The occurrence of arctic-alpine Betula species in the Hungarian Pleistocene

Zs. Medzihradszky1 & J. Bajzáth2

1*Department of Botany, Hungarian Natural History Museum
H-1087 Budapest, Könyves Kálmán krt. 40, Hungary
2Department of Education, Hungarian Natural History Museum
H-1083 Budapest, Ludovika tér 6, Hungary


Abstract — A rich fossil flora was found in a sandy peat layer from the Würm Glacial at Győr-Szabadrét-domb locality. This assemblage was analysed by palaeobotanical methods. From the very rich pollen- and macrofossil material we report the fossil remains of Betula nana, B. humilis and B. pubescens ssp. tortuosa. The age of this layer is 28470 ± 300 years BP dated by 14C method. With 11 figures.

INTRODUCTION

Several years ago in the course of an archaeological excavation a thin sandy peat layer was discovered under the cultural layer at Győr-Szabadrét-domb locality (47.40°N, 17.39°E). This peat material was sampled and complete palaeobotanical study (pollen and macrofossil analysis, was carried out. Radiocarbon dating made by the Institute of Nuclear Research of the Hungarian Academy of Sciences (No. Deb.-2231) determined the age of the layer as 28470 ± 300 years BP. The complete palaeobotanical investigation discovered new and very important data that calls for modifications in the current model of the vegetational history in the Carpathian Basin. In this paper we report some of the first results. The study proved the existence of several new species (Betula nana, B. humilis and B. pubescens ssp. tortuosa) which were previously unknown in the territory of Hungary.

RESULTS OF MACROFOSSIL-ANALYSIS

Five Betula species were determined from the plant fossil assemblage. The macrofossil assemblage discovered at the Győr-Szabadrét-domb locality consists of remains of typical glacial species such as Dryas octopetala, Salix herbacea, Salix polaris, Selaginella selaginoides, Koenigia islandica and birches forming a "Dryas-flora". Among the bir-
In the case of birch trees, there are two dwarf species: *Betula nana* and *Betula humilis*. Another interesting birch tree is *Betula pubescens* ssp. *tortuosa* which differs significantly from the other ones such as *Betula pendula* and *Betula pubescens*. Not only the nutlets of *Betula* were found but other macroremains of these species – twigs, leaves, buds, bud scales and fruit scales – are also parts of the fossil assemblage. The dwarf birches and *Betula pubescens* ssp. *tortuosa* is reported from Hungary for the first time. Here we provide a detailed description of these birch species.

**Betula nana** LINNAEUS, 1753
(Figs 1–4)

*Description.* Leaves (Fig. 1). Very characteristic, deeply and regularly toothed leaves of rounded shape and small size (0.5–0.8 mm). The venation of the leaves is typical for the genus. The terminal veins in the middle part of the leaves are curled.

Fruit scales (Fig 3). The fruit scales are deeply lobed, small, 1.9–2.0 mm 2–2.1 mm in size. The angles between the three lobes are narrow and U-shaped. The middle narrow lobe is the same size or a little longer than the other two. The width of the lobes is nearly the same.

Nutlets (Fig. 4). The rounded small nutlets are 1.25–1.6 mm 0.8–1.5 mm in size. The broadest part of the nutlets is almost of the middle section. The narrow wing around the body of nutlets is 0.15–0.3 mm in size.

*Discussion.* Three almost whole leaves, four fruit scales and 15 whole nutlets were found in the fossil assemblage. Several leaf fragments and nutlets of cf. *Betula nana* and numerous buds and budscales were also recovered. The determination of *Betula nana* from the bud scales is uncertain. The measurements of the budscales (1 × 1 mm) and their triangular outline resemble those of *Betula nana*. The other macrofossils unambiguously proved to be remains of *Betula nana*. These are the first macrofossil data of *Betula nana* from the Hungarian Pleistocene. An earlier determination of wood remains of *Betula nana* was uncertain and it lacked a radiocarbon age (ZOLYOMI 1953). This dwarf birch is a typical species of the glacial stages throughout Europe (LANG 1994). It occurred abundantly in the Weichsel-pleniglacials and Late-glacial. *Betula nana* belonged to the so-called “Dryas-flora” of that time, characterizing the glacial tundra or steppe-tundra vegetation in Europe. Here it also occurred as a characteristic member of “Dryas-flora”. The southern limit of the range of *Betula nana* in Europe reached the Alps during the Late-glacial similarly to its present distribution (LANG 1994).

Nowadays *Betula nana* is an arctic-subarctic-alpine element living in terrestrial habitats (mountain birch zone and forest-tundra) and in oligotrophic mires (bogs, moors) as well. In the northern Fennoscandia *Betula nana* lives either in terrestrial habitats or in mires showing the different ecotypes of this species. Besides the continuous arctic-subarctic-alpine distribution area of *Betula nana* in northern Europe, there are some other disjunct localities in Central and Western European mountains. There are only two localities in the Eastern Carpathian Mountains where *Betula nana* is a glacial relic species occurring only in oligotrophic bogs or moors. The main plant association where *Betula nana* belongs to today is characterized by *Sphagnion magellanici*. It is possible that of
the lowest latitude (in bogs of the alpine-subalpine zone) *Betula nana* is an acidofrequens ecotype of the species.

*Betula humilis* SCHRANK, 1789  
(Figs 5–7)

*Description.* Fruit scales (Fig. 7). The fruit scales are deeply lobed, small, but a little larger than those of *Betula nana*. They are 2.7–2.75 mm 1.6–1.8 mm in size. The angles between the three lobes are V-shaped. The middle narrow lobe is almost twice as long as the two others. The fruit scale resemble of birdfoot. The width of the lobes is nearly the same.
Nutlets (Figs 5–6). The roundish small nutlets are 1.6–1.7 mm 1.1–1.3 mm in size. The broadest part of the nutlets is above of the middle section. The wing around the body of nutlets is 0.4–0.6 mm in size.

**Discussion.** Two fruit scales and four pieces of whole nutlets were found in the fossil assemblage. Some budscales were also recovered. These scales are more rounded than the scales of *Betula nana*. The top of the buds is also rounded. They are 1 × 0.75 mm in size. They are similar to *Betula humilis*. The distinction of nutlets of *Betula nana* and *Betula humilis* is based on the outline, the size, the ratio of the length and width of nutlets and the wing size. The two dwarf birches can be readily distinguished by the width of their wings. The wings of *Betula humilis* are significantly broader than those of *Betula nana*. If the characteristic wings are lacking, the determination of the two species is possible using numerical methods (BIALOBŘEŠKA & TRUCHANOWICZÓWA 1960).

Nowadays *Betula humilis*, similarly to *Betula nana*, is also a glacial relic species in the alpine-subalpine regions of Europe. *Betula humilis* lives in the same habitats as the other dwarf birch, mainly in bogs and moors. In addition, it also occurs in birch and alder fen carr. The occurrence of *Betula humilis* in the Pleistocene deposits is scarcer than that of *Betula nana* (RALSKA-JASIĘWICZOWA 1966). It was more frequent in the territory of Russia and Belorusussia in the glacials (LITVINJUK 1979).

*Betula pubescens* ssp. *tortuosa* (LEBEDEV) NYMAN, 1881
(Figs 8–9)

**Description.** Fruit scales. The fruit scales are deeply lobed and strikingly large 6 × 5 mm in size. The lobes are long. The space between the three lobes is narrow U-shape.

Nutlets (Figs 8–9). The oboval very large nutlets are 2.5–3 mm 1.2–1.8 mm in size. The broadest part of the nutlets is in the middle section or above it. The wing around the body of nutlets is moderately broad, 0.55–0.25 mm in size. The beaks of the nutlets are long.

**Discussion.** Two fruit scales and 12 whole nutlets and several fragments of birch tree leaves were found in the fossil assemblage. The leaf remains could not be determined at the species level. These leaves resemble *Betula pubescens* in the structure of the leaf margin. The morphology and the size of the nutlets and the fruit scales of *Betula tortuosa* differ significantly from the other birch tree, i.e. *Betula pubescens*. Both the fruit scales and the nutlets of *Betula tortuosa* are much larger than those of *Betula pubescens*.

The occurrence of *Betula tortuosa* is almost as frequent in the Late glacial and early Postglacial periods as *Betula nana* and it also has a widespread distribution (GODWIN 1956, RALSKA-JASIĘWICZOWA 1966).

Most modern taxonomists regard *Betula tortuosa* as a subspecies of *Betula pubescens*, referring to the hybrid origin of this plant. In northernmost Fennoscandia (i.e. in Lapland) the mountain birch woods occupy the habitats at the forest-tundra transition. Here *Betula pubescens* ssp. *tortuosa* is the only climax tree species. Hybridization in this area is frequent and it is an important factor in the adaptation to the specific environment.
RESULTS OF POLLEN ANALYSIS

Morphological investigations and size measurements of Betula pollen were carried out in order to separate the pollen of Betula nana from the Betula alba type. The results unambiguously verified the presence of Betula nana pollen in accordance to the macrofossil analysis.

Methods. The sample was prepared by HCl, KOH, acetolysis, HF and it was mounted in glycerine. A Nikon microscope with 10 x oculars and 60 x oil immersion objective was used for the morphological identification and a 100 x oil immersion objective for the measurements. The grain diameter in polar view (Lt) and the pore depth (P-alt) of 104 Betula pollen grains were measured to the nearest ocular line (one line = 0.96μ).

Pollen morphological analysis. Each grain was attributed to either Betula nana or Betula alba type. The identification of Betula nana pollen was made according to the general pollen morphology criteria given by TERASMAE (1951), ERDTMAN et al. (1961), PRAGLOWSKI (1962) and GAILLARD (1983). For Betula nana type, the shape of the grain is rounded in polar view, the pores are rounded and slightly extruding, the pore annulus is narrow, and the exine is thin (Fig. 2). The Betula alba type differs from B. nana type by the more triangular shape of the grain in polar view; more or less rectangular pores, that are distinctly extruding; its larger pore annulus, and thicker exine. The morphological analysis clearly showed that there are two different types of Betula pollen grains in the studied material.

Fig. 10. Distribution of Lt/P-alt ratio of the Betula pollen (Győr, Szabadrét-domb)
Statistics method. To confirm this result, we measured the grain diameter and the pore depth of the studied pollen grains. Based on the measurements of recent Betula species, Birks (1968) showed that the grain diameter/pollen depth ratio (Lt/P-alt) is a suitable parameter to distinguish Betula pubescens from Betula nana. The mean ratio for Betula nana is between 11.32–11.47, whereas this ratio for Betula pubescens is 7.76–7.93. The results of our measurement and calculations, the grain diameter/pollen depth ratio are shown on Fig. 10. The Lt/P-alt value of each pollen grain was plotted independently from the previously morphological identification. We can distinguish one group between 6 and 8 and an other one between 10 and 12 values of the y axis. In our opinion, the first group corresponds the Betula alba type, while the second one represents the Betula nana type. The Betula pollen with values between 8–10 are thought to represent an indeterminated Betula type.

Based on the morphological and statistical analysis, 30% of the Betula pollen in our pollen spectra is Betula nana, 57% is Betula alba, while 13% is unidentified Betula type.

CONCLUSIONS

We identified the Betula nana type by means of single pollen morphology and confirmed our results through a statistical treatment using the Birks’ method (Birks 1968). We proved the occurrence of arctic Betula species in the Pleistocene of Hungary by palaeobotanical methods. The results of the macrofossil and pollen analysis are of special importance because they represent the first record of these typical glacial species from the vegetational history of Hungary. Further investigation of the locality is necessary.

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REFERENCES


