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Parrotia persica C.A.M. (Persian witch hazel, Persian ironwood) in the Mazovian (Holsteinian) Interglacial of Poland

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Palynological studies of Holsteinian lake sediments from the Podlasie region, eastern Poland, reveal a relatively abundant occurrence of *Parrotia persica* pollen (Hamamelidaceae). This species, unknown in the late stage of Pleistocene in Poland, was noted in the climatic optimum. This is a new floristic element, which permits a more precise identification of climate changes and which may also be potentially useful as a stratigraphical tool in age determination to separate different interglacial. The similarity to other pollen types of Hamamelidaceae is discussed, and a provisional description for pollen identification of some related taxa provided.

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The Podlasie region, in eastern Poland is a suitable place for palaeolimnological research. In this restricted area, numerous lake sediments from the Holsteinian and the Eemian occur on the surface of the Elsterian and the Saalian till plateau. A continuous subsidence of the Holsteinian lakes resulted in the accumulation of large thickness of sediments, consisting mostly of calcareous gyttja and lake marl. Several Holsteinian sites, from which a dozen were examined by means of pollen analysis, are known from this area (review in Nitychoruk 1994 and Krupiński 1995). There is no doubt that the demonstrated pollen sequence studied here represents the Holsteinian interglacial. Despite the fact that the pattern of succession trends is to some degree different in central and western Europe, especially in the first half of the interglacial, the high content of *Picea*, the presence of a *Taxus* phase, intra-interglacial cooling with *Pinus*, a pronounced *Carpinus-Abies* phase and finally the very characteristic expansion of *Pterocarya* separates this succession from the interglacials: Eemian and Ferdynandovian.

The present-day *Parrotia persica* (D.C.) C.A. Mey. forming multi-trunked shrubs or small trees, is known from many localities in northern Iran, e.g. in Elburs Mountains, Talysh Mountains and adjacent Lenkoran Lowland, as well as in the Alsan Valley (Azerbaijan), which is the northernmost locality of this tree in the Caucasus region. It grows most frequently in low mountain areas and adjacent lowlands in moderately wet forest with *Quercus castanaeifolia* Pantoc., *Carpinus caucasica* A.A. Grossh., *Zelkova carpinifolia* Dippel as well as *Buxus* (Safarov 1972, 1977; Łukasiewicz 1985). The mean annual precipitation in the centre of the species range is 1300 – 1400 mm. The temperature tolerance varies in different regions. In the Talysh mountains, where single localities of *Parrotia* occurs up to 1200 m a.s.l., the mean January temperature reaches 0°C, with the absolute minimum −28°C and the mean annual temperature is about 9 – 10°C. In localities at 200 – 400 m where ironwood grows most abundantly the mean annual temperature rises to 14 – 15°C, whereas in the Iranian part of the range the mean January temperature is +6.3°C (with the absolute minimum −6°C). Ironwood prefers sufficiently wet fertile soils. Observations made in the Botanical Garden of A. Mickiewicz University in Poznań, Poland (Łukasiewicz 1985) show its relative sensitivity to low winter temperatures especially without any snow cover, as well as to a summer drought. For this reason fruits are often not formed.

MATERIAL AND METHODS

In the present study pollen grains of *Parrotia*-type were noted at four Holsteinian sites in the Podlasie region: Kaliłów, Woskrzenice, Wilczyn and Lipnica (Bińka & Nitychoruk 1995, Bińka & Nitychoruk1996, Bińka et al. 1997; Fig. 1). The pollen flora analysed here is extracted from the core drilled at Kaliłów taken in the centre of a very large Holsteinian lake, longitudinally elongated and narrow (sampled between the depth 3.5 and 14.5 m below surface).

Modern pollen reference material for morphological studies was collected from living trees in the Botanical Garden of A. Mickiewicz University in Poznań (*Parrotia persica* (DC.) C. A. Mey.), the Botanical Garden of the Polish Academy of Sciences at Powsin (*Sinowilsonia henryi* Hemsl.), and the Arboretum of Warsaw Agricultural University at Rogów (*Fortunearia sinensis* Rehd. and Wils.).

Fossil and modern material were treated according to standard laboratory procedures (Faegri & Iversen 1989). For SEM investigation specimens were rinsed with a mixture of water and alcohol.

Palynological terminology used in pollen description follows that of Punt et al. (1994).

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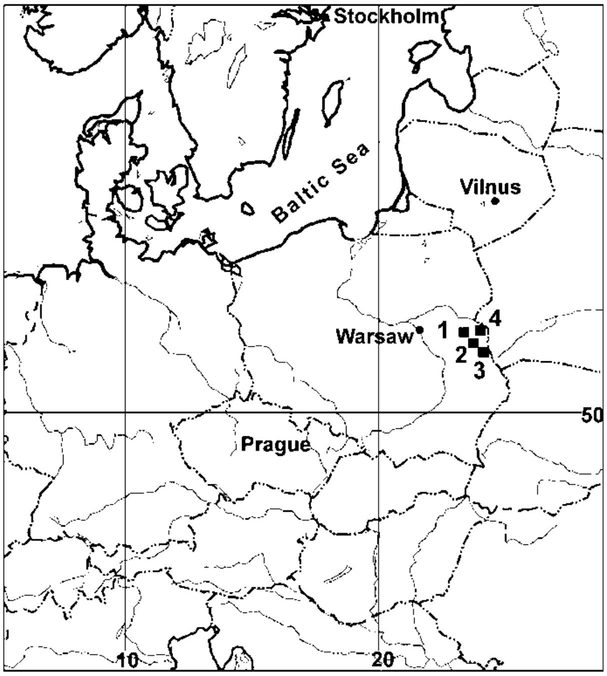

Fig. 1. Map showing location of interglacial sites in eastern Poland where pollen of *Parrotia* – type was noted: 1. Wilczyn, 2. Woskrzenice, 3. Kaliłów, 4. Lipnica.

RESULTS

Modern *Parrotia* pollen

Grains spherical or oblate, tricolpate, very rarely tetracolpate or porate. Colpus short to rather long and very broad, often irregularly shaped and disrupted in its central part. Colpus membrane covered with large granules, increasing towards the edges of ectoaperture (Fig. 2 B). Reticulum with two-size gradation of meshes-large lumina and small perforations. Large lumina, variable in shape, size from 1.5 to 2.3 μm in one examined grain and between individual pollen grains. Pollen with generally smaller meshes are seldom noted in the reference slide. A reticulum with very small meshes (Fig. 2 A, B) is also noted. The size of lumina decreases slightly in the polar area. Margo present but not clearly defined. Muri narrow, with small scabrae visible only on SEM images. Polar axis varies from 28 to 40 μm.

Fossil *Parrotia* – type pollen

Grains most often tricolpate (Fig. 3 E–G & H–J), rarely tetracolpate (Fig. 3 K, M) or sometimes pantoporate with more or less clearly defined pores. Semitectum with coarse or finely reticulate sculpture, rarely microreticulate (Fig. 3 A, B); sometimes irregularly perforate – microreticulate. In a few noted specimens it represents some kind of frustillate type (Fig. 3 C). A typical feature clearly visible in grains with coarse reticulum (Fig. 3 A, E, F) is two-size gradation of lumina – very small ones often in clusters (1–4) among larger lumina irregular in shape – rounded or angular. Typically, the size of lumina is only slightly reduced in the polar area in comparison with the mesocolpium. In the mesocolpium, the reduction in reticulum size is seen in a narrow belt around the colpi (building a not clearly defined margo) where the size of lumina is similar to that of small meshes of the mesocolpial area. Muri of reticulum exhibit minute granules. Apertures (hard to observe because of the delicate nature of the pollen) – rather short and broad colpi or rarely pori. Colpus membranes, often disrupted, are covered by large granules varied in size, isolated or arranged in large irregular, elongated and twisted structures (Fig. 3 G, O, R). The size range of fossil grains is difficult to measure because the pollen was often disturbed with disrupted pores. Polar axes vary in length from 35 to 40 μm.

The fossil pollen described above undoubtedly matches those of some taxa of the family Hamamelidaceae, especially *Parrotia persica*. The commonly observed features include a very characteristic definition of colpi covered with coarse granules, reticulum with two-size gradation of lumina and muri with supratectal scabrae. In our opinion, the fossil pollen represents *Parrotia persica*. A somewhat similar sculpture can be observed in *Fortunearia sinensis* and *Sinowilsonia henryi*.

Modern pollen of Hamamelidaceae has been studied in detail by many researchers (Chang 1964, Lee 1969, Bogle & Philbrick 1980, Zhang 2001). A close resemblance between *Parrotia* and other members of the family has been recorded. For example, Bogle & Philbrick (1980) suggested features of the reticulum of *Parrotia* resembled that of *Fortunearia* rather than *Sinowilsonia*. In typical specimens, the latter genus shows narrow muri without minute scabrae on the surface. Chang (1964) also cited some similarities between these three genera.

In our opinion, the character of the reticulum with smaller meshes is less typical in the fossil grains (Figs 3 B, F, G & R). The membrane features illustrated in this paper also has much common with that of *Sycopsis* Oliver (e.g. *S. sinensis* Oliver) and *Distylium* Sieb.et Zucc. (e.g. *D. racemosum* Sieb. et Zucc.) as can be seen in the high resolution SEM micrographs of Bogle & Philbrick (1980; Figs 27, 29) or in LM micrographs of Chang (1964; Fig. 14. 4–9).

Some of these types have ectoapertures developed as illdefined more or less rounded pori, and are similar to specimens in our fossil material. Identification of such fossil grains (rarely noted in the examined interglacial sections) may be less reliable.

The pollen differences in the exine building of *Parrotia persica* (Fig. 2 A–C), *Fortunearia sinensis* (Fig. 2 G–I) and *Sinowilsonia henryi* (Fig. 2 D–F) are presented in Table I. They are based on LM and SEM observations of the margo, the presence of supratectal elements, the variation of size of lumina in mesocolpia and in the polar area as well as the character of the membrane cover.

In the pollen diagram from the Kaliłów site (Fig. 4), single grains of *Parrotia* - type were recorded as early as at the end of a short *Pinus* and *Betula* culmination in assemblages of *Pinus* - *Larix* L. P.A.Z. (Bińka & Nitychoruk 1996). They were also recorded at the very beginning

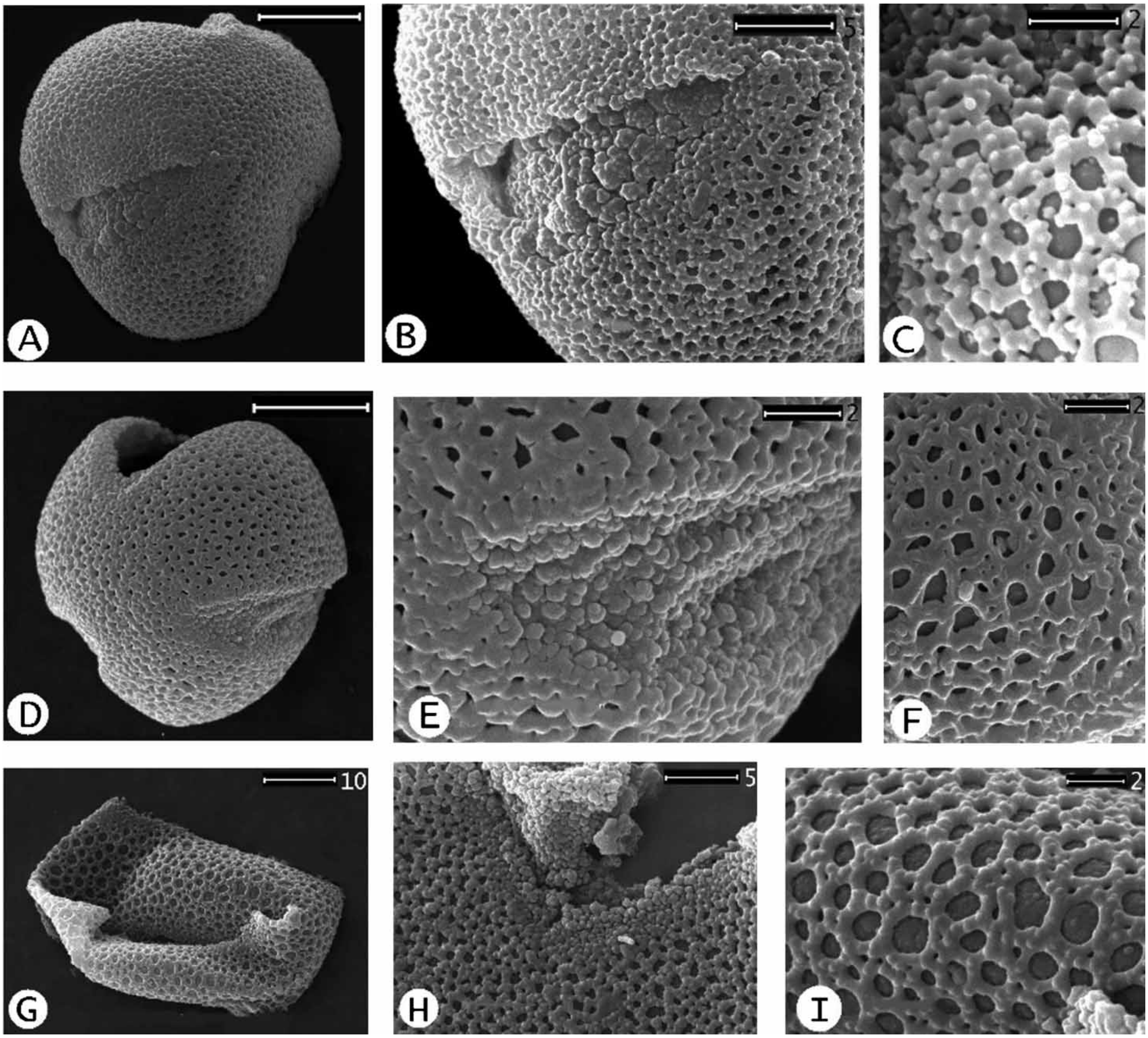

Fig. 2. SEM micrographs of modern pollen. A–C. *Parrotia persica*: (A) Oblique polar view, atypical pollen grains with small meshes of reticulum; (B) Colpus area, membrane cover with large granules and narrow belt of tectum perforated; (C) Typical size of lumina on mesocolpium, muri covered with small granules. D–F. *Sinowilsonia henryi* modern pollen: (D) Reticulum with broad muri and small meshes passes into tectum perforated in polar area; (E) Colpus area; (F) Muri of reticulum without granules. G–I. *Fortunearia sinensis* modern pollen: (G) pollen with coarse reticulum; (H) Colpus area with small granular membrane and clear perforate belts around; (I) Reticulum with small bumps in lumina and muri covered with granules. Scale bars – 10 µm (A, D, G); 5 µm (B, H); 2 mm (C, E, F & I).

of this subzone at Woskrzenice (Bińka & Nitychoruk 1995), however, its maximum abundance falls in the *Carpinus* - *Abies* L. P.A.Z. At the end of the interglacial thermal optimum, pollen of *Parrotia* - type gradually decreases.

DISCUSSION

The striking feature of the fossil grains is the irregular and variable structure of the semitectum. The semitectum varies from typical clear reticulum through to those with irregular lumina, (sometimes with the shape of meshes hardly defined), to a frustillate pollen type. Despite this variation they represent the same species; however, Bogle & Philbrick (1980) in their description of modern *Parrotia* pollen did not mention such variation of the reticulum. The same comment holds for the description of pollen of ironwood reported by Chang (1964) who documented a typical coarse reticulum only, with large lumina up to 2.88 µm in diameter.

In our reference material as well as in the fossil material, pollen have a somewhat finer reticulum (Figs 3 F–L, 2 A, C) than those illustrated by Bogle & Philbrick (1980) and Chang (1964). Grains from the Holsteinian resemble

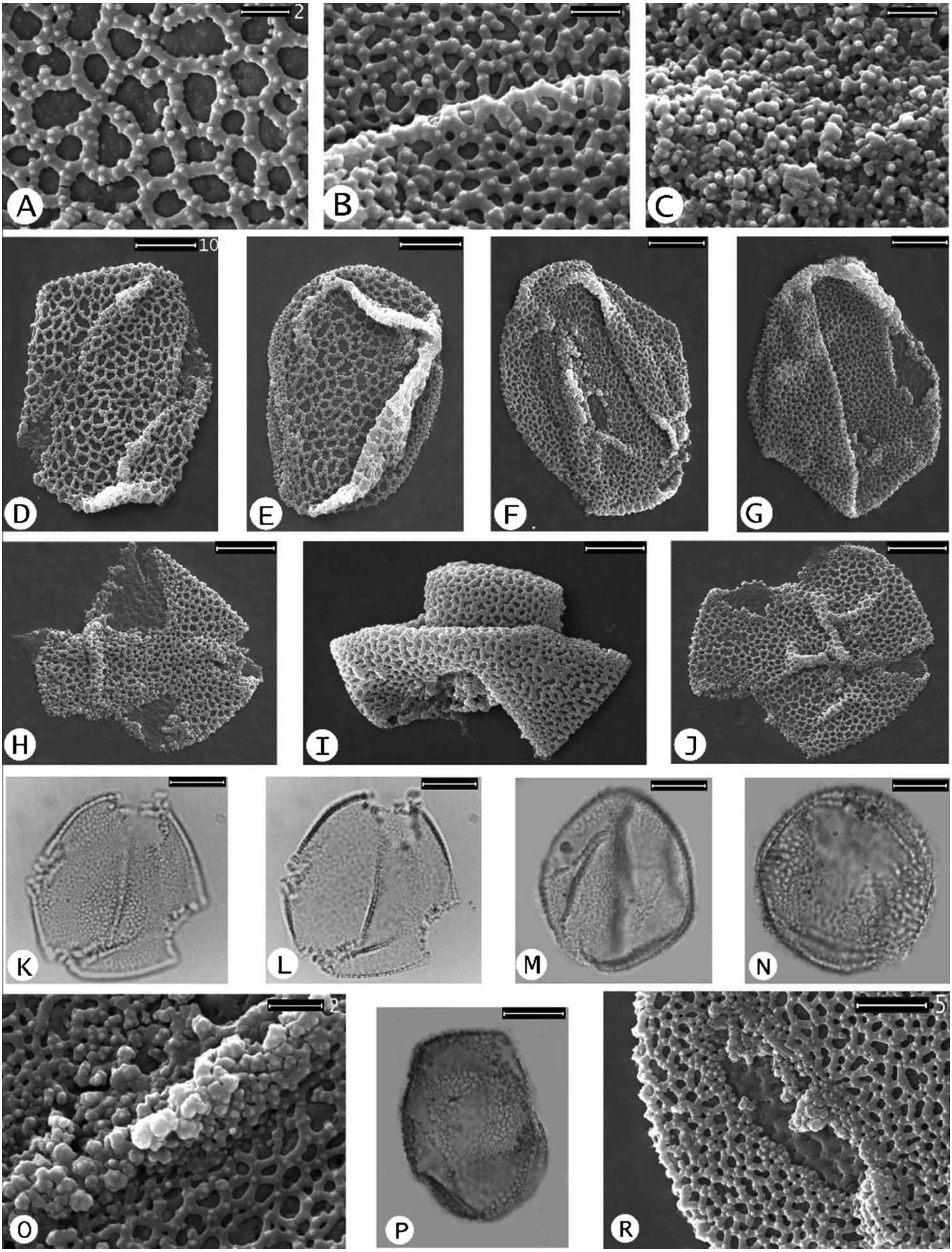

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Table I. *Differential characters of the Parrotia persica, Fortunearia sinensis and Sinowilsonia henryi pollen (modern material).*

Exine features	*Parrotia persica*	*Fortunearia sinensis*	*Sinowilsonia henryi*
membrane cover	coarse granules	fine granules	fine granules
margo	narrow microret. belt	broad belt (microret. or perforate)	more or less solid margo (sometimes with perforations) esp. near the ends of colpi, in the border with mesocolpium area not clearly defined, in grains with aberrant sculpture feature less visible
sexine 3	scabrae (SEM)	scabrae (SEM)	lack of scabrae
bottom of lumina	with rare small bumps	with small bumps	smooth
size of reticulum in mesocolpium and polar area	almost the same size	almost the same size	smaller than in mesocolpium

ironwood pollen from the Lower Pleistocene illustrated by Julia & Suc (1980). Lee (1969; quoted by Bogle & Philbrick 1980) reports variations in ectoaperture number (also observed in our modern material) in *Parrotia*, which may be syncolpate, dicolpate or tetracolpate. As it was described above, porate pollen was also recorded in the fossil and modern material.

Variations in the semitectum of the same species occur in other genera of the family Hamamelidaceae. Bogle & Philbrick (1980) noted that the foveolate and scrobiculate sculpturing occurs rarely in *Sinowilsonia henryi* modern pollen. Variation in mesh size can also be seen in modern *Fortunearia* pollen taken from bisexual and male flowers (cf. SEM micrographs in Zhang 2001; Figs 1–9).

In our reference material we also found *Sinowilsonia* pollen with an aberrant reticulate sculpture (Fig. 2 D–F) however, differently formed from that illustrated by Bogle & Philbrick (1980; Fig. 22 B–C).

There are only a few exotic plant taxa, known from the Holsteinian and the Eemian interglacial in Poland, that have potential diagnostic importance for age determination. Most taxa (i.e. *Buxus sempervirens* L., *Syringa*, *Viburnum lantana* L., *Rhus cotinus* L., *Olea*, *Tilia tomentosa* Moench, *Osmunda cinnamomea* L., *Ilex aquifolium* L., *Cornus mas* L. and *Vitis sylvestris* C.C. Gmelin) are noted in both interglacials with variable frequency. The last three taxa mentioned above have a western or southern distribution pattern in Europe (outside Poland), and they occur in the investigated area in the Holocene. The Holsteinian interglacial is distinguishable by the presence of *Pterocarya fraxinifolia* (Lam.) Spach., an important floristic component of forests of the European Lowland starting in the late *Carpinus* - zone extending to a lesser *Azolla filiculoides* Lam., the microspores of which were often found in the same spectra. These genera are noted also in older stratigraphical units.

Pollen grains of *Parrotia* occurring abundantly in the *Carpinus-Abies* phase, significantly supplementing the diagnostic possibilities for age determination. Indeed pollen and/or leaves of *Parrotia* were recorded from many Miocene and Pliocene sites in Europe (Tarasevich 1980, Leroy & Roiron 1996, Ferguson & Knobloch 1998, Hably & Kvacek 1998, Kvacek 1998, Ferguson et al. 1998), but along with other floristic elements of the Holsteinian, the age of interglacial deposits can be more precisely determined. However, the problem is that the delicate *Parrotia* pollen, often crumpled or rolled with disrupted pore or colpus area, may be overlooked during the pollen counts. It is therefore difficult to estimate the range of this species in Central Europe during the Holsteinian interglacial.

The climatic constraints of *Parrotia*, as assumed from its modern distribution pattern and temperature range (rainfall - 1200–1300 mm, mean annual temperature - 14–15°C in comparison with about 500 mm and 7°C in the Podlasie region), is confirmed by its fossil distribution. Its maximum in the pollen diagram from Kaliłów matches with the optima of oak, hornbeam and fir. In this zone we note indicator plants with a modern southerly distribution and high temperature requirements e.g. *Viburnum lantana*, *Vitis,* *Cotinus coggygria*, *Cornus mas*, *Celtis*, and *Buxus*.

All this suggests that the climatic conditions during the Holsteinian interglacial thermal optimum must have been much more favourable than today in this area, assuming that former requirements of ironwood meet in large part those from Caucasus. *Parrotia* had greater potential for migration already during the continental *Pinus-Larix* L.P.A.Z., but shady communities with *Taxus* and *Picea* probably retarded its spread despite its high range of tolerance in this respect. The fact that it may take about 25 years to produce flowers and fruits (Łukasiewicz 1985) is also important as a limiting factor for an interglacial migration of ironwood. The interglacial migration rate of *Parrotia* (similar to *Pterocarya*) was slow possibly due to the presence of a migration lag and a large distance from glacial refuges.

Fig. 3. Fossil pollen of *Parrotia* – type from Kaliłów. A–C. Semitectum variations: (A) Coarse reticulate; (B) Perforate-microreticulate; (C) Irregularly frustillate. D & E. Equatorial view of mesocolpium area. F & G. Slightly equatorial view with depressed colpi. H–J. Polar view of strongly deformed grains. K & L. Polar view of tetracolpate pollen with smaller meshes. M, N & P. Equatorial view, pori covered with granules, (*M*) mesocolpium with larger meshes (in N & P). O & R. Details of surface: (O) Colpus membrane covered with granules; (R) Short colpus, with removed granules and narrow belt of tectum perforated around colpus. Scale bars – 10 μm (D–N & P); 5 μm (R); 2 μm (A–C & O).

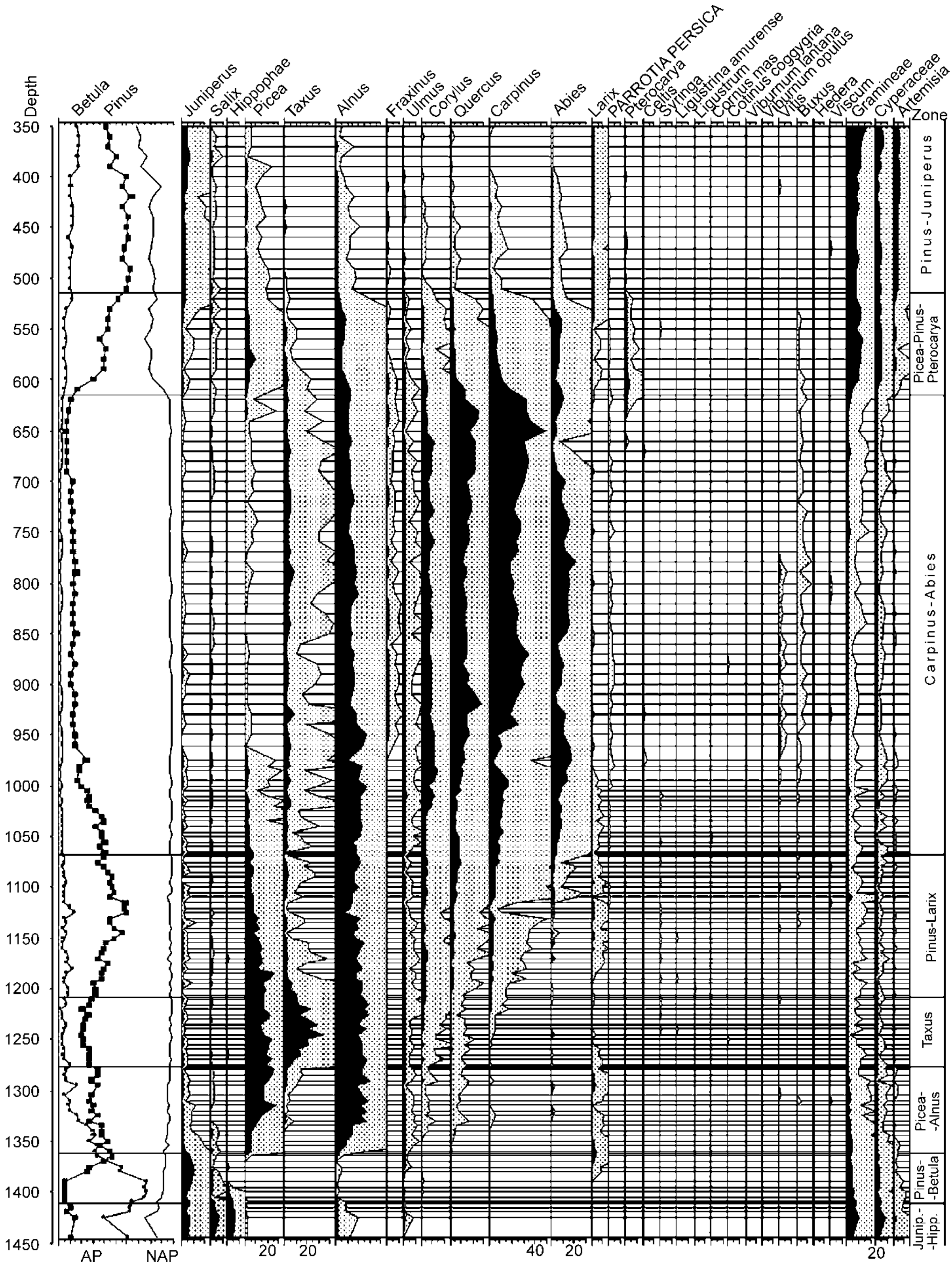

Fig. 4. Simplified pollen diagram of Holsteinian sediments at Kaliłów with the curve of *Parrotia* typed in capitals (after Bińka & Nitychoruk 1996).

These facts suggest that *Parrotia* may be a new important palaeofloristic component of interglacial communities of Poland, both as climatic indicator and useful stratigraphical tool in age determination.

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