

Carpinus betulus pollen accumulation rates in Roztocze (SE Poland) in relation to presence of *Carpinus* in Ferdynandovian pollen diagrams

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Abstract. *Carpinus* pollen has been recorded in fossil pollen diagrams of different interglacials. In case of the Ferdynandovian pollen sequence it is of particular importance to know if scattered presence of *Carpinus* pollen at the decline of Ferdynandovian 1 interglacial represents long distance transport of pollen or small isolated *Carpinus* populations. The study aims to trace the pollen-vegetation relationship in Roztocze (SE Poland) using Tauber-style pollen traps to understand better the pattern of *Carpinus* pollen dispersal and deposition. High and low pollen deposition years were recorded for *Carpinus betulus* in the period 1998–2010. Deposition was extremely high in 2002. Average annual pollen accumulation rate was calculated at 1348 grains cm⁻² year⁻¹, which was 4.1% of total pollen spectrum. The study confirms that the earlier pollen presence/absence threshold values of about 5% for the presence of *Carpinus* trees in vegetation (Huntley & Birks 1983) were too high. The pollen monitoring data from Roztocze support the opinion of Ralska-Jasiewiczowa et al. (2004) that low values of about 0.5% may reflect the presence of *Carpinus* trees in the forests. These data, in comparison to the scattered *Carpinus* pollen grains in the last part of the Ferdynandovian 1 interglacial seem to indicate that single trees of this genus may have occurred in the vegetation at the decline of interglacial optimum.

Keywords: *Carpinus betulus*, pollen monitoring, pollen deposition, fossil pollen diagrams, Ferdynandovian

1. Introduction

Pollen diagrams of different interglacials include *Carpinus* percentage pollen curves in Poland. The pattern of its occurrence differs significantly between Ferdynandovian/Cromerian, Mazovian/Holsteinian and Eemian interglacials (Mamakowa 2003). In the well-recognized interglacial pollen successions, including the Holocene, *Carpinus* usually occurs in the second part of interglacial optimum. The only exception is the first interglacial (F1) within the Ferdynandovian (=Cromerian) succession (Mamakowa 2003; Pidek 2013, 2015; Pidek & Poska 2013) in which *Carpinus* either does not occur at all, or occurs only in sporadic pollen grains at the very decline of climatic optimum (Fig. 1).

There is a matter of debate if this unusual occurrence indicates small scattered *Carpinus* populations or rather a long distance transport from sources situated far to the south.

Studies of modern pollen deposition of trees conducted in the Roztocze in the years 1998–2010 aim to trace pollen dispersal and deposition of main forest forming species of the Roztocze region, including *Carpinus betulus*. This tree is a central European element growing mainly in lowland conditions and in the highlands. In the mountains it usually does not reach altitudes above 700–1000 m a.s.l. *Carpinus* is an important element of the multispecies broadleaved forests and a species characteristic for the Carpinion betuli alliance (Boratyńska 1993). Faliński & Pawlaczyk (1993) suggest that the lack of sufficient warmth for seeds devel-

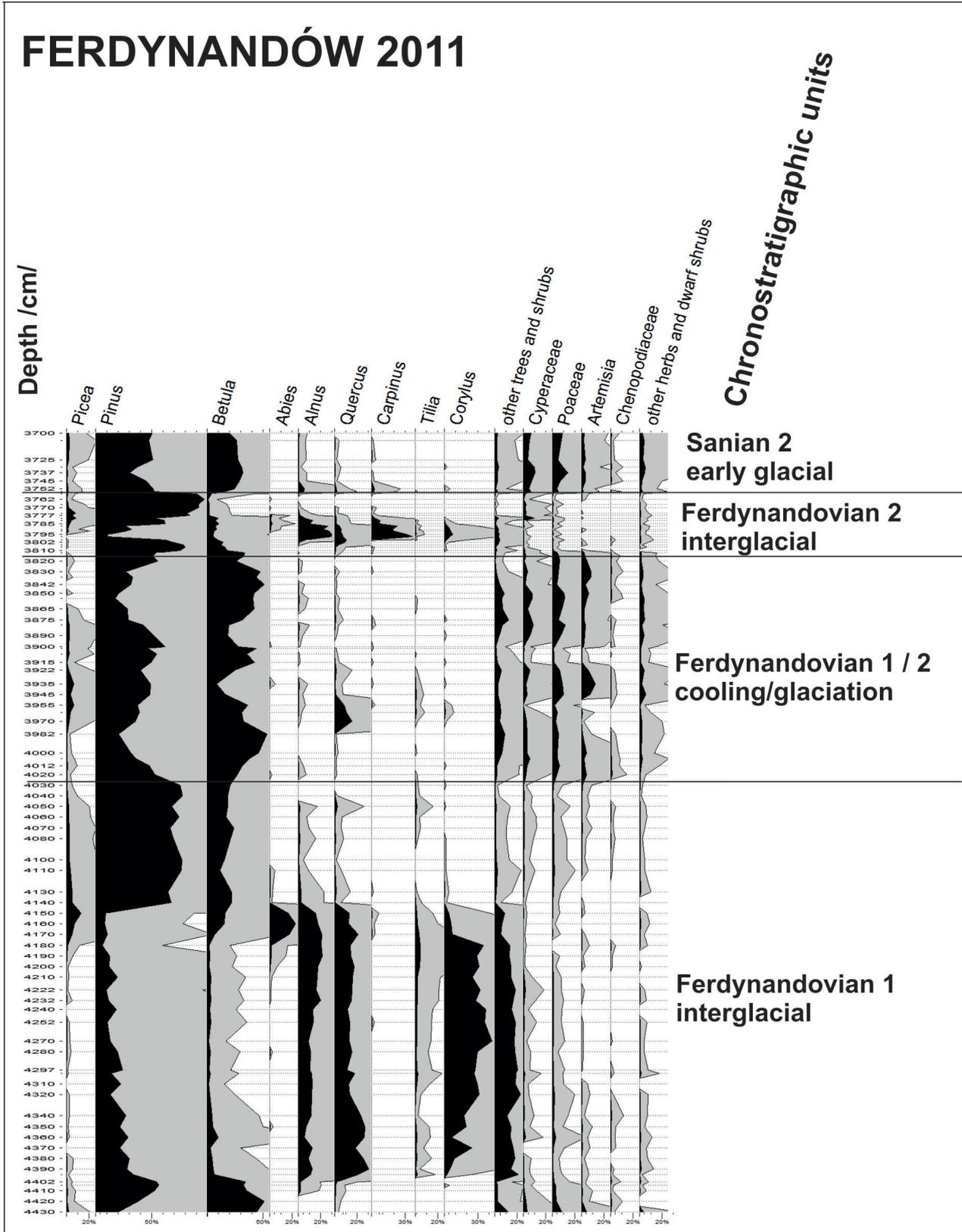


Figure 1. Simplified pollen diagram of Ferdynandovian pollen sequence in the stratotype profile Ferdynandów 2011, based on fossil pollen data by Pidek (2015). Chronostratigraphic units follow Lindner et al. (2004). For the drawing of the diagram the POLPAL software was used (Nalepka & Walanus 2003).

opment during late spring limits its distribution in the east. *Carpinus betulus* flowers in Poland between the end of April and the first half of May (Tomanek 1994).

Pollen Accumulation Rates (PAR) for *Carpinus* in Roztocze were traced in different situations according to the Pollen Monitoring Programme guidelines (Hicks et al. 1996; www.pollen trapping.org). These include 9 pollen trapping sites, among which there are traps located inside the forest, at the forest edge and in open situations. Detailed characteristics of pollen trapping sites are provided in Pidek (2004). The data series 1998–2010 has been analysed by van der Knaap et al. (2010) in terms of pollen-climate correlations and used to trace natural physiological rhythmicity in abundant flowering of tree species (Pidek et al. 2015).

The present study aims at calculating average Pollen Accumulation Rates (PAR) and percentages of *Carpinus* in relation to total pollen spectra in different vegetation situations in Roztocze in order to use these data to interpret presence or absence of *Carpinus* in the forests at the decline of Ferdynandovian 1 interglacial.

2. Study area

The Roztocze region forms an elevated highland area of the width of about 28 km in south-eastern Poland at the border between Poland and Ukraine. The region is characterized by rich multispecies forests of natural character in the central part of the area, which are protected within the

Roztocze National Park. Fir-tree forests (*Abietetum polonicum*) cover the lower and middle parts of the slopes, while Carpathian beech forests (*Dentario glandulosae-Fagetum*) cover the uppermost ones (Izdebski et al. 1992). Forests of *Tilio-Carpinetum* association are located mainly in gullies unsuitable for farming. Large areas overgrown by different pine communities occur on dunes and plains.

Nine pollen trapping sites are located around Guciów village in the protected zone of the Roztocze National Park. *Carpinus* is one of the main components of *Tilio-Carpinetum* association in the Park (2.8% of the Park area, Izdebski et al. 1992) and in the Guciów village (4.0% of the village area, Grądziel et al. 2006). *Carpinus* is also a very important tree in substitute communities from the Quercus-Fagetea class, where it occurs in lower tree layer and at the forest edge. The proportion of these communities in the Park is 23.7%, while in the Guciów village 4.7%.

3. Methods

Annual pollen accumulation rates (PARs) have been monitored with the use of Tauber-style traps according to the guidelines by Hicks et al. (1996). The pollen trapping sites are located in different situations (Table 1), i.e. from closed forest through the forest edge to open landscape, according to the guidelines of the Pollen Monitoring Programme (PMP; www.pollen trapping.org; Giesecke et al. 2010; Poska 2013). The annual pollen deposited in a trap over a year is subject to laboratory treatment with the

Table 1. Description of traps location in the Roztocze region and the distance to nearest *Carpinus* trees.

Trap no	Description of trap location	Size of the forest opening	Distance to nearest <i>Carpinus</i> tree
G 1	Small opening within <i>Abietetum polonicum</i>	10 x 10 m	200 m
G 2	Large opening within mixed pine-deciduous forest	40 x 120 m	40 m
G 3	Meadow on edge of mixed forest with <i>Pinus</i> and <i>Abies</i> as dominant trees	Forest edge – distance from nearest trees ca. 25 m from eastern side	25 m
G 4	Large clearing within mixed <i>Pinus-Betula</i> forest with admixture of other tree species	60-120 m	60 m
G 5	Meadow on edge of <i>Dentario glandulosae-Fagetum</i>	Forest edge – distance from nearest trees 2 m from western side	1 m
G 6	Open vegetation – abandoned field overgrown by <i>Betula</i> and <i>Salix</i>	Open vegetation	400 m
G 7	Open vegetation – meadow within cultivated and abandoned fields	Open vegetation, patch of pine and birch from eastern side at a distance of ca. 15 m	500 m
G 8	Large clearing within beech forest	80 x 100 m	40 m
G 9	Under canopy site within beech forest	Under canopy site, distance from nearest trees 8 m	30 m

addition of *Lycopodium* tablets (Stockmarr 1971), then filtering and Erdtman's acetolysis. The number of pollen grains of each taxon deposited on a surface of 1 cm² is calculated as PAR. Counting under a light microscope is continued until a minimum of 500 tree pollen grains and at least 100 *Lycopodium* spores is obtained. Average annual PAR was calculated for *Carpinus* based on pollen accumulation data from all the traps in the Roztocze region (Table 2).

4. Results

Pollen traps were placed in different types of plant communities (Table 1) including small forest openings (trap G 1 and G 9), large forest openings (traps G 2, G 4 and G 8),

forest edges with abundant hornbeam trees (traps G 3 and G 5) and open situations of abandoned arable fields (traps G 6 and G 7).

The closest distance to *Carpinus* trees 1–25 m were observed in trapping sites G 5 and G 3. In these two cases *Carpinus* forms forest edge and the values of average PARs are high, i.e. 3340 grains cm⁻² year⁻¹ (11.7%) and 1123 (2.8%), respectively. Quite high values were also obtained for traps G 4 and G 9 – 1901 (4.6%) and 1319 (3.9%), respectively; where the distance to *Carpinus* trees is bigger, but the forest edge is composed of this tree, too. The lowest average PARs were obtained for traps in open landscape (abandoned fields, traps nos G 6 and G 7), in which the distance to nearest *Carpinus* trees was 400–500 m. In these two cases average PAR ranges from 573 (trap G7) to 737 grains cm⁻² year⁻¹ (trap G 6) (or 1.7% in each case). The

Table 2. *Carpinus* PAR and percentages in pollen traps in Roztocze (1998–2010).

Trap no/ year	PAR	%		Trap no/ year	PAR	%		Trap no/ year	PAR	%
G 1/2010	360	1.5		G 4/2010	3421	7.7		G 7/2010	687	2.0
G 1/2009	-	-		G 4/2009	1071	2.6		G 7/2009	209	1.0
G 1/2008	254	1.4		G 4/2008	1216	1.8		G 7/2008	209	0.6
G 1/2007	886	3.0		G 4/2007	3624	9.6		G 7/2007	681	2.5
G 1/2006	-	-		G 4/2006	2169	6.7		G 7/2006	554	1.5
G 1/2005	196	1.6		G 4/2005	-	-		G 7/2005	376	1.2
G 1/2004	116	0.3		G 4/2004	509	1.6		G 7/2004	157	0.8
G 1/2003	363	2.1		G 4/2003	1130	2.8		G 7/2003	565	0.9
G 1/2002	-	-		G 4/2002	4913	9.2		G 7/2002	1751	4.9
G 1/2001	307	1.6		G 4/2001	1291	5.2		G 7/2001	512	1.5
G 1/2000	148	1.4		G 4/2000	471	3.2		G 7/2000	-	-
G 1/1999	521	2.7		G 4/1999	1044	2.7		G 7/1999	605	2.3
G 1/1998	-	-		G 4/1998	1958	2.3		G 7/1998	-	-
Average	350	1.7		Average	1901	4.6		Average	573	1.7
G 2/2010	1279	4.2		G 5/2010	5502	13.4		G 8/2010	1318	2.2
G 2/2009	554	2.6		G 5/2009	712	3.5		G 8/2009	-	-
G 2/2008	1180	3.6		G 5/2008	-	-		G 8/2008	1909	2.8
G 2/2007	1397	5.8		G 5/2007	2125	9.2		G 8/2007	1853	6.0
G 2/2006	1449	5.2		G 5/2006	6860	21.8		G 8/2006	3560	9.7
G 2/2005	785	3.3		G 5/2005	692	4.2		G 8/2005	1285	2.9
G 2/2004	454	1.2		G 5/2004	1389	7.2		G 8/2004	721	2.8
G 2/2003	396	1.2		G 5/2003	1141	3.6		G 8/2003	719	2.0
G 2/2002	2797	5.9		G 5/2002	7439	19.5		G 8/2002	4374	11.3
G 2/2001	408	1.2		G 5/2001	1861	6.7		G 8/2001	-	-
G 2/2000	467	3.0		G 5/2000	480	2.9		G 8/2000	640	1.8
G 2/1999	878	6.0		G 5/1999	8547	36.5		G 8/1999	752	6.3

Trap no/ year	PAR	%		Trap no/ year	PAR	%		Trap no/ year	PAR	%
G 2/1998	-	-		G 5/1998	-	-		G 8/1998	-	-
Average	1003	3.6		Average	3340	11.7		Average	1713	4.8
G 3/2010	1650	4.0		G 6/2010	793	1.4		G 9/2010	1416	4.0
G 3/2009	599	1.5		G 6/2009	310	1.4		G 9/2009	685	3.5
G 3/2008	458	1.6		G 6/2008	212	0.4		G 9/2008	-	-
G 3/2007	3923	8.6		G 6/2007	1178	3.0		G 9/2007	1983	6.5
G 3/2006	1207	3.3		G 6/2006	1240	2.7		G 9/2006	2037	3.7
G 3/2005	283	1.6		G 6/2005	441	1.4		G 9/2005	-	-
G 3/2004	467	2.3		G 6/2004	324	1.1		G 9/2004	871	2.5
G 3/2003	985	3.3		G 6/2003	507	1.1		G 9/2003	-	-
G 3/2002	2749	5.3		G 6/2002	1874	3.8		G 9/2002	3378	10.5
G 3/2001	733	1.0		G 6/2001	132	0.2		G 9/2001	47	0.3
G 3/2000	178	1.0		G 6/2000	-	-		G 9/2000	215	0.8
G 3/1999	620	1.6		G 6/1999	886	2.6		G 9/1999	1247	3.6
G 3/1998	758	1.9		G 6/1998	957	1.8		G 9/1998	-	-
Average	1123	2.8		Average	737	1.7		Average	1319	3.9

average annual PAR based on all the traps in the period 1998–2010 was about 1348 grains cm⁻² year⁻¹

The average annual PARs for *Carpinus* are comparable to the ones calculated by Pidek et al. (2015) for *Alnus* and *Fagus* (ca. 1300–1400, respectively) and much lower than the values of PARs recorded for *Pinus* and *Betula* (ca. 6000 and 5000 pollen grains cm⁻² year⁻¹, respectively).

In the *Carpinus* pollen data series (Table 2, Fig. 2) large year to year variation in pollen accumulation rates (PARs) was observed.

The highest PAR values were recorded in 2002, while for most other tree species in Roztocze 2003 was recorded as an exceptionally high pollen deposition year (Pidek et al. 2015). Other years of high pollen deposition of *Carpinus* were 2006, 2007 and 2010. 1999 can be considered as a high year in several traps. In general, the 2006 was extremely high year also for *Picea*, *Fagus*, *Fraxinus*, *Ulmus*, *Betula* and *Alnus*,

Low years for *Carpinus* pollen deposition were 2000, 2005 and 2009. In general, the year 2000 was also low for *Pinus*, *Alnus* and *Quercus*, and 2005 year – for *Pinus*, *Picea* and *Alnus*, and 2009 year for *Fagus*, *Abies*, *Ulmus*, *Alnus*, *Betula* and *Fraxinus*.

In terms of percentages the average value for *Carpinus* pollen in pollen spectra from Roztocze is about 4.1%. It seems comparable with the proportion of this tree or representation in the vegetation if we calculate only *Tilio-Carpinetum* association in the Park and in the Guciów

village (2.8%–4.0%). However, in relation to percentage representation of substitute communities from the *Quercus-Fagetea* class with frequent *Carpinus* at the forest edges; i.e. 23.7% in the Park and 4.7% in the Guciów village, it is clear that *Carpinus* is underrepresented in pollen assemblages. These conclusions agree with Ralska-Jasiewiczowa et al. (2004), who found that values as low as 0.5% in the Holocene pollen assemblages probably indicated the presence of *Carpinus* trees in the forests. The study confirms that the earlier pollen presence/absence threshold values of about 5% for the presence of hornbeam trees in vegetation (Huntley, Birks 1983) were too high.

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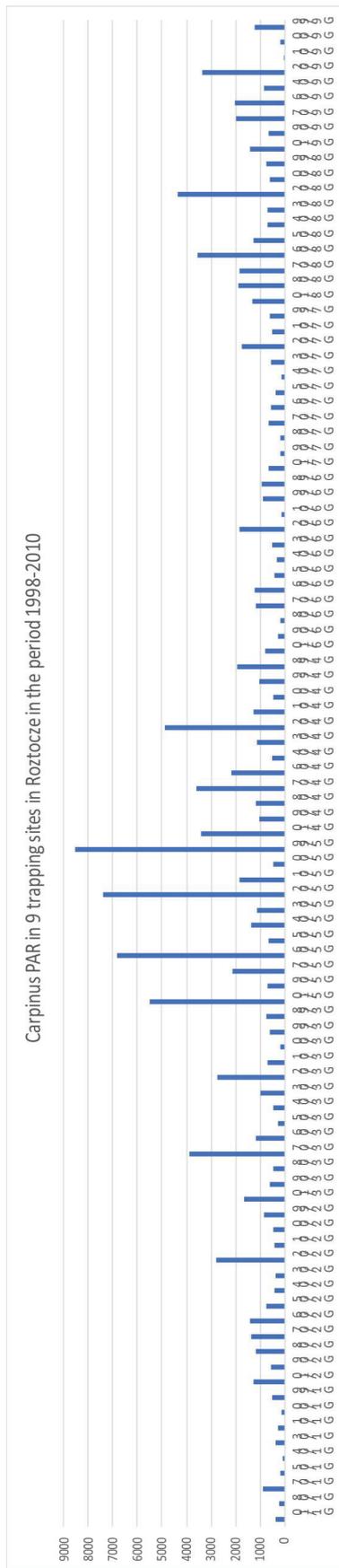


Figure 2. Pollen Accumulation Rates of Carpinus in the Roztocze in the period 1998–2010. Explanations to symbols: G 1/10 – Guciów pollen trapping no 1/year 2010.