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First IUCN National Assessment for *Thymus oehmianus* Ronniger & Soška (Lamiaceae) and *Viola kosaninii* (Degen) Hayek (Violaceae) in the Republic of North Macedonia

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Abstract

This paper presents the distribution, conservation status and habitat type of two relict and endemic species from the territory of the Republic of N. Macedonia. The subpopulations of the *Thymus oehmianus* Ronniger & Soška and *Viola kosaninii* (Degen) Hayek have a very limited distribution in the northwestern and central parts of the country. The conservation status was determined according to the latest IUCN methodology. Accordingly, *Th. oehmianus* is provisionally estimated as Critically Endangered (CR) while *V. kosaninii* has the status of Vulnerable (VU).

Keywords: N. Macedonia, endemic species, distribution, ecology, conservation status

Introduction

The Republic of N. Macedonia is located in the central part of the Balkan Peninsula. Although it is a country with a small area, due to the favorable climatic conditions which arise from geographical position and the geological history, it represents an area of significant floristic value, where a large number of plant species and lower taxa occur. The diverse floristic spectrum consists of over 3 200 species, (more than 3 700 including mosses), 920 genera and 210 families, with representatives of many different floristic elements (Matevski et al. 2003; Matevski 2013) are one of the main characteristics of the Macedonian flora. Their uniqueness was recognized a long time ago. The first floristic records back to the middle of the 19th century when the famous German botanist Griesebach published the first data on the flora of Macedonia in his important work „Spicilegium florae rumelicae et bithynicae" I-II (Griesebach 1843-1844). Floristic research continues up today and very often leads to new data for science, despite the small area of the country.

In 2017, the Priority Red List of Macedonia was prepared, which contains 480 species of rare, endemic and relict plants (Matevski et al. 2018). This means that 15% of the total vascular plant species are on the list. As this list was has been prepared recently, 14 species have been estimated so far, and their evaluations have been accepted by the Ministry of Environment and physical planning of North Macedonia. There are draft assessments for 14 other species that have yet to be approved. The conservation status of the species was determinated using the latest IUCN methodology (IUCN 2019). In this document, the conservation status of the species *Thymus oehmianus* Ronniger & Soška and *Viola kosaninii* (Degen) Hayek is determined and

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Figure 1. *Viola kosaninii* – Kozjak, Mt. Karadžica, on limestone rocks (foto by M. Kostadinovski)

Figure 2. *Thymus oehmianus*, near the village of Samokov, Makedonski Brod, N. Macedonia (foto by C. Cvetkoska)

preliminary assessments are given. *Viola kosaninii* is a shrub that grows on limestone rocks (Micevski 1995) (Figure 1). It was first described from the Babuna River springs (below the peak Solunska Glava), and part of its populations occurs along the vertical limestone cliffs of Mount Karadžica, which drop steeply into the gorge of the Treska River (Matevski 2013). *Thymus oehmianus* is an endemic and relict plant that grows in humid places, in gorges, on a limestone substrate (Matevski 2021). This plant is on the IUCN Global Red List (Walter and Gillet 1998), with the status of extinct species, but its small subpopulations still exist in several localities along the rivers Ocha, Treska and Mala Reka near the village of Samokov (municipality of Makedonski Brod) (Figure 2).

Materials and methods

Survey, identification and geographic distribution of plant species

Field surveys of the relict and endemic species *T. oehmianus* and the subendemic species *V. kosaninii* were conducted during 2021-2022. During the survey, the longitude, latitude and altitude of each site were recorded using OruxMaps (www.oruxmaps.com). The data on the geographical distribution of the two species in N. Macedonia are based on information from the Macedonian National Herbarium (MKNH) at the Institute of Biology of the Faculty of Natural Sciences and Mathematics in Skopje, and on literature data, e.g. from scientific papers (Košanin 1911a, 1911b; Tan, Stevanović & Vold 1998; Stevanović & Tan 2000; Mandžukovski 2009; Levkov et al. 2010; Teofilovski 2011; Matevski 2013) and Flora of the Republic of Macedonia (Micevski 1995; Matevski 2021), while the data from own researches were also considered. The distribution maps were created in QGIS 3.18 (QGIS Geographic Information System, http://www.qgis.org). The taxonomy and distribution range of the plant are consistent with the Euro+Med Plant database (https://www.emplantbase.org/home.html).

Identification of habitat types

Vegetation surveys were conducted to identify plant communities using the methodology of the Zurich-Montpellier school (Braun-Blanquet 1964). Species habitat data are determined by identifying the plant communities and their floristic composition. The Catalogue of Habitat types of EU importance in the Republic of North Macedonia (Matevski et al. 2021) was used to determine whether the plant communities belong to a particular habitat type.

Assessment of conservation status

The conservation status of the species was determined using the IUCN (2019) methodology. During the field research, the localities where the species occur were visited. Based on a survey, the number of locations for species was determined by defining the threats affecting the continued decline in the number of mature individuals in the population, the number of subpopulations, AOO, EOO and the area, extent and/or quality of habitat. The population size was determined by counting mature individuals in specific areas. The size of the areas was determined depending on the type

of terrain. Finally, a mean value was calculated for the number of mature individuals in the total area where the species has been registered so far. All distribution points of the species were entered into GeoCAT (Geospatial Conservation Assessment Tool). GeoCAT is an open-source, browser-based tool that performs rapid geospatial analysis to facilitate the process of Red Listing taxa. The analysis was developed to use spatially referenced primary occurrence data and focuses on two aspects of a taxon's geographic range: extent of occurrence (EOO) and the area of occupancy (AOO) (Bachman et al. 2011). All these informations made it possible to assess the conservation status of both species according to different categories and criteria.

Results and discussion

Distribution

Thymus oehmianus Ronniger & Soška (Lamiaceae) (Figure 3)

Localities from literature:

- Skopje: the lower course of the river Treska-Kapina, 760 m a.s.l. (Lindtner, 11.05.1937; Ronniger 1938; Soška, 1938; Drenkovski, 2000; Jalas, 1972), (Matevski 2021).

Localities from herbarium data:

- Skopje: N. Breznica, between N. Breznica and Kula, 1000 m a.s.l., 27.07.1995, V. Matevski;
- Skopje: Jasen - Vrba, along the river Ocha, in wet places, 806m a.s.l., 41°44'35" N; 21°15'27" E; 08.09.2010, V. Matevski (MKNH);
- Makedonski Brod: in front of the village of Samokov, by the road near Mala Reka, on silicate, (MKNH: 510 m a.s.l., 22.06.1986, V. Matevski s.n.; 09.10.1985 K. Micevski & V. Matevski s.n.; 12.10.1995 V. Matevski s.n.; 517 m a.s.l., 41°39'28" N; 21°12'09" E; 19.09.2003, V. Matevski; 22.09.2000 V. Matevski; 506 m a.s.l., 41°39'52" N 21°13'58" E; 19.09.2003, V. Matevski);
- Makedonski Brod: Zdunje-along the river Ocha, in wet places, one kilometer from the mouth of Treska river, 420 m a.s.l., 27.07.1995, V. Matevski;

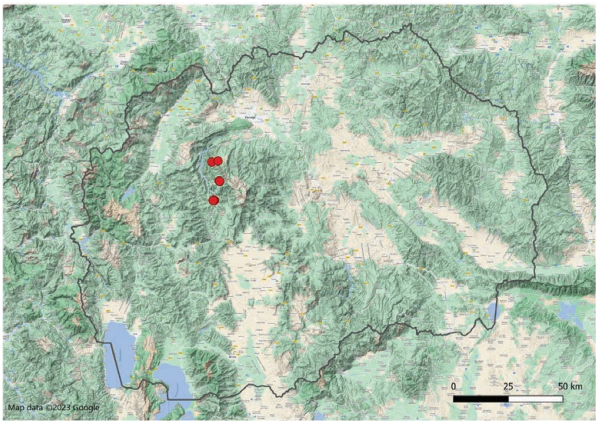

Figure 3. Distribution map of *Thymus oehmianus*

Personal data:

- Jasen: Selište, gorge of the river Ocha, 875 m a.s.l., 41.7410392 N; 21.2613348 E; 06.09.2021, S. Cvetanoska et al. s.n. 872 m a.s.l., 41.7419096 N; 21.2603476 E; 06.09.2021, S. Cvetanoska et al. s.n. (MKNH);
- Makedonski Brod: Mala Reka river, along the road for Mala Reka river-Samokov, limestone tuffs, 623 m a.s.l., 41.6648376 N 21.2280922 E; 08.10.2022, S. Cvetanoska et al. s.n. (MKNH); 640 m a.s.l. 41.6646597 N 21.2271732 E, 08.10.2022, S. Cvetanoska et al. s.n.

Thymus oehmianus is an endemic species known only from the northwestern part of N. Macedonia. This species occurs in multipurpose area „Jasen", along the Ocha river, from where it is described, and near the village Samokov, Makedonski Brod. During the field research, it was registered at the locality Jasen, near the river Ocha, on wet limestone rocks.

Viola kosaninii (Degen) Hayek *(Violaceae)* (Figure 4)

Localities from literature:

- Jakupica: Solunska Glava (Degen 1911);
- Mt Jakupica, northeastem steep slopes of stony mountain ridge, growing together with *Ramonda nathaliae*, 1800-2150m a.s.l., N. Košanin (1911a: 238, 1911b: 115);
- Village Lukovica, Zajačec, on the left side of the river Treska, on the slopes of mountain Suva Gora, on limestone, 500-800 m a.s.l., 16.05.1991, 01.05.1999, A. Teofilovski.

Localities from herbarium data:

- Mt Jakupica, on mountain crest above 2000 m a.s.l., 30.06.1910, N. Košanin (BEOU);
- Skopje: valley of the Ocha river and between Kula and Kapina, 600 m a.s.l., Lindtner, 1937 (BEO);
- Gorge of rivulet Ocha, left tributary of the Treska river, western slopes of Karadžica mountain towards Vrazija vodenica, 750 m a.s.l., 09.05.1937, V. Lindtner (BEO);
- Treska river basin, Poreče region, between Kula and Kapina, limestone rocks, growing together with *Ramonda nathaliae*, *Saxifraga grisebachii*, etc., 800 m a.s.l., 10.05.1937, V. Lindtner (BEO);
- Gorge of rivulet Ocha, on the left tributary of the Treska river, western slopes of Karadžica mountain towards Vrazija vodenica, Feov dol, 27.10.1934, H. Em (BEOU);
- Mt Jakupica, in chasmophytic communities together with *Ramonda nathaliae*, on limestone and dolomitic rocks, 700-1900 m a.s.l., ann. 1967, H. Em;
- Kapina: Perunika (leg. Oehm); Kapina: Leska (leg. Oehm & Lindtner); gorge of the rivulet

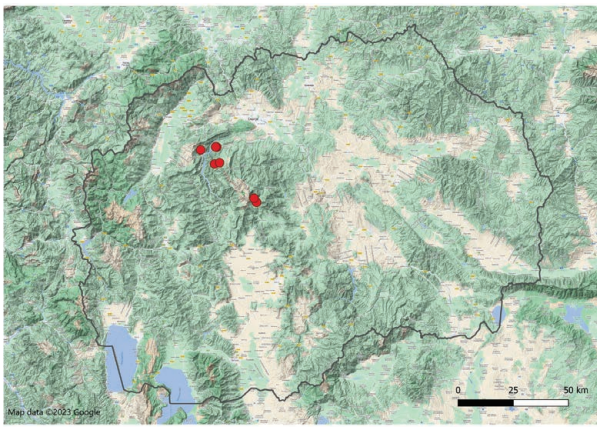

Figure 4. Distribution map of *Viola kosaninii*

Ocha, on the right tributary of the Treska river, western slopes of Karažica mountain towards Kapina, H. Em (BEO);
- Two records from the same locality, July 1938, T. Soška (BEO);
- Treska river basin, Pusta Breznica, limestone crevices in *Pinus pallasiana* forest, 28.08.1939, P. Černjavski (BEO);
- Treska river basin, supra loc. Kapina, in saxosis calcareis, 800 m a.s.l., 07.08.1945, O. Grebenščikov (BEO);
- Village of Nova Breznica, Kozjak, on limestone, (MKNH: 1100-1150 m a.s.l., 14.06.1988, K. Micevski s.n.; in *Quercus trojana* forest. 900 m a.s.l., 07.09.1978, H. Em s.n.; 30.05.1997, V. Matevski s.n.; 30.05.1997, V. Matevski s.n.; 31.05.1995; V. Matevski s.n.; 900-1000 m a.s.l., 28.07.1995, V. Matevski s. n.);
- Skopje: between Kula and Kapina, roadside cuts, on limestone screes, 900-1000 m a.s.l., V. Matevski s.n. (MKNH).

Personal data:
- Karažica: Kozjak, on limestone rocks, 1100 m a.s.l., 41.88632 N; 21.23097 E; 04.06.2021; 1090 m a.s.l. (MKNH), 41.88614 N 21.23093 E; 04.06.2021; 41.8870016 N 21.2252779 E; 05.06.2021; 41.8870607 N 21.2254773 E; 05.06.2021; S. Cvetanoska et al. s.n.;
- Jakupica: along the road, between v. Nežilovo and the mountain house Čeples, on rocks along the road, 1256 m a.s.l., 41.6813022N; 21.4312617E; 24.05.2022, S. Cvetanoska et al. s.n.

Figure 5. Habitat type of *Thymus oehmianus*. Gorge of Ocha river in multipurpose area "Jasen", Skopje, N. Macedonia (foto by S. Cvetanoska)

Viola kosaninii is endemic species with general distribution in several countries of the Balkan Peninsula: N. Macedonia, Albania, Greece and Montenegro (Hayek 1924; Stevanović & Tan 2000). In N. Macedonia this endemic species is found on the mountain Jakupica, peak Solunska Glava, from where it is described, and near the village Nova Breznica, Kozjak. During the fieldwork survey, it is registered at the locality: Nova Breznica-Kozjak.

Ecology

The habitat of *Thymus oehmianus*:
- Habitat Directive Annex 1: 7220 *PETRIFYING SPRINGS WITH TUFA FORMATION (CRATONEURION)
- EUNIS classification: C2.121 Petrifying springs with tufa or travertine formations, respectively.

Characteristic of this type of habitat is the accumulation of travertine due to the high concentration of calcium carbonate in the water. Accumulation usually occurs in springs or on limestone rocks where the water breaks through and flows over the surface of the rocks (Matevski et al. 2021) (Figure 5).

Viola kosaninii is chasmophytic species that develops in the crevices of vertical steep cliffs, where the growing conditions are unfavorable for a large number of plants. Soil is almost absent in the crevices or may be deposited in small amounts. The floristic composition of these habitats depends only on the ecological conditions. The habitat is dominated by calciphilous plants or by plants tolerant to this factor and very low substrate moisture (Matevski et al. 2021) (Figure 6).

The habitat of *Viola kosaninii*:
- Habitat directive Annex 1: 8210 Calcareous rocky slopes with chasmophytic vegetation
- EUNIS classification: H3.2A13 Balkan Range calcicolous hasmophyte communities.

During the field research the following characteristic taxa were recorded for this habitat: *Draba gr. aizoides, Micromeria cristata, Ramonda nathaliae, Saxifraga federici-augusti* subsp. *grisebachii, Saxifraga scardica, Sedum album, Sedum dasyphyllum, Sesleria tenerrima* and *Silene saxifraga* subsp. *saxifraga*.

The investigations revealed that the vegetation relevés with the species *Viola kosaninii* belongs to the association *Micromerio-Violetum kosaninii* Horvat 1936

within the alliance *Ramondion nathaliae* Ht. 1935. (Horvat 1936; Horvat et al. 1974)

Figure 6. Habitat type of *Viola kosaninii*. Limestone rocks in the gorge of Treska river, Kozjak, Skopje, N. Macedonia (foto by S. Cvetanoska)

Conservation status of the species

The most important results for assessment according to the IUCN methodology are presented in Table 1.

The species were evaluated according to all criteria and the most threatened status was selected.

Thymus oehmianus Ronniger & Soška

FINAL NATIONAL ASSESSMENT: CR B1ab(iii, v) + 2ab(iii, v)

Thymus oehmianus was listed as EX (extinct) in IUCN WORLD RED LIST of threatened plant species in 1997, but fortunately still a vital population of this species was recorded during field research.

The result of the National assessment according to IUCN methodology is CR B1ab(iii, v) + 2ab(iii, v).

Assessment according to Criteria A is VU A1abc: 20 years ago about 50% of the population was flooded due to the construction activities related to the artificial lake Kozjak. This threat was in the past and is not revisable. During this period, population size, AOO, EOO, and habitat quality declined.

The Geospatial Conservation Assessment Tool (GeoCAT) was used to determine the EOO and the AOO of the species. The Extent of occurrence (10.8 km^2) and the Area of occupancy (8 km^2) are very small and limited. There is only one location related to anthropogenic influence near the village of Samokov (the population is near the road). Additionally, future construction activities are expected in this area. The mentioned threat resulted with continuing decline in the quality of habitat and the number of mature individuals of the species. Assessment according to Criteria B is CR B1ab(iii, v) + 2ab(iii, v), and because this is the most threatened status it is the final assessment of the species.

As for Criteria C, the population size (about 2000 mature individuals) refers to category EN, but there are no fulfilled conditions for assessment according to this criterion.

Due to the fact that the AOO is very small and limited, and there is only one location, according to Criteria D the species is VU D2.

There are no data for assessment according to Criteria E.

Viola kosaninii (Degen) Hayek

FINAL NATIONAL ASSESSMENT: VU D2

In the IUCN WORLD RED LIST of threatened Plant species, 1997, *Viola kosaninii* is listed as R (Rare).

There are no data for assessments according to Criteria A and E.

Despite the fact that this is a plant that has a small range, which refers to the EN category (EOO is 117 km^2 and AOO is 24 km^2) and there is only one location, two conditions are not fulfilled, and can't be evaluated according to Criteria B.

A similar case is for using Criteria C. The number of mature individuals is about 2000 which refers to the category EN, but the conditions are not fulfilled.

There is only one location related to anthropogenic influence near the village of Kozjak (the population is located near the road) and according to Criteria D,

Table 1 Important parameters for IUCN methodology

species	EOO	AOO	Number of locations	Population size
Thymus oehmianus Ronniger & Soška	10.8 km^2	8 km^2	1	about 2000
Viola kosaninii (Degen) Hayek	117 km^2	24 km^2	1	about 2000

the species is evaluated as VU D2 which is the final assessment at the national level.

Viola kosaninii is stenoendemic plant species that is distributed in N. Macedonia, Albania, Greece, and Montenegro. The population in N. Macedonia is isolated (there is no close relation to other populations), so the final species assessment at the national level remains unchanged.

These data are a good basis for evaluating the species at the Regional and Global level, especially for *Th. oehmianus*, which is a local endemic. As for *V. kosaninii*, further surveys need to be conducted in aim to determine the conservation status according to the IUCN methodology.

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