Natural localities and nature conservation status of *Rhodiola rosea* in the Pirin National Park (Bulgaria)

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Abstract. The paper presents results of a survey of the natural localities and nature conservation status of *Rhodiola rosea* in the Pirin National Park. A total of 20 different local populations of various size – from few to several thousand individuals, occupying from 0.05 to 5 ha – were included in the study. The species reveals a viable population and good abilities for natural regeneration. The subpopulations consist of both generative and vegetative individuals, the generative ones predominating. No particular threats have been identified and the nature conservation status of the species is evaluated as favorable.

Key words: Favorable status, Golden Root, subpopulations, threats

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Introduction

Golden Root (*Rhodiola rosea* L., *Crassulaceae*, *Sedoideae*) is a rare species in the Bulgarian flora and, along with this, is highly valued as an important medicinal plant. It is included in the *Red List of Bulgarian Vascular Plants* (Meshinev 2009) and in the *Red Data Book of Bulgaria*, vol. 1 – Plants and Fungi (Meshinev 2015) as Critically Endangered [CR A4d; B2ab(iv)]. The species is protected under the Biodiversity Act of Bulgaria (2002).

Natural distribution of *R. rosea* includes most boreal and temperate parts of the Northern Hemisphere in Europe, Asia and North America (Plants of the World online/Kew Science). In Bulgaria, it is limited to the high-mountain zones of Rila, Pirin, Stara Planina, and Rhodopi Mountains, approximately within the altitudinal range of 2000-2600 m (Valev 1970, Meshinev 2015). With the exception of Rhodopes, practically all natural localities of the species are situated within the three Bulgarian national parks: Rila, Pirin and Central Balkan.

R. rosea is known for its adaptogenic effect and, besides being used worldwide in the traditional medicine, it is subject to examination in a number of clinical trials (Marchev & al., 2016). During the last 50 years, more than 140 chemical structures have been identified in the species (Panossian & al. 2010; Ioset & al., 2011). However, the demand for raw material of *R. rosea* is increasing and it cannot be met by collecting

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the plant in its natural localities, because the species is considered rare and endangered, and is protected in many European countries (see Marchev & al., 2016, for review). Therefore, its future use in medicine and pharmaceutical industry relies very much on the development of methods of cultivation (Platikanov & Evstatieva 2008). Even though the successful cultivation is difficult, due to the specific ecological requirements of the species (a psychrophyte adapted to conditions with high daily temperature amplitudes, low temperatures during most of the year, short vegetation period, etc.), this is the only way to sustain the increasing demand for raw material. (Platikanov & Evstatieva 2008, Marchev & al. 2016, 2017)

The largest localities and the highest growing stock of the species in Bulgaria are in Rila, while in Pirin the species is represented by small-sized populations (Meshinev 2015, Aneva & al. 2021). Therefore, the current status of *R. rosea* populations in Pirin is of substantial interest in relation to its conservation and, possibly, to its sustainable use. Besides evaluation of population parameters, identification of the threats is essential for better conservation of the natural localities.

In relation to the above statements, the objective of the present study was to assess the natural resources and conservation status of *Rhodiola rosea* on the territory of the Pirin National Park.

Material and methods

Twenty natural localities of *R. rosea* were included in the study on the territory of the Pirin National Park. They were identified after a thorough inventory of the northern part of the Pirin National Park by transect scores. Most localities have not been effectively isolated from each other and cannot be considered as different populations. A working term of "local populations" or "subpopulations" was adopted for the present study and will be applied to the localities hereafter. These objects were properly localized in the course of the study. Details of the studied local populations are presented in Table 1. Field studies were carried out in the period July-September 2014. The following parameters were recorded: area of the subpopulation; site conditions; local population size;

Table 1. Geographic coordinates, altitude and area of the studied local populations

No	Area (ha)	Geographic coordinates	Altitude (m)	Bedrock
1	5	41.735667° N 23.423306° E	2400	silicate
2	3	41.712389° N 23.502722° E	2300	silicate
3	1	41.700611° N 23.503833° E	2390	silicate
4	0.05	41.756806° N 23.408028° E	2200	silicate
5	5	41.73625° N 23.414139° E	2300	silicate
6	1	41.753472° N 23.408972° E	2300	silicate
7	1	41.754667° N 23.409278° E	2300	silicate
8	0.01	41.757417° N 23.411139° E	2170	silicate
9	0.05	41.754472° N 23.410528° E	2220	silicate
10	0.01	41.753944° N 23.411139° E	2120	silicate
11	1	41.706667° N 23.460917° E	2380	silicate
12	1	41.711806° N 23.460361° E	2520	silicate
13	1	41.716333° N 23.459306° E	2560	silicate
14	1	41.686556° N 23.446222° E	2120	silicate
15	0.1	41.686° N 23.447111° E	2200	silicate
16	1	41.685361° N 23.449361° E	2160	silicate
17	0.5	41.800889° N 23.363639° E	2400	silicate
18	0.01	41.79925° N 23.363528° E	2460	limestone
19	3	41.799° N 23.362111° E	2470	silicate
20	0.01	41.757011° N 23.433397° E	2740	silicate

population density; share of vegetative and generative individuals; health status, including damages caused by biotic or abiotic factors, and possible threats. Special forms were filled in for each local population with entries for all indicators of interest. Natural habitats with occurrence of *R. rosea* were identified following the respective Identification Manual of Habitats (Kavrakova & al. 2009). The favorable nature conservation status of the species was evaluated according to a modified template of Zingstra & al. (2009).

Wherever applicable, the data were analyzed by means of the descriptive statistics.

Results and discussion

Almost all local populations (about 3/4) were situated on very steep slopes (70 to 80°, mean 62°) and, therefore, were hard to access. In all cases, the exposition was northern and northeasterly, which was a prerequisite of sufficient water supply to the soils. An average size of the area occupied by the local populations was 1.8 ha, but it varied from 0.05 ha (Banderitza river) to 5 ha on the northern slopes above the lakes Baderishko Ribno and Dalgo.

The localities differed substantially in their area: the average size was 1.8 ha, but it ranged from 0.05 ha (Banderitza river) to 5 ha on the northern slopes above the lakes Baderishko Ribno and Dalgo. There were three local populations with an area of about 0.01 ha, five localities with an area less than 1 ha, and 12 populations with an area from 1 to 5 ha (Table 1). All but one local population were occurring on siliceous bedrocks, which corresponds to the life-history characteristics of the species.

Table 2. Size and density of the studied subpopulations

Subpopulation size (ind.)	No of subpopulations	Subpopulation density (ind. ha^{-1})	No of subpopulations
<20	5	<10	6
20-50	2	10-100	9
50-100	6	100-500	4
100-200	5	>500	1
990	1		
4200	1		

Subpopulations varied greatly in size (mean = 320 ± 208). Five subpopulations had less than 20 individuals, two between 20 and 50 individuals, six numbered between 50 and 100, five between 100 and 200, and two populations were considerably larger (Table 2). A total of 987 individuals were identified in the first of the last two (Suhodolsko Ezero), while the largest subpopulation was recorded on the slopes above the lake Banderishko Ribno: about 4200 individuals. Population density varied from as few as one ind. ha^{-1} to 835 ind. ha^{-1}, with a mean of 107 ± 42 ind. ha^{-1}. Such great variation indicated that mean values have not been informative for proper characterization of the population status, but classes of population size and density should be used instead. Most subpopulations had density within the range 10-100 ind. ha^{-1} (9) and less than 10 ind. ha^{-1} (6). Four local populations had density between 100 and 500 ind. ha^{-1} and only one exceeded 500 ind. ha^{-1}.

Natural regeneration was recorded in all local populations. In all but one locality there were both vegetative (without flowers) and generative (flowering) individuals. The share of vegetative individuals ranged from 0 to 30 %, with a mean value of 16.4 ± 2.3 %, but variation was very high as confirmed by the coefficient of variation (60 %). The share of generative individuals ranged from 70 to 100 (mean 83.5 ± 2.3 %), but the coefficient of variation was considerably lower (12 %) (Table 3). The presence of both generative and vegetative individuals indicated an ongoing process of natural regeneration, probably both vegetative and by seeds. No special observations were made on the sex ratio of dioecious *R. rosea*, but the overall impression was that there were enough male and female plants, especially in the larger subpopulations, thus providing sufficient opportunities for a normal pollination process. Richards (1988) had observed a predominantly male sex ratio in the species (1.56:1) growing on the sea cliffs in Northwest Scotland. Prokopyev & al. (2021) reported significant differences between male and female plants in a number of morphometric traits but did not record the sex ratio within the studied populations.

Table 3. Share (%) of the vegetative and generative individuals in the local populations

Population No	Vegetative individuals (%)	Generative individuals (%)
1	2	98
2	11	89
3	11	89
4	26	74
5	25	75
6	26	74
7	25	75
8	29	71
9	30	70
10	0	100
11	13	87
12	18	82
13	22	78
14	12	88
15	29	71
16	24	76
17	4	96
18	8	92
19	2	98
20	11	89
Mean ± SE (Coefficient of variation)	16.4 ± 2.3 (60 %)	83.5 ± 2.3 (12 %)

Natural habitats

Almost all Golden Root localities in Bulgaria could be classified as part of two Natura 2000 habitats (Council Directive 92/43/EEC): 8110 – Siliceous scree of the montane to snow levels, and 8220 – Siliceous rocky slopes with chasmophytic vegetation. In most cases, the local populations were situated in both habitats, which were being often adjacent to each other. There were two exceptions: one local population occurred on limestone and its habitat was classified accordingly as 8210 – Calcareous rocky slopes with chasmophytic vegetation, and another local population has got into habitat 4070 – Bushes with *Pinus mugo*. No geobotanical or phytosociological descriptions were made but simple observations confirmed the predominant species composition for the respective habitats as described in Kavrakova & al. (2009).

When considering the threats to the species, usually two groups have been identified: natural and anthropogenic. The natural threats could be of abiotic and biotic nature. The following main abiotic threats were identified:

– Heavy rainfalls and storms, leading to eradication of individual plants.

– Frosts and snowfalls during the flowering period, compromising the seed formation. This threat is occasional in character and of low importance.

– Avalanches could occur in some localities situated in the avalanche zones.

– Soil erosion occurred naturally due to orography.

All these threats are part of the natural disturbance regime in the alpine and subalpine zones and, therefore, are of low to moderate importance. They entail mostly disintegration of the vegetation and/or soil cover by avalanches and/or erosion, but usually at an extent of few m^2, which does not pose serious threats to the species.

No serious threats due to biotic factors were identified. Some insignificant damages caused by insects and pathogens were recorded in seven of the localities, but were of no importance for the health status of the subpopulations, which was evaluated as very good.

Occasional anthropogenic threats resulted from the proximity of tourist hiking trails and affected the local populations near the lakes Dalboko and Banderishko Ribno. However, only isolated examples of collecting rhizomes and above-ground parts for medicinal purposes were recorded.

The nature conservation status of *R. rosea* was evaluated as favorable. Different criteria and groups of indicators were considered. The area occupied by the species and local population sizes were evaluated as constant and, in some cases, slightly expanding. The same trend was recorded concerning the habitats with occurrence of *R. rosea*. Population structure, expressed by the ratio of generative to vegetative individuals was evaluated as appropriate for successful natural regeneration, and finally, the identified threats were evaluated as having very little, if any, negative effects on the local populations of *R. rosea* in Pirin. Therefore, the final assessment yielded a favorable nature conservation status of the species.

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