

Distribution and current status of mountain hawkweeds (*Hieracium*) populations in Mt. Králícký Sněžník

Patrik Mlčoch & Eliška Trčálková

Distribution and current status of mountain hawkweeds (*Hieracium*) populations in Mt. Králícký Sněžník.
– Acta Mus. Siles. Sci. Natur. 72: 260–282, 2023.

Abstract: Central European mountains are important diversity centers of the genus *Hieracium*. Here, we provide an account of the genus in supramontane to subalpine zones of summit parts of Mt. Králícký Sněžník, based on a detailed field inventory in 2021 and 2022. Ten species were recorded (*H. chrysostyloides*, *H. moravicum*, *H. nigritum*, *H. nivimontis*, *H. obscuratum*, *H. schustleri*, *H. stygium*, *H. uechtritizianum*, *H. murorum*, *H. lachenalii*), of which two (*H. moravicum* a *H. obscuratum*) were found here for the first time. New data about their ecology and habitat requirements are given and causes of their threat are discussed. The study also contains a summary of historical data relating to the locality.

Key words: *Hieracium*, mountain hawkweeds, ecology, Mt. Králícký Sněžník, alpine tundra

Introduction

National nature preserve Mt. Králícký Sněžník is located on the border of Olomouc and Pardubice Regions, on the border between the Czech Republic and Poland (AOPK 2014). Geologically, Králícký Sněžník belongs to the eastern part of the Lugicum region of the Bohemian massif. Specifically, it is located in the Orlica-Sněžník crystalline complex, and its rock composition consists of metamorphosed rocks, primarily ortho- and paragneisses, as well as migmatites, phyllites, schists, with lenses of crystalline limestones and dolomitic marbles (ibid.). Mt. Králícký Sněžník belongs to mainly cold area, average annual temperature is about 4 °C and 9 °C in growing season (ibid.). The area is very rich in precipitation with local differences. In terms of vegetation, Mt. Králícký Sněžník is more similar to the Hrubý Jeseník Mts. than to the Krkonoše Mts. *Pinus mungo* is naturally absent. *Ligusticum mutellina*, *Avenula planiculmis*, *Doronicum austriacum*, *Campanula barbata* are missing in the Krkonoše Mts., but they occur in the Jeseníky Mts. and in Mt. Králícký Sněžník. Very botanically rich is an avalanche pathway, created under the source of the Morava River (ibid.).

Arcto-alpine tundra is typical of many endangered plant species including endemic and relict species (Dančák 2004). In the Czech Republic there are three mountain ranges in the High Sudetes rising over the alpine timberline – the Krkonoše Mts. (with the highest point Sněžka, 1603 m a.s.l.), the Hrubý Jeseník Mts. and Mt. Králícký Sněžník. In the Krkonoše Mts. there is a large and well differentiated alpine area, five times bigger than the alpine area in the Hrubý Jeseník Mts. (Treml and Banaš 2000). Mt. Králícký Sněžník alpine area is a small enclave affected by summit phenomenon (Treml and Banaš 2000).

As indicator of original natural alpine area we consider plant communities (Treml and Banaš 2000). Their presence is caused by climatic extremes and periglacial phenomena on the highest peaks. Wind blown alpine grasslands with arcto-alpine species were formed on those ecotops (Treml and Banaš 2000). Arcto-alpine tundra is formed by biotic and abiotic (Körner 1999) (topography, soil characteristics, humidity and microclimate characteristic (Barrio et al. 1997)) factors, by its historical exploitation and by direct or indirect anthropogenic influences

(Körner 1999). In the last century, the alpine timberline artificially increased in consequence of afforestation and terminating pasture in the Hrubý Jeseník Mts. and in the Mt. Králický Sněžník (Treml and Banaš 2000). In contrast to the Krkonoše Mts., Mt. Králický Sněžník and the Hrubý Jeseník Mts. are also islands without native dwarf pine. (Treml and Banaš 2000).

Frequent plant species of arcto-alpine tundra are the hawkweeds (*Hieracium*). *Hieracium* s. str. is a highly diverse genus distributed mainly in temperate zones in Eurasia and North America (Fehrer et al. 2009). It is known for its taxonomical complexity, which is associated with variation in ploidy level, breeding system and most likely extensive hybridization in the past (Fehrer et al. 2009). Hawkweeds occupy forests, forest margins, various grasslands and rocks (Fehrer et al. 2009).

Hieracium is famous for its high diversity in European high mountain ranges, such as in the Pyrenees, Alps, Carpathians, mountain ranges in the Balkan Peninsula and in Scandinavia. In the Czech Republic high mountain (alpine) hawkweeds occur in the High Sudeties – in the Krkonoše Mts., Mt. Králický Sněžník and the Hrubý Jeseník Mts.

Many hawkweeds are endemic spectro more or less restricted mountain ranges. Outside the high mountain areas of the Alps and the Carpathians, endemic species are relatively rare in Central Europe (Krahulec 2006). The number of endemic species occurring in the Krkonoše Mts. is higher than in the mountain areas of the Hrubý Jeseník Mts. and Mt. Králický Sněžník, because the endemic taxa are concentrated in the summit parts and in the glacial cirques, which are the largest and most numerous in the Krkonoše Mts. (Krahulec 2006).

The alpine hawkweeds in the Czech Republic were studied by Wimmer and Grabowski for the first time in the 30. of the 19. century in the Hrubý Jeseník Mts. (Kocián & Chrtek 2017). The first studies in the Krkonoše Mts. go back to second half of the 19. century (Chrtek et al. 2007). Flora in Silesia and Moravia has been documented by several botanists. One of the most important one was Eduard Formánek (1845–1900), his crucial work is *Květena Moravy a rakouského Slezska* (1887). In this work, he proclaims Moravian botanist Adolf Oborny (1840–1924) and his repeated botanical journeys in South Moravia, in the Jeseníky Mts., Silesia, Carpathians, etc. A. Oborny summarized his findings in several works, hawkweeds, concretely, in *Die Hieracien aus Mähren und österr. Schlesien* (1905). Another Silesian botanist was Emil Fiek (1840–1897), his greater work is *Flora von Schlesien preussischen und österreichischen Anteils* (1881). Rudolf Uechtritz (1838–1886), honoured Silesian botanist of the 19. century, contributed to this work as well. He wrote *Die Vegetationslinien der schlesischen Flora part, he added status of flora occurring near Vratislav and part about hawkweeds* (Formánek 1887). Polish botanist Zbigniew Szeląg did floristic research in 1987–2000 in Mt. Králický Sněžník (Szeląg 2003). The Sudeten alpine hawkweeds were revised recently by J. Chrtek jun. (1997, 2004, Chrtek & Marhold 1998) in series of papers (Krahulec 2006). The alpine hawkweeds in the Hrubý Jeseník Mts. and in the Krkonoše Mts. have been very well examined and described. On the other hand, the alpine hawkweeds in Mt. Králický Sněžník have been studied just a few times and the status of populations is currently unknown.

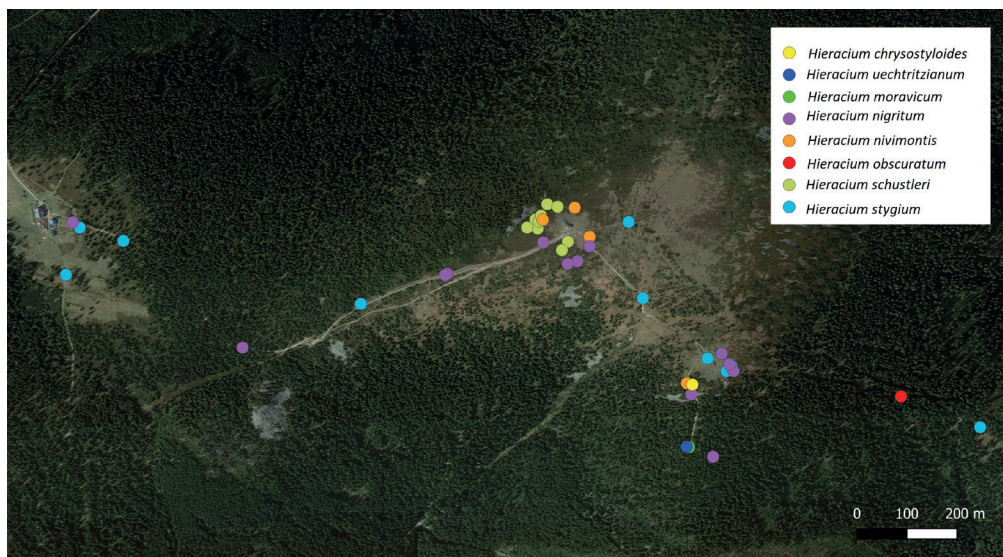


Fig. 1: Distribution of mountain hawkweed populations in the arco-alpine tundra of Mt. Králícký Sněžník. Data were collected in 2021 and 2022.

Materials and Methods

Data collection in the field

Data collection took place in Mt. Králícký Sněžník National Nature Reserve in the geomorphological area of the same name. The collection was mainly focused on the summit areas with primary forestlessness and on the grassy, disturbed edges of hiking trails in natural spruce forests at altitudes above 1100 m a. s. l., which are known for occurrence of mountain species of the genus *Hieracium* (Fig. 1). The sampling was divided into two years (2021 and 2022) and the date of the visit was chosen to best capture the phenology of all the species present here, it is 6. July 2021 and 23. July 2022. The sites were systematically explored on the Czech and Polish parts of the peak, including a revision of historical sites with the potential occurrence of some significant species. For all micropopulations, the number of plants was recorded, including sterile individuals. Subsequently, photo documentation and a preliminary determination of the plants were carried out. More significant finds were collected in the herbarium for detailed taxonomic study. The collection of plant material was carried out only in micropopulations with a frequency of 3 or more individuals, and at the same time the plants were collected without the underground part.

Determination of collected material

The plants were determined using the Key to flora of the Czech Republic (Kaplan et al. 2019) and Flora of the Czech Republic (Chrtěk 2004). The more significant and taxonomically more complicated collections were revised by J. Chrtěk. Voucher specimens are preserved in herbaria OL (Department of Botany, Palacký university in Olomouc) and NJM (Museum Novojičinska, Nový Jičín).

Statistical analyses

The basic statistical file was exported from Excel to the R Studio interface. Here was performed a basic statistical summarization of the results, which could then be visualized using the ggplot2 library (Wickham 2016) and basic R functions. For analyzing the habitat preferences of specific species, it was first necessary to determine and then classify the habitat in which the specific subpopulations were located. For this reason, the GPS coordinates were first converted into a GPX script, which was imported into the QGIS interface. Here, habitat mapping layer by the Nature Conservation Agency (AOPK ČR 2022) was used and the GPS coordinates were interpolated with this layer. Based on the locations of the micropopulations corresponding to the QGIS layer and on the basis of our own field observations, the biotope for each recorded micropopulation (n=49) was then precisely determined. Subsequently, a matrix of samples and species was created and the proportional and absolute representation of recorded species for individual biotopes was calculated. Furthermore, a distribution analysis of micropopulations was carried out using geographical coordinates with the rendering of their real sizes.

From the abundance matrix of species micropopulations in biotopes, principal component analyzes (tb-PCA) were performed in multidimensional space after Hellinger transformation of values. After visualizing the basic coordinates in the ordinal space, the corresponding vector coordinates were subsequently calculated, which were subsequently plotted in the PCA space. The Hellinger transformation of the values was performed using the vegan library (Oksanen et al. 2020), linear unconstrained ordination with used basic R functions.

Results

Recently confirmed species

Hieracium chrysostyloides (Zahn) Chrtek f. – Fig. 2, Tab. 1

This species is endemic to summit parts of Mt. Kralický Sněžník Mts and the Hrubý Jeseník Mts (Chrtek 2004). It occurs scattered to rare in the subalpine level. Previously, this species was scattered throughout the main ridge of Hrubý Jeseník Mts, but currently it is extinct in many localities (Kocián & Chrtek 2017). At Mt. Kralický Sněžník, only three plants were recently recorded at one site (this study). Historically, there are only three herbarium specimens collected by Oborny in 1886 and 1899 and determined as *H. eximium* from (Pladias 2023).

Herbarium specimens: 1. Kralický Sněžník Mts., Dolní Morava, at the edge of tourist trail between blueberries, 90 m southwest of elephant statue, 15. 7. 2021, GPS: 50.2031694N, 16.8505411E, leg. and det. P. Mlčoch, rev. J. Chrtek, herbarium OL.

Historical distribution: Oborny (1906): see *H. eximium*. Szelaġ (2003): summit part of the Kralický Sněžník hill, 1400–1420 m, high mountain rubbles with *Festuca airoides* and *Calluna vulgaris*, 30–40 flowering plants.



Fig. 2: *Hieracium chrysostyloides* on the edge of tourist trail in the blueberries. 15. 7. 2021, photo: P. Mlčoch. In bottom right detail of involucre.

Tab. 1: Current distribution of *Hieracium chrysostyloides* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'11.410"N, 16°51'1.948"E	2	1	15.07.2021	On the edge of tourist trail between blueberry	OL

***Hieracium moravicum* Oborny** – Tab. 2

Kocián and Chrtěk (2017) report this species as endemic to supramontane and subalpine belts of the Hrubý Jeseník Mts and some areas of the Carpathians. In the Hrubý Jeseník Mts, this species grows very rarely on Mt. Keprník (leg. R. Albín) and Mt. Červená Hora (leg. J. Chrtěk). Historically, it is documented e. g. from Ovčárna (Kocián & Chrtěk 2017). Here we present the first locality in Mt. Kralický Sněžník. The species was found here in the supramontane belt at the edge of the tourist path in a blueberry forest, where a relatively rich population of 33 individuals was recorded. The biotope site corresponds to other known sites in the Hrubý Jeseník Mts (e.g. Chrtěk 2004).

Herbarium specimens: 1. Kralický Sněžník Mts., Staré Město, on the edge of tourist trail, 260 m S of elephant statue, 23. 7. 2022, 1325 m a. s. l., GPS: 50.2014195N, 16.8504440E, leg. and det. P. Mlčoch, rev. J. Chrtěk. Herbarium OL.

Tab. 2: Current distribution of *Hieracium moravicum* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'5.110"N, 16°51'1.598"E	10	23	23.07.2022	On the edge of tourist trail, 260 m S of elephant statue	OL

***Hieracium nigratum* R. Uechtr.** – Fig. 3, Tab. 3.

In the supramontane and subalpine level of the Sudeten Mountains, a relatively a few widespread to rare species of mountain hawkweed, which is also relatively easy to recognize according to the color of the involucre, the peduncle and the stem (peduncles of head with scattered simple eglandular hairs between 1/3 to 1/5 blackish, with dense glandular hairs and numerous stellate hairs, phyllaries with scattered dark simple eglandular hairs and glandular hairs, on the edge with rarely phyllaries; Chrtěk 2004) and also according to the shape of the middle stem leaves. In the Kralický Sněžník Mts., a relatively common, but scattered growing species preferring grassy edges of hiking trails and subalpine sticks with blueberry. Oborny (1906) reported also *H. nigratum* subsp. *pseudoeximium*. However, its taxonomic value is still unknown, it probably represents only phenotypic plasticity of the species.

Herbarium specimens: 1. Kralický Sněžník Mts., Staré Město, on the edge of tourist trail, 118 m S of elephant statue, 1350 m, 15. 7. 2021, GPS: 50.2028942N, 16.8505117E, leg. and det. P. Mlčoch, rev. J. Chrtěk. Herbarium OL. 2. Kralický Sněžník Mts., Staré Město, on the edge of tourist trail, 125 m S of elephant statue, 1350 m, 15. 7. 2021, GPS: 50.2031694N, 16.8505411E, leg. and det. P. Mlčoch, rev. J. Chrtěk. Herbarium OL. 3. Kralický Sněžník Mts., Malá Morava, in the blueberries, 90 m S of Kralický Sněžník peak, 1415 m., 15. 7. 2021, GPS: 50.2066228N, 16.8473200E, leg. and det. P. Mlčoch, rev. J. Chrtěk. Herbarium OL.

Historical distribution: Oborny (1906): top part of Kralický Sněžník hill, Hala pod Sněžníkem (as *H. nigratum*). Diese, im Riesengebirge häufig vorkommende Pflanze, wächst im Gebiete mit Sicherheit nur auf dem Spiglitzer Schneeberge u. z. in einer niedrigen, breitblättrigen form mit kurzgestielten blättern, ferner auf dem silberkamm in den ostrudeten, zahn in koeh syn p 1889 (as *H. nigratum* subsp. *pseudoeximium*).



Fig. 3: *Hieracium nigritum*, 15. 7. 2021, photo: P. Mlčoch. Bottom left: detail of involucre.

Tab. 3: Current distribution of *Hieracium nigritum* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'25.349"N, 16°50'51.565"E	NA	1	15.07.2021		/
50°12'25.743"N, 16°50'46.890"E	NA	1	15.07.2021		/
50°12'23.580"N, 16°50'49.354"E	NA	1	15.07.2021		/
50°12'12.785"N, 16°51'6.115"E	NA	3	15.07.2021		/
50°12'10.419"N, 16°51'1.842"E	NA	3	15.07.2021	On the edge of tourist trail, 118 m S of elephant statue	OL
50°12'11.410"N, 16°51'1.948"E	NA	3	15.07.2021	On the edge of tourist trail, 125 m S of elephant statue	OL
50°12'23.842"N, 16°50'50.352"E	NA	3	15.07.2021	In the blueberries, 90 m S of Kralický Sněžník peak	OL
50°12.37623"N, 16°50.62008"E	0	1	06.07.2022		/
50°12.46275"N, 16°49.98989"E	0	2	06.07.2022		/

50°12.25243'N, 16°50.27587'E	0	1	06.07.2022		/
50°12.37415'N, 16°50.61640'E	0	1	06.07.2022		/
50°12.24208'N, 16°51.08170'E	6	7	06.07.2022		/
50°12.22396'N, 16°51.09459'E	0	4	06.07.2022		/
50°12.06897'N, 16°51.06710'E	0	1	06.07.2022		/
50°12.06897'N, 16°51.06710'E	0	1	23.07.2022		/

***Hieracium nivimontis* (Oborny et Zahn) Chrtek f.** – Fig. 4, Tab. 4.

It is an endemic species of Mt. Králický Sněžník Mts. (Chrtek 2004). It is scattered to very rare in the summit parts in altitudes between 1380 and 1423 m a. s. l. in alpine tundra vegetation. Populations were previously referred to as *H. nigrescens* or *H. eximium* (Oborny 1906; Chrtek 2004). This species was first recorded here by Oborny (1899, 1907), later by Schustler (1919) (Pladias 2023). The species forms a very small population, therefore its occurrence was considered questionable for a long time. In 2016 it was rediscovered by M. Banaš, V. Husek and M. Zeidler in the area of the ruins of the old Liechtenstein cottage (Husek 2017). Due to the subsequent removes of the ruins, a significant part of the original population on the rubble was reintroduced to another locations in the summit parts of Mt. Králický Sněžník, but the remaining population still survives on the rocks near the lookout tower. Not all reintroduced individuals were this species. This species requires taxonomic and molecular revision. It resembles *H. chrysostyloides* but differs by more numerous glandular hairs on the peduncles, darker tips and scars with numerous simple trichomes. The stem usually bears only one inflorescence, the number of lobed stem leaves is variable.

Herbarium specimens: 1. Kralický Sněžník Mts., Malá Morava, in the subalpine vegetation, rocks cca 50 m W from lookout tower at the top, 15. 7. 2021, GPS: 50.2077858N, 16.8463467E, leg. and det. P. Mlčoch, rev.J. Chrtek. Herbarium OL. 2. Kralický Sněžník Mts., Malá Morava, on the edge of tourist trail between blueberry, 90 m southwest of elephant statue, 6. 7. 2022, GPS: 50.2032064N, 16.8503844E, leg. and det. P. Mlčoch, rev.J. Chrtek. Herbarium OL.

Historical distribution: Szelağ (2003): top part of the Kralický Sněžník hill, 1400–1420 m, high mountain rubbles with *Festuca airoides* and *Calluna vulgaris*, 30–40 flowering plants.



Fig. 4: *Hieracium nivimontis* between blueberries in the subalpine zone of Mt. Králícký Sněžník, 6. 7. 2022, photo: P. Mlěoch. Above: view on the whole plant, at the top right: lower leaf, bottom: involucre view.

Tab. 4: Current distribution of *Hieracium nivimontis* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'26.313"N, 16°50'51.570"E	NA	1	15.07.2021	In the subalpine vegetation, 20 m S of Kralický Sněžník peak	/
50°12'28.029"N, 16°50'46.848"E	NA	3	15.07.2021	in the subalpine vegetation, rocks cca 50 m W from lookout tower at the top	OL
50°12'29.244"N, 16°50'50.069"E	11	3	06.07.2022	in the subalpine vegetation, cca 75 m N from lookout tower at the peak	/
50°12'11.543"N, 16°51'1.384"E	4	1	06.07.2022	on the edge of tourist trail between blueberry, 90 m southwest of elephant statue	OL

***Hieracium obscuratum* Murr** – Tab. 5.

A mountain species with an insufficiently known area of occurrence. In Slovakia, it grows scattered to rare, e.g. in the High Tatras Mts. (author's herbarium). This species was not previously known from Mt. Kralický Sněžník, the collection published here is the first documented find in the Eastern Sudetes. In the Czech Republic, this species is also known from the Šumava Mts and similar individuals were found also in the Krkonoše Mts (Kaplan et al. 2019). The site at the Kralický Sněžník is situated in the supramontane belt on the grassy edge of the tourist path, where several individuals were recorded.

Herbarium specimens: 1. Kralický Sněžník Mts., Staré Město, on the grassy edge of tourist trail near a Franciska – chata crossroad, 23. 7. 2022, 1250 m, GPS: 50.2028388N, 16.8563888E, leg. P. Mlčoch, det. J. Chrtek and P. Mlčoch. Herbarium OL.

Tab. 5: Current distribution of *Hieracium obscuratum* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'10.220"N, 16°51'23.000"E	0	5	23.07.2022	On the grassy edge of tourist trail near a Franciska – chata crossroad	OL

***Hieracium schustleri* Zlatník** – Fig. 5, Tab. 6.

This species from the *Hieracium alpinum* aggregate is well determinable according to its scaly stem leaves with numerous stalked glands, irregularly toothed leaves and brownish styles (Chrtek 2004). In Mt. Kralický Sněžník Mts., this is the only species from the *H. alpinum* group that occurs here. *H. schustleri* is reported only from subalpine grasslands on Mt. Luční hora and Mt. Studniční hora in the Krkonoše Mts and from the top parts of Mt. Kralický Sněžník (Oborný 1906; Szeląg 2003; Chrtek 2004). The population in Kralický Sněžník Mts. is limited only to the alpine tundra area in the altitudinal range of 1400–1420 m a. s. l. Szeląg (2003) reports a population of 20–30 flowering plants. In this study, four flowering plants were recorded in 2021 and nine flowering plants in 2022. Due to

the extreme climatic conditions, however, a large number of plants always remain sterile during one season, so it is methodologically impossible to estimate the total size of the population unambiguously.

Herbarium specimens: 1. Kralický Sněžník Mts., Malá Morava, arcto-alpine tundra, rocks W of the newly built lookout tower, 1410 m a. s. l., 15. 7. 2021, GPS: 50.2077858N, 16.8463467E, leg. and det. P. Mlčoch, rev. J. Chrtek, Herbarium OL.

Historical distribution: Oborny (1906): Selten, bisher nur auf dem Spiglitzer Schneeberg (as *H. alpinum* subsp. *calenduliflorum*). Szélag (2003): top part of Kralický Sněžník hill, 1400–1420 m.

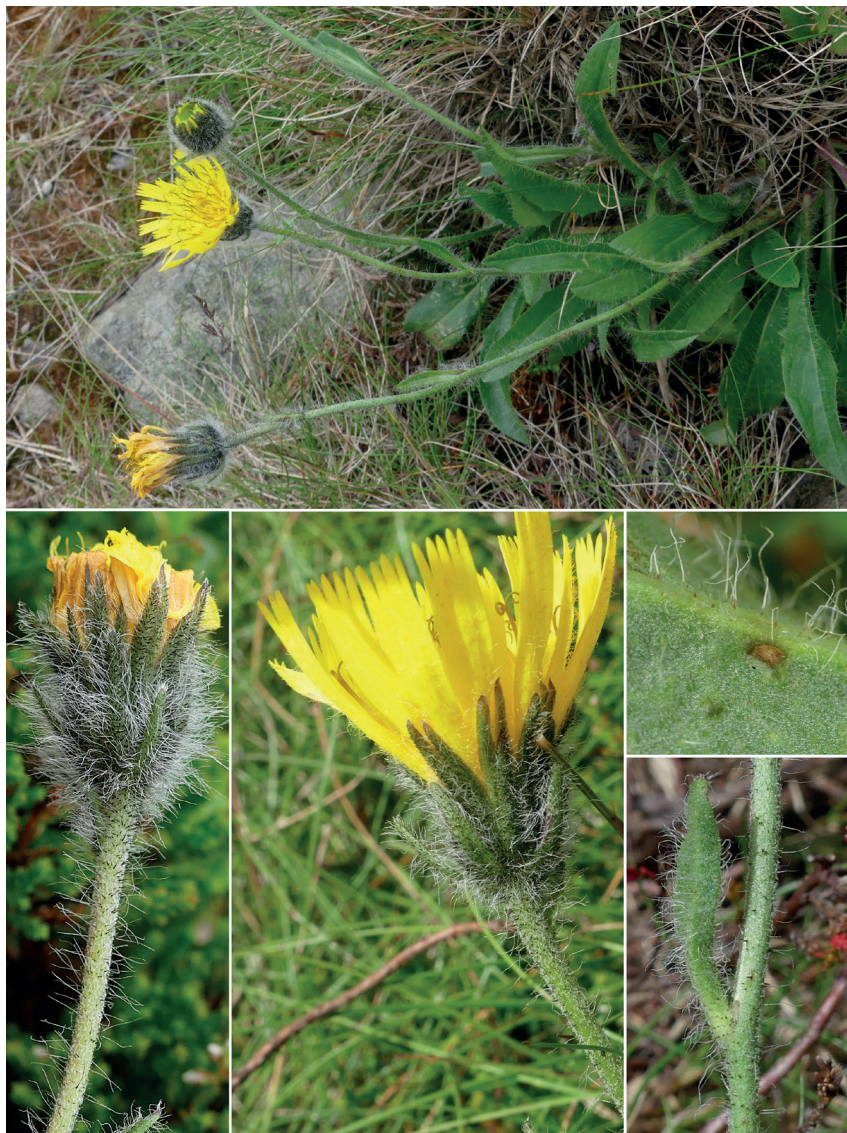


Fig. 5: *Hieracium schustleri* in the arcto-alpine tundra on the top of Mt. Králický Sněžník, 15.7.2021, photo: P. Mlčoch. Above: view on the whole plant, the bottom left and centre: involucre, right: detail of the hairs on the lower side of leaf and view on the stem lobed leaf.

Tab. 6: Current distribution of *Hieracium schustleri* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'25.812"N, 16°50'49.380"E	NA	1	15.07.2021	In the arcto-alpine tundra on the peak of hill	/
50°12'24.965"N, 16°50'48.776"E	NA	1	15.07.2021	In the arcto-alpine tundra on the peak of hill	/
50°12'28.029"N, 16°50'46.848"E	NA	3	15.07.2021	In the arcto-alpine tundra on the peak of hill	OL
50°12'28.040"N, 16°50'46.103"E	0	2	06.07.2022	In the arcto-alpine tundra on the peak of hill	/
50°12'27.146"N, 16°50'46.330"E	NA	1	06.07.2022	In the arcto-alpine tundra on the peak of hill	/
50°12'27.240"N, 16°50'45.265"E	NA	1	06.07.2022	In the arcto-alpine tundra on the peak of hill	/
50°12'27.863"N, 16°50'46.465"E	NA	1	06.07.2022	In the arcto-alpine tundra on the peak of hill	/
50°12'28.431"N, 16°50'46.672"E	NA	1	06.07.2022	In the arcto-alpine tundra on the peak of hill	/
50°12'29.584"N, 16°50'47.296"E	NA	1	06.07.2022	In the arcto-alpine tundra on the peak of hill	/
50°12'29.333"N, 16°50'48.344"E	NA	1	06.07.2022	In the arcto-alpine tundra on the peak of hill	/

***Hieracium stygium* R. Uechtr.** – Fig. 6, Tab. 7.

One of the most common hawkweed species of the subalpine belt of the Eastern Sudetes and the Western Carpathians (Chrtek 2004). It is distributed here in many different biotopes (graph 2). This species grows in Mt. Kralický Sněžník very often in relatively numerous subpopulations on alpine sticks, in shrubby vegetation, among blueberries, but also in places with recent disturbance. A well-recognizable species by the shape of middle stem leaves (which are often slightly clasping) and the involucre, which is very covered with dense glandular hairs and scattered short simple hairs with a dark lower half. The species is often confused with *H. lachenalii*, but the latter rarely reaches the arcto-alpine tundra, populations were only recorded in the montane and supramontane areas of Mt. Kralický Sněžník.

Studied herbarium material: 1. Kralický Sněžník Mts., Staré Město, grassy edge of red tourist trail near a Franciska – chata crossroad, 13. 8. 2012, 1225 m, GPS: 50.2020556N, 16.8582778E, leg. and det. J. Kocián, Herbarium NJM. 2. Kralický Sněžník Mts., Malá Morava, grassy edge of green tourist trail to 30 m SE of Schronisko na Sněžniku,

13. 8. 2012, 1220 m, GPS: 50.2077778N, 16.8331389E, leg. and det. J. Kocián, Herbarium NJM. 3. Kralický Sněžník Mts., Staré Město, the grassy edge of the yellow hiking trail, turnoff to the mountain service hut, 1250 m, 28. 7. 2008, GPS: 50.2028611N, 16.8560278E, leg. and det. J. Kocián, herbarium NJM.

Herbarium specimens: 1. Kralický Sněžník Mts., Staré Město, grassy edge of red tourist trail 200 m under a Franciska – chata crossroad, 15. 7. 2021, 1225 m, GPS: 50.2019764N, 16.8586100E, leg. and det. P. Mlčoch, rev. J. Chrtek, Herbarium OL. 2. Kralický Sněžník Mts., Staré Město, on the edge of tourist trail between blueberry, 250 m southwest of elephant statue, 6. 7. 2022, 1325 m, GPS: 50.2014194N, 16.8504439E, leg. and det. P. Mlčoch, rev. J. Chrtek, Herbarium OL.

Historical distribution: Oborný (1906): auf Spiglitzer Schneeberg. Szeląg (2003): locus classicus – Hala pod Snieznikiem, 100 flowering plants, high mountain rubbles and grasses with *Nardus stricta*.



Fig. 6: *Hieracium stygium* near the Elephant statue, 6.7.2022, photo: P. Mlčoch. Above: view on the whole plant, bottom right and left: involucre, bottom middle: middle stem leaf.

Tab. 7: Current distribution of *Hieracium stygium* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
NA	NA	3	15.07.2021	on the edge of red tourist trail between blueberry, under of elephant statue	/
50°12'12.768"N, 16°51'5.388"E	NA	15	15.07.2021	Near the elephant statue	/
50°12'13.328"N, 16°51'5.859"E	NA	3	15.07.2021	Near the elephant statue	/
50°12'13.328"N, 16°51'5.859"E	NA	3	15.07.2021	Near the elephant statue	/
50°12'14.053"N, 16°51'3.468"E	NA	1	15.07.2021	40 m W of elephant statue	/
50°12'7.115"N, 16°51'30.996"E	NA	3	15.07.2021	grassy edge of red tourist trail 200 m under a Franciska – chata crossroad	OL
50°12'7.115"N, 16°51'30.996"E	NA	3	15.07.2021	grassy edge of red tourist trail 200 m under a Franciska – chata crossroad	OL
50°12'20.113"N, 16°50'56.953"E	0	3	06.07.2022	50 N of the Morava spring, grassy edge of red tourist trail	/
50°12'19.544"N, 16°50'28.482"E	0	2	06.07.2022	Edge of red tourist trail, 220 m over Vlačstovčí kameny rock	/
50°12'22.482"N, 16°49'58.719"E	0	1	06.07.2022	Meadow spring near the Schronisko Na Sněžniku	/
50°12'27.232"N, 16°50'0.115"E	0	20	06.07.2022	near the Schronisko Na Sněžniku	/
50°12'25.887"N, 16°50'4.518"E	0	10	06.07.2022	near the Schronisko Na Sněžniku, edge of green tourist trail	/
50°12'27.797"N, 16°50'55.508"E	0	1	06.07.2022	Polish part of Kralický Sněžník peak	/
50°12'13.438"N, 16°51'5.675"E	0	30	06.07.2022	Near the elephant statue	/
50°12'5.110"N, 16°51'1.598"E	23	10	06.07.2022	on the edge of tourist trail between blueberry, 250 m southwest of elephant statue	OL

***Hieracium uechtritizianum* Gus. Schneid. – Fig 7., Tab. 8.**

The only species from the *H. fritzei* aggregate that was recorded at the Kralický Sněžník Mts. It is an endemic species found very rarely only in Kralický Sněžník Mts. and at several localities in the Krkonoše Mts. in the subalpine belt. This species grows in the summit partitions in the Kralický Sněžník Mts., but does not form very rich populations. In this study, it was recorded only at one site on the edge of the tourist trail. Due to the abundance of plants on the site, this is a rare species threatened with extinction.

Herbarium specimens: 1. Kralický Sněžník Mts. Staré Město, On the edge of red tourist trail under of elephant statue, 15. 7. 2021, 1325 m, GPS: 50.2014300N, 16.8503819E, leg. and det. P. Mičoch, rev. J. Chrtek, Herbarium OL.

Historical distribution: Oborny (1906): Sehr selten, mit Sicherheit nur auf dem Spiglitzer Schneeberge (as *H. fritzei*). Szelağ (2003): top part of Kralický Sněžník hill.



Fig. 7: *Hieracium uechtritizianum*, 15. 7. 2021. Above: view on the whole plant, bottom left: involucre view, bottom right: middle stem leaf.

Tab. 8: Current distribution of *Hieracium uechtritizianum* populations in the Kralický Sněžník Mts.

GPS	Number of sterile plants	Number of flowering plants	Date	Notes	Herb.
50°12'5.148"N, 16°51'1.375"E	1	3	15.07.2021	On the edge of red tourist trail under of elephant statue, 1325 m a. s. l.	OL

Historically recorded species

Hieracium atratum Fr.

A mountain species situated morphologically between *H. murorum* and *H. nigrescens*, common in the Krkonoše Mts. In Hrubý Jeseník Mts., it has only a few micro-localities in Mt. Keprník. It was collected in Mt. Kralický Sněžník Mts. Oborny (1906), Szeląg (2003) and recently also by J. Kocián. Occurrence in Mt. Kralický Sněžník is probably very rare, it has not been recorded at the locality of J. Kocián.

Studied herbarium material: 1. Kralický Sněžník Mts., Staré Město, the grassy edge of the yellow hiking trail, turnoff to the mountain service hut, 1250 m, 28. 7. 2008, GPS: 50.2028611N, 16.8560278E, leg. and det. J. Kocián (as. *cf. atratum*), herbarium NJM.

Historical distribution: Oborny (1906): Selten, bisher nur auf dem Spiglitzer Schneeberg. Szeląg (2003): the top part of the mountain.

Hieracium decipiens Tausch

Oborny (1906) reported it as very rare in summit parts of Mt. Kralický Sněžník, but new field research did not confirm the occurrence. It was probably a confusion with the very similar *H. nivimontis*.

Historical distribution: Oborny (1906): Sehr selten, bisher nur auf dem Spiglitzer Schneeberg.

Hieracium eximium Backh.f.

Oborny (1906) reports a scattered population of plants with dark stigmas from Mt. Kralický Sněžník, usually growing in groups. However, this species does not grow in Central Europe, it was a confusion with the similar species *H. chrysostyloides* from the same aggregate (Pladias 2023).

Historical distribution: Oborny (1906): Zerstreut, meist truppweise am Spiglitzer Schneeberg, auf dem Spiglitzer Schneeberg die typische form mit dunkelen Griffeln.

Hieracium inuloides Tausch.

The species is reported as very rare in Mt. Kralický Sněžník is reported by a number of authors (Oborny 1906; Szeląg 2003; Chrték 2004). However, it was not found in this study when visiting the biotopes and localities described below. Currently, it can be considered extinct in the locality (pers. comm. J. Kocián).

Historical distribution: Oborny (1906): auf dem Spiglitzer Schneeberg, zarstreut; auf dem Spiglitzer Schneeberg (as *H. inoloides subsp. pseudostriatum*); Im Gebiete des Spiglitzer Schneeberges (as *H. striatum*). Szeląg (2003): top part of Kralický Sněžník hill, 1360 m, western slope with *Pinus mugo* and *Picea abies*.

Hieracium nigrescens Willd.

A species rarely found in the subalpine belt in the Krkonoše Mts. Probably an endemic of this mountain range. Oborny (1906) reported it as rare in Mt. Kralický Sněžník, but the plants probably refer to later described endemic *H. nivimontis*.

Historical distribution: Oborny (1906): Bisher nur auf dein Spiglitzer Schneeberg. Bisher nur auf dem Spiglitzer Schneeberg, eine andere form, die etwa die mitte zwischen *H. nigrescens* und *H. eximium* hält, wächst auf dem Spiglitzer Schneeberg.

***Hieracium prenanthoides* Vill.**

Oborny (1906) reported this species as rare in Mt. Králický Sněžník. Recently, Szélag (2003) did not record the distribution of this species and only mentions herbarium sheet in the Moravian Museum in Brno. Within this research, biotopes with potential occurrence of this species were visited, but none were found. Historically, this species was present on Mt. Králický Sněžník, but recently it is probably extinct here.

Historical distribution: Oborny (1906): Im Schneeberggebiete, Spiglitzer Schneeberg (as *H. prenanthoides* subsp. *bupleurifolium*); Am Glatzer Schneeberge (as *H. prenanthoides* subsp. *lanceolatum*). Szélag (2003): only in Moravian regional museum in Brno.

***Hieracium sudetotubulosum* Szélag**

Oborny (1906) state this species from summit parts of Mt. Králický Sněžník, but this information is incorrect. *H. sudetotubulosum* is probably endemic to the Krkonoše Mts. and the Jizerské hory Mts. (Chrtěk 2004). Its apparently never grew in Králický Sněžník Mts. and was most likely confused with *H. schustleri*.

Historical distribution: Oborny (1906): Bisher nur auf dem Spiglitzer Schneeberg, selten (as *Hieracium alpinum* subsp. *tubulosum*).

Biotope preferences and current status of populations:

Graph 1 visualizes the total relative number of individuals of specific species of the genus *Hieracium* recorded at Mt. Králický Sněžník Mts. in 2021 and 2022. In total, 298 individuals belonging to 10 different species and 3 individuals that were not taxonomically resolved and therefore could not be included in the concept of this study were recorded. *H. chrysostylioides* and *H. uechtritizianum* represent 1% (both 3 recorded individuals) of the mountain hawkweeds population in the study area, *H. moravicum* and *H. nigratum* constituted 11% of the plants (both 15 recorded individuals), *H. nivimontis* 8% of the population (25 recorded individuals), *H. obscuratum* 1.6% (5 recorded individuals), *H. schustleri* 5% (15 recorded individuals) and *H. stygium* 42% (128 recorded individuals).

Graphs 2 and 3 visualize the representation of individual species of mountain hawkweeds in specific biotopes on Mt. Králický Sněžník. As can be seen from the graphs, particular species were located in a total of 7 different habitats, which are characteristic for the summit parts. *H. nigratum* was found the most abundantly in a subalpine *Vaccinium* vegetation, fewer populations occurred in wind-swept alpine grasslands, alpine heathlands and also in montane *Calamagrostis* spruce forest. The species *H. stygium*, which formed the largest population at the site, was recorded only in subalpine *Vaccinium* vegetation, subalpine tall grasslands and montane *Calamagrostis* spruce forest with a similar frequency of occurrence.

The species *H. schustleri* was recorded with the highest frequency in alpine heathlands, but some populations also extended into subalpine *Vaccinium* vegetation and acidophilous vegetation of alpine boulder screen. *H. nivimontis* was recorded from 76% in biotope acidophilous vegetation of alpine boulder screen and from 24% in biotope alpine heathlands. Only 3 individuals of *H. chrysostylioides* were recorded in biotope snow beds. In biotope montane *Calamagrostis* spruce forest, in addition to several subpopulations of *H. stygium* and *H. nigratum*, the population of *H. murorum*, the total population of *H. obscuratum* and the total population of the rare endemic *H. uechtritizianum* were also recorded. Plot 5 visualized spatial linear ordination based on Transformation-based principal component analyses.

Discussion

Biotope preferences and current status of populations

Based on the statistical summarization visualized in graph 1, it can be said that the most common species in the area was *Hieracium stygium*. There are also relatively numerous populations of *H. moravicum*, *H. nigrum* and *H. nivimontis*. *Hieracium stygium* is a typical species of arcto-alpine tundra in the Eastern Sudetes and it often forms very numerous subpopulations together with *Hieracium nigrum*. This species is also very common in the Králícký Sněžník Mts. Unlike *H. stygium* its populations are usually very small consisting of only a few individuals (graph 4) and they are characterized by a high degree of spatial dispersion in suitable habitats. Less abundant populations of *H. murorum* that were found near the Elephant statue are a rather atypical fragment dispersing to this altitude from lower locations. Likewise, the population of *H. lachenalii*, which was located on a stone wall below the top of Mt. Hraniční hora, no longer extends into the arcto-alpine tundra. There is a relatively large population of the stenoendemic species *H. nivimontis*, which includes 25 plants divided into 4 subpopulations. *H. moravicum* was recorded here for the first time in Mt. Králícký Sněžník Mts, until now this species was known only from one locality in the Krkonoše Mts and several collections from Mt. Šerák, Mt. Kepník and Mt. Červená Hora in the Hrubý Jeseník Mts (e. g. Kocián & Chrtěk 2017).

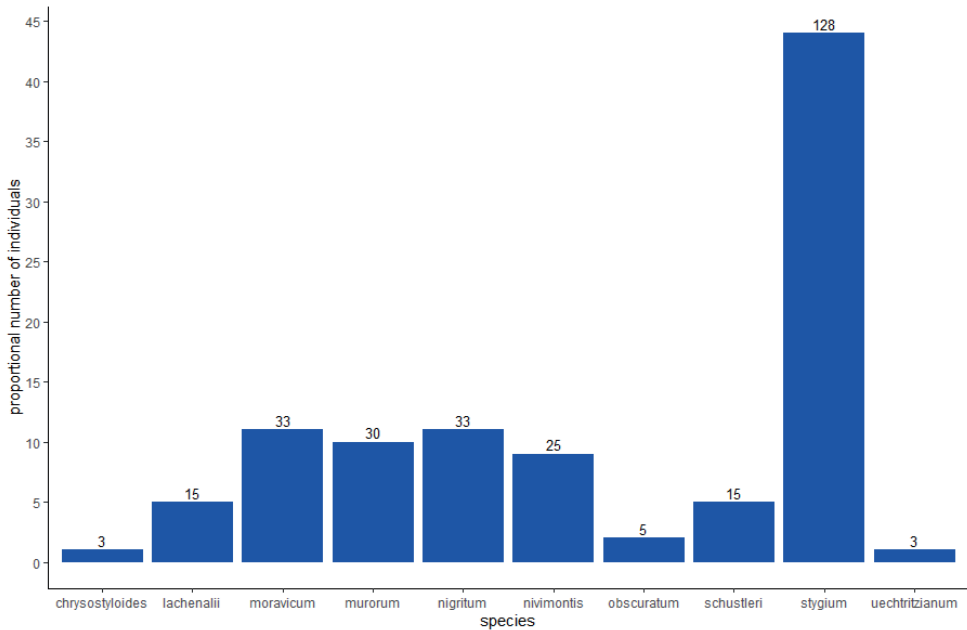
The species *H. chrysostyloides*, *H. obscuratum* and *H. uechtritizianum* can be considered very rare at the area. *H. obscuratum*, which is known mainly from the Carpathians, was also recorded for the first time in Mt. Králícký Sněžník. Based on our data, *H. uechtritizianum* can be considered as a very rare species that is on the verge of extinction. It was recorded at the same microsite as *H. moravicum*, but only a several meters away on the opposite side of the tourist trail. The situation here is also very serious for *H. schustleri*, the third Sudeten endemic species. All recorded populations were located on the top near the lookout, in an area where tourists roam freely and plants are trampled. The site is subject to a high degree of disturbance and the plants here were flowering in very small quantities at the time of the visits. The vast majority of plants were sterile. Due to the extreme habitats and climatic requirements that prevail on the top parts during the vegetative season, a large part of the plants do not bloom in a specific year, therefore they reproduce mainly vegetatively and very slowly. For this reason, it is also possible that many plants in a sterile state were not recorded in this study, therefore information about population sizes is only relative and indicative. However the population of the discussed plant species are threatened with extinction (especially in the case of endemic taxa) due to unregulated tourism and uncontrolled disturbance, destruction of the summit parts and other factors.

The analysis of the habitat preferences of mountain hawkweeds on Mt. Králícký Sněžník shows that there is probably a significant causality between the plant community (biotope) and the habitat preferences of the analyzed species. This statement is the most conclusive especially for the population of the species *H. stygium*, *H. nigrum* and *H. schustleri*. *H. nivimontis* formed four subpopulations that were located in two biotopes – alpine heathlands and acidophilous vegetation of alpine boulder screen. For other species, the hypothesis is a less significant due to the small number of recorded micropopulations. *H. schustleri* seems to prefer predominantly alpine heathlands, which are only found in summit parts. *H. stygium*, which was the most common species in Mt. Králícký Sněžník, was recorded only in three alpine biotopes with a similar frequency, the most abundant occurrence was recorded in subalpine tall grasslands.

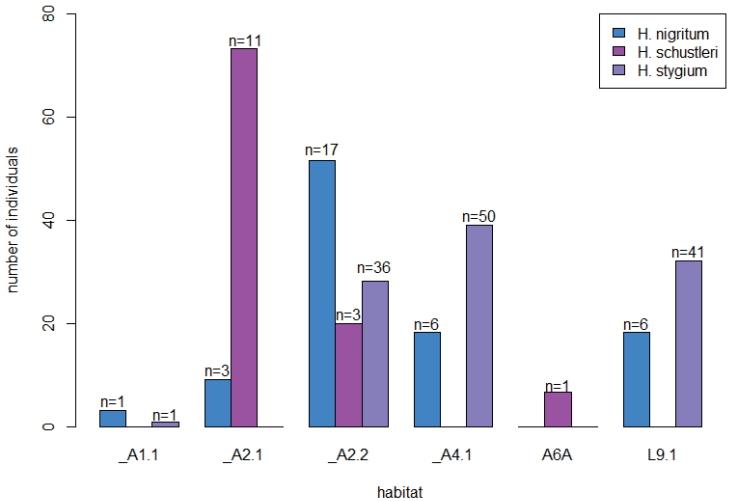
Unlike the previous three species, *H. nigrum* prefers subalpine *Vaccinium* vegetation, although it was recorded in relatively small abundances in other alpine biotopes as well. In terms of the species composition of mountain hawkweeds, the most valuable habitats are alpine heathlands and acidophillous vegetation of alpine boulder screen, where the majority of the population of the endemic species *H. schustleri* and *H. nivimontis* was recorded.

Transformation-based principal component analyses visualized using to linear unconstrained ordination demonstrated a direct vector correlation between abundance frequencies of subpopulations of analyzed species and biotopes of occurrence. *H. uechtritizianum*, *H. obscuratum* and *H. moravicum* seem to point towards the montane *Calamagrostis* spruce forest preference, while *H. nigrum* and *H. stygium* spatially correspond indirectly to subalpine tall grasslands and wind-swept alpine grasslands. *H. chrysostylioides* formed only one subpopulation in the snow beds at the locality, therefore, even if the analysis showed vector correspondence with this biotope, the result cannot be considered significant. In contrast, the *H. nivimontis* vector corresponding to habitat acidophillous vegetation of alpine boulder screen and the *H. schustleri* vector corresponding to habitat alpine heathlands can be considered relatively significant.

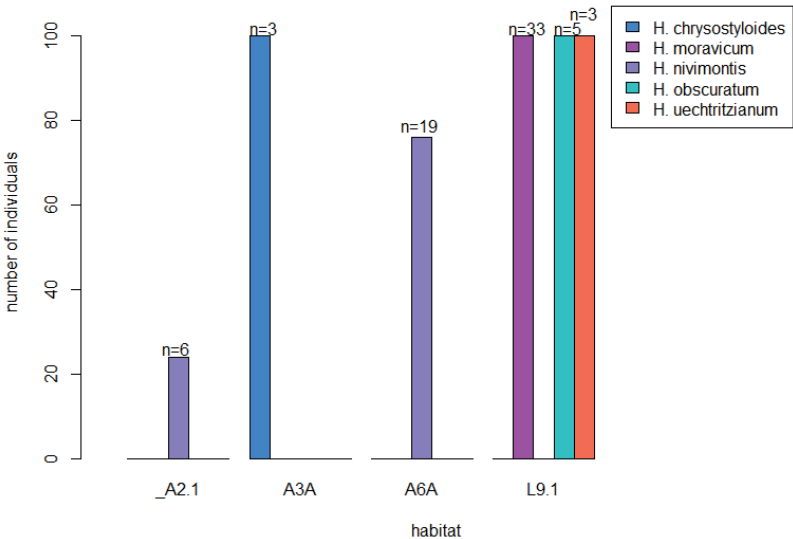
Graph 1: Proportional number of individuals of *Hieracium* species in the top parts of Mt. Králícký Sněžník. Numbers about columns are absolute values of numbers of species.



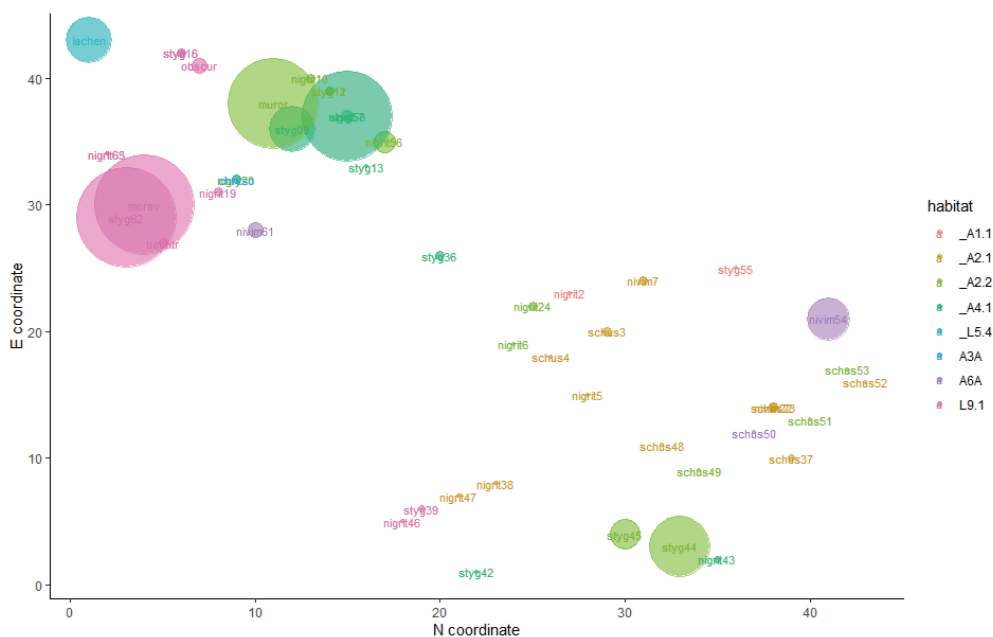
Graph 2: Dependence between types of habitat and frequency of occurrence of more common mountain hawkweeds species. Numbers of columns are absolute values of numbers of species. Habitat codes (Chytrý et al 2010): A1.1 – Wind-swept alpine grasslands (*Juncion trifidi*), A2.1 – Alpine heathlands (*Loiseleurio procumbentis-Vaccinion*), A2.2 – Subalpine *Vaccinium* vegetation (*Genisto pilosae-Vaccinion*), A4.1 – Subalpine tall grasslands (*Calamagrostion villosae*), A6A – Acidophilous vegetation of alpine cliffs and boulder screes (*Androsacion alpinae*), L9.1 – Montane *Calamagrostis* spruce forest (*Piceion abietis*).



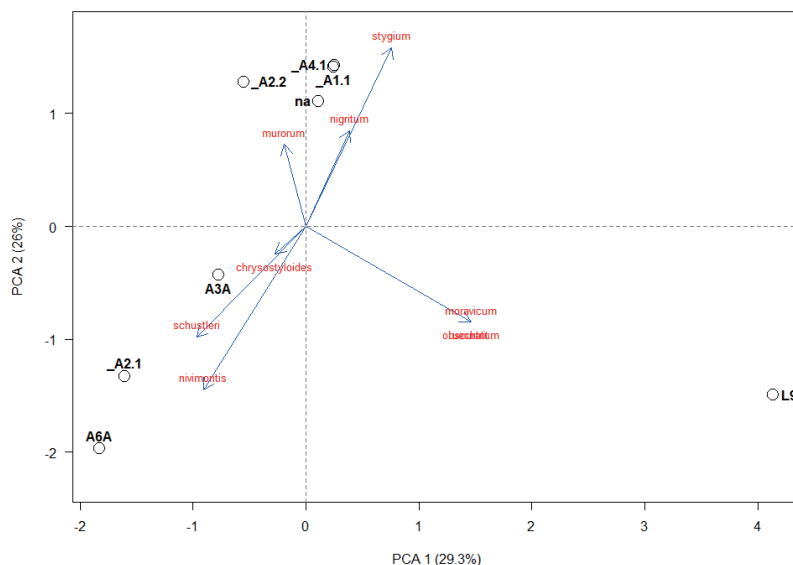
Graph 3: Dependence between types of habitat and frequency of occurrence of more rare mountain hawkweeds species. Numbers about columns are absolute values of numbers of species. Habitat codes (Chytrý et al 2010): A2.1 – Alpine heathlands (*Loiseleurio procumbentis-Vaccinion*), A3A – Snow beds (*Nardo strictae-Caricion bigelowii*), A6A – Acidophilous vegetation of alpine cliffs and boulder screes (*Androsacion alpinae*), L9.1 – Montane *Calamagrostis* spruce forest (*Piceion abietis*).



Graph 4: Spatial visualization group dispersion of mountain hawkweeds populations in the Kralický Sněžník hill with an added criterion of habitat. Sizes of groups corresponds to absolute sizes of individual micropopulations of recorded species. Lach = *H. lachenalii*, chryso = *H. chrysostylodes*, morav = *H. moravicum*, nigrit = *H. nigritum*, nivim = *H. nivimontis*, obscur = *H. obscuratum*, schus = *H. schustleri*, styg = *H. stygium*, uechtr = *H. uechtritizianum*. X and Y axes corresponded with real geographical GPS coordinates. Habitat codes (by Chytrý et al 2010): A1.1 – Wind-swept alpine grasslands (*Juncion trifidi*), A2.1 – Alpine heathlands (*Loiseleurio procumbentis-Vaccinion*), A2.2 – Subalpine *Vaccinium* vegetation (*Genisto pilosae-Vaccinion*), A4.1 – Subalpine tall grasslands (*Calamagrostion villosae*), A6A – Acidophilous vegetation of alpine boulder screen (*Androsacion alpinae*), L9.1 – Montane *Calamagrostis* spruce forest (*Piceion abietis*), A3A – Snow beds (*Nardo strictae-Caricion bigelowii*), L5.4 – Acidophilous beech forests (*Luzulo-Fagion sylvaticae*).



Graph 5: Visualization of transformation-based principal component analyses (tb-PCA) of mountain hawkweeds in the Kralický Sněžník Mts. and its habitats. Habitat codes (by Chytrý et al 2010): A1.1 – Wind-swept alpine grasslands (*Juncion trifidi*), A2.1 – Alpine heathlands (*Loiseleurio procumbentis-Vaccinion*), A2.2 – Subalpine *Vaccinium* vegetation (*Genisto pilosae-Vaccinion*), A4.1 – Subalpine tall grasslands (*Calamagrostion villosae*), A6A – Acidophillous vegetation of alpine boulder screen (*Androsacion alpinae*), L9.1 – Montane *Calamagrostis* spruce forest (*Piceion abietis*). “na” – Habitat non-specific (only one sample). Two species (*H. obscuratum* and *H. uechritzianum*) has the same vector coordinates near the *H. moravicum*.



Threatening factors influencing mountain hawkweeds negatively

(1) Vegetation changes in the subalpine zone (Kocián & Chrtek 2017). Especially termination of the pasture and mowing over the alpine timberline (Szeląg 2003). The pasture, regular mowing and hay removing prevent high grass to grow and give less expansive species a chance to plant and survive (Szeląg 2003). (2) Habitat loss due to historical *Pinus mungo* planting (Kocián & Chrtek 2017). *Pinus mungo* planting during the 19. century destroyed and occupied area over the alpine timberline in Mt. Králický Sněžník (Szeląg 2003). This significantly contributed to or caused extinction of *Hieracium inuloides* and *Hieracium prenanthoides* (Szeląg 2003). (3) Strong grazing pressure of wild herbivore mammals and collecting hawkweeds for herbaria (Kocián & Chrtek 2017). They are not the main threatening factors, but they can considerably impoverish the populations, especially the endemic ones (Szeląg 2003). (4) Immoderate tourism. Mt. Králický Sněžník is under strong tourist strain at the moment. The fence has been installed at the summit, to protect endangered and endemic species of arcto-alpine tundra from undisciplined tourists. A new lookout has been built at the Polish side of Mt. Králický Sněžník since 2020. This will probably increase the attendance here even more. (5) On the other hand, anthropogenic terrain disturbances are beneficial for the mountain hawkweeds, and they create their new habitats (Kocián & Chrtek 2017).



Fig. 8: Mountain hawkweed habitats in Mt. Králický Sněžník. A – habitat of the endemic *H. schustleri* threatened by human disturbance and trampling near the construction of the new lookout tower, 15. 7. 2021, B – Alpine heathlands are typical biotope for mountains hawkweeds, 6. 7. 2022, C – high air humidity and frequent unfavorable high-mountain microclimate during the vegetative season is the main factor for the low and often faintly flowering populations of hawkweeds in this area, 6. 7. 2022, D – typical habitat of the endemic *Hieracium nivimontis*.

Acknowledgements: At this point, we would like to thank everyone who participated in this research in some way. First of all from AOPK ČR, to the administration of the Jeseníky Protected landscape area and the chief botanist Radek Štencel for allowing access and free collection of data in the territory of the National Nature Reserve, then to Jiří Kocián for providing his own data and critical comments on the text, and last but not least also to Jindřich Chrtěk for revision and taxonomic consultation of the material found.

References

- AOPK ČR (2014) Plán péče pro národní přírodní rezervaci Králický Sněžník a její ochranné pásmo na období 2014–2023. AOPK ČR, Olomouc, https://drusop.nature.cz/ost/archiv/plany_pece/index.php?frame&ID=25291
- (2022). Aktualizace základního mapování biotopů. AOPK ČR, <https://data.nature.cz/ds/21>
- Barrio G., Alver B., Puigdefabregas J. & Diez C. (1997). Response of high mountain landscape to topographic variables: Central Pyrenees. – *Landscape Ecology* 12:95–115, <https://doi.org/10.1007/BF02698210>
- Husek V. (2017). Long-term changes of ruins' vegetation on the summit of the Králický Sněžník Mts. [bachelor's thesis]. Department of Ecology and Environmental Sciences, Faculty of Science, Palacky University in Olomouc, 34 pp., in Czech.
- Chrtěk J. (2004). *Hieracium* L. – jestřábník. – In: Slavík B., Štěpánková J. & Štěpánek J. (eds), *Květena České republiky* 7, p. 540–701, Academia, Praha.

- Chrtek J., Tonková M., Mráz P., Marhold K., Plačková I., Krahulcová A. & Kirschner J. (2007). Morphological and allozyme diversity in the *Hieracium nigrescens* group (Compositae) in the Sudety Mountains and the Western Carpathians. – *Botanical Journal of the Linnean Society* 153:287–300, <https://academic.oup.com/botlinnean/article/153/3/287/2420444?login=false>
- Chytrý M., Kučera T., Kočí M., Grulich V. & Lustyk P. (eds) (2010). Katalog biotopů České republiky. Ed. 2. Agentura ochrany přírody a krajiny ČR, Praha.
- Dančák M. (2004). Ohrožení a ochrana vegetace ČR. Olomouc: Department of Botany, Faculty of Science, Palacký University Olomouc. http://www.botanika.upol.cz/atlas/spolecenstva/index.html#_Toc90619951
- Fehrer J., Krak K. & Chrtek J. Jr. (2009). Intra-individual polymorphism in diploid and apomictic polyploid hawkweeds (Hieracium, Lactuceae, Asteraceae): disentangling phylogenetic signal, reticulation, and noise. – *BMC Evolutionary Biology* 9:239, <https://doi.org/10.1186/1471-2148-9-239>
- Formánek E. (1887). Květena Moravy a rakouského Slezska. Ed. 1. Eduard Formánek, Brno.
- Kaplan Z., Danihelka J., Chrtek J., Kirschner J., Kubát K., Štech M. & Štěpánek J. (eds). (2019). Klíč ke květeně České republiky [Key to the flora of the Czech Republic]. Ed. 2., Academia, Praha.
- Kocián J. & Chrtek J. (2017). Distribution of mountain hawkweeds (Hieracium s. str.) in the Hrubý Jeseník Mountains. – *Acta Musei Silesiae* 66:193–229, <https://doi.org/10.1515/cszma-2017-0024>
- Körner Ch. (1999). The alpine plant life. Ed. 1. Gustav Fischer Verlag, Heidelberg.
- Krahulec F. (2006). Species of vascular plants endemic to the Krkonoše Mts (Western Sudetes). – *Preslia* 78: 503–516.
- Oborny A. (1906). Die Hieracien Mähren und österr. Schlesien. II. Untergattung Euhieracium Torr. et Gray. *Verh. Naturforsch. Ver. Brünn.* 44: 1–79.
- Oksanen J., Blanchet F. G., Friendly M., Kindt R., Legendre P., McGlinn D., Minchin P. R., O'Hara R. B., Simpson G. L., Solymos P., Stevens H. H., Szoecs E., Wagner H. (2020). *vegan*: Community Ecology Package. R package version 2.5-7. <https://CRAN.R-project.org/package=vegan>
- Pládiás (2023). Database of the Czech Flora and Vegetation. www.pladias.cz
- Szeląg Z. (2003). Zagrożone gatunki flory naczyniowej Dolnego Śląska. Instytut Biologii Roślin, Uniwersytet Wrocławski. Górskie gatunki rodzaju Hieracium w Sudetach. Przemiany i zagrożenie. p. 197–215.
- Szeląg Z. (2000). Vascular plants of the Śnieżnik Massif and the Góry Bialskie Mts. *Fragm. Florist. Geobot., Ser. Polon., Suppl.* 3: 3–255 (in Polish with English summary).
- Trembl V. & Banaš M. (2000). Alpine timberline in the High Sudetes. – *Acta Universitatis Carolinae Geographica* 35:83–95.
- Wickham H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. – Springer, Verlag New York.

Author's addresses: Patrik Mlčoch; Department of Botany, Faculty of Science, Palacký University Olomouc, Šlechtitelů 27, CZ-783 71, Olomouc; E-mail: patrik.mlcoch01@upol.cz

Eliška Trčalková; Department of Ecology and Environmental Sciences, Faculty of Science, Palacký University Olomouc, Šlechtitelů 27, CZ-783 71 Olomouc; E-mail: eliska.trcalkova01@upol.cz