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Orchid species richness and composition in relation to vegetation types

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Summary: Terrestrial orchids in Europe inhabit a variety of vegetation types, both the forest and scrub types and herbaceous vegetation. The richness and composition of orchid species and subspecies in relation to vegetation types in the central Balkans (western Serbia) were investigated in the present study. In total, the phytocoenological affiliation of 55 orchid species and subspecies were analysed. Based on presence/absence data, similarity of the orchid flora among different vegetation types (orders and alliances) was analysed using the clustering method. Orchids were recorded in plant communities from 17 classes, 31 orders and 41 alliances. The greatest number of orchid species grow in communities of the classes *Festuco-Brometea*, *Molinio-Arrhenatheretea* and *Quercetea pubescentis*, the orders *Quercetalia pubescenti-petraeae*, *Brachypodietalia pinnati*, *Fagetalia sylvaticae* as well as the alliances *Fagion sylvaticae*, *Fraxino orni-Ostryion*, *Nardo-Agrostion tenuis* and *Arrhenatherion elatioris*. The results show that the vegetation types richest in orchid taxa are those that occur over a wide range of altitudes, mainly on carbonate substrates and on various bedrock types, indicating the cumulative effect of environmental factors in determining the patterns of orchid species richness. Furthermore, *Gymnadenia conopsea*, *Anacamptis morio*, *Dactylorhiza saccifera*, *Platanthera bifolia*, *Neottia ovata* and *Dactylorhiza sambucina* were found to grow in the largest number of vegetation types, suggesting their great ecological plasticity. In total, 12 statistically significant groups of vegetation orders and 11 statistically significant groups of vegetation alliances are distinguished. The study highlights the importance of certain vegetation types in defining priorities of orchid conservation.

Keywords: Orchidaceae, phytocoenological affiliation, diversity patterns, ecology, Serbia, Balkan Peninsula

The family Orchidaceae is regarded as one of the largest and most diverse families in the flowering plant kingdom, with an estimated number of about 28,000 species (Fay 2018). Orchids are particularly vulnerable to changes in land cover, climate, soil characteristics, light availability, hydrology and competition, primarily due to their dependence on both fungal symbionts and pollinators (Wotavová et al. 2004; Swarts & Dixon 2009; Pfeifer et al. 2010). Due to habitat loss as a result of various anthropogenic factors, a decline in the abundance and ranges of numerous orchid species has been reported in recent decades in Europe (Kull & Hutchings 2006; Vogt-Schilb et al. 2015).

Terrestrial orchids in Europe occur in most terrestrial ecosystems, from coasts to highlands, and they are known to inhabit primarily forests, scrubs, grasslands, meadows, heathlands, bogs, fens and marshes (Delforge 2006; Djordjević & Tsiftsis 2020). Furthermore, recent studies indicate that many orchids occur in anthropogenic habitats, including railway embankments, roadsides, city parks and hedges, cemeteries, industrial terrains, industrial waste places, plantations of ecologically unsuitable and non-native trees, sand pits, clay pits and quarries (Adamowski 2006; Rewicz et al. 2015, 2017; Fekete et al. 2019). Some studies provide detailed data on the ecological preferences of individual orchid species, summarizing knowledge about their phytocoenological affiliations (Tali et al. 2004; Bernardos et al. 2007; Vakhrameeva et al.

2008; Jacquemyn & Hutchings 2010; Jacquemyn et al. 2014; Jersáková et al. 2011, 2015; Meekers et al. 2012; Kotilínek et al. 2015, 2018; Kirca et al. 2020). However, these studies often indicate that orchid species inhabit different vegetation types in different geographical regions and that these differences are most noticeable when comparing the centre and the edge of their range (Duffy et al. 2009). According to the 'abundant-centre hypothesis', species in the centre of their range most often inhabit a great variety of vegetation types, whereas at the edges they mainly grow in a limited number of plant communities (Sagarin & Gaines 2002). Consequently, different conservation strategies need to be proposed in different parts of species ranges, taking into account the spatial variation in population needs on a geographical scale (Pfeifer et al. 2010). Moreover, species that have a wide geographical range often have populations that occur in different vegetation types (Hall et al. 1992). Although many studies have highlighted the importance of vegetation types in determining distribution patterns and abundance of orchids (Tsiftsis et al. 2008, 2019a; Djordjević et al. 2016a, b), there is a lack of knowledge about which vegetation types are particularly rich in orchids. In addition, there are limited data on which orchid species grow in a large number and which in a small number of vegetation types in certain geographical regions of Europe. Detailed insight into the preferences of orchids in relation to vegetation types will give us a better understanding of conservation priorities and make it possible to predict the distribution and abundance of species under future changes in land cover and climate. In the final analysis, such insight will lead to more successful planning of species conservation.

The Balkan Peninsula is known for its great richness of orchid species, especially in the Aegean part of Greece, where a large number of Mediterranean orchids inhabit broadleaved evergreen forests, coniferous forests of the Mediterranean type and scrub vegetation (Tsiftsis et al. 2007, 2019b; Djordjević & Tsiftsis 2020). However, the relationship between orchid species richness and vegetation types has been less explored in the central Balkans. Despite the long tradition of phytocoenological studies in this area of the Balkans, there is a need for more detailed studies of orchids in the synecological sense. The aim of the present study was to determine the preferences of orchids in relation to vegetation types in the central Balkans (western Serbia). The study addresses the following questions: (1) What is the number of vegetation classes, orders and alliances inhabited by orchids in western Serbia? (2) What is the richness of orchid species and subspecies in relation to vegetation types in western Serbia? and (3) What similarities of orchid flora composition exist between vegetation types?

Materials and methods

Study area. The study area covers ca 18 000 km^2 and includes the entire area of western Serbia, which is situated in the north-central part of the Balkan Peninsula. Two basic units stand out in the macro-relief of western Serbia: (a) lowland areas of the southern part of the Pannonian Plain, which cover the northern parts of the study area, and (b) a mountainous area belonging to the Dinaric Alps which occupies its central and southern part. The altitude ranges from 65 m (Šabac) to 2154 m (Pogled peak, Prokletije). Geological substrates are represented by carbonate rocks (limestones, dolomites, carbonate clastites), ultramafics and various silicate rocks, including the significant presence of ophiolitic mélanges (Djordjević & Tsiftsis 2019). The climate of western Serbia can be described as humid temperate, with more or less pronounced local characteristics. According to the Republic Hydrometeorological Service of Serbia and Gavrilović (2019), the mean annual temperature varies from ca 3°C (in the regions where altitude exceeds

1500 m) to 13.4°C (Loznica), while the mean annual precipitation sums range from 726.4 mm (Požega) to ca 1500 mm in some highland areas.

The vegetation of the study area is characterised mainly by a deciduous thermophilous forest zone (*Quercion frainetto*) and a mesophilous forest zone (*Fagenion*) (Horvat et al. 1974). In addition, conifer forests (*Vaccinio-Piceetea*) are distributed in the highlands of western and southwestern Serbia. The main types of recent vegetation formations and vegetation classes in Serbia comprise: (a) rock crevice, scree and boulder-field vegetation (*Asplenietea trichomanis*, *Thlaspietea rotundifolii*); (b) freshwater aquatic vegetation (*Lemnetea*, *Charetea intermediae*, *Potamogetonetea*); (c) vegetation of freshwater springs, shorelines and swamps (*Montio-Cardaminetea*, *Isoëto-Nanojuncetea*, *Phragmito-Magnocaricetea*); (d) bogs and fens (*Oxycocco-Sphagnetea*, *Scheuchzerio palustris-Caricetea fuscae*); (e) temperate grasslands, heaths and fringe vegetation (*Molinio-Arrhenatheretea*, *Festuco-Brometea*, *Calluno-Ulicetea*); (f) montane tall-herb, grassland, fell-field and snow-bed vegetation (*Mulgedio-Aconitetea*, *Salicetea herbaceae*, *Elyno-Seslerietea*, *Juncetea trifidi*); (g) temperate broadleaved forests and scrub (*Salicetea purpureae*, *Alno glutinosae-Populetea albae*, *Franguletea*, *Crataego-Prunetea*, *Carpino-Fagetea sylvaticae*, *Quercetea pubescentis*); (h) montane heaths and coniferous forests (*Loiseleurio procumbentis-Vaccinietea*, *Erico-Pinetea*, *Vaccinio-Piceetea*); and (h) weed communities (*Papaveretea rhoeadis*, *Polygono-Poetea annuae*, *Artemisietea vulgaris*, *Epilobietea angustifolii*, *Bidentetea*) (Kojić et al. 1998).

Data collection and data analysis. Data concerning the orchid occurrence and vegetation types were recorded in the course of the ecological and chorological research of orchids in western Serbia, in the period between 1995 and 2020. Data of 51 species and subspecies from 2317 localities were collected during field investigations. In addition, the data set contains literature data of 45 taxa from 499 localities and herbarium data of 38 taxa from 100 localities compiled from the Herbarium of the Institute of Botany and Botanical Garden 'Jevremovac', University of Belgrade [BEOU] and the Herbarium of the Natural History Museum in Belgrade [BEO]. In total, data of 55 orchid species and subspecies were collected from 2916 localities.

The identification of species was performed according to Delforge (2006), whereas nomenclature followed the World Checklist of Kew Gardens (WCSP 2020). Plant communities were determined by phytosociological sampling using the methodology of Braun-Blanquet (1964). The sample size ranged from 200 m^2 to 500 m^2 in the case of forests; the sample size for grasslands was 25 m^2, whereas that for fens and marshes was 10–16 m^2. The names of syntaxonomic units followed the phytocoenological nomenclature proposed by Mucina et al. (2016). Orchid richness (number of orchid species and subspecies) was calculated for all vegetation units (classes, orders and alliances).

Floristic similarities between the vegetation orders (alliances) were analysed using the clustering method, applying the unweighted pair group method with an arithmetic mean (UPGMA) on Euclidean distances together with a similarity profile analysis (SIMPROF; Clarke et al. 2008; Somerfield & Clarke 2013). The data analysis was based on the occurrence of orchid taxa (presence-absence data). All analyses were performed in R version 3.5.1 (R Core Team 2013) using the package 'clustsig' (Whitaker & Christman 2014).

Results

Orchid species richness in relation to vegetation types. A total of 55 orchid species and subspecies were recorded in plant communities from 17 classes, 31 orders and 41 alliances (Appendix 1, Figs 1–3). Overall, 43 orchid taxa were found to inhabit forest communities

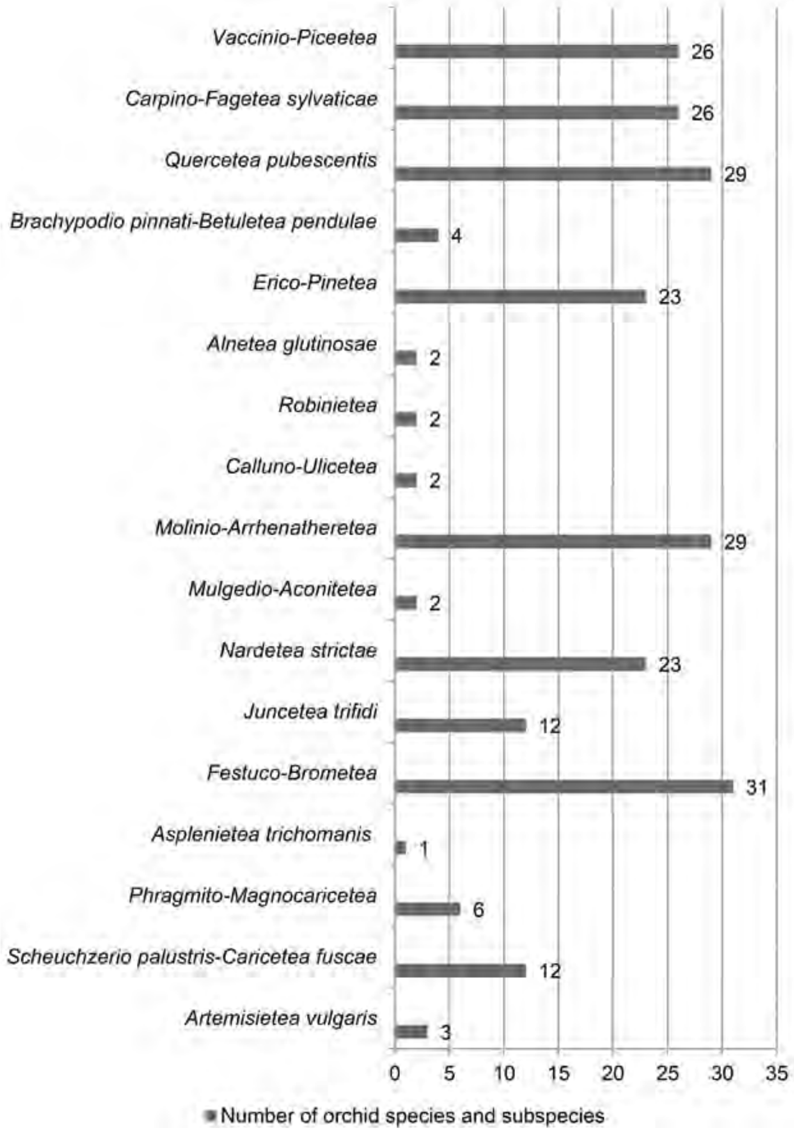

Figure 1. The orchid species and subspecies richness in relation to vegetation classes in the Central Balkans (western Serbia).

(*Lignosa*) (Appendix 1). Herbaceous vegetation types (*Herbosa*) host 41 orchid species and subspecies; out of these, 40 taxa grow in grasslands, meadows and heaths, whereas 12 species and subspecies inhabit fen communities of the class *Scheuchzerio palustris-Caricetea fuscae*, six species and subspecies grow in marshland vegetation (*Phragmito-Magnocaricetea*), and only one species was recorded in chasmophytic vegetation of crevices, rocky ledges and faces of rocky cliffs and walls (*Asplenietea trichomanis*) (Appendix 1). The richness of orchid species and subspecies in relation to vegetation classes, orders and alliances in western Serbia is presented in Figs 1–3.

The greatest number of orchids was recorded in the class *Festuco-Brometea* (31 taxa or 56.36% of the total analysed orchid flora in western Serbia), followed by *Quercetea pubescentis* and *Molinio-Arrhenatheretea*, each hosting 29 taxa or 52.73% (Fig. 1). A significant number of orchids were recorded in *Carpino-Fagetea sylvaticae* and *Vaccinio-Piceetea* (26 taxa each), *Nardetea strictae* and

Figure 2. The orchid species and subspecies richness in relation to vegetation orders in the Central Balkans (western Serbia).

Erico-Pinetea (23 taxa each), while the smallest number of orchid taxa was found in *Robinietea*, *Calluno-Ulicetea*, *Alnetea glutinosae*, *Mulgedio-Aconitetea* and *Asplenietea trichomanis* (Fig. 1).

Regarding the affiliation to vegetation orders, the greatest number of orchids was recorded in *Quercetalia pubescenti-petraeae* and *Brachypodietalia pinnati*, each hosting 29 species and subspecies (52.73%), followed by *Fagetalia sylvaticae* (25 taxa or 45.45%), *Nardetalia strictae* and *Erico-Pinetalia* (23 taxa each or 41.82%) as well as *Arrhenatheretalia elatioris* (22 taxa or 40%) (Fig. 2). The smallest number of orchid taxa was found in the orders *Halacsyetalia sendtneri* and *Moltkeetalia petraeae* (one orchid species each) (Fig. 2).

Concerning alliances, the greatest number of orchid taxa was recorded in the *Fagion sylvaticae* (25 taxa or 45.45%), followed by *Fraxino orni-Ostryion* (24 taxa or 43.64%), *Nardo-Agrostion*

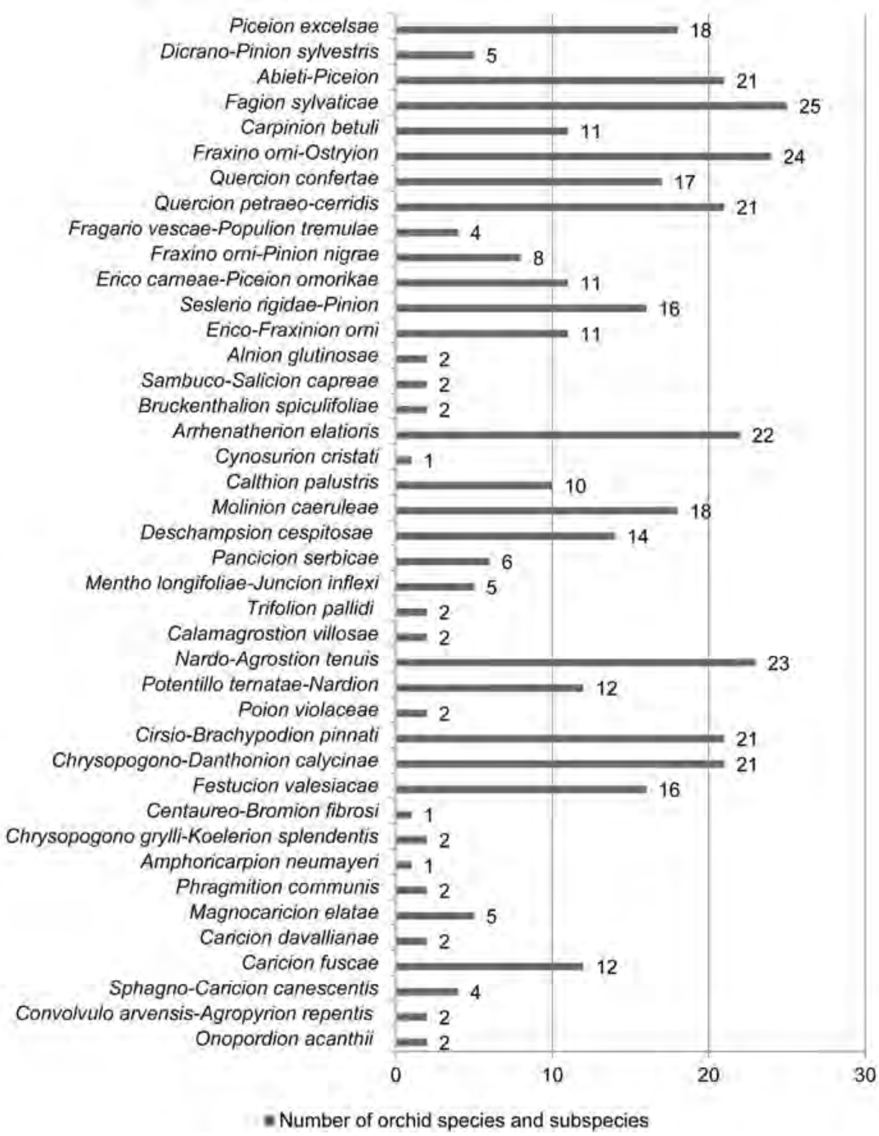

Figure 3. The orchid species and subspecies richness in relation to vegetation alliances in the Central Balkans (western Serbia).

tenuis (23 taxa or 41.82%), *Arrhenatherion elatioris* (22 taxa or 40%), as well as *Abieti-Piceion*, *Quercion petraeo-cerridis*, *Cirsio-Brachypodion pinnati* and *Chrysopogono-Danthonion calycinae* (21 taxa each or 38.18%) (Fig. 3). The smallest number of orchid taxa was found in the alliances *Cynosurion cristati*, *Centaureo-Bromion fibrosi* and *Amphoricarpion neumayeri* (one orchid species each) (Fig. 3).

The total number of vegetation classes, orders and alliances in which each orchid taxon was recorded in western Serbia is presented in Table 1. *Gymnadenia conopsea* was recorded in the highest number of vegetation types, followed by *Anacamptis morio*, *Dactylorhiza saccifera*, *Platanthera bifolia*, *Neottia ovata* and *Dactylorhiza sambucina* (Appendix 1; Table 1). In addition, orchids that have been recorded in a significant number of syntaxonomic units include *Dactylorhiza maculata* subsp. *transsilvanica*, *Platanthera chlorantha* and *Traunsteinera globosa*, followed by *Cephalanthera*

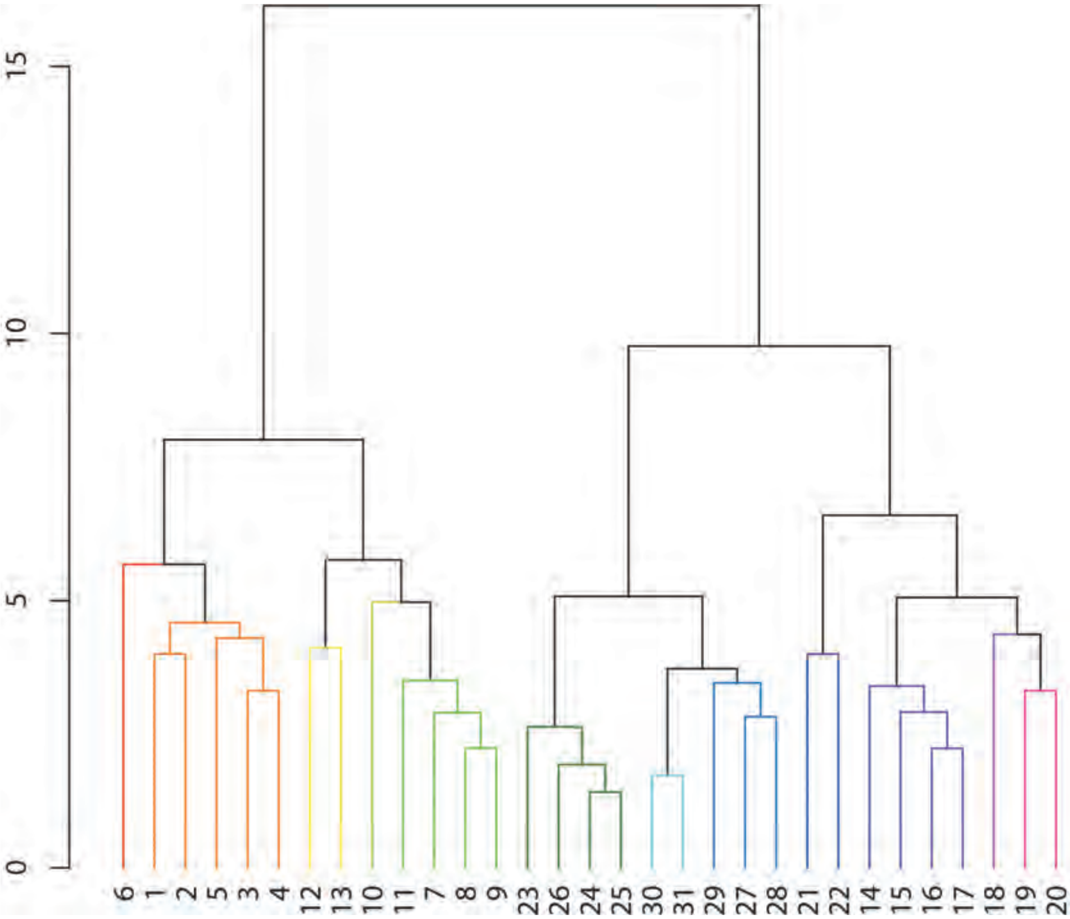

Figure 4. Cluster dendrogram of similarity of orchid flora among the analysed vegetation orders in the central Balkans (western Serbia): 1. *Piceetalia excelsae*; 2. *Pinetalia sylvestris*; 3. *Athyrio filicis-feminae-Piceetalia*; 4. *Fagetalia sylvaticae*; 5. *Carpinetalia betuli*; 6. *Quercetalia pubescenti-petraeae*; 7. *Fragario vescae-Populetalia tremulae*; 8. *Sambucetalia racemosae*; 9. *Vaccinio myrtilli-Genistetalia pilosae*; 10. *Erico-Pinetalia*; 11. *Alnetalia glutinosae*; 12. *Arrhenatheretalia elatioris*; 13. *Molinietalia caeruleae*; 14. *Poo alpinae-Trisetetalia*; 15. *Filipendulo ulmariae-Lotetalia uliginosi*; 16. *Trifolio-Hordeetalia*; 17. *Calamagrostietalia villosae*; 18. *Nardetalia strictae*; 19. *Festucetalia spadiceae*; 20. *Seslerietalia comosae*; 21. *Brachypodietalia pinnati*; 22. *Festucetalia valesiacae*; 23. *Halacsyetalia sendtneri*; 24. *Scorzoneretalia villosae*; 25. *Moltkeetalia petraeae*; 26. *Phragmitetalia*; 27. *Magnocaricetalia*; 28. *Caricetalia davallianae*; 29. *Caricetalia fuscae*; 30. *Agropyretalia intermedio-repentis*; 31. *Onopordetalia acanthi*. Different groups of vegetation orders are shown in different colors.

longifolia, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *D. viridis*, *Neotinea tridentata* and *N. ustulata* (Appendix 1, Table 1). Other orchid taxa were recorded in a smaller number of vegetation types.

Analysis of the similarity of orchid flora among vegetation types. The hierarchical cluster analysis, performed using the SIMPROF test, revealed 12 significant groups of vegetation orders (Fig. 4) and 11 significant groups of vegetation alliances (Fig. 5). The delimitation of the order and alliance groups was made at $p<0.05$.

Order groups. The first group includes only the order *Quercetalia pubescenti-petraeae*. The second group consists of forest orders whose communities are mostly mesophilous, meso-thermophilous to frigoriphilous and occur from medium to high altitude areas: *Piceetalia excelsae*, *Pinetalia sylvestris*,

Table 1. Number of vegetation classes, orders and alliances in which orchid taxa of western Serbia were recorded.

Taxon	Vegetation class	Vegetation order	Vegetation alliance
Anacamptis coriophora (L.) R.M.Bateman, Pridgeon & M.W.Chase	5	6	7
Anacamptis laxiflora (Lam.) R.M.Bateman, Pridgeon & M.W.Chase	1	1	3
Anacamptis morio (L.) R.M.Bateman, Pridgeon & M.W.Chase	10	16	22
Anacamptis palustris (Jacq.) R.M.Bateman, Pridgeon & M.W.Chase	1	2	2
Anacamptis papilionacea (L.) R.M.Bateman, Pridgeon & M.W.Chase	3	4	4
Anacamptis pyramidalis (L.) Rich.	4	6	10
Cephalanthera damasonium (Mill.) Druce	4	6	10
Cephalanthera longifolia (L.) Fritsch	6	8	11
Cephalanthera rubra (L.) Rich.	5	6	11
Corallorhiza trifida Châtel.	2	3	3
Dactylorhiza cordigera (Fr.) Soó	2	4	4
Dactylorhiza fuchsii (Druce) Soó subsp. *fuchsii*	3	3	3
Dactylorhiza incarnata (L.) Soó subsp. *incarnata*	6	8	11
Dactylorhiza maculata (L.) Soó subsp. *maculata*	6	6	9
Dactylorhiza maculata subsp. *transsilvanica* (Schur) Soó	7	8	10
Dactylorhiza saccifera (Brongn.) Soó subsp. *saccifera*	10	16	20
Dactylorhiza sambucina (L.) Soó	9	14	17
Dactylorhiza viridis (L.) R.M.Bateman, Pridgeon & M.W.Chase	6	6	6
Epipactis atrorubens (Hoffm.) Besser	5	5	7
Epipactis distans Arv.-Touv.	2	2	2
Epipactis helleborine (L.) Crantz subsp. *helleborine*	4	7	11
Epipactis leptochila subsp. *neglecta* Kümpel	2	3	3
Epipactis microphylla (Ehrh.) Sw.	3	3	5
Epipactis muelleri Godfery subsp. *muelleri*	1	1	1
Epipactis palustris (L.) Crantz	3	5	8
Epipactis pontica Taubenheim	1	1	1
Epipactis purpurata Sm.	2	3	3
Epipogium aphyllum Sw.	2	2	2
Goodyera repens (L.) R.Br.	3	4	5
Gymnadenia conopsea (L.) R.Br.	13	20	25
Gymnadenia frivaldii Hampe ex Griseb.	1	1	1
Gymnadenia odoratissima (L.) Rich. subsp. *odoratissima*	3	2	2
Gymnadenia rhellicani (Teppner & E.Klein) Teppner & E.Klein	2	2	2
Himantoglossum calcaratum (Beck) Schltr. subsp. *calcaratum*	4	6	8
Limodorum abortivum (L.) Sw.	5	5	7
Neotinea tridentata (Scop.) R.M.Bateman, Pridgeon & M.W.Chase subsp. *tridentata*	6	7	8
Neotinea ustulata (L.) R.M.Bateman, Pridgeon & M.W.Chase	5	7	9
Neottia cordata (L.) Rich.	3	4	5
Neottia nidus-avis (L.) Rich.	4	6	9
Neottia ovata (L.) Bluff & Fingerh.	10	14	18
Ophrys apifera Huds.	2	3	6
Ophrys insectifera L.	2	2	3

Taxon	Vegetation class	Vegetation order	Vegetation alliance
Ophrys scolopax subsp. *cornuta* (Steven) E.G.Camus in E.G.Camus	3	4	7
Ophrys sphegodes Mill. subsp. *sphegodes*	1	1	1
Orchis mascula subsp. *speciosa* (Mutel) Hegi	5	8	8
Orchis militaris L. subsp. *militaris*	3	3	3
Orchis pallens L.	5	6	7
Orchis purpurea Huds. subsp. *purpurea*	5	6	9
Orchis simia Lam. subsp. *simia*	4	6	8
Orchis spitzelii Saut. ex W.D.J.Koch subsp. *spitzelii*	1	1	1
Platanthera bifolia (L.) Rich.	10	15	22
Platanthera chlorantha (Custer) Rchb.	7	8	9
Pseudorchis albida (L.) Á.Löve & D.Löve	2	2	2
Spiranthes spiralis (L.) Chevall.	2	3	3
Traunsteinera globosa (L.) Rchb.	7	9	12

Athyrio filicis-feminae-Piceetalia, *Fagetalia sylvaticae* and *Carpinetalia betuli*. The third group includes vegetation orders of the class *Molinio-Arrhenatheretea* (*Arrhenatheretalia elatioris* and *Molinietalia caeruleae*), i.e. mesophilous and hygrophilous grasslands and meadows. The fourth group consists only of the vegetation order *Erico-Pinetalia*, i.e. pine forests and forests of *Picea omorika*. The fifth group consists of the following vegetation orders: *Fragario vescae-Populetalia tremulae*, *Sambucetalia racemosae*, *Vaccinio myrtilli-Genistetalia pilosae* and *Alnetalia glutinosae*. The sixth group consists of orders that include xerophilous communities within the class *Festuco-Brometea* (*Halacsyetalia sendtneri* and *Scorzoneretalia villosae*), chasmophytic communities of the class *Asplenietea trichomanis* (*Moltkeetalia petraeae*) and reed swamp vegetation communities (*Phragmitetalia*). The seventh group consists of ruderal types of vegetation (*Agropyretalia intermedio-repentis* and *Onopordetalia acanthi*). The eighth group is composed of vegetation orders that include fen communities (*Caricetalia davallianae* and *Caricetalia fuscae*) and sedge-bed marsh vegetation communities (*Magnocaricetalia*). The ninth group includes two orders of the class *Festuco-Brometea*, i.e. xerophilous and xero-mesophilous grasslands (*Brachypodietalia pinnati* and *Festucetalia valesiacae*). The tenth group includes three orders from the vegetation class *Molinio-Arrhenatheretea* (*Poo alpinae-Trisetetalia*, *Filipendulo ulmariae-Lotetalia uliginosi* and *Trifolio-Hordeetalia*), as well as the order *Calamagrostietalia villosae* implying tall-grass and herb-rich vegetation. The eleventh group is represented only by the order *Nardetalia strictae*, which includes secondary mat-grass swards, whereas the twelfth group consists of two orders of the class *Juncetea trifidi* (*Festucetalia spadiceae* and *Seslerietalia comosae*), which include acidophilous grasslands in high-altitude areas (Fig. 4).

Alliance groups. The first group is represented in forest alliances that include thermophilous and meso-thermophilous communities which are mainly distributed at low and medium altitudes (*Carpinion betuli*, *Fraxino orni-Ostryion*, *Quercion confertae* and *Quercion petraeo-cerridis*). The second group includes forest communities distributed from medium altitudes to highland areas (*Piceion excelsae*, *Dicrano-Pinion sylvestris*, *Abieti-Piceion* and *Fagion sylvaticae*). The third group consists of the following alliances: *Fragario vescae-Populion tremulae*, *Sambuco-Salicion capreae*, *Bruckenthalion spiculifoliae*, *Fraxino orni-Pinion nigrae* and *Erico carneae-Piceion omorikae*. The fourth group includes mesophilous communities of the alliance *Arrhenatherion elatioris*, whereas

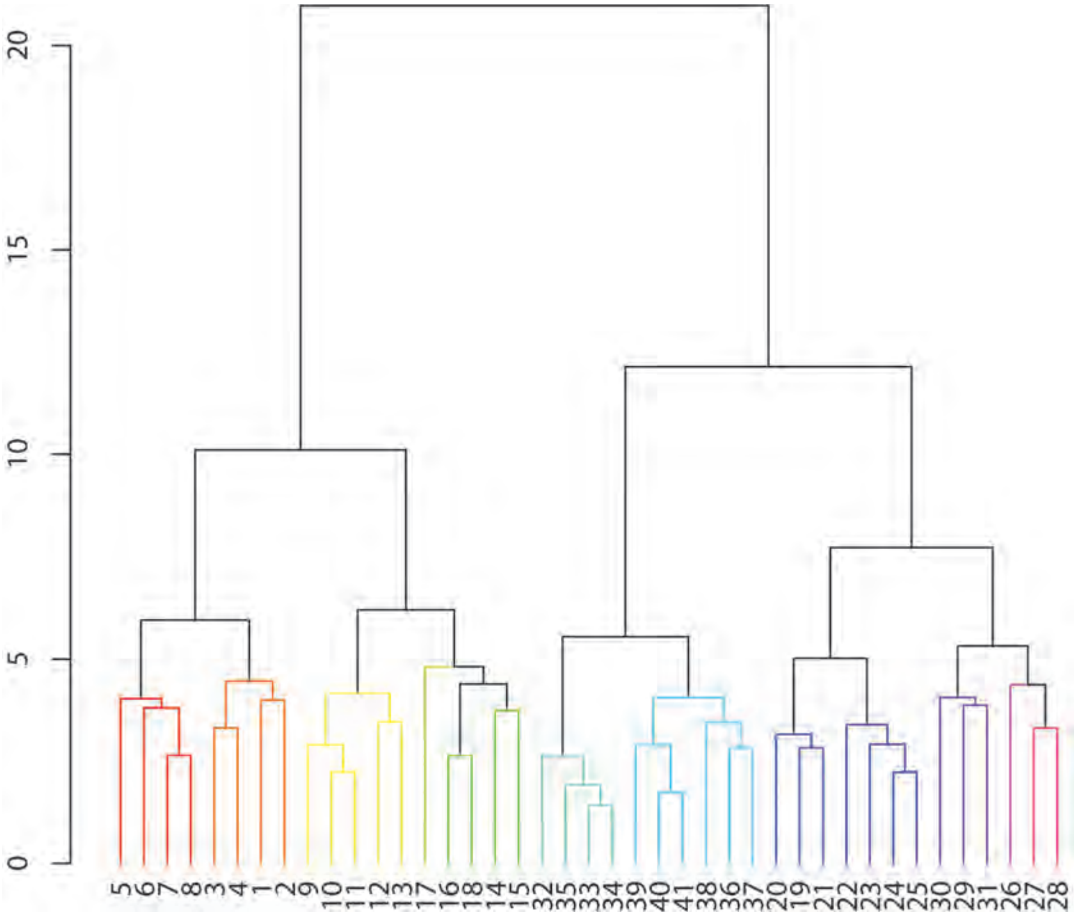

Figure 5. Cluster dendrogram of similarity of orchid flora among the analysed vegetation alliances in the central Balkans (western Serbia): 1. *Piceion excelsae*; 2. *Dicrano-Pinion sylvestris*; 3. *Abieti-Piceion*; 4. *Fagion sylvaticae*; 5. *Carpinion betuli*; 6. *Fraxino orni-Ostryion*; 7. *Quercion confertae*; 8. *Quercion petraeo-cerridis*; 9. *Fragario vescae-Populion tremulae*; 10. *Sambuco-Salicion capreae*; 11. *Bruckenthalion spiculifoliae*; 12. *Fraxino orni-Pinion nigrae*; 13. *Erico carneae-Piceion omorikae*; 14. *Seslerio rigidae-Pinion*; 15. *Erico-Fraxinion orni*; 16. *Alnion glutinosae*; 17. *Arrhenatherion elatioris*; 18. *Cynosurion cristati*; 19. *Calthion palustris*; 20. *Molinion caeruleae*; 21. *Deschampsion cespitosae*; 22. *Pancicion serbicae*; 23. *Mentho longifoliae-Juncion inflexi*; 24. *Trifolion pallidi*; 25. *Calamagrostion villosae*; 26. *Nardo-Agrostion tenuis*; 27. *Potentillo ternatae-Nardion*; 28. *Poion violaceae*; 29. *Cirsio-Brachypodion pinnati*; 30. *Chrysopogono-Danthonion calycinae*; 31. *Festucion valesiacae*; 32. *Centaureo-Bromion fibrosi*; 33. *Chrysopogono grylli-Koelerion splendentis*; 34. *Amphoricarpion neumayeri*; 35. *Phragmition communis*; 36. *Magnocaricion elatae*; 37. *Caricion davallianae*; 38. *Caricion fuscae*; 39. *Sphagno-Caricion canescentis*; 40. *Convolvulo arvensis-Agropyrion repentis*; 41. *Onopordion acanthi*. Different groups of vegetation alliances are shown in different colors.

the fifth group includes alliances *Alnion glutinosae*, *Cynosurion cristati*, *Seslerio rigidae-Pinion* and *Erico-Fraxinion orni*. The sixth group consists of alliances that include xerophilous communities within the class *Festuco-Brometea* (*Centaureo-Bromion fibrosi* and *Chrysopogono grylli-Koelerion splendentis*), chasmophytic communities of the class *Asplenietea trichomanis* (*Amphoricarpion neumayeri*) and reed swamp vegetation communities (*Phragmition communis*). The seventh group is represented in alliances that include fen communities (*Sphagno-Caricion canescentis*, *Caricion davallianae* and *Caricion fuscae*), sedge-bed marsh vegetation communities (*Magnocaricion elatae*) and the alliances of ruderal vegetation (*Convolvulo arvensis-Agropyrion repentis* and *Onopordion acanthi*). The eighth group includes hygrophilous and mesophilous grassland communities from the class *Molinio-Arrhenatheretea* (*Molinion caeruleae*, *Calthion palustris*, *Deschampsion cespitosae*, *Pancicion serbicae*, *Mentho longifoliae-Juncion inflexi* and *Trifolion pallidi*), as well as the alliance *Calamagrostion villosae* implying tall-grass and herb-rich vegetation. The ninth group is represented by xerophilous and xero-mesophilous communities within the class *Festuco-Brometea* (*Cirsio-Brachypodion pinnati*, *Chrysopogono-Danthonion calycinae* and *Festucion valesiacae*). The tenth group includes communities of the alliance *Nardo-Agrostion tenuis*, whereas the eleventh group is composed of acidophilous grasslands and secondary mat-grass swards mainly occurring in high-altitude areas within the alliances *Potentillo ternatae-Nardion* and *Poion violaceae* (Fig. 5).

Discussion

The present study indicates that forest vegetation types are inhabited by a great number of orchid species, which may be explained by the large area occupied by these ecosystems in western Serbia (ca 37% of the total area of western Serbia; Gavrilović 2019) and generally more stable ecological conditions within the forests in relation to open vegetation types, but also by historical factors and refugial character. Moreover, some orchids that are primarily characteristic of herbaceous vegetation types have also been found, although rarely, within forest ecosystems, which further explains the great richness of orchids. Grassland vegetation types are represented by a slightly smaller number of orchid taxa, which can be related to the smaller area of the areas they occupy (ca 25% of the total land in western Serbia; Gavrilović 2019) and the fact that they are often under a strong anthropogenic influence. Although they occupy a small part of the study area, fens and marshlands are represented by a significant number of representatives of orchids, which emphasises their important conservation value.

Grasslands and heaths. Our study indicates that the greatest number of orchid species and subspecies occur in the communities of the class *Festuco-Brometea* (Appendix 1, Fig. 1), which is in line with the results of numerous studies that have been conducted in Europe (Krauss et al. 2004; Haraštová-Sobotková et al. 2005; Vakhrameeva et al. 2008; Landi et al. 2009; Djordjević et al. 2016a; Leuschner & Ellenberg 2017). The high number of orchid taxa within this vegetation class can be explained by large representation of these communities in both lowland and highland areas with various topographic conditions, and the fact that a large proportion of these communities develop on carbonate substrates (limestones, dolomites, carbonate clastites) and soils of alkaline, neutral or slightly acidic reaction, which is favourable for the survival and growth of most orchids (Delforge 2006; Landi et al. 2009; Djordjević & Tsiftsis 2019; Hrivnák et al. 2020). Moreover, according to the Habitats Directive of the European Union (Council Directive 92/43/EEC on the conservation of natural habitats of wild fauna and flora), semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometalia*) represent significant orchid habitats (Calaciura & Spinelli 2008). However, in western Serbia, orchids within this class are also represented in communities on ultramafics, ophiolitic mélanges, andesite-dacite-porphyrite and schists-gneiss-phyllites, which further explains their great diversity.

The results show that the vegetation order *Brachypodietalia pinnati* includes more than 50% of orchid taxa recorded in western Serbia and that this is the richest order in orchid taxa (Appendix 1; Fig. 2). While the orchids inhabiting the communities of the alliance *Cirsio-Brachypodion pinnati* primarily occur on carbonate bedrock types, the orchids growing in the communities of the alliance *Chrysopogono-Danthonion calycinae* are distributed mainly on serpentine substrates (ultramafics). The significant abundance of orchids in these serpentine grasslands can be explained by the fact that ultramafics favour open vegetation with lower levels of competition between plants, which corresponds to competitively weak and light-demanding orchids (Djordjević et al. 2016a, b). In addition, the low content of nutrients that are characteristic of serpentine soils is favourable for most orchids, known for their sensitivity to high nutrient content (Figura et al. 2020). In Central and Western Europe, within the mentioned vegetation order, many orchids grow in xero-mesophilous communities of the alliances *Bromion erecti*, i.e. *Mesobromion* and *Xerobromion erecti* (Leuschner & Ellenberg 2017). Among the orchids recorded in Central Europe in communities of *Mesobromion* on carbonate substrates, the following should be noted: *Anacamptis pyramidalis*, *A. morio*, *Gymnadenia conopsea*, *Neotinea tridentata*, *N. ustulata*, *Ophrys apifera*, *O. sphegodes*, *O. holoserica*, *O. insectifera*, *Orchis mascula*, *O. militaris*, *O. purpurea*, *O. simia*, *Platanthera bifolia* and *Spiranthes spiralis* (Krauss et al. 2004; Meekers et al. 2012; Leuschner & Ellenberg 2017).

A significant number of orchids in western Serbia inhabit continental, subcontinental and sub-Mediterranean grassland communities of the order *Festucetalia valesiacae* and the alliance *Festucion valesiacae* (Appendix 1; Figs 2, 3), which are mainly distributed on carbonate substrates. This is consistent with the studies conducted in Central and Western Europe which highlighted the importance of these grasslands for the growth and survival of certain orchids (Haraštová-Sobotková et al. 2005; Leuschner & Ellenberg 2017). The small number of orchid species recorded in communities of the orders *Halacsyetalia sendtneri* and *Scorzoneretalia villosae* (Appendix 1; Fig. 2) can be attributed to their extreme habitat conditions. More specifically, *Anacamptis morio* is the only species recorded in the order *Halacsyetalia sendtneri* (Appendix 1), whose communities occur on serpentine soils, known for stressful conditions such as drought, high concentrations of Fe, Ni, Cr and Co, and an unfavourable ratio of Ca and Mg (Mišljenović et al. 2020).

Our study indicates that the vegetation class *Molinio-Arrhenatheretea* hosts a significant number of orchids that require mesophilous and hygrophilous habitat conditions (Appendix 1; Fig. 1). Earlier research has also highlighted the importance of this vegetation class, citing many orchid taxa (Wotavová et al. 2004; Bernardos et al. 2007; Vakhrameeva et al. 2008; Jersáková et al. al. 2015; Kotilínek et al. 2015; Budzhak et al. 2016). According to earlier studies, the following orchid taxa were recorded in the communities of the order *Arrhenatheretalia elatioris* in Europe: *Dactylorhiza sambucina*, *D. maculata*, *D. majalis*, *Epipactis palustris*, *Gymnadenia conopsea*, *Neotinea ustulata*, *Neottia ovata*, *Platanthera bifolia* and *Traunsteinera globosa* (Tali et al. 2004; Haraštová-Sobotková et al. 2005; Jersáková et al. 2015; Kotilínek et al. 2015; Budzhak et al. 2016).

Orchids of western Serbia, in particular those of the genus *Dactylorhiza*, have a significant presence in the mesophilous and hygrophilous meadow communities of the order *Molinietalia caeruleae*, especially within the alliances *Molinion caeruleae*, *Deschampsion cespitosae* and *Calthion palustris* (Appendix 1). Bearing in mind their sensitivity to droughts, changes in nutrient content, and the fact that they are subject to the negative impact of global warming and different anthropogenic impacts, considerable attention should be paid to the conservation of these vegetation types (Djordjević et al. 2016a). The importance of this vegetation order as a significant vegetation type also has been recognised in other European countries. Thus, the following species are most commonly recorded in *Molinion caerulae* communities in Europe: *Dactylorhiza cordigera*, *D. majalis*, *D. maculata* subsp. *maculata*, *Epipactis palustris*, *Gymnadenia conopsea*, *G. densiflora*, *Neotinea ustulata* and *Neottia ovata* (Delforge 2006; Meekers et al. 2012; Jacquemyn et al. 2014; Kotilínek et al. 2015; Budzhak et al. 2016). Furthermore, earlier studies indicate that the following orchids grow in *Calthion palustris* communities: *Dactylorhiza incarnata*, *D. maculata*, *D. majalis*, *D. praetermissa*, *Epipactis palustris*, *Gymnadenia conopsea* and *Neottia ovata* (Wotavová et al. 2004; Schrautzer et al. 2011; Meekers et al. 2012; Jacquemyn et al. 2014; Kotilínek et al. 2015). The results of the present study highlight the importance of communities of the endemic alliance *Pancicion serbicae* (*Poo alpinae-Trisetetalia*), inhabited primarily by orchids that prefer high-altitude areas such as *Dactylorhiza cordigera*, *D. sambucina*, *Gymnadenia conopsea* and *Traunsteinera globosa* (Appendix 1). Furthermore, the alliance *Mentho longifoliae-Juncion inflexi* (*Filipendulo ulmariae-Lotetalia uliginosi*) also represents an important vegetation type for the existence of species that require increased soil moisture, such as *Epipactis palustris*, *Dactylorhiza incarnata* and *D. saccifera*. However, far fewer orchids have been recorded within the alliance *Trifolion pallidi* (*Trifolio-Hordeetalia*) (Appendix 1), representing wet meadows of humid continental regions of the northern Central Balkans (Mucina et al. 2016).

Our results indicate that a significant number of orchids occur in communities of the *Nardo-Agrostion tenuis* (*Nardetalia strictae*, *Nardetea strictae*; Appendix 1). This vegetation type includes secondary mat-grass swards on nutrient-poor soils (Mucina et al. 2016), suggesting their sensitivity to increased nutrient content. The species recorded in similar communities in Central and Western Europe are following: *Neottia ovata*, *Gymnadenia conopsea*, *Dactylorhiza maculata*, *D. majalis*, *D. sambucina*, *Orchis militaris* and *Pseudorchis albida* (Farrell 1985; Wotavová et al. 2004; Ståhlberg 2009; Jersáková et al. 2011, 2015; Meekers et al. 2012; Kotilínek et al. 2015).

Orchids of western Serbia recorded within the class *Juncetea trifidi* are primarily cenobionts of the alliance *Potentillo ternatae-Nardion* (*Festucetalia spadiceae*), whereas a smaller number of taxa have been recorded in communities of the alliance *Poion violaceae* (*Seslerietalia comosae*) (Appendix 1). It is known that plant communities of this vegetation class are widespread at high altitudes and are characterised by acidic soil reaction (Mucina et al. 2016). Consequently, the importance of this type of vegetation in western Serbia is reflected in the presence of significant populations of highland orchid species (*Dactylorhiza sambucina*, *Gymnadenia rhellicani*, *Pseudorchis albida* and *Traunsteinera globosa*) as well as five taxa of the genus *Dactylorhiza* (Appendix 1). Similarly, studies in Europe indicate that *Dactylorhiza sambucina*, *D. maculata* and *Pseudorchis albida* inhabit communities of the class *Juncetea trifidi* (Ståhlberg 2009; Jersáková et al. 2011, 2015).

The small number of orchid representatives inhabiting tall-grass and herb-rich communities on dry acidic soils in the upper montane and subalpine belts (*Calamagrostion villosae*, *Mulgedio-Aconitetea*; Appendix 1) can be explained by lower representation and fewer studies about this vegetation type in the study area. Furthermore, a few orchid taxa were recorded in communities of the vegetation class *Calluno-Ulicetea*, i.e. in the alliance *Bruckenthalion spiculifoliae* (dwarf heath on siliceous substrates of the southern Carpathians and the Dinarides) (Appendix 1), which is also associated with lower prevalence of this type of vegetation in western Serbia.

Vegetation of bogs and fens. The results of this study show that a significant number of orchids, including some of the rarest ones, inhabit fen communities of class *Scheuchzerio palustris-Caricetea fuscae* (Appendix 1; Fig. 1). Orchids primarily occur in communities of *Caricion fuscae* and

Sphagno-Caricion canescentis (*Caricetalia fuscae*), whereas fewer orchid taxa have been recorded in the alliance *Caricion davallianae* (*Caricetalia davallianae*) (Appendix 1). The presence of 12 orchid taxa within this class is not negligible, given that fens have been estimated to occupy less than 0.001% of the entire territory of Serbia (Lazarević 2013). Moreover, a recent study indicates that *Gymnadenia frivaldii*, *Dactylorhiza cordigera*, *D. maculata* subsp. *maculata* and *D. saccifera* represent the indicator taxa of this vegetation class in western Serbia (Djordjević et al. 2016a). Well-known orchids that inhabit fen communities in Europe are following: *Dactylorhiza cordigera*, *D. incarnata*, *D. maculata*, *D. majalis*, *D. traunsteineri*, *Epipactis palustris*, *Gymnadenia conopsea*, *Hammarbya paludosa*, *Herminium monorchis*, *Liparis loeselii*, *Malaxis monophyllos*, *Neottia ovata*, *Pseudorchis albida*, *Spiranthes aestivalis* etc. (Wotavová et al. 2004; Delforge 2006; Illyés et al. 2009; Jersáková et al. 2011; Meekers et al. 2012; Jacquemyn et al. 2014; Kotilínek et al. 2015; Blinova 2016; Mucina et al. 2016; Tsiftsis & Antonopoulos 2017).

Marshlands. In western Serbia, orchids also inhabit marsh communities of the class *Phragmito-Magnocaricetea* (Appendix 1; Fig. 1). Some orchid taxa were found in the communities of *Magnocaricion elatae* (*Magnocaricetalia*), while a smaller number of orchid species were registered in communities of the alliance *Phragmition communis* (*Phragmitetalia*) (Appendix 1). Studies conducted in Europe indicate that *Epipactis palustris* inhabits communities of *Magnocaricion elatae* (Jacquemyn et al. 2014), whereas *Dactylorhiza incarnata*, *D. majalis*, *Epipactis palustris*, *Hammarbya paludosa* and *Liparis loeselii* have been reported to grow in communities, where *Phragmites australis* is highly abundant (Illyés et al. 2009; Schrautzer et al. 2011).

Forest and scrub vegetation. In western Serbia, a large number of orchids (about 50% of taxa) occur in forest communities of the class *Quercetea pubescentis* within the order *Quercetalia pubescenti-petraeae* (Appendix 1), which is in agreement with the results of numerous studies from other European countries (Haraštová-Sobotková et al. 2005; Tsiftsis et al. 2008; Vakhrameeva et al. 2008; Hrivnák et al. 2014; Kirca et al. 2020). It is known that forest communities of this vegetation class are distributed mainly at low and medium altitudes and that they are characterised by great richness of vascular plant species and a larger number of plants, compared to mesophilous forest communities distributed at higher altitudes (Čarni et al. 2016).

The large number of orchids in *Fraxino orni-Ostryion* forests can be explained by the fact that these forests develop mainly on carbonate substrates, which are generally suitable for most orchids (Djordjević & Tsiftsis 2019), as well as by the favourable conditions of the light regime, temperature and humidity of the habitat. These forests are distributed mainly in the gorges and canyons of western Serbia, where they are sheltered from extreme climatic influences. The presence of a large number of orchid species can also be associated with the great stability of these forests, which is reflected in reduced fluctuations in temperature and humidity of the habitats. According to our study, especially northerly exposed communities of *Ostrya carpinifolia* and *Fraxinus ornus* are inhabited by orchids. The importance of these forests is reflected in the great richness of orchid species from the Mediterranean and sub-Mediterranean chorological group and the presence of four *Ophrys* taxa (Appendix 1). High conservation values of these forest types have also been demonstrated in northeastern Greece, where 22 species of orchids have been recorded in the community consisting of *Ostrya carpinifolia*, *Carpinus orientalis* and *Fraxinus ornus* (Tsiftsis et al. 2006, 2007, 2008). The fact that a higher number of orchid taxa were recorded in *Quercion petraeo-cerridis* forests than in *Quercion confertae* forests in western

Serbia (Appendix 1; Fig. 3) can be explained by higher representation and greater altitude range of the communities of the first mentioned alliance. According to Tsiftsis et al. (2007), 21 orchid species were found in forest communities dominated by *Quercus frainetto* and *Quercus petraea* subsp. *medwediewii* in northeastern Greece.

In western Serbia, a large number of orchids have been registered in the vegetation class *Carpino-Fagetea sylvaticae*, especially in beech forest communities of the alliance *Fagion sylvaticae* (*Fagetalia sylvaticae*) (Appendix 1), which is quite understandable given that these communities occur throughout the vertical profile, from lowlands to high altitude areas (Karadžić 2018) and the fact that they develop on different bedrock types. A large number of orchid species from the Central European chorological group have been recorded in the beech forests of western Serbia, among which representatives from the genera *Epipactis*, *Cephalanthera* and *Neottia* stand out. Many studies also point out that a large number of orchids occur in beech forests (Delforge 2006; Hrivnák et al. 2014; Tsiftsis & Antonopoulos 2017). According to Tsiftsis et al. (2007), 22 orchid species and subspecies inhabit beech forests in northeastern Greece. Moreover, the beech forests of the Balkan Peninsula represent important refugia of *Epipactis* species, making the entire Balkans one of the most important centres of diversity of this genus in Europe (Delforge 2006; Tsiftsis & Antonopoulos 2017). A smaller number of orchids found in mesophilous forest communities of the alliance *Carpinion betuli* (*Carpinetalia betuli*) can be attributed to the lower presence of these communities in the study area. The following species stand out among the orchids recorded in *Carpinion betuli* communities in Europe: *Neottia nidus-avis*, *N. ovata*, *Orchis mascula*, *O. pallens*, *O. purpurea*, *Epipactis helleborine*, *E. purpurata*, *E. pontica* and *Platanthera bifolia* (Delforge 2006; Brzosko et al. 2009; Kooijman 2010; Hrivnák et al. 2014; Kotilínek et al. 2015).

A significant number of orchids recorded in the coniferous forests of the vegetation class *Vaccinio-Piceetea* within the orders *Athyrio filicis-feminae-Piceetalia* and *Piceetalia excelsae* (Appendix 1) can be explained by the large presence of these forests in western Serbia and a significant range of altitudes at which they are distributed. Although these vegetation types are primarily characteristic of high altitude areas of Serbia (1200–1600 m in the case of mixed spruce, beech and fir forests, as well as 1500–1700 m in the case of spruce forests), in western Serbia the stands of these communities are often present also at lower altitudes, primarily due to temperature inversion and high precipitation (Kojić et al. 1998; Cvjetićanin & Novaković 2010). According to Cvjetićanin & Novaković (2010), mixed forests of spruce, beech and fir (ass. *Piceo-Fago-Abietetum*) have built an oroclimatogenic belt in the area of the National Park Tara at an altitude above 950 m. A significant number of orchid species from the boreal and Central European chorological groups have been registered in coniferous forests in western Serbia (Appendix 1). Studies of European orchids also point out that many orchid representatives grow in coniferous forests (Delforge 2006; Bernardos et al. 2007; Vakhrameeva et al. 2008; Lõhmus & Kull 2011; Tsiftsis & Antonopoulos 2017).

In western Serbia, a significant number of orchids have been recorded in pine forest communities (*Erico-Pinetea*, *Erico-Pinetalia*), which is in line with earlier research on orchids conducted in Europe (Delforge 2006; Tsiftsis et al. 2007; Vakhrameeva et al. 2008; Kirca et al. 2020). Among the species found in the forests of *Picea omorika* (*Erico carneae-Piceion omorikae*) on Mt Zvijezda, Mt Tara and the Mileševka canyon, the boreal species *Goodyera repens* and *Neottia* *cordata* should be particularly emphasised, whereas forest communities of *Pinus nigra* and *P. sylvestris* on ultramafics within the alliance *Erico-Fraxinion orni* host a significant number of orchids that are characteristic cenobionts of grassland ecosystems (Appendix 1).

The small number of orchids in birch forests from the alliance *Fragario vescae-Populion tremulae*) is explained by the limited distribution of these forests and the fact that they mainly represent an unstable stage in the succession of forest vegetation in western Serbia. Namely, in western Serbia birch forests are widespread within the belt of oak, pine and beech forests, and they occur mainly after forest fires. According to Vakhrameeva et al. (2008), *Epipactis helleborine* and *Platanthera bifolia* grow in birch forests in Russia and the countries of the former Soviet Union, while Tsiftsis et al. (2007) recorded *Dactylorhiza sambucina*, *Epipactis helleborine*, *Neottia ovata* and *Platanthera chlorantha* in birch forests in northeastern Greece.

A small number of orchid species were found in communities of the class *Alnetea glutinosae* (Appendix 1), which is related to the generally lower representation of these forests in western Serbia. Studies in Europe indicate that *Dactylorhiza majalis* and *Neottia ovata* inhabit *Alnetea glutinosae* communities (Wotavová et al. 2004; Kotilínek et al. 2015). It is worth noting that in western Serbia, orchids were not recorded in communities of the class *Alno glutinosae-Populetea albae* (riparian gallery forests), which is explained by a lower degree of research of these forests as well as high nutrient content of the soils where these communities develop. Furthermore, few orchid species were found in *Salix caprea* scrubs within the alliance *Sambuco-Salicion caprae* (Appendix 1), which consists of communities of elder, willow and hazel scrubs on nutrient-rich soils in forest clearings (Mucina et al. 2016).

Anthropogenic vegetation. The present study highlights the importance of ruderal communities of the class *Artemisietea vulgaris* as vegetation types that are inhabited by some orchid representatives (Appendix 1). The presence of orchids in ruderal communities can be explained by the fact that orchids are competitively weak, belonging to the transitional group between ruderal plants and plants that tolerate stress (Djordjević & Tsiftsis 2020), which means that they can survive a certain degree of disturbance. Some orchids inhabit anthropogenic vegetation types primarily because of their favourable light regime and reduced competition between plants (Adamowski 2006). Moreover, newly-created sites and roadsides are suitable for some orchid taxa, as these habitats can have the effect of ecotones and are poorly covered by dominant plant species (Djordjević et al. 2016a; Fekete et al. 2019).

Vegetation of rock crevices and screes. A small number of representatives of the family Orchidaceae in the communities of the class *Asplenietea trichomanis* (Appendix 1) have been anticipated due to extreme habitat conditions such as droughts. *Gymnadenia conopsea* is the only species found within the chasmophytic vegetation of limestone crevices, i.e. alliance *Amphoricarpion neumayeri* (*Moltkeetalia petraeae*).

Orchid species and subspecies that grow in the largest number of vegetation types. The present study indicates that *Gymnadenia conopsea* inhabits the largest number of vegetation types in western Serbia (Table 1), which is in agreement with studies from other European countries stating that this species grows in various grassland, meadow and fen communities and less frequently in forest communities (Meekers et al. 2012). In addition, *Anacamptis morio*, *Dactylorhiza saccifera*, *Platanthera bifolia*, *Neottia ovata* and *Dactylorhiza sambucina* inhabit a large number of communities from different alliances, orders and classes in western Serbia (Table 1), indicating their great ecological plasticity and adaptability. This can be explained by the fact that these species grow successfully on different geological substrates, and that they occur in a wide range of altitudes (Djordjević et al. 2016a; Djordjević & Tsiftsis 2019). Moreover, in the case of *Gymnadenia conopsea*, it can be related to its lower degree of specialisation towards pollinators (Meekers et al. 2012). The results of our study are consistent with those showing that *Platanthera bifolia*, *Neottia ovata*, *Dactylorhiza sambucina*, *D. saccifera* and *Epipactis helleborine*, in particular, inhabit a large number of plant communities often occurring in both forests and herbaceous vegetation types, pointing to their generalist characteristics concerning their habitat conditions (Adamowski 2006; Delforge 2006; Tsiftsis et al. 2007, 2008; Jersáková et al. 2015; Kotilínek et al. 2015; Tsiftsis & Antonopoulos 2017).

Groups of vegetation orders and alliances. Analysis of the similarity of orchid flora among vegetation types indicates a separation of four groups of orders and alliances of forest vegetation and eight groups of orders and seven groups of alliances of herbaceous vegetation (Figs 4; 5), which emphasises the great diversity of herbaceous vegetation types concerning survival and growth of orchids. In general, groups of vegetation orders and alliances are separated mainly according to their classification in higher syntaxonomic units. The separation of significant groups is primarily related to elevation and factors that are expressed by elevation, such as temperature and humidity, but also to the light regime, soil moisture and type of substrate. This is in agreement with the underlying factors influencing distribution patterns and abundance of orchids (Tsiftsis et al. 2008; Djordjević & Tsiftsis 2020), which confirms the joint effects of several environmental factors in defining the patterns of composition and richness of orchid taxa. Moreover, a recent study has shown that, based on the data about frequency and abundance, orchids of herbaceous vegetation types form eight ecologically distinct groups (Djordjević et al. 2016a), indicating that the use of both quantitative and qualitative data provides good insight into differences between ecological preferences of studied orchids.

Conclusion

The study demonstrates that representatives of the family Orchidaceae inhabit forest and herbaceous vegetation types in western Serbia in a similar way in terms of the number of species and subspecies. The greatest number of orchid species was recorded in the communities of the classes *Festuco-Brometea*, *Molinio-Arrhenatheretea* and *Quercetea pubescentis* as well as in the orders *Quercetalia pubescenti-petraeae*, *Brachypodietalia pinnati* and *Fagetalia sylvaticae*. The general trend is such that the highest number of orchid species grow in vegetation types that are widely distributed and occur over a wide range of altitudes, i.e. from lowland to highland areas, mainly on carbonate substrates or various bedrock types. The orchids *Gymnadenia conopsea*, *Anacamptis morio*, *Dactylorhiza saccifera*, *Platanthera bifolia*, *Neottia ovata* and *Dactylorhiza sambucina* were recorded in the largest number of vegetation types, demonstrating that they are generalists in relation to the habitat conditions. Overall, 12 significant groups of vegetation orders and 11 significant groups of vegetation alliances were recognised based on the composition of orchid species. Future studies should investigate how richness and composition of orchid species vary in vegetation types on a small scale and should predict how future climate change and anthropogenic factors will affect the survival of orchid populations in certain types of vegetation. In addition, research on orchid performance such as reproductive success and ecophysiological characteristics in different types of vegetation is recommended.

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Appendix 1. Phytocoenological affiliation of orchid species and subspecies in the Central Balkans (western Serbia).

Orchid species and subspecies	Vegetation alliance	Vegetation order	Vegetation class
Cephalanthera damasonium, *Cephalanthera longifolia*, *Cephalanthera rubra, Corallorhiza trifida*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Dactylorhiza viridis*, *Epipactis atrorubens*, *Epipactis distans*, *Epipactis helleborine*, *Epipactis leptochila* subsp. *neglecta*, *Epipactis purpurata*, *Goodyera repens*, *Neottia cordata*, *Neottia nidus-avis*, *Neottia ovata*, *Orchis pallens*, *Platanthera bifolia*	***Piceion excelsae*** Pawłowski et al. 1928	***Piceetalia excelsae*** Pawłowski et al. 1928	***Vaccinio-Piceetea*** Br.-Bl. in Br.-Bl. et al. 1939
Dactylorhiza saccifera, *Dactylorhiza sambucina*, *Epipactis helleborine*, *Neottia ovata*, *Platanthera bifolia*	***Dicrano-Pinion sylvestris*** (Libbert 1933) W. Matuszkiewicz 1962	***Pinetalia sylvestris*** Oberd. 1957	***Vaccinio-Piceetea*** Br.-Bl. in Br.-Bl. et al. 1939
Cephalanthera damasonium, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Corallorhiza trifida*, *Dactylorhiza fuchsii*, *Dactylorhiza saccifera, Dactylorhiza sambucina, Epipactis helleborine*, *Epipactis leptochila* subsp. *neglecta*, *Epipactis microphylla*, *Epipactis muelleri*, *Epipactis purpurata, Epipogium aphyllum, Goodyera repens, Gymnadenia conopsea, Neottia cordata, Neottia nidus-avis, Neottia ovata, Orchis militaris, Platanthera bifolia, Platanthera chlorantha*	***Abieti-Piceion*** (Br.-Bl. in Br.-Bl. et al. 1939) Soó 1964	***Athyrio filicis-feminae-Piceetalia*** Hadač in Hadač et al. 1969	***Vaccinio-Piceetea*** Br.-Bl. in Br.-Bl. et al. 1939
Cephalanthera damasonium, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Corallorhiza trifida*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Epipactis atrorubens*, *Epipactis helleborine*, *Epipactis leptochila* subsp. *neglecta*, *Epipactis microphylla*, *Epipactis pontica*, *Epipactis purpurata*, *Epipogium aphyllum*, *Goodyera repens*, *Gymnadenia conopsea*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Neottia cordata*, *Neottia nidus-avis*, *Neottia ovata*, *Orchis mascula* subsp. *speciosa*, *Orchis pallens*, *Orchis purpurea*, *Orchis simia*, *Platanthera bifolia*, *Platanthera chlorantha*	***Fagion sylvaticae*** Luquet 1926	***Fagetalia sylvaticae*** Pawłowski 1928	***Carpino-Fagetea sylvaticae*** Jakucs ex Passarge 1968
Cephalanthera damasonium, *Cephalanthera longifolia*, *Dactylorhiza saccifera*, *Epipactis helleborine*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Limodorum abortivum*, *Neottia nidus-avis*, *Neottia ovata*, *Orchis simia*, *Platanthera bifolia*, *Platanthera chlorantha*	***Carpinion betuli*** Issler 1931	***Carpinetalia betuli*** P. Fukarek 1968	***Carpino-Fagetea sylvaticae*** Jakucs ex Passarge 1968

Continuation of Appendix 1.

Orchid species and subspecies	Vegetation alliance	Vegetation order	Vegetation class
Anacamptis pyramidalis, *Cephalanthera damasonium*, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Dactylorhiza saccifera*, *Dactylorhiza viridis*, *Epipactis atrorubens*, *Epipactis helleborine*, *Epipactis microphylla*, *Gymnadenia conopsea*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Limodorum abortivum*, *Neotinea tridentata*, *Neotinea ustulata*, *Neottia nidus-avis*, *Neottia ovata*, *Ophrys apifera*, *Ophrys insectifera*, *Ophrys scolopax* subsp. *cornuta*, *Ophrys sphegodes*, *Orchis militaris*, *Orchis purpurea*, *Orchis simia*, *Platanthera bifolia*	***Fraxino orni-Ostryion*** Tomažič 1940	***Quercetalia pubescenti-petraeae*** Klika 1933	***Quercetea pubescentis*** Doing-Kraft ex Scamoni et Passarge 1959
Anacamptis papilionacea, *Anacamptis pyramidalis*, *Cephalanthera damasonium*, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Epipactis helleborine*, *Epipactis microphylla*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Limodorum abortivum*, *Neottia nidus-avis*, *Ophrys apifera*, *Ophrys scolopax* subsp. *cornuta*, *Orchis pallens*, *Orchis purpurea*, *Orchis simia*, *Platanthera bifolia*, *Platanthera chlorantha*	***Quercion confertae*** Horvat 1958	***Quercetalia pubescenti-petraeae*** Klika 1933	***Quercetea pubescentis*** Doing-Kraft ex Scamoni et Passarge 1959
Anacamptis morio, *Anacamptis pyramidalis*, *Cephalanthera damasonium*, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Epipactis helleborine*, *Epipactis microphylla*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Limodorum abortivum*, *Neottia nidus-avis*, *Neottia ovata*, *Ophrys apifera*, *Ophrys insectifera*, *Ophrys scolopax* subsp. *cornuta*, *Orchis pallens*, *Orchis purpurea*, *Orchis simia*, *Platanthera bifolia*, *Platanthera chlorantha*	***Quercion petraeo-cerridis*** Lakušić et B. Jovanović in B. Jovanović et al. ex Čarni et Mucina 2015	***Quercetalia pubescenti-petraeae*** Klika 1933	***Quercetea pubescentis*** Doing-Kraft ex Scamoni et Passarge 1959
Anacamptis morio, *Dactylorhiza sambucina*, *Gymnadenia conopsea*, *Platanthera bifolia*	***Fragario vescae-Populion tremulae*** Willner et Mucina	***Fragario vescae-Populetalia tremulae*** Willner et Mucina in Willner et al. 2016 nom. inval.	***Brachypodio pinnati-Betuletea pendulae*** Ermakov et al. 1991
Anacamptis morio, *Anacamptis pyramidalis*, *Cephalanthera damasonium*, *Dactylorhiza sambucina*, *Epipactis atrorubens*, *Epipactis helleborine*, *Neottia nidus-avis*, *Orchis spitzelii*	***Fraxino orni-Pinion nigrae*** Em 1978	***Erico-Pinetalia*** Horvat 1959	***Erico-Pinetea*** Horvat 1959
Cephalanthera damasonium, *Cephalanthera rubra*, *Epipactis atrorubens*, *Epipactis helleborine*, *Goodyera repens*, *Gymnadenia conopsea*, *Neottia cordata*, *Neottia nidus-avis*, *Neottia ovata*, *Orchis mascula* subsp. *speciosa*, *Platanthera bifolia*	***Erico carneae-Piceion omorikae*** Mucina et Čarni	***Erico-Pinetalia*** Horvat 1959	***Erico-Pinetea*** Horvat 1959

Continuation of Appendix 1.

Orchid species and subspecies	Vegetation alliance	Vegetation order	Vegetation class
Anacamptis morio, *Anacamptis pyramidalis*, *Cephalanthera damasonium*, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Dactylorhiza viridis*, *Epipactis helleborine*, *Goodyera repens*, *Gymnadenia conopsea*, *Neotinea tridentata*, *Platanthera bifolia*, *Platanthera chlorantha*, *Traunsteinera globosa*	***Seslerio rigidae-Pinion*** Coldea ex Mucina et Čarni	***Erico-Pinetalia*** Horvat 1959	***Erico-Pinetea*** Horvat 1959
Anacamptis morio, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Epipactis atrorubens*, *Gymnadenia conopsea*, *Limodorum abortivum*, *Neottia cordata*, *Neottia ovata*, *Platanthera bifolia*	***Erico-Fraxinion orni*** Horvat 1959	***Erico-Pinetalia*** Horvat 1959	***Erico-Pinetea*** Horvat 1959
Dactylorhiza saccifera, *Neottia ovata*	***Alnion glutinosae*** Malcuit 1929	***Alnetalia glutinosae*** Tx. 1937	***Alnetea glutinosae*** Br.-Bl. et Tx. ex Westhoff et al. 1946
Dactylorhiza saccifera, *Neottia ovata*	***Sambuco-Salicion capreae*** Tx. et Neumann ex Oberd. 1957	***Sambucetalia racemosae*** Oberd. ex Doing 1962	***Robinietea*** Jurko ex Hadač et Sofron 1980
Dactylorhiza maculata subsp. *maculata*, *Neotinea tridentata*	***Bruckenthalion spiculifoliae*** Horvat 1949	***Vaccinio myrtilli-Genistetalia pilosae*** Schubert ex Passarge 1964	***Calluno-Ulicetea*** Br.-Bl. et Tx. ex Klika et Hadač 1944
Anacamptis coriophora, *Anacamptis morio*, *Anacamptis papilionacea*, *Anacamptis pyramidalis*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Gymnadenia conopsea*, *Gymnadenia odoratissima*, *Limodorum abortivum*, *Neotinea tridentata*, *Neotinea ustulata*, *Neottia ovata*, *Ophrys scolopax* subsp. *cornuta*, *Orchis mascula* subsp. *speciosa*, *Orchis pallens*, *Orchis purpurea*, *Orchis simia*, *Platanthera bifolia*, *Platanthera chlorantha*, *Traunsteinera globosa*	***Arrhenatherion elatioris*** Luquet 1926	***Arrhenatheretalia elatioris*** Tx. 1931	***Molinio-Arrhenatheretea*** Tx. 1937
Anacamptis morio	***Cynosurion cristati*** Tx. 1947	***Arrhenatheretalia elatioris*** Tx. 1931	***Molinio-Arrhenatheretea*** Tx. 1937
Anacamptis laxiflora, *Anacamptis morio*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza saccifera*, *Epipactis palustris*, *Gymnadenia conopsea*, *Neottia ovata*, *Platanthera bifolia*, *Traunsteinera globosa*	***Calthion palustris*** Tx. 1937	***Molinietalia caeruleae*** Koch 1926	***Molinio-Arrhenatheretea*** Tx. 1937

Continuation of Appendix 1.

Orchid species and subspecies	Vegetation alliance	Vegetation order	Vegetation class
Anacamptis coriophora, *Anacamptis laxiflora*, *Anacamptis morio*, *Anacamptis palustris*, *Anacamptis pyramidalis*, *Dactylorhiza fuchsii*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Epipactis palustris*, *Gymnadenia conopsea*, *Neotinea ustulata*, *Orchis mascula* subsp. *speciosa*, *Platanthera bifolia*, *Pseudorchis albida*, *Traunsteinera globosa*	***Molinion caeruleae*** Koch 1926	***Molinietalia caeruleae*** Koch 1926	***Molinio-Arrhenatheretea*** Tx. 1937
Anacamptis coriophora, *Anacamptis laxiflora*, *Anacamptis morio*, *Dactylorhiza cordigera*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Epipactis palustris*, *Gymnadenia conopsea*, *Neotinea ustulata*, *Neottia ovata*, *Platanthera bifolia*, *Traunsteinera globosa*	***Deschampsion cespitosae*** Horvatić 1930	***Molinietalia caeruleae*** Koch 1926	***Molinio-Arrhenatheretea*** Tx. 1937
Anacamptis morio, *Dactylorhiza cordigera*, *Dactylorhiza sambucina*, *Gymnadenia conopsea*, *Orchis mascula* subsp. *speciosa*, *Traunsteinera globosa*	***Pancicion serbicae*** Lakušić 1966	***Poo alpinae-Trisetetalia*** Ellmauer et Mucina 1993	***Molinio-Arrhenatheretea*** Tx. 1937
Dactylorhiza incarnata, *Dactylorhiza saccifera*, *Epipactis palustris*, *Gymnadenia conopsea*, *Platanthera bifolia*	***Mentho longifoliae-Juncion inflexi*** T. Müller et Görs ex de Foucault 2009	***Filipendulo ulmariae-Lotetalia uliginosi*** Passarge 1975	***Molinio-Arrhenatheretea*** Tx. 1937
Anacamptis morio, *Anacamptis palustris*	***Trifolion pallidi*** Ilijanić 1969	***Trifolio-Hordeetalia*** Horvatić 1963	***Molinio-Arrhenatheretea*** Tx. 1937
Gymnadenia conopsea, *Gymnadenia odoratissima*	***Calamagrostion villosae*** Pawłowski et al. 1928	***Calamagrostietalia villosae*** Pawłowski et al. 1928	***Mulgedio-Aconitetea*** Hadač et Klika in Klika et Hadač 1944
Anacamptis coriophora, *Anacamptis morio*, *Cephalanthera longifolia*, *Dactylorhiza fuchsii*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Dactylorhiza viridis*, *Epipactis distans*, *Gymnadenia conopsea*, *Gymnadenia rhellicani*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Neotinea tridentata*, *Neotinea ustulata*, *Neottia ovata*, *Orchis mascula* subsp. *speciosa*, *Orchis militaris*, *Platanthera bifolia*, *Platanthera chlorantha*, *Spiranthes spiralis*, *Traunsteinera globosa*	***Nardo-Agrostion tenuis*** Sillinger 1933	***Nardetalia strictae*** Preising 1950	***Nardetea strictae*** Rivas Goday et Borja Carbonell in Rivas Goday et Mayor López 1966

Continuation of Appendix 1.

Orchid species and subspecies	Vegetation alliance	Vegetation order	Vegetation class
Anacamptis coriophora, *Anacamptis morio*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza sambucina*, *Dactylorhiza viridis*, *Gymnadenia conopsea*, *Gymnadenia rhellicani*, *Platanthera bifolia*, *Pseudorchis albida*, *Traunsteinera globosa*	***Potentillo ternatae-Nardion*** Simon 1958	***Festucetalia spadiceae*** Barbero 1970	***Juncetea trifidi*** Hadač in Klika et Hadač 1944
Dactylorhiza sambucina, *Gymnadenia conopsea*	***Poion violaceae*** Horvat et al. 1937	***Seslerietalia comosae*** Simon 1958	***Juncetea trifidi*** Hadač in Klika et Hadač 1944
Anacamptis morio, *Anacamptis pyramidalis*, *Cephalanthera longifolia*, *Cephalanthera rubra*, *Dactylorhiza saccifera*, *Dactylorhiza sambucina*, *Epipactis atrorubens*, *Gymnadenia conopsea*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Neotinea tridentata*, *Neotinea ustulata*, *Neottia ovata*, *Ophrys apifera*, *Ophrys scolopax* subsp. *cornuta*, *Orchis mascula* subsp. *speciosa*, *Orchis pallens*, *Orchis purpurea*, *Orchis simia*, *Platanthera bifolia*, *Platanthera chlorantha*, *Traunsteinera globosa*	***Cirsio-Brachypodion pinnati*** Hadač et Klika in Klika et Hadač 1944	***Brachypodietalia pinnati*** Korneck 1974	***Festuco-Brometea*** Br.-Bl. et Tx. ex Soo 1947
Anacamptis coriophora, *Anacamptis morio*, *Anacamptis papilionacea*, *Anacamptis pyramidalis*, *Cephalanthera rubra*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza sambucina*, *Dactylorhiza viridis*, *Gymnadenia conopsea*, *Limodorum abortivum*, *Neotinea tridentata*, *Neotinea ustulata*, *Neottia ovata*, *Ophrys apifera*, *Ophrys scolopax* subsp. *cornuta*, *Orchis purpurea*, *Platanthera bifolia*, *Spiranthes spiralis*, *Traunsteinera globosa*	***Chrysopogono-Danthonion calycinae*** Kojić 1959	***Brachypodietalia pinnati*** Korneck 1974	***Festuco-Brometea*** Br.-Bl. et Tx. ex Soo 1947
Anacamptis morio, *Anacamptis papilionacea*, *Anacamptis pyramidalis*, *Dactylorhiza sambucina*, *Gymnadenia conopsea*, *Himantoglossum calcaratum* subsp. *calcaratum*, *Neotinea tridentata*, *Neotinea ustulata*, *Ophrys apifera*, *Ophrys insectifera*, *Ophrys scolopax* subsp. *cornuta*, *Orchis mascula* subsp. *speciosa*, *Orchis pallens*, *Orchis purpurea*, *Orchis simia*, *Spiranthes spiralis*	***Festucion valesiacae*** Klika 1931	***Festucetalia valesiacae*** Soo 1947	***Festuco-Brometea*** Br.-Bl. et Tx. ex Soo 1947
Anacamptis morio	***Centaureo-Bromion fibrosi*** Blečić et al. 1969	***Halacsyetalia sendtneri*** Ritter-Studnicka 1970	***Festuco-Brometea*** Br.-Bl. et Tx. ex Soo 1947
Dactylorhiza saccifera, *Gymnadenia conopsea*	***Chrysopogono grylli-Koelerion splendentis*** Horvatić 1973	***Scorzoneretalia villosae*** Kovačević 1959	***Festuco-Brometea*** Br.-Bl. et Tx. ex Soo 1947

Continuation of Appendix 1.

Orchid species and subspecies	Vegetation alliance	Vegetation order	Vegetation class
Gymnadenia conopsea	***Amphoricarpion neumayeri*** Lakušić 1968	***Moltkeetalia petraeae*** Lakušić 1968	***Asplenietea trichomanis*** (Br.-Bl. in Meier et Br.-Bl. 1934) Oberd. 1977
Epipactis palustris, *Gymnadenia conopsea*	***Phragmition communis*** Koch 1926	***Phragmitetalia*** Koch 1926	***Phragmito-Magnocaricetea*** Klika in Klika et Novák 1941
Anacamptis coriophora, *Anacamptis morio*, *Dactylorhiza incarnata*, *Gymnadenia conopsea*, *Traunsteinera globosa*	***Magnocaricion elatae*** Koch 1926	***Magnocaricetalia*** Pignatti 1953	***Phragmito-Magnocaricetea*** Klika in Klika et Novák 1941
Dactylorhiza cordigera, *Epipactis palustris*	***Caricion davallianae*** Klika 1934	***Caricetalia davallianae*** Br.-Bl. 1950	***Scheuchzerio palustris-Caricetea fuscae*** Tx. 1937
Anacamptis morio, *Dactylorhiza cordigera*, *Dactylorhiza incarnata*, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Dactylorhiza saccifera*, *Epipactis palustris*, *Gymnadenia conopsea*, *Gymnadenia frivaldii*, *Neottia ovata*, *Platanthera bifolia*, *Traunsteinera globosa*	***Caricion fuscae*** Koch 1926	***Caricetalia fuscae*** Koch 1926	***Scheuchzerio palustris-Caricetea fuscae*** Tx. 1937
Dactylorhiza incarnata, *Dactylorhiza maculata* subsp. *maculata*, *Dactylorhiza maculata* subsp. *transsilvanica*, *Epipactis palustris*	***Sphagno-Caricion canescentis*** Passarge (1964) 1978	***Caricetalia fuscae*** Koch 1926	***Scheuchzerio palustris-Caricetea fuscae*** Tx. 1937
Anacamptis morio, *Neotinea ustulata*	***Convolvulo arvensis-Agropyrion repentis*** Görs	***Agropyretalia intermedio-repentis*** T. Müller et Görs 1969	***Artemisietea vulgaris*** Lohmeyer et al. in Tx. ex von Rochow 1951
Anacamptis morio, *Orchis purpurea*	***Onopordion acanthii*** Br.-Bl. et al. 1936	***Onopordetalia acanthii*** Br.-Bl. et Tx. ex Klika et Hada c 1944	***Artemisietea vulgaris*** Lohmeyer et al. in Tx. ex von Rochow 1951