



# *Sesleria serbica* (Poaceae), a neglected species of the Balkan Peninsula

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**ABSTRACT:** *Sesleria serbica* is a neglected taxon traditionally wrongly synonymised with *S. rigida*. Our multifaceted study confirmed its specific status. Herewith we comprehensively describe its morpho-anatomical and ecological features. It is an obligate serpentinophyte, and a protected species in Serbia. Regarding its distribution, *S. serbica* is a Balkan endemic species (local endemic of the eastern part of the Illyrian province). Nomenclatural and taxonomical notes are also provided, as well as the national conservation status of this species.

**KEY WORDS:** *Sesleria serbica*, Poaceae, neglected species, morpho-anatomy, ecology, chorology

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## INTRODUCTION

The species, treated now as *Sesleria serbica* (Adam.) Ujhelyi, has been first recognised by ADAMOVIĆ (1896) as a variety of *S. rigida* Heuff. ex Rchb., and later raised to specific level by UJHELYI (1959a). Traditionally, the taxon *S. serbica* was included in the complex *S. rigida* (section Calcariae Deyl, sub-section Rigida Deyl; DEYL 1946). It was mostly treated as a lower infraspecific taxon or just as a serpentine ecotype of the species *S. rigida* (DEYL 1946, 1980; DIKLIĆ & NIKOLIĆ 1986; TATIĆ 1976), and only rarely as a “good species”, *S. serbica* as proposed by Ujhelyi (UJHELYI 1959a; STEVANOVIĆ *et al.* 1995, 2003; EURO+MED 2006).

Following Ujhelyi, detailed molecular, morpho-anatomical and chorological-ecological studies have been carried out with the aim to describe and confirm clear differences that occur between *S. serbica* and other members of *S. rigida* s.l. (KUZMANOVIĆ *et al.* 2009, 2012). The final confirmation and circumscription of *S. serbica* was published in KUZMANOVIĆ *et al.* (2013), where it was shown that within the complex *S. rigida* four species can be recognized – *S. ahtarovii*, *S. filifolia*,

*S. rigida* and *S. serbica*. These results have shown that the genetic differentiation pattern was reflected by morphological differentiation, where leaf morphology and especially anatomy play a primary role in morphological discrimination of the constituents of *S. rigida* s.l. In addition, further discrimination can be obtained using the characters of overall habit such as the shape of tufts (stoloniferous vs. compact) and spikes (lax and interrupted vs. dense and compact).

The aim of the present work is to describe in detail the anatomical, morphological, ecological and phytogeographical specialty of the species *S. serbica*, as well as to provide information regarding taxonomical and nomenclatural issues.

## MATERIAL AND METHODS

Plant material was collected during five vegetation seasons (2008–2012). Anatomical and morphometric analyses were performed on dissected plant organs preserved in 50% ethanol (leaves) or in 1:1 glycerol/ethanol solution (stems with spikes).

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**Table 1.** Accession used for morphometric analyses.

Locality	Coordinate	Altitude	Habitat	Voucher	Individuals
Serbia, Tara mountain, Paljevine	43.8769 N, 19.4168 E	950	black pine forests (Erico-Pinetum nigrae)	Lakušić, D. 27106	26
Serbia, Kopaonik, Neveske stolice	43.2605 N, 20.8298 E	1850	subalpine pasture (Festuco-Seslerietea)	Lakušić, D. 27617	15
Serbia, Kopaonik, Treska	43.2604 N, 20.7854 E	1600	subalpine pasture (Festuco-Seslerietea)	Jakovljević, K., Kuzmanović, N. 28735	28
Serbia, Mokra Gora 2	43.7319 N, 19.6431 E	800	black pine forests (Seslerio-Pinetum nigrae)	Kuzmanović, N. 28739	26
Serbia, Mokra Gora 1	43.8286 N, 19.5268 E	900	black pine forests (Seslerio-Pinetum nigrae)	Kuzmanović, N. 28740	26
Serbia, Zlatibor, Zlatiborska jezera	43.8142 N, 19.5132 E	1000	black pine forests (Seslerio-Pinetum nigrae)	Kuzmanović, N. 28741	30
Serbia, Gornji Milanovac, Brdjani's gorge	43.9934 N, 20.421 E	300	rocky grasslands (Festuco-Brometea)	Lakušić, D. et al. 28817	24
Serbia, Gornji Milanovac, Vužan	43.9858 N, 20.4478 E	550	rocky grasslands (Festuco-Brometea)	Lakušić, D. et al. 28830	28
Serbia, Maljen, Ljuti krš	44.1256 N, 19.9981 E	950	black pine forests (Seslerio-Pinetum nigrae)	Kuzmanović, N. 29507	26
Bosnia and Herzegovina, Gornja Maoča	44.7698 N, 18.6555 E	280	black pine forests (Seslerio-Pinetum nigrae)	Kuzmanović, N. et al. 29515	22
Bosnia and Herzegovina, Gornja Maoča	44.7606 N, 18.6526 E	300	rocky grasslands (Festuco-Brometea)	Kuzmanović, N. et al. 29516	28

Analysis of 27 anatomical leaf characters was performed on cross-sections of tiller leaves as described by KUZMANOVIĆ *et al.* (2009). 23 macromorphological characters were analysed following combined and adjusted methods used for *Festuca* L. (AUQUIER 1974; LAKUŠIĆ 1999; FOGGI *et al.* 1999, 2006) and *Sesleria* Scop. (ALEGRO 2007; DI PIETRO 2007). The anatomical measurements were performed on the cross-sections of 277 tiller leaves (each obtained from different individuals, 11 populations). Anatomical analyses of the leaves were done on permanent hand-made slides, prepared by a standard method for light microscopy. Cross sections of the tiller leaves were cleared in Parazone and thoroughly washed before staining in safranin (1 % w/v in 50 % ethanol) and alcian blue (1 % w/v, aqueous). The measurements were performed using a Leica Qwin (Leica Microsystem, Germany) and Digimizer Image Analysis software (MedCalc Software, Belgium). Statistical analyses were performed using Statistica 5.1

(STATSOFT 1996). Voucher specimens were deposited at BEOU. The information regarding populations used for the morphometric analyses is provided in Table 1.

Chorological and ecological data were based on recent field studies, analysis of herbarium material deposited at BEOU, BEO, BP, BUCA, GZU, PR, PRC, SOM, W and WU (herbarium acronyms follow THIERS 2013), as well as critically-evaluated literature data. All species-occurrence data are stored in a Microsoft Excel 2003 database. Following the principles and methods of data cleaning and data quality (CHAPMAN 2005a, 2005b), each original record was carefully reinterpreted, so that in addition to primary species data which included taxonomic and nomenclatural information and original spatial attributes (verbatim data) every row in the database contained an optimum of accurate and precise data on habitat, substrate, altitude, aspect and Universal Transverse Mercator (UTM)-coordinate in the Military Grid Reference System (MGRS). Distribution data were mapped on the grid

map with squares of 10 km × 10 km, based on the UTM projection according to LAMPINEN (2001).

## RESULTS AND DISCUSSION

**History of *Sesleria serbica*.** The first nomenclatural element that can be associated with the name *S. serbica* is the herbarium specimen collected in 1893 and deposited in the Herbarium Generale collection in the Hungarian Natural History Museum (BP 593596!) - “*Sesleria rigida* Heuff. var. *longifolia* m. In saxosis ad Gornji Milanovac. Solo serpentino. V. 1893 L. Adamović”. Since Lujó Adamović did not publish this name with the description or diagnosis, it can be considered as “nomen nudum” (Art. 38 Ex. 1, McNEILL *et al.* 2012). In the same year, in April and May, he collected a number of specimens that were deposited in more European herbaria mainly under the name *S. rigida* Heuff. (WU 0042093!, GZU 259577!). Furthermore, in the special collection of Josef Velenovský in PRC herbarium there is a specimen collected in April 1893 by Adamović “*In saxosis ad Gornji Milanovac*” that was originally determined by Adamović only as *Sesleria*, and probably sent to Velenovský for revision. Velenovský added the determination “*Sesleria rigida* Heuff. var.”, and wrote probably to Adamović that the plant represented a variety of *S. rigida* unknown to him (J. Štepanek 2009, pers.comm.). Probably after the correspondence with Velenovský, and on the basis of his own investigations, Adamović decided to describe *S. rigida* var. *serbica* (ADAMOVIĆ 1896) - “*Sesleria rigida* Heuff. v. *serbica* mihi, Rhizomate valde elongate tenui vix dense caespitoso, culmis elatiborius, foliis pungentibus infernos culmos aequantibus vel superantibus, spica elongate laxa interrupta. In rupestribus calcareis montis Vujan prope Gornji Milanovac, ca 500 m. Aprili florens”. From the locality it is apparent that this referred to the same taxon that he had previously named *S. rigida* var. *longifolia*, but with a difference on the geological substrate on which the plant was collected. Another specimen was found in W herbarium collected near Gornji Milanovac in the year when the protologue reference was published (W 1897-0006747!) - “*Sesleria serbica* Adamov. In rupestribus circa Gornji Milanovac. Loc. class. Solo calc. Apr. 1896 L. Adamović”. The protologue was published in *Allgemeine Botanische Zeitschrift Syst.* 2 (No. 7/8) – July and August, so the specimen collected in the same year in April can be unambiguously associated with the protologue and treated as part of the original material. However, the specimen from PRC appeared as the most appropriate for the nomenclatural type of the name *S. rigida* var. *serbica* (hence for the name *S. serbica* also), so it was designated as the lectotype in KUZMANOVIĆ *et al.* 2013 (PRC451931!, Figure 1).



Fig. 1. Lectotype of *Sesleria serbica* (Adam.) Ujhelyi (PRC 451931)

After Adamović, UJHELYI (1959a) in his work *Species Sesleriae generis novae* elevated this taxon to the species level under the name *S. serbica* (Adam.) Ujhelyi: “*Sesleria serbica* (Adam.) Ujhelyi pro specie.”, and indicated that synonyms are Adamović’s *S. rigida* var. *serbica* and *S. rigida* var. *longifolia* (in herb.). In this paper he gave an extensive description, however, instead of typifying the new combination by the basynonym type, he gave a new holotype for the taxon, which was not in accordance with Art 9.19 (McNEILL *et al.* 2012). Therefore, the “holotype” he left in the Herbarium of the Natural History Museum in Budapest (BP 734294!) cannot be considered as the nomenclatural type for *S. serbica*. Regardless of this mistake that he made, during his work on the genus *Sesleria*, József Ujhelyi gave a significant contribution to the knowledge of this complicated grass genus (UJHELYI 1938, 1940, 1959a, 1959b, 1960; UJHELYI & FELFOLDY 1948).

**Morphological description.** Plant perennial, broadly caespitosae (up to 1m in diameter), rhizome very elongated and without reticulate basal leaf sheaths (Figure 1A). Leaf sheaths yellowish-green, glabrous. **Culms** (15.7–) 23.8–42.6 (–55.9) cm tall, glabrous. The uppermost culm

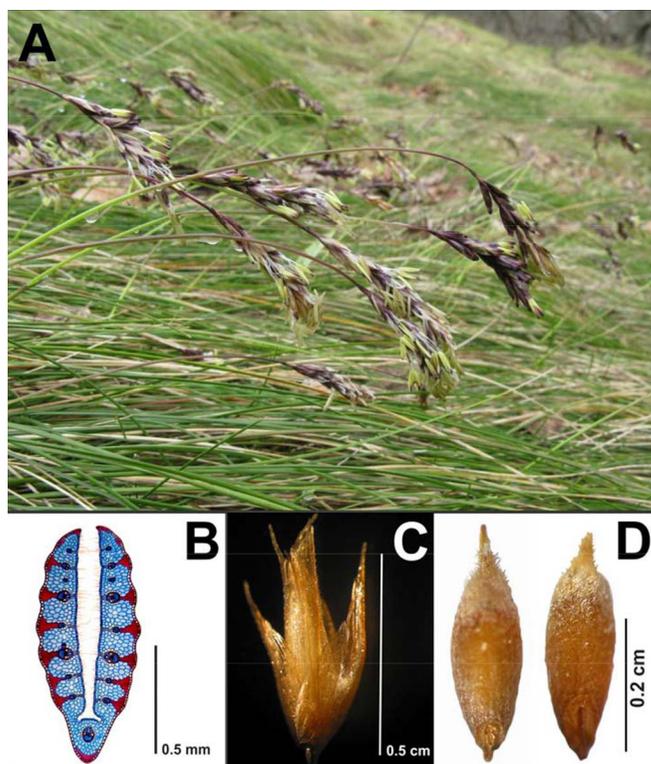


Fig. 2. *Sesleria serbica* (Adam.) Ujhelyi. A. Plant on the locus classicus (Mt. Vujan; photo D. Lakušić); B. Leaf transverse section, C. Spikelet, D. Seed

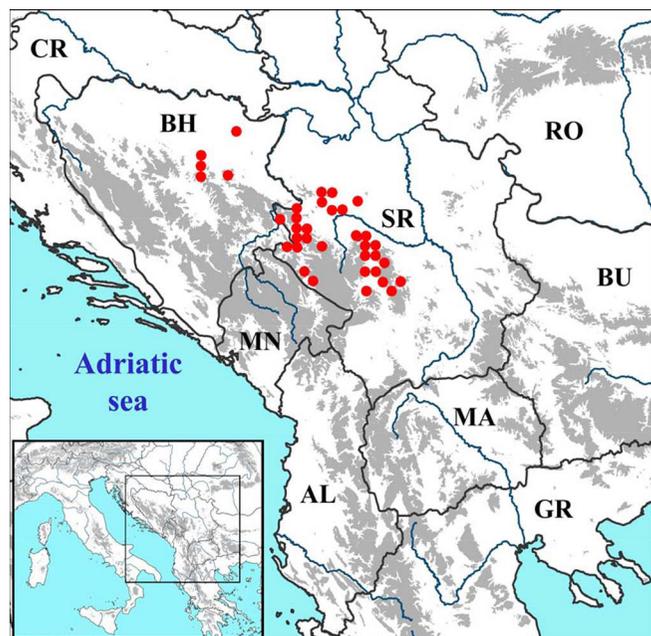


Fig. 3. Distribution of *Sesleria serbica* (Adam.) Ujhelyi (UTM Grid zone T34, spots correspond to the basic square of  $10 \times 10$  km)

leaf is 0.20-1.66 cm long. Ligules short, ciliate. **Tiller leaves** 4.5-45.3 cm long, setaceous, prostrate or slightly upright, never erect or rigid, dark green, shiny. The leaves are rolled around the central nerve (convolute), and their leaf blade form varies from the oval to elliptical (Figure 2B). Surface of the leaf blades ranges from 152.01 to 523.05 mm<sup>2</sup>. Width of the leaf blades ranges from 0.60 to 1.42 mm. Thickness of the leaf blades in the zone of the central vein varies from 0.18 to 0.29 mm, and the largest thickness from 0.14 to 0.28 mm. On the adaxial side of the leaf there is only a central rib whose width varies from 0.09 to 0.19 mm. The mesophyll is not differentiated to spongy and palisade tissues. It is built of the chlorenchyma cells which fulfill all the space not covered by sclerenchyma or vascular bundles and their sheath layer. The vascular bundles make just one row and they are located in the mesophyll, close to the epidermis of the adaxial side of the leaf. They are different in size, so it is easy to distinguish the "major" (big) and "minor" (small) bundles. All the bundles have elliptic form and are surrounded by one layer of cells, making the sheath of the vascular bundle. The major vascular bundles have clearly developed big tracheas. Number of major vascular bundles varies from 3 to 7. Minor vascular bundles are small, without or with hardly noticeable big tracheas. Number of minor vascular bundles varies from 3 to 12. Height of the central vascular bundle varies from 0.05 to 0.11 mm. Width of the central vascular bundle varies from 0.04 to 0.09 mm. Height of the largest lateral vascular bundle varies from 0.05 to 0.11 mm and width of the largest lateral vascular bundle varies from 0.04 to 0.08 mm. Sclerenchyma is interrupted, with a tendency to form a continual subepidermal layer in the older leaves. It is organized in the form of sclerenchyma girders (from the adaxial to the abaxial side of the leaf they descend to the vascular bundles) and strands (they do not touch the vascular bundles). The sclerenchyma strands on the adaxial side of the leaf are generally absent, while on the abaxial side of the leaf they are always present. The number of sclerenchyma strands on the abaxial side of the leaf varies from 1 to 6. Sclerenchyma girders appear both on adaxial and abaxial sides of the leaf in a similar number - number on adaxial side of the leaf varies from 6 to 14, and on the abaxial side from 5 to 14. Occasionally, the sclerenchyma strands and girders on the abaxial side of the leaf are mutually connected, forming sclerenchyma strands extending in a parallel way with the epidermis of the leaf. Extremely rarely, the sclerenchyma strands are registered on the adaxial side of the leaf as well. Height of the sclerenchyma strand of the central vascular bundle varies from 0.02 to 0.06 mm. Within the zone of the central vascular bundle the sclerenchyma is organized exclusively in the form of a sclerenchyma strand, located on the abaxial side of the leaf. The surface of the sclerenchyma

varies from 13.29 mm<sup>2</sup> to 98.69 mm<sup>2</sup>. Occasionally, in the mesophyll some colorless cells can be observed, within the zone of sclerenchyma girders on the adaxial side of the leaf. On the adaxial side of the leaf the presence of moderately to densely distributed simple hairs are observed, whose length varies from 0.02 to 0.10 mm. Thinned out hairs are present on the abaxial side of the leaf, whose length varies from 0.01 to 0.08 mm. Bulliform cells are present in the highest number of the analyzed leaves, and their dimension (expressed as a relative ratio of the lengths of bulliform cells and neighboring cells of the epidermis of the adaxial side of the leaf) varied in a range from 0.88 to 4.01. **Spike** cylindrical, elongated and slightly interrupted (16-) 19-30 (-44) mm  $\bar{I}$  (4-) 5-7 (-8) mm, with (7-) 11-16 (-20) spikelets. **Spikelets** on prominent pedicels, with 2-3 flowers (Figure 2C). **Glumes** unequal, membranous, with a single vein, obtuse, glabrous. Lower glumes 3.4-7.2×1.1-2.8 mm, upper glumes 3.6-7.8×1.4-2.9. **Lemma** oblong, sparsely pubescent to glabrous between the veins, membranous, with 3-5 veins and 3-5 awns (middle awn the largest), 3.8-6.3×1.7-3.4 mm with 0.4-1.4 mm long awn. **Palea** as long as or shorter than the lemma, two-veined, shortly awned, pubescent on the veins, obtuse, 3.7-6.1×1.3-3.0 mm. **Anthers** 2.44-4.48 mm long. **Seed** lanceolate, pubescent in the upper part, 2.05-3.24 mm long, 0.96-1.26 mm wide, hilum 0.46-0.96 mm long (Figure 2D).

**Distribution and ecology.** *Sesleria serbica* represents a local endemic taxon (Balkan endemic), distributed on the Inner Dinarides of central and eastern Bosnia (Mitrovići, Tajan, Krivaja, Varda, Konjuh, Gostović, Gornja Maoča) and western and central Serbia (Vujan, Brđanska gorge, Tučkovo, Maljen, Tara, Mokra Gora, Zlatibor, Studena planina mountain, Stolovi, Goč, Čemerno, Ibar valley, Studenica valley, Raška, Kopaonik, Jadovnik, Stari vlah, Ozren, Rogozna). A doubtful record from the serpentine areas in Banija (Croatia, SEKULIĆ *et al.* 1988) could not be confirmed in the course of the present study (N. Kuzmanović, field observations). Chorologically, it can be classified as an East Illyrian endemic, i.e. local endemic of the eastern part of the Illyrian province. Distribution is presented on the map with squares of 10 km × 10 km (Figure 3).

*Sesleria serbica* occurs only on serpentine bedrock, and by this feature it belongs to the group of obligate serpentinophytes (STEVANOVIĆ *et al.* 2003). However, in the protologue (and on some herbarium specimens), ADAMOVIĆ (1896) recorded the species on limestones of Mt. Vujan near Gornji Milanovac. Our recent field investigations could not confirm the presence of *S. serbica* on calcareous bedrock on mt. Vujan (where limestone and serpentine areas have a wide contact zone); it was

exclusively on serpentine outcrops confirming its belonging to serpentinophytes. Its populations occur at altitudes ranging from c. 300 m a.s.l. (Brđjani gorge, Gostovička river gorge) to 1900 m a.s.l. (Kopaonik-Nebeške stolice), mostly on north and northeast expositions, on the slopes ranging from 15 up to 85 degrees. According to DEYL (1946) it belongs to the eurythermal group of species, which are blooming in early spring.

Regarding phytosociological features, *S. serbica* has an important role in forming several types of primary and secondary communities. On the summits of mountains that it inhabits, it forms the primary community type *Seslerietum serbicae* (*Seslerietum filifoliae* Z. Pavlović 1955, *Luzulo-Seslerietum rigidae* D. Lakušić 1987) that can be included in the class *Elyno-Seslerietea* Br.-Bl. 1948. On the steep slopes, in northern expositions, on the lower altitudes, it dominates the understory of the specific forest community *Quercu-Pinetum* Z. Pavlović 1964, *Seslerio rigidae-Pinetum nigrae* Gajić 1954 and *Pinetum nigrae-sylvestris* Z. Pavlović 1951 (*Erico-Pinetea* Horvat 1959), as well as *Seslerio-Ostryetum*, *Seslerio-Fagetum* and *Seslerio-Betuletum* community types (*Quercu-Fagetea* Br.-Bl. et Vlieg. 1937). Furthermore, on places where the forests are degraded, it builds up the specific secondary community *Erico-Seslerietum rigidae* R. Jovanović et S. Jovanović 1985 and communities where *S. serbica* dominates on the open rocky grasslands that can be included in the class *Festuco-Brometea* Br.-Bl. et Tüxen ex Soó 1947. On the territory of Serbia, *S. serbica* was recorded in many other communities, e.g. in *Euphorbieto (cyparissias)-Brachypodietum pinnati* E. Vukićević 1965, *Ostryeto-Quercetum petraeae serpentinicum* E. Vukićević, *Helleboro-Quercu-Ostryetum* B. Jovanović 1967, *Pinetum nigrae* Gajić 1954, *Silenetum serbicae* D. Lakušić 1987, etc. (LAKUŠIĆ *et al.* 2005).

In Bosnia and Herzegovina, in the eastern parts, the species *S. serbica* builds up communities with *Viola beckiana* Fiala ex Beck (belonging to the class *Festuco-Brometea* Br.-Bl. et Tüxen ex Soó 1947) - *Sesleria rigida-Viola beckiana*=*Sesleria serbica-Viola beckiana* (KRAUSE & LUDWIG 1957, UJHELYI 1959a), while in central and northwest parts the community *Seslerio serbicae-Pinetum* Rt. 1970 is recorded (belonging to class *Erico-Pinetea* Horvat 1959, LAKUŠIĆ *et al.* 1977).

**Conservation status.** According to national legislation, *Sesleria serbica* is a protected species in Serbia (SL\_RS\_5/2010), and following STEVANOVIĆ *et al.* (1995) it was included in the Review of the vascular flora of Yugoslavia of international importance, evaluated as rare. Based on our recent studies, the high number of actually known populations, and the fact that *S. serbica* is usually a dominant species of various plant communities, we feel that the nature conservation status of the species should be reconsidered and that it is not threatened or a red list

species, even in Serbia and Bosnia and Herzegovina, while its occurrence needs confirmation in Croatia.

## CONCLUSION

Our comprehensive study employing morpho-anatomical, chorological and ecological data confirmed the specialty of *Sesleria serbica* that deserves to be treated as a species. It can be easily distinguished from other members of the complex *S. rigida* primarily for being an obligate serpentinophyte, while all other species are strictly calcicole, but also by having stoloniferous, broadly caespitose tufts, spikes that are elongated and lax (4-5 times longer than wide), and tiller leaf hairy on both sides. Additionally, *S. serbica* is restricted to the Illyrian province (Dinaric Mts. of eastern Bosnia and western Serbia), whereas *S. rigida* belongs to the Carpathian (Carpathians in Romania), *S. filifolia* to the Moesian (Balkan Mts. in eastern Serbia and western and northern Bulgaria and Munții Banatului in Romania) and *S. achtarovii* to the Macedonian-Thracian province (Rhodope Mts. in southern Bulgaria and northeastern Greece) with one isolated population on the island of Thassos in the Aegean province of the Macaronesian-Mediterranean region.

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Botonica SERBICA



REZIME

## ***Sesleria serbica* (Adamović) Ujhelyi (Poaceae), zapostavljena biljna vrsta sa Balkanskog poluostrva**

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*Sesleria serbica* je zapostavljen takson koji je tradicionalno sinonimiziran sa vrstom *S. rigida*. Naša sveobuhvatna istraživanja potvrdila su njen status vrste. U radu je dat detaljan opis njenih morfo-anatomskih, horoloških i ekoloških osobina. Takođe, detaljno su razmatrana i pitanja vezana za nomenklaturu i taksonomiju, kao i status ugroženosti ove vrste. Ustanovljeno je da je vrsta *S. serbica* obligatna serpentinofita, rasprostranjena u istočnom delu Ilirske provincije, u zapadnoj Srbiji i istočnoj Bosni, te da u tom smislu predstavlja lokalno endemičnu (istočno-ilirsku) vrstu Balkanskog poluostrva.

**Ključne reči:** *Sesleria serbica*, Poaceae, zapostavljena vrsta, morfo-anatomija, ekologija, horologija