

Population Status and Natural Localities of Rhodiola rosea in Rila Mts., Bulgaria

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Abstract. *Rhodiola rosea* L., a member of Crassulaceae family, is an alpine plant that grows in specific and sensitive high-mountain habitat and is, therefore, a very suitable for studying the effect of climate change. Although the natural area of *R. rosea* is wide and includes most of the boreal and temperate parts of the Northern hemisphere, urgent measures for conservation of natural resources of the species are necessary. In Bulgaria, the species occurs on stony and rocky places, often on screes, in habitats near late-melting snowdrifts, which provides sufficient soil moisture (2280 - 2600 m above sea level) in Pirin, Rila and Stara planina Mts. It is protected by the Biodiversity Act of Bulgaria and is listed in the Red List of Plants in Bulgaria. The species is included in the Red Data Book of the Republic of Bulgaria (Peev, ed., 2015). According to the IUCN criteria, its threat status is Critically Endangered. This study aimed to evaluate the population size and the conservation status of six natural localities of *R. rosea* in Rila Mts: 1) Seven Rila Lakes; 2) Skakavitsa's waterfall; 3) Kalin Dam; 4) Rusaliite; 5) Belmeken; 6) Musala hut. The best characteristics of both population size and conservation status were recorded in the localities situated in remote and hardly accessible areas with limited or no tourists' access. Based on thorough evaluations of trade levels and trends compared to population sizes, *R. rosea* must be considered to face serious threats from overexploitation and growing international trade due to its increasing use in herbal medicine.

Key words: Golden root, conservation, natural localities.

Introduction

R. rosea (synonyms: *Sedum rosea* (L.) Scop., *Rhodiola roanensis* Britton, *Rhodiola arctica* Boriss., *Rhodiola iremelica* Boriss. *Sedum rosea* var. *roanense* (Britton) A. Berger, *Sedum roseum* (L.) Scop., *Sedum roseum* var. *roanense* (Britton) A. Berger, *Sedum rosea* var. *roanensis* (Britton) A. Berger) is a member of Umbilicinae subtribe, Sedeae tribe, Sedoideae subfamily, Crassulaceae family (Engler, 1964). The plant's name can be

traced back to the ancient Greek physician Dioscorides, who first recorded medicinal applications of *rodia riza* in 77 C.E. in De Materia Medica (Mell, 1938). Linnaeus renamed it *Rhodiola rosea*, referring to the fresh-cut rootstock's rose-like fragrance (Linnaeus, 1749). Based on the reproductive systems' specifics, Linnaeus first differentiated the two close genera – *Rhodiola* and *Sedum*. Most of the species of the genus *Rhodiola* are dioecious, *R. rosea* including. Its

flowers are unisexual, rarely hermaphrodite, yellow to orange, with reddish nuance (Hegi, 1963, Lindman, 1964, Sandberg & Göthberg, 1998) and pleasant scent (Mossberg & Stenberg, 2003). Male flowers are more extensive and prominent during the flowering period (Dragland, 2005), lasting from June to August (Hegi, 1963; Mossberg & Stenberg, 2003), and male plants tend to be larger and heavier than female ones (Galambosi et al., 2006). *R. rosea* is an insect pollinating species. Therefore, it depends on many environmental factors that could affect its pollinators. Due to the severe climate condition in the alpine belt, the pollinator species occupy specific microhabitats. *R. rosea* is an alpine plant that grows in specific and sensitive high-mountain habitat and is, therefore, a very suitable for studying the effect of climate change. It is one of the priority species for conservation in many European countries: Finland, Lithuania, Sweden, Norway, Iceland (Cuerrier et al., 2015). Today it is not red-listed in the Scandinavian countries, except in the Swedish counties Västra Götaland (Kylin, 2010, Alnarp, Sweden – pers. comm.), Göteborg and Bohuslän (Mossberg & Rydberg, 1995). *R. rosea* is one of the protected species in the Czech Republic, Bosnia and Herzegovina (Lange 1998). In these countries it is endangered while in Slovakia it is considered vulnerable (Galambosi et al., 2006). It occurs in most European countries with wider distribution in the northern latitudes, while in the southern part of Europe its distribution is restricted mostly to high-mountain habitats. Genetic surveys revealed differentiation among the geographically distinct populations (György et al., 2016).

It is a subject of protection in many former Soviet Union Republics: Borodin, 1978; Malyshev & Sobolevskaya, 1980; Harkevich & Kachura, 1981; Takhtajan, 1988; The Red Book of the Murmansk region (Konstantinova et al., 2003), as well as the Komi Republic (Taskaev, 1999), the Central Urals, Arkhangelsk, Nenets and Khanty

Mansiysk Autonomous Area of the Russian Federation, including the Republic of Karelia (Kotiranta et al., 1998). *R. rosea* is one of the 202 rare species listed by the Red Data Book of Ukraine (Didukh, 2009). Ziman and Derbak (2013) studied the species' population status in the high mountain flora of the Ukrainian Carpathians and Balkan. As a result of long-standing monitoring, they determined *Rhodiola* populations' participation as a part of "hot spots" characterized by including 5 to more rare species. Authors recommended for conservations and protection of these hot spots. The largest population of the species in the world is found in Altai, south Siberia (Galambosi, 2006). The conservation status of the species in North America differs between the states and regions, but it is under protection in most of them (Booker et al., 2015). The same author stated that species status is better in Canada due to the more suitable habitats related to the northern climate.

Although the natural area of *R. rosea* is wide and includes most of the boreal and temperate parts of the Northern hemisphere, urgent measures for conservation of natural resources of the species are necessary. *R. rosea* is protected by the Biodiversity Act of Bulgaria (2002) and is listed in the Red List of Plants in Bulgaria. The species is included in the Red Data Book of the Republic of Bulgaria (Meshinev, 2015). According to the IUCN criteria, its threat status is Critically Endangered [CR A4d; B2ab(iv)]. In Bulgaria, the species occurs on stony and rocky places, often on screes, in habitats near late-melting snowdrifts, which provides sufficient soil moisture (2280 - 2600 m above sea level) in Pirin, Rila and Stara planina Mts. It is one of the characteristic plants of the priority habitats of Directive 92/43/EEC. The species' occurrence in Stara planina is very scarce, and the size of populations in Pirin is considered small (Meshinev, 2015). Therefore, its populations in Rila Mts are considered more important and deserving more attention.

The aim of this study was to evaluate the population size and the conservation status of six natural localities of *R. rosea* in Rila Mts: 1) Seven Rila Lakes; 2) Skakavitsa's waterfall; 3) Kalin Dam; 4) Rusaliite; 5) Belmeken; 6) Musala hut. The results obtained are part of long-term monitoring on the population status of the species in Bulgaria.

Materials and Methods

The objects of the study included six localities of the species in Rila Mts. They were selected based on preliminary information about the species' distribution and the attempt was to cover different parts of the mountain.

The climate conditions in the region of study are typical for the high mountain regions in Bulgaria. Because climate data are available from only one climate station (Musala), they could be considered, with some approximation, as valid for the whole region of study. The mean annual temperature is -3 °C, with the coldest month being January (-10.9 °C) and the warmest one - August (5.3 °C). The average monthly temperatures are positive only in June, July, August and September. Total annual precipitation is 1176 mm, predominantly snow, with maximum value 130 cm in March.

The field observations took place in the period June-September, 2016 - 2020. Transects were used for preliminary assessment of the regions of study and for determining the exact locations of the scoring plots. The plot size was 100 m², which was convenient enough considering the stony habitats with lower plant cover. Depending on the size of the locality, 2 to 3 scoring plots were established. The target characteristics of *Rhodiola rosea* localities were: population size, average density, and the status of the populations. The area covered by populations was determined by the positions of the peripheral plants of each locality. During the field observations GPS coordinates and altitude were scored, and

some other peculiarities of the locality have been described. The data from the control populations were included in particular "Terrain form" accepted by "National System for biomonitoring" (Gussev & Bancheva, 2016).

Results and Discussion

Generally, the populations of *R. rosea* in the studied region are represented by a small number of individuals. The most numerous is the population Belmeken with about 130 individuals growing on an area of approximately 1800 m². The poorest was the locality near Kalin dam, consisting of only 4 individuals, and Rusaliite (12 individuals). However, the places where the species occurs are sometimes difficult to reach, and one could skip few individuals, especially if *Pinus mugo* thickets grow on the screes. The average number of individuals per 100 m² varied between 4 and 7, which means that the population density is not strongly related to population size. There is insufficient information concerning the population size of the *Rhodiola rosea* populations in Bulgaria. Most studies focused on the chemical composition, medicinal properties and cultivation (Marchev et al., 2016), while few studies aimed at studying the population status and conservation (Meshinev, 2015).

The localities near the tourist roads are Seven Rila Lakes, Skakavitsa's waterfall, and Musala hut. They are characterized by a relatively large population area, but the number of individuals is small, and the distance between them is long. This makes pollination difficult, and there were no seedlings. Besides, we have registered violations related to the sale of the golden root in the locality of Panichishte, which is the start point of many tourist roads leading to Seven Rila Lakes and Skakavitsa's waterfall.

The best characteristics of both population size and conservation status were recorded in the localities situated in remote and hardly accessible areas with limited or no tourists' access. In relatively

good condition is the population in the region of Belmeken (Table 1). The locality can be accessed only by walking 8 km on rough terrain.

The other two localities (Kalin Dam and Rusaliite) have a small population area. The reason for the populations' poor state should be attributed to climate change and loss of habitats. Also, these two localities can be accessed by off-road vehicles and are thus more exposed to anthropogenic pressure.

The main reason for the small population size can be traced in its ecological requirements to the specific type of habitats. *R. rosea* occurs on stony and rocky, wet places on screes and along the mountain streams, above the treeline. The species could be found on areas close to the late melting snowdrifts, which provides sufficient soil moisture. Although *R. rosea* has succulent morphology (Fig. 1), it is highly dependent on relatively stable water supplies.



Fig. 1. *R. rosea* in its natural locality Belmeken (photo: Ina Aneva).

Therefore, collection and trade of this species from natural localities is a violation of the legislation and is a subject to punishment. However, we have observed in some popular tourist destinations (near the regions of Seven Rila Lakes and Skakavitsa's waterfall) that roots of *R. rosea* have been offered by private retailers, albeit in small quantities (up to 100-200 g in a package). Concerning trade abroad, to other countries, we do not have information. Officially it is not possible because of the protection status of the species. However, in some cases, collections from the wild could be declared as originating from cultivation and offered to the international market. It is possible, but we do not have information whether it happens frequently or not. Based on thorough evaluations of trade levels and trends compared to population sizes, *R. rosea* must be considered to face serious threats from overexploitation and growing international trade due to its increasing use in herbal medicine.

The localities of *R. rosea* in Bulgaria are part of three priority habitats: 8110 -

Siliceous screes of the montane to snow levels, 8220 - Siliceous rocky slopes with chasmophytic vegetation, and 4070 - Bushes with *Pinus mugo* of Directive 92/43/EEC (Table 1). Also, the locality Skakavitsa waterfall borders another priority habitat - 95A0 Forests of Macedonian pine (*Pinus peuce* Griseb.) and Bosnian pine (*Pinus heldreichii* Christ.). They harbour many rare and endemic species, like *Primula deorum* Velen., *P. minima* L., *Geum bulgaricum* Pančić, *Leontodon rilaensis* Hayek, *Pinguicula balcanica* Casper, *Soldanella pusilla* Baumg. Thus, the conservation measures taken to protect *R. rosea* natural habitats have multiple effects, by conserving the other rare and endangered plants in these habitats.

The conservation of the studied localities is insured by the fact that all they are part of protected territories: Rila National Park and Rila Monastery Nature Park. Also, part of the territory falls into the nature reserves "Ibar" and „Skakavitsa“, which have more strict protection status, including prohibition of collecting of any plant species on the territory.

Table 1. Characteristics of the studied localities. Legend: ¹⁾ According to Directive 92/43 EEC.

Locality	Habitat type ¹⁾	GPS coordinates	Altitude (m a.s.l)	Area of the locality (m ²)	Number of <i>R. rosea</i> plants	Mean number of individuals per 100 m ²
Seven Rila Lakes	8110	42°11'47.62"N 23°19'37.25"E	2400	1200	63	5
Skakavitsa's waterfall	8220	42°13'16.37"N 23°18'21.10"E	2050	600	48	6
Kalin Dam	8220	42°10'28.18"N 23°14'48.77"E	2400	100	4	4
Rusaliite	8110	41°58'46.33"N 23°23'56.20"E	2020	200	12	6
Belmeken	8110 and 4070	42°11'27.72"N 23°44'56.41"E	2200	1800	130	7
Musala hut	8110	42°11'30.74"N 23°35'22.20"E	2400	600	28	4

Conclusion

R. rosea is a species with high conservation value worldwide. Further active protection measures aimed at

achieving long-term conservation of the populations of *R. rosea* and the unique nature as a whole must be taken. Regular monitoring needs to be carried out. The

including of the species in CITES Appendix II should be done.

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