Nature conservation status of *Gentiana lutea* populations in the Pirin National Park

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Abstract. A survey of the natural localities and nature conservation status of *Gentiana lutea* was carried out in the Pirin National Park. Ten localities were included in the study, varying in size from few to several thousand individuals, while the occupied area ranged from 1 ha to 15 ha. The species has demonstrated viable populations and good abilities for natural regeneration. The subpopulations consisted both of generative and vegetative individuals, the vegetative ones predominating. No particular threats have been identified and the nature conservation status of the species was evaluated as favorable.

Key words: Yellow Gentian, favorable status, subpopulations, threats

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Introduction

The Yellow Gentian (*Gentiana lutea* L., *Gentianaceae*) is a valuable medicinal plant of high conservation value. It has been used for centuries in the traditional medicine and its properties and biological activity have been highly valued in modern pharmacology (see Ponticelli & al. 2022, for review). Due to its importance, the plant has been subjected to extensive studies related to its ecology and distribution (Peev & al. 2018), embryology (Yankova-Tsvetkova & Yurukova-Grancharova 2009), breeding systems (Kozuharova 1998), chemical composition, biologically active substances (Petrova & al. 2019, Karalija & al. 2021; Ponticelli & al. 2022), and *in vitro* propagation (Petrova & al. 2006).

Gentiana lutea is a traditionally used and popular medicinal plant: its roots are listed in the *European Pharmacopoeia*. Information on wider use of the aboveground parts of the species describes them as a natural preservative and antimicrobial agent (Karalija & al. 2021). The high demand in the raw material of *G. lutea* cannot be met by collection in its natural localities due to the conservation status of the species. Therefore, its future use in medicine and pharmaceutical industry would strongly depend on the development of efficient methods for its cultivation. (Radanović & al. 2014). Successful cultivation is a difficult task because of the specific ecological characteristics of the species (a psychrophyte adapted to high amplitudes of daily temperature, and low tem-

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peratures during most of the year), but it is the only way to sustain the increasing demand in raw material (Radanović & al. 2014, Marković & al. 2019).

The species is considered endangered in Bulgaria and thus is included in the *Red List of Bulgarian vascular plants* (Evstatieva 2009) and in the *Red Data Book of Bulgaria* (Evstatieva 2015) as Endangered [EN B1ab(ii,iii,iv,v)+2ab(ii); C2a(i)]. It is also protected by the Biodiversity Act of Bulgaria (Anonymous 2002). The main threat comes from the traditional use of the roots for medicinal purposes resulting in eradication of whole plants.

Natural distribution of the Yellow Gentian in Bulgaria is restricted to the high-mountain belts of five floristic regions: the Balkan Range, Mt Vitosha, Pirin Mts, Rila Mts, and Rhodopi Mts. Roughly, within the altitudinal range of 1500-2200 m. Its habitats lie usually above the alpine timberline or in the meadows within the forest belt (Peev & al. 2018). The species frequently occurs on steep slopes, occasionally exceeding 45° (Evstatieva 2015). The most extensive natural localities and the amplest stock of the species are in the Rila and Stara Planina Mts, while in the Pirin and Rhodopi Mts it is represented by a relatively smaller number of populations (Evstatieva 2015). Therefore, the current status of *G. lutea* populations in the Pirin Mts is of particular interest in relation to their conservation and sustainable use as a source of genotypes for future cultivation. Along with the assessment of the population status, it is particularly important to identify the threats to the populations, in order to design appropriate conservation measures. The objective of the present study is to assess the natural resources and nature conservation status of *G. lutea* on the territory of the Pirin National Park.

Material and methods

Ten natural localities of *G. lutea* on the territory of the Pirin National Park were included in the study. They were selected after a preliminary inventory by transects in the northern part of the Park. Six populations were in the Banderitsa Glacial Circus and four in the Bayuvi Dupki region. Most localities were not effectively isolated from each other and it was more realistic to consider the subpopulations of the large populations of the species in the Park, hereafter to be referred to as subpopulations (Table 1).

The field studies were carried out in the period July-September 2014. The related methodology was the one applied to species with similar life-history characteristics (Savev 2022). The following environmental parameters were recorded for each subpopulation: area, altitude, bedrock, exposition, soil conditions, slope inclination, humidity, and light conditions. The recorded parameters of *G. lutea* populations were: population size, density, share of vegetative and generative individuals, health status, damages due to bi-

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

No	Name of the locality	Area (ha)	Geographic coordinates	Altitude (m)	Bedrock type
1	Kabata	2	41° 45‘ 38.26“ N; / E 23° 24‘ 58.90“	1970	Silicate
2	Dibokoto Dere	15	N 41° 45‘ 45.69“ / E 23° 25‘ 3.96“	2100	Silicate
3	Kazanite	2	N 41° 46‘ 20.2“ / E 23° 25‘ 27.2“	1950	Limestone
4	Byala Reka	2	N 41° 49‘ 14.3“ / E 23° 21‘ 02.5“	1920	Silicate
5	Padinata	1	N 41° 49‘ 26.9“ / E 23° 21‘ 24.2“	1840	Silicate
6	Dunino Kuche	10	N 41° 45‘ 20.0“ / E 23° 24‘ 42.8“	2000	Silicate
7	Puknata Skala	3	N 41° 45‘ 26.2“ / E 23° 24‘ 42.7“	2200	Silicate
8	Gyubrishteto	1	N 41° 45‘ 18.7“ / E 23° 24‘ 37.4“	2180	Silicate
9	Izgoryalata Bachiya	2	N 41° 45‘ 28.6“ / E 23° 24‘ 43.1“	2180	Silicate
10	Kabata-Premkata	1.8	N 41°48‘33.79“/ E 23°23‘49.14“	1905	Limestone

otic and abiotic factors, and possible threats. A special form was filled in for each locality, with information on all parameters and indicators of interest. The natural habitats with participation of *G. lutea* were identified according to Kavrakova & al. (2009), while the nature conservation status was determined following a modified model of Zingstra & al. (2009). Whenever applicable, the data were analyzed by the methods of descriptive statistics.

Results and discussion

Most of the identified local populations (about 60%) were situated on steep and very steep slopes (from 60° to 80°) and, consequently, were hardly accessible. The remaining 40% of the local populations were situated on slopes of 10°-20°. The exposition in all cases was northern (N) or northeastern (NE), which reflected the higher moisture availability in the soil. The average area occupied by the local populations was 3.98 ha, ranging from 1 ha in the localities of Padinata and Izgoryalata Bachiya to 15 ha in the locality Dibokoto Dere. Seven local populations had an area from 1 ha to 2 ha, one locality was situated on 3 ha, and two localities occupied areas of 10 ha and 15 ha, respectively. The localities lay close to tourist trails and were easily accessible. Their altitude ranged from 1840 m to 2200 m, 2024 m on the average. The exposition was shaded, mostly NE and N. Eight populations grew on siliceous bedrock and two on marble limestone. The soils were luvisols, with numerous stony aggregates, mostly humid. The illumination (light availability) also varied considerably: from 35% in the forest populations to 70% in the furrows with NE exposition. Individuals of *G. lutea* covered up to 10% of the ground.

The subpopulations size varied considerably (mean 3,8 ± 0,02). All subpopulations exhibited high vitality and good natural regeneration, both vegetatively and by seeds, with age structure dominated by vegetative (non-flowering) individuals. Their health status was very good, with minor damages inflicted by insects and/or pathogens.

The size of three subpopulations amounted to less than 200 individuals, four populations had between 200 and 500 individuals, one – between 500 and 2000 individuals, and two subpopulations were considerably larger, varying between 2000 and 5000 individuals (Table 2). Or, more specifically, the subpopulations size ranged from 82 (Padinata) to 4620 (Puknata Skala) and 4905 individuals (Dibokoto Dere).

The subpopulations density varied from 82 ind. ha^{-1} (Padinata) to 571 ind. ha^{-1} in the furrows near Gybrishteto locality. In four subpopulations, it was within the range of 100-200 ind. ha^{-1}, in three exceeded 300 ind. ha^{-1}, and in two it was below 100 ind. ha^{-1} (Fig. 1). The great variations indicated that the mean values were not sufficiently informative for charac-

Fig. 1. Subpopulation density (ind. ha^{-1}).

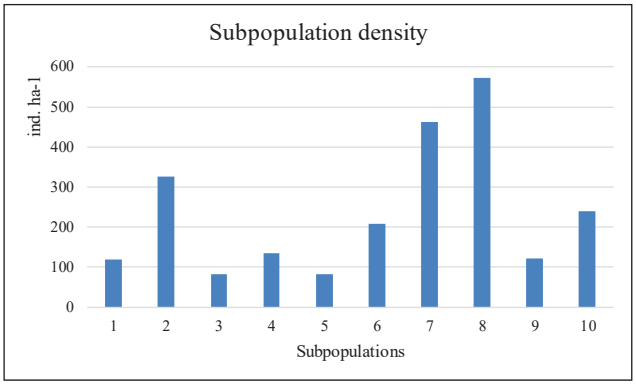

Table 2. Size and density of the studied subpopulations.

Subpopulation size (ind.)	No of subpopulations	Subpopulation density (ind. ha^{-1})	No of subpopulations
<200	3	<100	2
200-500	4	100-200	4
500-2000	1	200-300	1
2000-5000	2	>300	3

terization of the population status. Instead, size and density classes could be used.

Natural regeneration was observed in all subpopulations. They all had vegetative and generative (flowering) individuals. Juvenile individuals were recorded in only two subpopulations. Vegetative individuals predominated in all subpopulations, their percentage share varying from 55.8% to 82.9%, a mean 71.2%. The coefficient of variation was more than twice higher for the percentage of generative individuals (Table 3).

The subpopulations of *G. lutea* were situated in two types of natural habitats (Directive 92/43 EC): forests and grassland. The grasslands were represented by habitat 62D0 Oro-Moesian acidophilous grasslands, and the forest habitat was dominated by *Pinus peuce* Griseb. and *P. heldreichii* Christ. (habitat 95A0 High Oro-Mediterranean pine forests). In both cases, the vegetation cover was dense: between 70% and 90%. There were no detailed geobotanical and phytosociological descriptions, but a preliminary inventory revealed that the floristic composition in both habitats corresponded to the one described in Kavrakova & al. (2009).

Surveys of the possible threats to the natural localities of *G. lutea* have shown that in seven localities some individuals could be damaged by avalanches, heavy rainfalls and storms entailing soil erosion and eradication of single plants. Late frosts and snowfalls during the flowering period could compromise the propagation of seeds. However, such threats have been considered insignificant due to their rare occurrence. Change of character of the plant community was observed in one locality invaded by *Chamaecytisus absinthioides* subsp. *balcanicus*, where natural regeneration was embarrassed. Most of these threats were part of the natural regime of the alpine and subalpine zones and, therefore, were of low to moderate significance.

Insignificant damages by insects and pathogens were recorded in 60% of the localities but they were of low magnitude and did not affect the generally very good status of the subpopulations. Anthropogenic pressure ensued from proximity of the subpopulations to the tourist routes and affected six subpopulations. However, only occasional collection of the above-ground parts was registered.

The nature conservation status of *Gentiana lutea* in the Pirin Mts was evaluated as favorable on the grounds of different development criteria (Zingstra & al. 2009). The area occupied by the species and the local population size were evaluated as constant, and in some cases as slightly increasing. Age structure of the population was regarded as promoting the natural regeneration and the identified threats were evaluated as of low significance.

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

Subpopulation No	Vegetative individuals (%)	Generative individuals (%)
1	73.75	26.25
2	73.29	26.71
3	74.09	25.91
4	55.76	44.24
5	82.92	17.08
6	70.12	29.88
7	68.30	31.70
8	77.23	22.77
9	69.79	30.21
10	72.65	27.35
Mean ± SE (Coefficient of variation)	71.79 ± 2.2 (9.7 %)	24.82t ± 2.2 (24.8 %)

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