Contribution to the knowledge of the Adriatic lizard orchid (*Himantoglossum adriaticum*) in the area of the Slavonian highlands

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Abstract

The nearly threatened species Adriatic lizard orchid (*Himantoglossum adriaticum* H. Baumann) was previously known only from a few sites in the Slavonian highlands. This study was conducted to gain a better insight into the current distribution of the species and the status of its populations. Field surveys were mainly carried out from May to July 2020-2024 in known localities and other habitats suitable for the species. Large populations have been discovered at 15 new sites throughout the Slavonian highlands. The plant primarily grows in the areas of Požeška Gora and Psunj in habitats such as grasslands and shrublands. Favorable areas have been significantly reduced due to the abandonment of traditional land management practices and natural succession, while some areas are under strong pressure from invasive species. Even though the populations of *H. adriaticum* in the Slavonian highlands thriving due to favorable conditions in recent years, it is necessary to implement a continuous monitoring program and collect more extensive data to enable effective management of the areas and the preservation of the species.

Keywords: Orchidaceae, monitoring, conservation, flora, dry grassland

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Sažetak

Jadranska kozonoška (*Himantoglossum adriaticum* H. Baumann) gotovo je ugrožena vrsta za koju je do sada bilo poznato samo nekoliko lokaliteta na području slavonskog gorja. Cilj ovog istraživanja bio je dobiti bolji uvid u trenutnu rasprostranjenost vrste i stanje njezinih populacija. Terenska istraživanja provedena su u razdoblju od svibnja do srpnja 2020.-2024. godine na poznatim nalazištima i drugim pogodnim staništima za ovu vrstu. Velike populacije pronađene su na 15 novih lokaliteta diljem slavonskog gorja. Vrsta raste uglavnom na području Požeške gore i Psunja na staništima kao što su travnjaci i šikare. Povoljne površine znatno su smanjene zbog napuštanja tradicionalnog načina gospodarenja i sukcesije, dok su neka staništa izložena snažnom pritisku zbog pojave invazivnih vrsta. Iako se zbog povoljnih godina može smatrati da su populacije vrste na području slavonskog gorja u izuzetno dobrom stanju, potrebno je nastaviti s kontinuiranim monitoringom i prikupiti opsežnije podatke koji bi omogućili kvalitetnije upravljanje značajnim područjima i očuvanje vrste.

Ključne riječi: Orchidaceae, monitoring, zaštita, flora, suhi travnjaci

Introduction

The Adriatic lizard orchid (*Himantoglossum adriaticum* H. Baumann) (Fig. 1) is a long-lived orchid distributed in Italy, Austria, Slovenia, Croatia, Bosnia and Herzegovina, Hungary, the Czech Republic, and Slovakia (Dostalova et al. 2013). The genus *Himantoglossum* includes some of the most conspicuous orchids native to Europe (Bódis et al. 2019). Like most terrestrial orchids, this taxon is a geophyte and possesses two large ovoid tubers, from which lanceolate, pale green basal leaves emerge in autumn, forming a rosette. In spring, an upright and robust stem develops. The stem height ranges from 30 (14-40) to 100 (80-120) cm, making it the largest European orchid (Bódis et al. 2019). This species typically blooms from mid-May to mid-June. A loose inflorescence, measuring between 15 and 45 cm long, can produce up to 40 flowers (Delforge 2006) with a faint, sweetish, aromatic scent (Vöth 1999). The large and showy flowers are distinguished by a greatly elongated 3-lobed labellum adorned with purple papillae (Bateman et al. 2013; Bódis et al. 2019). After flowering, the stems and leaves wither and completely vanish during the summer months.

Figure 1. Habitus of Adriatic lizard orchid (*Himantoglossum adriaticum*) higher than 120 cm observed in Sokolovac (A) and conspicuous flowers (B) (Foto: M. Doboš).
Slika 1. Habitus jadranske kozonoške (*Himantoglossum adriaticum*) viši od 120 cm uočen na Sokolovcu (A) i upadljivi cvjetovi (B) (Foto: M. Doboš).

The *H. adriaticum* populations in Croatia are categorized into coastal and continental (Čičmir et al. 2014). Most of the continental populations are found around the hilly regions of north-western Croatia, while smaller populations exist in the area of Karlovac, Kordun, Mt. Kalnik, Samoborsko gorje and to the east, in the area of the Slavonian highlands (Nikolić et al. 2024). *H. adriaticum* is a species that thrives in light or semi-shaded habitats (Rybka et al. 2005; Delforge 2006) and in Croatia, it typically occupies dry, predominantly calcareous, sunny to mid-shade environments such as abandoned grasslands, scrublands on south and west-facing slopes, and forests with open canopies and forest edges (Čičmir et al. 2014). These habitats are often linked to the dry continental grasslands of the *Festuco-Brometea* class (NATURA 2000 code 6210, EUNIS code EI.26, NKS C.3.3.1.). However, unlike most orchids that favor open meadows, *H. adriaticum* prefers dry continental grasslands of the *Festuco-Brometea* class and meadows in the early stages of succession. The abandonment of traditional management practices has led to the neglect of many favorable grasslands, which are now affected by varying degrees of succession (Šincek et al. 2012). The discontinuance of mowing allows the development of fruits i.e. reproduction through seeds. However, due to the insufficient competitiveness of orchids, further overgrowth can result in habitat loss and the decline of their populations.

Due to the decline in suitable habitats, *H. adriaticum* is classified as Near Threatened (NT) in Croatia. Furthermore, it has been designated as a NATURA 2000 species, and systematic research has been conducted to identify areas for its protection and monitoring. In the Slavonian highlands, four NATURA 2000 sites, HR2001511 Suhe livade kod Sinlija, HR2001389 Banićevac, HR2001393 Nurkovac and HR2000580 Papuk, have been declared, with *H. adriaticum* being a target species (Institute for Environment and Nature of the Ministry of of Environmental Protection and Green Transition, 2024), although the number of localities where the species was found is significantly greater (Tab. 1).

The limited information on presence data (Whittaker et al. 2005), along with gaps in knowledge regarding local population trends, threats, and responses to changes in land use (Sala et al. 2000) and climate change (IPCC 2007), poses significant challenges to establishing conservation priorities and strategies. This is also true for *H. adriaticum*, whose distribution in Croatia was thought to be well-documented (Šincek et al. 2012). However, fieldwork in new areas over the recent years has revealed many previously unknown populations. Understanding these populations and their conservation is crucial for maintaining the integrity of the species' distribution area and ensuring its protection. This paper presents an overview of *H. adriaticum* occurence in the Slavonian highlands, updated with most recent findings.

Material and methods

Field surveys were conducted in the period from May to July 2020-2024. Fieldwork was planned according to habitat maps, geological maps and satellite images, as well as the known distribution, as registered in the Flora Croatica Database (Nikolić et al. 2024). The spatial processing and visualisation of the data were performed in the program QGIS. All new records were documented with photographs and georeferenced using a public database iNaturalist (www.inaturalist.org).

Results and discussion

Our research provides the first comprehensive overview of the distribution of *H. adriaticum* in the Slavonian highlands. However, it is important to emphasize that despite the extremely favorable conditions for this species, there may be other in sites we did not visit or in which individuals were dormant.

During our research, we observed more than 500 *H. adriaticum* individuals at 23 sites throughout the research area. Most of these sites are in dry limestone grasslands and shrublands that originate from overgrown grasslands, mown roadside verges, or abandoned vineyards and orchards (Tab. 2).

Table 1. Overview of literature references to the Adriatic lizard orchid (*Himantoglossum adriaticum*) in the area of Slavonian highlands.
Tablica 1. Pregled literaturnih navoda opažanja jadranske kozonoške (*Himantoglossum adriaticum*) na području slavonskog gorja.

Location	X	Y	Precision (m)	Year	Reference
Banićevac	45,3410	17,4602	3	2011	Borovečki-Voska 2011
Banićevac	45,3400	17,4578	3	2011	Borovečki-Voska 2012
Banićevac	45,33991	17,45782		2012	Šincek et al. 2012
Banićevac	45,34096	17,46023		2012	Šincek et al. 2012
Banićevac	45,33991	17,4578		2014	Čičmir et al. 2014
Banićevac	45,34096	17,46019		2014	Čičmir et al. 2014
Banićevac	45,337702	17,462551	1 500	2018	Samardžić & Galić 2018
Gornji Vrhovci	45,4701	17,5590	250	2006	Tomašević 2006
Gornji Vrhovci	45,473012	17,56734	1 100	2006	Tomašević et al. 2006
Gornji Vrhovci	45,473012	17,56734	1 100	2006	Tomašević 2016
Gornji Vrhovci	45,473012	17,56734	1 100	2007	Topić & Ilijanić 2007
Gornji Vrhovci	45,473012	17,56734	1 100	2016	Tomašević 2016
Gornji Vrhovci	45,473012	17,56734	1 100	2018	Samardžić & Galić 2018
Gornji Vrhovci	45,47064222	17,55873967	3	2020	Doboš & Jušić 2022
Gornji Vrhovci	45,470642 45,474574	17,55874 17,561758	3	2022	Doboš & Jušić 2022
Gornji Vrhovci	45,4746703941 45,4716588686 45,4718667111 45,4720896002 45,4739655484 45,4737523061 45,4736016019 45,4746908481 45,4724624907 45,4725934485	17,5616884232 17,5590625405 17,5592905283 17,5593941286 17,5591369718 17,5590219721 17,5598554686 17,5614852458 17,5590159371 17,5589706749	3	2023	Doboš & Kovačević 2023

Location	X	Y	Precision (m)	Year	Reference
Gornji Vrhovci	45,473012	17,56734	1 100	2015, 2016, 2017, 2018, 2020, 2021, 2022	Samarđić & Galić 2022
Kutjevo	45,422874	17,881257	2 500	1869	Schlosser & Vukotinović 1869
Kutjevo	45,422874	17,881257	2 500	2005	Kranjčev 2005
Nurkovac	45,32449	17,6104	750	2006	Tomašević 2007
Nurkovac	45,32449	17,6104	750	2006	Tomašević 2016
Nurkovac	45,3169	17,6102	3	2011	Borovečki-Voska 2011
Nurkovac	45,31688	17,61027		2012	Šincek et al. 2012
Nurkovac	45,31686	17,61025		2014	Čičmir et al. 2014
Nurkovac	45,32449	17,6104	750	2018	Samarđić & Galić 2018
Požega	45,33313	17,677019	5 000	2005	Kranjčev 2005
Požega	45,32252	17,66603		2012	Šincek et al. 2012
Požega - Sokolovac	45,32979	17,674	650	2006	Tomašević 2016
Požega - Sokolovac	45,32979	17,674	650	2006	Tomašević 2006
Požega-Sokolovac	45,3224	17,6660	3	2011	Borovečki-Voska 2011
Požega - Sokolovac	45,32979	17,674	650	2018	Samarđić & Galić 2018
Požeška valley	45,375198	17,804069	23 000	2005	Kranjčev 2005
Požeška valley and surrounding mountains	45,37581	17,73733	45 000	1977	Ilijanić 1977
Požeška valley and surrounding mountains	45,37581	17,73733	45 000	2005	Zima et al. 2005

Location	X	Y	Precision (m)	Year	Reference
Požeška valley and surrounding mountains	45,37581	17,73733	45 000	2006	Zima et al. 2006
Papuk Nature Park	45,509016	17,671528	18 500	2002	Pandža et al. 2002
Papuk Nature Park	45,509016	17,671528	18 500	2005	Samardžić 2005
Papuk Nature Park	45,509016	17,671528	18 500	2010	Pandža 2010
Rudina	45,389501	17,455144	500	2018	Samardžić & Galić 2018
Sinlije	45,35125	17,45391	1 100	2018	Samardžić & Galić 2018
Southern slopes of Papuk Mt.	45,458025	17,589903	30 000	2016	Krstonošić et al. 2016
Stara Kapela	45,2371	17,7013	3	2020	Prlić 2020

The first known records of *H. adriaticum* in this area were made by Schlosser and Vukotinović, as '*H. hircinum* Spr.', in their renowned monograph of 1869. They noted it in the vicinity of Kutjevo, where it was never recorded again (Schlosser and Vukotinović 1869). It was also mentioned by Ilijanić (1977), as '*H. hircinum* (L.) Koch', but this taxon was later excluded from our national flora and all the records are reassigned as *H. adriaticum* (Čičmir et al. 2014). In the early 2000s, this species attracted botanical attention once more, and new locations were reported in the research area (Pandža et al. 2002, Samardžić 2005, Kranjčev 2005, Zima et al. 2005, Zima et al. 2006, Pandža 2010), with more precise records provided by numerous authors (Tomašević 2006, Tomašević et al. 2006, Čičmir et al. 2014, Tomašević 2016, Krstonošić et al. 2016, Samardžić and Galić 2018, 2022, Doboš and Jušić 2022, Doboš and Kovačević 2023, Kovačević et al. 2023). Several field observations can be found in the Flora Croatica Database (Nikolić et al. 2024), while today, the largest number of findings can be found in the public database iNaturalist (www.inaturalist.org). Overall previous records from the literature, observations in Flora Croatica Database and iNaturalist that are more precise mention eight localities in total: Kutjevo (Schlosser and Vukotinović 1869, Kranjčev 2005), Banićevac (Šincek et al. 2012, Čičmir et al. 2014), Gornji Vrhovci (Tomašević et al. 2006, Topić & Ilijanić 2007, Tomašević 2016, Samardžić & Galić 2018, Doboš & Jušić 2022, Samardžić & Galić 2022, Doboš & Kovačević 2023), Nurkovac (Tomašević 2007, Šincek et al. 2012, Čičmir et al. 2014, Tomašević 2016, Samardžić & Galić 2018), Požega-Sokolovac (Kranjčev 2005, Tomašević 2006, Šincek et al. 2012, Tomašević 2016, Samardžić & Galić 2018), Rudina, Sinlije (Samardžić & Galić 2018) and Stara Kapela (Prlić 2020) (Tab. 1).

During the period from 2020 to 2024, *H. adriaticum* was confirmed in most of the previously recorded sites, but it was also found in new localities, thereby increasing the total number of known localities from fewer than 10 to 23 (Fig. 2). New locations include areas around Škrabutnik, Srednji Lipovac, Busnovi, Ivandol, Oblakovac, Opatovac (Požeška gora) and Vranić (between Papuk and Psunj), Mačkovac, Cikote, Šnjegavić, Podvrško, Skenderovci (Psunj Mt.) and Glogovica (Dilj gora) (Tab. 2).

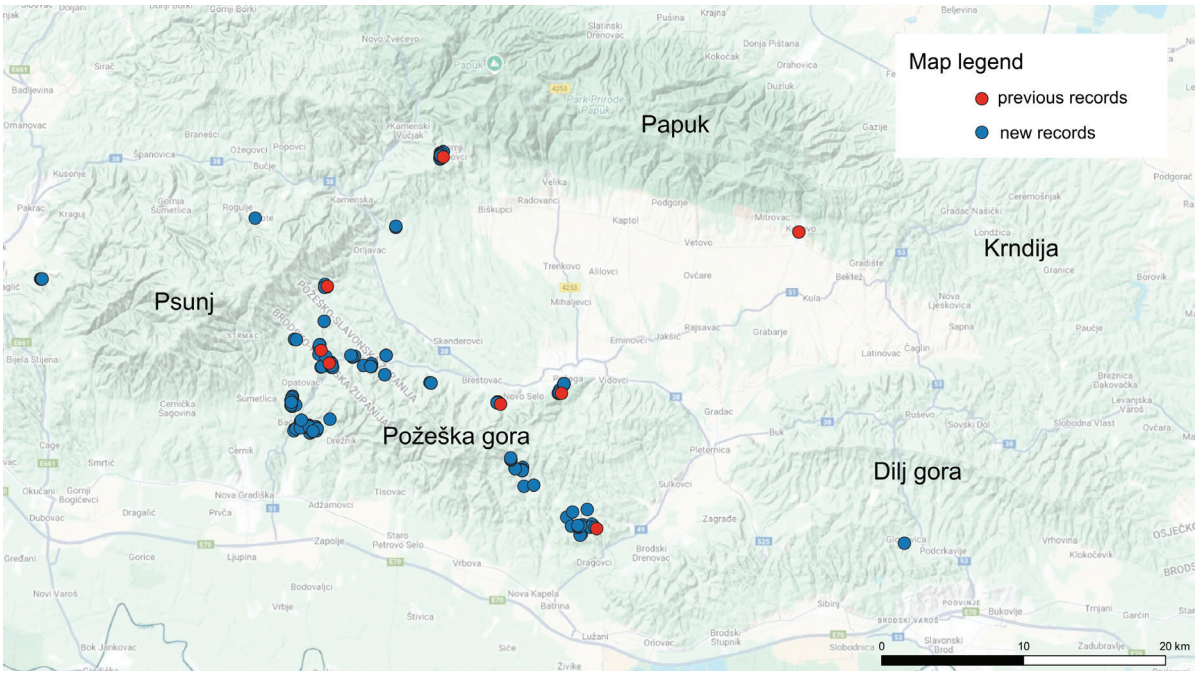

Figure 2. Distribution of Adriatic lizard orchid (*Himantoglossum adriaticum*) in the area of the Slavonian highlands.
Slika 2. Rasprostranjenost jadranske kozonoške (*Himantoglossum adriaticum*) na području slavonskog gorja.

Table 2. Observations of the Adriatic lizard orchid (*Himantoglossum adriaticum*) recorded during this study.
Tablica 2. Opažanja jadranske kozonoške (*Himantoglossum adriaticum*) zabilježena tijekom ovog istraživanja.

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Baćin Dol	45,304197	17,433354	202	meadow	06.06.2023	Karlo Mikić	166736490
Baćin Dol	45,305034	17,434257	204	overgrown orchard	06.06.2023	Karlo Mikić	179690111
Baćin Dol	45,304481	17,433272	201	overgrown meadow	06.06.2023	Karlo Mikić	179693214
Baćin Dol	45,30216	17,43956	273	overgrown meadow	11.06.2023	Karlo Mikić	166822935
Baćin Dol	45,302345	17,440814	277	overgrown meadow	11.06.2023	Karlo Mikić	166823041
Baćin Dol	45,302225	17,440746	276	overgrown meadow	11.06.2023	Karlo Mikić	166823191

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Baćin Dol	45,302222	17,43958	276	overgrown meadow	11.06.2023	Karlo Mikić	179684230
Baćin Dol	45,299816	17,428035	264	roadside verge	07.06.2023	Karlo Mikić	166327078
Baćin Dol	45,298746	17,427409	162	roadside verge	07.06.2023	Karlo Mikić	166737499
Baćin Dol	45,299938	17,429293	171	overgrown orchard	29.05.2023	Karlo Mikić	180800864
Baćin Dol	45,356504	17,427889	274	overgrown orchard	23.05.2023	Karlo Mikić	180435457
Baćin Dol	45,29869847	17,44449701	277	the edge of the forest road	29.04.2024	Karlo Mikić	211734213
Baćin Dol	45,30123902	17,44072901	248	overgrown meadow	09.05.2024	Karlo Mikić	214640267
Baćin Dol	45,30445	17,43331363	199	an overgrown vineyard/ orchard	09.05.2024	Karlo Mikić	214675393
Baćin Dol	45,30203056	17,43926587	270	an overgrown vineyard/ orchard	09.05.2024	Karlo Mikić	214676658
Baćin Dol	45,30198262	17,43946502	269	an overgrown vineyard/ orchard	09.05.2024	Karlo Mikić	214676852
Baćin Dol	45,30208735	17,43949008	271	an overgrown vineyard/ orchard	09.05.2024	Karlo Mikić	214677050
Baćin Dol	45,30202709	17,43932848	270	an overgrown vineyard/ orchard	09.05.2024	Karlo Mikić	214677603
Baćin Dol	45,30094234	17,43895121	237	overgrown meadow	09.05.2024	Karlo Mikić	214680874
Baćin Dol	45,30106539	17,43886178	241	overgrown meadow	09.05.2024	Karlo Mikić	214681136
Baćin Dol	45,30123919	17,43890779	248	the edge of the forest road	09.05.2024	Karlo Mikić	214681482
Baćin Dol	45,3011368	17,43896856	244	an overgrown vineyard/ orchard	09.05.2024	Karlo Mikić	214681613
Baćin Dol	45,3013229	17,4471311	286	the edge of the forest road	15.05.2024	Karlo Mikić	215945832
Baćin Dol	45,3012451	17,44653792	284	the edge of the forest road	15.05.2024	Karlo Mikić	215946193

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Baćin Dol	45,30120071	17,44634858	282	an overgrown vineyard/ orchard	15.05.2024	Karlo Mikić	215947335
Baćin Dol	45,30116543	17,44644916	282	an overgrown vineyard/ orchard	15.05.2024	Karlo Mikić	215947701
Baćin Dol	45,29862911	17,44442954	277	the edge of the forest	20.05.2024	Karlo Mikić	217267677
Baćin Dol	45,29871556	17,44441629	278	the edge of the forest road	20.05.2024	Karlo Mikić	217267713
Baćin Dol	45,29837903	17,44414665	276	the edge of the forest road	20.05.2024	Karlo Mikić	217267888
Baćin Dol	45,2976228	17,4419714	258	and edge of the meadow	20.05.2024	Karlo Mikić	217268207
Baćin Dol	45,29722945	17,44188814	253	meadow	20.05.2024	Karlo Mikić	217268473
Baćin Dol	45,29749348	17,44173358	254	meadow	20.05.2024	Karlo Mikić	217269254
Baćin Dol	45,30391079	17,43391301	215	and edge of the meadow	20.05.2024	Karlo Mikić	217326889
Baćin Dol	45,30378435	17,43381612	216	and edge of the meadow	20.05.2024	Karlo Mikić	217327502
Baćin Dol	45,30362715	17,43435659	223	the edge of the forest road	20.05.2024	Karlo Mikić	217327751
Baćin Dol	45,3030195	17,43571496	239	the edge of the forest road	20.05.2024	Karlo Mikić	217327956
Baćin Dol	45,3012526	17,43672833	249	the edge of the forest road	20.05.2024	Karlo Mikić	217328447
Baćin Dol	45,30095684	17,43672213	240	the edge of the forest road	20.05.2024	Karlo Mikić	217329200
Baćin Dol	45,30093853	17,4367953	240	the edge of the forest road	20.05.2024	Karlo Mikić	217329761
Baćin Dol	45,30109431	17,43687342	244	the edge of the forest road	20.05.2024	Karlo Mikić	217329965
Baćin Dol	45,30098735	17,43897208	239	overgrown meadow	20.05.2024	Karlo Mikić	217330278
Baćin Dol	45,30096736	17,43890637	238	overgrown meadow	20.05.2024	Karlo Mikić	217330770
Baćin Dol	45,30094016	17,43880101	237	an overgrown vineyard/ orchard	20.05.2024	Karlo Mikić	217331206

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Baćin Dol	45,30122904	17,43916973	247	an overgrown vineyard/ orchard	20.05.2024	Karlo Mikić	217331625
Baćin Dol	45,30108873	17,43900158	242	overgrown meadow	20.05.2024	Karlo Mikić	217331979
Baćin Dol	45,30465419	17,43345234	198	and edge of the meadow	22.05.2024	Karlo Mikić	217480970
Baćin Dol	45,30543052	17,43422683	191	roadside verge	26.05.2024	Karlo Mikić	218479502
Baćin Dol	45,30481419	17,43366801	198	an overgrown vineyard/ orchard	04.06.2024	Karlo Mikić	220535755
Baćin Dol	45,30055196	17,43322126	193	meadow	05.06.2024	Karlo Mikić	220761592
Baćin Dol	45,30117549	17,44121038	249	an overgrown vineyard/ orchard	05.06.2024	Karlo Mikić	220762626
Baćin Dol	45,3054855	17,4342335	190	the edge of the forest road	07.06.2024	Karlo Mikić	221091047
Baćin Dol	45,29877164	17,44782639	231	forest	15.05.2024	Karlo Mikić	215943070
Baćin Dol	45,3000635	17,4482905	261	forest	15.05.2024	Karlo Mikić	215943516
Baćin Dol	45,3001191	17,4483319	262	forest	15.05.2024	Karlo Mikić	215944465
Baćin Dol	45,3001127	17,4483563	262	forest	15.05.2024	Karlo Mikić	215944951
Baćin Dol	45,29828943	17,44433935	273	the edge of the forest road	20.05.2024	Karlo Mikić	217266631
Baćin Dol	45,29836005	17,44428503	274	the edge of the forest road	20.05.2024	Karlo Mikić	217266828
Baćin Dol	45,29855753	17,44447941	276	the edge of the forest road	20.05.2024	Karlo Mikić	217267268
Baćin Dol	45,30606691	17,45983791	308	meadow	08.06.2024	Karlo Mikić	221380070
Banićevac	45,341457	17,4602171	295	roadside verge	20.05.2022	Marko Doboš	117915190
Banićevac	45,341222	17,460047	296	roadside verge	03.06.2023	Vesna Andrić	165367570
Banićevac	45,341239	17,460089	296	roadside verge	05.06.2023	Iva Galić	
Banićevac	45,341505	17,46005	295	roadside verge	07.06.2023	Marko Doboš	166113849

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Banićevac	45,341175	17,459876	296	roadside verge	07.06.2023	Marko Doboš	166113928
Banićevac	45,340674	17,459278	293	roadside verge	07.06.2023	Marko Doboš	166114081
Banićevac	45,340821	17,459799	293	roadside verge	07.06.2023	Marko Doboš, Marija Kovačević	166107226; 166113595
Banićevac	45,341415	17,459995	295	overgrown meadow, above roadside verge	03.06.2023	Vesna Andrić	165368796
Banićevac	45,340755	17,458167	300	overgrown meadow, above roadside verge	07.06.2023	Marija Kovačević	166107664
Banićevac	45,340732	17,458831	294	overgrown meadow, above roadside verge	07.06.2023	Marko Doboš	166117023
Banićevac	45,338964	17,451786	329	overgrown meadow	05.06.2023	Iva Galić	
Banićevac	45,339267	17,452631	335	overgrown meadow	05.06.2023	Iva Galić	
Banićevac	45,341872	17,460817	293	roadside verge	05.06.2023	Iva Galić	
Banićevac	45,341404	17,460381	296	roadside verge	07.06.2023	Marko Doboš	166113784
Banićevac	45,34191	17,460844	293	roadside verge	07.06.2023	Marko Doboš	166113085
Banićevac	45,34066	17,460036	294	overgrown meadow along the field road	07.06.2023	Marko Doboš	166113691
Banićevac	45,340203	17,460262	288	overgrown meadow along the field road	09.06.2023	Marko Doboš	166455412
Banićevac	45,340947	17,461216	300	overgrown meadow	03.06.2023	Vesna Andrić	165368462
Banićevac	45,340839	17,461173	300	overgrown meadow	03.06.2023	Vesna Andrić	165368483
Banićevac	45,341169	17,461587	302	overgrown meadow	03.06.2023	Vesna Andrić	165368657
Banićevac	45,33865	17,461531	279	overgrown meadow	09.06.2023	Marko Doboš	166455567
Banićevac	45,338818	17,46138	279	overgrown meadow	09.06.2023	Marko Doboš	166455679
Banićevac	45,338626	17,46221	281	overgrown meadow	09.06.2023	Marko Doboš	166455746

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Banićevac	45,338745	17,462261	284	overgrown meadow	09.06.2023	Marko Doboš	166455837
Banićevac	45,339964	17,461268	288	overgrown meadow	09.06.2023	Marko Doboš	166455968
Busnovi	45,3341518	17,509078	286	and edge of the meadow	20.05.2024	Marija Kovačević, Iva Galić	217254747
Busnovi	45,3341496	17,5090419	287	and edge of the meadow	20.05.2024	Marija Kovačević, Iva Galić	
Cikote	45,432912	17,392703	506	schrubland	26.05.2023	Marko Doboš, Ivica Samarđić, Marija Kovačević	163812546; 163833668
Glogovica	45,22776	17,97633	380	meadow	28.05.2023	Vesna Andrić	164307558
Gornji Vrhovci	45,47064222	17,55873967	549	overgrown meadow	13.06.2020	Marko Doboš	49483436
Gornji Vrhovci	45,474574	17,561758	504	roadside verge	07.06.2022	Marko Doboš	120720795
Gornji Vrhovci	45,47467	17,561688	507	overgrown meadow along the field road	05.06.2023	Marko Doboš	165702505
Gornji Vrhovci	45,474691	17,561485	510	overgrown meadow along the field road	16.06.2023	Marko Doboš, Marija Kovačević	167703723; 167745084
Gornji Vrhovci	45,471692	17,559037	556	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167702648; 167744462
Gornji Vrhovci	45,471897	17,559247	554	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167702855; 167744544
Gornji Vrhovci	45,471895	17,559303	552	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167702915; 167744618
Gornji Vrhovci	45,472105	17,559057	553	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167703065; 168467126
Gornji Vrhovci	45,472217	17,558999	552	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167703098; 167744912

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Gornji Vrhovci	45,473983	17,55912	523	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167703222; 167744841
Gornji Vrhovci	45,473522	17,559845	530	meadow, succession occurs in some areas	16.06.2023	Marko Doboš, Marija Kovačević	167703698; 167744999
Gornji Vrhovci	45,472593	17,558971	547	overgrown meadow	16.06.2023	Marko Doboš	168467304
Gornji Vrhovci	45,4703897	17,5587798	576	overgrown meadow	05.06.2024	Marko Doboš	220869142
Gornji Vrhovci	45,4706722	17,5587447	574	overgrown meadow	05.06.2024	Marko Doboš	220869320
Gornji Vrhovci	45,4706815	17,5586912	574	overgrown meadow	05.06.2024	Marko Doboš	220869637
Gornji Vrhovci	45,4717175	17,5591561	554	overgrown meadow	05.06.2024	Marko Doboš	220870247
Gornji Vrhovci	45,4719111	17,5593054	532	overgrown meadow	05.06.2024	Marko Doboš	220870249
Gornji Vrhovci	45,4720964	17,5591584	552	overgrown meadow	05.06.2024	Marko Doboš	220870250
Gornji Vrhovci	45,4722581	17,559433	549	overgrown meadow	05.06.2024	Marko Doboš	220870253
Ivandol	45,340717	17,497308	257	overgrown meadow	05.06.2023	Iva Galić	
Ivandol	45,341208	17,497106	257	overgrown meadow	05.06.2023	Iva Galić	
Ivandol	45,3463917	17,510465	229	meadow	20.05.2024	Marija Kovačević, Iva Galić	217256756
Ivandol	45,3463844	17,5102073	232	meadow	20.05.2024	Marija Kovačević, Iva Galić	
Ivandol	45,34632661	17,51035315	230	meadow	20.05.2024	Marija Kovačević, Iva Galić	
Nurkovac	45,316647	17,610175	278	an overgrown vineyard/ orchard	23.05.2023	Marija Kovačević	163294323
Nurkovac	45,316612	17,610252	277	an overgrown vineyard/ orchard	09.06.2023	Vesna Andrić, Marko Doboš, Marija Kovačević	166457620

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Nurkovac	45,31686	17,611182	273	overgrown meadow	09.06.2023	Vesna Andrić, Marko Doboš, Marija Kovačević	166457840
Nurkovac	45,316871	17,611113	273	overgrown meadow	09.06.2023	Vesna Andrić	166463865
Nurkovac	45,31641023	17,61004792	274	an overgrown vineyard/ orchard	19.04.2024	Marija Kovačević	208082120
Nurkovac	45,316549	17,610136	276	an overgrown vineyard/ orchard	03.05.2024	Marija Kovačević	
Nurkovac	45,3168518	17,6102184	281	an overgrown vineyard/ orchard	03.06.2024	Marija Kovačević	220414626
Nurkovac	45,3166138	17,6101125	277	an overgrown vineyard/ orchard	03.06.2024	Marija Kovačević	220414895
Nurkovac	45,3165098	17,6100889	276	an overgrown vineyard/ orchard	03.06.2024	Marija Kovačević	
Oblakovac	45,339967	17,490042	305	overgrown meadow	05.06.2023	Iva Galić	
Oblakovac	45,339225	17,496836	256	overgrown meadow	05.06.2023	Iva Galić	
Oblakovac	45,339967	17,490042	305	overgrown meadow	05.06.2023	Iva Galić	
Oblakovac	45,339225	17,496836	256	overgrown meadow	05.06.2023	Iva Galić	
Oblakovac	45,33944531	17,49709843	254	and edge of the meadow	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218828131
Oblakovac	45,3394764	17,49654134	260	and edge of the meadow	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218828368
Oblakovac	45,33935312	17,49638988	260	and edge of the meadow	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218828481
Opatovac	45,31408789	17,4259746	249	the edge of the forest	18.5.2024	Karlo Mikić	216608428

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Opatovac	45,31506531	17,42911857	235	the edge of the forest	18.5.2024	Karlo Mikić	216609511
Opatovac	45,31914934	17,42590998	286	meadow	18.5.2024	Karlo Mikić	216644963
Opatovac	45,31977246	17,42622161	288	meadow	18.5.2024	Karlo Mikić	216645332
Opatovac	45,32024683	17,42602615	293	meadow	18.5.2024	Karlo Mikić	216646337
Opatovac	45,32027273	17,42602355	294	meadow	18.5.2024	Karlo Mikić	216646571
Opatovac	45,32027302	17,42603713	294	meadow	18.5.2024	Karlo Mikić	216646697
Opatovac	45,32060838	17,42618339	294	and edge of the meadow	18.5.2024	Karlo Mikić	216647342
Opatovac	45,31978893	17,42560906	292	meadow	18.5.2024	Karlo Mikić	216647573
Opatovac	45,31802357	17,42487045	269	meadow	18.5.2024	Karlo Mikić	216648257
Opatovac	45,3176665	17,4247236	265	meadow	18.5.2024	Karlo Mikić	216648746
Opatovac	45,31803489	17,42477113	268	meadow	18.5.2024	Karlo Mikić	216648945
Opatovac	45,31505361	17,42483483	249	meadow	18.5.2024	Karlo Mikić	216649325
Opatovac	45,31503572	17,4248246	249	meadow	18.5.2024	Karlo Mikić	216649876
Opatovac	45,31501837	17,42488956	249	meadow	18.5.2024	Karlo Mikić	216650110
Opatovac	45,31496543	17,4248733	249	meadow	18.5.2024	Karlo Mikić	216650710
Opatovac	45,31490387	17,42483164	248	meadow	18.5.2024	Karlo Mikić	216650901
Opatovac	45,31479155	17,42496324	248	meadow	18.5.2024	Karlo Mikić	216651122
Opatovac	45,31479553	17,42493952	248	meadow	18.5.2024	Karlo Mikić	216651341
Opatovac	45,31477496	17,42502786	248	meadow	18.5.2024	Karlo Mikić	216651408
Opatovac	45,31499004	17,42504228	251	meadow	18.5.2024	Karlo Mikić	216651615
Opatovac	45,31503438	17,4250054	251	meadow	18.5.2024	Karlo Mikić	216653084
Opatovac	45,31512067	17,42510967	253	meadow	18.5.2024	Karlo Mikić	216689837

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Opatovac	45,31512067	17,42510967	253	meadow	18.5.2024	Karlo Mikić	216690002
Opatovac	45,31672945	17,42524881	266	meadow	18.5.2024	Karlo Mikić	216690197
Opatovac	45,3167494	17,42509492	264	meadow	18.5.2024	Karlo Mikić	216690425
Pavlovci	45,24414	17,672706	206	overgrown meadow	31.05.2022	Marko Doboš	119702374
Pavlovci	45,247447	17,678008	194	shrubland	07.06.2023	Marija Kovačević	166053281
Pavlovci	45,249039	17,691133	162	shrubland	07.06.2023	Marija Kovačević	166053403
Podvrško	45,343505	17,343505	320	meadow	08.06.2023	Karlo Mikić	166736142
Podvrško	45,35629501	17,42960924	319	and edge of the meadow	22.03.2024	Karlo Mikić	203483194
Rudine	45,3911	17,45528	391	overgrown meadow	01.06.2022	Edi Thür	125152393
Rudine	45,38927	17,455038	412	meadow next to the archaeological site	02.06.2023	Marija Kovačević	165110509
Rudine	45,389655	17,457375	389	roadside verge	02.06.2023	Marija Kovačević	165110526
Rudine	45,38936927	17,45506624	412	meadow next to the archaeological site	17.05.2024	Marija Kovačević, Iva Galić	216298522
Ruševac	45,345264	17,480252	256	overgrown meadow	07.06.2022	Edi Thür	125223881
Ruševac	45,34527	17,48021	262	overgrown meadow	13.04.2023	Marija Kovačević	154675476
Ruševac	45,345942	17,481947	246	overgrown meadow	05.06.2023	Iva Galić	
Ruševac	45,345517	17,479819	263	overgrown meadow	05.06.2023	Iva Galić	
Ruševac	45,346336	17,478589	286	overgrown meadow	05.06.2023	Iva Galić	
Sinlije	45,353158	17,45076	296	overgrown meadow	01.06.2022	Edi Thür	125223818
Sinlije	45,35168	17,449988	333	overgrown meadow	09.06.2023	Marko Doboš	166457257
Sinlije	45,352985	17,450501	321	overgrown meadow	09.06.2023	Marko Doboš	166457434
Sinlije	45,3471	17,450556	352	overgrown meadow	09.06.2023	Marko Doboš	166456954

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Sinlije	45,347021	17,449913	350	overgrown meadow	09.06.2023	Marko Doboš	166457070
Sinlije	45,345819	17,455904	276	overgrown meadow	09.06.2023	Marko Doboš	166456522
Skenderovci	45,39449	17,20068	256	the edge of the forest road	09.05.2024	David Huška	
Skenderovci	45,394609	17,1996862	250	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	221050764
Skenderovci	45,3944689	17,2002631	253	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	221051140
Skenderovci	45,3944679	17,2003755	254	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	
Skenderovci	45,3944902	17,2005712	255	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	
Skenderovci	45,3945271	17,2008452	256	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	221051359
Skenderovci	45,3945185	17,201012	256	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	221051464
Skenderovci	45,3945484	17,2010638	256	the edge of the forest road	06.06.2024	Marija Kovačević, David Huška	221051503
Sokolovac	45,322513	17,665122	308	an overgrown vineyard/ orchard	05.06.2023	Marko Doboš, Marija Kovačević	165718674; 165752958
Sokolovac	45,322292	17,66537	308	an overgrown vineyard/ orchard	05.06.2023	Marko Doboš	165753068
Sokolovac	45,324657	17,666445	270	roadside verge	05.06.2023	Marko Doboš, Marija Kovačević	165751668; 165754245
Sokolovac	45,322312	17,665287	301	schrubland near power line	05.06.2023	Marko Doboš, Marija Kovačević	165721287; 165753477

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Sokolovac	45,322597	17,666022	301	schrubland near power line	05.06.2023	Marko Doboš, Marija Kovačević	165721648; 165753352
Sokolovac	45,327827	17,670015	203	an overgrown vineyard/ orchard	05.06.2023	Marko Doboš, Marija Kovačević	165731627; 165753684
Sokolovac	45,328116	17,669901	205	an overgrown vineyard/ orchard	05.06.2023	Marko Doboš, Marija Kovačević	165737490; 165753870
Sokolovac	45,328393	17,670037	235	an overgrown vineyard/ orchard	05.06.2023	Marko Doboš, Marija Kovačević	165751711; 165754020
Sokolovac	45,3224416	17,66518615	305	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	216057525
Sokolovac	45,322837	17,6661456	301	the edge of the forest road	15.05.2024	Marija Kovačević, Iva Galić	216058697
Sokolovac	45,3280556	17,670051	204	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	216058838
Sokolovac	45,3283546	17,6703118	200	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	216058888
Sokolovac	45,3283351	17,6703015	200	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	216059038
Sokolovac	45,3283319	17,670285	201	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	216058977
Sokolovac	45,3284761	17,6701717	197	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	
Sokolovac	45,3284966	17,6702576	197	an overgrown vineyard/ orchard	15.05.2024	Marija Kovačević, Iva Galić	
Srednji Lipovac	45,26372446	17,63427791	197	the edge of the forest road	27.05.2024	Marija Kovačević	218620165
Srednji Lipovac	45,26443694	17,64309319	208	the edge of the forest road	27.05.2024	Marija Kovačević	218620389
Stara Kapela	45,233337	17,685745	191	overgrown meadow	07.06.2020	Marija Kovačević	140404967

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Stara Kapela	45,237881	17,693783	145	roadside verge	31.05.2022	Marko Doboš	119642161
Stara Kapela	45,237852	17,69443	144	roadside verge	31.05.2022	Marko Doboš	119642427
Stara Kapela	45,237925	17,694741	144	roadside verge	31.05.2022	Marko Doboš	119698872
Stara Kapela	45,237976	17,693956	145	roadside verge	31.05.2022	Marko Doboš	119698883
Stara Kapela	45,237989	17,693944	147	roadside verge	31.05.2022	Marko Doboš	119698909
Stara Kapela	45,239744	17,695409	185	overgrown meadow	31.05.2022	Marko Doboš	119699263
Stara Kapela	45,239422	17,687183	193	meadow	31.05.2022	Marko Doboš	119700975
Stara Kapela	45,238549	17,676938	191	overgrown meadow	31.05.2022	Marko Doboš	119702560
Stara Kapela	45,237885	17,694129	145	roadside verge	29.05.2023	Marija Kovačević	164464058
Stara Kapela	45,237703	17,698078	137	roadside verge	31.05.2023	Vesna Andrić	164871835
Stara Kapela	45,233192	17,684803	209	schrubland	29.05.2023	Marija Kovačević	164464525
Stara Kapela	45,233212	17,684633	211	schrubland	29.05.2023	Marija Kovačević	164465033
Stara Kapela	45,23277	17,684808	212	schrubland	29.05.2023	Marija Kovačević	164465096
Stara Kapela	45,237788	17,683205	167	mowed parts along the path	29.05.2023	Marija Kovačević	164465341
Stara Kapela	45,237645	17,683088	166	mowed parts along the path	29.05.2023	Marija Kovačević	164465478
Stara Kapela	45,23823	17,683558	165	mowed parts along the path	29.05.2023	Marija Kovačević	164465739
Stara Kapela	45,23872	17,685272	174	overgrown meadow	29.05.2023	Marija Kovačević	164510291
Stara Kapela	45,238968	17,682688	211	overgrown meadow	31.05.2023	Vesna Andrić	164937205
Stara Kapela	45,239005	17,682688	171	overgrown meadow	31.05.2023	Vesna Andrić	164937645
Škrabutnik	45,27423	17,632567	303	roadside verge	07.06.2023	Marija Kovačević	166048260
Škrabutnik	45,274088	17,632533	301	roadside verge	07.06.2023	Marija Kovačević	166051769
Škrabutnik	45,273547	17,632675	297	roadside verge	07.06.2023	Marija Kovačević	166052568
Škrabutnik	45,275653	17,633137	323	roadside verge	07.06.2023	Marija Kovačević	166052777

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Škrabutnik	45,281117	17,622278	266	meadow	07.06.2023	Marija Kovačević	166051817
Škrabutnik	45,28082	17,622395	265	meadow	07.06.2023	Marija Kovačević	166052055
Škrabutnik	45,28139	17,622256	270	an overgrown orchard	07.06.2023	Marija Kovačević	166052359
Škrabutnik	45,273547	17,632675	295	an overgrown orchard	07.06.2023	Marija Kovačević	166052568
Škrabutnik	45,274262	17,6325316	303	the edge of the forest road	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218617180
Škrabutnik	45,27425089	17,63242407	302	the edge of the forest road	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218617332
Škrabutnik	45,274115	17,632507	301	the edge of the forest road	27.05.5024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218828376
Škrabutnik	45,2737875	17,632569	298	the edge of the forest road	27.05.5024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	
Škrabutnik	45,2736504	17,6326473	296	the edge of the forest road	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218617646
Škrabutnik	45,2750405	17,6261953	222	meadow	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	
Škrabutnik	45,2747907	17,626405	225	meadow	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	
Škrabutnik	45,274766	17,6264556	226	meadow	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218618773

Toponym	Coordinates		Altitude	Habitat	Date of visit	Observers	iNaturalist Refence (ID)
Škrabutnik	45,2810441	17,6223844	265	the edge of the forest road	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218619296
Škrabutnik	45,2802705	17,6226344	257	meadow	27.05.5024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	
Škrabutnik	45,2808874	17,6223396	263	meadow	27.05.5024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	
Škrabutnik	45,2815996	17,6223352	273	an overgrown vineyard/ orchard	27.05.2024	Marija Kovačević, Iva Galić, Kristina Ašenbrener	218619992
Šnjegavić	45,3678944	17,4546737	341	roadside verge	20.05.2024	Marija Kovačević, Iva Galić	217257615
Šnjegavić	45,3679268	17,4546254	341	roadside verge	20.05.2024	Marija Kovačević, Iva Galić	
Vranić	45,427258	17,519125	266	the edge of the forest road	02.06.2023	Marija Kovačević	165110314
Vranić	45,42722	17,519145	266	the edge of the forest road	02.06.2023	Marija Kovačević	165110485
Vranić	45,4272703	17,5191962	266	the edge of the forest road	03.06.2024	Marija Kovačević	220413307
Vranić	45,4270701	17,5190622	264	the edge of the forest road	03.06.2024	Marija Kovačević	
Vranić	45,4277972	17,5191317	272	the edge of the forest road	03.06.2024	Marija Kovačević	220415889
Zakorenje	45,328895	17,550745	250	garden	07.06.2023	Marija Kovačević	166054464
Zakorenje	45,329195	17,549745	251	the edge of the forest road	07.06.2023	Marija Kovačević	166054767
Zakorenje	45,328937	17,5507283	250	garden	20.05.2024	Marija Kovačević, Iva Galić	217255361
Zakorenje	45,3289218	17,5507275	250	garden	20.05.2024	Marija Kovačević, Iva Galić	217255425

This research has shown that the species occurs in a much larger area than previously assumed or recorded. Most of the sites were located in the Požeška gora and Psunj areas, in habitats such as grasslands and shrublands. Earlier observations indicated that large, extensive populations can commonly be found in open habitats (Fekete et al. 2017), while in open forests with a mosaic of fully sunny and shaded patches, the species appears in small groups (Bódis et al. 2019). The same pattern has been observed in our research, with the largest populations noted in the open dry grasslands of the Požeška gora area (Fig. 3).

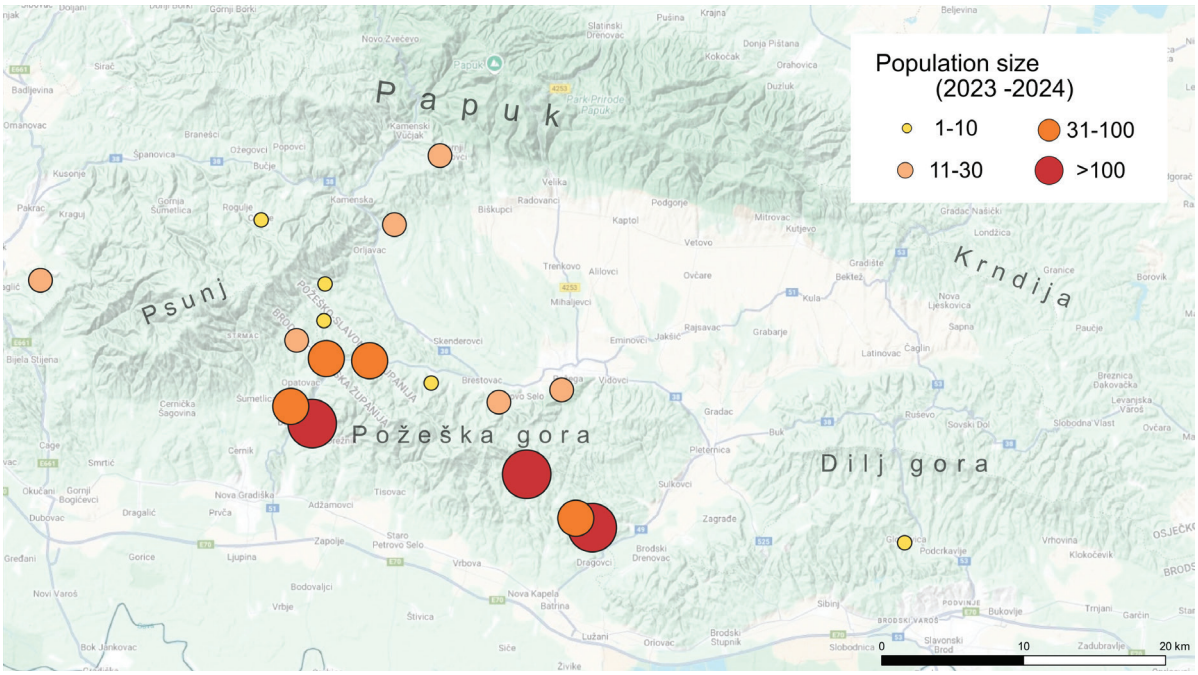

Figure 3. Population size of Adriatic lizard orchid (*Himantoglossum adriaticum*) in the area of the Slavonian highlands recorded from 2023 to 2024.
Slika 3. Brojnost populacija jadranske kozonoške (*Himantoglossum adriaticum*) na području slavonskog gorja tijekom 2023. i 2024.

At the investigated sites, *H. adriaticum* is primarily found alongside species typical of *Festuco-Brometea* grasslands. In well-preserved habitats, common species include orchids from the genera *Orchis* and *Ophrys*, as well as flaxes (*Linum flavum* L., *L. hirustum* L., and *L. tenuifolium* L.) and the genus *Carlina*. In areas affected by succession, woody species such as *Juniperus communis* L., *Pteridium aquilinum* (L.) Kuhn, *Prunus spinosa* L., *Cornus sanguinea* L., *Fraxinus ornus* L., *Crataegus monogyna* Jacq., *Rosa canina* L., *Sorbus torminalis* (L.) Crantz, and *Pyrus pyraster* (L.) Burgsd. appear. These mainly occur due to the abandonment of traditional land management practices and the discontinuance of mowing and grazing. This trend has been evident in the research area for years and is directly linked to the decline in the number of inhabitants in the surrounding areas.

The decline of dry grasslands due to the abandonment of traditional land-use practices (mowing or grazing) poses the most significant threat to *H. adriaticum* (Bódis et al., 2019). Consequently, changes occur in the composition of plant communities. These changes are recognized as the primary driver of orchid range dynamics (Jacquemyn et al. 2005,

Vogt-Schilb et al. 2015, Kull et al. 2016). Although *H. adriaticum* prefers semi-shaded habitats and often grows along the edges of forests or in scrubby grasslands following the abandonment of traditional land-use practices (mowing or grazing), scrubby vegetation eventually overtakes and suppresses the orchid. In such conditions, plants can survive for several years by assimilating resources during winter. These plants may occasionally flower, but their reproductive success is very low (Zadravec et al., 2014), which ultimately leads to the disappearance of such populations.

Once climatic limitations have been taken into consideration, the demography and fate of populations are primarily influenced by landscape properties and land use patterns rather than by soil structure (Pfeifer et al. 2010). Due to the overgrowth of favorable habitats i.e. grasslands, some large populations can be found in secondary habitats such as mown roadside verges or abandoned vineyards and orchards (Fekete et al. 2017). These habitats have proven to be extremely important for *H. adriaticum* populations across Europe (Hungary, Croatia, Italy, Slovenia, and Bosnia–Herzegovina) (Fekete et al. 2017). Such secondary habitats were recorded in Banićevac, Skenderovci, Stara Kapela, and Škrabutnik; however, the majority of the population is still found in nearby grasslands. Although secondary habitats are favorable for colonization, frequent or premature mowing can negatively impact the species' reproduction. Therefore, appropriate management of roadside verges will support the existence of valuable species and may hold significant conservation value (Hovd and Skogen 2005; Auestad et al. 2011).

Conversely, in certain areas, there is an intensification of agricultural production, which also threatens the survival of this species. Specifically, in the Banićevac area, plant nursery zones are being rapidly expanded, while in the vicinity of Glogovica, traditional meadows are being replaced by clover and corn crops. Such changes in land management lead to the use of pesticides and mineral fertilizers, ultimately resulting in a complete transformation of the habitat.

In addition to changes in land-use practices, dry limestone grassland communities are also threatened by invasive alien species and climate change. Specifically, some invasive species can create monocultures in certain areas, completely altering the composition of the original communities. One such species is *Ailanthus altissima*, which has been recorded at Sokolovac (Požega). *A. altissima* is classified as an invasive alien species (Anonymous 2019) with high resistance, rapid growth rate, and allelopathic effects that facilitate its swift spread (Hruševar & Posavec-Vukelić 2008). Consequently, *A. altissima* often forms dense assemblages that effectively suppress the indigenous flora (Nikolić et al. 2024). At the Sokolovac site, *A. altissima* communities are situated on the edge of the *H. adriaticum* habitat, which is already in an advanced stage of succession. The spread of this species accelerates succession, potentially leading to the complete disappearance of the habitat.

Weather conditions can significantly impact plant development, including habitus size, flowering time, and reproductive success. Favorable conditions, such as precipitation in May and June, can enhance the photosynthesis rate, resulting in taller plants with a greater likelihood of producing a large number of flowers (Pfeifer et al. 2006, Pfeifer et al. 2009, Pfeifer et al. 2010). Such conditions occurred during autumn 2022 and spring 2023 and resulted in the flowering of an exceptionally large number of individuals, enabling the mapping of numerous suitable habitats. Although *H. adriaticum* is a long-lived orchid with an average lifespan of 8 years (Bódis et al. 2019), it is characterized by irregular flowering. Due to the frequent dormancy periods, assessing suitable habitats and the condition of individual populations can be challenging without long-term research.

Moreover, during the winter period, frosts are the primary limitation, as the plant is highly sensitive (Bódis 2010) and frost represents one of the main constraints in the Slavonian mountains. Due to the occurrence of warmer springs, *H. adriaticum*,

like other plant species, begins its vegetative phase earlier. In such circumstances, delayed cold waves i.e. late frost have had a negative impact on *H. adriaticum*, and flowering was absent in plants that had been exposed to frost.

Conclusion

In the Slavonian Highlands, *H. adriaticum* is found in a wide variety of habitats. It primarily inhabits dry continental grasslands and arable lands that are in various stages of succession. Based on the number of newly documented localities and observed individuals, it has been demonstrated that a targeted and well-prepared approach to fieldwork is an effective strategy. This method of field research enables the collection of pertinent data on endangered and rare species at risk of extinction, as well as species for which only historical records exist, with no recent observations.

The focus of conservation efforts should be on protecting existing populations and favorable habitats through orchid conservation management techniques, which include preventing shrub encroachment via cutting, mowing, or controlled extensive grazing, ideally timed with the species' life cycle.

The discovery of numerous new sites for *H. adriaticum* during our research has significantly enhanced our understanding of the species' overall distribution. However, alongside continuous monitoring of population changes, it is crucial to explore other favorable habitats, particularly those in the Dilj gora region.

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