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The rare moss *Didymodon johansenii* (R.S. Williams) H.A. Crum in the Italian and Austrian Alps

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Abstract – *Didymodon johansenii* (R.S. Williams) H.A. Crum is recorded for the first time for Italy from the Brenta Dolomites of the Southern Alps, Province of Trento. In addition, a series of unpublished records from the Austrian Alps are presented and the known distribution of the species in Central Europe is mapped. The differentiation of the species, which is well-characterized among European species by a swollen, deciduous leaf apex, is discussed. *D. johansenii* is a cryophilous xerophyte, usually growing in full sun on S-facing rock walls of limestone and calcareous schist in the subalpine and alpine belt of the Alps. It probably belongs to a series of bryophyte species with Central Asian origin which reached the Alps by crossing the cold steppes during the glacial maxima of the Pleistocene.

***Didymodon* / mosses / Pottiaceae / distribution / ecology / phytogeography**

INTRODUCTION

Didymodon is one of the largest genera of Pottiaceae in Europe, comprising 27 species according to Hill *et al.* (2006). *Didymodon johansenii* is a rare European taxon already reported for the Alps, but the distribution and ecology of which are still poorly known. Monte Peller and Piani della Nana are located in the extreme north of the Brenta Dolomites (Adamello-Brenta Natural Park, Italian Alps). From the geological perspective this mountain area is famous for the diversity of co-occurring limestone rocks. To verify if and to what extent these geological formations possess differences in the composition of their lichen and bryophyte floras, the first author was commissioned with a scientific study by the authorities of the Natural Park. During extensive fieldwork in 2010, *Didymodon johansenii* was detected in two sites, about 1 km apart, on sunny and dry limestone rock walls, in both cases in low quantity. This is the first report of the species in Italy and increases the number of the Italian *Didymodon* species to 20 (Aleffi *et al.*, 2008). As well, our study presents a compilation of the known Alpine loca-

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lities, most of them being new. Based on considerable field-experience, we also provide a characterization of its ecology and an explanation for its rarity in Europe.

DISTRIBUTION

Williams (1921) described the moss (within the genus *Barbula*) based on a single specimen collected by Frits Johansen on Victoria Island, Canada. From North America it has been recorded also from Alaska, Alberta, the Northwest Territories, Nunavut and Yukon (Zander, 2007). It is furthermore known from continental parts of Asia, especially from Kyrgyzstan, Tajikistan, Yakutia, the Arctic Far East (Ignatov *et al.*, 2006), Pakistan (Sollman, 2008), Bhutan (Sollman, 2010), Mongolia (Tsegmed, 2006) and China (Redfearn *et al.*, 1996). From the European Arctic there is a single record from Svalbard (Frisvoll, 1978), while as far as the Central Europe is concerned, the first report was from Carpathians, in the Belianske Tatry Mountains (Pilous, 1995).

Kučera (2000) reported for the first time *D. johansenii* from the Alps, based on his herbarium revisions and records by HK. However, in that publication the exact distribution of the species was missing. Later, Köckinger *et al.* (2008) reported the species from the Carinthian part of the Hohe Tauern. The only historical record from the Alps comes from Switzerland where P. Culmann collected the species in 1912. During revision work it was detected by J. Kučera as an admixture in a specimen of *Grimmia andreaeoides* Limpr. This record was included in the Swiss Online-Atlas (www.nism.uzh.ch) but here we provide the full geographic information. The current knowledge of its distribution in Central Europe is mapped in Fig. 1.

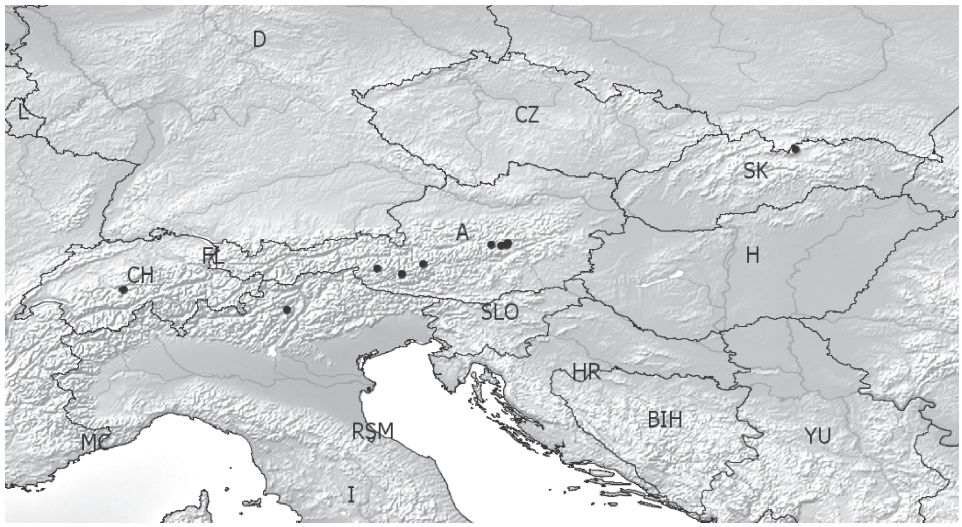


Fig. 1. Distribution of *Didymodon johansenii* in Central Europe.

Localities for *D. johansenii* in the Alps:
ITALY: **Province of Trento**: Brenta Dolomites: Monte Peller, Passo della Forcola, 2100 m, 22.6.2010, *D. Spitale* s. n., confirm. J.A. Jiménez, TR(cLIM003 BRYO 0002); Monte Peller, 2100 m, 19.9.2010, *D. Spitale* s. n., confirm. J.A. Jiménez, TR(cLIM003 BRYO 0003).
AUSTRIA: **Carinthia**: Hohe Tauern: Großfragant, Bretterach, S-Hang, *ca* 1950 m, 25.9.1999, *H. Köckinger* s.n., KL (Köckinger *et al.*, 2008). **Salzburg**: Radstädter Tauern: E of Zalußenalm, S-Hang der Plankowitzspitze, *ca* 1800 m, 4.8.1997, *H. Köckinger* 97-631, KL. **Styria**: Eisenerzer Alpen: Grüblzinken, S-slope, 1800-1900 m, 13.7.1998, *H. Köckinger* 14899, 6.9.1998, *H. Köckinger* 14900, GZU, J. Kučera 7169, 7171, 7182, 7183, CBFS, 28.9.2006, *H. Köckinger* 14901, GZU; Vordernberger Zinken, S-slope, *ca* 1820 m, 12.10.2006, *H. Köckinger* 14902, GZU; Wildfeld (mt.), S-slope, *ca* 1680-1700 m, 7.9.1998, *H. Köckinger* 14903, GZU, J. Kučera 7204, 7206, 7209, 7212, CBFS; Leobner Mauer N of Wald am Schoberpass, S-slope, *ca* 1800 m, 17.10.1998, *H. Köckinger* 14904, GZU; Polster NE of Präbichl, *ca* 1700 m, 30.7.1998, *H. Köckinger* 14905, GZU. **Eastern Tyrol**: Hohe Tauern: Muntanitz-Massiv, 1 km W der Sudetendeutschen Hütte, *ca* 2550 m, 20.8.1996, *H. Köckinger* 96-965, KL (Duplicates of the Austrian collections also in the private herbarium of H. Köckinger).
SWITZERLAND: **Berne**: Berner Alpen: unterhalb vom Loucherhorn am Faulhornweg, 2050 m, 24.7.1912, *P. Culmann* (Z-ZT).

IDENTIFICATION

Didymodon johansenii is well-characterized among European species by its thickened, long-cylindric or clavate leaf apex which is caducous and acts as a propagulum (Figs 2-7). Detailed descriptions of *D. johansenii* are given in Jiménez (2006) and Zander (2007).

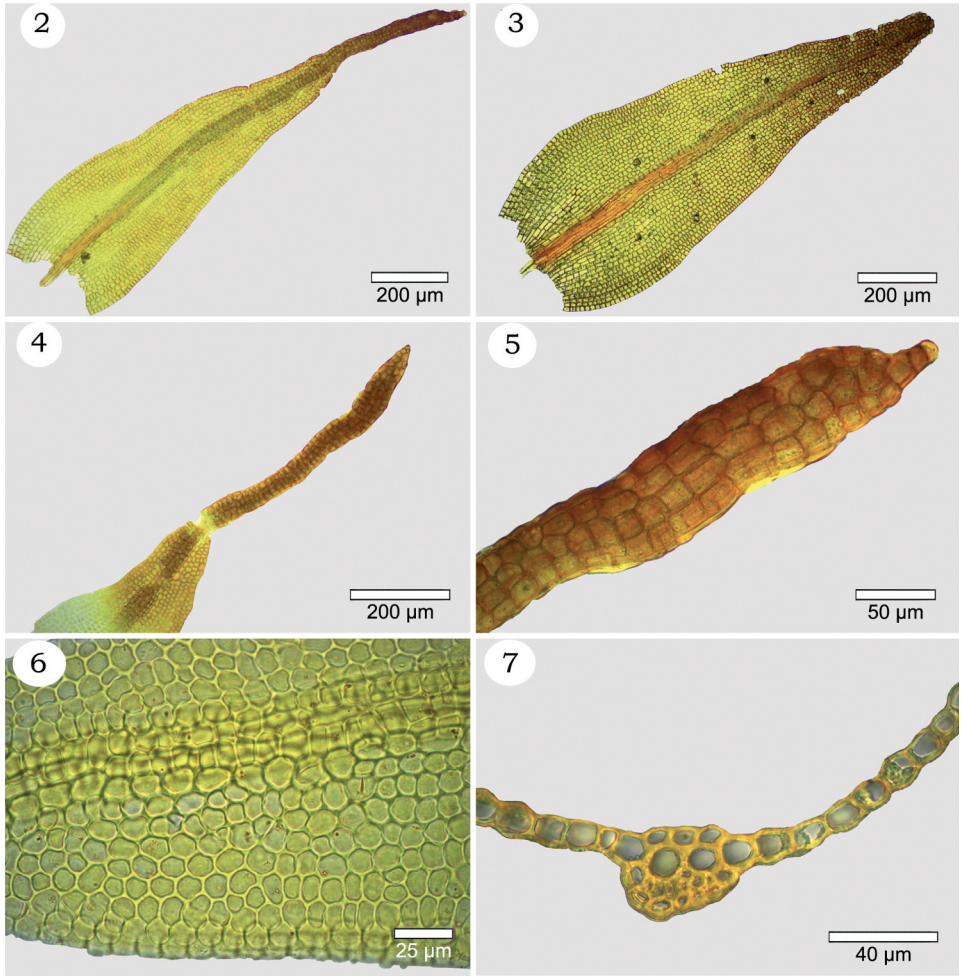
It most closely resembles *D. anserinocapitatus* (X.J. Li) R.H. Zander, a rare species known from very few stations in Central Asia and the USA (Jiménez *et al.*, 2004; Zander 2007). Both species share the deciduous, swollen leaf apex and an essentially identical habit. However, *D. johansenii* can be distinguished by its larger upper laminal cells (9-15 µm wide) and the transverse section of the costa with guide cells in one layer, while *D. anserinocapitatus* has smaller upper laminal cells (4-8 µm wide) and guide cells in two layers.

In Europe confusion is possible with the less similar but often associated *D. icmadophilus* (Schimp. *ex* Müll.Hal.) K. Saito and *D. rigidulus* Hedw. Sometimes *D. icmadophilus* presents deciduous apices but the subula is never distinctly swollen. Furthermore, its lamina cells are usually smaller and somewhat papillose (smooth in *D. johansenii*). *D. rigidulus* differs also in the gradually narrowed apex, the distally bistratose margin and the usual presence of axillary gemmae.

Swollen, deciduous leaf apices independently evolved in several genera of the Pottiaceae. *Molendoa taeniatifolia* Herzog, endemic to the Alps, represents a perfect case of convergent evolution. In habit, it is almost inseparable from *D. johansenii* but differs microscopically by distinctly papillose lamina cells and gametangia born on short lateral branches. Both species even may occur in similar habitats; the *Molendoa*, however, prefers moister crevices and was hitherto only found on calcareous schist.

ECOLOGY

Didymodon johansenii is a cryophilous xerophyte, in the Alps confined to sun-exposed, S-facing rock-walls and steep ledges in the subalpine and alpine belt (1680-2550 m). It forms low and dense, rigid, dull green to brown or nearly



Figs 2-7. *Didymodon johansenii*. **2.** Leaf. **3.** Leaf, apex broken. **4.** Upper part of leaf, preformed abscission point clearly visible. **5.** Propaguloid leaf apex. **6.** Upper lamina and costa. **7.** Transverse section of costa. 2-7 from *Spitale s.n.*, TR.

blackish cushions in shallow crevices of vertical to inclined rock surfaces or colonizes old cushions of *Schistidium* or *Grimmia* species, often associated with other *Didymodon* taxa.

Although being calciphilous in general, the species is highly demanding concerning the mineral composition of the rock. In addition to carbonates, it prefers rocks with high silica contents. This is obvious for the occurrences on calcareous schist but also for the known limestone localities in the Alps. In the Eisenerzer Alpen it is strictly confined to Palaeozoic marly limestone rock (rich in silicates) whereas it is absent from the neighbouring Triassic limestone rocks (carbonates). These rock types can be easily distinguished by colour, with the Palaeozoic limestone rock looking reddish (iron and other heavy metals containing) or yellowish, and the Triassic looking pure white. The northern part of the Brenta

Dolomites (area of Monte Peller – Piani della Nana) is rich in different calcareous sedimentary rocks (mainly Oolitic limestone, Ammonite-bearing red limestone, Scaglia Rossa). Here it is restricted to the Scaglia Rossa formation, a characteristic reddish coloured marly limestone rock of the late Cretaceous period. The Swiss collection originates from Jurassic limestone.

Among the associated plants there are many taxa indicating nutrient-rich rock, both among lichens and mosses. In the Austrian Alps, *D. johansenii* has been found growing together with the following taxa (arranged in descending order frequency): *D. subandreaeoides* (Kindb.) R.H.Zander, *Pseudoleskeella catenulata* (Brid. *ex* Schrad.) Kindb., *Grimmia anodon* Bruch *et* Schimp., *D. icmadophilus* (Schimp. *ex* Müll. Hal.) K.Saito, *D. rigidulus* Hedw., *Bryum argenteum* Hedw., *Tortella bambergeri* (Schimp.) Broth., *Grimmia tergestina* var. *tergestinoides* Culm., *G. teretinervis* Limpr., *Schistidium atrofuscum* (Schimp.) Limpr., *S. crassipilum* H.H. Blom, *Hypnum vaucheri* Lesq., *Syntrichia ruralis* (Hedw.) F.Weber *et* D.Mohr. Characteristic for the same special habitat, but more rare than the foregoing taxa, are *T. alpicola* Dixon, *P. tectorum* (Funck *ex* Brid.) Kindb. *ex* Broth. and the lichen *Teloschistes contortuplicatus* (Ach.) Clauzade *et* Rondon. The Swiss material of *D. johansenii* was detected by J. Kučera as an admixture in a specimen of *Grimmia andreaeoides* (= *D. subandreaeoides*). Table 1 presents the associated lichens and bryophytes at the two Italian sites.

The fragility of the propagula is only high in moist condition. In addition to wind, certainly also rainfall plays an important role for the dispersal of the plant. During rainy periods the propagula are flushed down on the rock walls where they may find places for germination in crevices, between lichen thalli or among the shoots of moss cushions. In Subarctic areas the propagula are also effectively dispersed by river water. Here, *D. johansenii* invades silt-covered logs or even tree-bases along mountain rivers (Cleavitt 2002). From the high Arctic even occurrences from soil habitats are reported. However, this peculiarity applies to many commonly saxicolous mosses in the Arctic.

PHYTOGEOGRAPHY

D. johansenii was first considered a genuine Arctic species (Steere, 1953) but now, based on the currently known distribution, we work from the hypothesis that a moss of Central Asian origin may be at hand which secondarily also reached some regions of the Arctic subject to a highly continental climate. The Asian origin of many Alpine vascular plants (e.g. the famous edelweiss) is well-known and it was postulated that also many genuine Central Asian bryophyte elements reached the Alps by crossing the cold steppes during the glacial maxima of the Pleistocene (Gams, 1932). Several examples might be found both among the high alpine elements (such as *Oreas martiana* (Hoppe & Hornsch.) Brid., *Voitia nivalis* Hornsch.) and the steppe-elements (*Pseudocrossidium obtusulum* (Lindb.) H.A.Crum & L.E.Anderson, *Syntrichia caninervis* Mitt.). The latter two were found at Austrian localities of *D. johansenii*, although not among the intimate associates. The Styrian and Italian localities were ice-free during the glacial maxima of the Pleistocene, hence these populations can be regarded as relict. They may have been the starting point of the postglacial colonisation of the interior of the Alps, where areas with a continental climate and the availability of calcareous schist were especially suitable for the establishment of *D. johansenii*.

Table 1. Associated lichens and bryophytes at the two Italian sites of *Didymodon johansenii*. The entry values for the species are the frequency obtained by counting the occurrence in ten quadrates of a rectangular plot (50 × 30 cm). Geographical coordinates are in decimal degrees (WGS84)

	Plot 1	*Plot 2*
GPS E	10.9319	10.9473
GPS N	46.3065	46.3109
altitude (m asl)	2123	2101
inclination of rock (°)	80	17
geological formation	Scaglia(*) Rossa	Scaglia Rossa
Lichens	Frequency	
Candelariella aurella (Hoffm.) Zahlbr.	5	9
Caloplaca flavescens (Hudson) Laundon	6	6
Physcia dubia (Hoffm.) Lettau	4	2
Farnoldia jurana (Schaerer) Hertel	5	1
Lecanora flotowiana Sprengel	5	1
Thelidium papulare (Fr.) Arnold	8	
Placynthium nigrum (Hudson) Gray	4	
Xanthoria elegans (Link) Th. Fr.	4	
Rinodina immersa (Körber) Zahlbr.	3	
Toninia alutacea (Anzi) Jatta	2	
Toninia taurica (Szat.) Oxner	2	
Peccania coralloides (A.Massal.) A.Massal.	1	
Protoblastenia incrustans (DC.) J.Steiner	1	
Caloplaca variabilis (Pers.) Müll.Arg.		3
Aspicilia contorta (Hoffm.) Krempelh. s.lat.		2
Lecidella patavina (Massal.) Knoph & Leuckert		2
Collema undulatum Flotow		1
Mosses		
Grimmia anodon Bruch & Schimp.	7	1
Pseudoleskeella catenulata (Brid. ex Schrad.) Kindb.	2	1
Didymodon johansenii (R.S.Williams) H.A.Crum	1	1
Schistidium crassipilum H.H.Blom		1
Syntrichia ruralis (Hedw.) Web. & D. Mohr ssp. ruralis		1

(*) Scaglia Rossa is a reddish coloured marly limestone rock of the late Cretaceous period.

Because of the rather large propagula which are not easily dispersed by wind and the putative absence of spores (sporophytes are currently only known from Canada), the moss has probably been unable to colonise all suitable sites. The low dispersal ability together with the highly selective habitat requirements might be the main reasons explaining its rarity and disjunct distribution in the Alps.

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