Paleopalynology of Holocene birch hybridization in Iceland

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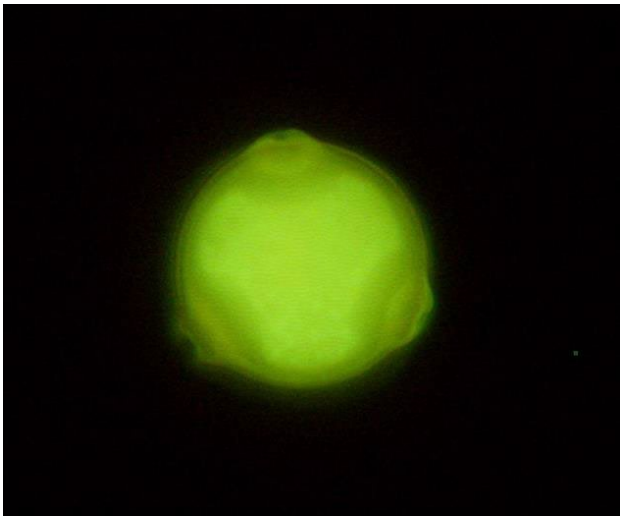
Betula L. (birch) is a genus of about 50–60 tree species distributed throughout the temperate, boreal, and arctic regions of the Northern Hemisphere. Birch woodlands are an integral component of the tundra biome, and birch is one of the key broad-leaved tree species of the circumpolar boreal forest. Birch woodlands in Iceland, which cover around 1.5% of the total land area, are composed of 80% birch shrubs less than 2 m tall. Similar birch shrubs, often referred to as mountain birch, are found in Fennoscandia, northern Russia, European mountain regions and beyond. Previous botanical, cytogenetic and molecular genetic studies have shown that shrub-like birch in Iceland is the result of introgressive hybridization between the two co-existing Betula species, the arctic dwarf birch (Betula nana) and the European downy birch (B. pubescens). As dwarf birch is a diploid species and downy tree birch a tetraploid species, their hybrids are triploid. In the introgression process, triploid hybrids, which are partially fertile, can backcross with the parental species, producing progenies comprising introgressed diploid, triploid, and tetraploid plants. Triploid plants produce both normal triporate pollen (with three pores) and abnormal, aborted pollen, due to dysfunctional meiosis. The type of pollen abnormality that can be detected and quantified is non-triporate pollen (with four or more pores in the pollen wall). The presence of non-triporate pollen was therefore used in the study resented here as a marker to trace birch hybridization in the past. In this study fossil pollen in samples from peat sediments was examined. The peat monoliths were extracted from three geographically diverse locations in Iceland, from Grímsnes (S), Eyjafjördur (N) and Thistilsfjördur (NE Iceland), and throughout the Holocene epoch. Ages were calibrated based on known volcanic tephra layers and by radiocarbon dating. By measuring the size of individual pollen grains, we were able to differentiate pollen of the shrub-like downy birch (B. pubescens) from its closely related dwarf birch species (B. nana). The results revealed an establishment and a rapid expansion of birch woodland predominated by shrub birch B. pubescens soon after the retreat of the Icelandic Pleistocene icesheet. Non-triporate pollen grains were detected in samples from all three locations and throughout the Holocene, but with different frequencies. The results showed peaks of intense hybridization following woodland expansion in the initial period of the Holocene, from about nine thousand years ago, and again in the warming period of the mid-Holocene Thermal Maximum, the period between five and three thousand years ago. Triploid hybrids that were produced during the intense period of hybridization could potentially backcross with the dwarf birch or the downy birch, allowing gene flow by introgression between the two species, presumably making birch more adaptive to environmental changes. Thus, climate warming in the current era is expected to promote this introgressive hybridization resulting in a significant change of landscape of the birch woodland in Iceland. Birch woodlands are likely to become more widespread. Furthermore, introgressed shrub birch is likely to be more competitive over dwarf birch as average summer temperature rises. Acknowledgements: I would like to thank Lilja Karlsdóttir and Ægir Thór Thórsson for their collaborative work combining paleopalynology with botanical, cytogenetic and molecular genetic analyses of woodland birch in Iceland.

Graphic:



Keywords:

Betula, birch, palynology, pollen, triploids

Reference:

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