

The BEOU herbarium as a valuable source of data on internationally important plant taxa in Serbia

Original Article

Abstract:

Herbarium collections are important sources of verifiable data for floristic research and conservation of endangered plant taxa. We surveyed the Herbarium of the University of Belgrade (BEOU) to document vascular plant taxa occurring in Serbia that are of international importance (listed in the Habitats Directive, the Bern Convention, CITES, and the EU Wildlife Trade Regulation). A total of 1315 herbarium sheets representing 128 taxa were observed. Although these data confirm the presence of many taxa in Serbia, 28 taxa reported in the literature lack herbarium specimens collected in Serbia since 1950 and deposited in BEOU, indicating lack of contemporary data based on vouchers. More than half of the taxa are represented by fewer than ten herbarium specimens, limiting reliable assessment of their national distribution. The results highlight the importance of herbarium data for identifying knowledge gaps and supporting conservation planning, and the need for targeted field research and deposition of specimens.

Key words:

Bern Convention, biodiversity conservation, chorological data, CITES, EU Wildlife Trade Regulation, Habitats Directive, herbarium collections

Apstrakt:

Herbarijum BEOU kao značajan izvor podataka o međunarodno značajnim biljkama koje su zabeležene u Srbiji

Herbarijumske zbirke predstavljaju važne izvore proverljivih podataka za floristička istraživanja i zaštitu ugroženih biljnih taksona. U ovom radu analizirana je zbirka Herbarijuma Univerziteta u Beogradu (BEOU), radi dokumentovanja taksona vaskularnih biljaka, koji su zabeleženi u Srbiji, a međunarodno su značajni (uključeni su u Direktivu o staništima, Bernsku konvenciju, CITES i EU regulativu o trgovini divljim vrstama). Evidentirano je ukupno 1315 herbarijumskih listova u kojima su primerci 128 međunarodno zaštićenih taksona. Iako podaci potvrđuju prisustvo brojnih međunarodno značajnih taksona u Srbiji, za 28 taksona navedenih u literaturi ne postoje primerci sakupljeni u Srbiji od 1950. godine i deponovani u BEOU, što ukazuje na nedostatke u savremenim podacima zasnovanim na vaučerima. Više od polovine taksona zastupljeno je sa manje od deset herbarijumskih primeraka, što ograničava procenu njihove rasprostranjenosti. Rezultati ukazuju na nedostatke u podacima o prisustvu i rasprostranjenju, značaj herbarijumskih podataka za planiranje zaštite i potrebu za daljim terenskim istraživanjima i deponovanjem primeraka u herbarijumske zbirke.

Ključne reči:

Bernska konvencija, zaštita biodiverziteta, horološki podaci, CITES, EU regulativa o trgovini divljim vrstama, Direktiva o staništima, herbarijumske zbirke

Introduction

Despite occupying less than 2% of the European territory, the Republic of Serbia hosts approximately 18% of the European vascular plant taxa (species and subspecies), reflecting its high floristic diversity and biogeographical heterogeneity (Tomović, 2007). The lists of plant species of international importance are given in several international legislative frameworks, including the Habitats Directive, the Bern Convention, the Convention on International

Trade in Endangered Species of Wild Fauna and Flora (CITES), and the EU Wildlife Trade Regulation. According to Stojanović et al. (2018), 161 plant taxa (vascular plants and bryophytes) mentioned in these documents have been reported for the territory of Serbia.

The accuracy of species inventories on the national level and conservation assessments depend on reliable, verifiable data on species occurrence. Numerous taxonomic revisions, synonymizations,

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erroneous reports, and newly published records have led to substantial changes in the interpretation of the presence and status of several internationally important taxa recorded in Serbia. Such changes highlight the need for voucher-based evidence to support floristic and conservation conclusions. Fourteen taxa mentioned in *Plants of International Importance in the Flora of Serbia* (Stojanović et al., 2018) are currently not listed in Revised Annex I of Resolution 6 (1998) of the Bern Convention or in Annexes II, IV or V of the Habitats Directive as reported. The discrepancy observed arises from differences between earlier and currently valid versions of these international conservation lists. In the meantime, certain taxa have been excluded or taxonomically revised and are therefore no longer included in the updated annexes, such as: *Dracocephalum ruyschiana* L., *Galium rhodopeum* Velen., *Geum bulgaricum* Panc., *Fritillaria graeca* Boiss. & Spruner, *Lindernia procumbens* (Krocker) Philcox, *Ramonda serbica* Pancic, *Ranunculus fontanus* C. Presl, *Salvinia natans* (L.) All., *Spiranthes aestivalis* (Poiret) L. C. M. Richard, *Trapa natans* L., *Typha minima* Funk and *T. shuttleworthii* Koch & Sonder. However, *Carex acuta* L. and *Huperzia selago* (L.) Bernh. ex Schrank & Mart., were not previously listed in the consulted international legal instruments. *Dactylorhiza latifolia* (L.) Soó is considered synonymous with *D. incarnata* (L.) Soó subsp. *incarnata*, *D. cordigera* (Fr.) Soó subsp. *bosniaca* (Beck) Soó with *D. cordigera* subsp. *cordigera*, whereas *Ophrys mammosa* Desf. is considered synonymous with *O. sphegodes* Mill. subsp. *taurica* (Aggeenko) Soó ex Niketić & Djordjević, and *O. oestrifera* M. Bieb. with *O. scolopax* Cav. subsp. *cornuta* (Steven) E. G. Camus (Govaerts, 2003; Niketić et al., 2018). In addition, *Ostericum palustre* (Besser) Besser listed as *Angelica palustris* (Besser) Hoffm. was erroneously reported for the flora of Serbia (Niketić et al., 2021). *Himantoglossum caprinum* (Bieb) V. Koch is not distributed in Serbia and reports of this taxon refer to *H. calcaratum* subsp. *rumelicum* (H. Baumann & R. Lorenz) Niketić & Djordjević (Niketić et al., 2018). Stojanović et al. (2018) list *Sternbergia lutea* (L.) Ker Gawl. ex Spreng. as possibly naturalized in Serbia, but Niketić & Tomović (2018) do not mention this species in An Annotated Checklist of Vascular Flora of Serbia 1.

On the other hand, novel data on the occurrence of several taxa not previously reported for the Republic of Serbia have been published recently for several orchid taxa (Djordjević et al., 2010, 2014, 2021a, 2021b, 2023, 2024), and subsequently for *Serapias bergonii* E. G. Camus (Bogosavljević et al., 2024).

Herbarium collections are considered to be

valuable, permanent sources of verified data on species identity, distribution, and historical occurrence (Funk, 2003; Page et al., 2015). They facilitate conservation through monitoring changes in the distribution and habitat of plants (Bebber et al., 2010; Greve et al., 2016; Nualart et al., 2017; Lang et al., 2019). Despite the rise of citizen science platforms, herbaria remain indispensable for research on plant diversity, ecology, and distribution (James et al., 2018; Batke et al., 2024; Eckert et al., 2024). Furthermore, they have been shown to complement surveys in under-researched areas (Versieux et al., 2017). However, the importance of the herbaria is rarely emphasised in the extant literature (Lavoie, 2013).

Herbarium specimens enable accurate plant identification and serve as permanent records of diversity and distribution, supporting biodiversity protection. Data from herbaria can improve conservation strategies and provide key insights to researchers, land managers, and policymakers (Eckert et al., 2024; Sharma et al., 2024; James et al., 2018). Specimens often contain overlooked data important for understanding rare or threatened taxa (Jenačković Gocić et al., 2020; Đurović et al., 2022; Sabovljević et al., 2022; Vukojičić et al., 2023; Niketić et al., 2024; Sabovljević et al., 2023; 2024; Tomović et al., 2024). Herbarium data are increasingly valued in conservation assessments, especially when population details are unavailable (Brummitt et al., 2015; Collen et al., 2016; Greve et al., 2016).

Recently, the use of deposited specimens in conservation status assessment has been emphasised (Greve et al., 2016; Nualart et al., 2017; Cantrill, 2018; Canteiro et al., 2019; Delves et al., 2023). Of course, it is important to have in mind that collection biases can affect the quality and quantity of available occurrence data, and thus the assessment (Betts et al., 2020; Nic Lughada et al., 2018).

Herbarium collections represent a fundamental resource for taxonomic research, as they provide permanently preserved, verifiable material that enables accurate species identification, critical evaluation of historical records, and resolution of taxonomic uncertainties. Through comparative study of voucher specimens, herbaria support taxonomic revisions, clarification of synonymy, and consistent application of species concepts across time and regions (Culley, 2013; Haberling et al., 2019; Rostański, 2024).

The Herbarium of the University of Belgrade (BEOU) is one of the largest botanical collections in the region, comprising more than 180,000 specimens and representing a significant repository of floristic and chorological information (Vukojičić

et al., 2011). Given its scope and historical depth, BEOU provides an important opportunity to evaluate the contribution of herbarium data to the documentation and conservation of internationally important plant taxa in Serbia.

Therefore, the aims of this study were to analyse the BEOU herbarium collection with respect to vascular plant taxa listed in international legislative frameworks as important occurring in Serbia, to identify taxa lacking recent voucher confirmation, and to assess the role of herbarium data in supporting national conservation planning and future research priorities.

Materials and methods

The herbarium collection of the Herbarium of the University of Belgrade (BEOU) was examined to document vascular plant taxa occurring in the Republic of Serbia that are listed in international legislative frameworks as important. The survey included taxa listed in Annexes II, IV and V of the Habitats Directive (Council Directive 92/43/EEC), the Revised Annex I of Resolution 6 (1998) of the Bern Convention, Appendices I, II and III of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and Annexes A, B, C and D of the EU Wildlife Trade Regulation (Council Regulation (EC) No 338/97).

Only herbarium specimens collected within the territory of the Republic of Serbia were included in the analysis. The term “herbarium specimen” is used here in a broad sense to include all preserved plant material stored on herbarium sheets. To evaluate the availability of recent, voucher-based evidence, special attention was given to specimens collected since 1950. This time span follows commonly applied criteria in conservation-oriented studies, in which the prolonged absence of confirmed records is interpreted as a lack of recent documentation rather than definitive evidence of extinction. In this context, international conservation frameworks such as CITES and the International Union for Conservation of Nature consider a species extinct when it has not been recorded over 50 years.

The survey encompassed three subcollections of the Herbarium of the University of Belgrade (BEOU): the Collection of the Department of Ecology and Geography of Plants (KEGB), the Collection of the Department of Morphology and Systematics of Plants (KMSB), and the Voucher Collection (V). Historical specimens deposited in the General Collection were not examined.

The identification of herbarium specimens followed the relevant national floristic literature and standard taxonomic treatments (Josifović,

1970–1977; Sarić & Diklić, 1986; Sarić, 1992; Stevanović, 2012) and cited taxonomic sources, whereas nomenclature followed the taxonomic concepts and accepted names provided by Plants of the World Online (POWO, Kew Science). To ensure consistency with currently accepted taxa names, attention was paid to relevant taxonomic and nomenclatural updates (Niketić & Tomović, 2018; POWO). For each specimen, original label data were transcribed, including taxon name, locality, sublocality, habitat, substrate, collection date, and collector name. Additional data fields were subsequently standardised or derived, including geographic coordinates (WGS84), UTM grid cell (10×10 km), georeferencing accuracy (expressed as a radius in metres), and elevation (m a.s.l.), based on the available label information. Collection-related metadata, including herbarium acronym (according to Thiers, 2025) and inventory number, were also recorded. In addition, higher taxonomic classification (kingdom, phylum, class, subclass, order, family, genus), regional classification (continent, country, province), and metadata related to data quality (accuracy, precision, certainty, and validation) are provided in the Supplementary Data file (**Appendix 1**).

Distribution records were georeferenced using GPS devices in the field or, when coordinates were absent from herbarium labels, by retrospective georeferencing with OziExplorer v.3.95. For all records, spatial information is also provided as UTM (MGRS) grid references at a resolution of 10×10 km (Lampinen, 2001). Missing elevation data were derived from the NASA Shuttle Radar Topography Mission (SRTM, 2013) digital elevation model using QGIS v.3.34 (2026). The structure of the examined specimen catalogue (**Appendix 1**), including terminology, follows CIB standards (Lakušić et al., 2021) and Darwin Core standards (Darwin Core Maintenance Group 2023).

Results and Discussion

A total of 1315 herbarium sheets representing 128 vascular plant taxa listed in international legislative frameworks as important were recorded in the collection of the Herbarium of the University of Belgrade (BEOU). Among these taxa, nine are listed exclusively in the Habitats Directive, six only in the Bern Convention, 27 only in CITES, and two solely in the EU Wildlife Trade Regulation, while the remaining taxa are listed in more than one international instrument (**Tab. 1**). A complete catalogue of the examined specimens, including locality data and information provided on herbarium labels, is presented in **Appendix 1**.

Table 1. Taxa listed in the Habitats Directive (HD), Bern Convention (BC), CITES and EU Wildlife Trade Regulation (EU) for which specimens collected in Serbia since 1950 are deposited in BEOU. The number of specimens found in BEOU is given.

Taxon	HD	BC	CITES	EU	BEOU
Lycopodiidae Beketov					
Lycopodiales DC. ex Bercht. & J.Presl					
Lycopodiaceae P.Beauv. ex Mirb.					
<i>Lycopodium alpinum</i> L.	V				0
<i>Lycopodium annotinum</i> L.	V				0
<i>Lycopodium clavatum</i> L.	V		+		15
<i>Lycopodium complanatum</i> L.	V				0
Magnoliidae Novák ex Takht.					
Alismatales R.Br. ex Bercht. & J.Presl					
Alismataceae Vent.					
<i>Caldesia parnassifolia</i> (L.) Parl.	II, IV	I			0
Asparagales Bromhead					
Amaryllidaceae J. St.-Hil.					
<i>Galanthus elwesii</i> Hook. f., nom. cons.			II	B	6
<i>Galanthus nivalis</i> L.	V		II	B	73
<i>Narcissus poeticus</i> subsp. <i>radiiflorus</i> (Salisb.) Baker		I			7
<i>Sternbergia colchiciflora</i> Waldst. & Kit.			II	B	15
Asparagaceae Juss.					
<i>Ruscus aculeatus</i> L.	V				42
Iridaceae Juss.					
<i>Gladiolus palustris</i> Gaudin	II, IV	I			4
Orchidaceae Juss.					
× <i>Gymnigritella suaveolens</i> (Vill.) E. G. Camus			II		2
<i>Anacamptis</i> × <i>nicodemi</i> (Cirillo ex Ten.) B. Bock nothosubsp. <i>nicodemi</i>			II		6
<i>Anacamptis coriophora</i> (L.) R. M. Bateman, Pridgeon & M. W. Chase			II	B	9
<i>Anacamptis laxiflora</i> (Lam.) R. M. Bateman, Pridgeon & M. W. Chase			II	B	2
<i>Anacamptis morio</i> (L.) R. M. Bateman, Pridgeon & M. W. Chase subsp. <i>morio</i>			II	B	56
<i>Anacamptis morio</i> (L.) R. M. Bateman, Pridgeon & M. W. Chase subsp. <i>caucasica</i> (K.Koch) H. Kretzschmar, Eccarius & H. Dietr.			II		0
<i>Anacamptis palustris</i> (Jacq.) R. M. Bateman, Pridgeon & M. W. Chase subsp. <i>palustris</i>			II		1
<i>Anacamptis palustris</i> (Jacq.) R. M. Bateman, Pridgeon & M. W. Chase subsp. <i>elegans</i> (Heuff.) R. M. Bateman, Pridgeon & M. W. Chase			II		11
<i>Anacamptis papilionacea</i> (L.) R. M. Bateman, Pridgeon & M. W. Chase			II	B	5

<i>Anacamptis pyramidalis</i> (L.) Rich.	II, IV	I	II	B	13
<i>Cephalanthera damasonium</i> (Mill.) Druce			II	B	18
<i>Cephalanthera longifolia</i> (L.) Fritsch			II	B	14
<i>Cephalanthera rubra</i> (L.) Rich.			II	B	12
<i>Coeloglossum viride</i> (L.) Hartm.			II		19
<i>Corallorhiza trifida</i> Châtel.			II	B	2
<i>Cypripedium calceolus</i> L.	II, IV	I	II	A	1
<i>Dactylorhiza ×serbica</i> (H. Fleischm.) Soó			II		0
<i>Dactylorhiza cordigera</i> (Fr.) Soó			II		16
<i>Dactylorhiza cordigera</i> (Fr.) Soó subsp. <i>bosniaca</i> (Beck) Soó			II		0
<i>Dactylorhiza cordigera</i> (Fr.) Soó subsp. <i>cordigera</i>			II		1
<i>Dactylorhiza fuchsii</i> (Druce) Soó subsp. <i>fuchsii</i>			II	B	2
<i>Dactylorhiza incarnata</i> (L.) Soó subsp. <i>incarnata</i>			II		7
<i>Dactylorhiza maculata</i> (L.) Soó			II	B	8
<i>Dactylorhiza maculata</i> (L.) Soó subsp. <i>maculata</i>			II	B	1
<i>Dactylorhiza maculata</i> (L.) Soó subsp. <i>transsilvanica</i> (Schur) Soó			II		3
<i>Dactylorhiza majalis</i> (Rchb.) P. F. Hunt & Summerh. subsp. <i>majalis</i>			II		0
<i>Dactylorhiza romana</i> (Sebast.) Soó subsp. <i>romana</i>			II		0
<i>Dactylorhiza saccifera</i> (Brongn.) Soó			II	B	18
<i>Dactylorhiza saccifera</i> (Brongn.) Soó subsp. <i>saccifera</i>			II	B	38
<i>Dactylorhiza sambucina</i> (L.) Soó			II	B	20
<i>Epipactis atrorubens</i> (Hoffm.) Besser			II	B	3
<i>Epipactis distans</i> Arv.-Touv.			II	B	8
<i>Epipactis exilis</i> P. Delforge			II		5
<i>Epipactis helleborine</i> (L.) Crantz			II	B	6
<i>Epipactis helleborine</i> (L.) Crantz subsp. <i>helleborine</i>			II	B	50
<i>Epipactis leptochila</i> (Godfery) Godfery subsp. <i>neglecta</i> Kümpel			II	B	9
<i>Epipactis microphylla</i> (Ehrh.) Sw.			II	B	12
<i>Epipactis muelleri</i> Godfery subsp. <i>muelleri</i>			II	B	2
<i>Epipactis palustris</i> (L.) Crantz			II	B	27
<i>Epipactis pontica</i> Taubenheim			II	B	3
<i>Epipactis purpurata</i> Sm.			II	B	28
<i>Epipactis tallosii</i> A.Molnár & Robatsch subsp. <i>tallosii</i>			II	B	0
<i>Epipogium aphyllum</i> Sw.			II	B	3
<i>Goodyera repens</i> (L.) R. Br.			II	B	5
<i>Gymnadenia conopsea</i> (L.) R. Br.			II	B	54
<i>Gymnadenia frivaldii</i> Hampe ex Griseb.			II	B	13
<i>Gymnadenia odoratissima</i> (L.) Rich. subsp. <i>odoratissima</i>			II	B	0

<i>Herminium monorchis</i> (L.) R. Br.	II	B	0
<i>Himantoglossum calcaratum</i> (Beck) Schltr. subsp. <i>calcaratum</i>	II		8
<i>Himantoglossum calcaratum</i> (Beck) Schltr. subsp. <i>rumelicum</i> Niketić & Djordjević	II		12
<i>Limodorum abortivum</i> (L.) Sw.	II	B	7
<i>Neotinea</i> × <i>dietrichiana</i> (Bogenh.) H. Kretzschmar, Eccarius & H. Dietr. subsp. <i>dietrichiana</i>	II		4
<i>Neotinea lactea</i> (Poir.) R. M. Bateman, Pridgeon & M. W. Chase	II	B	0
<i>Neotinea tridentata</i> (Scop.) R. M. Bateman, Pridgeon & M. W. Chase subsp. <i>tridentata</i>	II	B	30
<i>Neotinea ustulata</i> (L.) R. M. Bateman, Pridgeon & M. W. Chase var. <i>ustulate</i>	II	B	24
<i>Neottia cordata</i> (L.) Rich.	II	B	4
<i>Neottia nidus-avis</i> (L.) Rich.	II	B	25
<i>Neottia ovata</i> (L.) Bluff & Fingerh.	II	B	9
<i>Nigritella rhellicani</i> Teppner & E. Klein	II	B	6
<i>Ophrys apifera</i> Huds.	II	B	6
<i>Ophrys fuciflora</i> (F. W. Schmidt) Moench subsp. <i>fuciflora</i>	II	B	0
<i>Ophrys insectifera</i> L. subsp. <i>insectifera</i>	II	B	5
<i>Ophrys scolopax</i> Cav. subsp. <i>cornuta</i> (Steven) E. G. Camus	II	B	12
<i>Ophrys sicala</i> Tineo	II		0
<i>Ophrys sphegodes</i> Mill. subsp. <i>sphegodes</i>	II		0
<i>Ophrys sphegodes</i> Mill. subsp. <i>taurica</i> (Aggeenko) Soó ex Niketić & Djordjević	II		0
<i>Orchis</i> × <i>angusticuris</i> Franch. nothosubsp. <i>Angusticuris</i>	II		1
<i>Orchis</i> × <i>beyrichii</i> (Rchb. f.) A. Kern. nothosubsp. <i>Beyrichii</i>			1
<i>Orchis mascula</i> (L.) L. subsp. <i>mascula</i>	II		0
<i>Orchis mascula</i> (L.) L. subsp. <i>speciosa</i> (Mutel) Hegi	II		12
<i>Orchis militaris</i> L. subsp. <i>militaris</i>	II	B	7
<i>Orchis pallens</i> L.	II	B	13
<i>Orchis provincialis</i> Balb. ex Lam. & DC.	II	B	1
<i>Orchis purpurea</i> Huds.	II	B	20
<i>Orchis simia</i> Lam. subsp. <i>simia</i>	II		14
<i>Orchis spitzelii</i> Saut. ex W. D. J. Koch subsp. <i>Spitzelii</i>	II		0
<i>Platanthera bifolia</i> (L.) Rich.	II	B	20
<i>Platanthera chlorantha</i> (Custer) Rchb.	II	B	3
<i>Pseudorchis albida</i> (L.) Á. Löve & D. Löve	II	B	11
<i>Serapias bergonii</i> E. G. Camus	II	B	0
<i>Spiranthes aestivalis</i> (Poir.) Rich.	II		0
<i>Spiranthes spiralis</i> (L.) Chevall.	II		5
<i>Traunsteinera globosa</i> (L.) Rchb.	II		15

Asterales Link						
Asteraceae Bercht. & J. Presl						
<i>Artemisia eriantha</i> Ten.	V					0
<i>Artemisia pancicii</i> Ronniger ex Danihelka & Marhold	II, IV	I				0
<i>Cirsium brachycephalum</i> Juratzka	II, IV	I				4
<i>Klasea lycopifolia</i> (Vill.) Á. Löve & D. Löve	II, IV	I				0
Campanulaceae Juss.						
<i>Adenophora liliifolia</i> (L.) A. DC.	II, IV	I				5
Menyanthaceae Dumort.						
<i>Menyanthes trifoliata</i> L.				D		8
Boraginales Juss. ex Bercht. & J. Presl						
Boraginaceae Juss.						
<i>Pontechium maculatum</i> (L.) Böhle & Hilger	II, IV	I				78
Brassicales Bromhead						
Brassicaceae Burnett						
<i>Arabis scopoliana</i> Boiss.	II, IV	I				0
<i>Armoracia macrocarpa</i> (Waldst. & Kit.) Kit. ex Baumg.		I				2
<i>Crambe tataria</i> Sebeók	II, IV	I				3
Caryophyllales Juss. ex Bercht. & J. Presl						
Caryophyllaceae Juss.						
<i>Cerastium dinaricum</i> Beck & Szyszyl.	II, IV	I				0
<i>Dianthus polymorphus</i> M. Bieb.	II, IV	I				2
<i>Dianthus scardicus</i> Wettst.	II, IV	I				20
<i>Dianthus serotinus</i> Waldst. & Kit.		I				0
Droseraceae Salisb.						
<i>Aldrovanda vesiculosa</i> L.	II, IV	I				1
Ericales Bercht. & J. Presl						
Ericaceae Durande						
<i>Arctostaphylos uva-ursi</i> (L.) Spreng.				D		21
Primulaceae Batsch ex Borkh.						
<i>Cyclamen hederifolium</i> Aiton			II			12
<i>Cyclamen purpurascens</i> Mill.	II, IV	I	II	B		5
Gentianales Juss. ex Bercht. & J. Presl						
Gentianaceae Juss.						
<i>Gentiana lutea</i> L.	V			D		6
Lamiales Bromhead						
Gesneriaceae Rich. & Juss.						
<i>Ramonda serbica</i> Pančić	IV					33
Linderniaceae Borsch, Kai Müll. & Eb. Fisch.						

<i>Lindernia procumbens</i> (Krock.) Philcox	IV		5
Orobanchaceae Vent.			
<i>Tozzia alpina</i> L. subsp. <i>carpathica</i> (Woł.) Pawł.	II, IV	I	3
Colchicaceae DC.			
<i>Colchicum arenarium</i> Waldst. & Kit.	II, IV	I	19
Liliaceae Juss.			
<i>Fritillaria gussichiae</i> (Degen & Dörf.) Rix	IV		10
<i>Fritillaria montana</i> Hoppe ex W. D. J. Koch		I	39
<i>Lilium jankae</i> A. Kerner		I	11
<i>Tulipa hungarica</i> Borbás	II, IV	I	0
Ranunculales Juss. ex Bercht. & J. Presl			
Ranunculaceae Juss.			
<i>Adonis vernalis</i> L.		II	B 38
<i>Pulsatilla grandis</i> Wender. subsp. <i>grandis</i>	II, IV	I	5
<i>Pulsatilla pratensis</i> (L.) Mill.	II, IV		0
Saxifragales Berchtold & J. Presl			
Paeoniaceae Raf.			
<i>Paeonia officinalis</i> L. subsp. <i>banatica</i> (Rochel) Soó	II, IV	I	8
<i>Paeonia tenuifolia</i> L.		I	9
Polypodiales Link			
Aspleniaceae Newman			
<i>Asplenium adulterinum</i> Milde	II, IV	I	6
Marsileaceae Mirb.			
<i>Marsilea quadrifolia</i> L.	II, IV	I	12

Representation of internationally important taxa in BEOU

The number of specimens per taxon varied considerably. More than half of the recorded taxa were represented by fewer than ten herbarium sheets, indicating generally low representation within the collection. According to Rivers et al. (2011), such limited material restricts reliable inference on national distribution patterns and may reflect collection bias rather than actual rarity. Nevertheless, even sparsely represented specimens provide essential voucher-based evidence of species occurrence and constitute an important baseline for future floristic and conservation studies. Although such records do not provide information on current population status, they constitute verified evidence of species occurrence and may be the only available documentation for rare, overlooked or possibly extinct taxa. In this context, taxa represented by a single specimen in the BEOU collection should be

treated as priorities for targeted field surveys aimed at confirming their current presence, distribution and conservation status in Serbia.

The absence of recent voucher confirmations further highlights knowledge gaps and underscores the need for systematic re-evaluation of these taxa. Accordingly, future research should focus on field verification of historically recorded taxa, taxonomic reassessment where uncertainties exist, and integration of herbarium data into national conservation databases and decision-making processes. Such data are particularly valuable in regions where systematic field monitoring is incomplete or uneven.

Taxa lacking recent voucher confirmation

The survey identified 28 internationally important taxa reported in the literature to occur in Serbia for which no herbarium specimens collected in Serbia since 1950 were deposited in BEOU. These taxa are: *Anacamptis morio* (L.) R. M. Bateman,

Pridgeon & M. W. Chase subsp. *caucasica* (K.Koch) H.Kretzschmar, Eccarius & H. Dietr., *Arabis scopoliana* Boiss., *Artemisia eriantha* Ten., *A. panicii* Ronniger ex Danihelka & Marhold, *Caldesia parnassifolia* (L.) Parl., *Cerastium dinaricum* Beck & Szyszyl., *Dactylorhiza ×serbica* (H. Fleischm.) Soó, *D. cordigera* (Fr.) Soó subsp. *bosniaca* (Beck) Soó, *D. majalis* (Rchb.) P. F. Hunt & Summerh. subsp. *majalis*, *Dianthus serotinus* Waldst. & Kit., *Epipactis tallosii* A. Molnár & Robatsch subsp. *tallosii*, *Gymnadenia odoratissima* (L.) Rich. subsp. *odoratissima*, *Herminium monorchis* (L.) R. Br., *Klasea lycopifolia* (Vill.) Á. Löve & D. Löve, *Lycopodium alpinum* L., *L. annotinum* L., *L. complanatum* L., *Neotinea lactea* (Poir.) R. M. Bateman, Pridgeon & M. W. Chase, *Ophrys fuciflora* (F. W. Schmidt) Moench subsp. *fuciflora*, *O. sicula* Tineo, *O. sphegodes* Mill. subsp. *sphegodes*, *O. sphegodes* Mill. subsp. *taurica* (Aggeenko) Soó ex Niketić & Djordjević, *Orchis mascula* (L.) L. subsp. *mascula*, *O. spitzelii* Saut. ex W. D. J. Koch subsp. *spitzelii*, *Pulsatilla pratensis* (L.) Mill., *Serapias bergonii* E. G. Camus, *Spiranthes aestivalis* (Poir.) Rich., and *Tulipa hungarica* Borbás. The absence of recent voucher material in BEOU does not imply confirmed disappearance but rather indicates a lack of verifiable, collection-based evidence for their recent occurrence in Serbia. Also, specimens could be deposited in other Herbaria such as BEO, BUNS, PZZP, or small collections that are private and/or not registered. In addition, relevant herbarium material originating from Serbia may also be deposited in other European herbaria such as BP, W, WU.

For several taxa, the absence of recent specimens corresponds with their currently accepted conservation status or questionable occurrence reported in the literature. *Caldesia parnassifolia*, *Lycopodium complanatum*, *Ophrys fuciflora* subsp. *fuciflora*, *O. sicula* and *Tulipa hungarica* are considered extinct or possibly extinct in Serbia, whereas the occurrence of *Lycopodium annotinum* in Central Serbia and Kosovo and Metohija remains uncertain (Niketić & Tomović, 2018). In addition, literature records of *Orchis mascula* subsp. *mascula* have not been confirmed by voucher specimens (Djordjević, 2021). As no material of these taxa collected since 1950 was found in BEOU, their status remains unchanged based on the results of this study.

Implications for floristic research and conservation

Recent studies have shown that herbarium revision can both clarify doubtful records and support confirmation of long-unrecorded taxa. For example, after *Dactylorhiza romana* subsp. *romana* had previously been treated as an unconfirmed taxon in

Serbia (Djordjević et al. 2021a), its occurrence was recently confirmed and verified by field observations, although voucher specimens were not deposited in BEOU (Tomović et al., 2022). This case highlights the importance of systematic deposition of collected material in publicly accessible herbaria to ensure long-term data availability and verifiability. It should be noted that identification of some orchid taxa based on dried and pressed material may be challenging due to loss of diagnostic floral characters and morphological plasticity.

An important limitation of herbarium-based analyses is that they cannot confirm the current status of historically documented populations. Consequently, the persistence of populations represented by voucher specimens remains unknown without targeted field surveys. This is particularly relevant for declining and threatened taxa such as *Adenophora liliifolia*, *Crambe tatarica*, and *Dianthus polymorphus*, for which herbarium records may represent the only verified evidence of past occurrence in certain regions. These taxa should therefore be prioritised in future field investigations aimed at confirming their current distribution and conservation status.

The underrepresentation of more than half of the internationally important taxa emphasizes the need to integrate data from additional herbarium collections and to intensify targeted field surveys, particularly for taxa of high conservation concern. Similar approaches have already yielded additional records for *Serapias bergonii* (Bogosavljević et al., 2024) and *Gymnadenia odoratissima* (L.) Rich. subsp. *odoratissima* (Djordjević, 2021), demonstrating the value of combining herbarium research with focused floristic investigations. It should be emphasized that recommendations for specimen deposition refer exclusively to material collected in accordance with applicable national and international regulations and under appropriate collecting permits for protected taxa. The call for systematic herbarium deposition is intended to support scientific documentation and does not imply or encourage additional collection of protected taxa outside legally permitted frameworks. In addition, the development of digital herbaria and georeferenced photographic repositories provides an important complementary approach to traditional voucher-based documentation, enabling non-destructive recording of occurrences of protected and threatened plant species where collection is restricted by conservation legislation.

The results of this study are directly relevant to national and international conservation reporting obligations. Reliable voucher-based evidence is essential for the preparation of national reports under the Habitats Directive (Article 17 reporting),

as well as for updates of national Red Lists and Red Data Books. Herbarium data from BEOU provide verifiable records that can support confirmation of species presence, historical continuity, and changes in distribution patterns, particularly for taxa with sparse or outdated field data. The identification of taxa lacking recent voucher confirmation highlights priorities for targeted field surveys and can help refine national species checklists and conservation status assessments. Furthermore, integrating BEOU herbarium records with data from other national collections and field surveys would enable more robust spatial analyses, support evidence-based conservation planning, and improve the accuracy of biodiversity databases used by conservation authorities and policymakers.

The analysis revealed that herbarium vouchers in BEOU can both confirm previously uncertain records and contribute to refinement of species distribution patterns in Serbia. For example, taxa previously considered poorly documented or regionally uncertain have been verified through herbarium material, thereby improving the reliability of national occurrence data for *Adenophora liliifolia*, *Pulsatilla grandis* subsp. *grandis* and *Asplenium adulterinum*. Conversely, the absence of BEOU vouchers for certain taxa does not necessarily indicate uncertain occurrence in Serbia, as well-established populations are known based on field observations and material deposited in other herbaria, particularly in intensively studied regions such as Vojvodina. This applies, for example, to *Pulsatilla pratensis* and *Dianthus serotinus*, for which voucher specimens are deposited in the BUNS herbarium.

Overall, the results confirm that BEOU represents a valuable repository of contemporary data on internationally important plant taxa in Serbia. Limited amount of available data is a common problem (Funk et al., 1999; Tobler et al., 2007). However, although incomplete, the available herbarium records provide important insights into species occurrence, reveal gaps in current knowledge, and help identify priorities for future research. Through the results of this study, conservation planning and effectiveness at the national level could be significantly enhanced. It is important to emphasise the significance of depositing material at herbaria, as a considerable number of specimens could potentially represent new floristic records for the country (Djordjević, 2016; Djordjević et al., 2010, 2012, 2014, 2016, 2021a, 2021b; 2023, 2024; Batke et al., 2024) or may correspond to taxa that are currently insufficiently resolved from a taxonomic perspective. While herbarium vouchers represent the most robust and permanently verifiable form of documentation, certain species with distinctive morphology may

also be reliably recorded based on well-documented field observations or photographic evidence. Our intention was to show the potential of BEOU in the improvement of knowledge on biodiversity of the Republic of Serbia and the use of the data collected in research applied to conservation. Having in mind that collection biases can affect the amount and geographical representation of specimens, we would like to draw attention to all internationally important plant taxa growing in Serbia, especially those whose occurrence is not confirmed with results presented here and to encourage their further studies.

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