

Carpinus betulus L. – Hornbeam

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PRESENT DISTRIBUTION IN THE WESTERN CARPATHIANS

Hornbeam grows typically in both lowland and upland areas. In Poland it is a species whose distribution covers the entire country, mainly in the lowlands and foothills, less frequently in the mountains where its continuous range of occurrence does not exceed 500 m a.s.l. (Boratyńska 1993). In the Carpathians, the highest sites with hornbeam (single individuals) are located in the Bieszczady Mountains at an altitude of 900 m a.s.l. In the Gorce Mountains the taxon occurs at 695 m a.s.l. and in the Polica range (Beskid Żywiecki range) at 600 m a.s.l. In the Pieniny Mountains single trees attain altitudes exceeding 700 m a.s.l., however small, dense groves are not found above 500 m a.s.l. (Boratyńska 1993). *Carpinus betulus* does not grow in the Tatra Mountains, while in the Sudety Mountains, similarly as in the Carpathians, its continuous range of occurrence extends to 450–500 m a.s.l. (Boratyńska 1993). At higher altitudes of submontane and montane regions hornbeam is replaced by beech, *Fagus sylvatica* (Faliński & Pawlaczyk 1993).

ECOLOGY

Carpinus betulus is the main taxon in oak-lime-hornbeam forests, being fertile, multispecies deciduous forests widespread in Europe in the past (Faliński & Pawlaczyk 1993) and classified within the *Carpinion betuli* alliance according to J.M. Matuszkiewicz (2001). Hornbeam is also a contributory species in mixed coniferous forests of the *Dicrano-Pinion* alliance and a component of alder woodland (*Alnetea glutinosae* class). Occurrence of the species in forest communities of such diverse habitats results from its broad range of tolerance to edaphic, humidity and light conditions. *Carpinus* is known to prefer fertile, mesotrophic, meso-eutrophic, fresh and temporarily humid habitats (Faliński & Pawlaczyk 1993) and soils abundant in calcium (Boratyńska 1993).

Carpinus is a heliophilous, tree which reproduces freely and is tolerant of browsing. It displays features characteristic of pioneer plants but produces relatively heavy fruits, small hard nutlets dispersed by animals, air or by downslope settlement (Faliński & Pawlaczyk

1993). *Carpinus betulus* combines life strategies typical of many tree species found in oak-lime-hornbeam forests. It is long-lived, setting fruit regularly over many years, and is capable of vegetative regeneration, as well as creating a persistent seed bank. Under the right conditions young trees can rapidly colonize forest areas. The above-listed features make *Carpinus* the dominant forest tree in oak-lime-hornbeam communities (Faliński & Pawlaczyk 1993).

Hornbeam is a wind-pollinated species flowering in spring, before its leaves are developed. It is typified by a short pollination period lasting only a few days, more rarely between ten and twenty days (Ralska-Jasiewiczowa et al. 2004b). Its most highest pollen production is recorded on warm days; however the tree is not considered as producing large amounts of pollen. It releases two times less pollen than beech (*Fagus*) and nearly three times less pollen than oak (*Quercus*). Pollen of *Carpinus betulus* may be dispersed by wind action up to ca 120 km, a similar distance to that of birch (*Betula*) and twice as far as pollen of oak (Suszka 1993).

EXPANSION IN EUROPE DURING THE LATE GLACIAL AND EARLY HOLOCENE

Low percentages of *Carpinus* pollen are recorded from the Late Glacial and early Holocene sediments (before 9000 BP) from some areas of Europe, particularly Italy and the eastern and south-eastern regions of the continent (Huntley & Birks 1983). In Poland, this time period, and up to ca 7000 BP, is also marked by minor amounts of hornbeam pollen, most likely originating from long-distance transport or derived from reworking of older sediments (Ralska-Jasiewiczowa et al. 2004b).

HISTORY OF EXPANSION IN THE WESTERN CARPATHIANS DURING THE HOLOCENE

(Fig. 15)

7000–6500 BP

In pollen spectra, hornbeam is recorded as single and scattered occurrences, suggesting that the first traces of *Carpinus* appearing in the Polish Western Carpathians should be assigned to the Orawa-Nowy Targ Basin at

ca 7000 BP. The frequency are low and attain ca 0.1%, however at the end of this period, ca 6500 BP, they increase to over 0.2% in the Orawa-Nowy Targ Basin. Isopolls of similar values cover the central part of the Jasło-Sanok Depression.

6000–5500 BP

Nearly the entire Carpathians are covered by 0.2–0.5% isopolls. Slightly higher values are recorded for the north-western part of the Orawa-Nowy Targ Basin. In areas of the middle Raba river (borderland of the Beskid Makowski and Beskid Wyspowy ranges), the upper Biała river (tributary of the Dunajec river) and the upper Wisłok river amounts of hornbeam do not exceed 0.2%. In the Beskid Niski range, the frequency are even lower and do not attain 0.1%. Minor amounts of *Carpinus* pollen most likely can be accounted for by long-distance transport from the south and east, rather than the actual occurrence of this species in forest communities of the Polish Carpathians.

On the 5500 BP map, for the first time, isopolls exceeded the value of 1% in the Beskid Żywiecki range and the Bieszczady Mountains. Other regions of the Carpathians are covered by the 0.5% isopoll, except for the Beskid Niski range and the eastern part of the Beskid Sądecki range, which are marked by values between 0 and 0.2%.

5000 BP

The rather mosaic pattern observed in the preceding isopollen map becomes more organized and less diversified at ca 5000 BP. Apart from the Beskid Niski range, where *Carpinus* pollen is not found, most Carpathian areas are covered by 0.1–0.5% isopolls. Values slightly exceeding 2% and 1% respectively are only recorded in the Beskid Żywiecki range and in the north-western part of the Orawa-Nowy Targ Basin. Amounts higher than 0.5% are recorded also for the Western Bieszczady Mountains. The outline of isopolls for this period suggests that migration of hornbeam into the Polish Carpathians occurred from the south-west. The map plotted for this time-slot also provides a basis for the assumption that *Carpinus* is likely to have occurred in plant communities of the western part of the Carpathians, extending to the Skawa river in the east. In other areas of the Polish Western Carpathians, (excluding the Western Bieszczady Mountains) minor amounts of hornbeam pollen in spectra suggest wind transport, from the south and west, rather than the actual occurrence of the taxon.

4500 BP

On the 4500 BP map, isopolls covering areas to the east of the Dunajec river range from 1% to 2% and even exceed these values in the Western Bieszczady Mountains and in parts of the Beskid Niski range and the Pogórze Dynowskie Foothills. In the light of such values, it may be

assumed that *Carpinus betulus* occurred at a few scattered sites, at least in the eastern part of the Carpathians.

4000 BP

Hornbeam continued its expansion from the south-east. In the Bieszczady Mountains and the Jasło-Sanok Depression pollen values attain up to 10% and are notably higher in the Beskid Niski range. Other areas to the east of the Dunajec and Biała rivers (the Pogórze Ciężkowickie and Pogórze Dynowskie Foothills) are marked by values between 2 and 5%, while regions to the west of the two river valleys (the Western Beskid Mountains) are covered by the 1–2% isopoll. Two small areas, the north-western part of the Orawa-Nowy Targ Basin and the borderland of the Beskid Makowski and Beskid Wyspowy ranges, marked by isopolls of 2–5% and 1%, respectively, form an exception. The outline of isopolls indicates the expansion of *Carpinus* into the Polish Western Carpathians took place predominantly from a south-eastern direction.

3500 BP

The 3500 BP map presents the maximum pollen values of *Carpinus* in the area under discussion. Generally the entire Western Carpathians are covered by 2–5% isopolls. Higher values, ranging from 5 to 10%, are recorded in the Bieszczady Mountains and the Beskid Niski range. In the last-mentioned region the frequency locally attains 20%. In this period, hornbeam, accompanied by elm (*Ulmus*), lime (*Tilia*), and hazel (*Corylus*), is an important component of deciduous forest communities of the foothill zone. Lower proportions (below 2%) are observed only in the Beskid Makowski range.

3000–2000 BP

The beginning of this period is marked by a decrease from the maximum values of *Carpinus* in the Carpathians, most likely resulting from the replacement of the species by beech (*Fagus sylvatica*) at sites located at higher altitudes (Ralska-Jasiewiczowa et al. 2004b). Only the Bieszczady Mountains and the north-western part of the Beskid Niski range are covered by 5–10% isopolls. Other Carpathian areas are dominated by amounts between 2 and 5%, locally even below 2% (the Beskid Makowski and Beskid Żywiecki ranges). In the time period discussed here the initial decrease from its maximum values was followed by a stabilization of its proportions in oak-lime-hornbeam deciduous forest communities, developing in the Carpathians.

1500 BP

The 1500-year-long period marked by stable *Carpinus* isopollen values is followed by the retreat of this species from the Carpathians. However, at that time, the Polish lowlands showed the widest Holocene distribution of this species (Ralska-Jasiewiczowa et al. 2004b). Apart from the Bieszczady Mountains, with values still amounting to

5–10%, most Carpathian areas are covered by 2–5% isopolls. In the Beskid Śląski, Beskid Żywiecki and partly the Beskid Mały ranges frequency of hornbeam do not attain 2%. A decrease in pollen values is also recorded in the Jasło-Sanok Depression and the western part of the Orawa-Nowy Targ Basin.

1000 BP

The retreat of hornbeam from the Carpathians, initiated at ca 1500 BP, was intensified during this period. Isopolls of 2–5% cover only the south-eastern areas of the Carpathians: the Orawa-Nowy Targ Basin, the Beskid Sądecki range, the southern part of the Pogórze Ciężkowickie Foothills, the Beskid Niski range and the eastern part of the Pogórze Dynowskie Foothills. Amounts higher than 5% are recorded exclusively in the Bieszczady Mountains. In other Carpathian regions frequency do not exceed 2%.

500–0 BP

Maps plotted for this period present the proceeding retreat of *Carpinus* from the Western Carpathians. At ca 500 BP, the entire study area is covered by 1–2% isopolls. Furthermore, locally (the Jasło-Sanok Depression) the frequency do not attain even 1%. The Bieszczady Mountains and the central part of the Orawa-Nowy Targ Basin, with pollen values exceeding 2%, are an exception. The present-day values of *Carpinus* pollen in the area of Polish Western Carpathians generally do not exceed 1%, apart from the Bieszczady Mountains and the Beskid Żywiecki range with proportions attaining 1.1% in pollen spectra. This pattern observed in the present-day isopollen map is most likely an outcome of many factors, both natural (migration, interspecific competition, climatic changes) and anthropogenic ones, that have already been affecting the Polish population of *Carpinus* since 3000 BP (Ralska-Jasiewiczowa et al. 2004b).

CONCLUSIONS

Identification of the first occurrence of *Carpinus betulus* in the area of Polish Western Carpathians is not straightforward. According to Latałowa and Święta (2002, as cited by Ralska-Jasiewiczowa et al. 2004b), minor amounts of hornbeam pollen (0.5–2%) found in surface samples suggest its presence in local forest communities. Occasionally, even values below 1% in spectra may indicate the occurrence of the species *in situ*. Patterns observed in isopollen maps provide the basis for the assumption that the first, scattered sites with hornbeam appeared ca 5000 or even 5500 BP in the Beskid Żywiecki range and in the north-western parts of the Orawa-Nowy Targ Basin and the Bieszczady Mountains. However, it should be considered that conclusions based on present-day pollen counts do not always directly correspond to the composition of fossil spectra. Such data generally relate to lowland areas of Poland and, therefore, are not affected by variations in altitude and topography. Nevertheless, there is a great probability that at ca 4500–4000 BP *Carpinus* was already found in the Bieszczady Mountains and the Beskid Niski range, a conclusion that is confirmed by abundant macrofossil of this taxon recorded in the profile from Cergowa (site no. 124) and dated to 4000 BP (Szczepanek 2001b). This period was also marked by hornbeam migrating predominantly from a south-easterly direction.

Oak-lime-hornbeam forests were the dominant communities in the Carpathians at ca 3500 BP. The first decrease in *Carpinus* pollen values, resulting from the expansion of beech into their common habitats, was observed for ca 3000 BP and was followed by a period of stabilization lasting until ca 1500 BP, when the process of retreat of hornbeam from the Carpathians but its expansion in the Polish upland hills and lowlands was intensified.







