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THE DISTRIBUTION AND CONSERVATION STATUS OF *KNAUTIA DIPSACIFOLIA* (CAPRIFOLIACEAE, DIPSACALES) IN HUNGARY

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Abstract: It was proven during the herbarium revision work that confirmed data of the species *Knautia dipsacifolia* in Hungary only came from a few stream valleys of the volcanic (andesite) mountains of the Matricum (Visegrád Mts, Börzsöny Mts, Mátra Mts) characterised with cool microclimate. All other data from the country were found to be false reporting. Not a single individual has been found of the species, which is currently threatened with extinction and is disappearing from the Hungarian flora, in any formerly mapped places of occurrence in the last three years. Similarly to other mountainous relict species, *K. dipsacifolia* seems to be one of the victims of climate change in the Carpathian Basin, which has been characterised by increasingly frequent periods of drought and rising average temperatures.

Key words: floristics, herbarium revision, Matricum, phytogeography, relict species

INTRODUCTION

Knautia dipsacifolia Kreutzer (syn.: *K. sylvatica* (L.) Duby) is a European montane and subalpine species. The centre of its distribution area is the Alps and most of its occurrence data are known from the mountainous regions of Central and Southern Europe (Aeschimann *et al.* 2004, Jávorka and Soó 1951, Meusel and Jäger 1992, Szabó 1911, Tutin *et al.* 1976, http1). In his monograph on *Knautia*, Szabó (1911) provided a detailed overview of the diversity and distribution of the species occurring in Europe; he also distinguished several infraspecific taxa (varieties and forms) with specific geographical distribution for the species "*K. sylvatica*". In Hungary, characterised by plain, hilly and mid-mountain landscapes, *Knautia dipsacifolia* subsp. *dipsacifolia* occurs, where it is a rare, protected species (Farkas 1999), and also critically endangered according to the national red list (Király 2007).

The species was confirmed by Szabó (1911) based on herbarium specimens collected from the Mátra Mts and the vicinity of Szentendre (Visegrád Mts). Later, its occurrences were also reported from the Börzsöny Mts (Boros 1958, 1968), from the northern part of the Great Hungarian Plain (Simon 1985), and from the Bakony Mts (Farkas 1999). Lukács *et al.* (2019) have recently drawn the attention to the incorrectness of the data from the northern part of the Great Hungarian Plain.

At the beginning of our work, we aimed to verify the data of the species collected in the Bakony Mts. Due to errors detected during the inspection of the occurrences in the field, and of the herbarium specimens and sites of occurrences provided in public collections, we extended our investigation to include a revision of its available data in Hungary, and an assessment of its conservation status in Hungary.

MATERIAL AND METHODS

To summarise Hungarian occurrences of *K. dipsacifolia*, data from all relevant literature and specimens of the following herbaria were checked: Hungarian Natural History Museum, Budapest (BP), Eötvös Loránd University, Budapest (BPU), University of Debrecen, Debrecen (DE), Mátra Museum, Gyöngyös, University of Pécs, Pécs (JPU), Savaria Museum, Szombathely (SAMU), Móra Ferenc Museum, Szeged (SZE). In the enumeration the records are grouped geographically. Within each region the records are grouped according to localities and within localities the records are reported in chronological order. In cases where the sheets have a unique identifier, it is also provided.

The nomenclature of the plant taxa follows the Euro+Med Plantbase (http4). QGIS 2.18 (QGIS Development Team 2018) computer program was used to create the distribution map, where grid cells of 5 km × 6 km follow the Central European mapping system (Niklfeld 1971).

RESULTS

This chapter provides a systematic and critical review of literature and herbarium data.

Mátra Mts

Voucher specimen: **Parád** (Kitaibel, P., s.d., "in pratis ad Parád" BP Herbarium Kitaibelianum VII. 38).

The oldest occurrence data of the species from Hungary was collected in the Mátra Mts. Kitaibel may have collected this specimen during his research on the medicinal waters around Parád or in the last year of his life in 1817, when he was seeking a cure for his kidney disease (Jávorka 1957). There is no trace of this collection in Kitaibel's travel diaries (Gombocz 1945, Lőkös 2001), therefore accurate information is not available about the site.

The occurrence of the species in the Mátra Mts has not been confirmed for more than 200 years.

Visegrád Mts

Voucher specimens: **Szentendre** (Sándor, J., s.d. "Sz. Endre" BP 375551; Borbás, V., 10.07.1894, "in nemoribus ad Sz. Andream" BP 161057, BP 161065; **Szentendre: Dömörkapu, Bükkös-patak völgye** (Borbás, V., 10.07.1889, "Sz. Endre, in valle Dömörkapu" BP 533353; Simonkai, L., 03.03.1893, "...vallis Dömörkapu supra Szt. Endre" BP 161061, BP 161066, BP 161069, BP 536393, BP 537251, BP 537254, BP 537279; Simonkai, L., 03.03.1893, "in declivibus saxosis, fructiosis vallis Dömörkapu inter Szt-Endre et Pilis-Szt-Kereszt" BP 161068, BP 161070, BP 161081; Borbás, V., 10.07.1894, "Izbég: Dömörkapu" BP 536355; Vajda, L., 04.08.1929, "Bucsina völgy. Szentendre felett" BP 281146; Kárpáti, Z., 06.07.1941, "in silvaticis vallis Bucsinavölgy, prope locum Dömörkapu" BP 368099; Priszter, Sz., 05.07.1942, "in silvis vallis 'Bükkös patak' supra opp. Szentendre" BP 368099; Priszter, Sz., 05.07.1942, "in silvis vallis 'Bükkös patak' supra opp. Szentendre" DE; Papp, J., 18.07.1943, "Dömörkapu, Sz. endrei hegyek" BP 395430, BP 401101; Vajda, L., 04.08.1943, "in rupestribus vallis Bükköspatak prope Dömörkapu" BP 277705, 281145; Boros, Á., 17.06.1945, "In rupestribus andesit. ripae rivi vallis Bükkös-patak prope Szentendre" BP 461105, BP 461106; Boros, Á., 22.07.1945, "In rupestribus andesit. ripae rivi vallis Bükkös-patak prope Szentendre" BP 461103, BP 461104; Boros, Á., 12.08.1945, "In rupestribus andesit. ripae rivi vallis Bükkös-patak prope Szentendre" BP 461102, BP 461111, 461112; Bánó, L., 06.08.1946, "Pilis (Dunazug) hegység. Bükköspatak völgye" BP 425172; Papp, J., 11.08.1946, "...ad rivulum Bükköspatak, inter umbrosis saxa, prope Szentendre" BPU 3866; Bőhm, É. I., 18.08.2000, "Szentendre-Dömörkapu; Bucsinavölgy"; A Bükkös-patak mellett, kidőlt fatörzsek alatt. Gyertyános-kocsánytalan tölgyes és égerliget maradványa" BP 618209, BP 618210).

The occurrence of the species in the Visegrád Mts appeared for the first time in the monograph of Sadler (1825); the sites he mentioned include Szentendre, Pilisszentkereszt, Visegrád, and even Vác on the left bank of the Danube ("Sz. André, Sz. Kereszt, Visegradum et Váczium"). The latter site, however, is missing from the second edition of the Pest County flora (Sadler 1840). In the first half of the 19th century, József Sándor (?–?, chamber draftsman, herbalist) (see Nendtvich 1872), who performed a lot of plant collections in the Buda and Pest area, collected the first proven specimen of *K. dipsacifolia* from the region. This specimen (Fig. 1) was found in Johann Heuffel's herbarium; probably he reported the taxon *K. dipsacifolia* from Szentendre based on this specimen (Heuffel

Fig. 1. The oldest specimen of *Knautia dipsacifolia* from the Visegrád Mts, collected by József Sándor from the border of Szentendre (BP 375551).

1856). Some later reports (Borbás 1879, 1904, Baksay 1956, Bőhm 2001) and voucher specimens are known from the border of Szentendre (Dömörkapu, area of Bükkös-patak valley).

No voucher specimens have so far been found at the other sites listed by Sadler (Visegrád, Vác), nor at the sites mentioned in the works of Borbás (1879) and Feichtinger (1899). Borbás (1879) also reported the species from the vicinity of Pilisszentlászló. In Feichtinger's (1899) monograph, "Szentgyörgymezőn, Szentléleken, Aggastyánnál" are mentioned as sites of occurrences. Barina (2006) already confirmed that the data from the Gerecse Mts (current geographical name: Agostyán) is incorrect. No supporting specimens were found at the other two localities (Esztergom: Szentgyörgymező, Pilisszentlélek) either, so data from these sites are to be treated as doubtful.

In spite of the several site data published, the only reliable occurrence data of the species came from one area in the Visegrád Mts, the Bükkös-patak valley (~ "Bucsina valley") west of Szentendre, more specifically, from a few locations (Dömörkapu, Kárpát-forrás) of it. The plant is now strongly suppressed in the Visegrád Mts; its last known detection (in 2014) comes from the valley of Bükkös-patak at Szentendre (Kárpát-forrás) (observation by Károly Janata, Bőhm in litt.).

Börzsöny Mts

Voucher specimens: **Kemence: Barsi-bükk** (leg. Boros, Á., 12.10.1958, "Comit. Hont. In rupibus andesit. silvat. alvei rivi Kemence-patak infra Barsi-bükk pr. Kemence" BP 461046, BP 461047); **Kemence: Király-kút** (Nagy, J., 24.07.1994, "Diósjenő: Kemence-völgy, Király-kút közelében. Aegopodio-Alnetum társulásban a Kemence-patak partján. Alt.: cca. 400 m", BP HNHM-TRA 00129002).

In the Börzsöny Mts, Ádám Boros was the first who found and collected specimens of the species in the Kemence valley in 1958, under the Barsi-bükk (Boros 1958, 1968). A later confirmation of this occurrence is not known, but Nagy (1997, 2007) also mentioned a single polycormon in the Kemence valley, further south from the Barsi-Bükk, in the alder-hornbeam grove (*Aegopodio-Alnetum*) next to Király-kút (Fig. 2). A phytosociological relevé was made in this habitat:

Vegetation type: *Aegopodio-Alnetum* V. Kárpáti, I. Kárpáti et Jurko 1963, *Salix fragilis* consoc.

Location: Diósjenő: Kemence-völgy, Király-kút; Date: 06.07.1996, 05.05.1997; Quadrat size 350 m^2; Height above sea level: 400 m; Relevé was made by József Nagy; Average height of tree layer 16–18 m; Coverage per layers: A1 80%; A2 60%; B 25%; C 70%;

A1: *Acer campestre* 8%, *Alnus glutinosa* 3%, *Carpinus betulus* 7%, *Populus tremula* 2%, *Salix fragilis* 60%

A2: *Carpinus betulus* 2%, *Cornus sanguinea* 10%, *Corylus avellana* 40%

B: *Acer campestre* 1%, *Carpinus betulus* 0.5%, *Cornus sanguinea* 3%, *Corylus avellana* 10%, *Euonymus europaeus* 2%, *Rosa canina* 0.1%, *Rubus caesius* 0.5%, *Rubus fruticosus* agg. 1%, *Rubus idaeus* 1%, *Sambucus nigra* 0.1%, *Ulmus glabra* 0.1%

C: *Acer campestre* juv. 0.1%, *Aegopodium podagraria* 25%, *Aethusa cynapium* 0.1%, *Ajuga reptans* 0.1%, *Alliaria petiolata* 0.1%, *Anemone ranunculoides* 1%, *Arctium* sp. 0.1%, *Arum orientale* 0.2%, *Athyrium filix-femina* 0.1%, *Brachypodium sylvaticum* 0.1%, *Calystegia sepium* 0.1%, *Cardamine impatiens* 0.1%, *Carex acutiformis* 0.1%, *Carex remota* 0.1%, *Carpinus betulus* juv. 0.1%, *Cerastium fontanum* agg. 0.1%, *Chelidonium majus* 0.1%, *Chrysosplenium alternifolium* 1%, *Circaea lutetiana* 3%, *Cornus sanguinea* juv. 0.1%, *Corydalis solida* 1%, *Cuscuta europaea* 0.1%, *Dactylis polygama* 0.1%, *Dryopteris filix-mas* 0.1%, *Elymus caninus* 0.1%, *Epilobium montanum* 0.1%, *Equisetum arvense* 0.1%, *Euonymus europaeus* juv. 0.1%, *Eupatorium cannabinum* 0.1%, *Fallopia dumetorum* 0.1%, *Festuca gigantea* 0.1%, *Ficaria verna* 20%, *Gagea lutea* 0.2%, *Lamium galeobdolon* 25%, *Galeopsis speciosa* 0.1%, *Galium aparine* 0.1%, *Galium odoratum* 2%, *Geranium robertianum* 0.1%, *Geum urbanum* 0.3%, *Glechoma hirsuta* 10%, *Impatiens nolitangere* 20%, ***Knautia dipsacifolia* 0.4%**, *Lamium maculatum* 0.3%, *Lapsana communis* 0.1%, *Lathraea squamaria* 0.1%, *Lycopus europaeus* 0.1%, *Lysimachia vulgaris* 0.2%, *Mercurialis perennis* 0.1%, *Moehringia trinervia* 0.1%, *Mycelis muralis* 0.1%, *Myosoton aquaticum* 0.1%, *Oxalis acetosella* 0.3%, *Paris quadrifolia* 0.2%, *Phyteuma spicatum* 0.1%, *Poa nemoralis* 0.1%, *Persicaria hydropiper* 0.1%, *Pulmonaria officinalis* 5%, *Ranunculus repens* 0.2%, *Rumex obtusifolius* 0.1%, *Salix fragilis* juv. 0.2%, *Scirpus sylvaticus* 0.1%, *Scrophularia nodosa* 0.1%, *Scutellaria galericulata* 0.1%, *Senecio nemorensis* 0.1%, *Solanum dulcamara* 0.1%, *Stachys sylvatica* 2%, *Stellaria holostea* 4%, *Stellaria media* 0.1%, *Symphytum officinale* 0.1%, *Tussilago farfara* 0.1%, *Urtica dioica* 2%, *Veronica beccabunga* 0.1%, *Veronica chamaedrys* 0.1%, *Veronica montana* 0.1%, *Vicia dumetorum* 0.1%

In 2015 and 2017, experts of the Danube–Ipoly National Park confirmed its presence in the vicinity of Király-kút. The plant bloomed there in the summer of 2018 too, but since then it has disappeared, and systematic searches have not been able to confirm its occurrence. The polycormon discovered and regularly checked by J. Nagy was right on the bank of the stream exposed to water (see photograph, Farkas 1999, p. 178), and presumably it was washed away by one of the floods of the Kemence stream.

Fig. 2. Voucher specimen of *Knautia dipsacifolia* from the Börzsöny Mts, collected by József Nagy near the "Király-kút" spring (BP HNHM-TRA 00129002).

[Bakony Mts]

Farkas (1999) reported it from the Cuha valley, Bakony Mts, as an old occurrence. We could not find a published history of this data. During the search for the origin of the data, we found several herbarium specimens from the Bakony Mts in the *Knautia dipsacifolia* material of the BP herbarium determined under the names of "*K. dipsacifolia*" and "*K. sylvatica*", but all specimens had to be revised (rev. N. Bauer, 03.08.2020). Each of these specimens can be identified as *K. drymeia* Heuff.

The specimens of the Degen herbarium (BP 302644, BP 302645) were originally determined only at the genus level. The differentia specifica ("*sylvatica* Duby") was written on the label by an unknown person in a different script, so it cannot be revealed whose mistake the first data of *K. dipsacifolia* from the Bakony Mts was based on. Later, in July 1974, J. Szujkó-Lacza and D. Kováts (BP 596323) and J. Ujhelyi and D. Kováts (BP 595285, 596324, det. L. Felföldy 18.10.1997) also collected specimens from the Cuha valley and erroneously identified as *K. dipsacifolia*.

Although the Cuha valley, which is rich in forests of ravines and mesophilic forests and preserves many montane species, could be suitable for *K. dipsacifolia*, the systematic survey in the summer of 2020 confirmed only the occurrence of *K. drymeia*. The data on the occurrence of *K. dipsacifolia* in the Bakony Mts can certainly be considered wrong and should be deleted.

A review of the Hungarian data on *K. dipsacifolia* confirmed that the species was included in the literature based on erroneous determinations not only from the northern part of the Great Hungarian Plain (cf. Lukács *et al.* 2019), but also from the Bakony Mts. It has been proven, based on the revision of Hungarian herbarium specimens of the species, that its real data come only from the volcanic mountains of Matricum (see Pócs 1981), from the cool microclimate valleys of the Mátra Mts, the Visegrád Mts, and the Börzsöny Mts (Fig. 3). However, its current occurrence is uncertain, it has not been found during targeted field visits to assess its populations in the last three years (2019–2021).

DISCUSSION

The confirmed data of *Knautia dipsacifolia* in Hungary fits in well with the distribution pattern of the Slovak populations (Štěpánek and Kmetová 1985), which suggests the Carpathian connections of the Hungarian populations.

K. dipsacifolia occurs in stony-rocky open places and forest edges in the high mountains as well (Ellenberg 1996, Szabó 1911, Zupančič 1992), while in Hungary it only finds shelter in the deep rocky forests of ravines, mainly in nar-

row strips along streams (cf. Bőhm 2001, Nagy 2007). Even the early description of Sadler (1925) characterised the habitat the same way: "ad margines sylvarum, torrentum (in saxis), in locis umbrosis, sylvaticis, declivatibus montium, ad scaturigines...". Based on the revision of Hungarian data, emerging from regional distribution pattern and the narrow habitat preference, it seems reasonable that the species is considered a glacial relict in Hungary (Nagy 2007).

Based on the red list status criteria of IUCN (2012) the species is threatened with extinction (CR) in Hungary. However, it would be premature to establish the fact of extinction, because in the past, there were also unfavourable periods for the species (warmer, dry, water-scarce years), when its populations were not confirmed for decades. It is known with all certainty that at Szentendre the species was common at the end of the 19th century, while in the first decades of the 20th century the population declined. Citing the data of Borbás and Simonkai, Szabó (1911) made a remark that "azóta nyoma veszett Budapest környékén" [it has since been lost in the Budapest area]. It is possible that the current disappearance of the species is not permanent either. Based on long-term precipitation data, there were severe droughts in the first decade of the 20th century; between

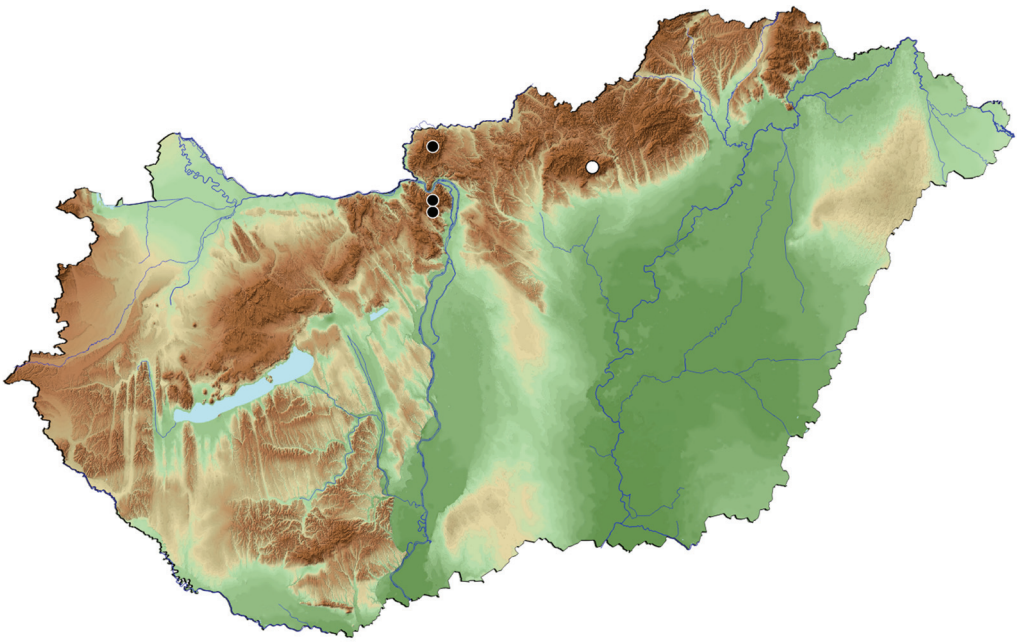

Fig. 3. Distribution of *Knautia dipsacifolia* in Hungary based on collected specimens (Legend: white circle: unconfirmed old data from the Mátra Mts (CEU grid cell: 8186.1 "Parád" locality); black circles: recent data from the last half century in the Börzsöny Mts (8079.2 "Barsi-Bükk" and "Király-kút" localities) and in the Visegrád Mts (8279.4 "Kárpát-forrás", 8379.2 "Dömörkapu" locality).

1900 and 1910 there were three years (1904, 1906, 1907) when the annual amount of precipitation at the Budapest measuring station near Szentendre did not reach 450 mm (http2) and the summers were dry, with nearly no precipitation in the summer months (http3).

Similarly to other montane relict plants (e.g. *Actaea europaea*, *Cypripedium calceolus*, *Dactylorhiza viridis*, *Lathyrus laevigatus* subsp. *transsylvanicus*, *Pleurospermum austriacum*) (Antal *et al.* 1994, Molnár V. and Sulyok 2011, Rónai *et al.* 2020, Sulyok 2006, Sulyok and Molnár V. 2011) of Hungary, *K. dipsacifolia* tends to be retreating and disappearing. It seems to be one of the victims of climate change with increasingly frequent periods of drought and rising average temperatures in Hungary (Bartholy *et al.* 2009, Spinoni *et al.* 2016).

The decline of Hungarian stands shows how significant risk factors are accidental events (such as the mentioned flood) in the case of small, unstable populations. Efforts should be made to protect the habitats and any possible elusive populations of *Knautia dipsacifolia*. During the protection of its habitat, care must also be taken to maintain the microclimatic conditions of the forest, which can be achieved by protecting not only forests of the narrow strips at the valley, but also the beech and scotch-oak forests on the surrounding valley sides. Closed forests are more resistant to the effects of drought and extreme heat waves (Zellweger *et al.* 2020), thus it is easy to see that the survival of species requiring a shady forest microclimate can only be expected if continuous forest cover is provided (Bartha and Puskás 2014, Ódor 2016). The role of responsible forest management is crucial in the preservation of our montane relict species. The systematic remapping of the species should be carried out in years characterised with cold winters and cooler and rainier than average weather conditions.

* * *

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Összefoglaló: Az elvégzett herbáriumi revíziós munka során bizonyítást nyert, hogy a *Knautia dipsacifolia* fajnak Magyarországról csak a Matricum vulkanikus (andezit) hegységeinek (Visegrádi-hegység, Börzsöny, Mátra) néhány extrém hűvös mikroklímájú patakos völgyéből vannak hiteles adatai. Minden egyéb korábbi hazai adata (Bakony, Észak-Alföld) téves közlésnek bizonyult, téves határozáson alapult. Az erdei varfű Magyarországon aktuálisan kipusztulással fe-

nyegetett, eltűnőben lévő faj, az elmúlt három évben egyetlen korábban térképezett előfordulási helyén sem jelentek meg egyedei. Más hegyvidéki fajainkhoz hasonlóan, a Kárpát-medencében is egyre gyakoribb aszályos időszakokkal és emelkedő átlaghőmérséklettel jellemezhető klímaváltozás egyik vesztesének látszik. A *Knautia dipsacifolia* élőhelyeinek, esetleg lappangó állományainak védelme érdekében erőfeszítéseket kell tenni. Élőhelyének védelme során az erdő mikroklimatikus viszonyainak fenntartására is gondot kell fordítani, ami úgy valósítható meg, hogy nemcsak a völgytalp keskeny sávjában jellemző szurdokerdőket és patakok menti égeres sávokat, hanem az állományt befoglaló, a környező völgyoldalakon álló bükkösöket és gyertyános-tölgyeseket is kímélni kell, mivel a zárt erdőállományok ellenállóbbak az aszályos és extrém meleg időszakok (hőhullámok) hatásaival szemben.

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