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BETULACEAE FROM SOŚNICA NEAR WROCŁAW (POLAND) – A REVISION OF GOEPPERT'S ORIGINAL MATERIALS AND A STUDY OF MORE RECENT COLLECTIONS

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ABSTRACT. This paper presents the results of a revision of the plant fossil remains from the family Betulaceae described by Goeppert (1852, 1855) from the Upper Miocene flora of Sośnica near Wrocław. In addition to the specimens derived from the original nineteenth-century collection of Goeppert, more recent materials (Łańcucka-Środoniowa et al. 1981) have been taken into account. The following species have been distinguished on the basis of morphological analyses and features of the epidermis: *Alnus adscendens* (Goeppert) Zastawniak et Walther, *Alnus gaudinii* (Heer) Knobloch et Kvaček (a species new to the Tertiary of Poland) and *Carpinus grandis* Unger. The remaining species: *Alnus cecropiaefolia* (Ett.) Berger, *A. julianiformis* (Sternberg) Kvaček et Holý, *Alnus menzelii* Raniecka-Bobrowska, *Betula similis* (Goeppert) Zastawniak et Walther comb. nov. and *Ostrya kryshtofovichii* Baykovskaya were identified exclusively on the basis of their morphological characters. In the fossil material from Sośnica there are also some strobiles of *Alnus kefersteinii* (Goeppert) Unger, inflorescences of *Alnus* sp., fruits of *Carpinus betulus* L. *fossilis* Engelhardt et Kinkelin, nuts and bracts of *Betula longisquamosa* Mädler and *Betula* sp. 1, inflorescences of *Betula* sp. and, isolated from it, pollen grains of *Betulaepollenites* sp.

KEYWORDS: fossil flora, leaves, carpology, revision, Betulaceae, Upper Miocene

INTRODUCTION

According to Goeppert (1855) the Betulaceae are represented in the fossil flora of Sośnica by leaves of several species (14 of *Betula*, 5 of *Alnus* and 3 of *Carpinus*). Moreover, he also reported some fructifications of *Betula* and *Carpinus*. Soon afterwards, Heer (1855–1859) rejected or synonymized some of these species (see Goeppert 1861: 196). In Central Europe, in addition to the Sośnica flora, that from the brown-coal beds at Senftenberg (Menzel 1906) contains a relatively high proportion of leaves of the Betulaceae. As a result, Menzel (1906), too, critically disposed of some taxa, while retaining some of the species originally proposed by Goeppert (1855). Goeppert's extant original specimens were examined by Reimann (1919) and Kräusel (1920, 1921) in connection with their critical revision of the fossil Betulaceae of Silesia. By drawing extensive comparisons, Reimann (1919) attempted to differentiate particular taxa within the Betulaceae. He had revised the original materials of Goeppert from Sośnica and also from other Silesian localities.

However hard Reimann (1919) tried, he only partly managed to distinguish particular genera on the basis of morphological leaf features. The authors of the present paper agree with Reimann (op.cit.) that the Betulaceae constitute one of the most difficult families in so far as their differentiation based on leaf morphology is concerned. The problem is exacerbated, not least of all, by the partial lack of a classification based on the characteristic features of the fossil taxa and also by the absence of modern systematic studies on the Betulaceae as a whole. The anatomical characters of the leaves also permit only a partial separation of the fossil taxa of the Betulaceae but they do make a division into genera possible (see Knobloch & Kvaček 1976, Hummel 1991b). Unfortunately, among the specimens from Sośnica, there are very few leaf remains suitable for cuticular analysis (Walther & Zastawniak 1991). In this study an attempt is made to distinguish particular genera and species of the Betulaceae from Sośnica on the basis of as many univocal sets of morphologi-

cal features as possible, using epidermal characters (as far as their state of preservation allows).

In numerous publications on the Neogene floras of Central Europe references are made to Goeppert's (1855) determinations and species. In addition, individual authors, often rightly, hold different opinions on the relative importance of characters and the range of variation of particular taxa, so a revision is urgently needed.

That is why the present study aims at a critical appraisal of the Betulaceae from Sośnica and attempts to identify the "good" species. Consequently, this work is not a comprehensive monograph of the fossil Betulaceae. Information provided in the literature concerning fossil Betulaceae from other localities remains unreliable, unless the original specimens have been retained for reference, and has not been taken into consideration in this work. Similarly, only limited comparisons with recent Betulaceae are given below.

MATERIAL AND METHODS

See Walther & Zastawniak 1991, p. 156.

The fossil specimen and cuticular slides form part of the following collections: Geological Museum, Wrocław University, Wrocław (MGUWr), W. Szafer Institute of Botany, Polish Academy of Sciences, Cracow (KRAM-P), Geological Museum of the Polish Geological Institute, Warsaw (MG PIG), Museum of the Earth, Polish Academy of Sciences, Warsaw (MZ), Palaontologisches Museum, Museum für Naturkunde der Humboldt-Universität zu Berlin (MP), Staatliches Museum für Mineralogie und Geologi zu Dresden (MMG). Goeppert's labels are attached to the specimens. The Roman numerals affixed to the numbers of several specimens indicate successive impressions of leaves on the same piece of rock.

DESCRIPTION OF TAXA

Alnus adscendens (Goeppert) Zastawniak & Walther in Zastawniak et al.

Fig. 1: *1–16*, Fig. 2: *1–7, 9, 10, 13–16a*, Fig. 3: *1–4, 7, 9–13, 15–17*, Fig. 4: *1, 2, 4, 6, 8, 9, 11, 14*, Figs 15–17, Fig. 18: *14*, Fig. 19: *8, 10*; Pl. 1, figs 1–5, Pl. 2, figs 1, 2, Pl. 3, figs 4–10, Pl. 4, figs 1–9

Lectotype. Goeppert 1855, pl. 5, fig. 2: *Carpinus adscendens* Goeppert, specimen MGUWr 741p; Reimann 1919, p. 51, pl. 3, fig. 17: *Alnus rotundata* Goeppert

Diagnosis emendavit. Leaves petiolate, ovate to broadly elliptic; base cuneate, broadly cuneate or rounded, sometimes decurrent, margin doubly serrate; primary teeth broadly triangular, secondary teeth smaller, somewhat falcate. Midrib sometimes weakly sinuous in the upper third. Pinnate secondary veins 7–9 (–11) pairs, craspedodromous, always ± curved, especially in the upper half of the leaf, always curved at the tips of the primary teeth. The secondary teeth (up to 4) are supplied by branches of the secondary veins or those of the outermost veins of the third order. The tertiaries form distinct, regular, stout anastomoses between the secondary veins. Cuticle of upper and lower epidermis with polygonal cells, anticlinal walls straight to weakly curved (Table 1). Anomocytic stomata distributed irregularly in the lower epidermis, greatly varying in size, 21.7 (16–36) μm × 15.7 (12–28) μm. Peltate four-cell gland-bases in lower epidermis, 20–24 μm in diameter. Peltate trichomes (44 μm) rare.

Synonyms

1850 *Carpinus betuloides* Unger, F. Unger, p. 408, non vidi

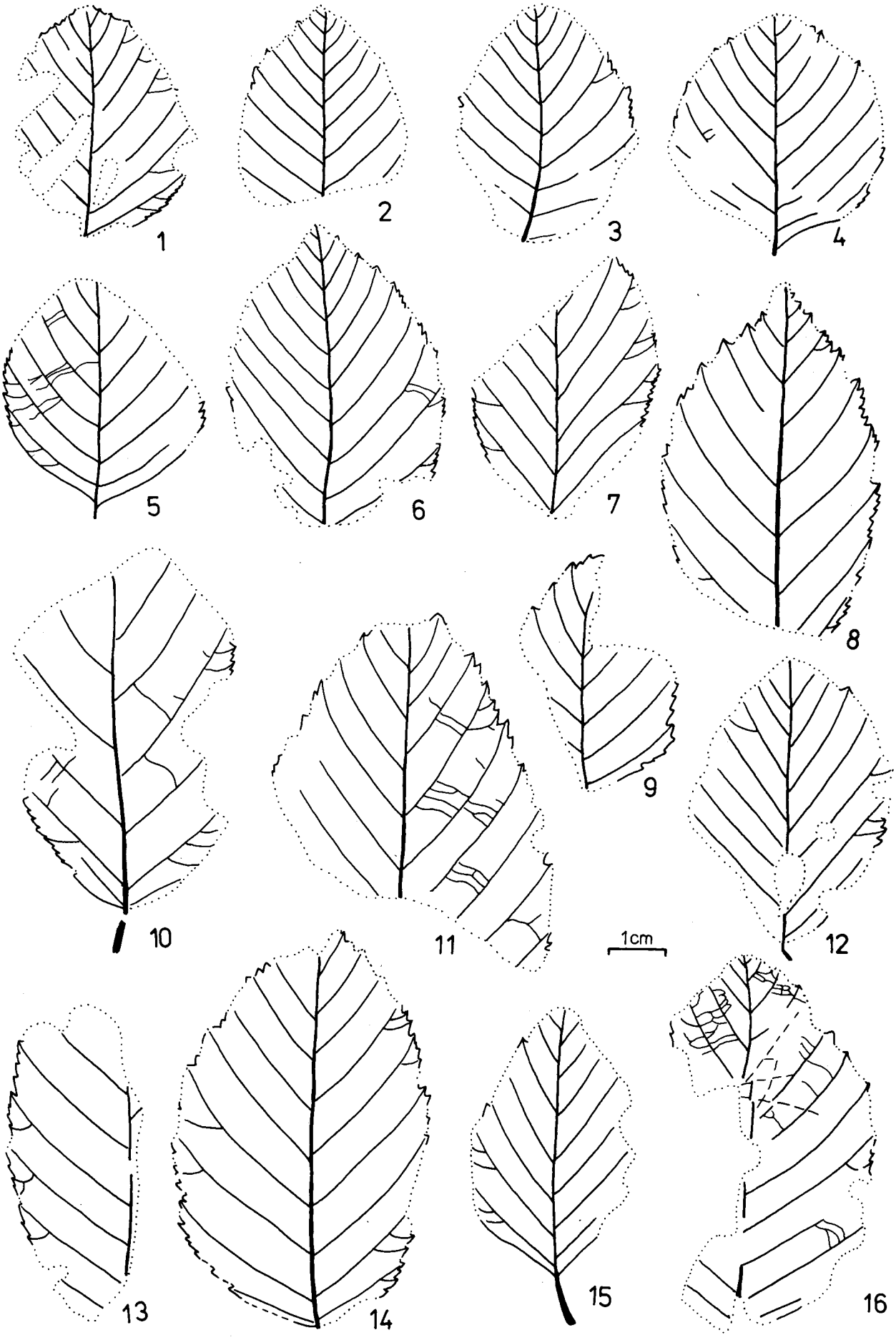
1851 *Betula prisca* Ett., C. Ettingshausen, pl. 1, fig. 16

1852 *Carpinus betuloides* Unger, F. Unger, pl. 43, fig. 6 (Radoboj), non vidi

1855 *Betula dryadum* Brongn., H. R. Goeppert, p. 10, pl. 3, fig. 1, specimen MGUWr 674p/4, twin impression of the original

1855 *Betula crenata* Goeppert, H. R. Goeppert, p. 11, pl. 3, fig. 7, specimen MGUWr 737p, fig. 8, specimen missing

Fig. 1. *Alnus adscendens* (Goeppert) Zastawniak et Walther: **1** – PIG 46.III.239/I, cuticular slides MMG So 8/88–16/88, **2** – MGUWr 1619p/10, **3** – MGUWr 1609p/2, **4** – MGUWr 820p/1, **5** – MGUWr 1157p/2, **6** – MGUWr 1172p, cuticular slides MMG So 1/93–10/93, **7** – KRAM-P 54/422/III, **8** – MGUWr 1384p, **9** – PIG 46.III.109, **10** – MGUWr 1390p, **11** – MGUWr 1618p, **12** – MGUWr 1896p, **13** – KRAM-P 54/1095/II, **14** – KRAM-P 54/651/I, **15** – MG PIG 46.III.299, **16** – KRAM-P 54/330/I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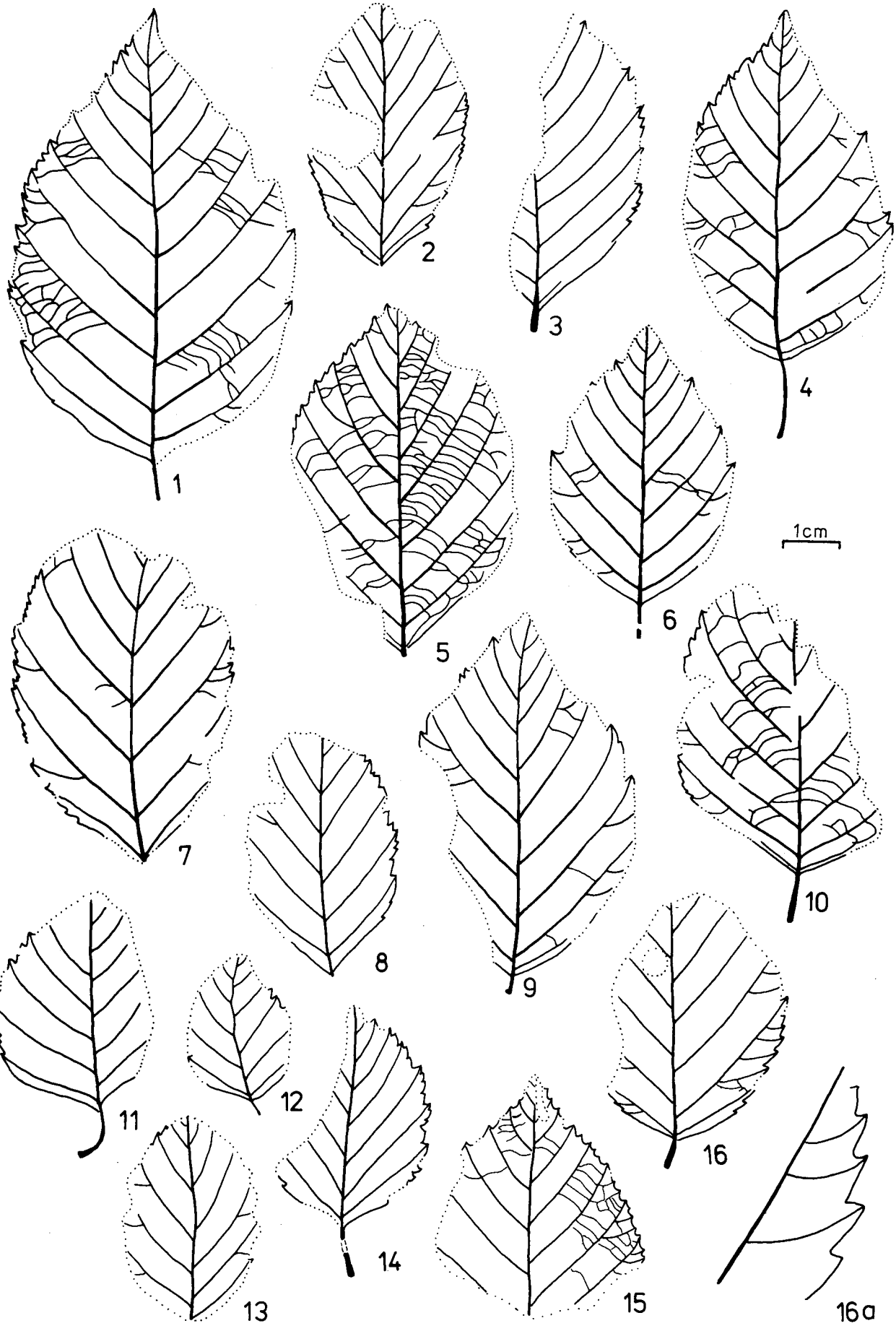
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1855 *Betula subovalis* Goeppert, H. R. Goeppert, p. 12, pl. 3, fig. 17, leaf on the drawing "to get straight", specimen MGUWr 726p, Reimann 1919, pl. 2, fig. 10: *Betula subpubescens* Goeppert

1855 *Alnus pseudoglutinosa* Goeppert, H. R. Goeppert, p. 12, pl. 4, fig. 1, specimen MGUWr 704p/1 + twin impression MGUWr 704/2

1855 *Alnus rotundata* Goeppert, H. R. Goeppert, p. 12, pl. 4, fig. 4, specimen MGUWr 706p

1855 *Alnus macrophylla* Goeppert, H. R. Goeppert, p. 12, pl. 4, fig. 6, specimen missing, Reimann 1919, p. 33, pl. 2, fig. 9: *Betula macrophylla* Heer

1855 *Alnus macrophylla* Goeppert, H. R. Goeppert, p. 12, pl. 5, fig. 1, specimen MGUWr 739p, Reimann 1919, p. 33, pl. 2, fig. 11: *Betula macrophylla* Heer

1855 ? *Carpinus alnifolia* Goeppert, H. R. Goeppert, p. 19, pl. 4, fig. 11, specimen No MGUWr 711 (damaged), Reimann 1919, pl. 4, fig. 10: *Carpinus grandis* Unger

1855 *Quercus ovata* Goeppert, H. R. Goeppert, p. 17, pl. 8, fig. 8, specimen missing

1855 *Fagus dentata* Goeppert, H. R. Goeppert, p. 18, pl. 5, fig. 11, specimen MGUWr 556p, Reichenbach 1919, p. 125, fig. 11: *Fagus dentata* Goeppert

1919 *Betula prisca* Ett.?, H. Reimann, p. 37, pl. 1, fig. 3, specimen MGUWr 686p/3

1919 *Betula macrophylla* (Goeppert) Heer, H. Reimann, pl. 2, fig. 9

1919 *Betula subpubescens* Goeppert, H. Reimann, pl. 2, fig. 10, specimen MGUWr 726p

1919 *Betula macrophylla* (Goeppert) Heer, H. Reimann, pl. 2, fig. 11, specimen MGUWr 739p

1919 *Betula subpubescens* Goeppert, H. Reimann, p. 39, pl. 2, fig. 20, specimen MGUWr 527p from Brzeg Dolny (Dyhernfurth)

1919 (?)*Alnus kefersteinii* (Goeppert) Unger, H. Reimann, p. 50, pl. 3, figs 1, 2, specimens missing

1919 *Betula prisca* Ett.?, H. Reimann, pl. 3, fig. 6, specimen MGUWr 686p/3

1919 *Alnus rotundata* Goeppert, H. Reimann, p. 51, pl. 3, fig. 8, specimen MGUWr 892p/2 from Brzeg Dolny [Dyhernfurth]), pl. 3, fig. 17, specimen missing

1919 *Carpinus grandis* Unger, H. Reimann, pl. 4, fig. 10, specimen MGUWr 711p (damaged)

1919 *Carpinus grandis* Unger, H. Reimann, p. 66, pl. 4, fig. 14, specimen missing, pl. 5, fig 5, specimen MGUWr 2592p

1981 *"Alnus" rotundata* Goepp., Łańcucka-Środoniowa et al., pl. 1, fig. 5

1981 *Alnus* sp., Łańcucka-Środoniowa et al., pl. 1, fig. 10

1991a *Betula* aff. *subpubescens* Goepp., A. Hummel, fig. 1: *2, 3*, pl. 1, figs 2, 3

1996 *Alnus adscendens* (Goeppert) Zastawniak et Walther comb. nov., E. Zastawaniak et al., p. 875, pl. 290, figs 5, 7, non fig. 4

Material. Goeppert's collection: MGUWr 522p (Goeppert's label: *Alnus macrophylla*); 523p/1; 523p/2 (Goeppert's label: *Alnus macrophylla*); 527p from Brzeg Dolny [Dyhernfurth], Reimann 1919, pl. 2, fig. 20: *Betula subpubescens*; 528p (Goeppert's label: *Carpinus adscentinervia* = *Carpinus alnifolia*); 535p/1 (Goeppert's label: *Carpinus ostryoides*); 539p/2/I; 539p/2/II; 542p; 543p/I; 556p (Goeppert 1855, pl. 5, fig. 11: *Fagus dentata*, Reichenbach 1919, p. 125, fig. 11: *Fagus dentata*); 669p/IV/1 (Goeppert's label: *Alnus*) + twin impression 669p/IV/2; 674p/1/II; 674p/8; 676p/1/I; 682p/2/I; 683p/3 (Reimann 1919, pl. 3, fig. 6: ?*Betula prisca*); 704p/1 (Goeppert 1855, pl. 4, fig. 1: *Alnus pseudoglutinosa*) + twin impression 704p/2; 706p (Goeppert 1855, twin impression of Pl. 4, fig. 4: *Alnus rotundata*); 708p (Goeppert's label: *Betula macrophylla*); 726p (Goeppert's label: *Betula subovalis*, Goeppert 1855, pl. 3, fig. 17: *Betula subovalis*. The leaf is, in fact, inflexed and the drawing in Goeppert's paper does not correspond to the original); 737p (Goeppert's label: *Betula crenata*, Goeppert 1855, pl. 3, fig. 7: *Betula crenata*); 739p (Goeppert's label: *Alnus macrophylla*, Goeppert 1855, pl. 5, fig. 1: *Alnus macrophylla*, Reimann 1919, pl. 2, fig. 11: *Betula macrophylla*); 741p (Goeppert's label: *Carpinus*, Goeppert 1855, pl. 5, fig. 2: *Carpinus adscendens*, Reimann 1919, pl. 3, fig. 17: *Alnus rotundata*); 742p/II; 792p/3/I (from Kokoszyce [Kokoschütz]; 820p/1; 821p; 848p/2; 891p/I; 892p/2, Reimann 1919, pl. 3, fig. 8: *Alnus rotundata* (from Brzeg Dolny [Dyhernfurth]); 894p/1/II; 955p/II; 956p/4/I; 979p/1; 1010p/7/II; 1012p/5/I; 1035p/3; 1161p/I; 2585p; 2802p;

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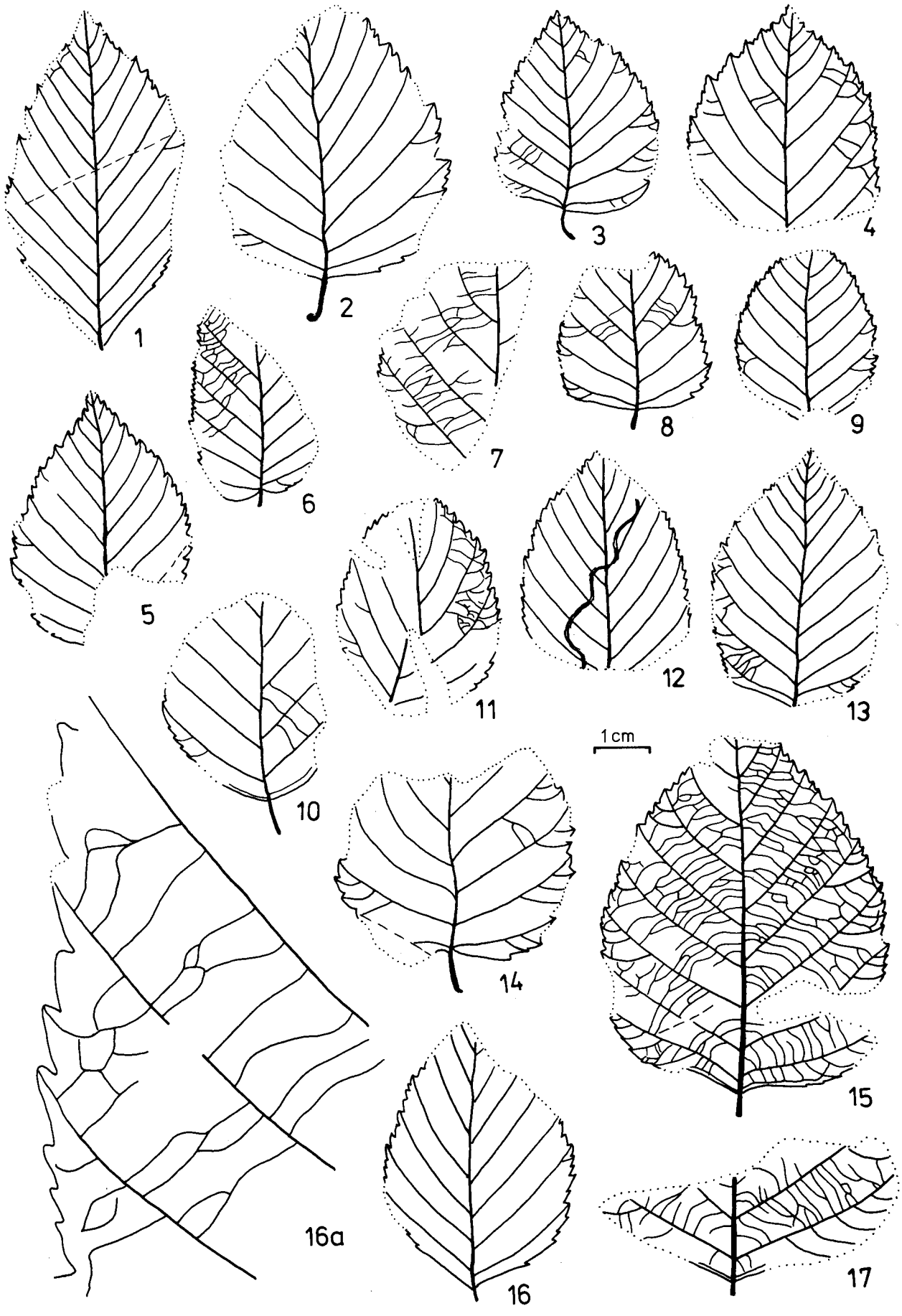
Fig. 2. *Alnus adscendens* (Goeppert) Zastawniak et Walther, **1** – Lectotype, MGUWr 741p (Goeppert's label: *Carpinus*, Goeppert 1855, pl. 5, fig. 2: *Carpinus adscendens* Goeppert, Reimann 1919, pl. 3, fig. 17: *Alnus rotundata* Goeppert): **2** – PIG 46.III.244, **3** – PIG 46.III.247, **4** – MZ VII/53/254, **5** – MGUWr 792p/3/I from Kokoszyce (Kokoschütz), **6** – MGUWr 527p from Brzeg Dolny (Dyhernfurth, Reimann 1919, pl. 2, fig. 20: *Betula subpubescens* Goeppert), **7** – KRAM-P 54/170/I; *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.: **8** – MGUWr 1011p/7 from Brzeg Dolny (Dyhernfurth, Reimann 1919, pl. 2, fig. 18: *Betula subpubescens* Goeppert); *Alnus adscendens* (Goeppert) Zastawniak et Walther: **9** – MGUWr 892p/2 from Brzeg Dolny (Dyhernfurth, Reimann 1919, pl. 3, fig. 8: *Alnus rotundata* Goeppert), **10** – MGUWr 2585p; *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.: **11** – MGUWr 1157/1, **12** – MGUWr 674p/4, twin impression of leaf of *Betula dryadum* Brongn. (Goeppert 1855, pl. 3, fig. 1); *Alnus adscendens* (Goeppert) Zastawniak et Walther: **13** – MGUwr 1161p/I, **14** – MGUWr 2288p/I, cuticular slides MMG So 42/77–44/77, 17/92–20/92, 58/92–65/92, **15** – MGUWr 535p/1 (Goeppert's label: *Carpinus ostryoides*), **16** – MGUWr 523p/2 (Goeppert's label: *Alnus macrophylla*), **16a** – Enlargement of leaf margin, × 3

2810p; 2816p (Goeppert's label: *Alnus similis*); 2821p; 2825p; 2837p; 2841p/I; 2847p/II; 5003p; 5027p; 5114p; 5120p; 5155p; 5159p; 5163p (Goeppert's label: *Alnus macrophylla*); 5171p. New collections: MGUWr 1157p/2; 1157p/3; 1157p/4/I; 1168p/1; 1170p/2; 1172p – cuticular slides MMG So 1/93–10/93; MGUWr 1384p; 1390p; 1599p/II; 1609p/2; 1618p; 1619p/10; 1619p/1; 1832p/I; 1842p/III; 1896p; 2031p; 2151p/I-III; 2180p/II; 2233p/II; 2288p/I – cuticular slides MMG So 42/77–44/77, 17/92–20/92, 58/92–65/92; MGUWr 2291p – cuticular slides MMG So 1/92–11/92; MGUWr 5129p; KRAM-P 54/31/IV; 54/43/II; 54/82/I, II+ twin impression 54/84; 54/86; 54/87; 54/117; 54/151/III; 54/157/I; 54/159/I; 54/170/I, II; 54/174/I; 54/180/I; 54/227/II; 54/330/I; 54/422/III; 54/466/III; 54/512/II; 54/533; 54/552; 54/586; 54/624/I; 54/651/I; 54/801/I; 54/811; 54/881/VI; 54/953; 54/955; 54/957; 54/959; 54/981/I; 54/999/II; 54/1035/IV; 54/1094/II; 54/1095/I, II; 54/1130/II + twin impression 54/1131; MG PIG 46.III.101; 46.III.107; 46.III.109; 46.III.110 a+b (twin impressions); 46.III.231; 46.III.239/I – prep. MMG 8/88–16/88; MG PIG 46.III.244; 46.III.247; 46.III.279; 46.III.295; 46.III.296; 46.III.299; 46.III.317; MZ VII/53/220; MZ VII/53/254; MZ VII/53/329/I; MZ VII/53/353; MZ VII/53/357; MZ VII/53/371; MZ VII/53/462; 139 leaves, 5 with twin impressions (2 leaves from Brzeg Dolny [Dyhernfurth], 1 from Kokoszyc [Kokoschütz])

Description. Leaves 4.8–8.7 (–9.8) cm long (Fig. 16) and (1.7–) 2.2–5.5 cm wide, most commonly ovate, broadly ovate or broadly elliptic. Base most frequently cuneate or broad-cuneate, but sometimes rounded, often decurrent. Leaf length/width ratio 1.2–1.7 (Fig. 15). Petiole up to 1.0 cm long. Apex acute, margin ± distinctly doubly serrate. Primary teeth of betuloid type, very broad, up to 2.5 mm at the base and up 3 mm long, concave-acuminate, secondary teeth smaller, sometimes slightly falcate. Venation pinnate, simple, craspedodromous. Midrib straight or sinuous in the upper third, secondary veins 7–9(–11) pairs, in basal part also pseudocraspedodromous. The basal secondary veins form an angle of 45–60^0 with the midrib. The secondary veins are often distinctly arched, their endings curved inside the primary teeth. The secondary veins in the middle of the leaf form an angle of 40–60^0 with the midrib which decreases to about 30^0 in the apical part. Some secondary teeth are supplied by small veins from the outermost tertiary veins in the manner typical of *Alnus* (Czeczott 1934). The tertiary veins join the secondaries nearly at right angles; these veins are simple or branched, convex, oblique in relation to the midrib. The quaternary veins leave the tertiaries at right angles.

Epidermal structure. The cuticle is delicate. The cells of the upper (adaxial) epidermis are polyhedral, with straight to very weakly curved anticlinal walls (Pl. 1, fig. 1b) and 10 × 28 × 36 μm across. The anticlinal walls have in part very weak thickenings. The cells of the lower (abaxial) epidermis correspond in shape and size with those of the upper, but the anticlinal walls are sometimes also undulate and 8 × 20 × 36 μm across. The anomocytic stomata are irregularly distributed, uneven in size, oval to almost circular, 21.75 μm (16–40) μm long and 15.7 μm (12–28) μm broad (Pl. 1, fig. 1a). The guard cells are weakly cutinized and have strong outer cuticular ledges. The pore is fusiform to narrow-ovoid. There are scattered heterostomata (giant stomata, Pl. 1, fig. 1d), scattered, 36 × 28 μm in size. Four-cell peltate gland bases, 20–24 μm in diameter, appear scattered in the intercostal areas and especially on the veinlets or veins of the fourth order (Pl. 1, fig. 1c). The umbrellas of the peltate glands are only very rarely preserved (in a single specimen 44 μm in diameter). Sporadic one-cell hair-bases (8–10 μm in diameter), strongly cutinized, occur mostly on veinlets.

Fig. 3. *Alnus adscendens* (Goeppert) Zastawniak et Walther: **1** – 54/170/II, **2** – MGUWr 739p (Goeppert's label: *Alnus macrophylla*; Goeppert 1855, pl. 5, fig. 1: *Alnus macrophylla* Goeppert, pl. 5, fig. 1; Reimann 1919, pl. 2, fig. 11: *Betula macrophylla* (Goeppert) Heer), **3** – KRAM-P 54/86, **4** – MGUWr 686p/3 (Reimann 1919, pl. 3, fig. 6: ?*Betula prisca* Ett.); *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.: **5** – KRAM-P 54/958; *Alnus menzelii* Raniecka-Bobrowska: **6** – KRAM-P 54/173/I; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **7** – MGUWr 704p/2 (Goeppert's label: *Alnus pseudoglutinosa*, twin impression of Goeppert's (1855) original specimen, pl. 4, fig. 1: *Alnus pseudoglutinosa* Goeppert); *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.: **8** – KRAM-P 54/90/I; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **9** – KRAM-P 54/180/I, **10** – MGUWr 821p, **11** – KRAM-P 54/117, **12** – MZ.VII/53/353, **13** – KRAM-P 54/87; *Alnus menzelii* Raniecka-Bobrowska: **14** – KRAM-P 54/81; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **15** – KRAM-P 54/82/I, **16** – MGUWr 523p/1, **16a** – Enlargement of leaf margin, × 8, **17** – MGUWr 1842p/III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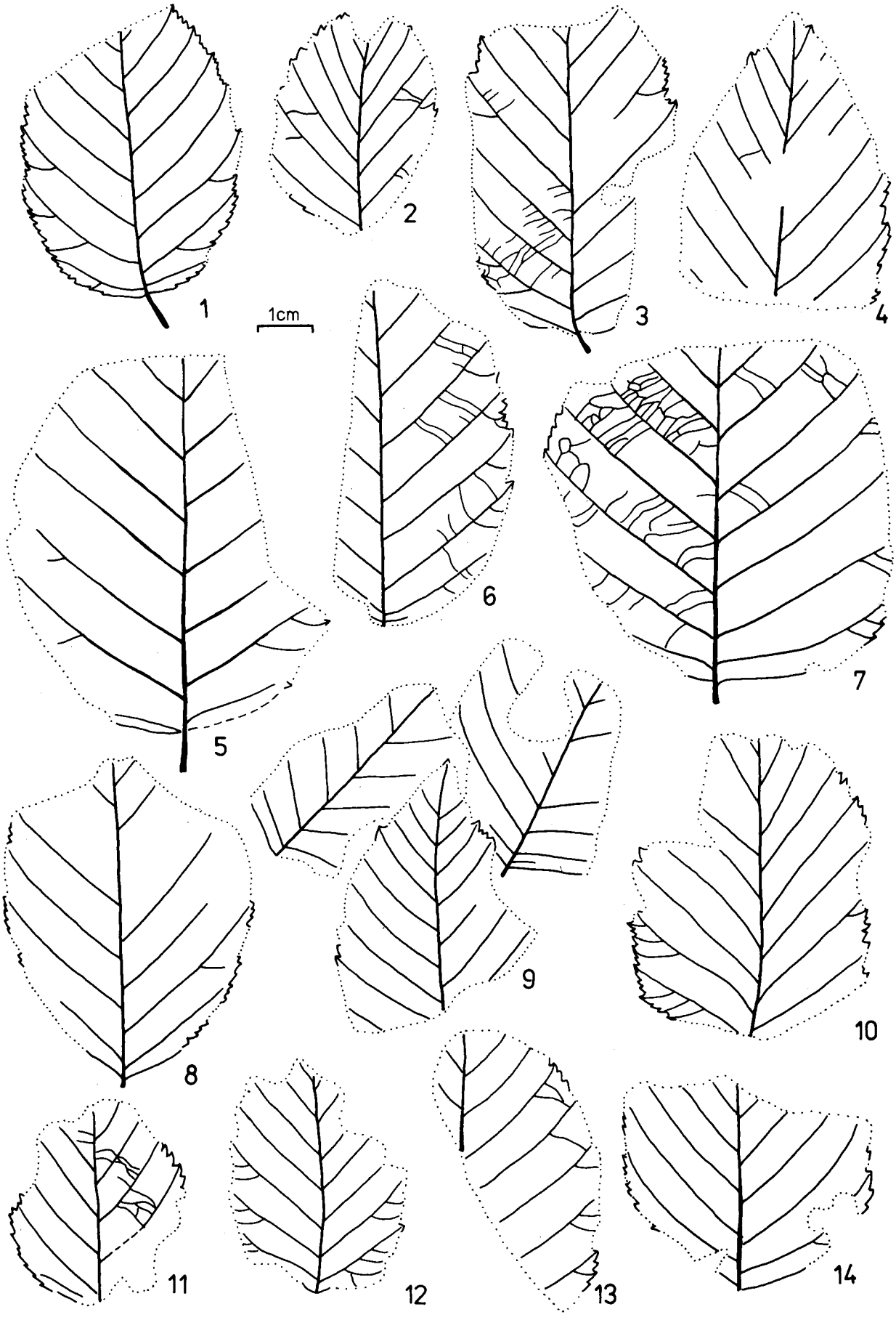
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Remarks. The lectotype shows the most typical shape of the leaves of this species, almost ovate, with a cuneate entire base and very characteristic teeth just above it.

The species is characterized by the broad and long betuloid teeth, particularly the primaries, the more or less curved course of the secondary veins. The supplying of some secondary teeth by branches of the outermost tertiaries is a characteristic feature of this species of *Alnus* as well. The set of characters making up the epidermal structure, i.e. the shape and size of the stomata and the occurrence of four-cell peltate trichome bases and roundish gland umbrellas, are all characteristic of *Alnus* Gaertner (see Knobloch & Kvaček 1976, Mai & Walther 1988).

Alnus adscendens (Goeppert) Zastawniak et Walther is an abundant species of the Betulaceae in the flora of Sośnica. Characteristic for this species are the shape of the blade, the course of the secondary veins, which curve slightly in the marginal areas and, arching towards the tip, terminate in the primary teeth. The tertiary venation is ± irregular and distinct. The marginal teeth, particularly the primaries, are large, broad and long. Cuticles were obtained from morphologically strongly differentiated leaves and they consistently show the same features: straight to arcuate, more rarely undulate, with delicate anticlines in the epidermis of both leaf surfaces; anomocytic stomata, irregularly distributed, strongly varying in shape and size. The "giant stomata" are noteworthy. Scattered four-cell gland bases occur, their umbrellas being very rarely preserved.

Small leaves of *Alnus adscendens* are very similar to the fossil leaves known as *Betula subpubescens* Goepp. and *Carpinus grandis* Unger emend. Heer. Moreover, the Goeppert original of *Betula subpubescens* (Goeppert 1855, pl. 3, fig. 9, specimen No MGUWr 731p) from Sośnica is now only the upper part of a leaf with some secondary veins and some teeth. These teeth are very similar to those of *Alnus adscendens*. The original drawing "*Betula subpubescens*" is most probably incorrect. The leaf base should be the same as that of the lectotype of *Alnus adscendens* (Goeppert 1855, pl. 5, fig. 2: *Carpinus adscendens*). The species name "*Betula subpubescens*" should be considered invalid.

The original specimens of *Betula prisca* described by Ettingshausen (1851, Pl. 1, fig. 16 only) from the flora of Arsenal, revised by Hummel (1991a, Pl. 1, figs 2, 3; Fig. 1: *2, 3* sub *Betula* aff. *subpubescens* Goepp.), are, in fact, typical leaves of *Alnus adscendens* (Goeppert) Walther et Zastawniak. Because Ettingshausen's specimens cannot be verified by cuticular analysis the name "*prisca*" must be invalid.

The small leaves of *Alnus adscendens* (Goeppert) Zastawniak et Walther and *Betula similis* (Goeppert) comb. nov. are somewhat similar. It is often very hard to tell one of these taxa from the other because the differences in morphology between them are very small. In general, the leaves of *Betula similis* are smaller, have fewer secondary veins which are ± straight. The leaf base is cuneate and a pair of delicate, slender veins parallel to the basal margin is visible. Unfortunately, the impressions of leaves assigned to *Betula similis* at Sośnica have no epidermis preserved and so their identification cannot be supported by cuticular studies. Evidence of the presence of birches in this flora is provided by what are indisputably nutlets and scales of *Betula* (cf. p. 105).

Sometimes it is also difficult to separate *Alnus adscendens* from fossil leaves of *Carpinus grandis* Unger, which are close in shape and dimensions. The most important morphological differences between these taxa are:

1. the leaves of *Alnus adscendens* are broadest in a short section of the lower or middle part of the leaf; the leaves of *Carpinus*

Fig. 4. *Alnus adscendens* (Goeppert) Zastawniak et Walther: **1** – MGUWr 2291p, cuticular slides MMG So 1/92–11/92, **2** – MGUWr 669p/1/IV (Goeppert's label: *Alnus*); *Alnus menzelii* Raniecka-Bobrowska: **3** – MGUWr 2800p/III; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **4** – MGUWr 542p; *Alnus cecropiaefolia* (Ett.) Berger: **5** – MG PIG 46.III.259/I; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **6** – KRAM-P 54/955; *Alnus cecropiaefolia* (Ett.) Berger: **7** – MGUWr 521p/1; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **8** – MGUWr 708p (Goeppert's label: *Betula macrophylla*), **9** – MGUWr 2151p/I-III; *Alnus menzelii* Raniecka-Bobrowska: **10** – MGUWr 531p (Goeppert's label: *Carpinus alnifolia*); *Alnus adscendens* (Goeppert) Zastawniak et Walther: **11** – MGUWr 1157p/3; *Alnus menzelii* Raniecka-Bobrowska: **12** – MGUWr 2836p; **13** – MGUWr 529p (Goeppert's label: *Alnus macrophylla*); *Alnus adscendens* (Goeppert) Zastawniak et Walther: **14** – MGUWr 1157p/4/I

are broadest over an extended section of the middle part of the leaf;

2. the leaf bases of *Carpinus grandis* and *Alnus adscendens* are generally cuneate, but *Alnus* sometimes has a decurrent base, a feature which has never been observed in *Carpinus*;

3. the serration of the margins: the teeth in leaves of *Alnus adscendens* are distinctly larger and less numerous than in *Carpinus* whose teeth are narrower and more acute. Both, however, have the same betuloid tooth type;

4. the lateral veins: in *Alnus adscendens* these are more widely spaced than in *Carpinus* and are curved, either throughout their length, or only towards the leaf margins. The lateral veins of *Carpinus* are ± straight and more frequent (Fig. 17);

5. the tertiary venation in *Alnus adscendens* is more distinct and less regular then in *Carpinus* whose tertiary venation is more delicate.

In the case when we have only leaf fragments it is generally impossible to separate these taxa. Such specimens in the fossil flora from Sośnica have been placed in the group named Betulaceae gen. et sp. diverse and indeterminate.

The frequent occurrence in the fossil flora of large and small leaves, and every possible intermediate, indicates that they had scarcely travelled before being deposited and permitted Gastaldo et al. (1996) to treat them as parautochthonous. And so *A. adscendens* (Goeppert) Zastawniak et Walther presents itself as an important azonal element of the riparian forest.

A distinct resemblance to *Alnus rostaniana* Saporta sensu Walther in Mai & Walther (1991) can be observed (comp. Table 1), but it is impossible to draw any conclusive inferences. There are some analogies with recent taxa in the *Alnus* section Gymnothyrsus Spach group (see Mai & Walther 1991, p. 64).

Alnus cecropiaefolia (Ett.) Berger

Fig. 4: 7, Pl. 2, fig. 2, 3

1851 *Artocarpidium cecropiaefolium* Ett., C.v. Ettingshausen, p. 15, pl. 2, figs 3, 4
1955 *Alnus cecropiaefolia* (Ett.) Berger, W. Berger, p. 87, fig. 30

Material. MGUWr 521p/1, Goeppert's label: *Alnus macrophylla*, det. R. Kräusel: *Betula macrophylla*; KRAM-P 54/345; MG PIG 46.III.259/I; impression of three leaves.

Description. Leaves nearly orbicular, 6.6 × 8.5 cm, base truncate or slightly cuneate-decurrent. Venation craspedodromous. Somewhat more than 7 pairs of secondary veins, which are alternate and arise from the main vein at an angle of 78^0 at the base and 44^0 in the upper part of the leaf. Margins dentate. Tertiary veins numerous, simple or forked, perpendicular to the secondary veins.

Remarks. The shape of the leaves, their size and venation are characteristic of the fossil species *Alnus cecropiaefolia* (Ett.) Berger.

Alnus gaudinii (Heer) Knobloch et Kvaček

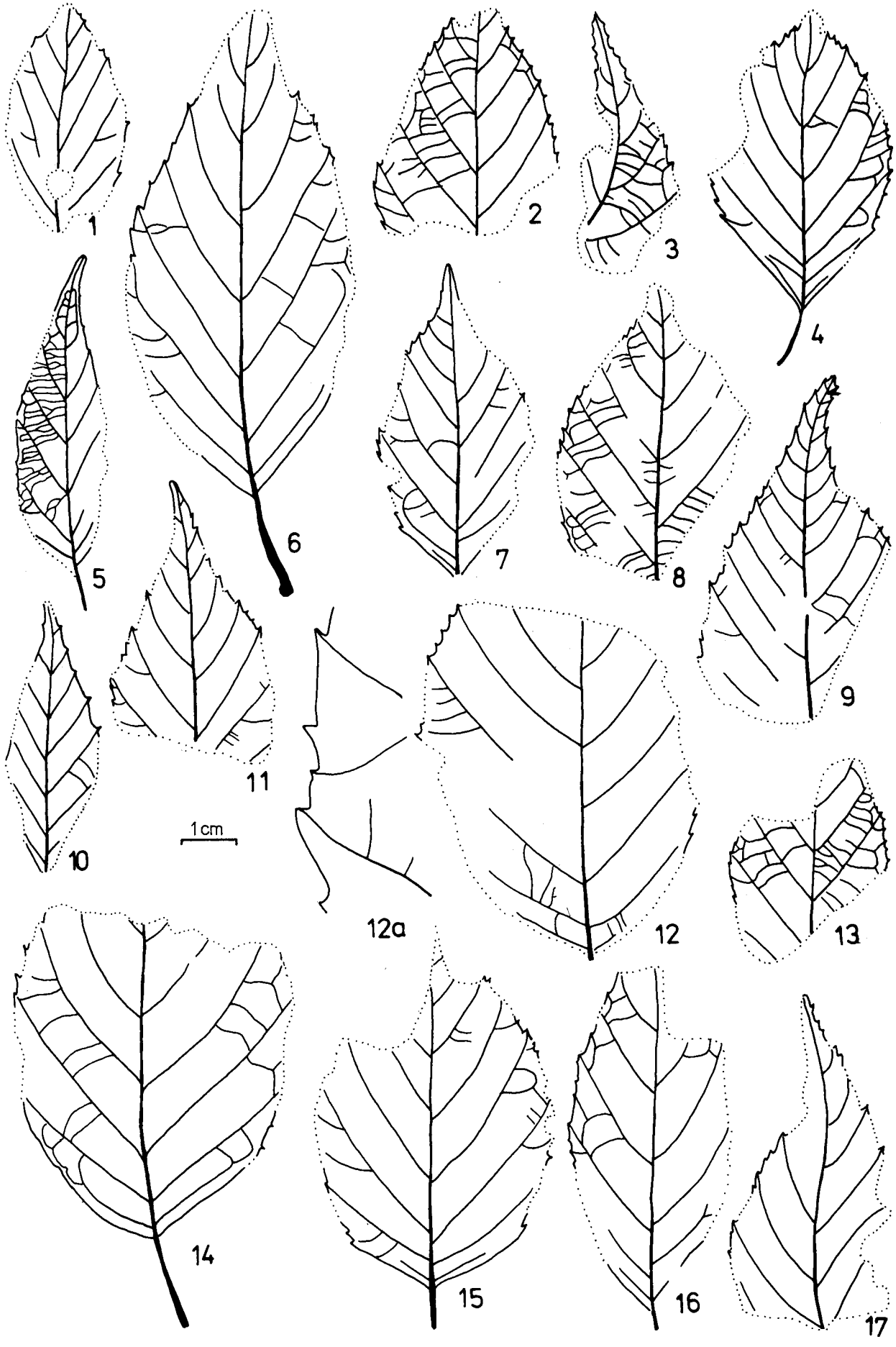
Fig. 6: *5–8*, Fig. 7, Pl. 7, figs 1–1c, 6, 8

1856 *Rhamnus gaudinii* Heer, O. Heer, p. 79, pl. 124, figs 4–15, pl. 125, figs 1, 7, 13
1954 *Rhamnus gaudinii* Heer, J. Raniecka-Bobrowska, p. 20, pl. 9
1976 *Alnus gaudinii* (Heer) Knobloch & Kvaček, E. Knobloch & Z. Kvaček, p. 33, pl. 6, figs 1, 3, pl. 7, figs 1, 5, pl. 13, fig. 4, pl. 15, figs 1–4, 7, 8, 10, 11, 13, 15, 17, pl. 16, figs 1–5, pl. 19, fig. 15, pl. 20, fig. 10; text figs 11, 12
1988 *Alnus gaudinii* (Heer) Knobloch & Kvaček; D. H. Mai & H. Walther, p. 133, text figs 46, 48; pl. 24, figs 1–15, pl. 33, figs 6–12
1991 *Alnus gaudinii* (Heer) Knobloch & Kvaček, D. H. Mai & H. Walther, p. 65, pl. 34, figs 5–7, text fig. 5/11

Material. Goeppert's collection: MGUWr 632p/II; 1616p/I. New collections: MGUWr 2131p; MG PIG 46.III.264, cuticular slides MMG So 33/92–49/92; MG PIG 46.III.297; 5 specimens.

Description. Leaves narrow-ovate, to about 7 cm long and 1.7–4.8 cm wide. Apex acute, triangular; base cuneate, asymmetrical;

Fig. 5. *Alnus julianiformis* (Sternberg) Kvaček et Holý: **1** – MGUWr 729p (Goeppert 1855, pl. 3, fig. 14: *Betula denticulata* Goeppert), **2** – MGUWr 537p/2 (Goeppert's label: *Betula caudata*), **3** – MGUWr 2822p, **4** – KRAM-P 54/111, **5** – KRAM-P 54/420, **6** – MZ VII/53/32, **7** – MGUWr 1933p, **8** – MGUWr 730p (Goeppert 1855, pl. 3, fig. 15: *Betula denticulata*), **9** – MGUWr 733p/1 (Goeppert's label: *Betula caudata*, Goeppert 1855, pl. 3, fig. 5: *Betula caudata*), **10** – KRAM-P 54/535, **11** – MGUWr 539p/1/I (Reimann 1919, pl. 5, fig. 6: *Carpiniphyllum caudatum* (Goepp.) Reimann), **12** – MGUWr 2247p, 12a – Enlargement of leaf margin, × 8, **13** – MGUWr 533p/II, **14** – MZ VII/53/33, **15** – KRAM-P 54/321, **16** – MGUWr 906p, **17** – MGUWr 2368p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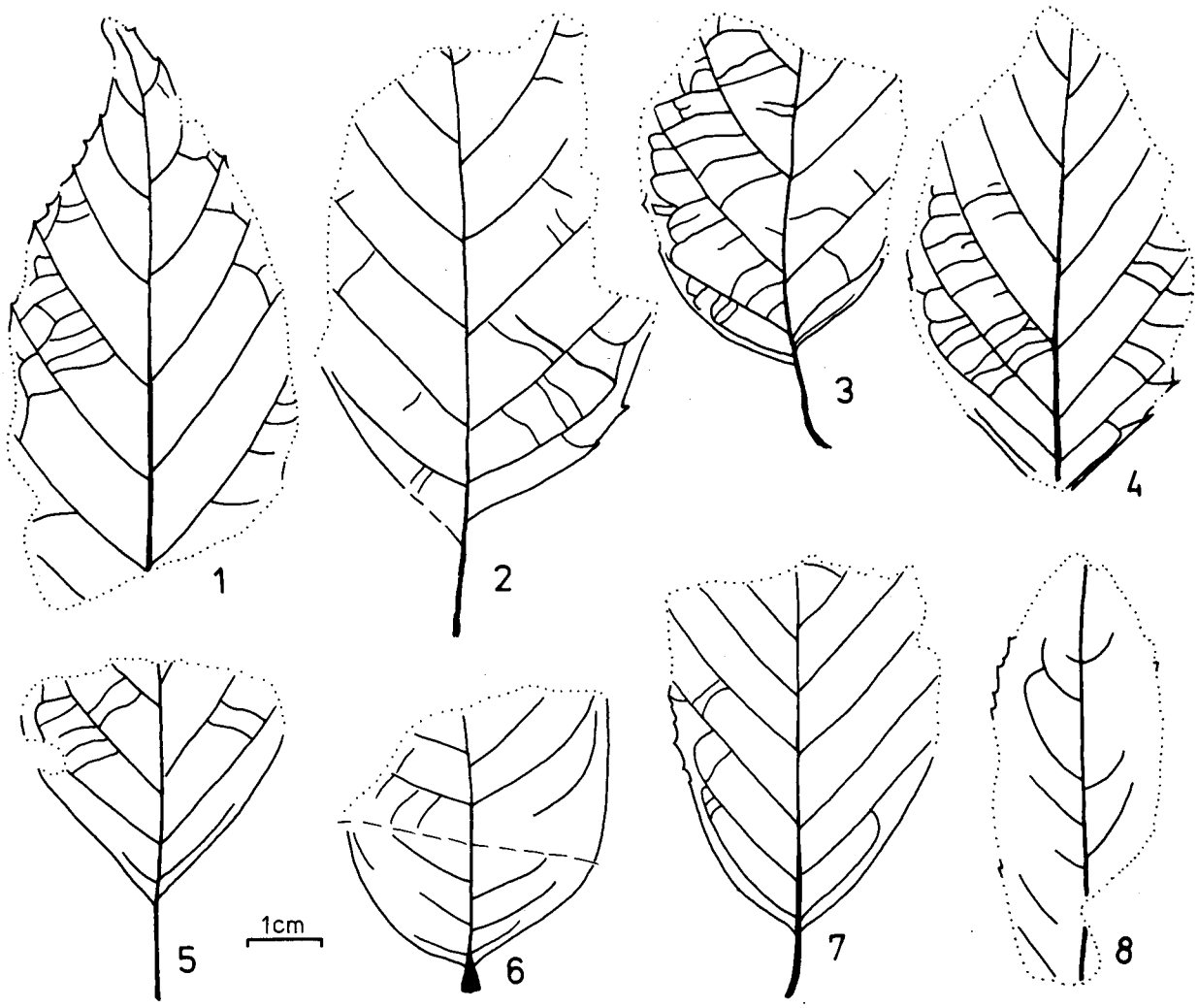


Fig. 6. *Alnus julianiformis* (Sternberg) Kvaček et Holý: **1** – MGUWr 743p (Goeppert's label: *Quercus attenuata*, Goeppert 1855, pl. 8, fig. 4: *Quercus acuminata*), **2** – MGUWr 1827p, **3** – MGUWr 740p (Goeppert 1855, pl. 5, fig. 10: *Fagus inaequalis*), **4** – MGUWr 520p/1 (Goeppert's label: *Alnus macrophylla*); *Alnus gaudinii* (Heer) Knobloch et Kvaček: **5** – PIG 46.III.297, cuticular slides MMG So 27/88–28/88, **6** – MGUWr 2131p, **7** – MGUWr 1616p/I, **8** – PIG 46.III.264, cuticular slides MMG So 33/92–49/92

petiole 13 mm long. Margin more or less distinctly, finely serrate. Teeth irregular, secondary teeth falcate, with rounded apices, unequal in size, almost perpendicular to the leaf-margin, 4–5 in each centimetre of margin. Midrib stout, straight to weakly curved; about 8 pairs of secondary veins, almost to perfectly alternate, third pair from the base opposite, semicraspedodromous. From the midrib secondary veins arise at an angle of $32–42^0$; the size of the angle varies irregularly from base to apex. The secondary veins run slightly curved towards the margin, where they form loops, from which branches lead into the tooth apices. Sporadic secondary veins terminate directly in the tooth apices. Intersecondary veins present; venation of higher orders invisible; lamina massive.

Epidermal structure (Table 1). Cuticle of lower epidermis delicate, cells polyhedric 26×36×56 μm in size. Anticlinal walls straight, curved to coarsely undulate, in part with fine cuticular striae. Stomata irregularly distributed, frequently loosely grouped; they vary considerably in size and shape, are anomocytic, oval to broadly oval, 28.2 μm (16–40 μm) long and 21.6 μm (12–32 μm) wide (Pl. 7, fig. 1a). Giant stomata scattered, up to 40 × 32 μm in size. Pore fusiform, front cavity ledges strongly cutinized. All round the peripheries of the stomata there are partly radial cuticular striations. Fairly strongly cutinized, four-cell trichome bases, 16–28 μm in diameter, are distributed irregularly. Peltate trichomes (Pl. 7, fig. 1c), 44–72 μm in diameter, are rarely preserved. Strongly cutinized roundish trichome bases, 20–24 μm in diameter, are scattered, especially on veinlets.

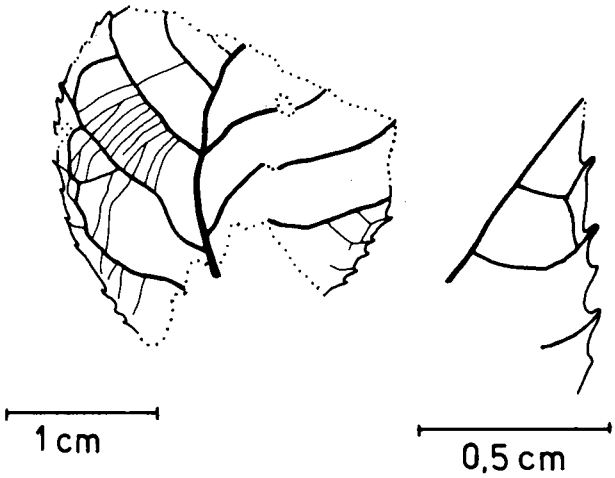


Fig. 7. *Alnus gaudinii* (Heer) Knobloch et Kvaček, MGUWr 632p/II, enlargement of the leaf and marginal tooth

Remarks. At first sight this species may be confused with *Alnus julianiformis* (Sternberg) Kvaček et Holý because of its longish oval leaf shape. There are, however, many differences in morphology and anatomy:

1. the leaves of *Alnus gaudinii* have the lamina base distinctly asymmetrical,

2. the leaf teeth are in part more widely spaced than in *Alnus julianiformis*, but are similar in shape,

3. the secondary veins are semicraspedodromous,

4. the epidermal cells are not finely undulate, the anomocytic stomata are larger and vary considerably in shape and size; moreover the peltate trichomes are preserved. The stomata surrounded by partial cuticular striation, which may also appear at the four-cell trichome bases, make it possible to distinguish *Alnus gaudinii* from other *Alnus* species. It may be stated in general that the cuticle is much stronger than in *Alnus julianiformis* (Sternberg) Kvaček et Holý (see Knobloch & Kvaček 1976).

Knobloch & Kvaček (1976) rightly found that the leaves described by Heer (1859) as *Rhamnus gaudinii* from the Tertiary of Central Europe agree almost completely in their morphology with those of *Alnus gaudinii*. The epidermal structure of the leaves described by Knobloch & Kvaček (1976) unquestionably assigns them to the genus *Alnus* Gaertn. One of the authors (H. W.) of the present paper had the opportunity to examine Heer's type material in the University of Lausanne. The state of its preservation (the leaves are coated with insoluble varnish) does not permit analytical study of the cuticle and so no information can be obtained from it as to whether they really are the leaves of *Alnus*.

According to Mai & Walther (1988, 1991),

Table 1. Comparison of epidermal data of some *Alnus* species of the Middle – European Tertiary

Fossil species	Anticlinal	Stomata (µm)	peltate gland bases	stratigraphy
	EpU	length / width	diameter (µm)	locality, author
Alnus rostaniana Saporta sensu Mai et Walther	curved, coarsely undulate	21.5 (17–30) / 17.5 (13–22)	15–23	Upper Oligocene, Bockwitz, Delitzsch; Mai & Walther 1991
Alnus gaudinii (Heer) Knobloch & Kvaček	curved, slightly undulate	28.5 (15–45) / 21.4 (10–35)	14–25	Upper Oligocene, Bockwitz, Delitzsch; Mai & Walther 1991
Alnus gaudinii (Heer) Knobloch & Kvaček	straight till undulate	22–27 (15–30) /	present	Lower Miocene, Oder 1, 2a, 2d, Oswald-Mulde, Knobloch & Kvaček 1976
Alnus gaudinii (Heer) Knobloch & Kvacek	stright, curved, coarsely undulate	28.2 (16–40) / 21.6 (12–33)	16–28	Upper Miocene, Sośnica, this paper
Alnus gaudinii (Heer) Knobloch et Kvaček	stright till slightly undulate	23.3 (16–35) / 21.1 (14–34)	18–30	Upper Pliocene, Berga, Mai & Walther 1988
Alnus julianaeformis (Sternberg) Kvaček & Holý	undulate	15–20 (–25) /	present	Lower Miocene, Oder 1, 2a, 2d, Oswald-Mulde, Knobloch & Kvaček 1976
Alnus julianaeformis (Sternberg) Kvaček & Holý	undulate	19–24 / 17–22	19–23	Middle Miocene, Soby-Fasterholt, Christensen 1976
Alnus julianaeformis (Sternberg) Kvaček & Holý	curved, undulate	16–20 (13–22) / 13–15 (18)	13–18	Lower Pliocene, Ruszów, Hummel 1991
Alnus adscendens (Goeppert) Zastawniak & Walther	straight, sligtly curved	21.7 (18–36) / 15.7 (12–28)	20–24	Upper Miocene, Sośnica, this paper

starting from the Upper Oligocene, *Alnus gaudinii* appeared more or less frequently as a typical element of azonal forest in the Tertiary of Europe. Extensive investigations of recent materials show its very close relation to the East Asiatic *Alnus nitida* (Spach) Endlicher of the section Clethropis (Spach) Endlicher (Mai & Walther 1988).

Alnus julianiformis* (Sternberg) Kvaček et Holý

Fig. 5: *1–17*, Fig. 6: *1–4*, Pl. 7, figs 2–5, 7, 9–10, Pl. 8, figs 1–4, 8, 10

1823 *Phyllites julianaeformis* Sternberg, K. Sternberg, p. 37, 39, pl. 36, fig. 2
1974 *Alnus julianaeformis* (Sternberg) Kvaček & Holý, Z. Kvaček & F. Holý, p. 367, text fig. 1, pl. 1–3, pl. 4, fig. 1

Synonyms

1855 *Betula flexuosa* Goeppert, H. R. Goeppert, pl. 3, fig. 4, specimen MGUWr 734p
1855 *Betula caudata* Goeppert, H. R. Goeppert, pl. 3, fig. 5, specimen MGUWr 735p/1 + twin impression 735p/2
1855 *Betula denticulata* Goeppert, H. R. Goeppert, pl. 3, fig. 14, specimen MGUWr 729p, pl. 3, fig. 15, specimen MGUWr 730p
1855 *Betula parvula* Goeppert, H. R. Goeppert, pl. 3, fig. 13, specimen MGUWr 728p/1
1855 *Fagus inaequalis* Goeppert, H. R. Goeppert, pl. 5, fig. 10, specimen MGUWr 740p
1855 *Quercus venosa* Goeppert, H. R. Goeppert, pl. 8, fig. 3, specimen missing
1855 *Quercus attenuata* Goeppert, H. R. Goeppert, pl. 8, fig. 4, specimen MGUWr 743p (with original label: *Quercus acuminata*); pl. 8, fig. 5, specimen missing
1855 *Quercus acuminata* Goeppert, H. R. Goeppert, pl. 8, fig. 7, specimen missing
1855 ? *Quercus ovata* Goeppert, H. R. Goeppert, pl. 8, fig. 8, specimen missing
1919 *Carpiniphyllum caudatum* (Goeppert) Reimann, H. Reimann, pl. 5, fig. 1, specimen MGUWr 734p, pl. 5, fig. 6, specimen MGUWr 539/1/I
1991 non *Alnus julianaeformis* (Sternberg) Kvaček & Holý, H. Walther & E. Zastawniak, p. 160, fig. 2 (*Fagus attenuata* Goeppert 1855, pl. 5, fig. 9) specimen MGUWr 2584p
1991 *Alnus julianaeformis* (Sternberg) Kvaček & Holý, A. Hummel, p. 74, pl. 1, figs 1–5, pl. 2, fig. 2; fig. 3: 1–8

Material. Goeppert's collection: MGUWr 520p/1 (with Goeppert's label *Alnus macrophylla*) + twin impression 520p/2; 533p/II; 537p/2 (with Goeppert's label *Betula caudata*); 539p/1/I (Reimann 1919: *Carpiniphyllum caudatum* (Goepp.) Reimann, pl. 5, fig. 6); 729p (Goeppert's label III, 14, Goeppert 1855, pl. 3, fig. 14: *Betula denticulata* Goeppert); 730p (Goeppert's label Bet... III, 14, 15, Goeppert 1855, pl. 3, fig. 15: *Betula denticulata* Goeppert) + twin impression 2827p); 733p/1 (with Goeppert's label: *Betula caudata*; Goeppert 1855, pl. 3, fig. 5: *Betula caudata*) + twin impression 733/2); 734p (Goeppert's label *Betula flexuosa*, Goeppert 1855, pl. 3, fig. 4: *Betula flexuosa*; Reimann 1919, pl. 5, fig. 1: *Carpiniphyllum caudatum* (Goepp.) Reimann); 743p (Goeppert's label: *Quercus acuminata*; Goeppert 1855, pl. 8, fig. 4: *Quercus attenuata*); 740p (Goeppert 1855, pl. 5, fig. 10: *Alnus inaequalis*) + twin impression 818p; 906p; 957p/II; 971p/2; 975p/1/I; 2827p; 2849p/I (Goeppert's label: *Betula attenuata*). New collections: MGUWr 1438p, 1827p, 1929p, 1933p, 2247p, 2368p, 2822p, KRAM-P 54/111, 54/321, 54/417+ twin impression 54/420; 54/535, MG PIG 46.III.230, 46.III.242, MZ VII/53/32, VII/53/33, VII/53/73, VII/53/212, VII/53/215, VII/53/448. 35 specimens, 4 with twin impressions.

Description. See Kvaček & Holý (1974), Knobloch & Kvaček (1976), Hummel (1991b). Leaf length 4.2–9.0 cm, leaf breadth 1.8–4.1 cm. Venation craspedodromous, lateral veins 5–7 pairs, petiole 7–20 mm long.

Remarks. *Alnus julianiformis* (Sternberg) Kvaček & Holý is a species with easily recognized morphological characters, such as its marginal dentation (very tiny teeth are sometimes present) and the craspedodromous type of venation. It occurs relatively often at Sośnica. Kilpper (1971) and Knobloch (1971) were the first to pay attention to its presence there.

Alnus menzelii Raniecka-Bobrowska

Fig. 3: *6, 14*, Fig. 4: *3, 10, 12, 13*, Fig. 8: *2, 3, 5, 8, 10, 13, 14*, Fig. 13: *2, 19*; Pl. 9, fig. 9

1910 *Corylus mac quarri* Forbes, P. Menzel, p. 177, pl. 12, figs 7b, 8, 9, pl. 13, figs 6, 7, 13, pl. 14, figs 1a, 3, 4, 6, 10, Pl. 15, figs 3, 5, 8, 9 (non vidi)
1919 *Carpinus grandis* Unger, H. Reimann, pl. 9, fig. 7, specimen missing
1954 *Alnus menzelii* Raniecka-Bobrowska, Raniecka-Bobrowska, p. 11, fig. 4, photos 11–13
1954 *Betula prisca* Ett., Raniecka-Bobrowska, p. 9, fig. 3, photo 8
1991 *Alnus menzelii* Raniecka-Bobrowska, Hummel, p. 78, pl. 2, fig. 4; Fig. 4

Material. Goeppert's collection: MGUWr

* Correct spelling according to the International Code of Botanical Nomenclature

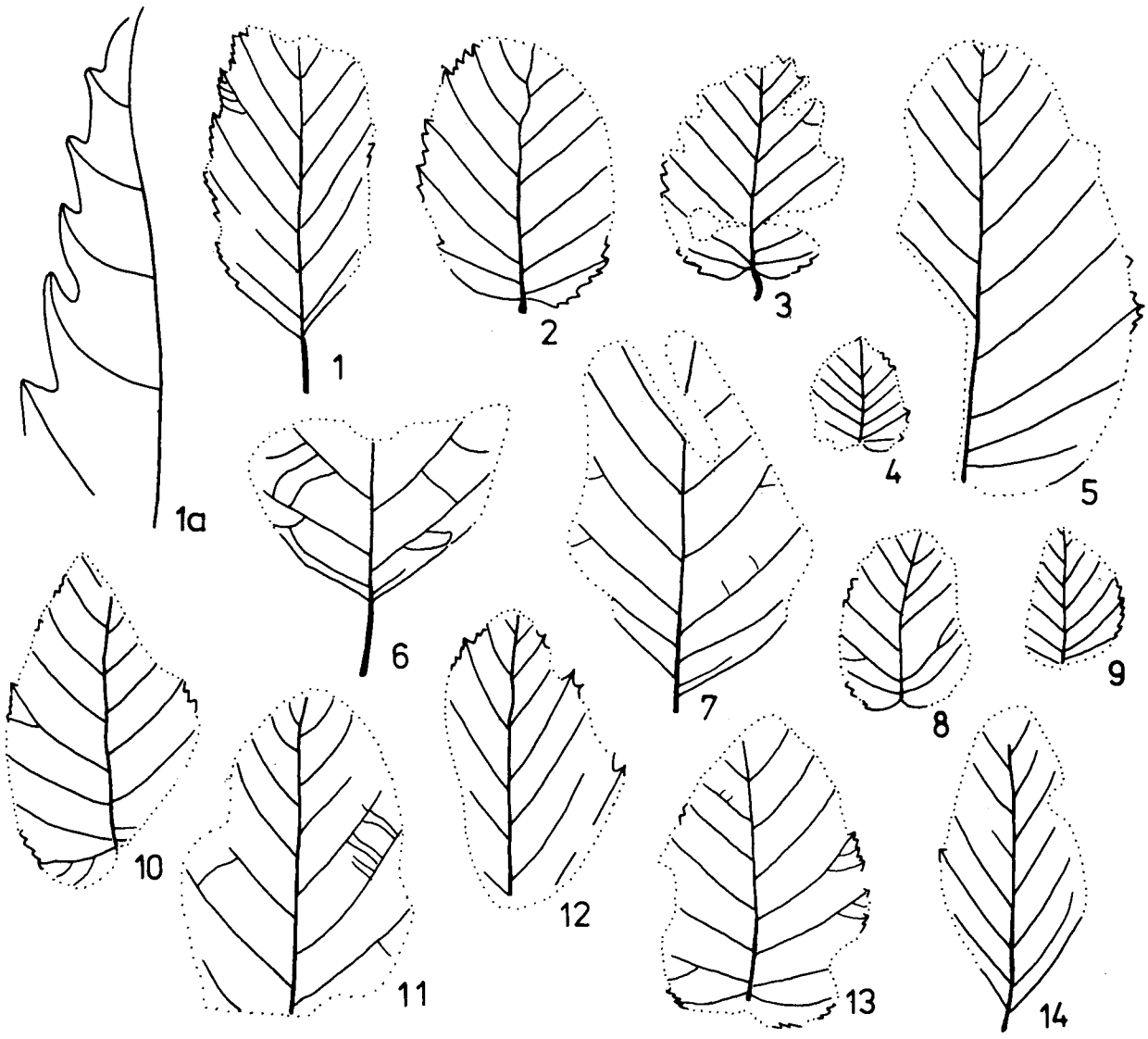


Fig. 8. Betulaceae gen. et sp. diverse et indeterminate: **1** – MGUWr 2155p (aff. *Alnus incana* (L.) Moench), 1a – Enlargement of leaf margin, × 8; *Alnus menzelii* Raniecka-Bobrowska: **2** – MG PIG 46.III.102, **3** – MG PIG 46.III.104; Betulaceae gen. et sp. diverse et indeterminate: **4** – MGUWr 2829p/II; *Alnus menzelii* Raniecka-Bobrowska: **5** – MGUWr 1027p; Betulaceae gen. et sp. diverse et indeterminate: **6** – MZ VII/53/461 (?*Alnus* sp.), **7** – PIG.46.III.301, cuticular slides MMG So 25/88, 26/88 (?*Alnus* sp.); *Alnus menzelii* Raniecka-Bobrowska: **8** – MGUWr 1018p; Betulaceae gen. et sp. diverse et indeterminate: **9** – MGUWr 1030p; *Alnus menzelii* Raniecka-Bobrowska: **10** – MGUWr 677p; Betulaceae gen. et sp. diverse et indeterminate: **11** – MGUWr 1616p/II (?*Alnus* sp.), **12** – KRAM-P 54/285/III, *Alnus menzelii* Raniecka-Bobrowska: **13** – MGUWr 979p/2; Betulaceae gen. et sp. indeterminate: **14** – MGUWr 1015p/11/II

529p (Goeppert's label: *Alnus macrophylla*); 531p (Goeppert's label: *Carpinus alnifolia*); 547p; 584p/3/II (Goeppert's label: *Betula cordata*); 659p/I; 677p; 686p/6; 695p (Goeppert's label: *Pyrus denticulata*); 979p/2; 1015p/8; 1018p; 1027p; 1063p/1/II; 2800p/III; 2836p; 5004p/I. New collections: MGUWr 2434p; KRAM-P 54/77/I; 54/81; 54/173/I; 54/453 + twin impression 54/457; 54/803/II; 54/1022/I; 54/1184/I; MG PIG 46.III.102; 46.III.103; 46.III.104; 46.III.222; MZ VII/53/466a+b (twin impressions): 29 specimens, 2 with twin impressions.

Description. Leaves narrowly to broadly ovate, 1.7–6.5–(–7.0)) cm long and 2.0–5.6 cm wide. Apex acute, base ± cordate. Leaf petiole 0.6 cm long. Margin doubly serrate. Venation pinnate, simple, craspedodromous. Primary vein straight or sinuous, secondary veins 7–11 pairs, the lowermost very often opposite, diverging at an angle of 82–90^0 or even more. Upper secondary veins straight or slightly arcuate. Several secondary veins send one to four branches into the secondary teeth in a craspedodromous manner, at varying distances from the leaf margin. The tertiary veins

join the secondaries nearly at right angles; these veins are single or branched, convex, oblique in relation to the midrib. The quaternary veins leave the tertiaries at right angles.

Remarks. The identification of leaves of this species is based exclusively on their morphological features, since none of the specimens was suitable for anatomic examination. The most important leaf characters of this taxon are their ovate shape and distinctly cordate base, the extensive branching of the secondary veins, notably just above the base, and the comparatively wide teeth on the leaf margin. The leaves vary in size: in addition to small leaves (Fig. 13: *19*) some are medium-sized (Fig. 13: *2*) and others relatively large (Fig. 4: *3*). They all have the characteristic features of the leaves of this species: the ovate shape, distinctly cordate base and frequent branches of the secondary veins, especially in the lower part of the leaf.

Alnus menzelii was described by Raniecka-Bobrowska (1954) from the Miocene leaf flora of Konin. In her opinion this alder was also frequent in the Miocene of Koronowo near Bydgoszcz (sub *Corylus mac quarrii* (Forbes) Heer, Menzel 1910). It has so far been reported from a small number of the Neogene sites of Europe, e.g. from the Sarmatian flora of Achldorf (Knobloch 1986), the Pliocene of Ruszów (Hummel 1991b) and recently also from the Lower Rhine Embayment (NW Germany, Belz & Mosbrugger 1994). According to the present authors, it was relatively common. Leaves of this species have been assigned various specific and even generic names. It seems to us that in many cases the remains of leaves known as "*Betula prisca*" Ett. may be the smaller leaves of *Alnus menzelii* Raniecka-Bobrowska. This is particularly clear in a study on the flora of Konin, in which the leaf labelled *Betula prisca* Ett. (Raniecka-Bobrowska 1954, Fig. 3) is an undoubted leaf of this alder.

Sometimes, however, the remains of leaves of "*Betula prisca*" Ett. with cordate bases may in fact be hornbeam leaves (Hummel 1991a, comp. also Białobrzeska 1972)), as is the case in the leaf with a distinctly cordate base illustrated in Goeppert's (1855) paper Pl. 3, fig. 12 (Hummel l.c.). The dentation of the leaf margin is typical of the leaves of *Carpinus*.

The most typical leaves of *Alnus menzelii* are found in the floras of the Middle Miocene, when this species contributed to the formation of marsh forest in very wet habitats. In younger floras the leaves of *Alnus menzelii* may occur in a comparatively large form (some specimens in the flora of Sośnica and that of Ruszów – Hummel 1991b, Fig. 4) or, not so characteristically, as the smaller and/or narrower leaves of the type of the earlier "*Betula prisca*". As has been shown (Hummel 1991a), the original specimens of *Betula prisca* of Ettingshausen, stored in Vienna, have utterly different morphological characters and have nothing in common with the leaf of "*Betula prisca*" Ett. from Sośnica. Most probably, these original specimens from Vienna, belong, in our opinion, to *Alnus adscendens* (Goepert) Walther et Zastawniak, but, without cuticular analysis one cannot be certain.

Alnus menzelii Raniecka-Bobrowska resembles two present-day species of alder: the North American *Alnus serrulata* Willd. and the Caucasian *Alnus subcordata* C. A. Mey. (Raniecka-Bobrowska 1954).

Alnus kefersteinii (Goeppert) Unger – strobiles

Pl. 3, figs 1–2a

1836 *Alnites kefersteinii* Goeppert, H. R. Goeppert, p. 364, pl. 41, figs 1–19
1847 *Alnus kefersteinii* (Goeppert) Unger, F. Unger, p. 115, pl. 33, figs 1–3

Material. New collection: MP, sine numero. 2 specimens.

Remarks. The species described by Goeppert (1836) from Salzhausen as *Alnites* was later (Unger 1847) included in *Alnus*. The name "*kefersteinii*" created for strobiles, was incorrectly applied to fossil leaves.

Alnus sp. – male inflorescence

Fig. 9, Pl. 3, fig. 3

1855 Fructus *Myricae*, H. R. Goeppert, pl. 14, fig. 23, specimen MGUWr 819p/2
1920 *Alnus* sp. (cf. *viridis* DC. ?), R. Kräusel, p. 367, pl. 20, fig. 9, pl. 21, fig. 6

Material. Goeppert's collection: MGUWr 819p/1. 1 specimen.

Remarks. This impression was described by Goeppert (1855) as "Fructus *Myricae*". From the same specimen (MGUWr 819p/2) Kräusel (1920) isolated pollen grains which were determined by him (Kräusel op. cit., fig. 9) as *Alnus* sp. He reported many five, and even some six-

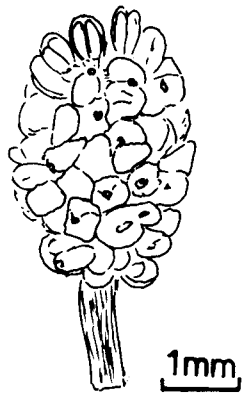


Fig. 9. *Alnus* sp.: MGUWr 819p/1 – male inflorescences (Goeppert 1855, pl. 14, fig. 23: Fructus *Myricae*; Kräusel 1920, pl. 20, fig. 9, pl. 21, fig. 6: *Alnus* sp. cf. *viridis* DC. ?), × 9

pored pollen grains of alder and changed Goeppert's determination.

Betula similis (Goeppert) Zastawniak & Walther comb. nov.

Fig. 2: *8, 11, 12*, Fig. 3: *5, 8*, Fig. 10: *1–13*, Fig. 13: *12, 13*, Pl. 4, fig. 5, Pl. 5, figs 1–7, Pl. 6, figs 6–8

Lectotype. Specimen MGUWr 707p, pl. 5, fig. 3, 3a, Fig. 10: *1* (Goeppert 1855, pl. 4, fig. 5: *Alnus similis* Goeppert).

1855 *Alnus similis* Goeppert, H. R. Goeppert, p. 13, pl. 4, fig. 5

1919 *Betula subpubescens* Goeppert, H. Reimann, p. 39, pl. 2, fig. 18, specimen MGUWr 1011p/7 from Brzeg Dolny [Dyhernfurth],

1981 *Betula prisca* Ett., Łańcucka-Środoniowa et al., pl. 1, fig. 6

1996 *Alnus adscendens* (Goeppert) Zastawniak et Walther, Zastawniak et al., p. 875, pl. 290, fig. 4

Material. Goeppert's collection: MGUWr 524p (Goeppert's label: *Betula crenata*); 526p/4 (Goeppert's label: *Alnus similis*); 550p/IV; 562p/4; 674p/4 (twin impression of *Betula dryadum* Goeppert 1855, pl. 3, fig. 1); 675p/1/II; 675p/9; 676p/2 (Goeppert's label: *Alnus similis*); 707p (Goeppert's label: *Alnus similis*, Goeppert 1855, pl. 4, fig. 5: *Alnus similis*); 919p/II; 982p/8/II; 1011p/7 (Reimann 1919, pl. 2, fig. 18: *Betula subpubescens*, from Brzeg Dolny [Dyhernfurth]; 1012p/8/III; 1019p/II; 2026p; 5150p. New collections: MGUWr 1157p/1; KRAM-P 54/31/II; 54/43/III; 54/83/I; 54/85; 54/88; 54/89/I; 54/90/I; 54/261/I; 54/606/III, IV + twin impression 54/819/I, II; 54/843; 54/911/I; 54/958; 54/965/I, II; 54/1056 + twin impression 54/1062; 54/1079 + twin impression 54/1081/II; MG PIG 46.III.225; 35 leaf remains, 5 with twin impressions.

Description. Leaves ovate, broadly ovate or elliptic to broadly elliptic, 2.9–5.7 (–8.3) cm long and 1.6–3.7 (–4.1) cm wide, with cuneate, sometimes truncate, base and acute apex. Leaf petiole up to 1.5 cm long. Leaf length/width ratio 1.3–1.8 (–2.0). Venation pinnate, craspedodromous. Primary vein sometimes slightly sinuous. Secondary veins 5–8 (–10) pairs, almost opposite in the basal part of the leaf, diverging from the midvein at an angle of 28–60^0 at intervals of 4.0–7.5 mm; outer secondary veins present. The lowest pair of faint secondary veins run parallel to the leaf base. Leaf margins serrate, teeth relatively large, betuloid.

Remarks. It is difficult to identify the leaves of this member of the Betulaceae, solely on the basis of their morphology. Unfortunately, the epidermis has not been preserved on the specimens of *Betula similis* (Goeppert) comb. nov. distinguished at Sośnica. The leaves of this fossil birch resemble some of the leaves of *Alnus adscendens*, but are smaller, widest below the middle, and have a longer petiole. The margins bear teeth typical of *Betula* leaves, in that they are fairly long and show little variation in size. The venation just within the cuneate base of the leaves is very characteristic. Parallel to the basal margin runs a pair of delicate veins, which are connected with the next lowest pair of secondary veins by a series of small loops. The marginal teeth are supplied by the secondary veins or their branches.

In its morphology *Betula similis* (Goeppert) Zastawniak et Walther comb. nov. comes nearest to the fossil species *Betula plioplatyptera* Hummel from the Pliocene of Ruszów (Hummel 1991b), whose epidermis is known. It has, in Hummel's (l.c.) opinion, characteristic features of *Betula*, namely the verrucose cuticle of the upper epidermis, stomata varying greatly in size within the same leaf, the presence of heterostomata furnished with striations of the cuticle perpendicular to the stomatal aperture, and the six celled bases of glandular setae. In comparing this fossil species with the present-day species of *Betula*, Hummel (l.c.) found a great convergence of its morphological characters with those of the North American *Betula papyrifera* Marsh and *B. nigra* L. and in respect of anatomical structure with the East Asiatic *B. platyphylla* Sukatschev. The leaves of *Betula similis* from Sośnica are also closely similar to *Betula platyphylla* Sukatschev in morphology, as are the nutlet and bract of *Betula* sp. 1 (Fig. 12: *7, 9*).

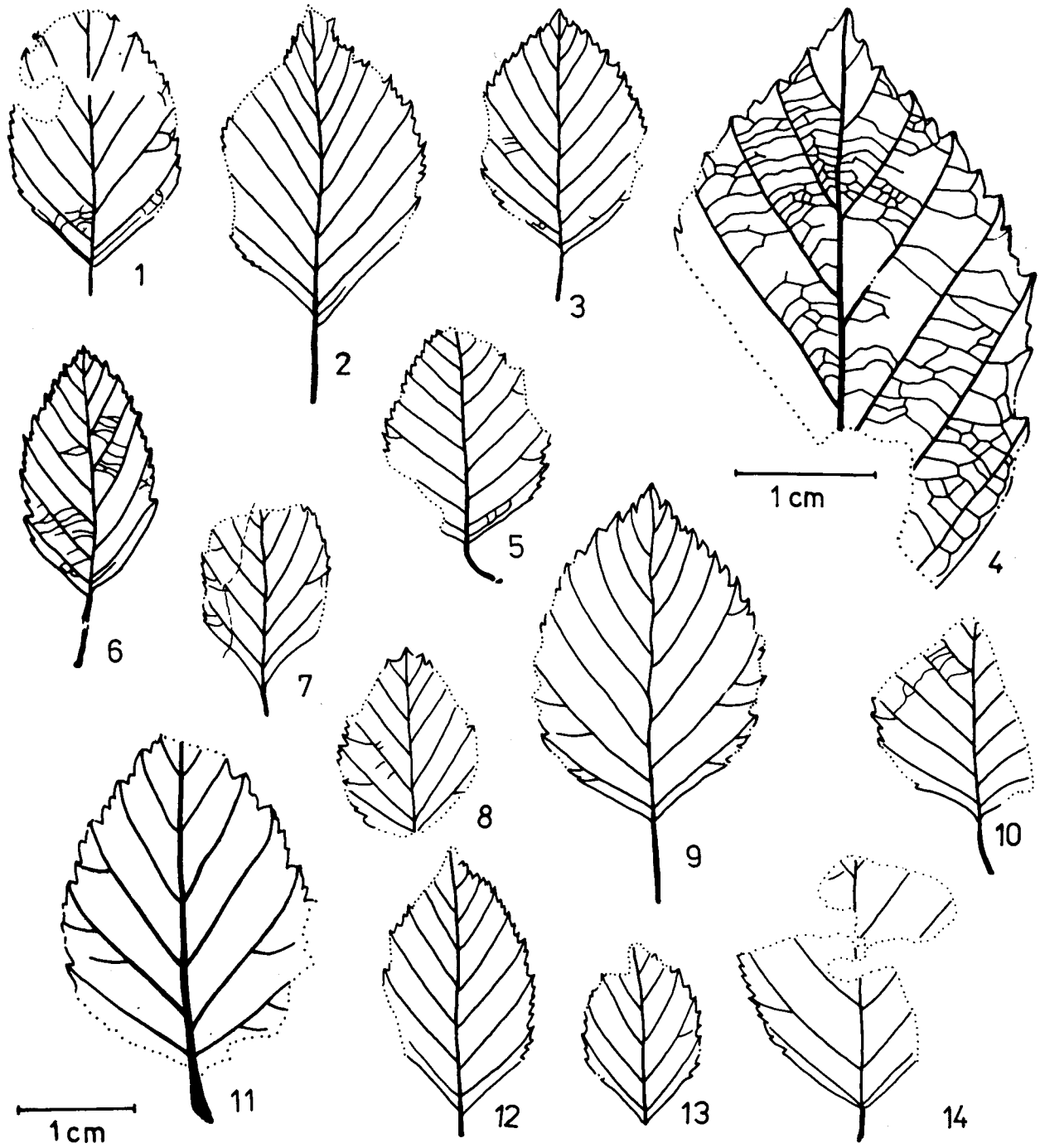


Fig. 10. *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.: **1** – Lectotype, MGUWr 707p (Goeppert's label: *Alnus similis*, Goeppert 1855, pl. 4, fig. 5: *Alnus similis*), **2** – KRAM-P 54/89/I, **3** – KRAM-P 54/85, **4** – KRAM-P 54/31/II, enlargement of leaf, **5** – KRAM-P 54/83/I, **6** – KRAM-P 54/843, **7** – KRAM-P 54/1079+ twin impression 54/1081/II, **8** – MGUWr 982p/8/II, **9** – KRAM-P 54/261/I, **10** – KRAM-P 54/965/I, **11** – KRAM-P 54/911/I, enlargement of leaf, **12** – KRAM-P 54/88, **13** – MG PIG 64.III.225; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **14** – PIG 46.III.231

The present authors think that *Betula plioplatyptera* Hummel should not be regarded as a synonym of *Betula similis* (Goeppert) Zastawniak et Walther comb. nov. from Sośnica, since the structure of the epidermis of the latter cannot be verified.

Betula longisquamosa Mädler

Fig. 11: *1–4, 6*, Fig. 12: *1–6, 8, 10–12*, Pl. 4, fig. 10, Pl. 6, figs 1–4

1855 Squama amenti femin., H. R. Goeppert, pl. 3, fig. 18, specimen MGUWr 852p/1/I
1855 Semen *Betulae*, H. R. Goeppert, pl. 26, fig. 19, specimen MGUWr 854p/I
1855 Squama *Betulae*, H. R. Goeppert, pl. 26, fig. 20, specimen missing

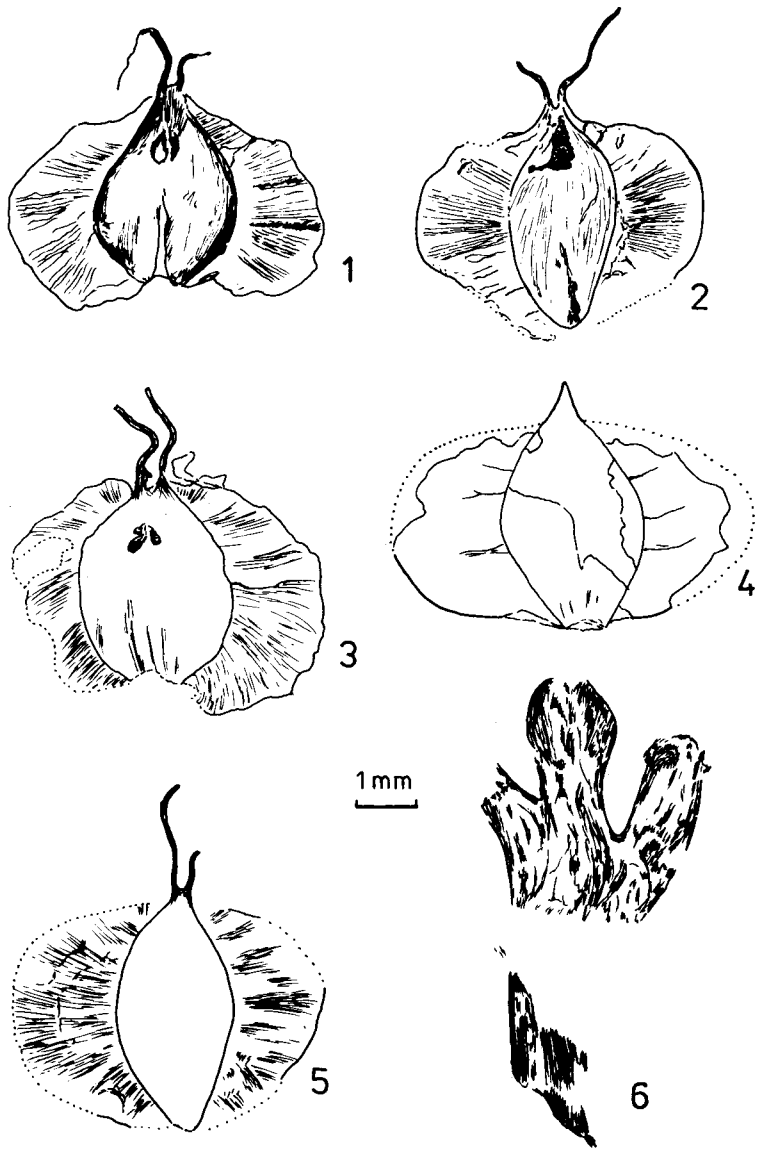


Fig. 11. Fruits and scale of *Betula longisquamosa* Mädler: **1** – MZ VII/53/340, **2** – MGUWr 854p/I, **3** – MGUWr 2279p/V, **4** – MGUWr 1015p/2; Betula sp. 1: **5** – MGUWr 981p/2/I, *Betula longisquamosa* Mädler: **6** – KRAM-P 54/490

1939 *Betula longisquamosa* Mädler, K. Mädler, p. 73, pl. 6, figs 20, 21, pl. 7, figs 3–14

Material. Goeppert's collection: MGUWr 854p/I (Goeppert 1855, pl. 26, fig. 19); 854p/I, II; 1015p/2. New collection: MGUWr 2279p/V; MZ VII/53/340; KRAM-P 54/407; 54/490; 54/705; 54/1023/I, II + twin impression 54/1024/I, II; 5 nut impressions and 6 isolated nuts, 5 impressions of bracts.

Description. From the impressions of the winged nuts the nut, excluding wing, measures 3.3–4.0 × 2.0–2.6 mm. Width of wing are 1.35 mm (Fig. 11: *1*), 1.62 mm (Fig. 11: *2*, pl. 6, fig. 2) and 2.0 mm (Fig. 11: *4*). In three cases two thread-like stigmas are visible. Specimen MZ VII 53/340 (Fig. 11: *1*, Pl. 6, fig. 2) bears traces of pubescence in the upper part of the fruitlet. Wings very distinct in the impression with even their venation visible. The fruitlet is not perfectly horizontal and this is why the lower part of the winglet seems to be somewhat shortened. Size of isolated nuts: 3.65–4.90 × 1.80 × 2.30 mm.

Three-lobed bracts 4.5–8.5 × 3.1–4.1 mm, 1.5 cm wide at base. Bracts asymmetrical, lateral lobes distinct, unequal, one 1.50–3.00 mm long, the other 3.85–4.25 mm long.

Remarks. This fossil species is frequent in

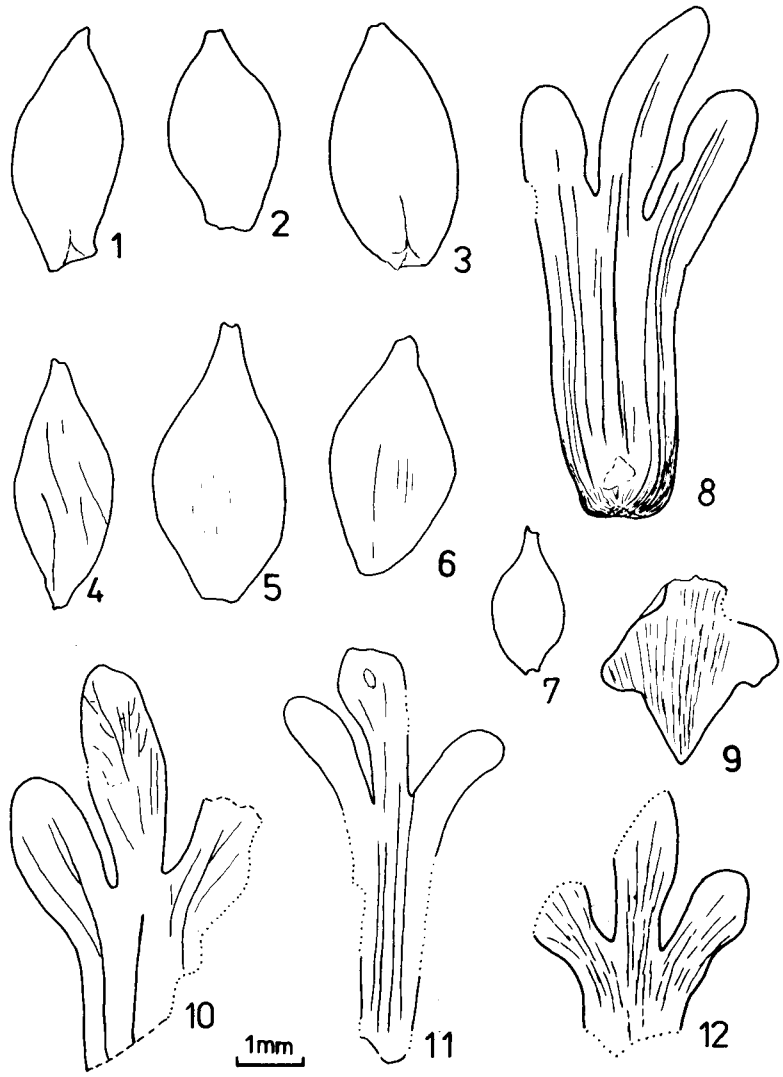


Fig. 12. *Betula longisquamosa* Mädler: **1–6** – Fruits, KRAM-P 54/705; *Betula* sp. 1: **7** – Fruit, KRAM-P 54/716; *Betula longisquamosa* Mädler: **8** – Scale, 54/1023p/I; *Betula* sp. 1: **9** – Scale, MGUWr 852p/1/I (Goeppert 1855, pl. 3, fig. 18: Squama amenti femin.); Betula *longisquamosa* Mädler: **10** – Scale, KRAM-P 54/1023/II, **11** – Scale, KRAM-P 54/407, **12** – Scale, MGUWr 854p/II

the floras of the Miocene and Pliocene of Europe. Dorofeev (1982) considers it to be comparable with the modern North American *Betula nigra* L. and to two species from Mongolia: *Betula taurica* V. Baran. and B. *derbetica* V. Baran. Mai & Walther (1988) consider that it is closely related to other contemporary species from East Asia: *B. delavayi* Franch., *B. ermanii* Cham., *B. grossa* Sieb. et Zucc. and *B. utilis* D. Don.

Betula sp. 1. – nuts, bract

Fig. 11: *5*, Fig. 12: *7*, *9*

Material. Goeppert's collection. Specimen Nos MGUWr 852p/1/I (Goeppert 1855, pl. 3, fig. 18) + twin impression 852p/2; No MGUWr 981p/2/I; 1015p/2. New collection: KRAM-P 54/716. One nut impression, one isolated nut and one bract.

Description. Impression of winged nut 4.0 × 1.8 mm (excluding wing), width of wing 1.6 mm, pistil 2.0 mm long. Rugosity on winglet clearly visible. Isolated nut (Fig. 12: *7*) 2.6 × 1.25 mm. Bract 3.5 × 3.1 mm, triangular, with small lateral lobes (Fig. 12: *9*).

Remarks. A birch species distinct from *Betula longisquamosa* Mädler as shown by the shapes of the bract, nutlet and particularly its winglet. The nut and bract are very similar to the recent species *Betula platyphylla* Sukatchev, (see Kuang & Li 1979, fig. 25) which occurs in Eastern Siberia and the Far East (So-

kolov 1951). It should be added here that, in Hummel's (1991b) opinion, the same modern species agrees in anatomical structure with the fossil *Betula plioplatyptera* Hummel from Ruszów, which in turn very much resembles our fossil birch from Sośnica – *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.

Betula sp. – male inflorescences

Pl. 6, fig. 5

1855 Amenta *Carpin.*, H. R. Goeppert, pl. 26, fig. 26, MGUWr 983p
1920 *Betula* sp. (?), R. Kräusel, p. 366, pl. 21, fig. 4, specimen MGUWr 983p

Material. Goeppert's collection: MGUWr 880p/27/II (twin impression 880p/30/II), palynological slides KRAM-P 54/1200–1201; 983p; one impression of inflorescences.

Description. Fragments of male inflorescences, the largest one 2.20 × 0.5 cm, bracts 1.6–2 × 1.25–1.5 mm. The structure of the flowers is indistinct, the impression obliterated. Pollen grains of *Betula* (pl. 6, figs 9–11) have been isolated from specimens MKUWr 880p/27/II and 880p/30/II.

Carpinus grandis Unger

Fig. 13: *3–11, 15–18, 20, 21*, Fig. 14–17, Fig. 18: *1 – 13, 15–18, 20, 21*, Fig. 19: *1–7, 9, 11–16*, Pl. 9, figs 1–8, 10, 11, Pl. 10, figs 1, 2, 4–13a, Pl. 11, figs 1–5a

1852 *Carpinus grandis* Unger, F. Unger, pl. 43, figs 4, 5.
1855 *Betula subtriangularis* Goeppert, R. H. Goeppert, p. 10, pl. 3, fig. 2, drawing incorrect, specimen MGUWr 732p
1855 *Betula prisca* Ett., H. R. Goeppert, p. 11, pl. 3, fig. 11, see Hummel 1991a, p. 64; fig. 12 (with Goeppert's label: *Betula prisca* Ett.), Reimann 1919, pl. 2, fig. 12
1855 *Carpinus ostryoides* Goeppert, H. R. Goeppert, p. 19, pl. 4, fig. 8, drawing incorrect; specimen MGUWr 950p/2 with damaged base and leaf margin; fig. 9, drawing incorrect, specimen MGUWr 710p (Reimann, pl. 4, fig. 15: *Carpinus grandis* Unger); fig. 10 – specimen missing
1855 *Fagus attenuata* Goeppert, H. R. Goeppert, pl. 5, fig. 9, specimen MGUWr 2584p, Walther & Zastawniak 1991, p. 160, fig. 2
1919 *Betula prisca* Ett., H. Reimann, pl. 2, fig. 12, specimen MGUWr 850p
1919 ?*Alnus rotundata* Goeppert, H. Reimann, pl. 2, fig. 16, specimen No 546p
1919 *Carpinus grandis* Unger, H. Reimann, p. 66, pl. 3, fig. 7, specimen missing; pl. 4, fig. 12, specimen missing; pl. 4, fig. 13, specimen No MGUWr 950p/2; pl. 4, fig. 14, specimen missing; pl. 4, fig. 15, specimen No MGUWr 710p; pl. 5, fig. 3, specimen missing; pl. 9, fig 1, specimen missing
1919 non *Carpinus grandis* Unger, H. Reimann, pl. 3, fig. 5, specimen No MGUWr 929p = *Ulmus carpinoides* Goeppert; pl. 9, fig. 5, specimen No MGUWr 727p = *Ulmus carpinoides* Goeppert
1981 *Carpinus grandis* Ung. sensu Heer, M. Łańcucka-Środoniowa & al., pl. 1, fig. 1
1981 *Betula brongniarti* Ett., M. Łańcucka-Środoniowa et al., pl. 1, fig. 2

Material. Goeppert's collection: MGUWr 517p/I (Goeppert's label: *Betula prisca*); 519p/I; 526p/1+2; 530p/I (Goeppert's label: *Carpinus adscendens*); 534p/I (Goeppert's label: *Quercus*); 535p/2; 538p/1 (Goeppert's label: *Carpinus ostryoides*); 538p/2 (Goeppert's label: *Carpinus ostryoides*); 541p/I (Goeppert's label: *Alnus carpinoides*); 544p/I (Goeppert's label: *Carpinus alnifolia*); 545p/1/I (Goeppert's label: *Carpinus alnifolia*); 546p (Reimann 1919, pl. 2, fig. 16: ?*Alnus rotundata*); 548p/1/I (Goeppert's label: *Carpinus ostryoides*); 548p/10 (Goeppert's label: *Carpinus ostryoides*); 548p/11; 620p/1; 648p/1/II; 674p/6; 682p/3 + twin impression 682p/4; 701p; 710p (Goeppert's label: *Carpinus ostryoides*, Goeppert 1855, pl. 4, fig. 9: *Carpinus ostryoides*, Reimann 1919, pl. 4, fig. 15: *Carpinus grandis*); 850p (Goeppert's label: *Betula prisca*, Goeppert 1855, pl. 3, fig. 12: *Betula prisca*, Reimann 1919, pl. 2, fig. 12: *Betula prisca*); 889p; 892p/1; 926p/2; 950p/2 (Goeppert 1855, pl. 4, fig. 8: *Carpinus ostryoides*, drawing incorrect, leaf base damaged); 970p/3/I; 978p/1/II; 984p/7; 1010p/1; 1011p/8; 1011p/19/II; 1012p/8/I; 1012p/9; 2592p (Reimann 1919, pl. 5, fig. 5: *Carpinus grandis*); 2804p (Goeppert's label: *Carpinus ostryoides*); 2811p; 2834p; 5014p; 5110p; 5145p. New collections: MGUWr 1066p/I; 1107p/3; 1150p; 1151p/1; 1151p/2; 1152p – 1154p; 1162p/I; 1164p/2; 1165p; 1166p/1; 1167p; 1171p/1, 2; 1580p/1; 1582p/1; 1604p; 1610p; 1815p/III – cuticular slides MMG So 12/77–13/77; 27/77–28/77; MGUWr 1820p; 1837p/II; 1911p; 2032p; 2040p/I – cuticular slides MMG So 12/93–21/93; MGUWr 2046p; cuticular slides MMG 21/77 – 23/77, 29/93–38/93; MGUWr 2052p; 2227p; 2299p; 2346p; 2453p; 2584p (Goeppert 1855: *Fagus attenuata*, pl. 5, fig. 9); KRAM-P 54/74/IV; 54/171; 54/172/I; 54/184; 54/264; 54/329/II; 54/331/I; 54/343; 54/344; ?54/401; 54/424; 54/433; 54/460/II; 54/550/IV; 54/557/I; 54/625/I; 54/649 cuticular slides MMG So 25–32/92; 54/896/I; 54/926/II; 54/952/I; 54/964; 54/1028/VII; 54/1039; 54/1082/IV; 54/1105/I; 54/1156/I + twin impression 1183/II; 54/1178/I + twin impression 54/1179/I; MG PIG 46.III.106;

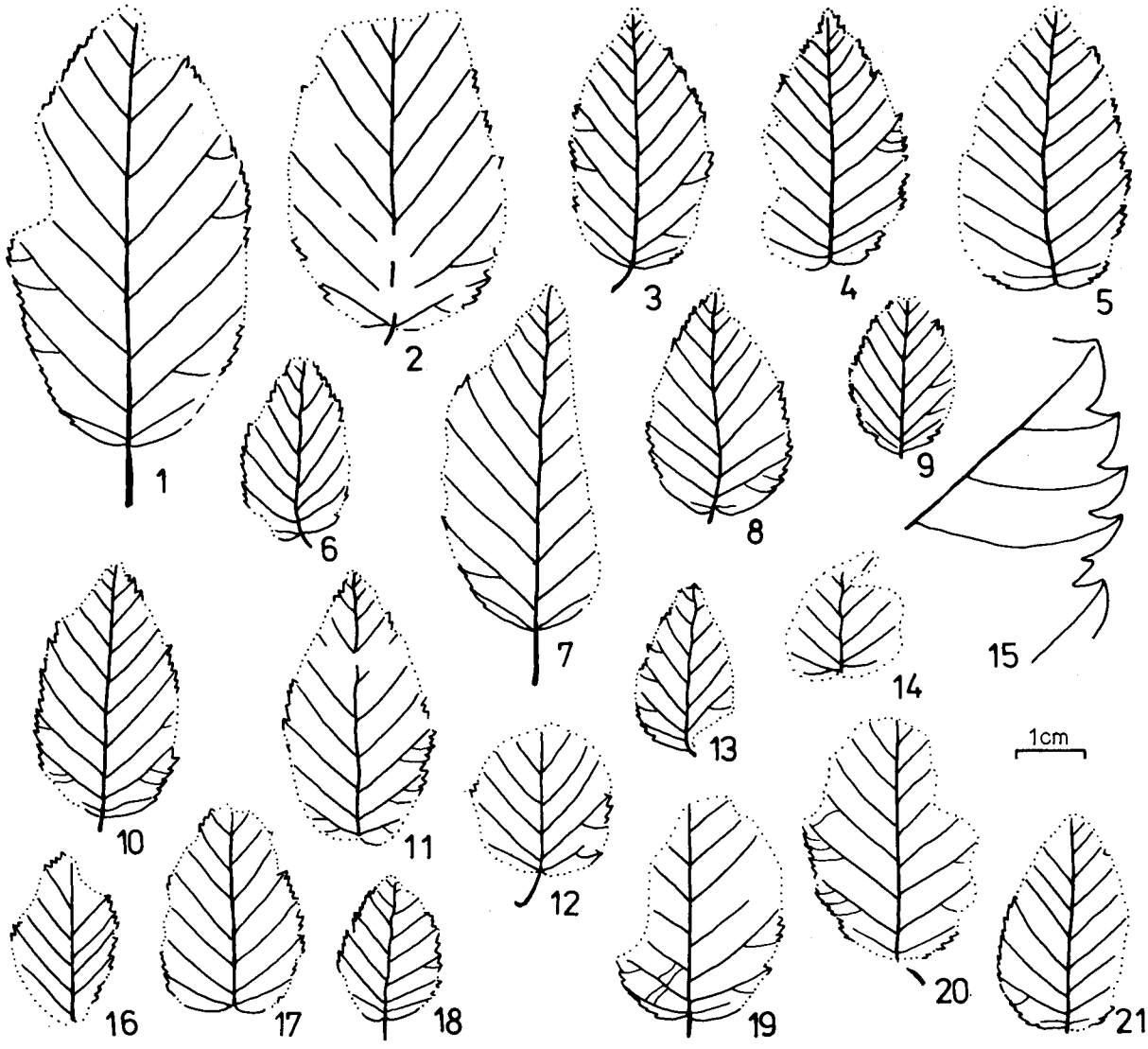
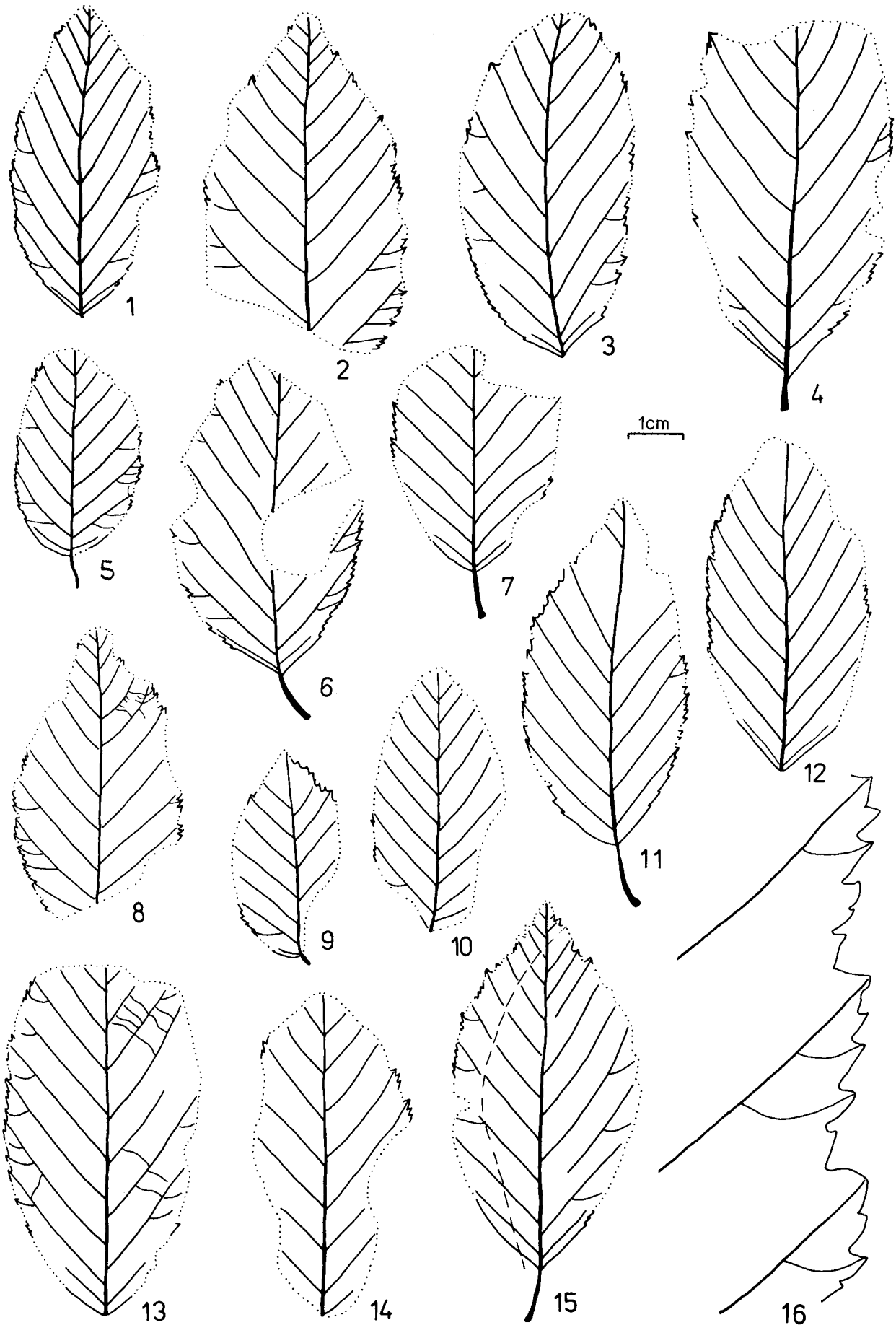


Fig. 13. *Carpinus grandis* Unger: **1** – MGUWr 548p/1/I (Goeppert's label: *Carpinus ostryoides*); *Alnus menzelii* Raniecka-Bobrowska: **2** – KRAM-P 54/1022/I; *Carpinus grandis* Unger: **3** – MGUWr 2227p, **4** – MGUWr 517p/I (Goeppert's label: *Betula prisca*), **5** – MGUWr 984p/7, **6** – KRAM-P 54/74/IV, **7** – MGUWr 620p/1, **8** – KRAM-P 54/1179/I, **9** – MGUWr 2346p, **10** – KRAM-P 54/1156/I, **11** – MGUWr 850p (Goeppert's label: *Betula prisca*, Goeppert 1855, pl. 3, fig. 12: *Betula prisca* Ett., Reimann 1919, pl. 2, fig. 12: *Betula prisca* Ett.); *Betula similis* (Goeppert) Zastawniak et Walther comb. nov.: **12** – MGUWr 675/9, **13** – KRAM-P 54/43/III; Betulaceae gen. et sp. indet.: **14** – MGUWr 732p (Goeppert 1855: *Betula subtriangularis*, pl. 3, fig. 2); *Carpinus grandis* Unger: **15** – MGUWr 517p/I, enlargement of teeth on the leaf margin, × 8, **16** – MGUWr 2040p/I, with the impression of *Carpinus* fruit on the same specimen, cuticular slides MMG So 12/93–21/93, **17** – MGUWr 2453, **18** – KRAM-P 54/184, *Alnus menzelii* Raniecka-Bobrowska, **19** – MGUWr 695p; *Carpinus grandis* Unger: **20** – KRAM-P 54/460/II, **21** – KRAM-P 54/1178/I

46.III.113; 46.III.114 + twin impression 189; 46.III.115; 46.III.119; 46.III.151; 46.III.214; 46.III.234; 46.III.236; 46.III.240; 46.III.246; 46.III.262; 46.III.265; 46.III.277; 46.III.305; MZ VII 53/96/II; VII 53/133a, b (twin impressions); VII 53/178; VII 53/190; VII 53/195; VII 53/197; VII 53/414; VII 53/466a; 123 impressions of leaves, 5 with twin impressions.

Fig. 14. *Carpinus grandis* Unger: **1** – MGUWr 534p/I (Goeppert's label: *Quercus*), **2** – MGUWr 519p/I, **3** – MGUWr 538p/1 (Goeppert's label: *Carpinus ostryoides*), **4** – MGUWr 1066p/I, **5** – MGUWr 535p/2, **6** – MGUWr 541p/1 (Goeppert's label: *Alnus carpinoides*), **7** – MGUWr 2811p, **8** – KRAM-P 54/557/I, **9** – KRAM-P 54/433, **10** – MZ VII 53/190, **11** – MGUWr 1154p, **12** – MGUWr 2046p, cuticular slides MMG So 21/77–23/77, 29/93–38/93, **13** – MGUWr 545p/1/I (Goeppert's label: *Carpinus alnifolia*), **14** – MGUWr 1815p/III, cuticular slides MMG So 12/77–13/77, 27/77–28/77, **15** – MGUWr 1162p/I, **16** – KRAM-P 54/172/I, enlargement of leaf margin, × 8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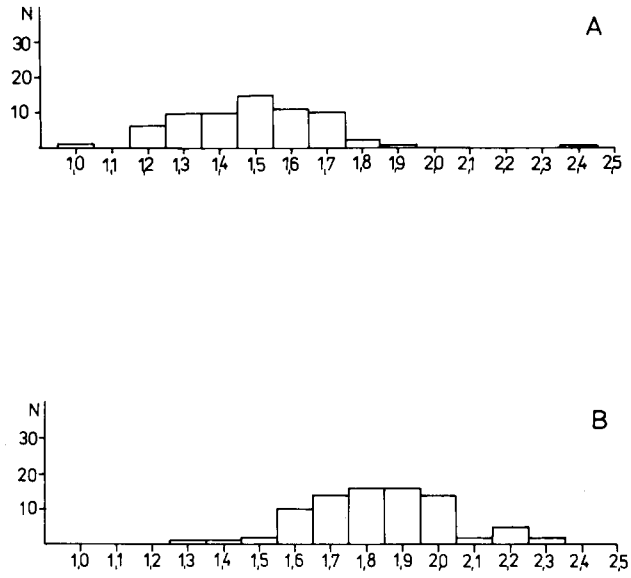


Description. Leaves elliptic, broadly elliptic to narrowly ovate, (2.4–) 4.3–7.5 (–9.0) cm long (Fig. 16) and (1.7–) 2.7–4.6 cm wide. Base mostly cuneate, sometimes rounded, apex acute, sometimes slightly attenuate. Petiole up to 1.6 cm long. Margin doubly serrate throughout. Primary teeth betuloid, narrow, with elongate apices, secondary teeth (2 to 4) smaller, narrow, also with elongate apices. Venation simple, pinnate, craspedodromous.

Midrib often sinuous, or straight. Secondary veins (6–) 7–10 (–11) pairs, running to the primary teeth and arising from the midrib at about 60–87^0 in the basal part of the leaf and 40–58^0 in the middle, generally straight. Single, sometimes double outer secondary veins are visible in the basal and/or middle parts of the leaves. Third order veins minute, perpendicular to the secondary veins, numerous.

Epidermal structure. Cells of upper epidermis polygonal, 16–24 (–40) μm in size. Anticlinal walls undulate, those close to the margin straight or curved (Pl. 9, figs 2a, 3). Cuticle of lower epidermis delicate, cells polygonal, with undulate anticlinal walls. Anomocytic stomata irregularly disposed in the intercostal areas, oval to suborbicular, 22.0 μm (16–38 μm) long and 19.0 (16–32) μm wide. Guard-cells present, only weakly cutinized. Pores broad, fusiform, outer cavity ledges strongly cutinized. Scattered, strongly cutinized suborbicular hair-bases, 8–10 μm in diameter, occur, particularly on veinlets.

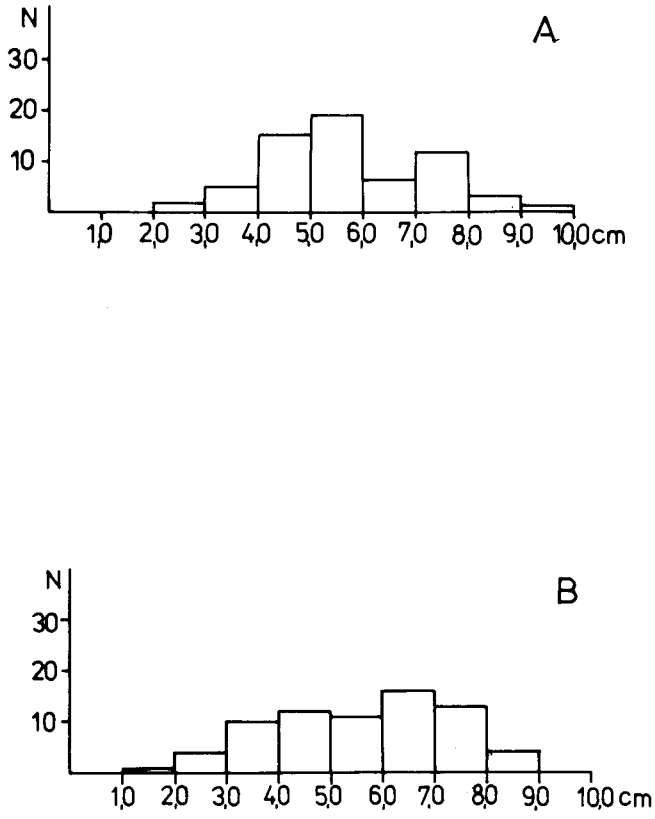


Fig. 16. Histograms of length of leaves of *Alnus adscendens* (Goeppert) Zastawniak et Walther (A) and *Carpinus grandis* Unger (B)

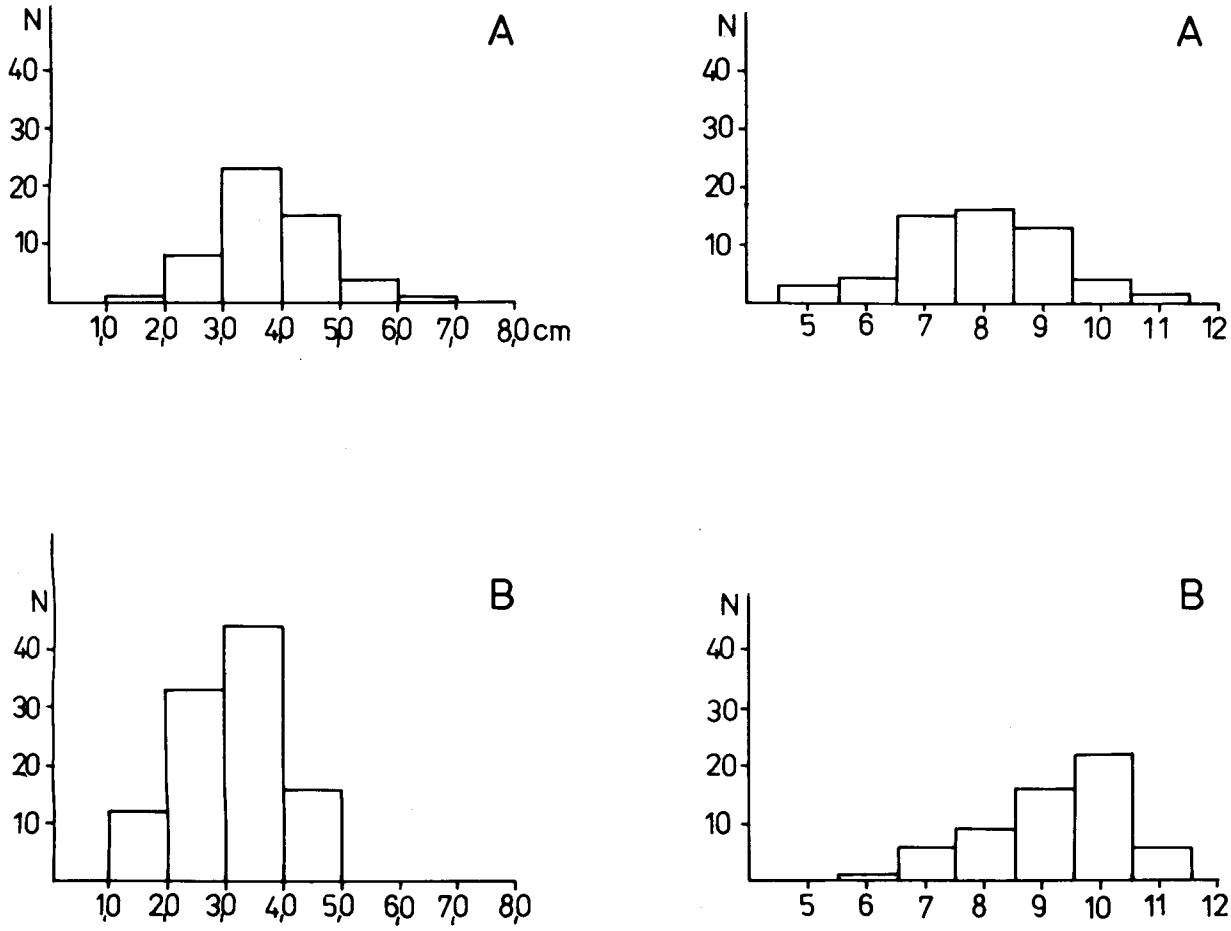


Fig. 17. Histograms of width of leaves of *Alnus adscendens* (Goeppert) Zastawniak et Walther (A left) and *Carpinus grandis* Unger (B left) and number of secondary veins of *Alnus adscendens* Zastawniak et Walther (A right) and *Carpinus grandis* Unger (B right)

Remarks. The leaves of *Carpinus* in the flora of Sośnica are morphologically similar to some leaves of *Alnus adscendens* (Goeppert) Zastawniak et Walther (Figs 15–17). The two genera can be distinguished on the basis of the:

1. size and shape of the teeth at the leaf margin (*Alnus adscendens* has the primary teeth generally larger than the secondary teeth, whereas in *Carpinus* the difference is very small);

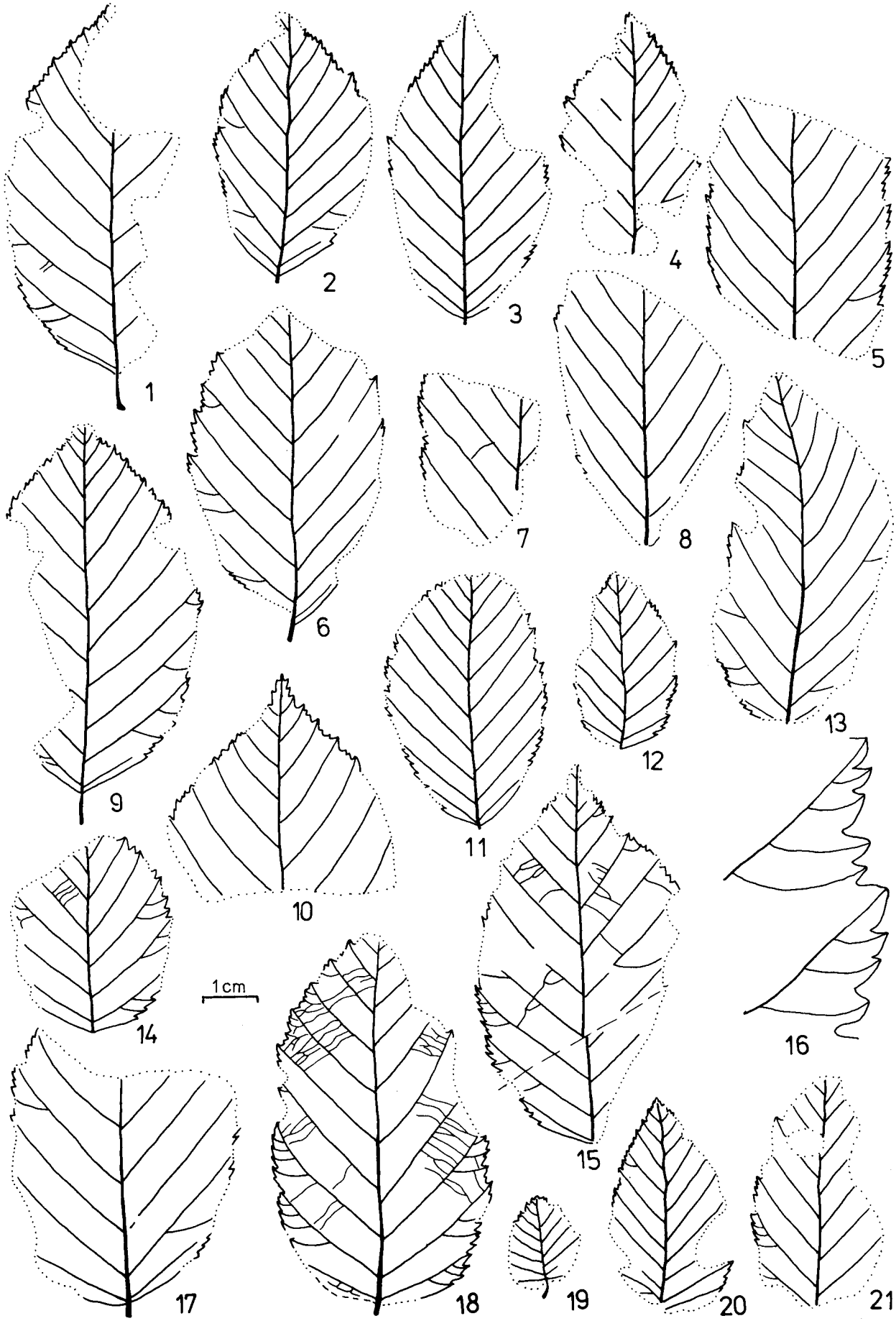
2. more numerous and straighter secondary veins in the *Carpinus* leaves (Fig. 17);

3. tertiary veins which in *Carpinus* are delicate and regular.

For other differences see p. 95.

We accept only the specimen from Radoboj illustrated by Unger 1852 in pl. 43, fig. 4 as the possible lectotype of *Carpinus grandis* and as syntype the second leaf from Radoboj (pl. 43, fig. 5), although we have not seen either of them. The leaves of *Carpinus* from Oehningen (Heer 1856) need verification, so we have refrained from using the term "emendavid Heer".

Carpinus grandis Unger has been accepted as a collective species which occurred in Central Europe from the lower Middle Oligocene to the Upper Pliocene (Mai & Walther 1978, 1988; Hummel 1991b). Differences can be found in the epidermal structure, the development of the anticlinal walls and the size of the stomata over the period from the Middle Oligocene until the Pliocene, and so an evolutionary series may be assumed, comprising several species. Their division on the basis of the sets of characters available is, however, impossible. From the Lower Middle Oligocene, through the Upper Oligocene, Middle Miocene to the Lower Pliocene the anticlinal walls were changing from straight, through coarsely undulate, undulate to curved, in parallel with increasing stomata size (see Mai & Walther 1978, 1991; Hummel 1991b). From the Upper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Oligocene, gland bases began to appear in addition to the bases of the normal cover (Mai & Walther op. cit.; Hummel op. cit.). The number of secondary veins, the occurrence of undulate anticlinal walls and the existence of strongly cutinized outer stomata ledges indicate the presence, not only of representatives of the section Distegocarpus (Sieb. & Zucc.) Sargent, but also species of the section Eucarpinus Sargent, illustrating once more the intermediate position of these Late Tertiary hornbeams (Hummel 1991b; Mai & Walther 1991).

In the Pliocene of Thuringia (Mai & Walther 1988) the so-called *Carpinus grandis* is very rare. The leaf remains of *Carpinus* are accompanied in the Sośnica flora by many *Carpinus* involucres (see below), which suggest that trees of *Carpinus* were in situ.

Carpinus betulus Linné *fossilis* Engelhardt et Kinkelin

Fig. 20: 1–13, Pl. 11, figs 6–17

1908 *Carpinus betulus* Linné *fossilis*, H. Engelhardt and F. Kinkelin, p. 232, pl. 28, fig. 8 a-c
1855 Fruct. *Carp.*, H. R. Goeppert, pl. 5, fig. 5, specimen MGUWr 845p
1855 Fruct. *Carpini*, H. R. Goeppert, pl. 5, fig. 6, specimen MGUWr 848p/1
1855 Fruct. *Carp.*, H. R. Goeppert, pl. 5, fig. 4, specimen MGUWr 849p/I
1855 non Fructus *Carpini*, H. R. Goeppert, pl. 5, fig. 3, specimen MGUWr 844p, drawing erroneous, impression indeterminable 1855 non Semen *Carp.....* , H. R. Goeppert, pl. 5, fig. 7 (indeterminable bud, M. Łańcucka– Środoniowa, oral inf.)
1919 *Carpinus grandis* Ung., H. Reimann, pl. 3, fig. 4, specimen MGUWr 849p/I, pl. 3, fig. 18, specimen MGUWr 845p
1991 *Carpinus grandis* Unger sensu Berger, A. Hummel, p. 100, pl. 13, figs 4–6; Fig. 12

Material. Involucres. Goeppert's collection: MGUWr 352/1/I (Goeppert's label: Fructus *Carpini*); 352/2; 530p/II, III; 536p; 540p (Goeppert's label: Fructus *Carpini* spec.); 548p/2–4 (Goeppert's label: Fructus *Carpinis* spec.); 548p/5 (Goeppert's label: Fructus *Carpinis* spec.); 548p/6/I; 548p/7; 548p/8 (Goeppert's label: *Carpinus* – fructus); 548p/9/I; 814p/II; 845p (Goeppert 1855, pl. 5, fig. 5: Fruct. *Carpini*, Reimann 1919, pl. 3, fig. 18: *Carpinus grandis* Ung.); 848p/1 (Goeppert's label: *Carpinus* cupulae dentatis, Goeppert 1855, pl. 5, fig. 6); 849p/I (Goeppert's label: *Carpini* semen, Goeppert 1855, pl. 5, fig. 4, Reimann 1919, pl. 3, fig. 4: *Carpinus grandis* Ung.); 880p/28/VII; 891p/II; 895p; 897p; 937p/2; 953p/1; 970p/3/II; 984p/1; 1010p; 1016p; 1034p; 1079p/1/II; 5123p. New collections: MGUWr 1159p/1; 1159p/2; 1159p/3; 1577p./II; 1816p/I; 1901p/II; 2040p/II; 2058p; 2059p; 2395p/II; 2446p; 2805p; KRAM-P 54/260p/II; 54/262p/I; 54/446–54/451; 54/477; 54/650/I; 54/651/II; 54/682/III; 54/927/I + twin impression 54/931/I; 54/1162/I + twin impression 54/1164/I; MG PIG 46.III.116; MZ VII/53/61 + twin impression 62; VII/53/145; VII/ 53/181/I, II, III; VII/53/182; VII/53/184/3; VII/53/321; 65 specimens, 3 with twin impressions.

Nuts. New collections: KRAM-P 54/708; 54/708–1; (4 isolated nut fragments), MZ VII 53/183 (nut compression).

Description. Involucres generally with 3, occasionally 2 lobes, up to 3.5 cm long and 1.2–2.2 cm broad, with peduncle 5–7 mm long. The central lobe is narrow, sometimes broader in the lower part, 2.0 – 3.1 cm long and 4.5–9.0 mm wide, much longer than the lateral lobes, margin toothed or entire. Lateral lobes 0.5–1.8 cm long and O.2–0.4 cm wide, asymmetrical. Apices of all lobes acute, margin entire or with some acute teeth. A single nut, or the scar following its detachment is visible at the base of the involucres.

The venation is identical to that of *Carpinus* involucres from the Pliocene flora of Ruszów (comp. Hummel 1991b, p. 100).

Nuts of *Carpinus betulus* L. type (Pl. 11, figs 18–20) ovoid, 5.0–6.0 × 4.5 mm, rounded at the base, narrowed apically, broadest in the middle. 4–6 ribs are visible on the surface.

Remarks. The *Carpinus* involucres from Sośnica are characterized by their relatively

Fig. 18. *Carpinus grandis* Unger: **1** – KRAM-P 54/896/I; **2** – MGUWr 546p (Reimann 1919, pl. 2, fig. 16: ?*Alnus rotundata* Goeppert); **3** – MGUWr 648p/1/II; **4** – MGUWr 2032p; **5** – MG PIG 46.III.246; **6** – MG PIG 46.III.113; **7** – KRAM-P 54/649, cuticular slides MMG So 25/92–32/92; **8** – MGUWr 1604p; **9** – KRAM-P 54/952/I; **10** – PIG 46.III.115; **11** – KRAM-P 54/1028/VII; **12** – KRAM-P 54/926/II; **13** – MGUWr 538p/2 (Goeppert's label: *Carpinus ostryoides*); *Alnus adscendens* (Goeppert) Zastawniak et Walther: **14** – MGUWr 676p/1/I; *Carpinus grandis* Unger: **15** – PIG 46.III.119, **16** – KRAM-P 54/964, enlargement of leaf margin, × 8, **17** – MGUWr 1011p/8, **18** – MGUWr 530p/I (Goeppert's label: *Carpinus adscendens*); *Alnus menzelii* Raniecka-Bobrowska: **19** – MGUWr 584p/3 (Goeppert's label: *Betula cordata*); *Carpinus grandis* Unger: **20** – KRAM-P 54/264, **21** – KRAM-P 54/344

long and narrow central lobe. *Carpinus* fruits were studied by Jentys-Szaferowa (1958, 1960, 1961) and more recently have been found in the Pliocene floras of Thuringia (Mai & Walther 1988) and Ruszów (Hummel 1991b). They are all characteristic of the taxon *Carpinus betulus* L. *fossilis* Engelhardt et Kinkelin.

Only one specimen (MGUWr 814p/II, Fig. 20: *5*) seems to be of another type, comparable with the fossil form *Carpinus tschonoskii*-type (comp. Berger 1953, Fig. 11, Jung 1966, pl. 7, fig. 9). Those involucres with a greater number of basal veins were regarded by Mai & Walther (1988) as "abnormal falls".

The name *Carpinus pyramidalis* Gaudin used by Kovar-Eder (1988) for this type of *Carpinus* involucre isn't correct because Gaudin and Strozzi (1858) described *Ulmus* leaf remains under this name.

Ostrya kryshtofovichii Baykovskaya. ex Stephyrtza

Fig. 21: *1–6*, Pl. 8, figs 5–6a, 9, 11–11a

1974 *Ostrya kryshtofovichii* Bayk., A. G. Stephyrtza p. 81, pl. 21, figs 1, 2

1965 *Ostrya kryshtofovichii* Baik., A. N. Krishtofovich & T. N. Baykovskaya, p. 46, pl. 9, fig. 11, pl. 19, figs 11, 12, text fig. 19

Material. New collections: KRAM-P 54/156/I; 54/176; 54/346; 54/347; 54/511; 5 leaf impressions.

Description. Leaves ca 5.7–9.0 × 2.8–4.6 cm, narrow-elliptic or elliptic, length/width ratio 1.9–2.7, base cuneate to subcordate, petiole up to 8 mm long. Margin serrate throughout, singly in the lower half of the leaf, doubly so above. Primary teeth betuloid, narrow, secondary smaller, both with elongate apices. Midrib straight, secondary veins up to 10 pairs, extending to the primary teeth and arising from the midrib at about 40–50^0. The secondary teeth are supplied by obscure basal branches of the secondary veins. Third-order venation imperceptible.

Remarks. In the flora of Sośnica there are rare leaf remains whose morphology suggests *Ostrya* Scop. They differ from the leaves of *Carpinus* in the shape of the teeth. Similar marginal dentation occurs in the recent genus *Ostrya* Scop. whose leaves have sharp narrow teeth with elongate apices; while *Carpinus* leaves have been found at Sośnica, there is no evidence for *Ostrya* Scop. there so far (Łańcucka-Środoniowa et al. 1981). The leaves in hand show a close similarity to *Ostrya kryshtofovichii* Bayk. ex Stephyrtza (Kryshtofowich & Baykovskaya 1965).

Betulaceae gen. et sp. div. et indet.

Fig. 8: *1, 1a, 4, 6, 7, 9, 11, 12*

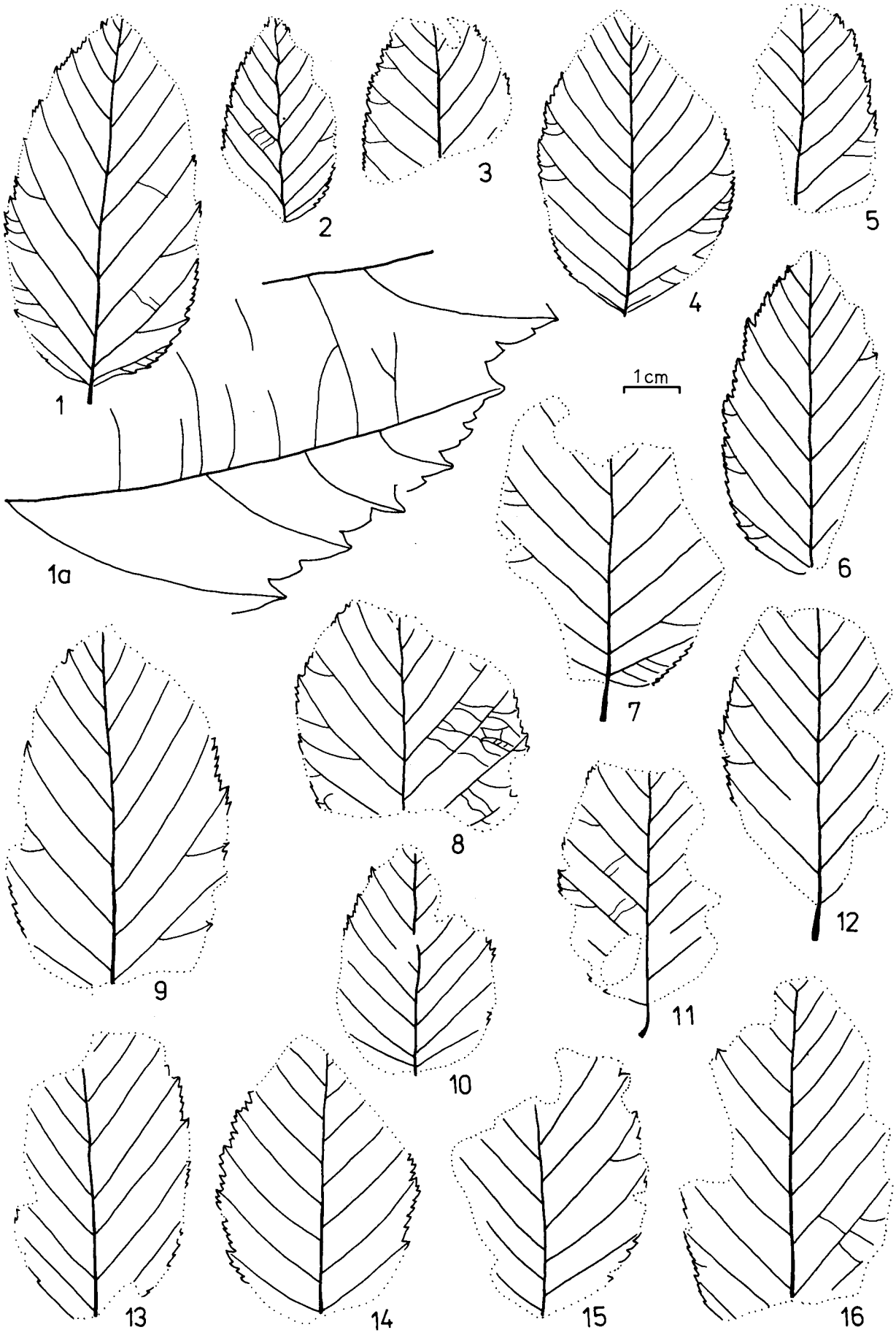
1919 *Betula subpubescens* Goeppert, H. Reimann, pl. 1, fig. 6 (specimen missing)

1919 *Betula subpubescens* Goepp. H. Reimann, pl. 2, fig. 17, specimen missing, pl. 2, fig. 19, specimen missing, pl. 3, fig. 9, specimen missing

Material. Goeppert's collection: MGUWr 518p; 521p/2; 548p/1/II; 550p/V; 679p/2; 682p/1; 711p (Goeppert 1855, pl. 4, fig. 11: *Carpinus alnifolia*); 731p (Goeppert 1855, pl. 3, fig. 9: *Betula subpubescens*); 732p (Goeppert 1855, pl. 3, fig. 2: *Betula subtriangularis*); 888p/1/II; 893p; 968p/3; 974p/3; 982p/1/I; 982p/6; 983p/2; 1010p/14/I, II; 1011p/1/I; 1012p/6; 1012p/8/II; 1015p/11/I, II; 1015p/14/II; 1030p; 1033p/3; 1055p/2/II; 1163p; 2155p; 2829p/II; 2832p; 2849p/II; 5017p; 5022p; 5119p; 5121p; 5130p; 5140p/2; 5154p; 5179p/1 (Goeppert's label: *Carpinus ostryoides*); 5182p. New collections: MGUWr 1109p/2/II; 1168p/2; 1170p/1; 1592p/2; 1616p/II; 1996p/III; 2057p/IV; 2090p; 2232p/II; 2233p/III; 2272p/III; 2280p/II; 2371p; KRAM-P 54/31/III; 54/110; 54/160/II; 54/285/III; 54/316/II; 54/317; 54/331/III; 54/624/I; 54/909/VIII; 54/960; 54/966/II; 54/1008p/II/III; 54/1035p/II; 54/1056 + twin impressions 1062; 54/1126; 54/1161/III; MG PIG 46.III.235; 46.III.259/II; 46.III.301; 46.III.304; MZ VII 53/117; VII 53/461; 77 specimens.

Remarks. These poorly preserved fragments of leaves cannot be univocally determined to generic level on the basis of the morphological characters preserved. Specimen KRAM-P

Fig. 19. *Carpinus grandis* Unger: **1** – KRAM-P 54/329/II, 1a – enlargement of leaf margin, × 8, **2** – PIG 46.III.214, **3** – KRAM-P 54/1039, **4** – MGUWr 2592p (Reimann 1919, pl. 5, fig. 5: *Carpinus grandis* Unger), **5** – KRAM-P 54/964, **6** – KRAM-P 54/331/I, **7** – PIG 46.III.262, *Alnus adscendens* (Goeppert) Zastawniak et Walther: **8** – KRAM-P 54/174/I, *Carpinus grandis* Unger: **9** – MGUWr 1150p; *Alnus adscendens* (Goeppert) Zastawniak et Walther: **10** – PIG 46.III.101; *Carpinus grandis* Unger: **11** – MGUWr 2299p, **12** – MGUWr 1911p, **13** – KRAM-P 54/550/IV, **14** – KRAM-P 54/343, **15** – KRAM-P 54/424, **16** – MGUWr 1107p/3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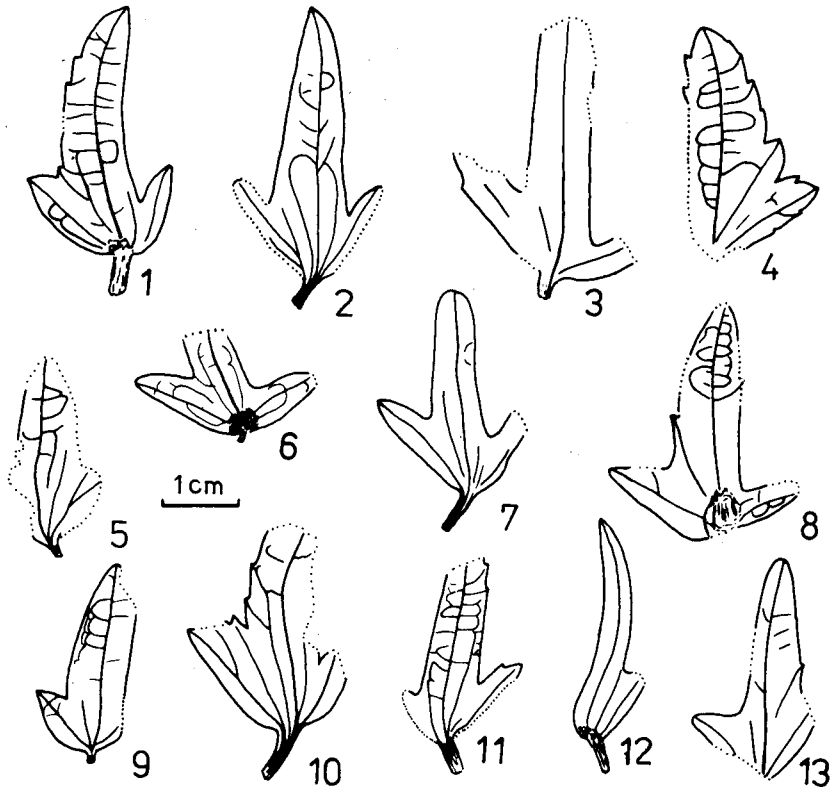

Fig. 20. *Carpinus betulus* Linné *fossilis* Engelhardt et Kinkelin-fruits: **1** – MGUWr 2058p, **2** – MGUWr 548p/7, **3** – KRAM-P 54/451, **4** – MGUWr 845p (Goeppert 1855, pl. 5, fig. 5: Fruct. *Carp.*; Reimann 1919, pl. 3, fig. 18: *Carpinus grandis* Ung.), **5** – MGUWr 814p/II, **6** – MGUWr 1159p/1, **7** – MGUWr 891p/II, **8** – MGUWr 849p/I (Goeppert's label: *Carpinis* semen, Goeppert 1855, pl. 5, fig. 4: Fruct. Carp., Reimann 1919, pl. 3, fig. 4: *Carpinus grandis* Ung.), **9** – PIG 46.III.116, **10** – MGUWr 1577p/II, **11** – MGUWr 548p/4, **12** – MGUWr 352p/1/I (Goeppert's label: Fructus *Carpini*), **13** – MZ VII/53/62

54/649 was the subject of cuticular studies (? *Carpinus* sp.). Specimen MGUWr 2155p has a very distinct doubly serrate leaf margin. This specimen is closely similar to leaves of the recent *Alnus incana* (L.) Moench.

GOEPPERT'S (1855) BETULACEOUS SPECIES INCLUDING SPECIMENS BELONGING TO OTHER FAMILIES AND THOSE TO BE EXPUNGED

Betula dryadum Brongn., Goeppert 1855
pl. 3, fig. 1

Material. Specimen MGUWr 674p/4.
= *Betula similis* (Goeppert) Zastawniak & Walther comb. nov.

Betula subtriangularis Goeppert 1855
pl. 3, fig. 2

Material. Specimen MGUWr 732p.
= Betulaceae gen. et spec. indet.

Betula angulata Goeppert 1855
pl. 3, fig. 3

Material. Specimen MGUWr 735p/3.
A small leaf which Goeppert described as *Betula angulata* shows the typical morphology of *Platanus leucophylla* (Unger) Knobloch.

Betula flexuosa Goeppert 1855
pl. 3, fig. 4

Material. Specimen MGUWr 734p.
= *Alnus julianiformis* (Sternberg) Kvaček & Holý

Betula caudata Goeppert 1855
pl. 3, fig. 5

Material. Specimen MGUWr 733p/1+2.
= *Alnus julianiformis* (Sternberg) Kvaček & Holý

Betula attenuata Goeppert 1855,
pl. 3, fig. 6

Material. Specimen MGUWr 736p.
The original is broken into many small frag-

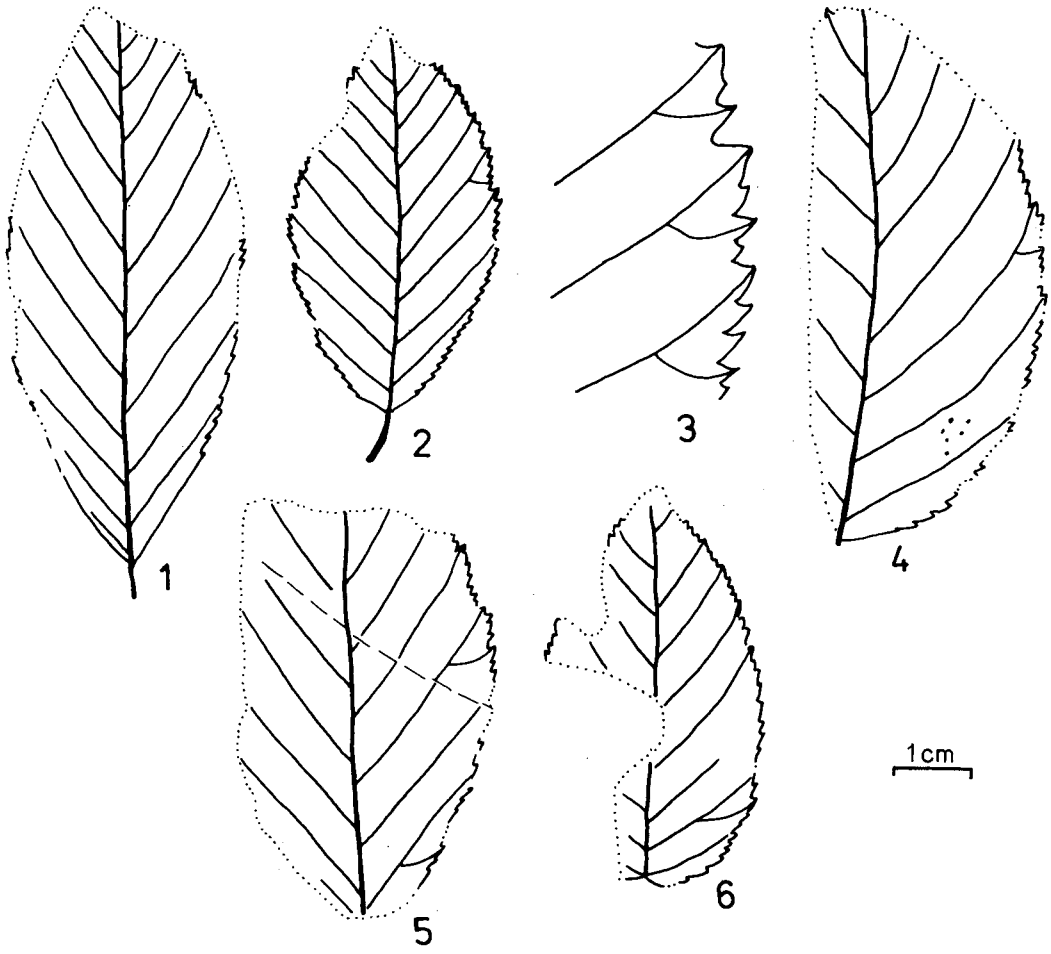

Fig. 21. *Ostrya kryshtofovichii* Baik. ex Stephyrtza: **1** – KRAM-P 54/156/I, **2** – KRAM-P 54/347, **3** – KRAM-P 54/347, enlargement of the leaf margin, **4** – KRAM-P 54/346, **5** – KRAM-P 54/176, **6** – KRAM-P 54/511

ments, which makes identification impossible. According to Goeppert's 1855 (pl. 3, fig. 6) illustrations, the leaf remains appear to be those of *Pterocarya*.

Betula crenata Goeppert 1855
pl. 3, figs 7, 8

Material. Specimen MGUWr 737p (fig. 8 – specimen missing).

= *Alnus adscendens* (Goeppert) Zastawniak & Walther

Betula subpubescens Goeppert 1855
pl. 3, fig. 9

Material. Specimen MGUWr 731p.

The drawing is most probably a product of the imagination. Only the upper part of the leaf with some secondary veins and teeth is visible on the specimen. The teeth are similar to those of *Alnus adscendens*. The specimen is, however, included in Betulaceae gen. et sp. indet. because it is too incomplete.

Betula mucronata Goeppert 1855
pl. 3, fig. 10

Material. Specimen MGUWr 2593p, twin impression 2588p.

On rechecking the illustration against the original, we found the venation and dentation suggest that the leaf does not belong to the Betulaceae but should be assigned to *Ulmus carpinoides* Goeppert. The upper part of the leaf is damaged and does not show the mucronate apex visible in the illustration.

Betula prisca Ett. Goeppert 1855
pl. 3, fig. 11

Material. Specimen missing.

= ?*Carpinus grandis* Unger (Hummel 1991b)

Betula prisca Ett. Goeppert 1855
pl. 3, fig. 12

Material. Specimen MGUWr 850p.

= *Carpinus grandis* Unger (Hummel 1991a)

Betula parvula Goeppert 1855
pl. 3, fig. 13

Material. Specimen MGUWr 728p/1.

This is, in all probability, a young leaf of *Alnus*; no closer determination is possible.

Betula denticulata Goeppert 1855
pl. 3, figs 14, 15

Material. Specimens MGUWr 729p, 730p.

= *Alnus julianiformis* (Sternberg) Kvaček & Holý

Betula carpinoides Goeppert 1855
pl. 3, fig. 16

Material. Specimen MGUWr 727p.

The prominent venation of the second order, asymmetrical lamina base and type of marginal teeth refer these remains to *Ulmus carpinoides* Goeppert.

Betula subovalis Goeppert 1855
pl. 3, fig. 17

Material. Specimen MGUWr 726p.

=*Alnus adscendens* (Goeppert) Zastawniak et Walther

The leaf on the specimen is, in fact, inflexed, on the drawing it has been "straightened".

Semen-*Bet.* Goeppert 1855
pl. 3, fig. 19

Material. Specimen MGUWr 851p/1, 2.

Specimen No MGUWr 851p/1 is very poorly preserved. Specimen No MGUWr 851p/2 is not a fossil betulaceous seed but anther remains ca 3 mm long of uncertain origin (M. Łańcucka-Środoniowa, oral inf.).

Alnus pseudoglutinosa Goeppert 1855
pl. 4, fig. 1

Material. Specimen No MGUWr 704p/1, 2.

= *Alnus adscendens* (Goeppert) Zastawniak et Walther

Alnus pseudoglutinosa Goeppert 1855
pl. 4, fig. 2

Material. Specimen MGUWr 705p/1, with Goeppert's label: *Alnus devia* Goeppert.

Fragment of a leaf of *Ulmus*.

Alnus devia Goeppert 1855
pl. 4, fig. 3

Material. Specimen MGUWr 705p/2.

The basal part of the original is damaged; in no case does the leaf-stalk occur as shown in Pl. 4, fig. 3; neither is the configuration of the margin recognizable. The venation would allow the specimen to be assigned to either the Betulaceae or the Ulmaceae. The original is therefore indeterminable and should be expunged.

Alnus rotundata Goeppert 1855
pl. 4, fig. 4

Material. Specimen MGUWr 706p.

= *Alnus adscendens* (Goeppert) Zastawniak et Walther

Alnus similis Goeppert 1855
pl. 4, fig. 5

Material. Specimen MGUWr 707p.

=*Betula similis* (Goeppert) Zastawniak et Walther comb. nov., lectotype.

Alnus macrophylla Goeppert 1855
pl. 4, fig. 6

Material. Specimen missing.

= *Alnus adscendens* (Goeppert) Zastawniak et Walther

Carpinus ostryoides Goeppert 1855
pl. 4, fig. 7

Material. Specimen MGUWr 709p, twin impression 929p/1.

The twin impression is illustrated by Reimann (1919) as *Carpinus grandis* Unger (pl. 3, fig. 5). The specimen belongs to *Ulmus carpinoides* Goeppert.

Carpinus ostryoides Goeppert 1855
pl. 4, figs 8, 9 (fig. 10 – specimen missing)

Material. Specimen MGUWr 950p/2, 710p.

= *Carpinus grandis* Unger

Carpinus alnifolia Goeppert 1855
pl. 4, fig. 11

Material. Specimen MGUWr 711 with original label.

= ?*Alnus adscendens* (Goeppert) Zastawniak et Walther

The same specimen was illustrated by Re-

imann (1919) in pl. 4, fig. 10 as *Carpinus grandis*. Unfortunately, the specimen MGUWr 711p was later damaged and now only a small part of the leaf base is visible.

Alnus macrophylla Goeppert 1855
pl. 5, fig. 1

Material. Specimen MGUWr 739p.
= *Alnus adscendens* (Goeppert) Zastawniak et Walther

Carpinus adscendens Goeppert 1855
pl. 5, fig. 2

Material. Specimen MGUWr 741p.
= *Alnus adscendens* (Goeppert) Zastawniak et Walther, lectotype.

Fructus *Carpini* Goeppert 1855
pl. 5, fig. 3

Material. Specimen MGUWr 844p.
By no means does the drawing correspond to the original. It can only be identified as a *Fagus* cupule. All the other fossils referred to as fruit remains are products of the imagination.

Semen *Carp.* Goeppert 1855
pl. 5, fig. 7

Material. Specimen MGUWr 846p.
According to Prof. M. Łańcucka-Środoniowa (oral inf.), these are the remains of a bud of uncertain systematic position.

Carp. involvens Goeppert 1855
pl. 5, fig. 8

Material. Specimen missing.
The drawing suggests that the remains are possibly those of "*Getonia*" *membranosa* Goeppert = *Hydrangea membranosa* (Goeppert) Mai (Mai 1985).

Ament. mas *Betulae*. Goeppert 1855
pl. 22, fig. 12

Material. Specimen missing.
Following Kräusel (1920, p. 367) this is a male cone of *Pinus*.

Squama *Betulae*. Goeppert 1855
pl. 26, fig. 20

Material. Specimen MGUWr 1033p/1 with Goeppert's label "Squama *Betulae*".
The specimen is badly damaged; the scale flaps illustrated in Goeppert's work are not visible and the remains are indeterminable.

Amenta *Carpin.* Goeppert 1855
pl. 26, fig. 26

Material. Specimen MGUWr 983p/22.
Represented here are male inflorescences of *Betula* sp. (*Betula* sp. (?) Kräusel 1920, pl. 21, fig. 4)

GOEPPERT'S ORIGINAL SPECIMENS OF THE FAGACEAE WHICH BELONG TO THE BETULACEAE

Fagus attenuata Goeppert 1855
pl. 5, fig. 9

Material. Specimen MGUWr 2584p.
= *Carpinus grandis* Ung. (non *Alnus julianiformis* (Sternberg) Kvaček & Holý, see Walther & Zastawniak 1991 p. 160)

Fagus inaequalis Goeppert 1855
pl. 5, fig. 10

Material. Specimen MGUWr 740p + twin impression 818p/I
= *Alnus julianiformis* (Sternberg) Kvaček & Holý
In his first revision of the flora from Sośnica Reichenbach (1919 p. 126) questioned whether *Fagus inaequalis* (Goeppert 1855, pl. 5, fig. 10) really were the remains of *Fagus*. He drew attention to the asymmetrical leaf base, the long, slender petiole and the very large areas between the secondary veins. Raniecka-Bobrowska (1954, p. 20) identified this leaf from Sośnica as "*Rhamnus gaudinii*" Heer. Weyland (1942) included the leaves of *Rhamnus gaudinii* Heer from Kreuzau in *Alnus palaeojaponica* Weyland. Undoubtedly, this leaf belongs to *Alnus*.

Fagus dentata Goeppert 1855
pl. 5, fig. 11, Reichenbach 1919, p. 125, fig. 11

Material. Specimen MGUWr 556.
= *Alnus adscendens* (Goeppert) Zastawniak et Walther

Quercus venosa Goeppert 1855
pl. 8, fig. 3

Material. Specimen missing.
= *Alnus julianiformis* (Sternberg) Kvaček et Holý

Quercus attenuata Goeppert 1855
pl. 8, fig. 4

Material. Specimen MGUWr 743p (leaf base missing).

= *Alnus julianiformis* (Sternberg) Kvaček et Holý

Quercus attenuata Goeppert 1855
pl. 8, fig. 5

Material. Specimen missing

= *Alnus julianiformis* (Sternberg) Kvaček & Holý (Knobloch & Kvaček 1976)

Quercus ovata Goeppert 1855
pl. 8, fig. 8

Material. Specimen missing.

= *Alnus adscendens* (Goeppert) Zastawniak et Walther

Drawing depicting teeth of specimen probably erroneous.

SPECIMENS FROM GOEPPERT'S COLLECTION FOR WHICH THE ORIGINAL LABELS WERE FOUND TO BE INCORRECT

Specimen MGUWr 525p with Goeppert's label *Betula dryadum* Brongn.

= *Zelkova zelkovaefolia* (Unger) Bůzek et Kotlaba

Specimen MGUWr 537p/1 with Goeppert's label *Betula caudata*

= *Liquidambar europaea* A. Br.

Specimen MGUWr 548p/12 with Goeppert's label "fructus *Carpinii*"

Specimen destroyed, indeterminable.

Specimen MGUWr 711p with Goeppert's label: *Alnus macrophylla*, orig. zu Taf. IV, fig. 11 *Carpinus alnifolia*

Only the small, basal part of the betulaceous leaf is visible on the specimen.

Specimen MGUWr 864p has Goeppert's original label "Amentum masculum Betulae Taf. XXII, Fig. 6", whereas pl. 22, fig. 6 in Goeppert's paper shows "fem. Amenta *Salicin*". Moreover, the specimen is indeterminable. The information given on the label attached to it does not agree with the illustration in Goeppert's paper, neither does it relate to the specimen itself on whose surface there are no identifiable impressions.

Specimen MGUWr 5020p with Goeppert's label: *Betula parvula* = ?? Betulaceae

Specimen MGUWr 5022p with Goeppert's label:*Alnus similis*.

Probably Betulaceae, but only a small part of the leaf base is visible.

Specimen MGUWr 5119p with Goeppert's label: *Alnus similis*.

Deformed leaf of Betulaceae, probably *Carpinus*.

Specimen MGUWr 5130p with Goeppert's label: *Betula prisca*.

Deformed leaf of Betulaceae, but non *Betula*.

Specimen MGUWr 5179p/1 with original label: *Carpinus ostryoides*.

Indeterminable member of Betulaceae.

GENERAL REMARKS

The following picture has been obtained on the basis of the present investigation of the Betulaceae from Sośnica. *Carpinus grandis* Unger is the taxon yielding the greatest number of individuals. Also the relatively frequent presence of involucres suggests the common occurrence of *Carpinus* L. The genus *Betula* L. is represented by the leaves of *Betula similis* (Goeppert) Zastawniak et Walther comb. nov. and some remarkably well-preserved flower and fruit remains. *Alnus adscendens* (Goeppert) Zastawniak et Walther and *Alnus julianiformis* (Sternberg) Kvaček & Holý are frequent, with the remaining taxa *A. gaudini* (Heer) Knobloch et Kvaček, *Alnus cecropiaefolia* (Ett.) Berger and *Alnus menzelii* Raniecka-Bobrowska occurring less often or only occasionally. Fruiting bodies of *Alnus* Gaertn. are only sporadically recorded from Sośnica (Kräusel 1920).

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PLATES

Plate 1

Alnus adscendens (Goeppert) Zastawniak et Walther

1. Specimen No MGUWr 2288p/I

1a. Abaxial cuticle, stomata in the intercostal region, MGUWr 2288p/I, MMG So 42/77, × 400

1b. Adaxial cuticle, leaf margin cells, MGUWr 2288p/I, MMG So 43/77, × 500

1c. Abaxial cuticle, multicellular base of the peltate glandular trichome, MGUWr 2288p/I, MMG So 43/77, × 500

1d. Abaxial cuticle, "giant stomata", MGUWr 2288p/I, MMG So 20/92, × 500

1e. Abaxial cuticle, stomata, leaf margin cells, MGUWr 2288p/I, MMG So 43/77, × 500

2. Specimen No MGUWr 523p/2

3. Specimen No MGUWr 820p/1

4. Specimen No MZ VII/53/353

5. Specimen No MGUWr 686p/3 (Reimann 1919, pl. 3, fig. 6: ?*Betula prisca* Ett. ?)

1, 2–5 photo A. Pachoński
1a–1e photo H. Walther


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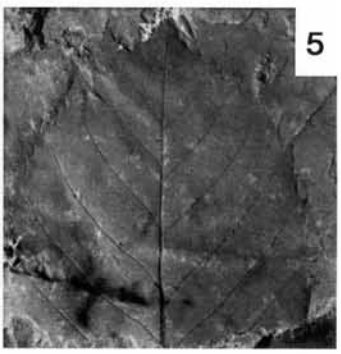
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Plate 2

Alnus adscendens (Goeppert) Zastawniak et Walther

1. Specimen No MGUWr 1172p

1a. Abaxial epidermis, arrangement of stomata, unicellular trichome base, MGUWr 1172p, MMG SO 7/93, × 820

1b. Adaxial epidermis, veinlets with unicellular trichome base, MGUWr 1172p, MMG So 8/93, × 820

1c. Abaxial epidermis, four-celled trichome base, MGUWr 1172p, MMG So 4/93, × 820

1d. Abaxial epidermis, multicellular trichome base, MGUWr 1172p, MMG So 8/93, × 400

1e. Abaxial epidermis, base of peltate trichome, "normal" stomata and "giant" stomata (heterostomata), MGUWr 1172p, MMG So 8/93, × 820

2. Specimen No KRAM-P 54/86

Alnus cecropiaefolia (Ett.) Berger

3. Specimen No MGUWr 521p/1 (Goeppert's label: *Alnus macrophylla*)

1–3 photo A. Pachoński
1a–1e photo H. Walther


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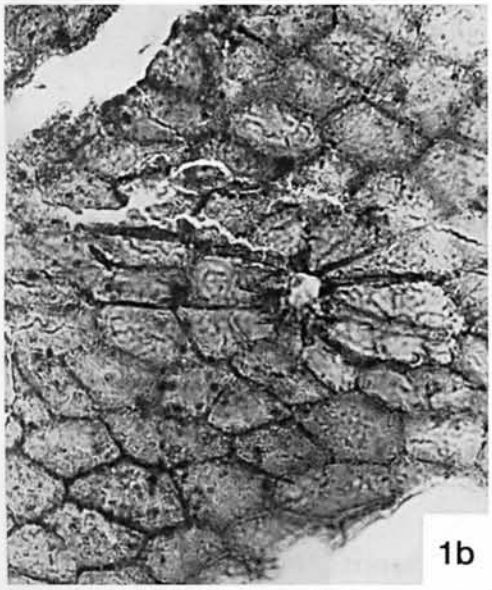
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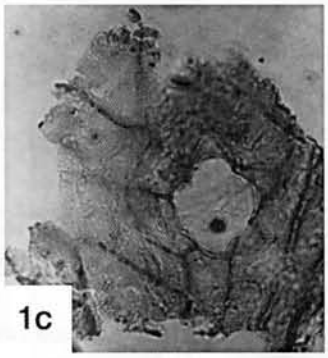
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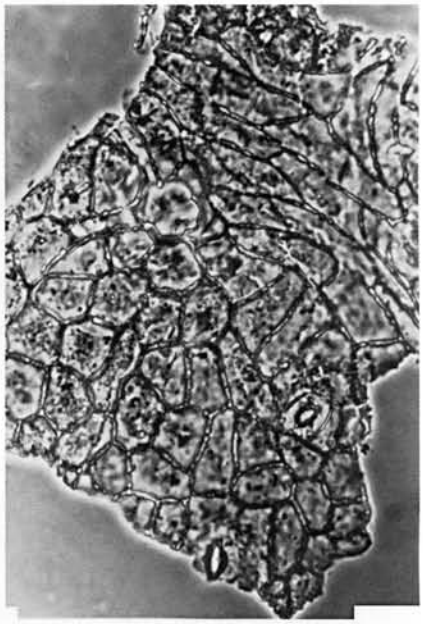
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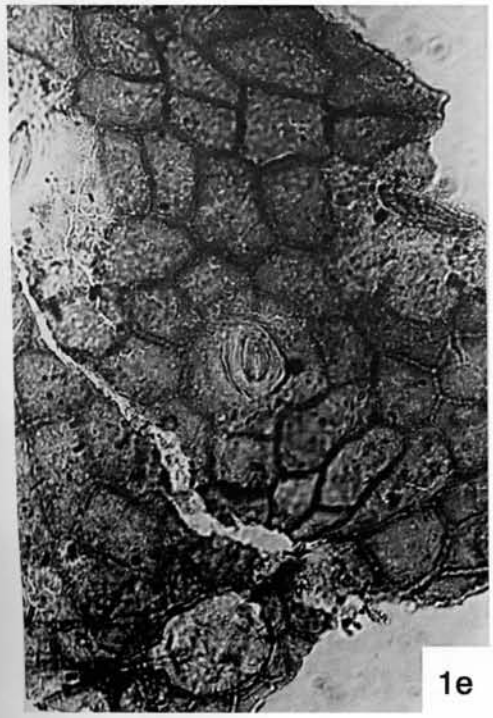
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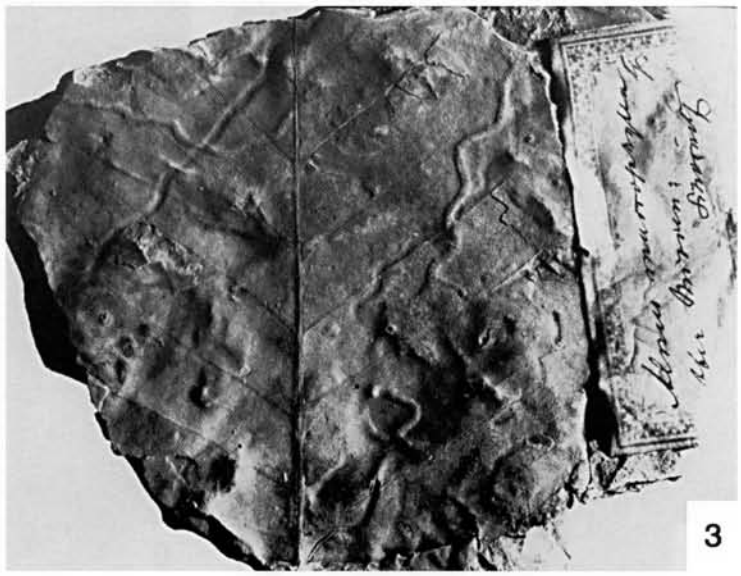
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Plate 3

Alnus kefersteinii (Goeppert) Unger – strobiles

1. Specimen MP, sine numero

1a. Ibidem, × 2

2. Specimen MP, sine numero

2a. Ibidem, × 2

Alnus sp. – male inflorescence

3. Specimen No 819p/1, × ca 6 (Goeppert 1855, pl. 14, fig. 23: Fructus *Myricae*; Kräusel 1920, pl. 20, fig. 9: *Alnus* sp. (cf. *viridis* DC. ?)

Alnus adscendens (Goeppert) Zastawniak et Walther

4. Specimen No MGUWr 726p (Goeppert 1855, pl. 3, fig. 17, the leaf on the drawing has been "straightened")

5. Specimen No MGUWr 2585p

6. Specimen No MGUWr 523p/1

6a. Enlargement of leaf margin, × 2

7. Specimen No MGUWr 739p (Goeppert's label: *Alnus macrophylla*, Goeppert 1855, pl. 5, fig. 1: *Alnus macrophylla*, Reimann 1919, pl. 2, fig. 11: *Betula macrophylla*

8. Specimen No MGUWr 1896p

9. Specimen No MGUWr 1157p/2

10. Specimen No MGUWr 741p, lectotype (Goeppert 1855, pl. 5, fig. 2: *Carpinus adscendens*, Reimann 1919, pl. 3, fig. 17: *Alnus rotundata*)

photo A. Pachoński


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Plate 4

Alnus adscendens (Goeppert) Zastawniak et Walther

1. Specimen No KRAM-P 54/170/I
2. Specimen No MGUWr 556p (Goeppert 1855, pl. 5, fig. 11: *Fagus dentata*)

2a. Enlargement of leaf margin, × 2

3. Specimen No MGUWr 792p/3/I from Kokoszyce [Kokoschütz]
4. Specimen No KRAM-P 54/82/I

4a. Enlargement of leaf margin, × 2

6. Specimen No MG PIG 46.III.107
7. Specimen No KRAM-P 54/87
8. Specimen No MG PIG 46.III.244
9. Specimen No KRAM-P 54/117

Betula similis (Goeppert) Zastawniak et Walther comb. nov.

5. Specimen No 54/90/I

Betula longisquamosa Mädler – bract

10. Specimen No KRAM-P 54/407, × 7

photo A. Pachoński

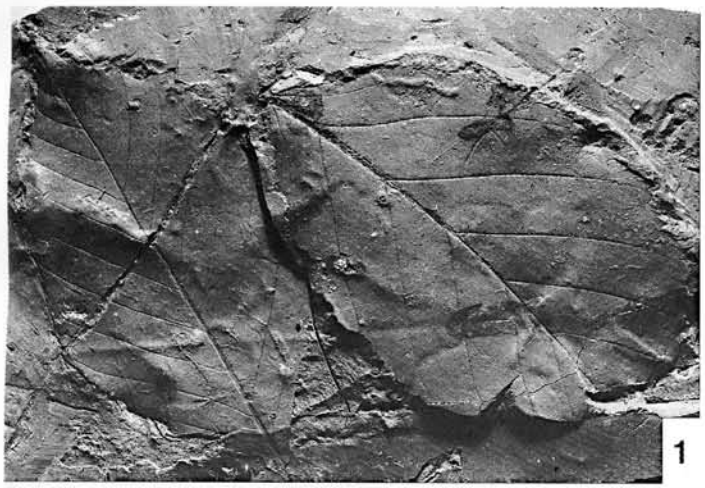
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Plate 5

Betula similis (Goeppert) Zastawniak et Walther comb. nov.

1. Specimen No KRAM-P 54/843
1a. Enlargement of leaf, × 2
2. Specimen No KRAM-P 54/83/I
2a. Enlargement of leaf, × 2
3. Specimen No MGUWr 707p, lectotype (Goeppert's label: *Alnus similis*, Goeppert 1855, pl. 4, fig. 5: *Alnus similis*)
3a. Enlargement of leaf, × 2
4. Specimen No KRAM-P 54/88
5. Specimen No KRAM-P 54/85
5a. Enlargement of leaf, × 2
6. Specimen No MG PIG 46.III.225
7. Specimen No KRAM-P 54/89/I

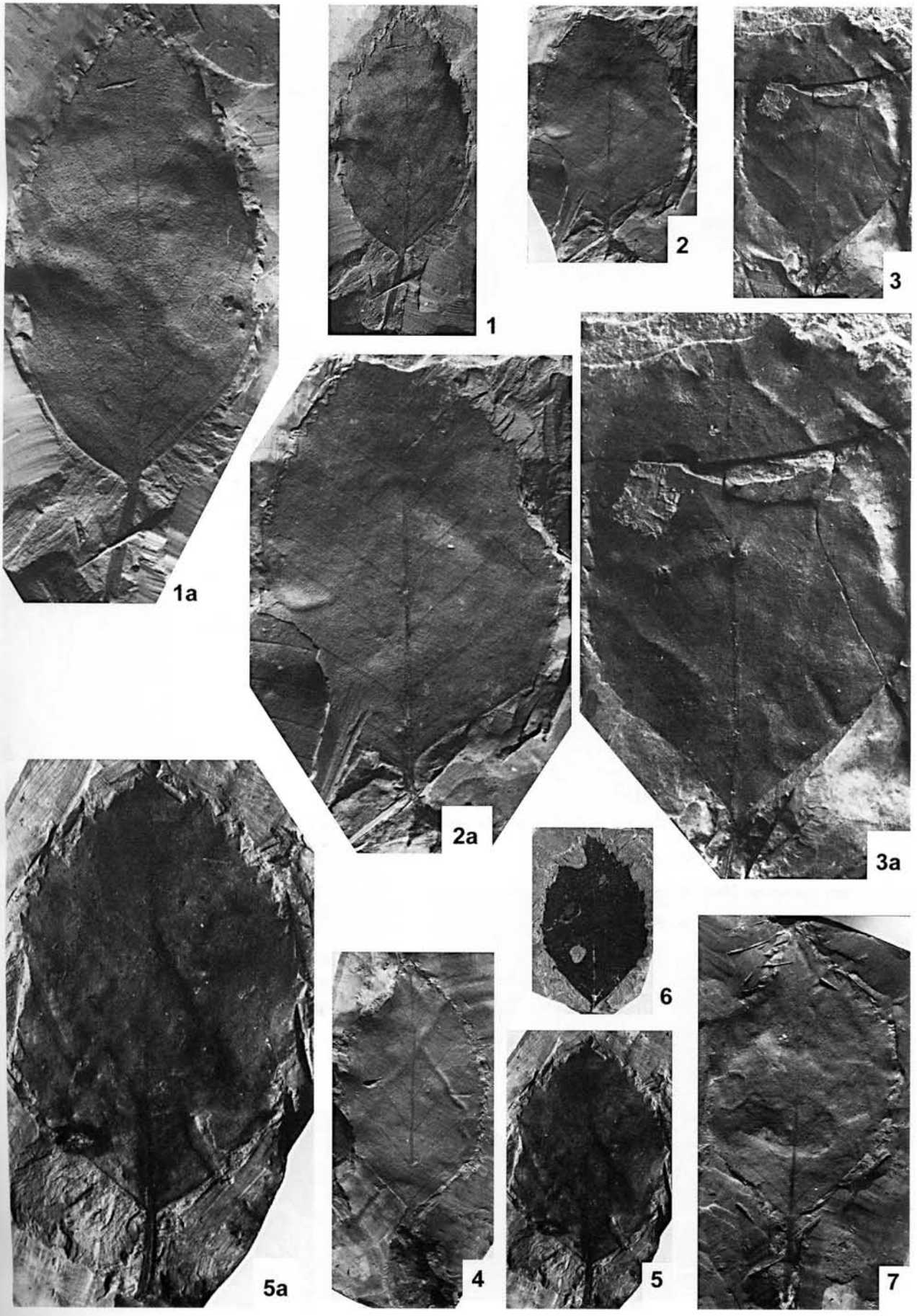
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Plate 6

Betula longisquamosa Mädler, winged nut with stigmas

1. Specimen No MGUWr 2279p/V, × 7
2. Specimen No MZ VII/53/340, × 7
3. Specimen No MGUWr 854p/I, × 7

Betula longisquamosa Mädler, three-lobed bract, × 7

4. Specimen No KRAM-P 54/490

Betula sp. – male inflorescences

5. Specimen No MGUWr 983p/22, × 2

Betula similis (Goeppert) Zastawniak et Walther comb. nov.

6. Specimen No KRAM-P 54/958

6a. Enlargement of leaf, × 2

7. Specimen No KRAM-P 54/31/II

7a. Enlargement of leaf, × 2

8. Specimen No KRAM-P 54/911/I

Betulaepollenites sp. – pollen grains isolated from male inflorescences of *Betula*

9. From specimen MGUWr 880p/27, × 300
10. From specimen MGUWr 880p/30, × 300
11. From specimen MGUWr 880p/30 × 2.500

1–8 photo A. Pachoński
9, 10 photo I. Grabowska
11 photo M. Ziembińska


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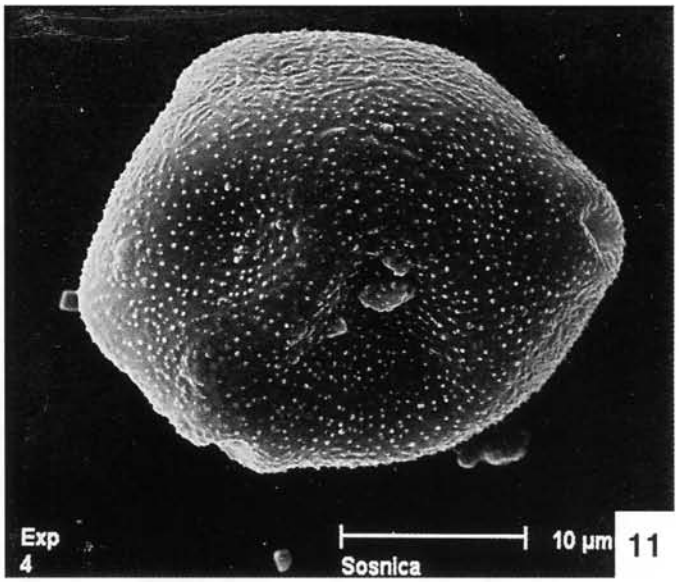

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Plate 7

Alnus gaudinii (Heer) Knobloch et Kvaček

1. Specimen No MG PIG 46.III.264

1a. Abaxial cuticle, stomata and peltate trichome, × 400, MMG So 49/92

1b. Abaxial cuticle, anomocytic stomata, × 400, MMG So 46/92

1c. Abaxial cuticle, isolated peltate trichome, × 400, MMG So 43/92

Alnus julianiformis (Sternberg) Kvaček et Holý

2. Specimen No MGUWr 729p (Goeppert 1855, pl. 3, fig. 14: *Betula denticulata*)

3. Specimen No KRAM-P 54/420

4. Specimen No MGUWr 1616p/I

5. Specimen No MGUWr 730p (Goeppert's label: *Bet*...III, 14, 15; Goeppert 1855, pl. 3, fig. 15: *Betula denticulata*)

Alnus gaudinii (Heer) Knobloch et Kvaček

6. Specimen No MGUWr 2131p

Alnus julianiformis (Sternberg) Kvaček et Holý

7. Specimen No MGUWr 2247p

Alnus gaudinii (Heer) Knobloch et Kvaček

8. Specimen No MG PIG 46.III.297, MMG So 27/88, 28/88

Alnus julianiformis (Sternberg) Kvaček et Holý

9. Specimen No KRAM-P 54/535

10. Specimen No KRAM-P 54/321

1–3, 5, 7, 9, 10 photo A. Pachoński
1a–1c photo H. Walther
4, 6, 8 photo B. Bastian


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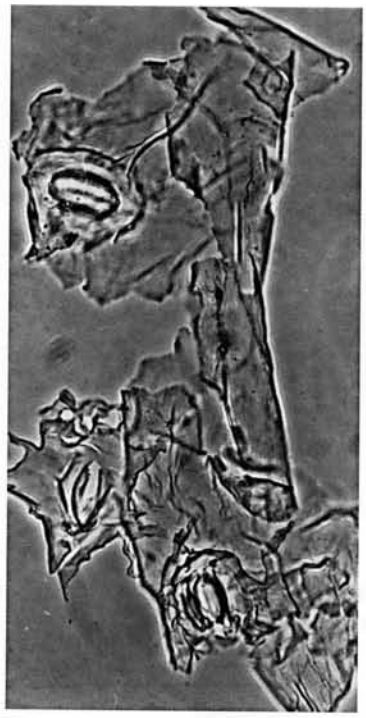
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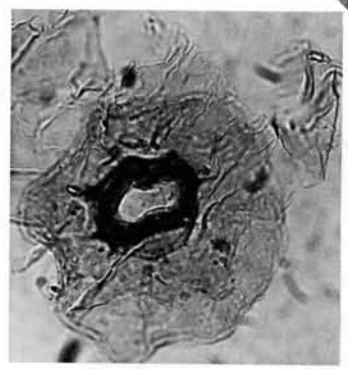
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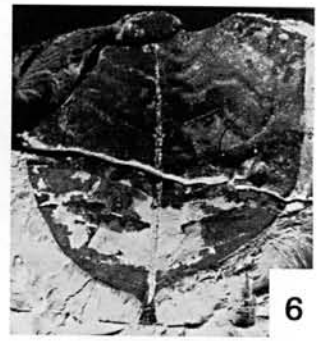
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Plate 8

Alnus julianiformis (Sternberg) Kvaček et Holý

1. Specimen No MGUWr 743p
2. Specimen No MGUWr 734p (Goeppert's label: *Betula flexuosa*, Goeppert 1855, pl. 3, fig. 4: *Betula flexuosa*; Reimann 1919, pl. 5, fig. 1: *Carpiniphyllum caudatum*)
3. Specimen No MGUWr 1933p
4. Specimen No KRAM-P 54/111

Ostrya kryshtofovichii Bayk. ex Stephyrtza

5. Specimen No KRAM-P 54/156/I
6. Specimen No KRAM-P 54/176

6a. Enlargement of leaf margin, × 2

Alnus julianiformis (Sternberg) Kvaček et Holý

7. Specimen No MG PIG 46.III.230, MMG So 21/92–24/92
8. Specimen No MG PIG 46.III.242

Ostrya kryshtofovichii Bayk. ex Stephyrtza

9. Specimen No KRAM-P 54/347

Alnus julianiformis (Sternberg) Kvaček et Holý

10. Specimen No MGUWr 733p/1 (Goeppert's label: *Betula caudata*, Goeppert 1855, pl. 3, fig. 5: *Betula caudata*)

Ostrya kryshtofovichii Baik. ex Stephyrtza

11. Specimen No KRAM-P 54/511

11a. Enlargement of leaf margin, × 2

Photo A. Pachoński


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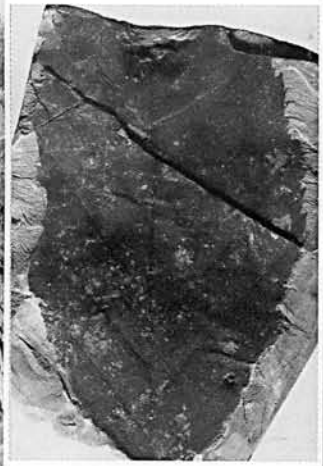
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Plate 9

Carpinus grandis Unger

1. Specimen No MGUWr 2046p

1a. Lower epidermis, MMG So 21/77, × 400

2. Upper epidermis, specimen No MGUWr 1815p, MMG So 13/77, × 400

2a. Lower epidermis, MMG So 12/77, × 400

3. Upper epidermis, KRAM-P 54/649, MMG So 26/92, × 500

4. Specimen No KRAM-P 54/172/I, with the fruit of *Pterocarya limburgensis* C. et E. M. Reid on the surface of leaf impression

5. Specimen No MGUWr 517p/I

5a. Whole leaf, × 2

Carpinus grandis Unger

6. Specimen No MG PIG 46.III.214

7. Specimen No KRAM-P 54/171

8. Specimen No KRAM-P 54/264

Alnus menzelii Raniecka-Bobrowska

9. Specimen No MG PIG 46.III.103

Carpinus grandis Unger

10. Specimen No MGUWr 2346p, × 2

11. Specimen No KRAM-P 54/1156/I


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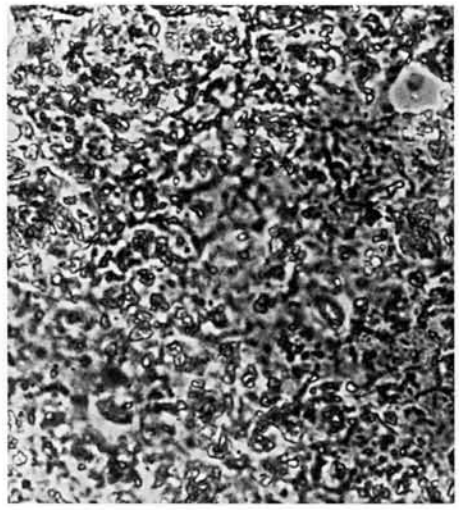
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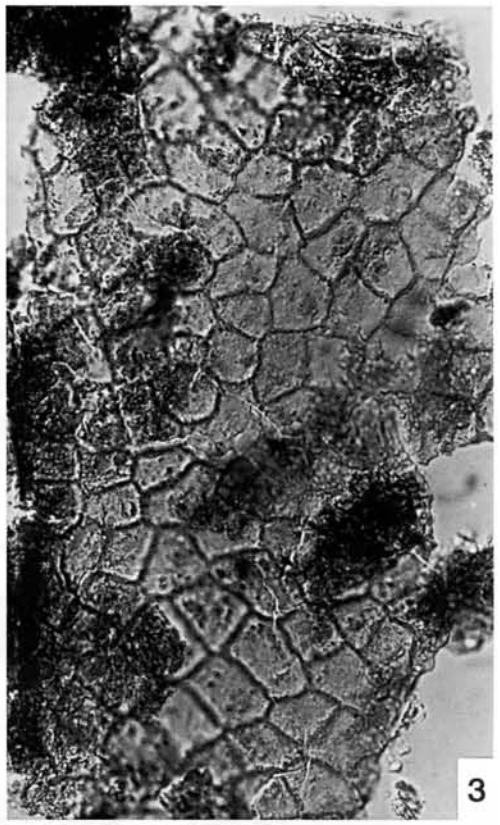
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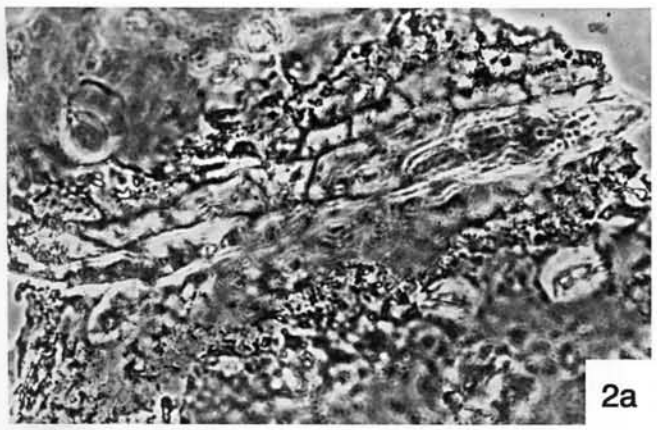
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Plate 10

Carpinus grandis Unger

1. Specimen No MGUWr 710p (Goeppert 1855, pl. 4, fig. 9: *Carpinus ostryoides*, Reimann 1919, pl. 4, fig. 15: *Carpinus grandis*)
2. Specimen No MGUWr 1011p/8

Betula similis (Goeppert) Zastawniak et Walther comb. nov.

3. Specimen No KRAM-P 54/43/III

Carpinus grandis Unger

4. Specimen No MGUWr 2040p/I, MMG So 12/93–21/93
5. Specimen No MGUWr 1151p/1
6. Specimen No MG PIG 46.III.240
7. Specimen No MGUWr 1580p/1
8. Specimen No MGUWr 1837p/II
9. Specimen No KRAM-P 54/952/I
10. Specimen No MGUWr 1154p
11. Specimen No KRAM-P 54/329/II
12. Specimen No MZ VII/53/178
13. Specimen No 2227p

13a. Enlargement of leaf, × 2

1–11, 13 photo A. Pachoński
12 photo Maria Małachowska-Kleiber


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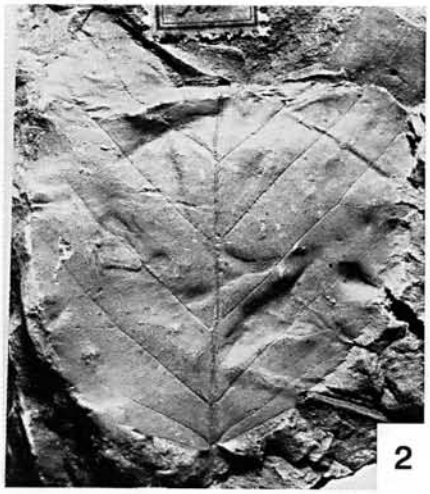
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E. Zastawniak & H. Walther
Acta Palaeobot. 38(1)

Plate 11

Carpinus grandis Unger

1. Specimen No KRAM-P 54/331/I
2. Specimen No MGUWr 2040p, MMG So 12/93–21/93, × 2
3. Specimen No MGUWr 2592p
4. Specimen No MG PIG 46.III.277, with *Taxodium dubium* (Sternberg) Heer
5. Specimen No 850p (Goeppert's label: *Betula prisca*, Goeppert 1855, pl. 3, fig. 12: *Betula prisca* Ett. Reimann 1919, pl. 2, fig. 12: *Betula prisca* Ett.

5a. Enlargement of leaf margin × 2

Carpinus betulus L. *fossilis* Engelhardt et Kinkelin, involucres

6. Specimen No MGUWr 891p/II, × 1.5
7. Specimen No KRAM-P 54/449, × 1.5
8. Specimen No KRAM-P 54/451, × 1.5
9. Specimen No MZ VII/53/61, × 1.5
10. Specimen No KRAM-P 54/448, × 1.5
11. Specimen No MZ VII/53/182, × 1.5
12. Specimen No KRAM-P 54/446, × 1.5
13. Specimen No MG PIG 46.III.116
14. Specimen No MGUWr 845p (Goeppert 1855, pl. 5, fig. 5: Fructus *Carpini*, Reimann 1919, pl. 3, fig. 18: *Carpinus grandis* Unger)

14a. The same involucre, × 2

15. Specimen No MGUWr 2058p
16. Specimen No MZ VII/53/181, × 1.5
17. Specimen No MGUWr 849p/I, × 2 (Goeppert's label: *Carpini* semen Schossnitz V.4., Goeppert 1855, pl. 5, fig. 4: Fruct. *Carp.*, Reimann 1919, pl. 3, fig. 4: *Carpinus grandis* Unger) *Carpinus betulus* L. type – fruits
18. Specimen No MZ VII/53/183, × 3

19, 20. Specimens No KRAM-P 54/708–1 × 3


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