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Distribution and ecology of *Trichocolea tomentella* in Norway

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The liverwort *Trichocolea tomentella* is known from 65 localities in southern Norway. Almost half of these are in Hordaland county in Western Norway. *T. tomentella* has been observed at many localities (42%) in the last decade. On the other hand it has not been observed at 23% of the previously known localities after 1950, although a complete re-survey has not been performed. The species seems to be thriving in its main distribution centre in Western Norway, but in southeastern Norway urbanisation and modern forestry are major threats. In this part of Norway the species has probably gone extinct or is on its way to extinction at several of the localities. To preserve the species logging and draining close to springs, streams and gullies should be ceased. This will also preserve habitats that are species rich, in particular in bryophytes.

The growing interest in conservation biology has also resulted in increasing concern for smaller organisms like bryophytes (Söderström et al. 1992, Nilsson and Ericson 1997). Nevertheless, for a long time there was much less focus on bryophytes than on vascular plants, and less recognition of the need for active conservation measures for bryophytes (Hallingbäck 1995, Söderström 2006, Hylander and Jonsson 2007). Bryophyte conservation has now developed much further, and bryophytes have been successfully included in the IUCN system (Vanderporten and Hallingbäck 2008). However, sound management of threatened species requires adequate knowledge of their environmental requirements, population dynamics, reproduction, dispersal ability and genetic structure (Pharo and Zartman 2007, Jongejans et al. 2008, Frankham 2010). Such knowledge is rarely available for bryophytes (Söderström et al. 1992). In most cases, we also lack detailed information on their actual distribution (Cleavitt 2005) and how it has changed during time. Such information is also needed to achieve sound conservation and management of bryophyte species (Hallingbäck 2007).

In some European countries, for example the UK and Ireland, the distribution of bryophytes is rather well known, both for the whole country (Hill et al. 1991) and on a regional scale (Bates 1995). In contrast, in Norway, little up-to-date, detailed information is available on the distribution of bryophytes, with notable exceptions for a few species (Røsok et al. 2005, Jordal and Hassel 2010). Information is scarce partly because collected data are not readily accessible (although Artsobservasjoner <www.artobservasjoner.no/>, and Artsdatabanken <www.artsdatabanken.no/>, will gradually change this), partly because of a lack of investigations and partly because little has been published based on collections in herbaria. This is an obstacle to the management of bryophytes, making it difficult to know which precautions to take and where. Bryophyte species may as a result be lost, locally or regionally, through habitat change or destruction.

Trichocolea tomentella is a liverwort that was classified as 'requiring consideration' in the first red list of bryophytes in Norway (Frisvoll and Blom 1992), but was not included in subsequent red lists (Kålås et al. 2006, 2010). *Trichocolea tomentella* is a large dioecious liverwort. It is conspicuous, with a characteristic greenish-white colour, highly dissected leaves and abundant paraphyllia (Damsholt 2009), and should be easily distinguished from other bryophytes even by the inexperienced bryologists.

Our aims are to detail the present distribution of *T. tomentella* in Norway, give a summary of its ecology, present

threats to the species, and make recommendations for its management.

Nomenclature follows Artsdatabanken <www.arstdatabanken.no>

Ecology

Trichocolea tomentella usually grows in moist, well-shaded places, particularly in deciduous forest (Fig. 3), often near springs, streams or gullies. This has been observed both in Norway and Sweden (Jørgensen 1934, Hallingbäck 1991, Frisvoll and Blom 1992, Aronsson et al. 1995) and in other countries (Schuster 1953). In western Norway, *T. tomentella* grows in two quite different habitats: in *Alnus glutinosa* forests dominated by *Carex remota* (Blom 1982, Fremstad and Elven 1987), and on poorer mineral soils in narrow river gorges either dominated by *Betula pubescens* or almost treeless, fern dominated sites. In addition it has been found in one grassland locality. In southeastern Norway, typical localities are *Picea abies* swamp forests. The critical factors that limit its distribution on a local scale appear to be a constant water supply and moderately diffuse light (Schuster 1953).

Trichocolea tomentella may grow in almost pure patches both in Norway (unpubl.) and in other countries, sometimes covering an area of as much as 75 m^2 (e.g. Gotland in Sweden, Högström 1996). It has a high capacity for clonal reproduction by branching, enabling it to form dense patches (Pohjamo et al. 2008). However, these are often mixed with other species. The bryophytes that most frequently grow together with *T. tomentella* (based on the Norwegian herbarium material, Blom 1982 and our own observations from three localities in southeastern Norway) are *Brachythecium rivulare*, *Thuidium tamariscinum* and *Loeskobryum brevirostre* (W Norway only). Other taxa often associated with *T. tomentella* in Norway are *Calliergonella cuspidata*, *Chiloscyphus pallescens*, *Kindbergia praelonga*, *Pellia epiphylla, Plagiomnium undulatum*, *Rhizomnium punctatum*, *Rhytidiadelphus loreus*, *R. subpinnatum*, *R. triquetrus* and *Sphagnum squarrosum*. In river gorges, *Ctenidium molluscum*, *Hylocomiastrum umbratum* and *Riccardia chamaedryfolia* are characteristic companion species.

Trichocolea tomentella rarely produces sporophytes: instead, it reproduces predominantly asexually by clonal regeneration (Pohjamo et al 2008). Fertile specimens of *T. tomentella* have never been observed in Norway and only once in Sweden (Damsholt 2009). In other parts of its distribution range, e.g. in eastern North America, *T. tomentella* produces sporophytes more regularly (Schuster 1966, Zehr 1979). A recent study of 18 *T. tomentella* populations from four countries (Finland, Lithuania, the UK and Canada) showed that populations that reproduced predominantly asexually, and thus had restricted gene flow, nevertheless exhibited relatively high genetic diversity (Pohjamo et al. 2008). The authors explained this pattern by long-term accumulation of genotypes and somatic mutations, and the ability of the population to persist for a long period of time by asexual reproduction. Low levels of genetic similarity among individuals were observed between nearby populations (1 km) along the same tributary stream, suggesting dispersal limitations even on this scale (Pohjamo et al. 2008). The lack of sexual reproduction and of specialized asexual diaspores may mean that the dispersal ability of *T. tomentella* is currently restricted in the Nordic countries, but that random colonization of detached shoot fragments by water, mammals or birds may occur (Pohjamo et al. 2008). How effective such forms of dispersal are in *T. tomentella* remains to be examined, but generally asexual reproduction by gametophyte fragmentation is much rarer in hepatics than in mosses, and such fragments are seldom likely to be effective except at very short distances (Longton and Schuster 1983).

Distribution

Trichocolea tomentella (Fig. 1) is widely distributed in temperate climates in the northern hemisphere, particularly in oceanic and suboceanic regions (Schuster 1966). Its distribution range in Europe stretches from northern Portugal and Spain northwards to southern Norway, Sweden and Finland, and from Ireland and the UK to western Russia (Damsholt 2009). It also occurs in Asia, North Africa and eastern North America (Schuster 1966, Damsholt 2009).

In Sweden, *T. tomentella* is known from about 700 localities, and it has been found in many new localities since 1970 (Ingelög et al. 1987, Aronsen et al. 1995, Högström 1996, Gärdenfors 2010). It has therefore been placed in the least concern (LC) category (Gärdenfors 2010). In Norway, we know of 65 localities. These are all in the southern part of the country, where *T. tomentella* occurs in a belt along the coast, reaching its northern distribution limit in Sogn og Fjordane county (Fig. 2). The main distribution centre is in Hordaland county, western Norway, with almost half of the known localities and a relatively large number of new records since 2000 (Fig. 2). The previous distribution lacuna in southwestern Norway (Rogaland and Vest-Agder counties) is now partly filled because of several new discoveries in the last 10–15 years (Fig. 2). However, we do not expect this region to be a major distribution area for *T. tomentella*, because large parts of it are dominated by poor soils or intensively cultivated farmland, and thus lack suitable habitats.

There are recent records (2000 and later) of *T. tomentella* from a relatively high proportion (42%) of the localities. On the other hand, it has not been observed (according to our material) at 23% of the localities after 1950 (Fig. 2). *Trichocolea tomentella* seems to be thriving

Figure 1. Close-up of *Trichocolea tomentella* at one of the localities in Hordaland (Bergen). Photo: Einar Heegaard.

in its main distribution centre in Norway (Hordaland), but the situation is disquieting in southeastern Norway, in particular in the Oslofjord area where urbanisation and modern forestry are major threats to the species.

During the 1990s, we searched for *T. tomentella* in the Oslofjord area, both at localities where there were previous records and at new ones. At two old localities we were unable to relocate it (Svenskedalen, Nittedal municipality and Jeløya, Moss municipality), but at both known localities in Ås municipality we were successful. In addition we found it at a new locality in Skedsmo municipality (Lukedammen), but here the nearby forest had recently been clear-cut. At Åsmyra in Ås municipality, where *T. tomentella* was found in 1943 (Størmer 1947), it grows close to a spring in the transition between a mire and a forest with a tree layer of *Picea abies, Alnus glutinosa* and *Betula* spp. Earlier *T. tomentella* covered a large area but nowadays only around 0.55 m^2. This change is likely due to habitat alteration by logging, combined with ditching of the mire.

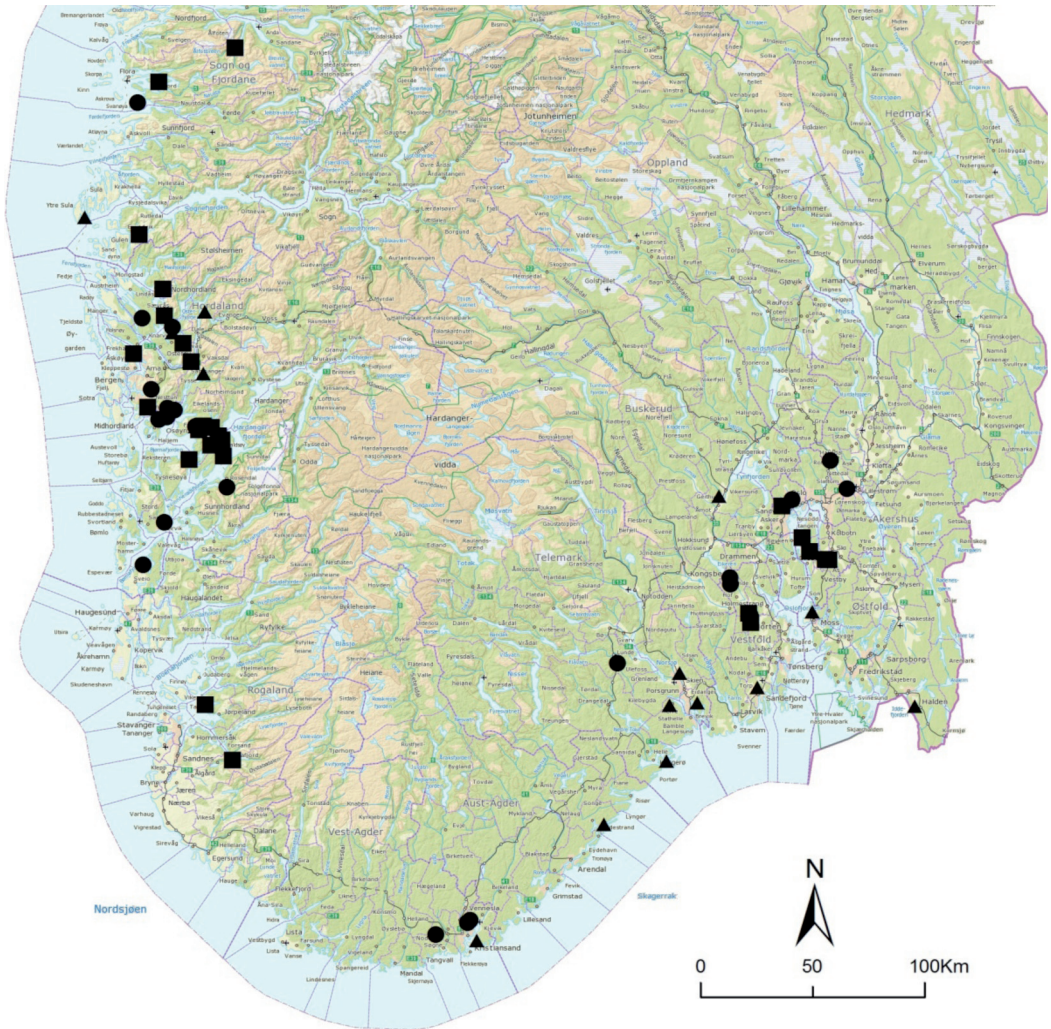

Figure 2. The distribution of *Trichocolea tomentella* in Norway. Squares – latest observation after 1999, circles – latest observations between 1950–1999; triangles – latest observation before 1950.

Threats, status and management recommendations

Trichocolea tomentella seems to be thriving in Hordaland, its distribution centre in Norway, but population trends in southeastern Norway, in particular in the Oslofjord region, appear to be much more negative. In this region, *T. tomentella* usually grows in lowland *Picea abies* swamp forests. Such forests have been regularly logged and drained to such an extent that made it difficult to find intact sites for inclusion in the national protection plan for coniferous forest (H. Korsmo, pers. comm.). Logging and draining create a much more exposed and drier habitat, and these conditions do not favour the persistence of *T. tomentella*. At several of the relatively few known localities in this area, *T. tomentella* has probably gone extinct or is on its way to extinction.

In order to stop the destruction of known and suitable habitats for *T. tomentella*, swamp forests should not be logged, and drainage in a belt along river systems, including the moister parts of the habitats (e.g. swamp forests), should be avoided. This would also be of benefit in protecting habitats with high species richness (Ohlson et al. 1997, Hörnberg et al. 1998, Økland et al. 2001, 2003). We know that the dispersal ability of both *T. tomentella* (Pohjamo et al. 2008) and other swamp forest species (Økland et al. 2003) is low. Such habitats should therefore be safeguarded together with sufficient buffer areas (Hylander et al. 2002, Fenton and Frego 2005, Dynesius and Hylander 2007, Perhans et al. 2009, Roberge et al. 2011)

Figure 3. Helledalen, Fusa, Hordaland county, one of the localities with the most viable population of *Trichocolea tomentella* in Norway. Photo Per G. Ihlen.

to maintain the microclimate and moisture conditions of the whole habitat. The scientific community should give more priority to communicating knowledge about threatened species to other groups, particularly those who are responsible for land management, in order to raise awareness of problems such as those described here (Söderström et al. 1992, Hågvar 1994). Too often, valuable habitats are destroyed simply because of a lack of communication or negative attitudes to conservation (cf. Korsmo 1991, Hågvar 1994). The forestry sector needs knowledge of threatened species in order to develop more sustainable operating routines that can meet the requirements of an environmentally concerned society.

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