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DISCOVERY, UPDATED DISTRIBUTION AREA AND HABITAT PREFERENCES OF *CAMPANULA TOMMASINIANA*, A NARROW ENDEMIC OF MT UČKA (LIBURNIAN KARST, NORTH-WESTERN ADRIATIC)

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Surina, B.: Discovery, updated distribution area and habitat preferences of *Campanula tommasiniana*, a narrow endemic of Mt Učka (Liburnian karst, north-western Adriatic). Nat. Croat., Vol. 22, No. 1., 171–180, 2013, Zagreb.

Campanula tommasiniana is a narrow endemic of Mt Učka occupying 6-7 km^2 between 50-1396 m a.s.l. Within its distribution range, five more or less homogenously inhabited micro-sites were identified. The majority of the population occupies rock crevices of boulders, cliffs and rocky outcrops above 900 m a.s.l., within the zonal thermophytic and altimontane and subalpine beech forests, although specimens were frequently recorded in various secondary habitats across its distribution range. Due to the lack of data on species biology, density, genetic population structure and potential gene flow within and among microsites it is difficult to estimate the extent of particular threats to the species. Nevertheless, destruction of already occupied and potential habitats may represent a real threat for the long-term survival of this narrow endemic with pronouncedly patchy distribution. Hence, every established and potential growth site, especially rocky outcrops and cliffs should be strictly preserved.

Key words: *Campanula tommasinana*, Campanulaceae, endemic taxa, areal, Dinaric Alps, Mt Učka

Surina, B.: Otkriće, aktualizirano područje rasprostranjenosti i izbor staništa učkarskog zvončića (*Campanula tommasiniana*), stenoendema Učke (Liburnijski krš, SZ Jadran). Nat. Croat., Vol. 22, No. 1., 171–180, 2013, Zagreb.

Učkarski zvončić (*Campanula tommasiniana*) je stenoendem planine Učke, koji se rasprostire na području od svega 6 do 7 km^2 u pojasu između 50 i 1396 m nadmorske visine. Unutar areala ove vrste uočeno je pet uglavnom homogeno nastanjenih mikrolokaliteta. Veći dio populacije vrste uspijeva u pukotinama stijena i litica iznad 900 m n.m., unutar pojaseva klimazonalne termofilne te altimontanske i subalpinske šume bukve, iako su pojedini primjerci često zabilježeni u različitim sekundarnim staništima duž cijelog areala. Uslijed nedostatnog poznavanja biologije, gustoće populacije, genetske strukture populacije i potencijalnog protoka gena unutar i između mikropopulacija učkarskog zvončića, teško je točnije pretpostaviti stupanj njegove ugroženosti. Međutim, uništavanje primarnih staništa ovog stenoendema izrazito točkastog (diskontinuiranog) areala, može predstavljati stvarnu prijetnju njegovu dugoročnom opstanku, te je stoga vrlo važno strogo čuvati sva ustanovljena i potencijalna staništa ove vrste.

Ključne riječi: *Campanula tommasinana*, Campanulaceae, endemi, areal, Dinaridi, Učka

INTRODUCTION

Discovery and systematics of *Campanula tommasiniana*

It was the unorthodox combination of Hungarian botanist and chemist Pál Kitaibel (1757–1817) and Austrian soldier, explorer and naturalist Franz de Paula Adam Norbert

Wenzel Ludwig Valentin von Waldstein (1759–1823), connected through their passion for botany, that made them one of the most famous pairs of explorers in botanical history. In an expedition heading towards the Velebit Mountains in the Dinaric Alps that started on May the 3rd 1802 in Pest (nowadays Budapest, Hungary) and lasted for almost four months, they gathered an incredible amount of data on the natural history of the area. The excursion resulted in a valuable collection of herbarized plants kept at the Hungarian National Museum in Budapest (BP) and a monumental three volume work entitled *Descriptiones et icones plantarum rariorum Hungariae* (Waldstein & Kitaibel, 1802; 1805; 1812), with descriptions and colour pictures of plants, many of them made on the spot by an accompanying painter (Schütz). On July 14th they climbed the Samar group of peaks in Velebit Mountains and, in addition to records of many plant taxa, Kitaibel wrote in his diary (see Degen, 1936): »… *Campanula rotundifolia, thyrsoidea, glomerata* und *flexuosa*, eine neue Art der *rotundifolia* ähnlich caulibus multifloris, flexuosis, foliis lanceolatis, serratis; …«. The plant was described and pictured in the second volume of their *Descriptiones* (Waldstein & Kitaibel, 1805, p. 145, Tab. 136) as *Campanula flexuosa* Waldst. et Kit. Unfortunately, the name had already been in use for two years for another bellflower from the North American flora (Michaux, 1803), *C. flexuosa* Michaux. Hence, 14 years latter, Roemer & Schultes (1819) proposed a valid name: *C. waldsteiniana* R. et S. It is a typical chasmophyte restricted to the altimontane to subalpine belt of the northwestern Dinaric Alps: Mt Snežnik in Slovenia (Kovačić & Surina, 2006), the Velebit and Plješivica mountain ranges in Croatia (Janchen, 1908; Rossi, 1930; Degen, 1938; Dambolt, 1965; Kovačić, 2004) and Mts Ilica and Osječenica (Handel-Mazzetti, 1905), as well as the upper part of the Una river canyon (Handel-Mazzetti, 1905) above the monastery of Rmanj (A. Ž. Lovrić, personal communication) in western Bosnia and Herzegovina.

After some time, morphologically similar exemplars with rhomboid to ovate and dentate upper cauline leaves, which in shape were similar to the lower ones, and with, in contrast to specimens of *C. waldsteiniana* narrowly tubular corolla tubes, were found on Mt Učka above the Kvarner bay in the northern Adriatic region. Despite an extensive study of literature data and relevant sources the first to record the specimens on Mt Učka remains unknown. Quite possibly (although it is not easy to prove) the discoverer could be Giacomo Filippo Tomasini (1595-1655), a bishop from Novigrad in Istria, after whose notes Prospero Petroni (1608-1688) in 1681 (manuscript) described in detail the cultural and natural heritage of Mt Učka and the surroundings (Borri, 1968, see also Bertoša, 2010). Petroni quoted more than 150 plant taxa which made the mountain famous. Among them, a *Campanula* is mentioned without additional information. However, since at least nine species of the genus *Campanula* have been recorded by botanists for the mountain till now, it is not possible to know specifically which taxon Petroni had in mind.

At first, Liburnian specimens were treated as a variety of *C. waldsteiniana* – var. *tubulosa* (Candolle, 1830), while Reichenbach (1860), based on herbarium material collected by Freyer (in 1845) and Tommasini (in 1853, 1858), named the specimens *C. waldsteiniana* var. *freyeri*. It was Koch who in specimens from Mt. Učka recognized a distinct taxon at the species rank (*C. tommasiniana* Koch) and shared his finding with Tommasini in a correspondence letter, published afterwards by Schultz in his *Archives* (Schultz, 1852). Nevertheless, in his exsiccates Schultz persisted with ranking those samples as *C. waldsteiniana* thus neglecting Koch's proposal. This misled Reuter (1865) who quite understandably missed Koch's correspondence with Tommasini and raised this variety of *C. waldsteiniana* to a new species (see Dambolt, 1965). It was just a remarkable coincidence that he proposed the same species' epithet as Koch did: *C. tommasiniana*! Still, Nyman

(1878-1882) treated the Liburnian specimens as a subspecies of *C. waldsteiniana*, Arcangeli (1882) as a variety of the same species, while Tanfani (1888), Pospichal (1899) and Šugar (1971) simply called it *C. waldsteiniana*. Nowadays, based on plenty of evidence, there is a generally accepted consensus among botanists (e.g., Fedorov, 1976; Pignatti, 1982; Domac, 2002), who rank the Liburnian specimens as a distinct species.

Campanula tommasiniana Koch is a perennial polycarpic plant with short rhizome, simple and numerous stems 50-300 mm in length. Basal leaves are small (up to 15 mm), orbicular-ovate, petiolate and wither with anthesis. Cauline leaves are petiolate, elliptical to rhomboid to ovate, dentate, the upper sessile, small and lanceolate, in shape similar to the lower ones. Calyx teeth are linear, but patent to deflexed at anthesis, up to 3 mm in length (about ¼ as long as the tube). Corolla is round 20 mm in length and 10 mm in width with up to 5 mm long corolla lobes (Kovačić & Nikolić, 2006). Flowers are arranged in few to many-flowered inflorescence. Capsule is erect, turbinate and opens by two pores (Dambolt, 1965; Fedorov, 1976).

Based on evidence from morphology (Dambolt, 1965), cytology (Marchal, 1920; Merxmüller & Dambolt, 1962; Gadella, 1964; Podlech & Dambolt, 1964), hybridization experiments in cultivation (Crook, 1951; Dambolt, 1965; Lewis & Lynch, 1998) and molecules (Park *et al*., 2006; Liber *et al*., 2008), *C. tommasiniana* is closely related to the allopatric *C. waldsteiniana* R. & S. (for data on the distribution range see Kovačić & Surina, 2006), despite the striking difference in corolla shape: tubular (*C. tommasiniana*) vs. rotate (*C. waldsteiniana*). The results of molecular phylogenetic analyses (Park *et al*., 2006; Liber *et al*., 2008), supported by the ability to hybridize, suggest that *C. tommasiniana* and *C. waldsteiniana* represent a sister group to the *C. pyramidalis* aggregate, which is, judging from morphology and physiognomy of *C. pyramidalis* only, even more surprising. Nevertheless, together they form an »isophylloid« group of taxa comprised of the pyramidalis group (*C. pyramidalis, C. versicolor* and *C. secundiflora*) and the waldsteiniana group (*C. tommasiniana* and *C. waldsteiniana*).

Literature data on distribution range and habitat preferences of *Campanula tommasiniana*

According to Horvatić (1963), *C. tommasiniana* is a chasmophyte growing in calcareous rock crevices within thermophytic beech forests of the association *Seslerio autumnalis-Fagetum* (Horvat 1938) M. Wraber ex Borhidi 1963, building an association *Campanuletum tommasinianae-justinianae* Horvatić 1960 *nom. nud.* Despite the relative abundance of literature data on species distribution (e.g., Reuter, 1865; Skofitz, 1866; Neilreich, 1868, 1869; Freyn, 1879; Hooker, 1881; Beck, 1894; Pospichal, 1899; Schiffner, 1905; Rossi, 1930; Horvatić, 1960, 1963; Dambolt, 1965; Šugar, 1971), there are few more or less detailed distribution data. For example, Pospichal (1899) quoted »*In Felsspalten auf dem M. Maggiore im letzten Drittel des Aufstieges von Vela Učka, wo Buchenwald aufhört. (Auch unten bei Lovrana im Strandkies). – August*«, while Freyn (1879) gave the following localities: »*Felsen am Fuss des kleinen Gipfels gegen Mala Utzka und auf Mauern und Felsen in letzterem Orte zahlreich. Auch auf buschigen Felsen im obern Theil der Draga di Moschienizze*«. While reviewing plant material from European herbaria (acronyms according to Index herbariorum, available at http://sciweb.nybg.org/science2/IndexHerbariorum.asp), Dambolt (1965) quoted the following localities: Mala Učka – Baenitz (GOET), Mt. Maggiore – Tommasini (FR, GOET, W), Sintenis (FR, IBF), Baenitz (GOET), Freyn (FR), Spencer (M); dto. supra pag. Lovrana lit. austr. – Borbas (FR), Baenitz (M); Osthang der Učka, 3 km südlich Lovran, Felsen am Bach – Merxmüller & Podlech (M).

Since it is such a prominent local endemic, the data on the chorology and habitat preferences of *Campanula tommasiniana* are surprisingly scarce. Therefore the present study aims (1) to determine the area of distribution of the narrow endemic *Campanula tommasiniana* precisely, and (2) to get insights into its habitat preferences in order to propose preliminary long-term effective *in situ* measures for species conservation.

MATERIAL AND METHODS

In summer and autumn 2011, several field trips were performed across the whole mountain range with special emphasis on the distribution data provided in older literature. Detailed floristic surveys of stands with *Campanula tommasiniana* with accompanying data records on site ecology, elevation and geographical position were made with the results reported elsewhere (Surina & Martinčič, in review). General conditions and number of specimens and habitats were estimated on the spot and notes were taken on causes for possible reduction in number of specimens or habitat threats. Specimens were counted directly on several sampling plots and a total number of plants per polygon/microsite was estimated according to habitat number and area. Habitat types of growth sites were defined according to National Habitat Classification Codes (Narodne Novine, 2009). A map was produced by plotting locality data and distribution range using ArcView 3.2. (ESRI, 2009). Digital distribution data, including shape files, were delivered to the authorities of the Učka Nature Park and the State Institute for Nature Protection. Nomenclature of the forest syntaxa follows Poldini (2008) and Vukelić *et al.* (2008), while nomenclature and taxonomic source for the phanerogams is Flora Europaea (Tutin *et al.*, 2001). Names of mosses are according to Sabovljević (2006).

RESULTS AND DISCUSSION

Campanula tommasiniana is a narrow endemic chasmophyte of Mt Učka occupying 6-7 km^2 between 50-1396 m a.s.l. (Fig. 1, Tab. 1). Within its distribution range, there are 5 more or less homogenously inhabited micro-sites. The majority of the population occupies rock crevices of boulders, cliffs and rocky outcrops above 900 m a.s.l., within the zonal thermophytic beech stands of the association *Seslerio autumnalis-Fagetum* and altimontane beech stands of the association *Ranunculo platanifolii-Fagetum*. On eastern slopes, along the valleys Mošćenička draga and Lovranska draga, specimens may descend nearly to the sea (see Pospichal, 1899), although the lowest elevation of recorded specimens was 50 m a.s.l. in a torrent channel of Medvejski potok at the lower part of the Lovranska draga valley. On the western slopes, specimens only rarely descend below 1000 m a.s.l. (e.g., rock crevices in Mala Učka settlement). According to some literature sources (e.g., Reuter, 1865; Skofitz, 1866; Neilreich, 1869; Hooker, 1881; Rossi, 1930; Horvatić, 1963), *C. tommasiniana* was recorded on Mt Planik, a disjunct locality approximately 8 km north of the summit of Mt Učka. However, in our study we were not able to confirm those records. The specimens were not observed in Vranska draga valley either, despite there being plenty of suitable habitats.

Campanula tommasiniana inhabits rock crevices of primary (habitat types B.1.3.2. in the (alti)montane, and B.1.4.1. in the lower vegetation belt) and secondary origin (habitat types B.4.1, J.1.1.2.3, J.1.1.2.4, J.3.3.1, A.2.4.2) along a broad elevational range and in various ecological conditions (Surina & Martinčič, in review). Although preferably within beech forests and rocky outcrops of higher elevation (polygons 1 & 2, Tab. 1), specimens thrive well in rock crevices at lower elevations within stands of thermophytic

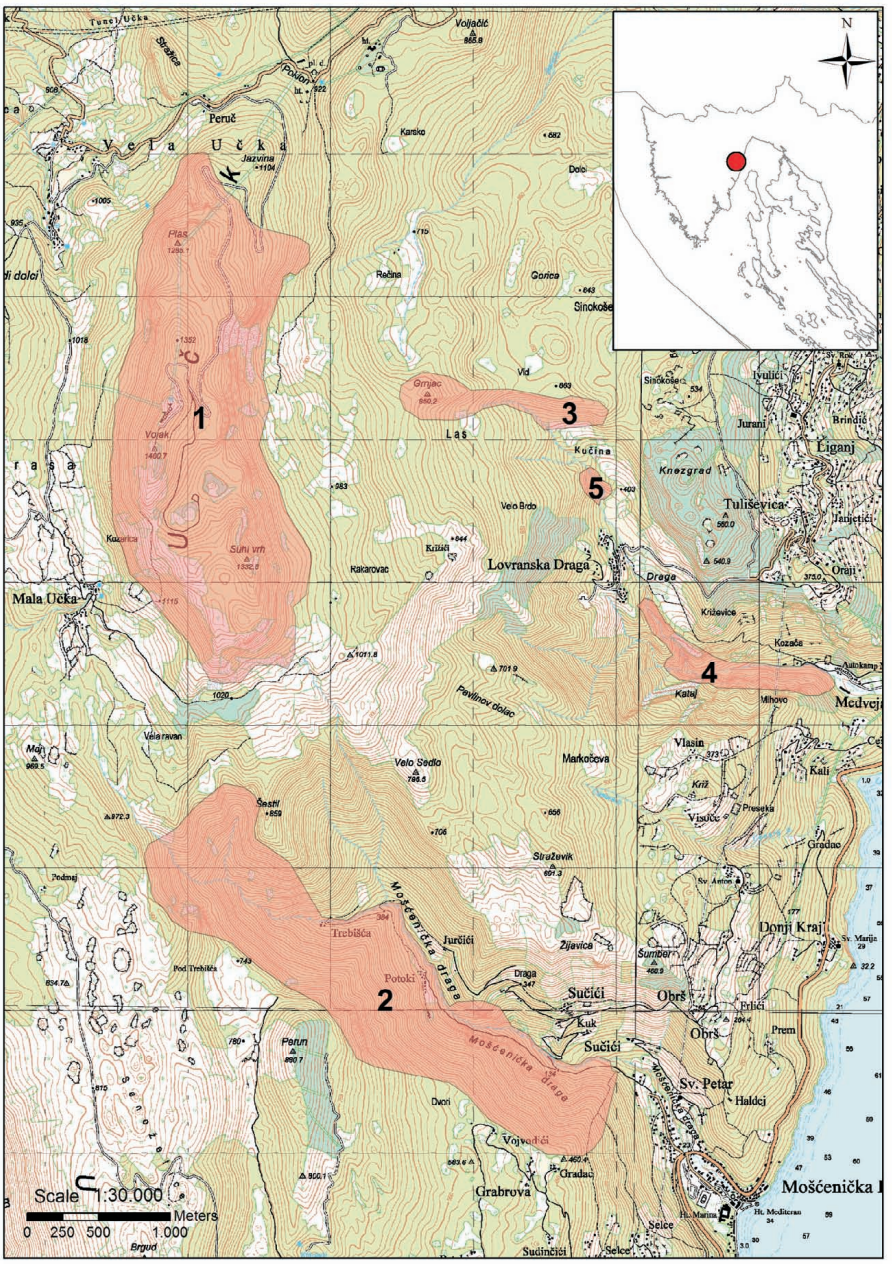

Fig. 1. Distribution area of *Campanula tommasiniana* on Mt Učka (Liburnian karst, northwestern Adriatic; numbers correspond to those in Tab. 1).

deciduous (*Querco-Carpinetum orientalis*, *Aristolochio luteae-Quercetum pubescentis* and its degradation phases, *Seslerio autumnalis-Ostryetum*) and even evergreen forests (*Fraxino orni-Quercetum ilicis*). This suggests that the impact of abiotic factors on the occurrence

Tab. 1. Microsites of *Campanula tommasiniana* on Mt Učka (Liburnian karst, north-western Adriatic) according to area, elevation, estimated number of specimens and prevailing forest types.

	polygon	area (km^2)	elevational range (m)	habitat type	estimated no. of specimens	forest type
1	Učka	3.5	900-1396	B.1.3.2 B.4.1	< 6000	*Ranunculo platanifolii-Fagetum* *Seslerio autumnalis-Fagetum*
2	Sredić	2.64	100-1000	B.1.3.2 J.1.1.2.3 J.1.1.2.4 J.3.3.1	< 5000	*Seslerio autumnalis-Ostryetum* *Aristolochio luteae-Quercetum pubescentis*
3	Grnjač	0.295	600-850	B.1.3.2	100-200	*Aristolochio luteae-Quercetum pubescentis*
4	Lovranska draga	0.27	50-300	B.1.4.1 A.2.4.2	50-100	*Aristolochio luteae-Quercetum pubescentis* *Querco-Carpinetum orientalis*
5	Slap	0.034	400-450	B.1.4.1 A.2.4.2 J.3.3.1	50-100	*Fraxino orni-Quercetum ilicis* *Aristolochio luteae-Quercetum pubescentis*
	total	6.739			~ 10.000 spec.	

and survival of *C. tommasiniana* prevails over biological competition, a feature shared with the majority of petrophytic and range-restricted plant taxa in the Mediterranean (e.g., Lavergne *et al*., 2004; Thompson, 2005; Surina & Martinčič, 2012). Specimens of *C. tommasiniana* were frequently recorded in various secondary habitats, e.g. rocky flanks of road cuts (B.4.1), in wall cracks of ruins (J.1.1.2.4) and abandoned houses (J.1.1.2.3) of small settlements, channel banks of torrents consolidated with blocks of stone (A.2.4.2) and rocky walls (J.3.3.1). According to literature data (compare Pospichal, 1899) but unconfirmed by our study, specimens were recorded even on the coast (F.3.2), »…unten bei Lovrana im Strandkies« (Pospichal's locality most probably refers to Medveja).

In only two out of 127 relevés made by Surina and Martinčič (in preparation) the species occurred in an atypical habitat. On the southern slopes above Mala Učka settlement, in the vicinity of the **Sedlo (Saddle) between peaks of Suhi vrh and Vojak towards Argun** (45°16'38.9''N 14°12'10.8''E), specimens of *C. tommasiniana* occurred on a scree (habitat type B.2.2.1 – Illyrian-Adriatic littoral screes) dominated by *Rosa pimpinellifolia*. A relevé reflecting the floristic composition and structure of stands, where coverage and abundance of species were estimated by means of a Domin scale (sensu Dahl & Hadač, 1941), is given here; elev.: 1128 m, exp.: WSW, incl. 25°, coverage: rocks – 50%, herb layer (C) – 50%, moss layer (D) – 1%; rel. area: 25 m^2, date: 17.8.2011, leg. B. Surina: C – *Rosa pimpinellifolia* 7, *Galium lucidum* 5, *Cerastium strictum* subsp. *arvense* 4, *Rubus* sp. 3, *Campanula marchesettii* 3, *Gymnocarpium robertianum* 3, *Dianthus monspessulanus* 2, *Euphorbia cyparissias* 2, *Senecio abrotanifolius* 2, *Campanula tommasiniana* 1, *Festuca* sp. +, *Globularia cordifolia* +, *Ligusticum lucidum* subsp. *seguieri* +, *Teucrium chamaedrys* 2; D – *Schistidium* sp. 2, *Tortella tortuosa* var. *fragilifolia* 2.

On **the summit of Mt. Argun** (45^{0}16'24.3''N 14^{0}12'31.8''E), *C. tommasiniana* was recorded in another atypical habitat, rocky grassland with *Sesleria juncifolia* (habitat type C.3.5.2 – Illyrian-Dinaric steppic pastures on shallow calcareous soils) completely dominating the stand: alt. 1258 m, exp.: NW, incl. 15^0, coverage: rocks – 20%, herb layer (C) – 80%; rel. area: 20 m^2, date: 17.8.2011, leg. B. Surina: C – *Sesleria tenuifolia* 9, *Satureja subspicata* subsp. *liburnica* 4, *Juniperus communis* 3, *Campanula tommasiniana* 2, *C. marchesettii* 2, *Globularia cordifolia* 2, *Potentilla australis* 2, *Lotus corniculatus* 1, *Rosa pimpinellifolia* 1, *Senecio abrotanifolius* 1, *Gentiana lutea* subsp. *symphyandra* +.

Within the distribution range of the species (Fig. 1), five more or less homogenously and densely inhabited areas could be distinguished and intercepted by the lack of suitable habitat for colonization, suggesting limited gene flow and possible establishment of metapopulations (e.g., Levins, 1970). In petrophytic vegetation, micro-habitats such as rock crevices are colonized by species rare or absent in surrounding vegetation. In order to test this assumption and to get insights into population structure and genetic diversity of the species, samples were taken from several populations over the species distribution range and analyses are on the way. In either case, *C. tommasiniana* on Mt. Učka has a patchy distribution due to the spatial heterogeneity in the habitat.

Although it is certain that rock crevices represent the primary or almost exclusive habitat type of *Campanula tommasiniana*, it is less clear whether or not the species prefers open habitats, e.g. rocky outcrops and cliffs fully exposed to sun and strong winds, or rocks and boulders within forest stands shaded intensively by the tree canopies. Specimens from the exposed sites, having shorter stems and thus compact but smaller leaves, differ markedly from specimens thriving within forest stands and shady but sheltered sites. In order to resolve the impact of abiotic and biotic factors on plant physiognomy and population genetic structure, extensive research on reproductive biology, pollination ecology and plant fitness in general is required. Nevertheless, based on our field observation, as yet unsupported scientifically, it seems that the primary habitats of the species are open and exposed sites.

Campanula tommasiniana, despite being a typical chasmophyte, demonstrated a rather high degree of ecological plasticity at least with regards to various abiotic factors. Hence its extremely narrow distribution range is even more puzzling. Similarly, *Hladnikia pastinacifolia* (Apiaceae), a monotypic species and a narrow endemic of the Trnovski gozd plateau in the north-western Dinaric Alps (Mayer, 1960) with an even narrower distribution area (4 km^2), colonizes an even broader range of habitats – stony grasslands, rock crevices and screes (Šajna *et al*., 2012). Nevertheless, *H. pastinacifolia* has remained confined to an extremely narrow distribution area, despite many available habitats in the vicinity and without reasonable explanation.

Due to the lack of the data on species biology, genetic population structure and potential gene flow among specimens experiencing different ecological conditions and among specimens from different areas within the species distribution range, it is hard to assume the extent of particular threats to the species. However, destruction of already occupied and potential habitats may represent a real threat for long-term survival of this narrow endemic with a pronouncedly patchy distribution. Hence, every established and potential growth site, especially rocky outcrops and cliffs, should be strictly preserved.

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SAŽETAK

Otkriće, aktualizirano područje rasprostranjenosti i izbor staništa učkarskog zvončića (*Campanula tommasiniana*), stenoendema Učke (Liburnijski krš, SZ Jadran)

B. Surina

Učkarski zvončić (*Campanula tommasiniana*) je stenoendem planine Učke, hazmofit rasprostranjen na površini od 6 do 7 km^2 u pojasu između 50 i 1396 m n.m. Unutar areala ove vrste uočeno je pet uglavnom homogeno nastanjenih mikrolokaliteta. Najveći dio populacije uspijeva u pukotinama stijena i litica iznad 900 m n.m., unutar sastojina klimazonalnih zajednica termofilne (*Seslerio autumnalis-Fagetum*) te altimontanske šume bukve (*Ranunculo platanifolii-Fagetum*). Na istočnim padinama Učke, u Mošćeničkoj i Lovranskoj dragi, primjerci učkarskog zvončića mogu se naći i gotovo na samoj obali mora, dok se na zapadnim padinama planine ova vrsta rijetko spušta ispod 1000 m n.m.

Učkarski zvončić uspijeva u pukotinama primarnih i sekundarnih stijena relativno širokog visinskog raspona, u različitim ekološkim uvjetima te ima diskontinuirani areal zbog fragmentiranosti odgovarajućih staništa. Iako je sigurno da pukotine stijena predstavljaju primarni i gotovo jedini stanišni tip ove vrste, nije sasvim jasno preferira li otvorena staništa, odnosno stijene i litice u potpunosti izložene sunčevoj svjetlosti i snažnim vjetrovima, ili stijene unutar šumskih sastojina, zasjenjene i od vjetrova zaštićene krošnjama drveća. Temeljeno na našim terenskim zapažanjima, i iako još uvijek bez znanstvenih dokaza, čini se da su primarni habitatni tipovi ove vrste upravo pukotine stijena izložene suncu i vjetru. Učkarski zvončić, iako tipični hazmofit, pokazuje relativno visoku ekološku plastičnost, barem prema različitim abiotskim čimbenicima, zbog čega je izrazito usko područje rasprostranjenosti te vrste još zagonetnije. Uslijed nedostatnog poznavanja biologije, gustoće i genetske strukture populacije, te potencijalnog protoka gena unutar i između ustanovljenih mikropopulacija učkarskog zvončića, teško je točnije pretpostaviti stupanj njegove ugroženosti. Međutim, uništavanje primarnih staništa ovog stenoendema izrazito točkastog (diskontinuiranog) areala može predstavljati stvarnu prijetnju njegovu dugoročnom opstanku, te je stoga vrlo važno strogo čuvati sva ustanovljena i potencijalna staništa ove vrste.