Demographic variation of dwarf birch (*Betula nana*) in communities dominated by *Ledum palustre* and *Vaccinium uliginosum*

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**Abstract:** The structure and demographic processes were compared in shrub communities to test the effects of vegetation succession on population growth, fecundity and abundance of the dwarf birch (*Betula nana* L.), which is a rare and endangered plant species in Poland and a glacial relict in Central Europe. The effects of *Ledum palustre* L. and *Vaccinium uliginosum* L. were studied in the Linjen nature reserve in Chełmierskie Lake District (northern Poland), in three permanent plots on a peat bog. Vegetative growth and reproduction of *B. nana* were lower in plant communities dominated by *L. palustre* and *V. uliginosum*, than in a reference site. Fecundity was also lower, despite the fact that the percentage share of potentially fertile age groups was similar in all study sites. Mortality of ramets was independent of vegetation, both for juvenile and mature stages. The results confirm that *B. nana* is intolerant of shade, and it is more abundant in vegetation without competitors. Light limitation can lead to its decline, primarily by a decrease in vegetative growth. Sexual reproduction may be negatively affected by shade, but it plays only small role in population growth. Butterfly larvae can destroy inflorescences, and thus contribute to low effectiveness of sexual reproduction. Increasing density of shrubs and trees in peat bogs can reduce the abundance of dwarf birch, and can lead to the extinction of its local populations.

**Key words:** clonal plant; competition; glacial relict; peat bog; vegetative growth

**Introduction**

Peat-bogs belong to the ecosystems most endangered by human activity. The majority of them have been destroyed in past decades, and their area has decreased throughout Europe due to desiccation, peat extraction and agricultural land use. Drainages of these wetlands, caused by economic utilization, has important ecological consequences, namely mineralisation of peat soils and subsidence of peat deposits (Brag et al. 2003). Drawdown of ground-water table induces vegetation succession, i.e., development of shrubs and forests instead open bog communities (Laine et al. 1995; Frankl & Schmeidl 2000; Pellerin & Lavoie 2003).

Changes of vegetation due to environmental conditions influence microhabitats within plant communities, e.g. light availability and light quality, soil temperature and moisture; and vegetation cover can have an immediate influence on plant populations (Breshears et al. 1997, 1998). The alterations in habitats can lead to the decline and even local extinction of highly specialised plant species. In this study the geographically isolated glacial relict inhabiting peat bogs were taken into consideration (Gostyńska-Jakuszewska & Lekavičius 1989).

The dwarf birch, *Betula nana* L., is a glacial relict in the flora of Poland. It is a richly branched clonal shrub growing up to 1 m in height, forming prostrate to ascending shoots (de Groot et al. 1997; Jonsell 2000). It has a circumpolar distribution, spreading from western coastal regions of Greenland and Iceland across Northwestern Europe and Siberia to North America. In central Europe it occurs in isolated localities, e.g. in the Alps, Swiss Jura, Ardennes and Sudety Mts and only rarely in the lowlands (Jalas & Suominen 1976). It is included in the Red Books and Red Lists of Plants of Poland, Germany, Bohemia, Lithuania and Belarus, and is endangered and strictly protected in Poland. Currently, it occurs in this country in three localities: two in the Sudety Mts and one in the Pomeranian region.

Dwarf birch is intolerant of waterlogging (Ejankowski 2008). It grows mainly in dry sites in arctic and subalpine tundra and at elevated hummocks of the mires where it commonly forms dense cushions (Virmanen & Oksanen 1999; Jonsell 2000). It is a characteristic species of open bogs and understory of open tree stands with widely dispersed trees, but not under closed canopies. It is intolerant of shade and afforestation (Hutchinson 1966; Laine et al. 1995).

Conservation of threatened species requires knowledge of the effects of the environment on demographic processes and the viability of a population. This knowledge may be helpful for predicting population changes in the future. Many studies have been carried out on the ecology of *B. nana* in the tundra (Bret-Harte et al.
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2001; van Wijk et al. 2003). Relatively little is known about its responses to the succession proceeding in peat bogs.

Variation in demography in different environmental conditions and successional stages have been found for a few plant species in mires (Gunnarsson & Rydin 1998; Nordbakken et al. 2004). The objective of this study was to test the influence of plant communities on the demographic processes in B. nana, and to evaluate the consequences of vegetation succession on its abundance, distribution and fecundity.

Material and methods

The study sites were chosen in the Linje nature reserve in south-western part of Chelmno Lake District in northern Poland (Kondracki 1998). The mire of ca. 6 ha is situated in moraine landscape, which originated from the late glacial period (Noryśkiewicz 2005). Shrubs and open bog communities belonging to the class Oxyccoco-Sphagneta currently dominate in the area. This raised bog vegetation is surrounded by transitional bog communities, and partly by bushes and forests of the class Alnetea glutinosae. The mire is surrounded by mixed forests with Scots pine. The area was drained in the second half of 19th century, and hence strong changes were induced in the vegetation cover (Ejankowski & Kunz 2006).

Study plots were staked out randomly in three homogeneous plant communities, dominated in the shrub layer in Site A by labrador tea Ledum palustre L. (80.5% of percentage cover) and in Site B by Vaccinium uliginosum L. (65%). The reference Site R was composed mainly of Betula nana in the shrub layer (62.2%) with a scarcity of the above mentioned shrubs. The permanent plots were delimited as rectangles five meters long and two meters wide, and each of them was systematically divided into ten one-meter squares in 2001. In 2002–2003 each plot was subdivided into 160 smaller squares of 0.0625 m² to facilitate counting of plants. In this study a ramet (sensu Harper 1977) was treated as a unit.

According to morphological criteria, ramification, number of shoot scars, and development of bark, the following stages of ramets were distinguished and counted separately: Stage 1 – one-year old unbranched, Stage 2 – two-year old unbranched, Stage 3 – two-year old branched, Stage 4 – branched ramets that were three or more years old.

The effects of sexual and vegetative reproduction on the dynamics of B. nana were studied. The number of first-year old ramets originating from vegetative growth was followed in 2001–2003 at each plot. The length of 500 one-year-old long shoots was also measured in each plot. The mortality of juvenile unbranched ramets, and mature branched ramets, were assessed separately by comparing the number of ramets of Stages 1–4 in permanent plots in consecutive years. Fertile ramets and female catkins were also counted, and the number of fruits produced at each Site was determined on the ground for twenty cones. The probability of transition from vegetative to the reproductive state, and the inverse switching, were additionally assessed using fifty marked ramets.

Age and size measurements of fifty ramets at each site were carried out in October and November 2001. Age was determined by counting annual growth rings, and cross sections of wood were dyed with Lugol’s solution in order to make the vessels more visible and to distinguish the growth rings.

Normality of the data was initially analysed by scatter plots and the Levene test, and homogeneity of variances was tested by the Shapiro-Wilk test. Since the data did not fit the assumptions of normality and homogeneity, non-parametric statistical tests were used according to Sokal & Rohlf (1995). Calculations were carried out with Statistica 8.0 software.

Results

During the course of the study no seedlings of Betula nana were observed in the peat bog. Reproduction proceeded only by vegetative growth. The density of one-year old ramets in Sites A, B and R averaged 124 m⁻², 33.5 m⁻² and 84.5 m⁻², respectively (Fig. 1). Generally, the multiplication of ramets in the period 2001–2003 was associated with vegetation types. The number of new ramets was limited only in Site B, where Vaccinium uliginosum was dominant in the shrub layer (Table 1). There was no significant effect of Ledum palustris on vegetative reproduction in Site A.

Another indicator of vegetative growth, the annual increase in lateral shoot length, was also affected by veg-

Table 1. Z-values of Mann-Whitney test of the effect of Ledum palustris (Site A) and Vaccinium uliginosum (Site B) on vegetative reproduction, annual increase, leaf number on long shoots, ramet density, ramet size and age of Betula nana. Signatures: * p < 0.05, ** p < 0.01, *** p < 0.001.

<table>
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<tr>
<th>Effect</th>
<th>Reproduction</th>
<th>Annual Increase</th>
<th>Leaf Number</th>
<th>Ramet Density</th>
<th>Ramet Size</th>
<th>Ramet Age</th>
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<td>1.53</td>
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<td>11.8**</td>
<td>−2.87***</td>
<td>−4.14***</td>
<td>−2.4*</td>
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<td>Site B</td>
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<td>−13.89***</td>
<td>13.89**</td>
<td>−3.71***</td>
<td>−11.84***</td>
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