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THE *SPHAGNUM* PEATBOGS OF MOLHAȘUL DE LA RÂȘCA - DEALUL NEGRU, CLUJ COUNTY

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Abstract

Molhaşul de la Râşca - Dealul Negru is a montane oligotrophic peatbog complex in Cluj County (1042-1070 m a.s.l.), within the alpine biogeographical region of north-western Romania. Covering 35 ha, it comprises a mosaic of Sphagnum-dominated peat-forming communities, and for S. affine is the only site in Romania. The structure and hydrology of the site have been slightly altered by past drainage, grazing pressure, surrounding land-use changes and the expansion of woody vegetation, leading to anthropogenic habitat fragmentation and partial isolation from the neighbouring Râşca Răchitiş mire. Based on new field surveys, the present study documents the diversity, distribution patterns and habitat preferences of Sphagnum species across the active raised bog and evaluates the conservation value of Molhaşul de la Râşca - Dealul Negru as one of the regional reference sites for Sphagnum-dominated ecosystems in the Gilău Massif.

Key words*: Molhaşul de la Râşca, Natura 2000, peatbog, Romania, Sphagnum.*

INTRODUCTION

Peatlands represent critical reservoirs of carbon worldwide, covering about 3.0% of the total land area but storing much more carbon than any terrestrial ecosystem (Scharlemann et al., 2014; Keane et al., 2025). One of the key ecosystem services that peatlands provide is biodiversity support, or even refugia for some rare species. Alongside climate regulation, water management and cultural heritage, this makes peatlands essential for sustainable environmental stewardship and long-term conservation. These ecosystems host a unique variety of species, many rare, endangered, or even adapted to wet, acidic, and nutrient-poor environments (Joosten et al., 2017). Therefore, protecting increasingly threatened peatlands thus directly supports biodiversity conservation.

Molhaşul de la Râşca - Dealul Negru Peatbog (CJ-016) represents one of the largest peatbogs in the Apuseni Mountains (21.59 ha).

From a historical perspective, E. Pop first described Molhaşul de la Râşca Peatbog (also known as *Mohuş-ul de la Dealul Negru* or *"Lágyas"*) in 1947 as being the only Apuseni site with natural *Pinus sylvestris*, though it was already invaded by trees (*Picea*, *Pinus*, *Betula pendula*, *B. pubescens,* and *Populus tremula*) and generally drier (with *Calluna vulgaris*, *Empetrum nigrum*, and *Vaccinium myrtillus*) (Pop, 1947). He noted early signs of degradation due to the nearby village (Pop, 1947; Pop, 1960). Later, he reported a 2.2 m-thick peat layer (ca. 120,000 m^3 formed mainly of sub-Atlantic origin, pH 3.90-5.00), along with some crises: underground peat burning (1910-1912) and exploitation from 1952 onwards (Pop, 1960).

Concerning the bryophyte flora of the study site, Györffy and Péterfi (1919) recorded two *Sphagnum* taxa from "*Lágyas*": *Sphagnum compactum* var. *squarrosa* and *Sphagnum imbricatum* var. *cristata* fo. *fuscescens*. Between 1936 and 1946, E. Pop collected additional *Sphagnum* species from Molhaşul de la Râşca and nearby sites, later determined and published by T. Ștefureac (1958) as *S. acutifolium* Ehrhardt (*S. nemoreum* Scop.), *S. capillaceum* (Weis.) Schrank (1936) and var. *versicolor* Warnst. (1936), and *S. magelanicum* Brid. (currently referred to as *S. medium* Limpr; 1936).

Sphagnum represents one of the most dominant plants in many peatlands. It engineers favourable conditions for its proliferation through moisture retention via capillary action,

nutrient efficiency, acidification, slow decomposition (due to the polyphenol content), and microbial suppression by specialized metabolites (Keane et al., 2025). As a *Sphagnum*-dominated peatbog, Molhașul de la Râșca - Dealul Negru`s accumulated organic matter - peat - is composed of a high percentage of this specific decomposed species due to its known resistance to decomposition (Kuhry & Vitt, 1996).

Some *Sphagnum* species from this site have a conservative importance, being the keystone of the ecosystem. *Sphagnum affine* Renauld & Cardot holds NE (not evaluated) conservation status in Romania due to data deficiency (Ștefănuț & Goia, 2012; Hodgetts et al., 2020). Recently confirmed in one site in Romania (Molhașul de la Râșca - Dealul Negru), therefore the conservation status changed from NE to CR (critically endangered) B1ab (ii, iii) + B2ab (ii, iii) (Sabovljević et al., 2025; Sass-Gyarmati et al., 2025; Ștefănuț et al., 2026). *S. affine*`s occurrence could be underestimated due to morphological similarities with *S. palustre*, particularly as they co-occur (Figure 1). Until now, we could consider *S. affine* a threatened species nationally, and it should have a protected conservation status.



Figure 1. *Sphagnum affine* mixed with *S. palustre,* Molhașul de la Râșca - Dealul Negru, 6.10.2025 (photo by Ștefănuț S.)

Similarly, *Hamatocaulis vernicosus* (Mitt.) - varnished hook-moss - is listed in Annex II of the EU Habitats Directive (European Union. Council Directive 92/43/EEC), with a 'Vulnerable' status in the Red Data Book of European Bryophytes (European Committee for the Conservation of Bryophytes) and the Red List of Romanian Bryophytes (Ștefănuț & Goia, 2012).

It faces a projected pessimistic future scenario of major range losses due to climate change (Ștefănuț et al., 2025), underscoring the need to protect it alongside peatland habitats.

Even though many Romanian peatlands face severe degradation, Molhașul de la Râșca Peatbog represents a rare functional oligotrophic system with Atlantic affinities (Sass-Gyarmati et al., 2025).

Despite historical documentation, no comprehensive bryophyte inventories have existed for over several decades. This data deficiency for conservation assessments of Molhașul de la Râșca Peatbog shaped this study`s objectives: (1) inventory bryophyte biodiversity, (2) assess PeatRO-identified pressures and conservation priorities, and (3) propose management measures for long-term protection. These efforts provide the scientific basis for the integration of Molhașul de la Râșca Peatbog within Apuseni Natural Park (RONPA0004) or its designation as a Natura 2000 Site of Community Importance (SCI).

MATERIALS AND METHODS

Study Area and Site Importance

Molhașul de la Râșca - Dealul Negru (CJ-016; 46.710460° N, 23.050730° E) lies within Râșca commune, Cluj County, Romania. Biogeographically, it belongs to the alpine region, situated in the northwest of Romania on the Dealul Negru plateau between Călata and Râșca valleys 1042-1070 m a.s.l., Gilău Massif, covering 35 ha (Figure 2). The site is located at 0.6 km to Apuseni Natural Park (RONPA0004) and Apuseni Natura 2000 site (ROSCI0002).



Figure 2. Geographical limits of Molhașul de la Râșca - Dealul Negru (grey). In blue is the Apuseni Natural Park

Pop (1947) positioned Molhașul de la Râșca – Dealul Mare and Molhașul de la Călățele (the largest peat bogs in the area) opposite each other across adjacent watersheds drained by Valea Călățele (Figure 3, a and b). Geologically, he describes the parent rock in the area as consisting primarily of nutrient-poor Eocene sandy clay, with exceptional outcrops of crystalline schists in contact with sandstone substratum (Pop, 1960).

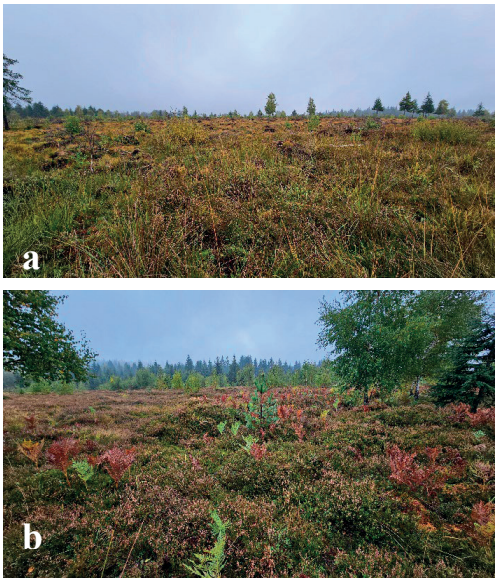


Figure 3. Molhașul de la Râșca Peatbog, ground view (a and b), 6.10.2025 (photo by Ștefănuț S.)

Currently, the general aspect of the site is an oligotrophic bog, with a deficient water regime. Dominant vegetation includes mosses (mainly *Sphagnum*) and the presence of some nano-phanerophytes such as *Calluna vulgaris*, *Empetrum nigrum*, *Vaccinium myrtillus*, *V. vitis-idaea,* and *Juncus squarrosus* - the latter representing its only national occurrence as an Atlantic species (Frink et al., 2017; Sass-Gyarmati et al., 2025; PeatRO Project).

Field survey and sample collection

Molhașul de la Râșca Peatbog was selected due to underreported bryophyte diversity, highlighting the need for additional conservation assessments. To inventory bryophytes, a field survey was made in order to collect samples on 6 October 2025.

For each species population, we recorded GPS coordinates (Garmin 64s, <50 cm accuracy), captured aerial imagery (DJI Mini 2 drone), and integrated the ground-based data to map habitat distribution.

The collected samples of bryophytes were morphologically identified under the light microscope, and the nomenclature of *Sphagnum* species was made after Hodgetts et al. (2020) and Hassel et al. (2025).

Pressures and threats

As a part of the PeatRO Project (2015-2017), Molhașul de la Râșca - Dealul Negru (CJ-016) and 215 other Romanian peatlands were evaluated for their conservation status in order to inform national strategies limiting biodiversity loss. Anthropogenic and environmental pressures noted during this project included drainage, cattle grazing, land-use changes and woody vegetation encroachment. Main threats comprise climate change and habitat fragmentation linked to the adjacent Râșca Răchitiș mire. Subsequent to the identification of these existing pressures, the project proposed restoration measures aimed to mitigate these pressures and to preserve the habitats.

RESULTS AND DISCUSSIONS

During our field surveys, we identified a number of ten *Sphagnum* species, of which many are specific to the peat bogs of the Apuseni Mountains, and others are bryophyte species with great conservation potential, such as *Hamatocaulis vernicosus*.

Sphagnum affine Renauld & Cardot

The species was first reported from Molhașul de la Râșca Peatbog as *Sphagnum imbricatum* Hornsch. var. *cristata* fo. *fuscescens* Warnst Comit. Kolozs: in turfosis Lágyas supra Magyarvalkó, alt. cca 920 m.s.m., 1915.25.X., leg. & det. Györffy I. and Péterfi M., BP (Budapest Herbarium) 7450/S, 7451/S, rev. Ștefănuț M-M. (Györffy & Péterfi, 1919; Sabovljević et al., 2025).

The species was rediscovered at the same site on 26 July 2013 (46.70849° N, 23.05224° E, 1070 m a.s.l.), *leg*. Sass-Gyarmati A., Jakab G., *det*. Sass-Gyarmati A., 2014, EGR (Eger

Herbarium), CL (Cluj-Napoca Herbarium), reported on 30 June 2025 (Sass-Gyarmati et al., 2025), BUCA (Institute of Biology Bucharest Herbarium), *B12946* (*conf.* Ștefănuț M.-M., 23 June 2025).

Both records were a compelling reason for us to look further for *S. affine* (Figure 4) in Molhașul de la Râșca peatbog, being the only location in Romania where it has been reported. Therefore, we confirmed its presence on 6 October 2025 at Molhasul de la Râsca - Dealul Negru, 46.709174° N, 23.049022° E, 1053 m a.s.l., *leg*. Ștefănuț M.-M., Moroșanu A.-M., Ștefănuț S., *det*. Ștefănuț M.-M., confirmed by Ștefănuț S., BUCA *B12617* (Ștefănuț et al., 2026).



Figure 4. *Sphagnum affine*, close-up (photo by Ștefănuț S.)

Sphagnum compactum Lam. & DC.

An Atlantic species which was previously reported as *Sphagnum compactum* DC. var. *squarrosa* Russ., *Comit Kolozs: in turfosis Lágyas prope pagum Magyarvalkó, alt. 1000 m.s.m.* (25.10.1915), by Györffy and Péterfi (1919), confirmed by Sass-Gyarmati et al. (2025).

We also found *S. compactum* at Molhașul de la Râșca Peatbog, 46.708450° N, 23.051975° E, 1063 m a.s.l., 6.10.2025, *leg*. Ștefănuț M.-M., Moroșanu A.-M., Ștefănuț S., *det*. Ștefănuț M.-M., confirmed by Ștefănuț S., BUCA *B12671-B12672* (Figure 5).

We did not find two *Sphagnum* species previously recorded: *Sphagnum platyphyllum* (Lindb. ex Braithw.) Warnst. (Meleshko et al., 2025; Sass-Gyarmati et al., 2025), and *S. subsecundum* Nees (Meleshko et al., 2025).



Figure 5. *Sphagnum compactum*, close-up (photo by Ștefănuț M.-M.)

Hamatocaulis vernicosus (Mitt.) Hedenäs

Even though drier, but an oligotrophic peatbog, Molhașul de la Râșca proved to be a suitable host for *H. vernisosus*, as it prefers such habitat conditions. We recorded for the first time this species in this site, 46.707762° N, 23.051411° E, 1065 m a.s.l., 6.10.2025, *det*. Ștefănuț S., Moroșanu A.-M., Ștefănuț M.-M. Also, we confirm the presence of *H. vernisosus* in Dâmbu Negru – La Pod site, 46.691190° N, 23.037044°E, 1079 m a.s.l., 7.10.2025, *det*. Ștefănuț S., Moroșanu A.-M., and Ștefănuț M.-M. (Figure 6).



Figure 6. *Hamatocaulis vernicosus,* close-up (photo by Moroșanu A.-M.)

Also, we found *Sphagnum angustifolium* (C.E.O. Jensen ex Russow) C.E.O. Jensen, *S. capillifolium* (Ehrh.) Hedw. (Figure 7), *S. divinum* Flatberg & Hassel (Figure 8), *S. girgenshonii* Russow, *S. inundatum* Russow (Figure 9), *S. medium* Limpr. (Figure 10), and *S. palustre* L. (Figure 11).



Figure 7. *Sphagnum capillifolium*, close-up (photo by Ștefănuț M.-M.)



Figure 8. *Sphagnum divinum*, close-up (photo by Ștefănuț S.)



Figure 9. *Sphagnum inundatum*, close-up (photo by Ștefănuț M.-M.)

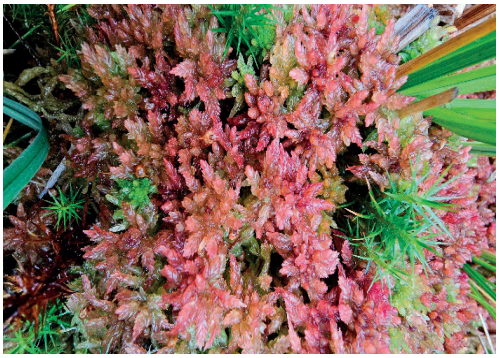


Figure 10. *Sphagnum medium*, close-up (photo by Ștefănuț S.)



Figure 11. *Sphagnum palustre*, close-up (photo by Ștefănuț M.-M.)

Management recommendations

The relatively dry conditions mentioned several decades ago by Pop (1947), also currently observed, alongside the decreasing abundance of peat-forming bryophytes, will materialise into a reduction of the peat accumulation and therefore a significant atmospheric carbon release. Bryophytes thus serve as key indicators for the structure and function of the peatland ecosystems (Vitt & House, 2021).

Furthermore, the vascular plant encroachment proved to be an early indicator of peatland degradation, a warning signal of warming- and drought-driven *Sphagnum* decline which accelerates ecosystem transition (Yu et al., 2026).

Considering all the anthropogenic and environmental pressures identified during the PeatRO Project (2015-2017), we consider that some priority conservation measures are

essential across short-, medium- and long-term periods, supported by a national legal framework, in order to protect the site and its biodiversity.

Short-term measures include grazing prohibition (fencing) and control of woody encroachment (manual removal), while medium-term measures include rehydration (dam construction and restoring the hydrological connectivity with Râșca Răchitiș mire CJ-017) and periodic monitoring efforts. In the long-term, the legal designation of Molhasul de la Râsca-Dealul Negru (CJ-016) as a Site of Community Importance (SCI) under the Natura 2000 umbrella or integration within Apuseni Natural Park (RONPA0004).

CONCLUSIONS

Molhașul de la Râșca - Dealul Negru is remarkable as a key reference site for oligotrophic peat bogs in Apuseni Mountains, housing Romania`s unique *Sphagnum affine* (CR) population, alongside other rare bryophytes (*S. compactum*, *Hamatocaulis vernicosus* - VU).

This study inventories eleven *Sphagnum* species, bridging historical records while highlighting populations` resilience despite the PeatRO-identified pressures.

Current reports underscore the importance of continuous monitoring, given the anthropic pressures and habitat fragmentation.

Priority management measures recommended are short-term (grazing prohibition and control of woody encroachment), and medium-term (rehydration efforts and monitoring), which, alongside long-term legal measures (integration within Apuseni Natural Park RONPA0004 or designation as a SCI Natura 2000), will contribute to site conservation in a declining climate change context.

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