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Luzula spicata (Juncaceae) in the Ukrainian Carpathians: on the brink of extinction

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Abstract. Historical records on distribution of *Luzula spicata* in the Ukrainian Carpathians from past publications and herbarium specimens were analyzed. This arctic-alpine species formerly occurred at the uppermost elevations in three mountain massifs: the Chornohora, Marmarosh and Chyvchyny Mts. It was confined to acidic sandstone and conglomerate rocks on mountain summits and ridges with the lowest thermal conditions. Thorough recent surveys of all the eight previously documented localities allowed to reconfirm the occurrence of *L. spicata* in one station only, namely near the summit of Mt. Pip Ivan (1990 m a.s.l.) in the Chornohora Mts where its small population has survived. Apparently, the species has become extirpated elsewhere in the Ukrainian Carpathians. A map of current and extinct localities is provided, as well as an image of the recent herbarium specimen. *Luzula spicata* is one of the most cryophilic species of the Carpathian flora and its Ukrainian localities refer to the lower limit of the species altitudinal range. Therefore, its decline and extinction can be attributed to climate change that has also been reported from other mountain systems of Europe. Analysis of past data showed that most probably the species has already been gradually dying off since the end of the so-called "Little Ice Age" (i.e. 100–150 years ago) that was followed by progressive warming. *Luzula spicata* is a poorly competitive species confined to rocky habitats with scarce vegetation cover. It is vulnerable both to the direct impact of warming and to replacement by taller graminoids or dwarf shrubs encroaching on the alpine habitats in the course of the climate-induced succession. Because *L. spicata* is on the brink of extinction, it should be included in the next edition of the *Red Data Book of Ukraine* as Critically Endangered (CR).

Keywords: cryophilic species, climate change, locality, extinction, Carpathians

Introduction

Assessment of current conservation status of rare and endangered species, as well as determining the level of threat to them require repeated surveys of their known localities, which enable to reveal dynamic trends in their populations. However, many plant species listed in the *Red Data Book of Ukraine* (Chervona knyha Ukrainy..., 2009) lack such comprehensive data, which also refers to other rare species. That fully concerns the Carpathian region where inventories are most hard to perform because of poor accessibility of some high-mountain areas.

This article is supposed to fill that gap with regard to one oreophytic species – *Luzula spicata* (L.) DC. The aim of the study was to check the known localities of the species and to define its current status. Another goal was to find out whether the species still occurs in the

Ukrainian Carpathians because reasonable doubts in its survival have been expressed (Olshanskyi, 2014; Kobiv et al., 2017).

Luzula spicata is an arctic-alpine species spread in the north of America and Europe, as well as in the temperate zone at upper elevations in the mountains of North America, Eurasia and North Africa (Atlas Mts).

The species is rather polymorphic and its several subspecies have been defined in Europe (Kirschner, 2002). In the Carpathians, it is represented by *L. spicata* subsp. *conglomerata* (W.D.J. Koch) Murr (= *L. spicata* subsp. *mutabilis* Chrtek & Křisa), a subspecies with disjunct distribution, which also occurs in the Pyrenees, Alps, Swiss Jura and Northern Apennines (Chrtek, Křisa, 1962, 1980; Kirschner, 2002).

In the Carpathians, *L. spicata* is the only representative of the section *Alpinae* (Chrtek, Křisa, 1962, 1980; Kirschner, 2002) and is well-distinguishable for its



Fig. 1. A recent herbarium specimen of *Luzula spicata* from Mt. Pip Ivan in the Chornohora Mts

spike-like nodding inflorescence (Fig. 1) differing from other native species of *Luzula* DC.

Materials and methods

Past publications and available herbarium data on *Luzula spicata* in the Ukrainian Carpathians have been analyzed. In total, I found 10 corresponding herbarium sheets: 9 – in Polish herbaria of Cracow (*KRAM*, *KRA*), and 1 – in Lviv (*LWS*).

Historical records were checked in the Chornohora (in 2015, 2016, and 2017), Marmarosh (2016) and Chyvchyny Mts (2012) during field research. Suitable rocky and low-sward alpine habitats were thoroughly surveyed in search of the species in its previously documented localities and their vicinity.

The collected specimen (Fig. 1) is deposited at the Herbarium of the M.G. Kholodny Institute of Botany, Kyiv (*KW*).

Results and discussion

Previous data on distribution in Ukraine. *Luzula spicata* is mentioned in the main floristic compendia regarding the Ukrainian Carpathians (Krechetovych, Barbarych, 1950; Chopyk, 1976; Vyznachnyk roslyn..., 1977).

However, information on the species occurrence is based merely on original historical data from the second half of the 19th – first half of the 20th century. The first author to record *L. spicata* in the part of the Carpathians, which now belongs to Ukraine, was Rehman (1873) who reported it from several highest summits of the Chornohora ridge – Mts Hoverla, Rebra, Brebeneskul and Pip Ivan.

Zapałowicz (1889), who performed the most comprehensive floristic inventory of the Chornohora in the 1880s, reconfirmed the species occurrence on Mts Pip Ivan and Rebra and documented its exact location.

Localities of *L. spicata* in the Chornohora Mts were also proved by herbarium specimens gathered in the 1930s by Maǰalski at high altitudes (≥ 1910 m a.s.l.) on Mts Pip Ivan, Gutyn-Tomnatyk and Turkul. The herbarium labels indicate the location of these stations quite explicitly.

In addition, the species was reported by Zapałowicz (1889) from the Marmarosh range, namely from Mt. Pip Ivan Marmaroskyi. Its elevation (1940 m a.s.l.) corresponds to the very top of the mountain.

Another series of the species records refers to the summit of Mt. Hnetiesa in the Chyvchyny Mts, where it was discovered by Wołoszczak (1888) in the late 19th

century. That locality was reconfirmed later by a number of herbarium specimens gathered mostly in the 1930s. Moreover, in Pawłowski and Walas' (1949) publication on the vegetation of the Chyvchyny Mts *L. spicata* is listed in the phytosociological relevé of the community *Cetrario-Festucetum airoidis* (alliance *Juncion trifidi*) from the saxicolous locality. Comments in the above publications and on the herbarium labels show that all this set of data refers to the conglomerate rock at the Ukrainian-Romanian border on the very top of Mt. Hnetiesa at 1760–1765 m a.s.l.

Thus, there are reliable historical data on the past occurrence of *L. spicata* in three mountain ranges of the Ukrainian Carpathians: the Chornohora, Marmarosh and Chyvchyny Mts (Fig. 2). While in the former two ranges the species is known from the high elevations in the alpine zone (> 1900 m a.s.l.), its locality in the Chyvchyny Mts can be regarded as subalpine.

Luzula spicata was also erroneously mentioned for the town of Chernivtsi by Tkachyk (2000), which resulted from misidentification of the herbarium specimen.

Ecological requirements. According to European compendia on ecological values of plants (Landolt, 1977; Ellenberg et al., 1992; Zarzycki et al., 2002), *L. spicata* is a highly specialized oreophyte and can be regarded as one of the most cryophilic species of the Carpathian flora. In the Carpathians, its ecological optimum and distribution range correspond to conditions of the subnival and upper alpine zones (Mirek, 1989).

Dahl (1998) stated that the main factor that determines the lower or southernmost limits of distribution of many cryophilic species is maximum summer temperature. He claimed that critical maximum summer temperature for *L. spicata* is $+24$ °C, therefore climate warming should lead to the decline on the trailing (i.e. lower) edge of its distribution.

All the mentioned localities of *L. spicata* in the Ukrainian Carpathians have been reported from the uppermost parts of the mountains, i.e. their summits or ridges where the temperature is the lowest. The fact that most of the species localities have been documented in the Chornohora can be explained by the highest elevation of that range and, consequently, the lowest thermal conditions, which are crucial for that cryophilic species. However, these sparse suitable sites that comply with ecological requirements of *L. spicata* referred to the lowermost limits of the species altitudinal range as follows from its distribution in the Alps (Pauli et al., 2007; Frei et al., 2010) and Western Carpathians (Mirek, 1989). Therefore, climate warming, which has

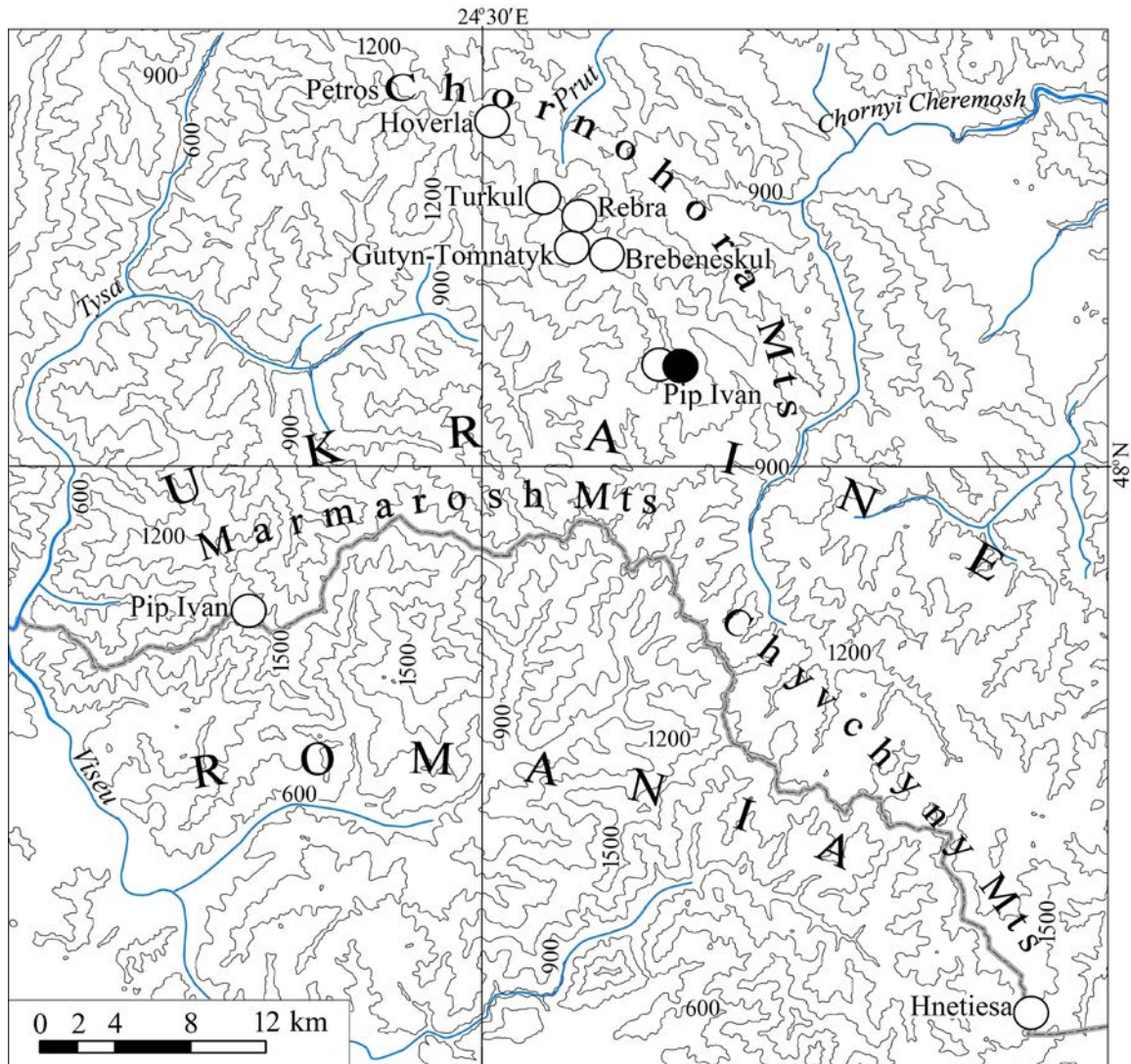


Fig. 2. Distribution of *Luzula spicata* in the Ukrainian Carpathians: ● – current locality; ○ – extinct localities

been confirmed for the Carpathians lately (Spinoni et al., 2015) should have been causing the decline and extinction of that cryophilic species that has no available habitats to colonize.

The above-mentioned past publications and herbarium labels show that *L. spicata* in the Ukrainian Carpathians is a saxicolous species confined to sandstone and conglomerate rocks. It is defined as a characteristic species for the acidophilic syntaxonomic order *Caricetalia curvulae* and alliance *Juncion trifidi* (Matuszkiewicz, 2002). As follows from phytosociological prodromes of some Carpathian countries (Moravec, 1995; Matuszkiewicz, 2002), *Luzula spicata* is often associated with other markedly

cryophilic alpine species – *Agrostis rupestris* All. and *Oreochloa disticha* (Wulfen) Link, whose negative dynamics was reported recently (Kyyak, 2013; Kobiv, 2017) and can also be explained by the adverse impact of climate change.

Current status and conservation implications. All the eight previously documented localities of *Luzula spicata* – 6 in the Chornohora, 1 – in the Marmarosh and 1 – in the Chyvychny Mts (Fig. 2) were checked during the surveys. However, despite the thorough search in these and nearby suitable habitats, I managed to find the species in one locality only. It is situated in the alpine zone on the flat south-eastern ridge of Mt. Pip Ivan in the Chornohora Mts at 1990 m a.s.l. (48°02'46"N,

24°37'58"E) about 400 m from the summit. The species occurs on the southern aspect of a sandstone rock on about 10 m². The population is low-numbered and included only 6 flowering individuals in August 2017. The largest tufts cover up to 15 cm². The number of vegetative individuals could hardly be estimated because they can be confused with those of the other graminoids. Vegetation cover at the site amounts to 25 % and is formed by the following species with corresponding grades of the Braun-Blanquet scale: *Luzula spicata* – +, *Festuca airoides* Lam. – 2, *Juncus trifidus* L. – 1, *Carex atrata* L. – +, *Hieracium alpinum* L. – +, *Campanula kladniana* (Schur) Witasek – +, *Racomitrium canescens* (Hedw.) Brid. – 2, *Tortella tortuosa* (Hedw.) Limpr. – 1. The size of that population of *L. spicata* is critically small and does not ensure its further survival even in the mid-term perspective. Apparently, the population is merely a remnant of formerly much larger entity, which once inhabited several ridges at the summit of Mt. Pip Ivan above 1980 m a.s.l. as follows from Zapałowicz's (1889) records and herbarium labels (KRAM 2745, 6209, 80235). These numerous historical data imply that this population could be the largest in the Ukrainian Carpathians in the past, which enabled it to survive until now.

Thus, the surveys carried out in the previously known localities showed that most probably *L. spicata* has declined significantly in its remaining locality on Mt. Pip Ivan in the Chornohora Mts and died out elsewhere in the Ukrainian Carpathians due to unfavorable climate warming impact, while thermal conditions in its scarce habitats got beyond the ecological range of that cryophylic species. The species is on the brink of extinction in Ukraine and its long-term survival in the region is problematic.

Luzula spicata is a poorly competitive saxicolous species confined to rocky habitats with scarce vegetation cover. It is vulnerable to replacement by taller graminoids or dwarf shrubs ingressing into the alpine habitats in the course of the climate-induced succession.

It is remarkable, that the old authors who surveyed the Carpathians in the 19th century found the localities of *L. spicata* more often than their successors. For instance, Rehman (1873) after his rather brief investigation of the Chornohora Mts managed to report it from as much as four summits (see above). In addition, Deyl (1940), who performed the most comprehensive survey of the flora of Mt. Pip Ivan Marmaroskyi in the 1930s, did not mention *L. spicata*, though he could hardly miss it making a set of relevés on the top of that mountain where it had occurred in the late 19th century (Zapałowicz, 1889).

Such a decreasing trend in the species findings could indicate that it has already been gradually dying off since the end of the so-called "Little Ice Age" (i.e. 100–150 years ago) that was followed by progressive warming (Free, Robock, 1990). The lack of the species records in the Ukrainian Carpathians since World War II shows that most possibly it has become extremely rare in the region by the second half of the XX century.

Upward shifts in the species distribution and decline at its lower limit have been documented in the Alps recently (Pauli et al., 2007; Frei et al. 2010).

In the Ukrainian Carpathians, *L. spicata* is not only ecologically marginal (i.e. restricted to atypically low elevations), but also geographically peripheral, because it occurs at the north-eastern limit of the species distribution in Central Europe (Kobiv, 2017). Its closest to Ukraine localities are situated ca. 30 km westwards from the state border, in the Rodna Mts, Romanian Carpathians (Grințescu, 1966). Therefore, partial or total extinction of *L. spicata*, as well as other cold-demanding alpine species (*Agrostis rupestris*, *Saxifraga oppositifolia* L., *S. pedemontana* All.) in the Ukrainian Carpathians leads to considerable contraction of their geographical ranges (Kobiv, 2017). This proves that climate change is a significant factor of biodiversity loss in the European scale, which particularly concerns alpine ecosystems.

Luzula spicata is on the Red List of the Czech Republic as "Critically Endangered" (Grulich, 2012), because it has been declining in the Sudeten Mts where it occurs at comparatively low elevation, apparently at the limit of its altitudinal range.

The species should be included in the next edition of the *Red Data Book of Ukraine* as Critically Endangered (CR) because it is threatened by extinction already in the mid-term perspective.

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Проаналізовано наявні історичні дані про поширення *Luzula spicata* в Українських Карпатах, наведені в публікаціях і гербарних зразках. Цей аркто-альпійський вид раніше траплявся на найбільших висотах у трьох гірських масивах: Чорногорі, Мармароських і Чивчинських горах. Він був приурочений до пісковикових чи конгломератових скель з кислою реакцією, розташованих на гірських вершинах чи хребтах, де температурний режим є найнижчим. Недавнє ретельне обстеження усіх восьми раніше задокументованих локалітетів дозволило підтвердити наявність *L. spicata* лише в одному оселищі, а саме біля вершини г. Піп Іван у Чорногорі (1990 м н.р.м.), де збереглася його мала популяція. Очевидно, вид зник на решті території Українських Карпат. Подається карта теперішнього і зниклих локалітетів, а також ілюстрація недавно зібраного гербарного зразка. *Luzula spicata* – один з найбільш криофільних видів карпатської флори, а його локалітети в Україні приурочені до нижньої межі висотної амплітуди виду. Тому його регресування й вимирання пов'язані з кліматичними змінами, що було відзначено й в інших гірських системах Європи. Аналіз давніх даних свідчить, що цей вид найімовірніше зазнавав поступового відмирання ще з часу закінчення так званого малого льодовикового періоду (100–150 років тому), після якого розвивалося потепління. *Luzula spicata* – це низькоконкурентний вид, приурочений до наскельних оселищ з нещільною рослинністю. Він вразливий як до безпосереднього впливу потепління, так і до витіснення конкурентоспроможнішими злаково-осоковими чи чагарничковими видами, що проникають до альпійських оселищ у процесі кліматогенної сукцесії. Оскільки *L. spicata* перебуває на межі зникнення, її слід внести до наступного видання "Червоної книги України" як критично zagrożений (CR) вид.

Ключові слова: криофільний вид, кліматичні зміни, локалітет, зникнення, Карпати

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Проанализированы имеющиеся исторические данные о распространении *Luzula spicata* в Украинских Карпатах, приведенные в публикациях и гербарных образцах. Этот аркто-альпийский вид раньше встречался на наибольших высотах в трех горных массивах: Черногоре, Мармарошских и Чивчинских горах. Он приурочен к песчаниковым или конгломератовым скалам с кислой реакцией, расположенным на горных вершинах или хребтах с самым низким температурным режимом. Недавнее тщательное обследование всех восьми ранее задокументированных локалитетов позволило подтвердить наличие *L. spicata* только в одном местопроизрастании, а именно возле вершины г. Поп Иван в Черногоре (1990 м н.у.м.), где сохранилась лишь малая популяция. Очевидно, вид исчез на остальной территории Украинских Карпат. Прилагается карта сохранившегося и исчезнувших локалитетов, а также иллюстрация недавно собранного гербарного образца. *Luzula spicata* – один из наиболее криофильных видов карпатской флоры, а его локалитеты в Украине приурочены к нижней границе высотной амплитуды вида. Поэтому его регрессирование и вымирание связаны с климатическими изменениями, что отмечалось и в других горных системах Европы. Анализ давних данных свидетельствует, что этот вид вероятно подвергался постепенному вымиранию еще со времени окончания так называемого малого ледникового периода (100–150 лет назад), после которого развивалось потепление. *Luzula spicata* – низькоконкурентный вид, приуроченный к наскальным местообитаниям с разреженной растительностью. Он уязвим как к непосредственному воздействию потепления, так и к вытеснению более конкурентоспособными злаково-осоковыми или кустарничковыми видами, проникающими в альпийские местообитания в ходе климатогенной сукцессии. Поскольку *L. spicata* пребывает на грани вымирания, ее следует включить в следующее издание "Красной книги Украины" как находящийся под критической угрозой исчезновения (CR) вид.

Ключевые слова: криофильный вид, климатические изменения, локалитет, исчезновение, Карпаты