

SAXIFRAGA AIZOIDES (SAXIFRAGACEAE) IN UKRAINE

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Abstract. *Saxifraga aizoides* L. is endangered in the Ukrainian Carpathians. It became extinct in the Chyvchyny Mts and its only remaining metapopulation in the Chornohora Mts is in gradual decline. The paper gives the exact location, morphological characters, population parameters and habitat conditions of the species in the Chornohora locality, and briefly discusses the main threat factors.

Key words: Carpathians, distribution, endangered species, extinction, peripheral population, *Saxifraga aizoides*

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INTRODUCTION

Saxifraga aizoides L. is an arctic-alpine species with a mostly ampho-Atlantic distribution (Hultén & Fries 1986). In Europe, in addition to the northern part of its range, the species has a disjunct distribution in the Pyrenees, Alps, Apennines, Carpathians, and mountains of the Balkan Peninsula (Fig. 1). Its Central European localities are confined primarily to high elevations in the subalpine, alpine and subnival zones (up to 3000 m a.s.l.), with some stations much lower in the mountains or even Prealpine lowlands (Meusel *et al.* 1965; Hultén & Fries 1986; Lutz *et al.* 2000). *Saxifraga aizoides* is a calcicole and mainly hygrophytous. It is restricted mostly to cold-water springs and riparian habitats or wet rocks. It is considered a pioneer species, which colonizes open sites with vegetation-free gravel (Raffl *et al.* 2007).

In the Carpathians the species occurs in all three (western, eastern, southern) parts of the mountain system in Poland, Slovakia, Ukraine and Romania (Webb & Gornal 1989; Jalas *et al.* 1999). It is red-listed as endangered in Ukraine (Kobiv 2009a). This paper is intended to clarify the distribution of *S. aizoides* in the Ukrainian Carpathians and to describe its population parameters, in order to establish level of threat to this species in the region and to provide the baseline for further monitoring.

MATERIAL AND METHODS

I analyzed previous publications and herbarium data on *Saxifraga aizoides* before surveying its known localities *in situ*.

The results are from field research carried out in 1996, 2000 and 2014 in the Chornohora Mts and in 2012 in the Chyvchyny Mts, part of the Ukrainian Carpathians. Biometric data were acquired from 20 plants *in situ*; all measurements and descriptions refer to live plants.



Fig. 1. Distribution of *Saxifraga aizoides* L. in Europe, according to Meusel *et al.* (1965), Hultén and Fries (1986) and Jalas *et al.* (1999).

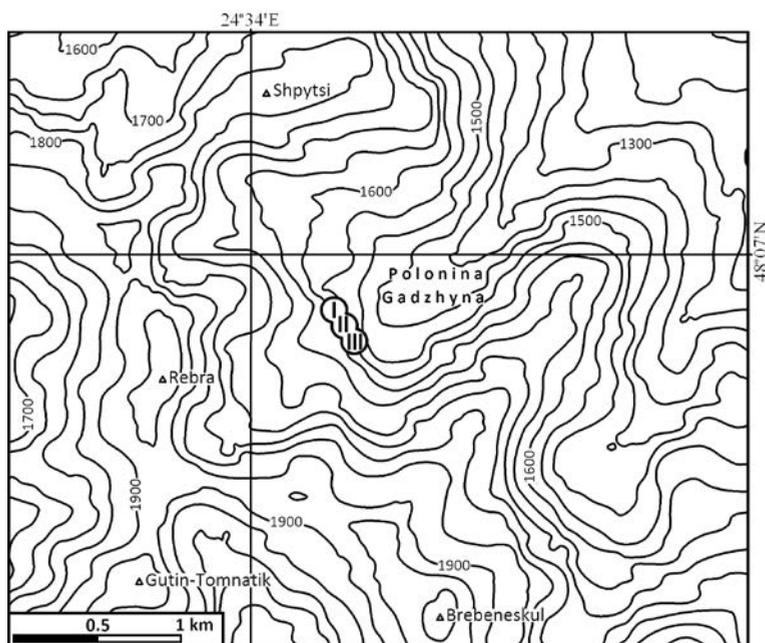


Fig. 2. Location of the metapopulation of *Saxifraga aizoides* L. in the Chornohora Mts. I–III – the largest subpopulations.

Population density was estimated from a set of 10 square plots, demarcated by randomly placing a 0.5×0.5 m² or a 0.1×0.1 m² frame ten times in different parts of a given subpopulation (Rabotnov 1964; Harper 1977). For species abundance, Table 2 uses Braun-Blanquet's (1965) scale. Exact site locations were determined in the WGS-84 system with a Garmin eTrex Global Positioning System (GPS) navigator (10 m accuracy). Calcium and magnesium content in soil was measured complexometrically, and pH(H₂O) electrometrically (Arinushkina 1970). Vascular plant nomenclature follows Mirek *et al.* (2002), and bryophyte nomenclature follows Hill *et al.* (2006).

RESULTS

DISTRIBUTION IN UKRAINE

In Ukraine, *Saxifraga aizoides* occurs only in the Carpathians, where its two localities are known. One was reported by Pawłowski (1948: 21) in the Chyvychny Mts, referring to Mądalski's finding of the species in the region. It is confirmed by two sheets collected in 1935 and 1936, stored in the Herbarium of the W. Szafer Institute of Botany,

Polish Academy of Sciences, Kraków, in Mądalski's personal collection (KRAM 48673–74). The labels indicate that it occurred at 1300–1323 m a.s.l. 'on a high limestone cliff located in spruce forest on the left bank of the southern stream which flows from Polonina Gropa on Mt. Hnytesa'.

My examination of that site in June 2012 indicated that the species does not occur there any more. The location of the site is certain because the mentioned limestone cliff is easily found, and the presence of other rare species [*Saussurea discolor* (Willd.) DC., *Saxifraga corymbosa* Boiss.] that J. Mądalski collected from the same cliff in the 1930s confirms that it is the right locality. Its geographic coordinates are 47°44'11.9"N, 24°54'07.1"E. My survey of the mentioned stream and nearby ones on limestone bedrock over a considerable range of elevation did not reveal any occurrence of *S. aizoides* in that area at present.

Another locality is at Polonina Gadzhyna in the Chornohora Mts (Fig. 2). It was first reported by Zapałowicz (1889), who stated that *S. aizoides* occurs there at 1570–1620 m a.s.l. Several herbarium samples have been collected since then.

It is now the only remaining locality of the species in Ukraine; the data given below refer to the Chornohora population.

MORPHOLOGICAL CHARACTERISTICS OF THE CHORNOHORA PLANTS

Saxifraga aizoides is an evergreen clonal perennial. Stems prostrate, branching, radicant, *ca* 1 mm in diameter, with ascending flowering and vegetative shoots in their distal parts. Proximal (>1-year-old) creeping parts of stems leafless, black, with sparse adventitious roots. Vegetative shoots 2.5–8.0 cm high, flowering shoots 5.5–13.5 cm high, densely foliate. Leaves alternate, fleshy, sessile, persistent, 4–16 × 1.5–3.0 mm, oblong-lanceolate or linear-lanceolate, acute, apiculate or obtusate. Leaf surface lucid, glabrous. Margins entire, with occasional firm spinose hairs, often on the tips. Flowering stems with short glandular indumentum. Inflorescence a lax cyme, with 3–13 pentamerous flowers. Receptacle dark green, 2 mm high. Sepals free, greenish yellow, glabrous, glandular, broadly ovate, obtuse, 4.0–5.5 × 3.5–4.5 mm. Petals bright yellow with numerous pink spots, obovate or elliptic, longer than calyx, 4.5–6.5 × 2–3 mm in size. Stamina 10, as long or slightly longer than petals. Ovary semi-inferior, glabrous; carpels 2, broadly ovoid, greenish yellow, partly fused, flattened, with divergent 2.5–3.0 mm long styles and globose stigmas. Seeds brownish, oblong-ellipsoid, *ca* 1.0 × 0.5 mm in size.

POPULATION AND HABITAT CHARACTERISTICS

Saxifraga aizoides forms one metapopulation in the Chornohora Mts, consisting of several subpopulations of different size. They are confined

to the northeastern and eastern aspects of a steep conglomerate rocky face and its bottom (Fig. 2). At present the whole metapopulation forms a *ca* 200 m long intermittent chain of subpopulations restricted to a narrow range of elevation (1560–1575 m a.s.l.). In 1996 and 2000 the species distribution was significantly wider. Several outlying mats of it occurred much higher: at 1610 m a.s.l. on the banks of a small tarn in the lower part of a post-glacial cirque and on moist sites on its moraine slope. Zapałowicz (1889) stated that at the end of the 19th century the species occurred as high as at 1620 m a.s.l. there.

There are three large subpopulations covering >10 m² each, and *ca* 10 smaller and more or less isolated clusters of clones scattered in their vicinity. Easternmost subpopulation I is the largest. It stretches along a cold stream (Fig. 3) falling from a steep (60–70°) rock and forms a strip confined to the right bank now. At present the strip is *ca* 25 m long and its width does not exceed 6 m. In 1996 and 2000 the species occurred on both sides of the stream along a much longer strip (*ca* 40 m). Regression of the main population has been noted since 2000 at that locality (Table 1); it shows the most rapid decrease in the number of seedlings and flowering shoots. In consequence, the role of seed reproduction in population replenishment has declined. Due to that site's NNE aspect, strong shading from shrub vegetation, and proximity to the stream, microclimatic conditions there are the coldest among all the sites.

Another large subpopulation, the central one (II), is on a gentle slope at the base of a rock face *ca* 120 m east of subpopulation I. The species occurs next to a cold-water spring on a *ca* 15 × 5 m patch of gravel scree. The habitat is almost

Table 1. Dynamics of population characteristics of *Saxifraga aizoides* L. in subpopulation I in the Chornohora Mts.

Parameter	Year	
	2000	2014
Density of flowering shoots per m ²	332±18	178±11
Density of vegetative shoots per m ²	791±52	635±35
Ratio of flowering to vegetative shoots	0.42	0.28
Density of seedlings per m ²	2.42±1.90	0.65±0.05



Fig. 3. *Saxifraga aizoides* L. on a stream bank in the Chornohora Mts.

unshaded and is exposed to insolation for a large part of the day. The density of flowering shoots of *S. aizoides* is the highest there (687 ± 42 per m^2).

The next large easternmost subpopulation (III) is confined to another spring *ca* 70 away from the central one (II). This subpopulation, which covers *ca* $15 m^2$, is situated on a mossy open patch among subalpine scrub.

In all subpopulations, individual plants of *S. aizoides* form lax mats resulting from intensive vegetative proliferation. Annual clonal growth varies from 2.5 to 12.0 cm (mean 8.7 ± 0.4 cm). Repent, radicated parts of old shoots persist for several years and can reach up to 40 cm in length. The average size of the mats is *ca* 15×10 cm, and the largest of them cover $0.25\text{--}0.50 m^2$. Such mats are formed by one clone or several interwoven clones. The density of flowering shoots in the mats is 4.2 ± 0.3 on average but can reach 12 shoots per $100 cm^2$. The ratio of flowering to vegetative shoots ranges from 0.12 to 2.10 (mean 0.35).

Apparently the metapopulation is maintained mostly by vegetative reproduction. Seed-related replenishment takes place as well; there are some seedlings and immature plants at the locality.

The spatial contour of the Chornohora metapopulation is not constant: some small outlying mats may appear or die off *ca* 50–100 m away from the above-described large subpopulations. They establish in suitable wet microhabitats by seed dispersal from parental subpopulations. Production of viable seeds within a clone does not necessarily require allogamy, because self-pollination is common in *S. aizoides* (Raffl *et al.* 2007).

Fragments of mats can be pulled away by water flow and established on the bank downstream; I observed this in subpopulation I and it has also been reported from the Alps (Jenny-Lips 1948).

In the Chornohora Mts, *Saxifraga aizoides* is restricted to *Cratoneuro-Saxifragetum aizoidis* hygrophytous riparian or spring communities belonging to the *Cratoneurion commutati* alliance (Matuszkiewicz 2001) with high abundance of bryophytes (Table 2). This association is not mentioned in Malynovski and Kriesfalusy's (2002) prodrome of high-mountain vegetation of the Ukrainian Carpathians, as no phytosociological relevés were ever made at the locality earlier.

The measured soil parameters in the habitats of the large subpopulations do not vary significantly and are as follows: pH(H_2O) 5.94–6.08; calcium content 7.91–8.32 mg-eq./100 g, and magnesium content 3.50–3.72 mg-eq./100 g. The calcium content of the conglomerate bedrock is not high; such a level of calcium in substrate is atypical for *S. aizoides* habitats.

DISCUSSION

Localities of *Saxifraga aizoides* in the Ukrainian Carpathians are confined to the northeastern limit of the Central European (alpine) part of the species range; its populations are peripheral (Fig. 1). The nearest known localities are in the Marmarosh and Rodna Mts in the Romanian Carpathians, not far from the Ukrainian border, at 1475–1850 m a.s.l. (Zapałowicz 1889; Răvăruț 1956).

Table 2. Floristic composition at localities of the largest subpopulations of *Saxifraga aizoides* L. in the Chornohora Mts.

Number of subpopulation	I	II	III
Geographic coordinates:	48°06'49.3"N 24°34'21.9"E	48°06'46.2"N 24°34'22.2"E	48°06'45.9"N 24°34'22.5"E
Date	10.07.14	10.07.14	10.07.14
Area of relevé (m ²)	25	25	10
Elevation (m a.s.l.)	1560–1575	1560	1565
Aspect	NNE	NE	NE
Inclination (°)	65	7	10
Cover of shrub layer (%)	15	5	10
Cover of herb layer (%)	30	40	30
Cover of moss layer (%)	30	30	40
DAss. <i>Cratoneuro-Saxifragetum aizoidis</i>			
<i>Saxifraga aizoides</i>	3	4	3
ChCl. <i>Montio-Cardaminetea</i>			
<i>Brachythecium rivulare</i>	2	2	3
<i>Bryum pseudotriquetrum</i>	3	1	+
<i>Epilobium alsinifolium</i>	1	1	.
OTHER SPECIES			
<i>Alchemilla glabra</i>	+	.	+
<i>Alnus viridis</i>	2	1	2
<i>Caltha laeta</i>	1	2	+
<i>Carex sempervirens</i>	.	1	1
<i>Deschampsia caespitosa</i>	1	2	2
<i>Heliosperma quadridentatum</i>	2	1	.
<i>Ligusticum mutellina</i>	1	+	2
<i>Pedicularis verticillata</i>	+	.	+
<i>Salix bicolor</i>	1	+	.
<i>Swertia punctata</i>	1	.	2
<i>Veratrum album</i>	+	+	1
<i>Campylium stellatum</i>	+	1	1
<i>Rhytidadelphus triquetrus</i>	.	+	1

SPORADIC SPECIES: *Bartsia alpina* III(+), *Cardamine pratensis* subsp. *rivularis* I(+), *Cirsium waldsteinii* III(2), *Crepis paludosa* III(1), *Juncus triglumis* I(+), *Rumex alpinus* II(+), *Salix silesiaca* III(1), *Tussilago farfara* III(+), *Viola biflora* I(+).

The Ukrainian locality of *S. aizoides* in the Chyvychny Mts was at an elevation (ca 1300 m a.s.l.) atypically low for the Eastern Carpathians, representing the lowermost limit of the species distribution in the region. Thus, its extinction at that locality may be due to climate change, in addition to past logging. Climate-induced extinctions of small populations of arctic-alpine species at the limits of their geographical and ecological ranges have been noted in different mountain systems (Lesica & McCune 2004; Marcysiak 2010). In the 20th and early 21st centuries, the significant decline or extinction of the following arctic-alpine

species have also been recorded in the Ukrainian Carpathians: *Dryas octopetala* L., *Hedysarum hedysaroides* (L.) Schinz. & Thell., *Pedicularis oederi* Vahl, *P. verticillata* L., *Oxyria digyna* (L.) Hill, and *Saxifraga oppositifolia* L. (Kobiv 2009b, 2011, 2013, 2014).

Another factor apparently contributing to the shrinking of the Chornohora population of *Saxifraga aizoides* is the gradual natural replacement of open patches of vegetation with shrubs [*Alnus viridis* (Chaix) DC., *Salix* spp.], resulting from a significant reduction of grazing at that locality. Similar secondary successional changes tending

toward restoration of primary vegetation after massive abandonment of traditional land uses (grazing and mowing) are taking place across vast tracts in mountains all over Europe (MacDonald *et al.* 2000), including the Carpathians (Kuemmerle *et al.* 2008). In the Ukrainian Carpathians this process threatens many herbaceous, mostly low-growing plants occurring at the edge of their range and confined to grasslands or other open communities, such as *Erigeron atticus* Vill., *Erysimum witmannii* subsp. *transsilvanicum* (Schur) P. W. Ball., *Festuca rupicola* subsp. *saxatilis* (Schur) Rauschert, *Minuartia verna* subsp. *oxypetalata* (Wol.) G. Halliday, *Potentilla thuringiaca* Link, *Sempervivum marmoreum* L., *Silene zawadzkae* Herbich, *Thlaspi dacicum* Heuff. and *Th. kovatsii* Heuff. (Kobiv 2014).

The locality of *Saxifraga aizoides* in the Chornohora Mts is not included in the reserve zone of Carpathian National Nature Park. Because the intensity of grazing at the site is very low recently, it is not a question of limiting pastoral pressure to prevent the further decline of its metapopulation. On the contrary, post-anthropogenic succession triggered by the decrease of grazing, as well as climate warming, are the main threats to the species.

Saxifraga aizoides is endangered in Ukraine. It has become extinct in the Chyvchyny Mts. Its only remaining metapopulation in the Chornohora Mts is in decline. The rate of that decline is slow, however, so its complete extinction at that locality cannot be expected in the mid-term perspective.

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