Phytoecological investigation of the Hungarian Oak *(Fagaceae)* forests in Maleshevska Mountain

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Abstract. The aim of this study is to present a characteristic of monodominant communities of Hungarian Oak in Maleshevska Mountain. Investigations have been carried out in 2018 – 2020 (March – September) to evaluate some structural indicators: species composition, abundance, forest inventory. Biological type, life forms and floristic elements for the vascular plants have been determined. Results of the floristic analysis of the investigated phytocoenosis have shown 63 species of vascular plants, referred to 22 families and 52 genera. Hungarian Oak communities belong to habitat 91M0 Pannonian-Balkanic turkey oak- sessile oak forests. The results have been compared with other studies of the Hungarian Oak communities in Bulgaria.

Key words: *Quercus frainetto* Ten., forest inventory, floristic composition

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Introduction

Quercus frainetto Ten. is naturally distributed in Italy, Southeast Europe and Asia Minor. In Bulgaria, it occurs in the plains or on the mountain slopes with southern, western and southwestern exposition, at altitude up to 1000 m. Quite extensive forests are spread in the Eastern Balkan Range, Eastern Rhodopes and Mt Strandzha (Ganchev 1966). As a representative of the xerothermic vegetation, it developes well in drier and warmer places and could prove a very valuable species, if the forecast for climate warming comes true (Popov 1999). The species often participates in the composition of mixed deciduous forests, mostly with *Q.cerris* L., Q. *dalechampii* Ten. and Q. *pubescens* Willd., and seldom forms monodominant ecosystems (Yurukov, 2015). Some of the most compact natural forests of *Q. frainetto* in Bulgaria are preserved on the territory of the Sokolata Reserve forest in Maleshevska Mountain.

Maleshevska Mountain comprises diverse habitats: Mediterranean vegetation, temperate forests and subalpine meadows, which predetermine significant biodiversity. Tzankov & al. (2013) have identified 33

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habitat types in the Mountain, all under the protection of the Biological Diversity Act in Bulgaria (2002) and included in the Volume 3 of the *Red Data Book of the Republic of Bulgaria* (2015). Six of them are with conservation priority under the Habitats Directive 92/43/EEC of the European Union. *Q. frainetto* is a key species in the following natural habitats subject to conservation in the Natura 2000 sites in Bulgaria: 9150 Thermophilic beech forests (Cephalanthero-Fagion), 91H0 *Panonian forests with *Quercus pubescens*, 91M0 Balkan-Pannonian turkey oak –essile oak forests, 91W0 Moesian beech forests, and 91AA *Eastern white oak forests (Kavrakova & al. 2009).

The protected zone BG0000224 Ograzhden – Maleshevo under NATURA 2000 classification, and especially forests of *Q. frainetto*, are in the focus of interest of this study. Information on the flora of this region has been published by Asenova (2005) and Dimitrov (2012). A floristic classification of the oak communities has been carried out and the habitats on the territory of the Sokolata Reserve have been listed by Gogushev (2009).

The aim of this study is to offer a characteristic of the natural communities of Hungarian Oak in the Maleshevska Mountain to be used further for evaluation services for these ecosystems. The results are compared with data on the Hungarian Oak communities in the Sokolata Reserve (Asenova 2005) and the indigenous xerotermic forest vegetation in Bulgaria of Hungarian Oak and Turkey Oak (Lyubenova & al. 2009).

Material and methods

The objects of research were the monodominant communities of Hungarian Oak, situated at an altitude of about 700-900 m in Maleshevska Mountain, Southwest Bulgaria. According to the phytogeographical zoning of Bondev (1982), these forests fall within the West Bulgarian Frontier Region and the Middle Struma Area of the Mediterranean Sclerophyllous Forest Region. As part of the Osogovo-Belasitsa mountain group, the investigated region is included in the Submediterranean climatic area, characterized by warm and dry summer, mild winter and thin snow cover. The average annual air temperature in the low-altitude mountain belt (600-1000 m) is 10.0-12.0°C. The average July temperature is 18.0-20.0°C, and the average January temperature is 1.0-2.0°C. The period of vegetation continues about 250 days, from March to November. Average annual precipitation is between 650 and 950 mm. A subtropical rainfall regime determines the autumn-winter maximum precipitation (maximum in November, minimum in July-August). Prolonged droughts are typical (Velev 2002). The soils in the mountain are chromic cambisols, medium and highly eroded (Ninov 2002).

For the purpose of this study, three sample areas (SA) were selected. Two of them, with a size of 0.4 ha and 2.6 ha, were located on the territory of the Strumyani State Forestry Farm. The third one, with a size of 0.5 ha, was situated in the Sokolata Reserve forest.

Identification of the species was made by Kozhuharov (1992, 1995) and Delipavlov & Cheshmedzhiev (2003), and Raunkiaer's (1934) classification was used for the life forms. The floristic elements followed the classification scheme of Walter (Assyov & al. 2012). The species of conservation significance have been identified according to the Biological Diversity Act (2002), *Red Data Book of R. of Bulgaria*, Volume 1 (Peev & al., 2015), CITES (2009) and Bern Convention (1979). The Medicinal Plants Act (2000) was used for determining the medicinal plants. Endemic elements were identified according to Petrova (2006) and Petrova & Vladimirov (2010).

The communities belonged to the association *Digitali viridiflorae-Quercetum frainetti Gamisans et Herbard 1980,* according to the classification of Gogushev (2009).

Phytocoenological descriptions were made in 2018–2020 (March–September) to evaluate some structural indicators. Species composition and abundance were estimated in each sample area, and forest inventory of the tree layer was also made. The number of trees was established after counting all trees per ha. The age of the forest phytocoenosis was studied based on the data in the Forest Management Plan (FMP) of the Strumyani State Forestry Farm. Origin, canopy of the tree layer, litter depth, exposure and slope of the

terrain, etc. were estimated in the field. Height (H) of the tree layer was measured with a B3T 0101 altimeter. Tree diameter at breast height of 1.3 m (DBH) and basal diameter (BD) in the north-south and east-west directions were measured, as well as the minimum and maximum of the crown diameter. GPS GARMIN Montana 650 was used to take the coordinates of all investigated trees in the area.

A plotless sampling method was used for description of the shrub layer and a multiplot method for description of the grass layer. Ten sample plots with size 1×1 m were chosen in each area. Grass layer description included coverage and abundance according to Braun-Blanquet (1964), and mulch depth measurements were taken (Lyubenova 2004).

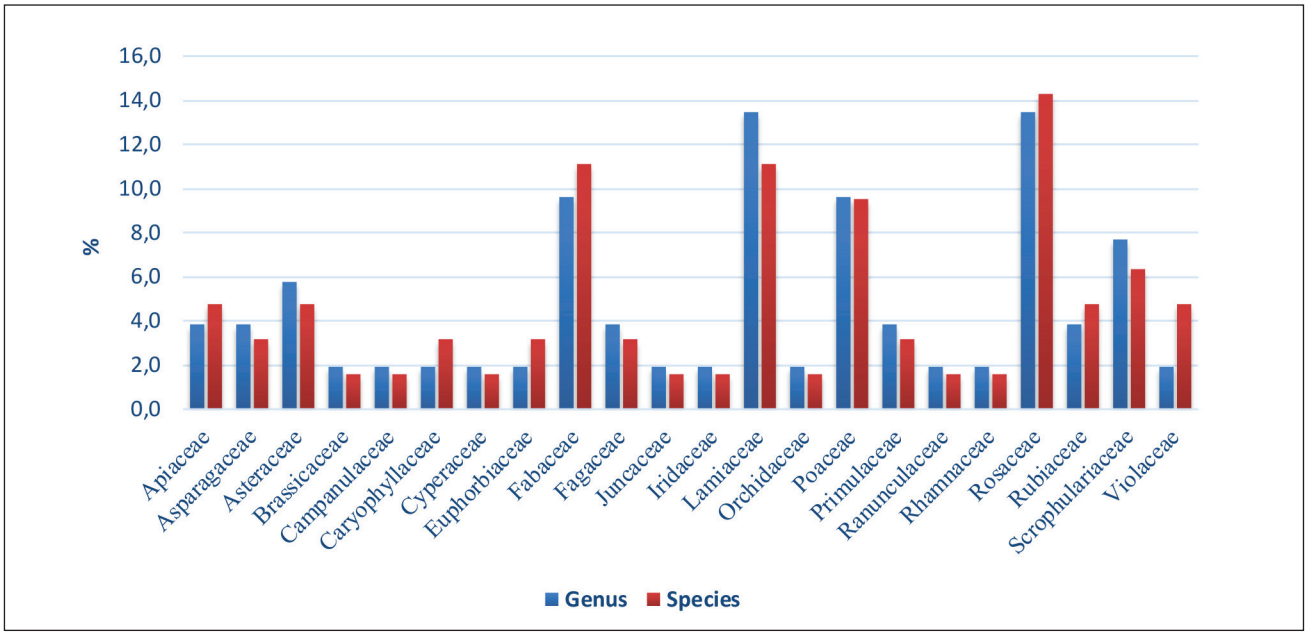
Results and discussion

Floristic analysis

Preliminary results from the floristic analysis of the investigated phytocoenosis in Maleshevska Mountain have shown 63 species of vascular plants, referred to 22 families and 52 genera (Appendix 1). That accounts for about 1.5 % of the species in the Bulgarian flora (Petrova & Vladimirov 2010). The following families were represented with the greatest number of species: *Rosaceae* – 14.3 %, *Fabaceae* – 11.1 %, *Lamiaceae* – 11.1 %, and *Poaceae* – 9.5 %. The *Rosaceae* and *Lamiaceae* families also had a greater number of genera – 13.5 %. The most common species from the *Rosaceae* family were *F. vesca, R. canina, R. caesius* and *C. monogyna*. *Clinopodium vulgare* L., *Melittis melissophyllum* L. and *Salvia glutinosa* L., identified only in the Reserve area with a high abundance rating, were the most widespread species from the *Lamiaceae* family. The *Fabaceae* and *Poaceae* families included five genera each. Representatives of the *Poaceae* family were dominant in the grass layer: *F.heterophylla*, *B.pinnatum*, *B. sylvaticum*, *D. Glomerata,* and *Poa nemoralis* L. Most families were represented by one to two species (Fig.1).

The species *Primula veris* L., which is under regulated usage according to the Bulgarian Law on Biological Diversity (Annex No. 4, Art. 41, para. 1), has been also identified. Three species have been determined as very important for the natural habitats protected by the Natura 2000 sites in Bulgaria: *Q. frainetto*, *Mycelis muralis* (L.) Dumort and *Luzula luzuloides* (Lam.) Dandy. About 43 % of all identified species were classified as medicinal plants under the Bulgarian Medicinal Plants Act (2000). The presence of endemic spe-

Fig.1. Families with the greatest participation of species and genera in the flora of the investigated area.



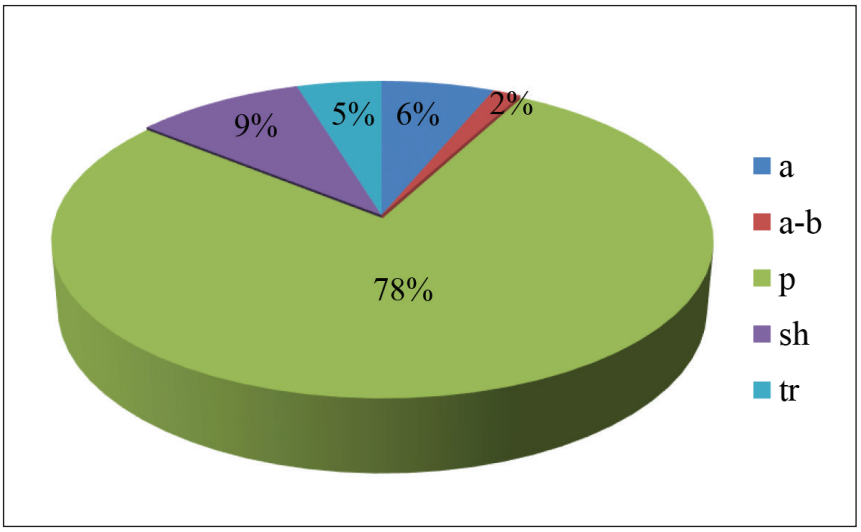


Fig.2. Percentage ratio of biological types in the investigated area. Legend: a – annual; a-b – annual to biennial; p – perennial; sh – shrub; tr – tree.

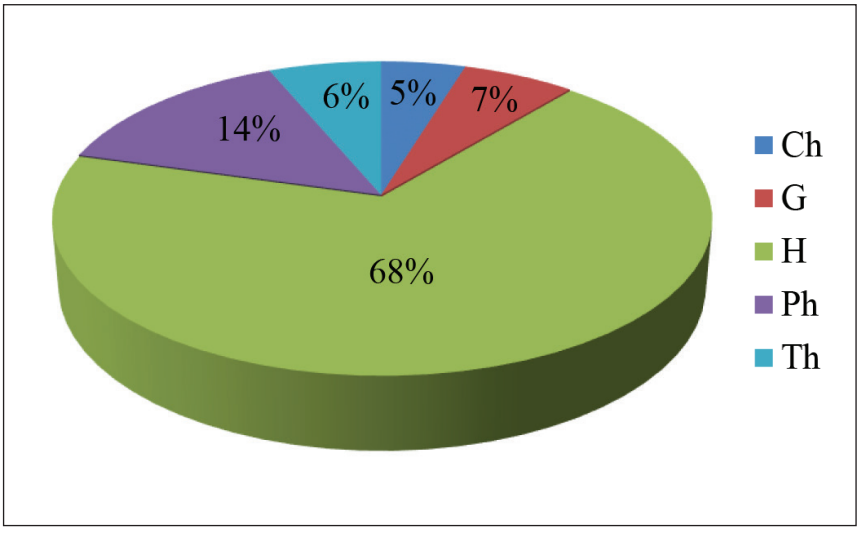


Fig.3. Percentage ratio of life forms in the investigated area. Legend: Th – Therophytes; Ch – Chamaephytes; H – Hemicryptophytes; G – Geophytes; Ph – Phanerophytes.

cies was negligible: only *Digitalis viridiflora* Lindl., a Balkan endemic. The small number of endemics and species of conservation value could be explained by the anthropogenic impact, which has brought changes to the natural habitats and destruction of some populations. Many species are very useful: some of them, being nectariferous, attract useful insects, others are suitable for forage, cooking or for cosmetic industry, trees provide good material for furniture- making, musical instruments and production of resin.

Results of the biological analysis have shown that perennial herbaceous plants claim the highest share 77.8 % of the identified plants, followed by shrubs with 9.5 %, annual plants 6.3 %, trees 4.8 %, and annual-biennial plants 1.6 % (Fig. 2). The high percentage of perennial plants is typical for the Central European broad-leaved forest communities.

The following life forms were identified in the flora of the studied area: hemicryptophytes 68.3 %, phanerophytes 14.3 %, therophytes 6.3 %, geophytes 6.3 %, and chamaephytes 4.8 % (Fig.3). In terms of the biological range, the group of hemicryptophytes predominated. Such high percentage of hemicryptophytes was characteristic for the broad-leaved forests and for the biological range of the Bulgarian flora (Bondev, 1991). The low amount of therophytes indicated that the oak community was relatively stable, with low participation of pioneer species. There was a great variety of the floristic elements in Maleshevska Mountain, which was characteristic for Bulgaria because of its geographical location and varied relief.

The species distributed in the investigated area were referred to 17 floristic elements. Their shares were determined as follows: Euro-Asiatic (15.9 %), European (14.3 %), Euro-Mediterranean (12.57 %), Sub-Mediterranean (12.57 %), and Euro–Siberian (11.1 %) (Fig.4). That distribution was normal for the temperate continental climate and the Bulgarian flora. The high participation of Euro-Mediterranean and Sub-Mediterranean floristic elements could be explained by the Mediterranean climate influence.

A comparison of the results with other studies on the Hungarian Oak communities in the Sokolata Reserve forest (Asenova, 2005) and for the Hungarian Oak and Turkey Oak communities across the country (Lyubenova & al. 2009) has

shown in this research fewer species of vascular plants, probably due to the smaller area of examination (Table 1). Mention deserves the fact that the *Asteraceae* family, which has shown prevalence in the other two studies, along with the *Fabaceae* family, have been represented by lower numbers in the investigated area. On the other hand, the *Rosaceae* family has recorded twice more representatives: 14.3 %.

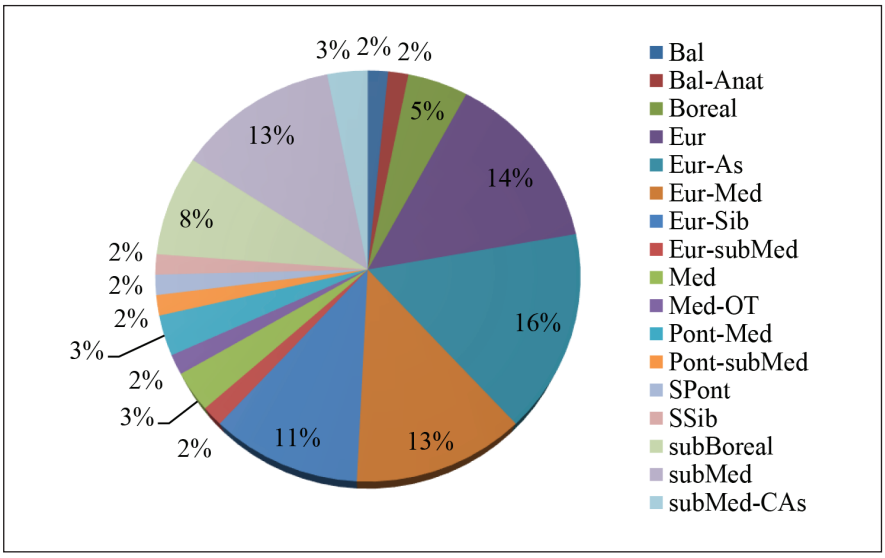


Fig.4. Percentage ratio of the floristic elements in the investigated area.

Forest communities

In all sample areas, the tree layer was formed by *Q. frainetto* of seed origin. The number of trees was 515 n.ha^{-1} in the sample area (SA)1, 351 n.ha^{-1} in SA2 and 355 n.ha^{-1} in SA3. The canopy varied from 0.7-0.8 in SA1, to 0.8 in SA2 and 0.9 in SA3. According to data from the Forest Management Plan, the forest in SA1 was 120 years old, age class XII. The second studied phytocoenosis was multi-aged and included class X and class II, which means 100- and 15-year-old trees, as age class II dominated there. Three classes of trees were determined in the Sokolata Reserve: class XXII – 220-year-old trees, class III – 30-year-old trees and class I - about 5-year-old trees. Classes III and I had greater participation. There was one tree sublayer in SA1 and SA2, and two sublayers in SA3, formed by younger trees of the same species. Single species of Q. *dalechampii* Ten., *Fagus sylvatica* L., *Acer campestre* L., *Caprinus betulus* L., and *C. orientalis* Mill. were found in the Reserve.

The average tree height was 10.9 m, 10.6 m and 9.0 m, respectively, in SA1, SA2 and SA3. The average values of DBH and BD were 33.6 cm and 38 cm, respectively, in SA1, 15.9 cm and 20.7 cm in SA2, and 3.7 cm and 18.5 cm in the Sokolata Reserve, due to the great number of young trees. The average diameter of the tree crowns was very different in all investigated communities: 6.7 m^2, 4.6 m^2 and 2.8 m^2, respectively, in SA1, SA2 and SA3. The height of self-cropping was 2-4 m in the first two areas, and 6-8 m in the third one.

The shrub layer covered about 40% of the land surface in SA1, 30% in SA2 and 20% in SA3. It included *Crataegus monogyna* Jack., *Rhamnus cathartica* L., *Rosa canina* L., and *Rubus caesius* L., reaching a height of 30-150 cm. *R. caesius* dominated (3) in SA3, followed by *R. canina* (2) and *C. monogyna* (1). The undergrowth was formed mostly by young individuals of *Q. frainetto* (5) and single specimens of *F. sylvatica* (+) and *Prunus avium* L. (+), with height of 50 to 200 cm.

The grass layer had 10-50% of projection cover in the Sokolata Reserve and 70-80% in the other sample areas. The dominant species were *Festuca heterophylla* Lam. (3), *Brachypodium pinnatum* L. (2), *B. sylvaticum* (Huds.) P. Beauv. (2), and *Dactylis glomerata* L. (1).

Table 2 presents a comparison of the current results for the Hungarian Oak phytocoenoses in the Sokolata Reserve forest and the data published by Asenova (2005).

In spite of the good regeneration and formation of one more age class from 2005 until present days, the results of this study have shown a smaller number of trees per hectare. The average height of the tree layer was much lower and the average DBH was significantly smaller. A considerable difference was

Table 1. A comparative floristic analysis of the Hungarian Oak communities in the Maleshevska Mountain, Sokolata Reserve, and the xeroterm oak communities in Bulgaria

Sample areas	Total numer of species, n	Biological type, %					Life form, %						Predomimant floral element
		a	a-b	p	sh	tr	Ch	Cr	G	H	Ph	Th	
Maleshevska Mountain	63	6.3	1.6	77.8	9.5	4.8	4.8	-	6.3	68.3	14.3	6.3	Eur-As
"Sokolata" Reserve	72	10	1	75	7	1.5	4	6	-	69	10	10	Eur-As
Bulgaria	595	-	-	-	-	-	3.1	11.5	-	55.8	11.5	16	Eur-As

Legend: a – annual; a-b – annual to beannual; p – perennial; sh – shrubs; tr – trees; Ch – Chamaephytes; Cr - Cryptophytes ; G - Geophytes; H - Hemicryptophytes; Ph – Phanerophytes; Th – Therophytes**.**

observed between the average crown diameter in both investigations. The canopy of the tree layer was greater than in the earlier investigations of Asenova (2005). The number of Hungarian Oak trees was 355 per ha, or by 49 per ha less than those found in the above-cited study. Probably, the main reason for this variation was the presence of many young trees of Hungarian Oak and the single participation of other tree species, such as Q. *dalechampii*, *F. sylvatica*, *A. campestre*, *C. betulus*, *C. orientalis*, grown in the Reserve.

Table 2. Tree layer measurements of Hungarian Oak in the Sokolata Reserve: the presently obtained data and data cited by Asenova (2005)

Year	n.ha^{-1}	DB-H_{av}, cm	S_{av} crown, m^2	H_{av}, m	$H_{self\text{-}cropping}$, m	Canopy
2018	355	18.5	2.8	9	6-8	0.9
2005	404	45.9	6.8	27-29	4.5	0.2 - 0.5

Legend: n.ha^{-1} - number of trees per ha; DBH_{av} – average diameter of breast height; S_{av} –average crown area; H_{av} – average height of trees; $H_{self\text{-}cropping}$ – average height of self-cropping

Conclusion

The families presented in *Q. frainetto* phytocoenoses by a greater number of species are some of the most widespread families in Bulgaria. The prevalent species in the shrub and grass layers are distinctive for these communities. Floristic analysis shows that these Hungarian oak communities are typical for broad leaved forests and for the biological specter of Bulgarian flora. The distribution of floristic elements with a predominance of Euro-Asiatic group is normal for the temperate continental climate and the high participation of Euro-Mediterranean and sub-Mediterranean floristic elements should be due to Mediterranean climatic influence in this part of the country. The low number of rare and protected species in the investigated area (*D. viridiflora* and *P. veris),* showed anthropogenic activities such as collecting herbs, fruits or mushrooms and livestock grazing. Furthermore, *Q. frainetto* was determined as very important for natural habitats, protected in Natura 2000 sites in Bulgaria, *M. muralis* and *L. luzuloides* and about 43% of all identified grass species were medicinal plants according to the Bulgarian Medicinal plants Act (2000).

The received average tree layer measurements of Hungarian oak as number of trees per ha, DBH (cm), S crown (m^2) and H (m) in "Sokolata" Reserve were lower than those received by Asenova (2005) due to the tree layer natural regeneration and the presence of many young trees in the layer.

The shown phytoecological characteristics define the plant communities that have been selected as characteristic of Maleshevska Mountain and on the basis of which an ecosystem services assessment will be evaluated.

Appendix 1

Family	Species	Biological type	Life form	Floristic element
Apiaceae	*Anthriscus caucalis* M.Bieb.	a	Th	Eur-Med
Apiaceae	*Anthriscus sylvestris* (L.) Hoffm.	p	H	Eur
Apiaceae	*Physospermum cornubiense* (L.) DC.	p	H	Eur-Med
Asparagaceae	*Muscari neglectum* Guss.ex Ten	p	G	Med-OT
Asparagaceae	*Ornithogalum umbellatum* L.	p	G	Pont-subMed
Asteraceae	*Cirsium ligulare* Boiss.	a-b	H	Med
Asteraceae	*Leontodon crispus* Vill.	p	H	Pont-Med
Asteraceae	*Mycelis muralis* (L.) Dumort	p	H	Med
Brassicaceae	*Rorippa sylvestris* (L.) Besser	p	H	Eur-As
Campanulaceae	*Campanula persicifolia* L.	p	H	Eur-Sib
Caryophyllaceae	*Silene noctiflora* L.	a	Th	Eur-Sib
Caryophyllaceae	*Silene vulgaris* (Moench) Garcke	a	Th	Eur-As
Cyperaceae	*Carex caryophyllea* Latourr.	p	H	Boreal
Euphorbiaceae	*Euphorbia amygdaloides* L.	p	H	Eur
Euphorbiaceae	*Euphorbia cyparissias* L.	p	H	Eur
Fabaceae	*Chamaecytisus hirsutus* (L.) Link	sh	Ch	Eur-Sib
Fabaceae	*Dorycnium herbaceum* Vill.	p	Ch	Eur-Med
Fabaceae	*Lathyrus laxiflorus* (Desf.) Kuntze	p	H	subMed
Fabaceae	*Lathyrus venetus* (Mill.) Wohlf.	p	H	Eur-Med
Fabaceae	*Lathyrus vernus* (L.) Bernh.	p	H	Eur-Sib
Fabaceae	*Trifolium alpestre* L.	p	H	Eur-Sib
Fabaceae	*Vicia cassubica* L.	p	H	Eur-Med
Fagaceae	*Fagus sylvatica* L.	tr	Ph	Eur
Fagaceae	*Quercus frainetto*Ten.	tr	Ph	Eur
Iridaceae	*Crocus pulchellus* Herb.	p	G	Bal-Anat
Juncaceae	*Luzula luzuloides* (Lam.) Dandy	p	H	Eur
Lamiaceae	*Ajuga genevensis* L.	p	H	SPont
Lamiaceae	*Clinopodium vulgare L.*	p	H	SubBoreal
Lamiaceae	*Melittis melissophyllum* L.	p	H	Eur
Lamiaceae	*Salvia glutinosa* L.	p	H	Eur-As
Lamiaceae	*Scutellaria columnae* All.	p	H	subMed
Lamiaceae	*Teucrium chamaedrys* L.	p	Ch	subMed
Lamiaceae	*Thymus striatus* Vahl.	p	H	subMed
Orchidaceae	*Orchis morio* L.	p	G	Eur-subMed
Poaceae	*Brachypodium pinnatum* (L.) P.Beauv.	p	H	SSib
Poaceae	*Brachypodium sylvaticum* (Huds.) P.Beauv.	p	H	Eur-As
Poaceae	*Dactylis glomerata* L.	p	H	Eur-As
Poaceae	*Festuca heterophylla* Lam.	p	H	Boreal

Family	Species	Biological type	Life form	Floristic element
Poaceae	*Melica uniflora* Retz.	p	H	Eur
Poaceae	*Poa nemoralis* L.	p	H	Boreal
Primulaceae	*Lysimachia vulgaris* L.	p	H	Eur-As
Primulaceae	*Primula veris* L.	p	H	Eur-Med
Ranunculaceae	*Clematis vitalba* L.	p	Ph	Eur
Rhamnaceae	*Rhamnus cathartica* L.	sh	Ph	Eur-As
Rosaceae	*Crataegus monogyna* Jacq.	sh	Ph	subBoreal
Rosaceae	*Filipendula ulmaria* (L.) Maxim	p	H	subBoreal
Rosaceae	*Filipendula vulgaris* Moench.	p	H	Eur-Med
Rosaceae	*Fragaria vesca* L.	p	H	subBoreal
Rosaceae	*Prunus avium L.*	tr	Ph	subMed
Rosaceae	*Rosa canina* L.	sh	Ph	subMed
Rosaceae	*Rubus caesius* L.	sh	Ph	Eur-As
Rosaceae	*Rubus sanguineus* Friv.	sh	Ph	Pont-Med
Rosaceae	*Sanguisorba minor* Scop.	p	H	subBoreal
Rubiaceae	*Cruciata glabra* (L.) Ehrend.	p	H	subMed-CAs
Rubiaceae	*Cruciata laevipes* Opiz.	p	H	subMed-CAs
Rubiaceae	*Galium rotundifolium* L.	p	H	subMed
Scrophulariaceae	*Digitalis viridiflora* Lindl.	p	H	Bal
Scrophulariaceae	*Melampyrum cristatum* L.	a	Th	Eur-Sib
Scrophulariaceae	*Verbascum phoeniceum* L.	p	H	Eur-Sib
Scrophulariaceae	*Veronica chamaedrys L.*	p	H	Eur-As
Violaceae	*Viola odorata L.*	p	H	Eur-Med
Violaceae	*Viola reichenbachiana* Jord. ex Boreau	p	H	Eur-As
Violaceae	*Viola riviniana* Rchb.	p	H	subMed

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