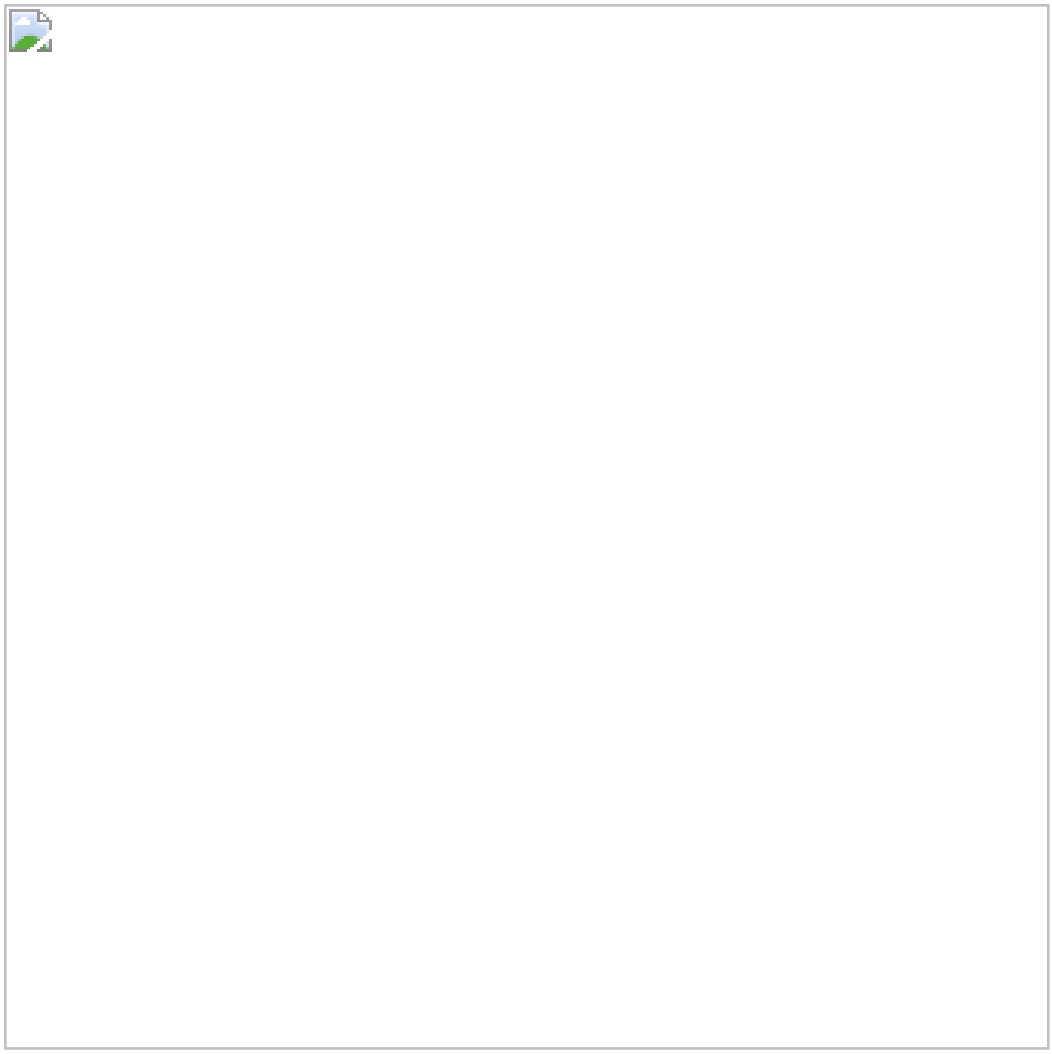

ITS sequence data confirm the presence of Schistidium marginale in Scandinavia and indicate connections to the Caucasus

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Bryological note

ITS sequence data confirm the presence of *Schistidium marginale* in Scandinavia and indicate connections to the Caucasus

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We document the presence of *Schistidium marginale* (Grimmiaceae) in Trollheimen, central Norway. The sequence of the nuclear ITS region aligns identically with an accession from the Caucasus, distinct from Alpine accessions. This may suggest post-glacial colonization originating from south-eastern rather than southern populations. The new locality exhibited only a few tufts and shared habitat similarities with Alpine locations, albeit with a potentially more base-rich substrate.

Keywords: biodiversity, biogeography, grimmiaceae, norway, saxicolous

Although being only recently described (Blom et al. 2016), *Schistidium marginale* H.H. Blom, Bedn.-Ochyra & Ochyra is one of the widespread and regionally common species of the genus. In Europe, it is locally frequent in the Alps (Austria, France, Italy, Switzerland) and the Caucasus mountains but also known from Albania, Macedonia, NW Russia (Murmansk Province) and Spain (Blom 1997, Köckinger et al. 2008, Ignatov et al. 2017, Hodgetts and Lockhart 2020). In Asia, it is reported from east and south Siberian mountains: Altai, Kuznetzky Alatau, Putorana Plateau and the Transbaikalian region (Ignatov et al. 2017). Notwithstanding the intensive work on *Schistidium* carried out by HHB in Scandinavia (Blom 1996, 1998), *S. marginale* has so far not been recorded there. Only recently HHB discovered small plants that showed characteristics of *S. marginale* at Mt Høghøa in the Trollheimen mountains, Trøndelag county (Fig. 1):

Norway, Trøndelag, Oppdal, Høghøa, SE slope, ca 1120 m a.s.l., 22 July 2020, leg. H.H. Blom (TRH).

At this locality *S. marginale* was only found in 2–3 small tufts at one site where it grew on low inclined (40°) phyllite ledges on a steep south-faced slope. The bedrock is base-rich siliceous mica-shist with garnets (https://geo.ngu.no/kart/berggrunn_mobil) and *S. marginale* grew together with *Schistidium dupretii* and a yet undescribed *Schistidium* species.

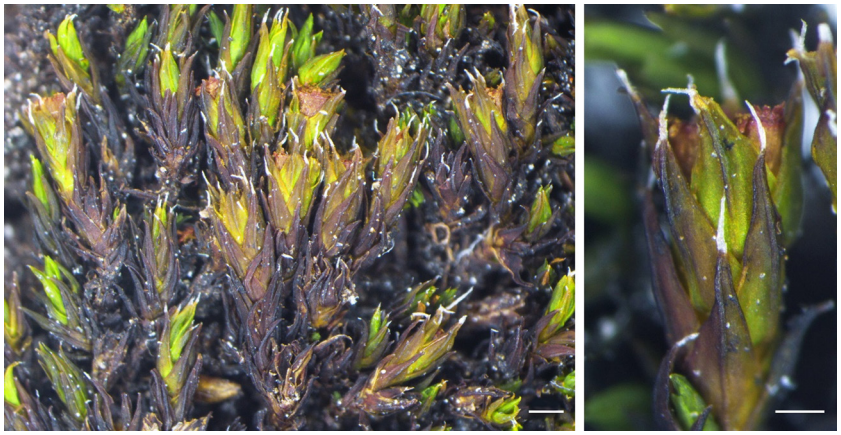

Figure 1. Plant of *Schistidium marginale* collected at Mt. Høghøa, Oppdal Province (TRH). Scales: left 500 µm, right 250 µm.

Since the plants were poorly developed (Fig. 1), we aimed at confirming the morphological diagnosis molecularly. We targeted the ITS region which is the most used molecular marker for species delimitation and phylogenetic inference in the genus (Ignatova et al. 2010, Milyutina et al. 2010). We extracted DNA and performed PCR and sequencing following previous work (Kiebacher 2020, Kiebacher et al. 2021). A BLAST search using the generated sequence (GenBank no. OQ653437) as input to the megablast algorithm (https://blast.ncbi.nlm.nih.gov/Blast.cgi) with default settings confirmed the morphological hypothesis. The sequence from the Norwegian specimen was identified as most similar to the three *S. marginale* accessions available in GenBank (two from Austria and one from Russia; Ignatova et al. 2010). The subsequent manual alignment to these accessions showed that the sequence from the Norwegian specimen is identical with the Russian accession from Caucasus (Karachaevo-Cherkessiya, HM053921) and these two differ from the Austrian accessions (HM053919, HM053920) at two sites in ITS2 (Fig. 2): an indel (position 29 of ITS2), a transversion (28) and and a transition (32) at the first site and an inversion (202–205) at the second site.

The ecological conditions in the Scandinavian mountains and the Alps are similar and most of the species' pool of these regions is shared (cf. Hodgetts and Lockhart 2020). Although most species occur in the same habitats and with about the same frequencies in both regions, some species occur either in one or the other region, or, are rather common in one and rare in the other. *Schistidium marginale* is one such example of the latter and this phenomenon could arise from Pleistocene glaciation. Possibly, its (and other species') high frequency in the Alps is due to in situ persistence or recolonization from glacial refugia close to the Alps and its rarity in Scandinavia could be due to later long-distance dispersal and limited local spread since then. Certainly, also other scenarios are possible such as recolonisation of Scandinavia from glacial refugia following the last glacial maximum (LGM) and limited spread due to suboptimal ecological conditions for the founder genotype(s). Under both scenarios, the molecular uniformity of the Norwegian and Caucasian accession suggests colonisation from south-eastern rather than southern populations, although, due to the limited sampling we cannot exclude the occurrence of this genotype in the Alps or central and western Europe. Colonisation of Scandinavia after the LGM from refugia east of the Scandinavian ice shield has been proposed also for other bryophyte species (Kyrkjeeide et al. 2014) and within the genus, the connections between Scandinavia and the Caucasus are further evidenced by *S. flexipile* (Lindb. ex Broth.) G.Roth. This primarily northern-Holarctic species was described from Caucasus and is widespread and locally abundant in Scandinavia (and Island), but was hitherto not reported from the Alps.

From a different view, the considerable genetic differences between the Alpine and the Scandinavian and Caucasian accessions of *S. marginale* rise the question whether this coincides with morphological and/or ecological differentiation and if it is taxonomically relevant. As an example, the two morphologically well-differentiated subspecies of *S. submuticum* Zickendr. ex Blom cannot be distinguished based on ITS sequences (Ignatova et al. 2010), suggesting that the diversification in *S. marginale* may rely on a speciation process rather than on within-taxon variation. However, the Norwegian plants conformed well to the description and we have not observed characteristics that distinctly deviated from the variability in the Alps.

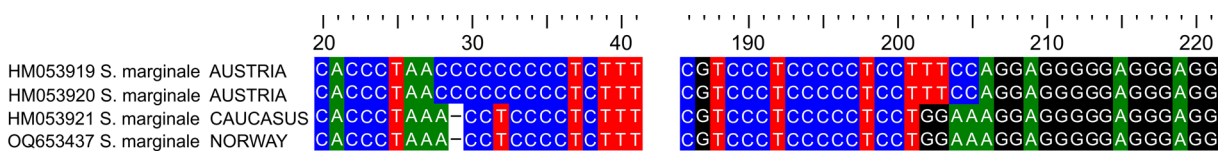

Figure 2. Differences in ITS2 of accessions assigned to *Schistidium marginale*. The second site represents a four bases-inversion, most likely caused by a hairpin structure due to a 13 bases inverted repeat up- and downstream.

We aim to further explore these issues in our future studies, which will require an in depth morphological and genetic analysis of an extended set of well-developed specimens sampled across the area of occurrence of *S. marginale*. Here, we primarily aim to update our knowledge on the moss flora of the Scandinavian mountains and to rise the attention to this inconspicuous species. *Schistidium marginale* is a representative of the *Confertum* group (Blom 1996, Ignatova et al. 2010) as indicated by its small to medium size, the spinulose hair point, the partially bistratose lamina and the slightly sinuous lamina cells. It is distinctive in the prominent costa that is often subangular or even dorsally furrowed in transverse section and the very thick leaf margins, that are often four-stratous in the upper part of the leaves.

In the Alps, *S. marginale* typically colonises rather poor and acidic rocks at warm sites in the subalpine and alpine zones. This pattern aligns with the Norwegian locality, with the exception of potentially more base-rich conditions. Hence, the search for further localities in the Scandinavian mountains should focus on such habitats, especially S-facing cliffs in the alpine zone.

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Data availability statement

There are no additional data for this paper.

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