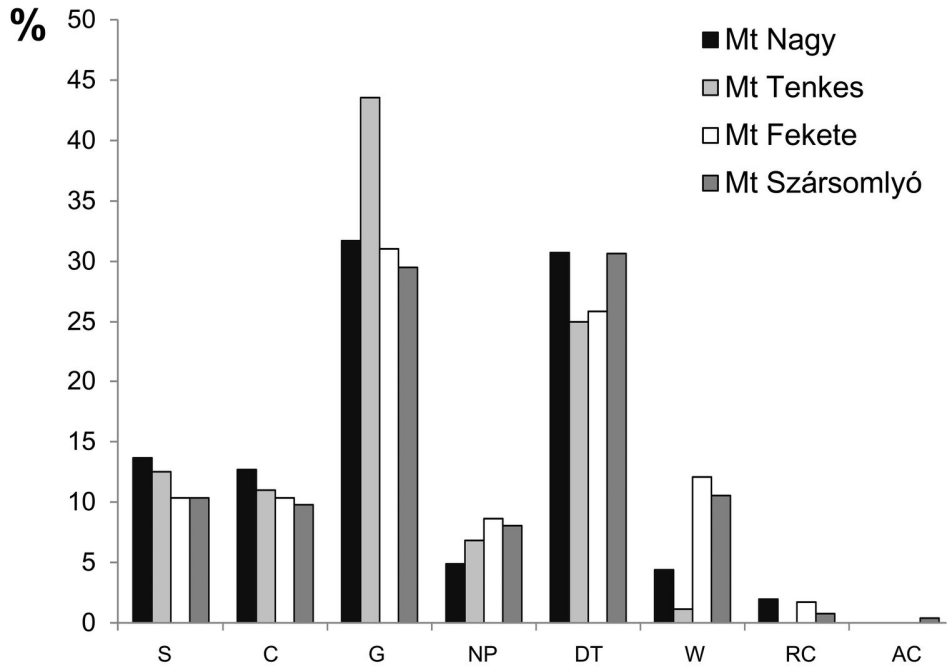

Fig. 6. Spectra of the social behaviour types in four stands of the closed calcareous grasslands of the Villány Mts. S: specialist (+6), C: competitor (+5), G: generalist (+4), NP: natural pioneer (+3), DT: disturbance tolerant (+2), W: weed (+1), RC: ruderal competitor (-2), AC: aggressive alien competitor (-3).

In the ordination scatterplot, relevés are separated according to their locations (Fig. 5). Relevés of Mt Nagy are relatively distinct from the other relevés. On the other hand, social behaviour type spectra do not show great differences among the stands, suggesting that disturbance regime is similar in every location where the association can be found (Fig. 6).

Concerning species richness of *Festuco rupicolae-Arrhenatheretum*, only moderate differences were revealed among the three locations (Fig. 7). The closed calcareous grasslands of Mt Nagy seemed to be somewhat poorer in species than the same association on Mt Szársomlyó or Mt Tenkes, although differences were not significant.

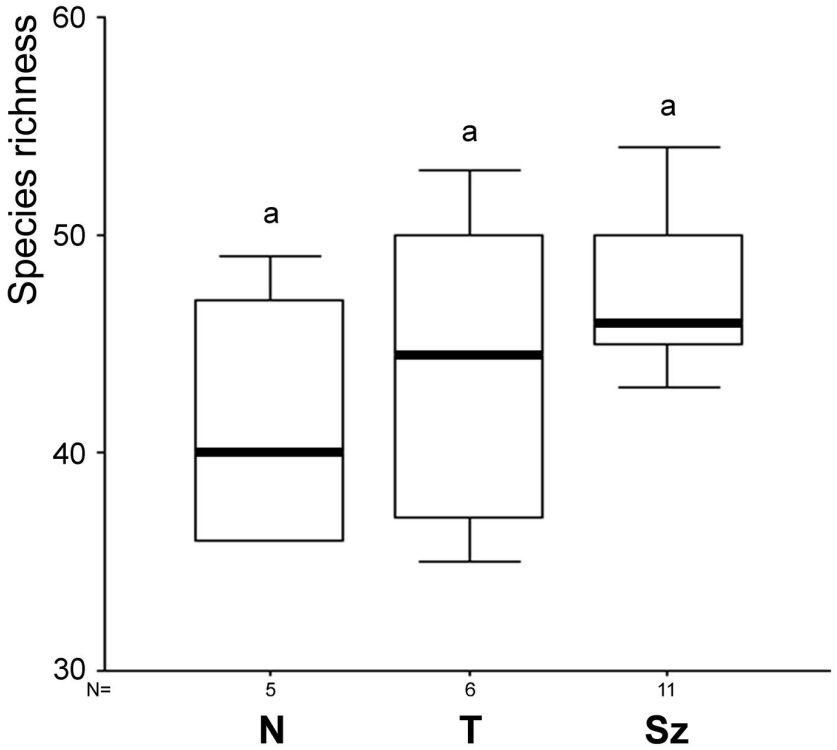

Fig. 7. Species richness of the closed calcareous grasslands of the Villány Mts. N: Mt Nagy, T: Mt Tenkes, Sz: Mt Szársomlyó. All relevés were recorded on north-facing slopes.

Open calcareous grassland *Sedo sopianae-Festucetum dalmaticae* Simon 1964

The open calcareous grassland *Sedo sopianae-Festucetum dalmaticae* is situated around the plateau and on a neighbouring, south-facing slope. The total cover of the grassland is 40-55%, but in some cases it may be as high as 70%. The remaining area consists of rock surfaces and bare soil. The lower grasses are 10-20 cm high, whereas higher grasses and some herbs are up to 50-60 cm tall.

The dominant species are *Botriochloa ischaemum*, *Melica ciliata* and *Artemisia alba*. Constant species include *Allium flavum*, *Euphorbia cyparissias*, *Festuca valesiaca*, *Galium lucidum*, *Linaria genistifolia*, *Medicago minima*, *Orlaya grandiflora*, *Potentilla arenaria*, *Sanguisorba minor* and *Stipa capillata*. Protected and strictly protected species of the relevés were *Convolvulus cantabrica*, *Jovibarba globifera* ssp. *hirta*, *Ophrys sphegodes*, *Ranunculus illyricus*, *Sedum acre* ssp. *neglectum* (Tab. 3).

Tab. 3. Phytosociological table of the association *Sedo sopianae-Festucetum dalmaticae* of Mt Nagy.

	1	2	3	4	5	K%	A-D
Chenopodietea, Polygono-Chenopodietalia, Secalietea, Secalietalia and Aperetalia species							
Geranium columbinum	0.1	0.1	0.1	0.1	0.1	100	0.1
Polycnemum arvense	0.1	0.1	0.1	0.1	-	80	0.1
Valerianella rimosa	0.1	0.1	1	0.1	-	80	0.1-1
Buglossoides arvensis	0.1	0.1	0.1	-	-	60	0.1
Fumaria officinalis	-	-	0.1	0.1	-	40	0.1
Arabidopsis thaliana	-	-	-	-	0.1	20	0.1
Echium vulgare	-	-	-	-	0.1	20	0.1
Lamium amplexicaule	-	-	-	-	0.1	20	0.1
Papaver confine	-	-	0.1	-	-	20	0.1
Sedo-Scleranthetea, Sedo-Scleranthetalia and Festuco-Sedetalia species							
Acinos arvensis	0.1	0.1	0.5	0.1	0.5	100	0.1-0.5
Alyssum alyssoides	0.1	0.1	0.5	0.1	0.1	100	0.1-0.5
Cerastium brachypetalum	0.1	0.1	0.1	0.1	0.1	100	0.1
Viola arvensis+kitaibeliana	0.1	0.1	0.1	0.1	0.1	100	0.1
Myosotis stricta	0.1	-	0.1	0.1	-	60	0.1
Poa bulbosa	0.1	-	0.1	0.5	-	60	0.1-0.5
Sedum sexangulare	-	-	0.5	-	-	20	0.5
Festuco-Brometea species							
Bothriochloa ischaemum	5	25	2	4	3	100	2-25
Medicago minima	0.1	0.1	0.1	0.1	0.1	100	0.1
Sanguisorba minor	0.1	0.1	0.1	0.5	2	100	0.1-2
Linaria genistifolia	0.1	-	0.1	0.1	0.1	80	0.1
Potentilla arenaria	6	5	1.5	-	12	80	1.5-12
Trinia glauca	0.5	-	0.1	0.1	0.1	80	0.1-0.5
Chrysopogon gryllus	-	-	1	0.1	0.5	60	0.1-1
Elymus hispidus	-	-	0.5	0.5	4	60	0.5-4
Silene otites	0.1	-	-	0.1	0.1	60	0.1
Taraxacum erythrospermum	0.1	0.1	0.1	-	-	60	0.1
Teucrium chamaedrys	0.5	-	0.1	4	-	60	0.1-4
Tragopogon dubius	0.1	-	0.1	0.1	-	60	0.1
Helianthemum ovatum	-	0.5	0.5	-	-	40	0.5
Thesium linophyllon	0.5	-	0.1	-	-	40	0.1-0.5
Asperula cynanchica	-	-	-	-	0.1	20	0.1
Koeleria cristata	0.1	-	-	-	-	20	0.1
Orobanche caryophyllacea	0.1	-	-	-	-	20	0.1
Stachys recta	-	-	-	1	-	20	0.1

Tab. 3. – cont.

	1	2	3	4	5	K%	A-D
Festucetalia valesiacae species							
Allium flavum	0.1	0.1	1.5	0.5	0.1	100	0.1-1.5
Festuca valesiaca	2	0.1	0.1	0.5	8	100	0.1-8
Melica ciliata	0.5	0.1	30	2	3	100	0.1-30
Orlaya grandiflora	0.5	1.5	-	10	15	80	0.5-15
Stipa capillata	10	-	1	0.5	0.1	80	0.1-10
Arabis auriculata	-	0.1	0.1	-	0.1	60	0.1
Verbascum phoeniceum	0.1	-	0.1	-	0.1	60	0.1
Cruciata pedemontana	-	-	0.1	-	0.1	40	0.1
Lactuca viminea	-	-	-	0.1	4	40	0.1-4
Anthericum ramosum	-	-	-	-	0.1	20	0.1
Hesperis tristis	-	-	-	-	1	20	1
Jovibarba globifera ssp. *hirta*	-	-	-	-	0.1	20	0.1
Petrorhagia saxifraga	-	-	-	-	1	20	1
Festucion rupicolae, Asplenio-Festucion pallentis and Saturejon montanae species							
Convolvulus cantabrica	0.5	3	0.5	2	1	100	0.5-3
Galium lucidum	0.1	2	0.5	10	25	100	0.1-25
Sedum acre ssp. *neglectum*	1	0.1	-	1.5	3	80	0.1-3
Thymus spp.	0.1	0.1	-	0.5	0.5	80	0.1-0.5
Artemisia alba	30	20	35	-	-	60	20-35
Cleistogenes serotina	8	0.1	2	-	-	60	0.1-8
Lathyrus sphaericus	-	-	0.1	0.1	0.1	60	0.1
Ranunculus illyricus	-	-	0.1	-	-	20	0.1
Sideritis montana	-	-	-	-	0.1	20	0.1
Indifferent species							
Arenaria serpyllifolia	0.1	0.1	0.5	0.5	0.5	100	0.1-0.5
Euphorbia cyparissias	1.5	0.1	-	5	1	80	0.1-5
Hypericum perforatum	-	0.1	-	0.1	0.1	60	0.1
Ornithogalum umbellatum	0.1	0.1	-	-	0.1	60	0.1
Veronica arvensis	-	-	0.1	0.1	0.1	60	0.1
Centaurea biebersteinii	-	-	0.1	0.1	-	40	0.1
Chondrilla juncea	-	-	-	0.5	0.5	40	0.5
Thlaspi perfoliatum	-	-	0.1	-	0.1	40	0.1
Trifolium arvense	-	0.1	-	0.1	-	40	0.1
Erodium cicutarium	-	-	0.1	-	-	20	0.1
Erophila verna	-	0.1	-	-	-	20	0.1
Eryngium campestre	-	-	-	-	0.1	20	0.1
Falcaria vulgaris	0.1	-	-	-	-	20	0.1
Muscari comosum	0.1	-	-	-	-	20	0.1
Opuntia sp.	-	-	-	2	-	20	2
Vicia angustifolia	-	-	-	-	0.1	20	0.1
Vincetoxicum officinale	-	-	-	-	2	20	2
Other species							
Bromus squarrosus	1	-	1	0.1	0.1	80	0.1-1
Arrhenatherum elatius	-	-	0.1	-	-	20	0.1
Fraxinus ornus	0.1	-	-	-	-	20	0.1
Ophrys sphegodes	0.1	-	-	-	-	20	0.1
Prunus spinosa	-	-	-	8	-	20	8

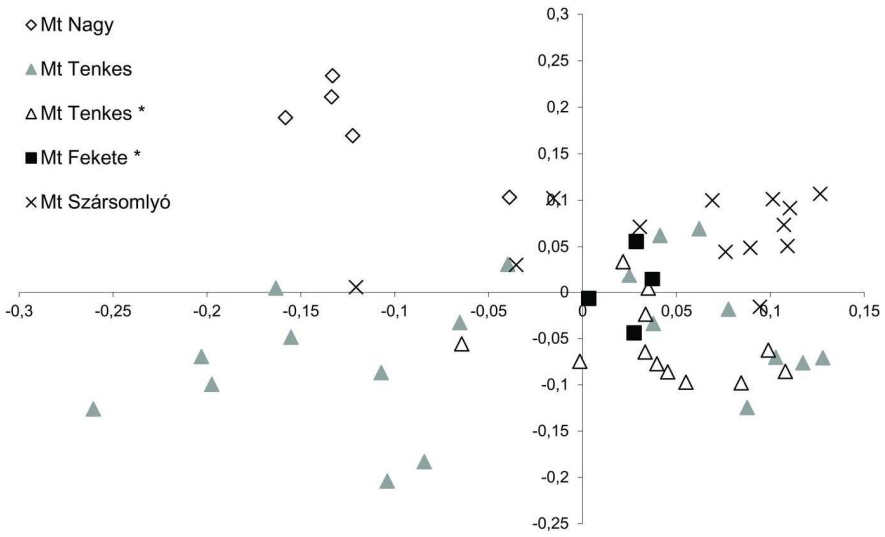

Fig. 8. Ordination scatterplot of 53 open calcareous grassland relevés from the Villány Mts. All relevés were recorded on south-facing slopes. Asterisks denote mountains with dolomite bedrock; in other cases the bedrock is limestone.

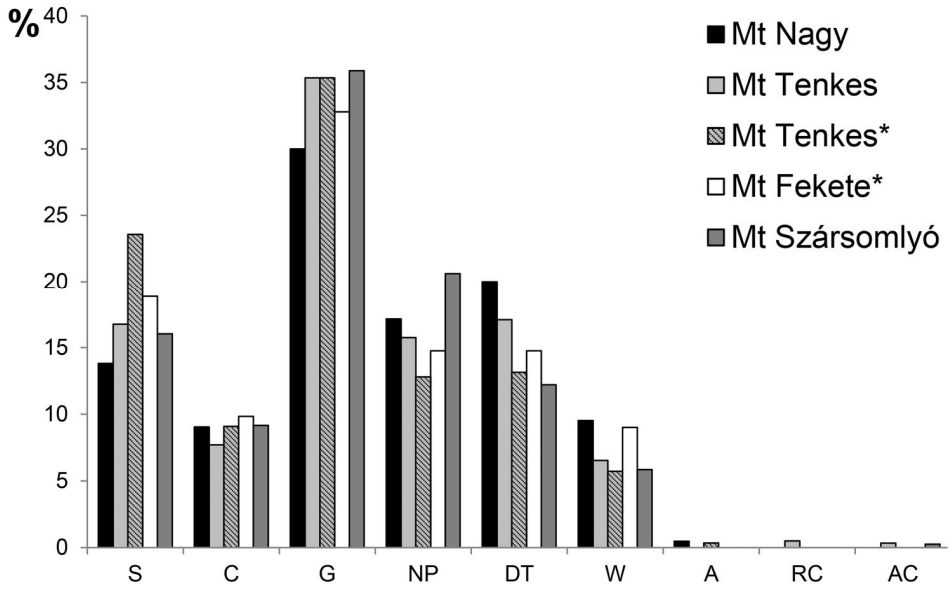

Fig. 9. Spectra of the social behaviour types in the stands of the open calcareous grasslands of the Villány Mts. S: specialist (+6), C: competitor (+5), G: generalist (+4), NP: natural pioneer (+3), DT: disturbance tolerant (+2), W: weed (+1), A: adventive (-1), RC: ruderal competitor (-2), AC: aggressive alien competitor (-3).

In the ordination space, most relevés are situated within a relatively dense cluster (Fig. 8). However, some of the relevés of Mt Tenkes are separated, and so are those of Mt Nagy, diverging from all other open calcareous grassland stands.

The social behaviour type spectra suggest that the open calcareous grasslands of Mt Nagy are somewhat more disturbed than the other stands: the proportion of the specialists and generalists is the lowest, while there are several disturbance-tolerants and weeds (Fig. 9). Nevertheless, it should be noted that differences are not particularly pronounced: groups indicating severe degradation (i.e. adventives, ruderal competitors, agressive alien competitors) are rare in all stands.

For the species richness, a quite interesting pattern can be seen (Fig. 10). Open calcareous grasslands of Mt Nagy were significantly ($p<0.05$) more species-rich than any of the other localities.

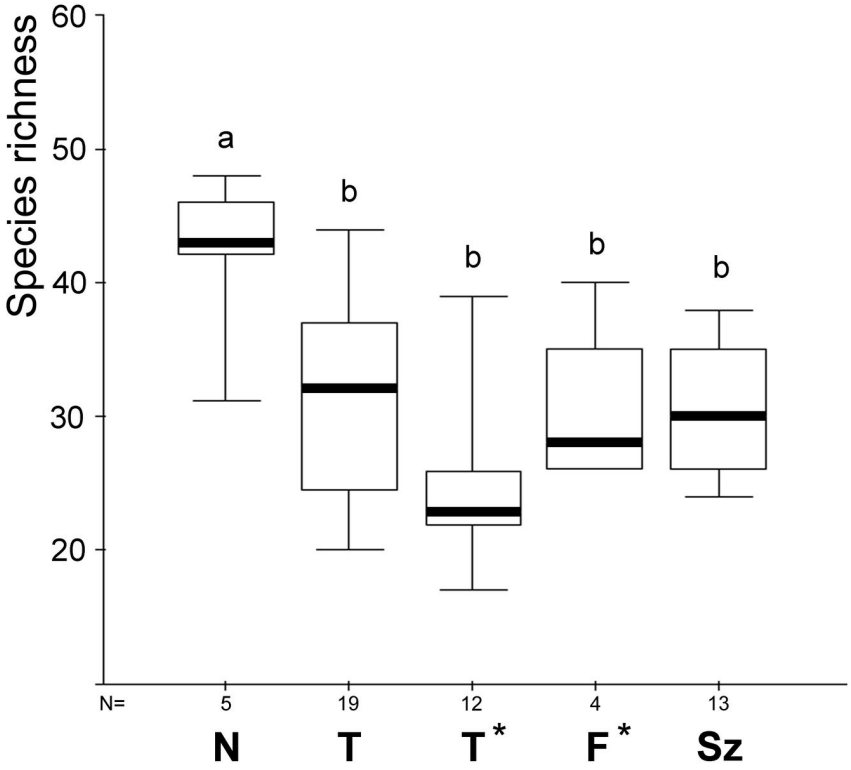

Fig. 10. Species richness of the open calcareous grasslands of the Villány Mts. N: Mt Nagy, T: Mt Tenkes, F: Mt Fekete, Sz: Mt Szársomlyó. All relevés were recorded on south-facing slopes. Asterisks denote mountains with dolomite bedrock; in other cases the bedrock is limestone.

Protected and strictly protected plant species of Mt Nagy

During our field work, we found 21 protected plant species (in the case of the rare species, population size is also given): *Adonis vernalis*, *Allium sphaerocephalon*, *Convolvulus cantabrica*, *Dianthus giganteiformis*, *Dictamnus albus*, *Galanthus nivalis*, *Helleborus odorus*, *Iris variegata*, *Jovibarba globifera* ssp. *hirta* (ca. 10 specimens), *Jurinea mollis*, *Linum tenuifolium*, *Lonicera caprifolium*, *Orchis morio* (4 specimens), *Orchis tridentata*, *Ranunculus illyricus*, *Ruscus aculeatus*, *Sedum acre* ssp. *neglectum*, *Sempervivum tectorum* (ca. 10 specimens), *Spiranthes spiralis* (ca. 10 specimens), *Tamus communis*, *Thalictrum aquilegiifolium* (ca. 10 specimens). In addition, one strictly protected species was also discovered: *Ophrys sphegodes* (ca. 80 specimens).

Discussion

We analysed the natural and near-natural plant associations of Mt Nagy, in comparison with the other parts of the Villány Mts in this paper. We found that the communities in question represent remarkable nature conservation values.

The stands of *Inulo spiraeifoliae-Quercetum pubescentis* on Mt Nagy are dominated by *Fraxinus ornus*. In contrast, the scrub stands of the other parts of the Villány Mts are dominated by *Quercus pubescens* (DÉNES 1995). The high abundance of *Fraxinus ornus* can indicate degradation (BOBINAC 2003), though in the present case it does not seem serious, as indicated by the social behaviour types. Moreover, regeneration processes are expected (BÖLÖNI et al. 2012). It should also be mentioned that *Juniperus communis* can be found in the scrubs of Mt Nagy, whereas this species is extremely rare in other parts of the Villány Mts (DÉNES 2000). This supports the possibility of more severe degradation, since *Juniperus* indicates grazing (cf. DÉNES 2000).

According to the Red Data Book of the Hungarian plant associations (BORHIDI and SÁNTA 1999), every stand of the calcareous scrub *Inulo spiraeifoliae-Quercetum pubescentis* should be protected and conserved. Since all previous analyses have ignored the stands of Mt Nagy, the present study would like to emphasize their nature conservation importance.

Concerning the closed calcareous grassland *Festuco rupicolae-Arrhenatheretum*, we found considerable differences in species composition compared with the other localities. For example, *Anthoxanthum odoratum* is constant on Mt Nagy (Tab. 2), whereas the same species is absent from this association on other parts of the Villány Mts (ERDŐS et al. 2010b). In contrast, mesic species (e.g *Corydalis solida*, *Galanthus nivalis*) that are common in other stands, do not occur on Mt Nagy. This fact may be explained by the effect of the neighbouring plant communities: *Festuco rupicolae-Arrhenatheretum* is adjacent to a secondary scrub and to a degraded forest on Mt Nagy, none of which provides habitat for plants with higher water requirement. On the other parts of the Villány Mts, *Festuco rupicolae-Arrhenatheretum* is always adjacent to near-natural mesic forests, from where mesic plants can invade the grassland (ERDŐS et al. 2010b).

In conformity with the above-mentioned compositional differences, the *Festuco rupicolae-Arrhenatheretum* stand of Mt Nagy was clearly separated from the other relevés by the PCoA analysis (Fig. 5), although some moderate differences were revealed by social behavior types (Fig. 6) and species richness values (Fig. 7). This may indicate that species composition on Mt Nagy is altered due to the lack of neighbouring forests, but the natural state of the grassland is similar throughout the Villány Mts.

According to our results, the open calcareous grasslands (*Sedo sopianae-Festucetum dalmaticae*) of Mt Nagy differ from the other stands, which can be attributed to a higher level of disturbance. The explanation for this may be that the stands in other parts of the Villány Mts are less accessible due to the steep slopes. In addition, the stands on Mt Fekete and Mt Szársomlyó belong to nature reserves. In contrast, the open calcareous grasslands of Mt Nagy are easily accessible and do not belong to a nature reserve.

However, the species richness of the community *Sedo sopianae-Festucetum dalmaticae* of Mt Nagy was extremely high (Fig. 10). It is possible that the moderate level of disturbance is high enough to enable the existence of some disturbance tolerant and weedy plants, but it is not high enough to eliminate more susceptible species (intermediate disturbance hypothesis; CONNELL 1978).

The *Sedo sopianae-Festucetum dalmaticae* is a relict plant community, which should be strictly protected (BORHIDI and SÁNTA 1999). Its occurrence is restricted to the Villány Mts in Hungary (BORHIDI et al. 2012), but previous studies did not include any analyses from this community on Mt Nagy, where it also occures and, according to our analysis, represents a great conservation value.

Despite its limited area, Mt Nagy hosts not only valuable plant communities but it provides habitats for a high number of protected and strictly protected plant species. Beside the 21 protected and one strictly protected plant species detected during our study, previous records of other protected and strictly protected species are also available from Mt Nagy: *Aster amellus* (KEVEY 1988), *Linum flavum* (ERDŐS et al. 2011), *Linum hirsutum* (ERDŐS et al. 2011), *Ophrys scolopax* (ERDŐS et al. 2011), *Orchis simia* (SOMLYAY 2000), *Primula vulgaris* (ERDŐS et al. 2011), *Trigonella gladiata* (DÉNES 1996). In summary, 27 protected and 2 strictly protected plant species have been found in the study area so far. The high number of orchid species is particularly remarkable. Also, there are several sub-Mediterranean plants typical of southwestern Hungary. Unfortunately, there are at least two protected plants reported earlier, which may have become extinct. *Aster amellus* has not been found recently, despite intensive searches. Also, *Orchis simia* has not been encountered during the last fifteen years. In this latter case, only one specimen was originally found by SOMLYAY (2000).

During the field works, we encountered numerous protected animals (e.g. *Eresus cinnaberinus, Mantis religiosa*, *Iphiclides podalirius*, *Papilio machaon*, *Lacerta viridis*, *Coronella austriaca*). Therefore, we conclude that Mt Nagy, which is a Natura 2000 site presently, should receive a higher level of protection, that is, a nature conservation area should be designated. This would allow the long-

term survival of the natural values of Mt Nagy. We think that it should be included in the Villány Mts Landscape Protection Area, whose establishment is currently in progress.

The protection of the plant communities analysed in this study is of high priority. However, restoration of the degraded plant communities (degraded forests and petrophytic steppes) of Mt Nagy is also desirable. As a result, the plant community pattern typical of the Villány Mts could occupy not only the small area around the plateau, but also other areas downhill.

Acknowledgements

We are indebted to Zoltán Korsós and Virág Krizsik for their help in preparing the article.

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Received: October 16th 2013
Revised: March 19th 2014
Accepted: March 28th 2014