

INSIGHT INTO THE CHOROLOGY AND ECOLOGY OF SOME RARE AND ENDANGERED PLANT SPECIES IN SERBIA

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The most recent estimates indicate that the vascular flora of Serbia comprises approximately 4,246 species and subspecies, native and non-native naturalized. It is estimated that approximately 20 % of this total number of taxa is considered to be endangered. Despite the extensive research conducted on the flora of Serbia over the past decades, new species are still being discovered as well as new localities for the species that were previously considered extinct or critically endangered. During the field research carried out in Serbia in previous years, new sites were discovered for the following rare and endangered taxa: *Cardamine amara* L. subsp. *amara*, *Cardamine waldsteinii* Dyer, *Hypericum androsaemum* L., *Onoclea struthiopteris* (L.) Roth, *Tulipa sylvestris* subsp. *australis* (Link) Pamp. and *Typha shuttleworthii* W. D. J. Koch & Sond. The distribution of these taxa was determined through a comprehensive review of numerous floristic literature, herbarium collections, and our own field data. This information is presented on UTM grid maps at a scale of 10×10 km. In addition, the habitats in which the abovementioned plants are found, and the status of the populations are described, thereby providing a comprehensive overview of their current status in Serbia.

Key words: vascular flora, distribution, habitat, red lists, Serbia

INTRODUCTION

The initial and most significant research on the flora of Serbia was conducted during the first half of the 19th century by the renowned botanist and scientist, Josif Pančić (Pančić 1856, 1865, 1874, 1884). In the contemporary era, following the contributions of Pančić and his subsequent followers, as well as the collective efforts of 20th and 21st-century botanists, significant progress has been made in our understanding of the flora of Serbia. According to the most recent taxonomic estimates, the vascular flora of Serbia comprises 4,246 taxa, encompassing 3,690 species and 556 subspecies of native and non-native, naturalised plants (Niketić & Tomović 2018, Stevanović 2022). Nevertheless, the last few centuries have seen the extinction of numerous plant and animal species worldwide. Furthermore, human activities have destroyed and modified habitats to such an extent that the survival of many species is now threatened (Stevanović 1999). It is estimated that approximately 20% of this total number of taxa is to some extent threatened, underscoring the necessity for effective conservation measures. However, it is evident that certain species, formerly categorised as extinct or critically endangered, have been rediscovered and are, in fact, more abundant than previously estimated (Tomović *et al.* 2009a, Vukojičić *et al.* 2023). There are numerous species whose distribution and ecological characteristics still require comprehensive investigation.

The main aim of this paper is to present novel data on the chorology and ecology of some rare and endangered species in Serbia, providing a comprehensive overview of their present conservation status. These include: *Cardamine amara* L. subsp. *amara*, *Cardamine waldsteinii* Dyer, *Hypericum androsaemum* L., *Onoclea struthiopteris* (L.) Roth, *Tulipa sylvestris* subsp. *australis* (Link) Pamp. and *Typha shuttleworthii* W. D. J. Koch & Sond.

MATERIALS AND METHODS

Recent field studies, along with analysis of herbarium material deposited in the Herbarium of the Institute of Botany and Botanical Garden "Jevremovac", Faculty of Biology, University of Belgrade (BEOU, acronym according to Thiers 2025), and literature sources, have been used to compile the chorological and ecological data. The occurrence of the analysed taxa in the field was recorded using a GPS device (Garmin GPS Map 64s). The georeferencing of all other distribution data, gathered from herbarium and literature, was conducted using the OziExplorer 3.95 4s

program. The coordinates for most of these findings are provided in the World Geodetic System 84 format (WGS84). For the remaining findings, however, the available information is limited to the UTM (MGRS) 10×10 square. The nomenclature of taxa is in accordance with Euro+Med PlantBase. The distribution maps were created using QGIS software version 3.20 and the occurrences are presented as UTM grid maps at a scale of 10×10 km.

RESULTS AND DISCUSSION

Based on all available sources (literature data, herbarium specimens and field observations), we provide chorological and ecological data and distribution maps of *Cardamine amara* subsp. *amara*, *Cardamine waldsteinii*, *Hypericum androsaemum*, *Onoclea struthiopteris*, *Tulipa sylvestris* subsp. *australis* and *Typha shuttleworthii* in Serbia.

1. *Cardamine amara* L. subsp. *amara*

General distribution: The distribution of *C. amara* subsp. *amara* extends throughout the major part of Europe, with the exception of the most northerly regions (Jalas & Suominen 1994). Its southern distribution reaches as far as northern Italy and the Stara Planina Mts in Bulgaria (Marhold *et al.* 1996).

Distribution in Serbia: The species *Cardamine amara* has been recorded in the flora of Serbia since Pančić (1856). Following Pančić, this species was documented by other Balkan researchers, with some attributing it to the name *C. barbaraeoides* Halácsy (Velenovský 1891, Hayek 1925, Jovanović-Dunjić 1972). For a considerable period, the precise taxonomic classification of this species remained uncertain. However, recent research has revealed that two distinct subspecies of *C. amara* are present in Serbia: *C. amara* subsp. *amara* with $\pm$ glabrous stem and *C. amara* subsp. *balcanica* Marhold, Ančev & Kit Tan with densely hairy stem (Marhold *et al.* 1996, Tomović *et al.* 2009b). A review and analysis of herbarium specimens belonging to the genus *Cardamine* in available herbarium collection, coupled with their own field research, led Tomović *et al.* (2009b) to conclude that the available data concerning the presence of *C. amara* in Stara Planina Mts, Mt. Kopaonik and the Vlasina plateau pertain to the subspecies *C. amara* subsp. *balcanica*. However, due to the absence of herbarium specimens from western, southwestern Serbia and Metohija province, the authors state that they were unable to determine with certainty which subspecies it is (Tomović *et al.* 2009b) and that the only reliable herbarium data is for northwestern Serbia, i.e. the surroundings of Loznica (Borinska Gorge).

New findings (Fig. 1):

Western Serbia: **Ivanjica**, Lučka river, MGRS 34T DP42, 43.60744 N, 20.280676 E, 578 m (leg./det. Vukojičić, S., Kuzmanović, N., Stevanoski, I. BEOU 68475, 09.05.2022), Lučka river, MGRS 34T DP42, 43.595014 N, 20.277774 E, 557 m (leg./det. Vukojičić, S., Kuzmanović, N., Stevanoski, I. BEOU 68477, 09.05.2022); **Lučani**, Kotraž, the Bjelica river valley, Beli Kamen, MGRS 34T DP33, 43.687230 N, 20.235603 E, 450 m, along the river bank in association with *Alnus rohlenae* Vit & al., on moist soil (leg./det. Vukojičić, S. BEOU 80022, 01.05.2021); **Lučani**, Guča, Rti, Rčanska river, MGRS 34T 43.733507 N, 20.243165 E, DP34 392 m, along the river bank in association with *Alnus rohlenae* (leg./det. Vukojičić, S. BEOU 68571, 02.05.2022).

Habitat: *Cardamine amara* subsp. *amara* is a typical representative of wetland and riverine herbaceous vegetation, soft-water springs and alluvial forests. The only known occurrence of this subspecies was in the Borinska Gorge in northwestern Serbia (between Loznica and Krupanj) (Tomović *et al.* 2009b). However, our recent findings have revealed new sites on the Lučka and Rčanska rivers, within the forest of *A. rohlenae*, together with *Onoclea struthiopteris*.

2. *Cardamine waldsteinii* Dyer (= *C. savensis* O. E. Schulz)

General distribution: The native range of this species is southern Austria to southern Hungary, including the western part of the Balkan Peninsula (Croatia, Bosnia and Herzegovina, Montenegro, Serbia and Slovenia) (POWO 2024, Marhold 2011).

Distribution in Serbia (Fig. 1): A comprehensive review of available herbarium collections and relevant literature data has revealed that *C. waldsteinii* has been recorded in the mountainous regions of Western (Mt. Tara, Mt. Zvezda, Mt. Golija, Mt. Jelova Gora), Northwestern Serbia (Gučevo, Povlen, Jablanik, Medvednik, Boranja) and Central Serbia (Goč - Gvozdac, Crni vrh) (Jovanović 1957, Gajić 1984). A summary of the existing findings is provided in Sabovljević *et al.* (2022).

New findings (Fig. 1):

Western Serbia: **Mt. Jelova Gora, Seča Reka – Zarići village**, Tmuša river valley, MGRS 34T DP07, 43.9888125 N, 19.7942347 E, c. 567 m, *Ostrya-Fagetum* (leg./det. Vukojičić S. BEOU 72127, 03.03.2024); **Jelova Gora**, MGRS 34T DP06, 43.947458 N, 19.758522 E, 918 m, on the edge of *Sphagnum* peat bog adjacent to a road to Konder, coniferous forest (Vukojičić S., field observation, photo documentation, 03.03. 2024); **Mt. Tara**, Biljeg, MGRS 34T CP66, 43.9167758 N, 19.3583014 E, 1083 m, next to the road, wet meadow (Kuzmanović N., Vukojičić S., field observation, photo documentation, 26.04.2024),

Drlje, MGRS 34T CP67, 43.9837432 N, 19.2959521 E, 1349 m, *Allio ursini-Fagetum* (Kuzmanović N., Vukojičić S., field observation, photo documentation, 26.04.2024).

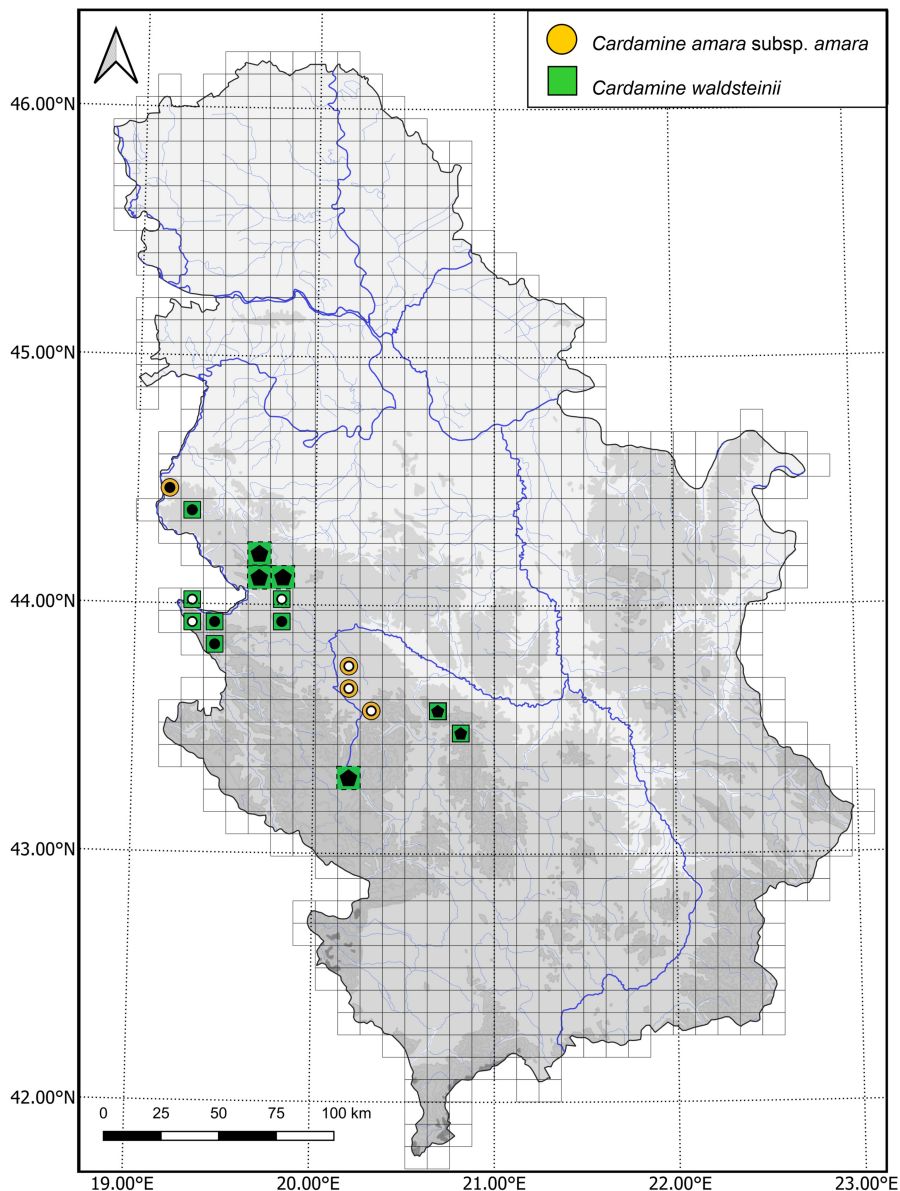


Fig. 1. – Distribution of *Cardamine amara* L. subsp. *amara* (verified data only) and *C. waldsteinii* Dyer in Serbia. Small circles within the symbols: white – new records, black – literature and herbarium records, black trapezoid – literature records. Big square with dotted frame – imprecise data.

Habitat: *Cardamine waldsteinii* was recorded within the following habitat types: mixed swamp forest of alder and Serbian spruce, beech forest, wet meadows, and peat bog. The new finding in western Serbia, on the Mt. Jelova Gora, lies on the edge of a *Sphagnum* peat bog in a mixed deciduous-coniferous forest of beech, spruce and fir (*Fageto-Abieto-Piceetum* type). The second location is situated on the slope of Mt. Jelova Gora towards Kosjerić, at lower elevation, in the *Ostryo-Fagetum* community type, next to the river Tmuša near Seča Reka.

3. *Hypericum androsaemum* L.

General distribution: *Hypericum androsaemum* is native to a number of countries in western Europe, as well as several countries in southern and southeastern Europe, North Africa, Asia Minor, the Caucasus, Iran and Turkmenistan. The species' primary distribution is within the Atlantic-Western Mediterranean region, with populations in the Balkans, including Serbia, being considered relic (Zlatković 2022).

Distribution in Serbia (Fig. 2): To date, *H. androsaemum* has been recorded in northwestern Serbia, specifically in the vicinity of Krupanj and Loznica (Mt. Boranja, Mt. Gučevo, Mt. Cer) (Zlatković 2022) and surrounding of Mionica (Novović *et al.* 2022). It has also been mentioned for the area of central Serbia - Vidojevica (Zlatković 2022), which is a mistake because it is actually the Vidojevica hill on the Mt. Cer near Loznica, and not the Vidojevica mountain in central Serbia.

New findings (Fig. 2):

Western Serbia: Mt. Jelova Gora: Đakov Kamen-Jasikovac, MGRS 34T DP06, 43.924504 N, 19.788226 E, 977 m, beech-spruce forest (leg./det. Vukojičić, S. BEOU 68427, 31.07.2022), MGRS 34T DP06, 43.925228 N, 19.787537 E, c. 977 m, at the edge of beech-fir-spruce forest (leg./det. Vukojičić, S., Kuzmanović, N. BEOU 71344, 17.11.2023), Crnušine, MGRS 34T DP06, 43.928526 N, 19.781504 E, 969 m, beech forest (Vukojičić, S., field observation, photo documentation), Okolišta, MGRS 34T DP06, 43.937434 N, 19.786142 E, c. 982 m, forest of the *Piceeto-Fagetum* type, with a significant presence of Douglas fir - *Pseudotsuga menziesii* (Mirb.) Franco (Adžić, M., Vukojičić, S., field observation, photo documentation).

The population of *H. androsaemum* on Mt. Jelova Gora is not numerous, with a total of about 50 shrubs observed. The most significant location is located adjacent to the macadam road from Đakov Kamen to Kadinjača. A total of around 20 plants were recorded, exhibiting favourable conditions and reproductive capacity. The most prevalent plant in this habitat is blackberry, which has been observed to hinder the growth of shrubby St. John's wort, potentially posing a long-term threat. In close

proximity to this site, within the deeper areas of the mixed beech-fir-spruce forest, a single fruiting specimen of *H. androsaemum* was found. Location in the Okolište area is also in good condition, numbering approximately 10 individuals, which are situated in a clearing among Douglas firs. Another individual specimen was found in another locality – Crnušine, in a beech forest above the village of Čamići, at an elevation of about 700 m a.s.l. The specimen was discovered in 2022. It was in the vegetative phase and has not flowered or fruited yet.

Habitat: *Hypericum androsaemum* is a typical representative of beech forests. It was known from the locations in NW Serbia (Podrinje region) (Zlatković 2022). It has been recorded at new site on Mt. Jelova Gora in a mixed deciduous and coniferous forest of the *Piceeto-Fagetum* type, with a significant presence of fir (*Abies alba* Mill.) and Douglas fir (*Pseudotsuga menziesii*), which have invaded the natural vegetation from the nearby tree nursery and spread throughout the mountain region.

4. *Onoclea struthiopteris* (L.) Roth [= *Matteuccia struthiopteris* (L.) Tod.]

General distribution: The native range of this species is temperate Eurasia. It has been observed in the following regions: Europe (west to Belgium, south to the southwestern Alps and the western part of the Balkan Peninsula, east to the Urals, north to the boreal part of European Russia); Asia from the Caucasus to China, including Siberia and Kamchatka in the north, as well as the eastern parts of North America (Tatić & Marin 1999).

Distribution in Serbia (Fig. 2): The species *Onoclea struthiopteris* is considered to be critically endangered species in Serbia (Tatić & Marin 1999), with the only known locality in the Gorge of the Moravica river, between Ivanjica and Arilje, in western Serbia (Petković *et al.* 1991). However, a recent discovery in the Bjelica river valley near Kotražica indicates that the species may be more widespread than previously thought (Sabovljević *et al.* 2021a).

New findings (Fig. 2):

Western Serbia: Ivanjica: Lučka river, MGRS 34T DP42, 43.595014 N, 20.277774 E, 557 m, along the river bank in association with *Alnus rohlenae*, on moist soil (leg./det. Vukojičić, S., Kuzmanović, N., Stevanoski I. BEOU 68479, 09.05.2022); **Lučani:** Guča, Rti, Rčanska river, MGRS 34T DP34, 43.733507 N, 20.243165 E, 392 m, along the river bank in association with *Alnus rohlenae* (leg./det. Vukojičić S. BEOU 68573, 02.05.2022).

This rare fern was documented at the newly identified sites on the Lučka and Rčanska rivers, in the vicinity of Ivanjica in western Serbia, in the same habitat type. Populations of this fern are numerous and for now in

good condition. Next to these communities, there is arable land under intensive anthropogenic activity. Therefore, these habitats should be protected as soon as possible.

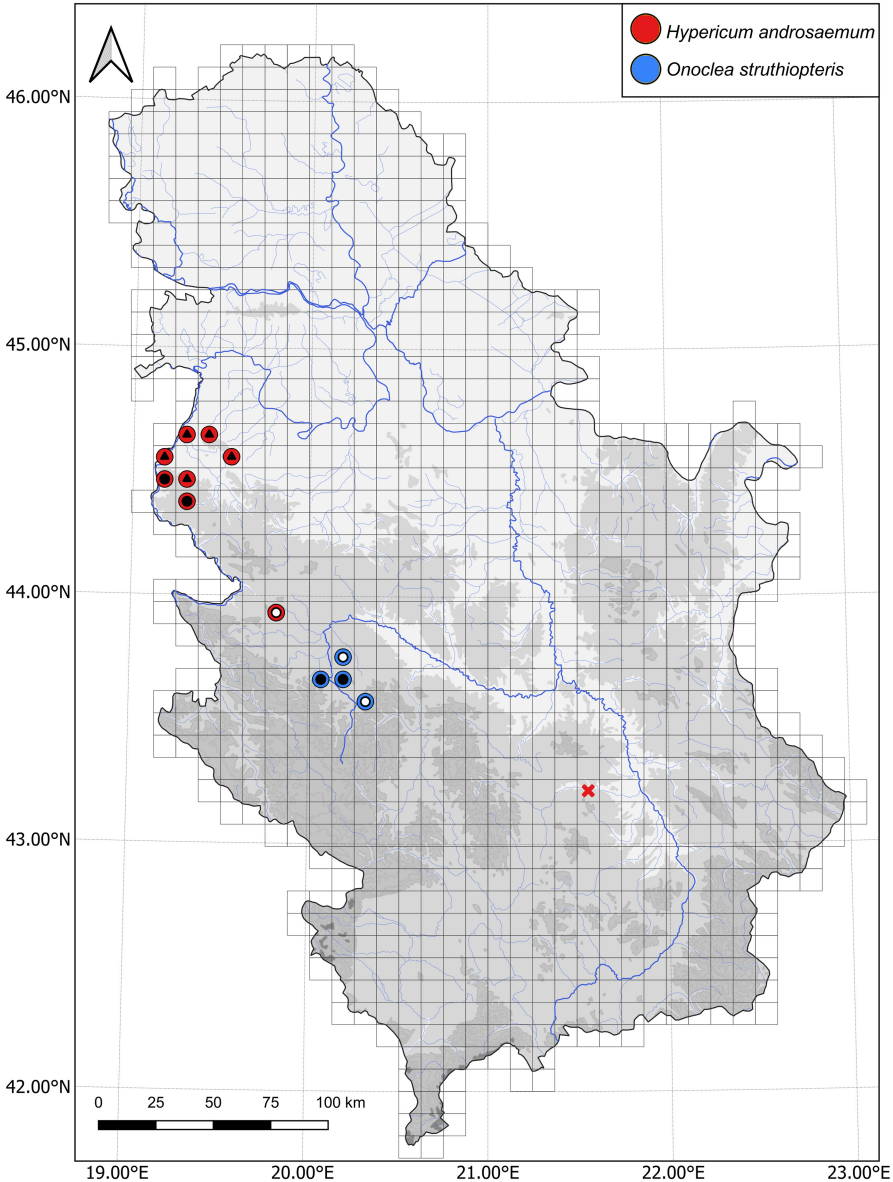


Fig. 2. – Distribution of *Hypericum androsaemum* L. and *Onoclea struthiopteris* (L.) Roth in Serbia. Small circles within the symbols: white – new records, black – literature and herbarium records, black triangle – literature records. Red cross – erroneously reported record for *H. androsaemum*.

Habitat: *Onoclea struthiopteris* is a typical representative of wetland and riverine herbaceous vegetation, and alluvial forests. To date, the only known occurrences of this species have been within the forest of black alder (Petković *et al.* 1991, Sabovljević *et al.* 2021a).

5. *Tulipa sylvestris* subsp. *australis* (Link) Pamp.

General distribution: The native range of this subspecies is Mediterranean region, south-central and eastern Europe, western and central Asia to northwestern China (Xinjiang) (POWO 2024).

Distribution in Serbia (Fig. 3): Since the work of Josif Pančić (1884) and Sava Petrović (1882), there have been reports of its spontaneous growth in the vicinity of Niš, albeit with no precise locations recorded (Diklić 1975). The locations confirmed by herbarium specimens include Kozjak mountain and the surroundings of Prohor Pčinjski monastery in southeastern Serbia (Niketić *et al.* 2018), as well as Šar Planina Mts (Duraki *et al.* 2017), and the surroundings of Kosovska Mitrovica in Kosovo (Prodanović 2007).

New findings (Fig. 3):

Eastern Serbia: **Stara Planina Mts**, Kaluderski waterfall, MGRS 34T FP30, 43.377420 N, 22.671208 E, c. 1374 m, in the grassland vegetation on silicates (leg./det. Vukojević, S. BEOU 71326, 20.05.2023).

Habitat: *Tulipa sylvestris* subsp. *australis* has so far been recorded at two locations in Serbia proper, namely in the southern part of the Pčinja river region in Serbia (Kozjak Mountain and near the Monastery of St. Prohor Pčinjski), where it inhabits thermophilous shrub vegetation (*Ostrya-Carpinion aegaeum*), at elevation of 400–560 m a.s.l. In Kosovo and Metohija, it has been recorded on rocky grasslands in the Ibar river valley (near Kosovska Mitrovica) and on pastures in the Šar Planina Mts. The new finding on the Stara Planina Mts is located at the foot of peak Midžor, next to the Kaluderski waterfall, in the grassland vegetation on silicates, at c. 1300 m a.s.l., which is under warmer climatic influences coming through the valley of the Toplodolska river to the village of Topli Do.

6. *Typha shuttleworthii* W. D. J. Koch & Sond.

General distribution: The native range of this species is Europe to Iran. It occurs in Europe, from France east through the Czech Republic and Hungary to Romania and Ukraine, the Caucasus and Asia (Turkey) (POWO 2024). It has been recorded in all Balkan countries - Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Greece, Montenegro, Serbia and Slovenia (POWO 2024, von Raab-Straube & Raus 2024).

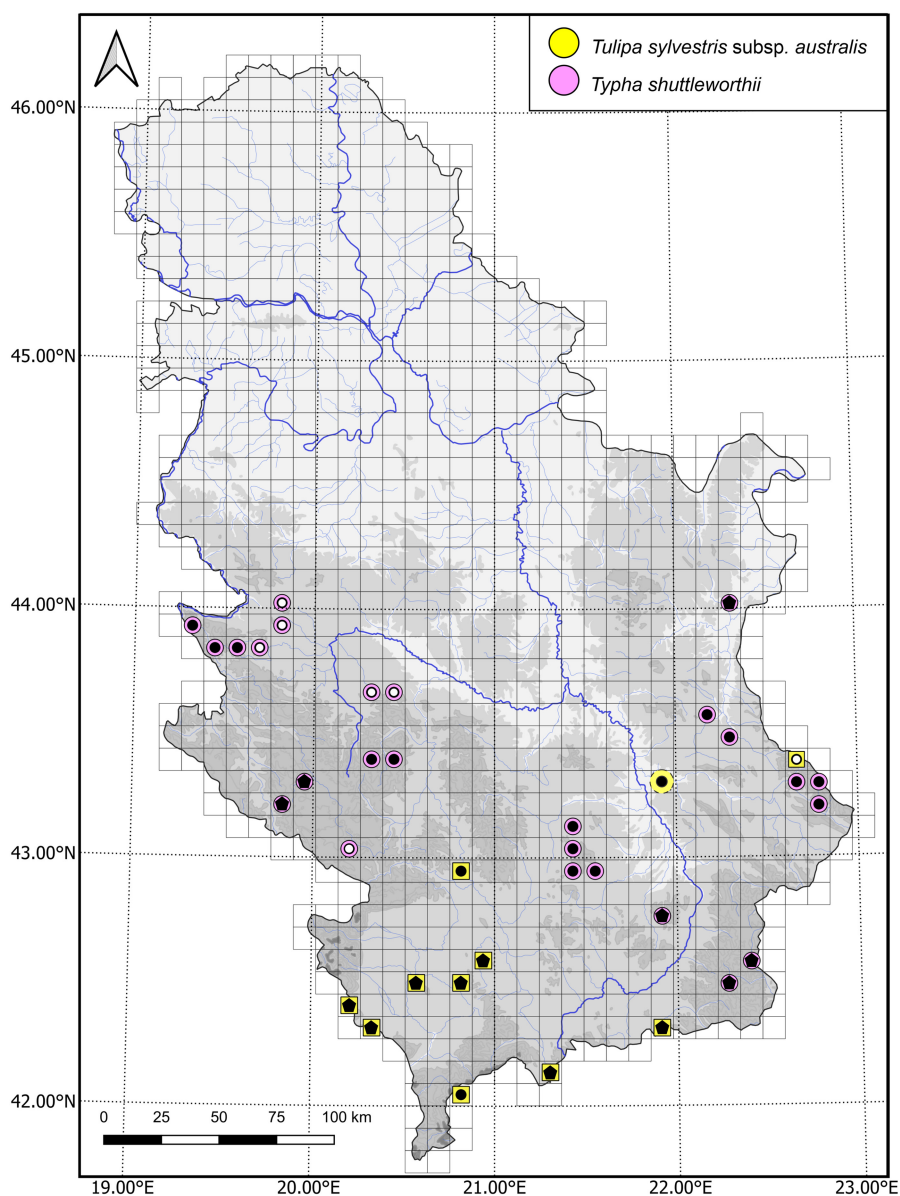


Fig. 3. – Distribution of *Tulipa sylvestris* subsp. *australis* (Link) Pamp. and *Typha shuttleworthii* W. D. J. Koch & Sond. in Serbia. Small circles within the symbols: white – new records, black – literature and herbarium records, black trapezoid – literature records. Big circle with dotted frame – imprecise record.

Distribution in Serbia (Fig. 3): The species was considered a critically endangered in Serbia, due to its limited distribution in only a few localities in southwestern (surrounding of Sjenica) and southern Serbia (Kukavica),

while it was considered to be extinct in Vojvodina (Randjelović 1999). Recent field investigations have revealed that the species is much more widely distributed in Serbia than previously thought. New localities of the species were discovered in the western Serbia (Mt. Tara and Mt. Jelova Gora), southwestern (Mt. Golija and Mt. Ozren), northwestern (surroundings of Bor), eastern (surroundings of Svrljig and Stara Planina Mts), southeastern (surroundings of Bosilegrad) and central Serbia (Mt. Radan) (Tomović *et al.* 2009a, Jenačković-Gocić *et al.* 2020, Tomović *et al.* 2020, Sabovljević *et al.* 2021b).

New findings (Fig. 3):

Western Serbia: Mt. Jelova Gora, Jovanova Voda, MGRS 34T DP06, 43.929880 N, 19.792461 E, 933 m (*Vukojičić, S.*, field observation); Glog, MGRS 34T DP07, 43.978036 N, 19.785869 E, 720 m (*Kuzmanović N., Vukojičić S.*, field observation, photo documentation); **Bioska**, MGRS 34T CP95, 43.8690475 N, 19.6680423 E, 695 m (*Kuzmanović N., Vukojičić S.*, field observation, photo documentation, 17.08.2023), **Gornji Dubac**, MGRS 34T DP43, 43.6580558 N, 20.3558361 E, 938 m (*Kuzmanović N., Vukojičić S., Stevanoski I.*, field observation, photo documentation, 09.05.2022); **Bogutovac**, Lopatnica Gorge, MGRS 34T DP53, 43.6811865 N, 20.4893115 E, 323 m (*Kuzmanović N., Vukojičić S.*, field observation, photo documentation, 12.05.2024). **Southwestern Serbia: Pešter**, Leskova, MGRS 34T DN36, 43.027807 N, 20.169137 E, c. 1213.9 m, reed swamp (leg./det. *Lakušić, D., Kuzmanović, N., Janković, I., Zbiljić, M.* BEOU 63995, 15.07.2018).

Habitat: It was found at six new sites in the western, southwestern and central Serbia regions. These sites are characterised by relatively small patches with *T. shuttleworthii*, which typically cover no more than a few square metres. The majority of these patches are found in roadside ditches, where the water remains for longer periods.

Acknowledgements

This research was funded by the Science Fund of the Republic of Serbia under Grant number 7750112, Balkan biodiversity across spatial and temporal scales patterns and mechanisms driving vascular plant diversity (BalkBioDrivers), and by the Ministry of Science, Technological Development and Innovations of the Republic of Serbia, contracts No. 451-03-65/2024-03/200178 and 451-03-66/2024-03/200178. We would like to thank the anonymous reviewer for valuable suggestions, and to Boštjan Surina (Rijeka) for his assistance in providing information relevant to Slovenia.

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ПРИЛОГ ХОРОЛОГИЈИ И ЕКОЛОГИЈИ НЕКИХ РЕТКИХ И УГРОЖЕНИХ БИЉНИХ ВРСТА У СРБИЈИ

СНЕЖАНА ВУКОЛИЧИЋ, ДМИТАР ЛАКУШИЋ, ИВАНА СТЕВАНОСКИ,
НЕВЕНА КУЗМАНОВИЋ

Р Е З И М Е

Најновије процене показују да васкуларну флору Србије чини око 4.246 врста и подврста, аутохтоних и алохтоних натурализованих. Процењује се да је приближно 20% овог укупног броја таксона угрожено. Упркос обимним истраживањима флоре Србије спроведеним током протеклих деценија, и даље се откривају нове врсте, као и нови локалитети за врсте које су се раније сматрале ишчезлим или критично угроженим. Током теренских истраживања у Србији претходних година откривена су нова налазишта за следеће ретке и угрожене таксоне: *Cardamine amara* L. subsp. *amara*, *Cardamine waldsteinii* Dyer, *Hypericum androsaemum* L., *Onoclea struthiopteris* (L.) Roth, *Tulipa sylvestris* subsp. *australis* (Link) Pamp. и *Typha shuttleworthii* W. D. J. Koch & Sond. Распрострањење ових таксона утврђено је опсежним прегледом бројне флористичке литературе, хербарских збирки и сопствених теренских података. Ове информације су представљене на UTM мрежним картама у размери од 10×10 km. Поред тога, описана су станишта у којима се јављају наведени таксони, као и статус популација, чиме се даје свеобухватан преглед њиховог тренутног стања у Србији.