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Rediscovery of *Gymnadenia frivaldii* Hampe ex Griseb. at its northern distribution limit (Eastern Carpathians, Romania)

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A *Gymnadenia frivaldii* Hampe ex Griseb. újrafelfedezése areája északi határán (Keleti Kárpátok, Románia)

Összefoglalás – A Frivaldszky-bibircsvirág a Délkeleti-Kárpátok orchideaflórájának egyik ritkasága, amelynek fajneve híres Balkán kutatónk, Frivaldszky Imre (1799–1870) emlékét őrzi. Hegyvidéki lápokon, vízszivárgós, üde helyeken fordul elő a Balkán-félsziget hegyvidékein (Bulgária, Románia, Görögország, Macedónia, Montenegró, Albánia). A fajra a Kárpátokban először Heuffel János bukkant rá a Szárkő-hegységben. Habár a fajt Simonkai 1874-ben gyűjtötte a Retyezátban (Zenóga- és Bukura-tó), a példánya (BP33967) azonosságában bizonytalan volt, ezért az a halvány bibircsvirág (*Gymnadenia albida*) alá sorolva szerepel monográfiájában. Azóta több helyről előkerült a Retyezátból, így a Peleaga-havasról, a Zănoaga-, Zănoguţa-, Ana- és Bucura-tavak mellől és a Judele-völgyből, továbbá a Szárkő-hegység egy-két pontjáról is. Az utolsó szerzőnek a faj egy öt évtizeddel korábbi, csupán egy fitocönológiai tabellában dokumentált előfordulását sikerült megerősítenie a Hargita hegységben (Keleti-Kárpátok). Ez a lelőhely a faj areájának északi határán helyezkedik el, ezért növényföldrajzi szempontból igazán fontos adat. A közlemény bemutatja a faj felfedezésének történetét és jelenleg ismert elterjedését és veszélyeztetettségi státuszát a Kárpátokban, továbbá a Hargita hegységi élőhelyét.

Kulcsszavak: bibircsvirág, Frivaldszky Imre, Hargita, Kárpátok, Orchidaceae, természetvédelem

Abstract – Frivald's Gymnadenia is a very rare Balkan species in the South-Eastern Carpathians. The specific epithet "frivaldii" honours Imre Frivaldszky (1799–1870), a Hungarian naturalist. The species occurs in the drawdown zone of mountain fens of the Balkan Peninsula (Bulgaria, Romania, Greece, Macedonia, Montenegro, Albania), at elevations between 1000 and 2300 m. In the Carpathians the species was first reported from the Ţarcu Mts (Southern Carpathians) by János Heuffel. In 1874 Simonkai collected a specimen (BP 33967) in the Retezat Mts, but he was uncertain about its identity, thus this record eventually appeared as *G. albida* (*Pseudorchis albida*) in his monograph. Since then the species has been found at several localities in both the Retezat Mts (Mt Peleaga, Zănoaga, Zănoguţa, Ana and Bucura glacial lakes, Judele Valley) and the Ţarcu Mts. This paper reports on the discovery of Frivald's Gymnadenia in the area of "Szökő-láp" (Harghita Mts, Eastern Carpathians), which can be considered a confirmation of the old literature record. This is the northernmost locality of this Balkan species known so far. The chorology and conservation status of *G. frivaldii* in the South-Eastern Carpathians are discussed.

Keywords: biodiversity conservation, Carpathians, *Gymnadenia*, Harghita, Imre Frivaldszky, Orchidaceae

Redescoperirea speciei *Gymnadenia frivaldii* aflată la marginea nordică a arealului (Carpaţii Orientali, România)

Rezumat – *Gymnadenia frivaldii* este o orhidee rară şi periclitată, a cărei nume de specie a fost dată în onoarea naturalistului Frivaldszky Imre (1799–1870). Specia este răspândită în munţii din nordul Peninsulei Balcanice (Bulgaria, România, Grecia, Macedonia, Muntenegru, Albania), în pajişti umede şi în mlaştini dominate de muşchiul de turbă (*Sphagnum* spp.) din zona subalpină şi alpină. În Carpaţi, specia a fost găsită prima oară de J. Heuffel spre mijlocul secolului al XIX-lea, înainte de publicarea monografiei sale despre flora Banatului. Este foarte surprinzător că, deşi Lajos Simonkai găseşte specia în Munţii Retezat înainte de publicarea lucrării sale despre flora Transilvaniei, totuşi *Gymnadenia frivaldii* nu este inclusă în monografie ca atare, ci sinonimizată cu *Gymnadenia albida* = *Pseudorchis albida*. De atunci însă, specia a fost găsită în mai multe puncte din Munţii Retezat, atât în Poiana Pelegii, în zona lacurilor glaciare Zănoaga, Zănoguţa, Ana, Bucura, precum şi în Valea Judele. De asemenea, *G. frivaldii* a fost descoperită în două puncte din Munţii Ţarcu. Specia a fost menţionată în a doua parte a secolului al XX-lea, din Munţii Harghita (Carpaţii Orientali), într-un studiu fitocenologic publicat într-o revistă de circulaţie mai redusă. Din păcate, de atunci specia nu a mai fost menţionată din Munţii Harghita în principalele lucrări botanice româneşti de sinteză. Autorii acestui articol au reconfirmat în anul 2012 specia *G. frivaldii* după aproape jumătate de secol de la ultima menţionare, într-o mlaştină eu-mezotrofă din Munţii Harghita. Redescoperirea este extrem de valoroasă din punct de vedere biogeografic, deoarece locul este situat la margine de areal, reprezentând cel mai nordic punct din arealul acestui element carpato-balcanic. In acest studiu prezentăm corologia speciei *G. frivaldii* în Carpaţii Sud-Estici, descrierea habitatului din Munţii Harghita, precum şi statusul de periclitare al acesteia.

Cuvinte cheie: conservarea biodiversităţii, Carpaţi, *Gymnadenia*, Harghita, Imre Frivaldszky, Orchidaceae

Introduction

Due to climate change, extensive habitat destruction and fragmentation, and landuse change, many plant species over the world have suffered a rapid decline in their population density, and this trend is predicted to continue in the future (SALA *et al*. 2000). Members of the orchid family are especially vulnerable to landuse changes and uncontrolled harvesting (LIU *et al*. 2015, VOGT-SCHILB *et al.* 2015). In the South-Eastern Carpathians the number of threatened species (especially orchids) increased during the recent decades, due largely to intensive grazing (DIHORU & NEGREAN 2009).

One of the rarest orchid species in the Carpathians is *Gymnadenia frivaldii*, a Balkan subendemic element (MOORE 1980), whose distribution in the Carpathians is restricted to a few spots in the southeastern part of the mountains (DELFORGE 2006). This taxon has been previously assigned to the genus *Pseudorchis* (MOORE 1980). However, recent molecular analyses revealed a great difference between the two genera (*Pseudorchis* and *Gymnadenia*) and showed that *Pseudorchis frivaldii* should be included in the genus *Gymnadenia* (BATEMAN *et al.* 2006, EFIMOV 2013). *Gymnadenia frivaldii* is reported to be a diploid taxon (TRÁVNÍČEK *et al.* 2012), which can frequently hybridise with *Pseudorchis albida* and other species of the genus *Gymnadenia* (JERSÁKOVÁ *et al.* 2011). The species occurs in the drawdown zone of mountain fens at elevations between 1000 and 2300 m, with a strict requirement for non-carbonate substrates (DJORDJEVIĆ *et al.* 2016).

The aims of our study were to (1) survey the Romanian distribution records of this species, (2) describe the new locality in the Harghita Mts, (3) evaluate of the conservation status of *G. frivaldii* in the Carpathians.

Material and methods

The traced herbarium specimens stored at BP, BUC, BUCA, BVS, CL, I, IAGB, IASI, SIB (abbreviations following THIERS 2016) and available chorological information from botanical literature were compiled in order to clarify the distribution of *G. frivaldii* in the Romanian Carpathians. We could not trace relevant specimens in the herbaria of BVS, I, IASI, IAGB, BUCA, BUC and CRAI. Several field trips were made between 2003 and 2016 to the localities from where the species was previously reported: the Retezat and Ţarcu Mts (Southern Carpathians), and the Harghita Mts (Eastern Carpathians).

For identification of specimens a few floristic monographs (MOORE 1980, PAUCĂ & ŞTEFUREAC 1972, SÂRBU *et al.* 2013) were consulted. The nomenclature follows the Euro+Med Plantbase [1].

The distribution maps of *G. frivaldii* were compiled using the ArcGIS 9.3 (ESRI 1999–2009) software and WorldClim digital elevation model (HIJMANS *et at.* 2005) downscaled to 90 m.

Former records of *Gymnadenia frivaldii* in the Southern-Carpathians

In the 19th century, during his research aimed at elaborating a monograph on the vascular flora of the Banat region, the Hungarian botanist János Heuffel visited the Ţarcu (Szárkő) and the Godeanu (Godján) Mts in the Southern Carpathians. The main scientific results of these trips were published in a floristic monograph (HEUFFEL 1858), including the discovery of *G. frivaldii* that was a new taxon for the flora of the whole Carpathians. The species was found by Heuffel in a highly interesting floristic area of the Ţarcu Mts, the northern glacial circus named Groapa Bistrei (Gropa Bisztri).

In 1874 Lajos Simonkai collected a specimen (BP 33967) in the Retezat (Retyezát) Mts, but he was uncertain about its identity, thus this record eventually appeared as *G. albida* (*Pseudorchis albida*) in his great monograph (SIMONKAI 1887).

Later, Jávorka cited the Retezat and Ţarcu Mts in the Southern Carpathians as the only localities of *G. frivaldii* in the territory of historical Hungary (JÁVORKA 1924–1925). The occurrence of *G. frivaldii* in these mountain ranges is well documented in the herbaria of CL, BP and SIB.

BORZA (1934) also noticed the presence of *G. frivaldii* in the Retezat Mts (the glacial circus system of Zănoaga and Zănoguţa), in a phytocoenosis composed of *Sphagnum cuspidatum* Ehrh. ex Hoffm., *Juncus filiformis* L. and *Dactylorhiza cordigera* (Fr.) Soó. In the second half of the 20th century, floristic surveys carried out in the Retezat Mts uncovered several notable aspects regarding the peat bogs dominated by *Sphagnum cuspidatum*. Specifically, a group of researchers led by Nicolae Boşcaiu listed 24 alpine and subalpine peat bogs in the glacial complex of the Judele valley. Three of these peat bogs harboured the orchid *G. frivaldii* (BOŞCAIU *et al.* 1972, BOŞCAIU *et al.* 1974).

Interestingly, in the Romanian Flora (PAUCĂ & ŞTEFUREAC 1972) only a single locality of this species is mentioned from the Retezat Mts (Peleaga peak). OPREA (2005), CIOCÂRLAN (2009) and SÂRBU *et al.* (2013) record this species from the Retezat and Ţarcu Mts.

Further field research is required to broaden or knowledge of the species' distribution in Romania, with special respect to its alleged presence in the Semenic Mts (SOÓ 1958, see DIHORU & NEGREAN 2009) and the Piatra Craiului Massif (GRIEBL 2015). No voucher of *G. frivaldii* from the latter localities could be traced in the visited herbaria.

Former records of *Gymnadenia frivaldii* in the Eastern-Carpathians

The first record of the species from the Eastern Carpathians (Harghita Mts) was reported by SOÓ (1958) in his brief travelogue in Romania. According to Soó, *G. frivaldii* had been found by Samu Pap, a teacher from Odorheiu Secuiesc (Székelyudvarhely), in a newly discovered peat bog near Harghita Racu Mt (Rákosi-Hargita). Additionally, Soó had the opportunity to examine a specimen of *G. frivaldii* in the collection of Gábor Szabó (a photographer and amateur botanist in Făgăraş city) that was collected in the Semenic Mts (Southern Carpathians). These records were cited by DIHORU & NEGREAN (2009).

In the paper of COLDEA & PLĂMADĂ (1970) *G. frivaldii* appears in a single relevé, taken in a peat bog (*Caricetum fuscae*) located near the peak of Harghita Mădăraş Mt (Madarasi-Hargita). Surprisingly, this new locality was overlooked in the subsequent Romanian literature (e.g. OPREA 2005, CIOCÂRLAN 2000, CIOCÂRLAN 2009, SÂRBU *et al.* 2013).

Unfortunately, we could not trace any voucher of *G. frivaldii* from the Harghita Mts in the visited herbaria.



Fig. 1. Inflorescence and habit of *Gymnadenia frivaldii.*
Harghita Mts, Szökő-láp, 30 June 2012 (photo by G. Jakab)
1. ábra. A *Gymnadenia frivaldii* virágzata és habitusa.
Hargita, Szökő-láp, 2012. június 30. (Jakab G. felvétele)

On 30 June 2012, however, during his studies on the flora and vegetation of Szökő-láp ("Mlaştina în trepte"), Gusztáv Jakab found a relatively small population (ca. 10 specimens) of *G. frivaldii* (Fig. 1), in a phytocoenosis composed of *Carex dacica* Heuff., *C. echinata* Murray,

C. canescens L., *Caltha laeta* Schott, Nyman & Kotschy., *Myosotis scorpioides* L., *Galium palustre* L., *Trifolium pratense* L., *Dactylorhiza cordigera* (Fr.) Soó subsp. *siculorum* (Soó) Soó, *Potentilla erecta* (L.) Räusch., *Luzula spicata* (L.) DC. (Ass. Caricetum dacicae). The "Mlaştina în trepte" (Szökő-láp, Rákosi Sáté) is an oligo-mesotrophic peat bog located at an altitude of 1600–1700 m in the Harghita Mts (Eastern Carpathians), near the Mădăraş-Harghita peak (the summit of the Harghita Mts, 1801 m).

The vegetation of the peat bog is composed of Caricetum nigrae, Sphagno-Caricetum rostratae, Carici echinatae-Sphagnetum, Carici lasiocarpae-Sphagnetum, Carici flavae-Eriophoretum associations (JAKAB *et al.* 2007). The checklist of Szökő-láp consists of several rare species like *Paludella squarrosa* (Hedw.) Brid., *Cladopodiella fluitans* (Nees) Jörg., *Carex viridula* Michx., *C. limosa* L., *C. pauciflora* Lightf., *Menyanthes trifoliata* L., *Pinguicula vulgaris* L., *Comarum palustre* L., *Neottia cordata* (L.) Rich., *Empetrum hermaphroditum* Hagerup (JAKAB *et al.* 2007).

This very important finding can be considered a rediscovery of the enigmatic *G. frivaldii* in the Eastern Carpathians after half a century (COLDEA & PLĂMADĂ 1970). At the same time it represents the northernmost record of this Balkan species.

Based on the reviewed herbarium material (Appendix 1) and available literature data, we present the distribution maps of *G. frivaldii* in the Balkan peninsula in general and the Carpathians in particular (Fig. 2).

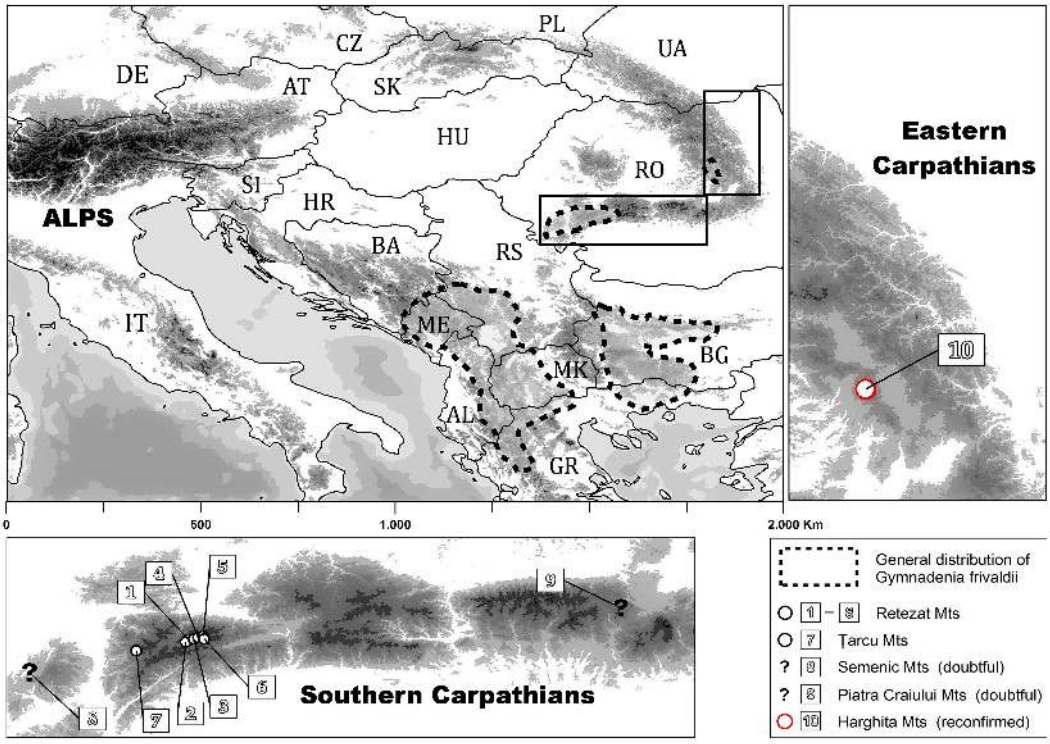


Fig. 2. Distribution of *Gymnadenia frivaldii*
2. ábra. A *Gymnadenia frivaldii* elterjedése

Conservation status of *G. frivaldii* in the South-Eastern Carpathians

Only seven populations of *G. frivaldii* are known with certainty in the South-Eastern Carpathians, specifically in the Ţarcu Mts (Groapa Bistrei), Retezat Mts (Peleaga Mt, Judele valley, Bucura valley, Zănoaga lake, Zănoguţa lake) and Harghita Mts (Szökő-láp). The localities are partly included in the protected areas network of Romania: "Natura 2000 Ţarcu" and the Retezat National Park. However, the territory of Szökő-láp with the discovered population of *G. frivaldii* (Harghita Mts) is not protected.

Unfortunately, the protected territories mentioned above are exposed to intense grazing. We hereby propose a strict protection for the areas in the Retezat, Ţarcu and Harghita Mts, where this species occurs. In 2012, Attila Bartók found a very small population of *G. frivaldii* in the Retezat National Park, near the Poiana Pelegii. Unfortunately, subsequent observations at this locality in 2013 and 2015 could not confirm the existence of the population. This is most probably due to the installment of a sheepfold in the vicinity of this valuable botanical site. Besides grazing, in the Harghita Mts touristic infrastucture developments are threatening the habitat of *G. frivaldii*, especially by reducing the water supply of the peat bog, because the groundwater had been canalised towards the nearby hotels.

The estimated IUCN conservation status (IUCN 2012) of *G. frivaldii* in the Carpathians: Endangered (criteria B1bc (i, ii, iii)).

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[1] Euro+Med Plantbase (http://www.emplantbase.org)

Appendix 1 – List of validated *Gymnadenia frivaldii* specimens included in this study

- Hungaria Orientalis: in alpibus Retyezát [Retezat], circa lacum Zenoga [Zănoaga] et Bukura [Bucura], 30 Jul 1874, Simonkai (BP)
- In alpibus Retyezát [Retezat] ad lacum Zenoga [Zănoaga], 25 Jul 1888, Barth (BP)
- Retyezát-havasok [Munţii Retezat]: Pelaga [Peleaga], cca. 1700–1800 m, 16 Jun 1901, Győrffy (BP)
- Retyezát-hegység [Munţii Retezat]: ''Pelaga-havas'' [Muntele Peleaga], a Font. Pelaga [Poiana Pelegii] vadvízes partján, 16 Jun 1901, Győrffy (CL)
- Comit. Hunyad [Judeţul Hunedoara], Retyezát [Retezat], in monte Vurfu Pelaga [Vf. Peleaga], alt. cca. 2200 m, 19 Aug 1903, Degen (BP)
- In pratis subalpinis ad Gropa Bisztra [Groapa Bistrei] sub alpe Szárkó [Muntele Ţarcu], 25 Jun 1905, Lengyel (BP)
- Transsilvania, Montibus Retyezát [Munţii Retezat], Vf. Slăveiul déli oldalán, 21 Jul 1909, Nyárády (SIB)
- Transsilvania, Montibus Retyezát [Munţii Retezat], Zanogatónál [Lacul Zănoaga] 1973 m, granit, 22 Jul 1909, Nyárády (SIB)
- Transilvania, distr. Hunedoara, montibus Retezat: in abruptis vallis majoris Zănoguţae, alt. cca. 1900–2000 m, Borza & Nyárády, 10 Aug 1933 (CL)
- Transsilvania, distr. Hunedoara, montibus Retezat: in graminosis humidis ad lacum Zănoaga, alt. cca. 1900 m, Borza & Nyárády, 10 Aug 1933 (CL)
- Transilvania, distr. Hunedoara, montibus Retezat: in turfaceis alpinis ad marginam occid. lacum Zănoaga, alt. cca. 1980 m, Borza & Nyárády, 10 Aug 1933 (SIB)
- Transsilvania, distr. Hunedoara, montibus Retezat: in regione alpina inter lacus Ana, Viorica et Puşa, vallis Bucura, alt. cca. 1985–2090 m, Borza & Nyárády, 12 Aug 1933 (CL)
- Comit. Hunyad, Mt Retyezát [Munţii Retezat]: in sphagneto ad lacum Zenoga [Lacul Zănoaga] supra Gurazlata, alt. cca. 2000 m, 28 Jul 1938, Kárpáti (BP)
- Transsilvania meridionalis: in pratis alpinis turfosis prope lacu Zenoga [Lacul Zănoaga], Retyezát [Retezat], alt. cca. 2000 m, 28 Jul 1938, Vajda (BP)
- Transsilvania meridionalis: in limosis regionis alpinis supra lacu Zenoga [Lacul Zănoaga], Retyezát [Retezat], alt. cca. 2050 m, 29 Jul 1938, Vajda (BP)
- Alpibus Retezatensibus [Munţii Retezat]: in pratis paludosis subalpinis ad aqua torrentis ''Poiana Pelegii'', eodemque vicinis locis spongiosis, in societate plantarum: *Cardamine amara* L., *Dactylorhiza cordigera* (Fr.) Soó et *Saxifraga stellaris* L., 11 Jun 2012, A. Bartók & S.I. Bartók (herbarium of A. Bartók)

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