MORPHOLOGY OF POLLEN GRAINS OF THE JUGLANDACEAE

Morfologia pylku rodziny Juglandaceae

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The *Juglandaceae* probably appeared in the Upper Cretaceous and were apparently wide-spread in the Tertiary. Of the existing genera we should mention the following five which are well known and often encountered in fossil form in Tertiary deposits:

1. *Juglans* L. — tropic, subtropic and temperate zone of Northern Hemisphere of Asia and America. In the Southern Hemisphere it appears only in Brazil and the Andes. *Juglans* is a component of mixed forests growing in the mountains.

2. *Carya* Nutt. — temperate zone of North America.

3. *Pterocarya* Kunth. — Caucasus, China, Japan.

4. *Engelhardtia* Leschen. — Indo-Malayan Archipelago, China.

5. *Platycarya* Sieb. et. Zucc. — Japan, North China. Besides these five genera of this family there are three monotypic genera:

6. *Alfaroa* Standley — Costarica.

7. *Ramphocarya* Kuang — China.

8. *Oreomunea* Oerst. — Costarica.

The number of the species belonging to the first four genera differs remarkably among different authors. For the genus *Juglans* this number varies from 12 (J. C. Willis) to 69 (Index Kewensis). For *Carya* from 12 (Willis) to 43 (Index Kewensis). For *Pterocarya* from 4 (Willis) to 20 (Ind. Kewensis). For *Engelhardtia* from 10 (Willis) to 16 (Ind. Kewensis).

The present paper contains a description of the morphology of pollen grains of 32 species belonging to five genera of the *Juglandaceae*. The described material has been taken from Lauterbach's Herbarium of the

Botanic Institute in Wrocław, from the Herbarium of the Botanic Institute in Kraków, and also from Herbaria in Kew Gardens and British Museum (London) and of the Royal Botanic Garden in Edinburgh.

METHODS

The pollen material was prepared for the study by means of the acetolysis method of Erdtman (1954). The measurements were carried on one hundred normally developed pollen grains of each species. On the basis of measurements the lower and upper size limit and modal size were established. The outline of pollen grains of all described species is usually regular (circular, triangular or angular) so one measurement of each grain was sufficient. The microphotographs were made by applying an eyepiece of $\times 10$ and objective of $\times 40$, the pictures being enlarged to $\times 1000$. The photographs were taken of the grains with the features appearing most frequently.

THE CHARACTERISTIC OF POLLEN GRAINS IN THE FAMILY JUGLANDACEAE

The pollen grains in this family are very simple. Suboblate, oblate, spheroidal or quite spherical; exine without distinct sculpture and furrows, in most species only more or less granular. Pores conspicuously or slightly aspidate, or going deeply into exine. All the germ pores, or the great part of them, arranged equatorially. The exineous thickenings with distinct granulation surround the pores nearly always. The outline of the grains in polar view is circular or angular. The diameter in polar position $13,5\ \mu$ (*Engelhardtia Wallichiana*) to $96,5\ \mu$ (*Carya ovalis*).

KEY TO THE GENERA

- I. Pores limited to one hemisphere. The exineous thickenings thin but extensive.
 - A. Grains oblately-spheroidal, 31 to $58\ \mu$ in diameter, pores more than three, generally 12 — 17 . Exineous thickenings not fused. Texture smooth or finely granular

Juglans
 - B. Grains nearly or quite spheroidal, $36,4$ to $96,5\ \mu$ in diameter, pores generally 3 , occasionally 4 , 5 or 6 . Exineous thickenings completely fused, somewhat encroaching on the other hemisphere. Texture smooth or granular

Carya

II. Most pores arranged equatorially. The exineous thickenings of small extent.

A. Grains decidedly flattened, angular in outline, 24,5 to 46,8 μ in diameter, pores 3—10, mostly equatorially arranged. Texture smooth or finely granular

Pterocarya

B. Grains oblately flattened, circular or angular in outline, 13,5 to 31,5 μ in diameter. Pores generally 3, occasionally 4 or 5, equatorially arranged. Texture faintly or coarsely granular.

1. Grains circular or angular in outline, 13,5 to 31,5 μ in diameter, pores always 3, their apertures elliptical or circular. Texture faintly granular

Engelhardtia

2. Grains generally triangular in outline, uniform in shape and size, occasionally square, rectangular or pentagonal, 18,7 to 27 μ in diameter. Pores mostly 3, sometimes 4 or 5, slit-shaped. Texture coarsely granular, crossed by arcoid grooves

Platycarya

DESCRIPTION OF THE DISCUSSED GENERA AND SPECIES

Juglans L.

Pollen grains oblately flattened, circular or angular in outline. Number of pores different in particular species, mostly 12 to 17, confined to one hemisphere. About $\frac{2}{3}$ of total number of pores arranged equatorially, the rest being irregularly dispersed all over the hemisphere. Texture smooth or fine granular. The granulosity most distinct around the pores. Exineous thickenings circular, not fused. Pores elliptical or circular. The diameter of grains 31 to 58 μ .

Considerable variation in size of grains within each of described species, variable number of pores and the lack of remarkable features make the particular species of *Juglans* very difficult to recognize; sometimes the identification is quite impossible. Depending upon the degree of thickness of the exine, protrusion of pores and the regularity of outline of the grains as well as upon the way of pore arrangement some provisional groups were established within the eight described species of *Juglans* embracing the most similar among them.

Group I

Grains in outline regularly angular. Exine thick (to 2μ). Pores 11—17, aspidate.

Juglans rupestris Engelm.

Plate I, fig. 1—3

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Pores 11 — 17, mostly regularly arranged around the equator, the remaining dispersed on one hemisphere, Grains 34,3 to 46,3 μ in diameter.

Juglans nigra L.

Plate I, fig. 4—6

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Pores 12 — 17. Grains 33,2 to 45 μ in diameter. Otherwise as in preceding species.

Juglans mollis Engelm.

Plate I, fig. 7, 8

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Grains 40,6 to 56,2 in diameter. Pores 12 — 17. Otherwise as in two preceding species.

Pollen grains of these three species are so similar that only a greater size of some grains of *J. mollis* can help to distinguish this species from the two remaining.

Group II

Grains less regular in outline, exine thinner. Pores 10 — 15, less elevated.

Juglans sigillata Dode.

Plate II, fig. 1, 2

Geographical distribution: China.

Material: Botanic Institute in Wrocław.

Pores 12—15, irregularly arranged around the equator and in one hemisphere, slightly elevated. Exine thin. Diameter of the grains 40,6 to 53,1 μ .

Juglans regia L.

Plate II, fig. 3, 4

Geographical distribution: West Asia.

Material: Botanic Institute in Wrocław.

Pores 10—15, grains 36,7 to 58 μ in diameter. Otherwise as in *J. sigillata*.

Group III

Pores 8—10 not elevated, sometimes even slightly dipped so that the outline of the grains differ from the remaining species and is more similar to grains of *Carya*. The thickenings around the pores more distinct. Diameter 34,3 to 43,7 μ .

Juglans neotropica Diels.

Plate II, fig. 5—7

Geographical distribution: South America.

Material: Botanic Institute in Wrocław.

Distinctly different characteristics of this species do not justify including it in any other group.

Group IV

The outline regularly angular, pores 5—10, slightly, or not, elevated, almost all arranged equatorially; one or two pores outside equator. Grains in this group resemble to grains of *Pterocarya*. Diameter 31,2 to 50 μ .

Juglans Sieboldiana Maxim.

Plate III, fig. 1—4

Geographical distribution: Japan.

Material: Botanic Institute in Wrocław.

Grains 37,5 to 50 in diameter. Pores 7—10.

Juglans cinerea L.

Plate III, fig. 5, 6

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

The most characteristic feature of this group, the arrangement of pores, is presented in the table below:

Arrangement of pores (for one hundred grains)

Species	All pores arranged equatorially	One pore outside the equator	Two pores outside the equator
<i>J. Sieboldiana</i>	2	75	23
<i>J. cinerea</i>	32	64	4

It was not easy to find the features which would characterize particular groups. In all of the described 8 species (with exception of *J. neotropica*) a great variety of forms appears.

Within particular species, besides pollen grains with the most common features, there are also less numerous grains which resemble other species. The great variability in size as seen in the table below, makes the proper classification into species difficult.

Species	Diameter in μ	The most frequent diameter in μ
<i>J. rupestris</i>	34,3 — 46,3	40,6
<i>J. nigra</i>	33,5 — 45,0	38,5
<i>J. mollis</i>	40,6 — 56,2	46,8 — 50,0
<i>J. sigillata</i>	40,6 — 53,1	43,7 — 46,8
<i>J. regia</i>	36,7 — 58,0	40,2
<i>J. neotropica</i>	34,3 — 43,7	37,5
<i>J. Sieboldiana</i>	37,5 — 50,0	43,7
<i>J. cinerea</i>	31,2 — 46,8	37,5

Carya Nutt.

Grains oblate-spheroidal to nearly or quite spherical, in outline circular, rounded-triangular or angular. Number of pores different: gene-

rally 3, about 10% of grains have 4 pores, 1—2% — 5 pores. Pores elliptical to circular, usually equatorially spaced. The thickening around the pores completely fused, covering more than a half of the surface of the grain but leaving polar area always free. Pores not elevated, usually conspicuously depressed. Exine granular, 2—5 μ thick. Diameter of the grains 36,4 to 96,5 μ .

Also in this genus, as in the description of *Juglans*, some groups were established by joining species which show the greatest similarity of features.

Group I

Nearly all the grains three-pored, uniform in shape, triangular or rounded-triangular in outline. The exineous thickenings discrete.

Carya aquatica (Michx.) Nutt.

Plate IV, fig. 1—3

Geographical distribution: North America.

Material from the Herbarium in Kew Gardens.

Grains 36,4 to 54,2 in diameter. Otherwise as in general description of this group.

Carya Pecan (Marsh.) Engl. and Graebner.

Plate IV, fig. 4—6

Syn.: *C. olivaeformis* Nutt., *C. illinoensis* K. Koch.

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Grains 38,5 to 56 μ . Otherwise as in the type.

These two species show no differences with the exception of slightly greater size of grains of *C. Pecan*.

Group II

Germ pores generally three, about 10% of grains four-pored, 1% five-pored. The exineous thickenings more distinct than in the former group. Grains rather irregular in outline.

Carya cordiformis (W a n g h.) K. K o c h

Plate V, fig. 1—3

Syn.: *C. amara* Nutt., *Hicoria cordiformis* Brit., *Hicoria minima* Brit.

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Grains 40,2 to 50,7 μ in diameter.*Carya tomentosa* (L a m.) N u t t.

Plate V, fig. 4—6

Syn.: *C. alba* K. K o c h.

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Grains 45,5 to 59,5 μ in diameter.

In spite of the great similarity of these two species, *C. cordiformis* can be distinguished from *C. tomentosa* by smaller size, more distinct irregularity of outline and more conspicuous thickenings of exine around the pores.

Group III

Pollen grains mostly three-pored, varying in outline from regularly circular, rounded-triangular with sides gently rounded to distinctly triangular and hexagonal. Exineous thickenings conspicuous, extending nearly all over the whole surface of the grain leaving only the polar area covered with thinner exine. This area is usually triangular with thick folds on the sides. Pores regularly spaced on a circle slightly above the equator are responsible for the characteristic appearance of the grain: pores are distinctly seen on the surface of hemisphere, whilst in both former groups pores are always arranged equatorially.

Carya ovata (M i l l.) K. K o c h

Plate VI, fig. 1—3

Syn.: *C. alba* Nutt., *Hicoria ovata* Brit.

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Diameter of the grains 42 to 61,2 μ .

Carya glabra (Mill.) Sweet.

Plate VI, fig. 4—6

Syn.: *C. porcina* (Michx.) Nutt., *Hicoria glabra* (Mill.) Brit.

Geographical distribution: North America.

Material: Botanic Institute in Krakow.

Grains 38,5 to 59,5 μ in diameter.

Pollen grains of both species included to this group are almost identical, the difference being that *C. ovata* has a larger diameter than *C. glabra*.

Group IV

Pores generally three, about 10% of grains four-pored, 1% five-pored. Occasionally some grains with greater number of pores, always much larger than three- or four-pored grains. Pores equatorially arranged, depressed in thick (to 5 μ) exine. Grains circular, rounded-triangular or angular in outline. Exine faintly or distinctly granular.

Carya ovalis (Wangh.) Sarg.

Plate VII, fig. 1—3

Syn.: *C. microcarpa* Nutt., *Hicoria minima* Brit.

Geographical distribution: North America.

Material: Botanic Institute in Wroclaw. Diameter 56 to 96,5 μ .*Carya pallida* Ashe

Plate VII, fig. 4—5

Syn.: *Hicoria glabra villosa* Sarg.

Geographical distribution: North America.

Material: Botanic Institute in Wroclaw.

Diameter 53 to 75 μ .

Grains of these both species are very similar, apparently offering no differences. Only some exceptionally large grains of *C. ovalis* can be recognized with certainty.

The last two of ten described species do not show any features which would justify their being treated together or being included to any other group; they must be treated separately.

Carya myristicaeformis (Michx.) Nutt.

Plate VIII, fig. 1—4

Syn.: *Hicoria myristicaeformis* Brit., *H. fernoviana* Ludv.

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Grains unusually various in outline: the three-pored are circular, triangular, hexagonal. Four-pored (about 10%), five-pored (about 2%) and some grains with greater number of pores are, for the most part, regularly angular. Some grains are irregular, similar to grains of *C. cordiformis* and *C. tomentosa*. Exineous thickenings distinct. Diameter 38,5 to 59,5 μ .

Carya laciniosa (Michx.) Loud.

Plate VIII, fig. 5—6

Syn.: *C. sulcata* Nutt.

Geographical distribution: North America.

Material: Botanic Institute in Wrocław.

Germ pores three or four. Grains in outline rather regular, circular, rounded-triangular or quadrangular. Exine smooth or faintly granular, exineous thickenings distinct but of small extent, arranged only in equatorial area. Diameter of grains 45,5 to 68,2 μ .

The recognition of the species in *Carya* is as difficult as in *Juglans*. The large variation in size within each species also makes, as in *Juglans*, the recognition almost impossible. In the table below are shown variations in diameter as well as the most frequent size of pollen grains in each species:

Species	Diameter in μ	The most frequent diameter in μ
<i>C. aquatica</i>	36,4 — 54,2	43,7
<i>C. Pecan</i>	38,5 — 56,0	49,0
<i>C. myristicaeformis</i>	38,5 — 52,5	43,7 — 52,5
<i>C. glabra</i>	38,5 — 59,5	49,0 — 52,5
<i>C. cordiformis</i>	40,2 — 50,7	45,5 — 47,2
<i>C. ovata</i>	42,0 — 61,2	49,0 — 52,5
<i>C. tomentosa</i>	45,5 — 59,5	52,5
<i>C. laciniosa</i>	45,5 — 68,2	52,5 — 54,2
<i>C. pallida</i>	53,0 — 75,0	62,0
<i>C. ovalis</i>	56,0 — 96,5	65,5

Pterocarya Kunth.

Grains much flattened, usually regularly angular in outline, rarely triangular, rounded-triangular or quadrangular. Number of pores 3 to 10, their apertures elliptical to circular, pores generally equally spaced around the equator. The majority of seven described species has, however, a small fraction of grains (0,5 to 9%) with one pore outside the equator. Only *Pterocarya rhoifolia* has a large proportion of grains (about 75%) with one, rarely with two pores outside the equator line. Around the pores exineous thickenings distinct but of small extent. The degree of protrusion of pores varying: from not elevated to distinctly elevated. These two typical and many transitory forms of pores occur in all seven described species of *Pterocarya*. This fact makes the recognition of individual species very difficult. Exine faintly granular or smooth. Diameter of grains 25,4 to 46,8 μ .

On account of the wide diversity of characteristic among the pollen grains of the seven described species of *Pterocarya* each of them is treated separately.

Pterocarya fraxinifolia (Lam.) Spach.

Plate IX, fig. 1—5

Syn.: *P. caucasica* C. A. Mey, *P. spachiana* Lav., *P. laevigata* Hort., *P. sorbifolia* Dip.,

Geographical distribution: Caucasus.

Material: Botanic Institute in Wrocław.

Pores 3 to 8 (more than 50% have 6), less or more elevated. Large proportion of the grains with distinctly protruding pores. All the pores usually equatorially spaced. The numerous six-pored regularly hexagonal, about 1% of them having pores converging in pairs. Grains 30,6 to 43,2 μ in diameter.

Pterocarya rhoifolia Sieb. et Zucc.

Plate IX, fig. 6—8

Geographical distribution: Japan.

Material: Botanic Institute in Wrocław.

Pores 6 to 10 (a large proportion of grains with 7 or 8), mostly equatorially spaced; one or, very rarely, two pores outside the equator. Pores less or more aspidate, occasionally slightly elevated or not. Grains 37,8 to 46,8 μ in diameter.

The grains with pores slightly or not elevated closely resemble those of *Juglans cinerea*. The recognition of these two species belonging to two different genera is difficult, on account of nearly the same diameter of their pollen grains (see p. 126).

Pterocarya insignis R. et W.

Plate X, fig. 1—3

Geographical distribution: China.

Material: Herbarium of the Royal Botanic Garden in Edinburgh.

Pores 5 to 8 (most grains with 6), equatorially arranged. The degree of protrusion of pores varies as in the two former species. Grains regularly angular in outline, 33,8 to 44,5 μ in diameter.

Pterocarya forrestii W. W. Smith

Plate X, fig. 4—6

Geographical distribution: China.

Material: Herbarium of the Royal Botanic Garden in Edinburgh.

Pores 4—7 (most grains with 5 or 6), generally all equally equatorially spaced; 10% of grains with one pore outside the equator. All kinds of pores are represented in this species, but more frequent are the grains with pores conspicuously protruding as in the grains of *Pt. fraxinifolia*, similar to those of *Carpinus*.

Pterocarya stenoptera D. C.

Plate X, fig. 7—9

Geographical distribution: China.

Material: Botanic Institute in Wrocław.

Pores 6—8 (most grains with 6), generally equally arranged around the equator, occasionally one pore outside. Pores of all kinds, most frequently not elevated. Grains 30,6 to 39 μ in diameter.

Pterocarya paliurus B a t a l.

Plate XI, fig. 1—6

Geographical distribution: China.

Material: Herbarium of the Royal Botanic Gardens in Kew.

Pores 3 — 5, mostly 4, all in the equator line of the grains. The few five-pored grains generally regular in outline. The numerous four-pored grains varying in shape:

- a. regularly square (plate XI, fig. 3),
- b. rectangular, difference in length of sides about 2μ ,
- c. rectangular; more different in length of sides (plate XI, fig. 1),
- d. rhombic (plate XI, fig. 2),
- e. numerous irregular forms.

From among the three-pored grains were distinguished:

- a. triangular, equilateral,
- b. isosceles with a shorter base,
- c. isosceles with a larger base.

Some of three-pored grains are tetragonal in outline just as some four-pored grains are pentagonal.

Diameter of the three-pored and five-pored grains — $24,5$ to 40 , 25μ . Four-pored, square in outline — $24,5$ to 35μ . Rectangular — $24,5 \times 26,5$ to $33,5 \times 35\mu$.

Pterocarya hupehensis S k a n.

Plate XI, fig. 7—11

Geographical distribution: China.

Material: Herbarium of the Royal Botanic Garden in Edinburgh.

Pores 4—7, mostly 5 or 6, equatorially arranged, more or less elevated. The outline of the four-pored grains square, rectangular or irregular. Among the irregular four-pored grains pentagonal forms occur just as in *P. paliurus*. The five-pored grains generally regular in outline, sometimes irregularly hexagonal.

Among the six-pored grains two kinds can easily be distinguished:

1. regular hexagonal (plate XI, fig. 9),
2. with pores converging (plate XI, fig. 10, 11) in pairs. This form, very rare in other species is very frequent in *P. hupehensis*.

Diameter of the grains 28 to $36,7\mu$.

Almost identical five- and six-pored forms appearing in all described species and nearly identical seven — and eight-pored forms from among the four species of *Pterocarya* make the recognition of these species very difficult. The resemblance is strengthened by the existence of all kinds of pore patterns and by large differences in size within each species.

The following features can make the recognition of particular species easier:

Size:

a. Three species relatively small in size: *P. paliurus*, *P. hupehensis*, *P. stenoptera*.

b. Four species larger in size: *P. fraxinifolia*, *P. forrestii*, *P. insignis*, *P. rhoifolia*.

In the table below is shown the size of all mentioned species:

Species	Diameter in μ	The most frequent diameter in μ
<i>P. paliurus</i>	24,5 — 40,25	30,0
<i>P. hupehensis</i>	28,0 — 36,7	31,5
<i>P. stenoptera</i>	30,6 — 39,0	36,0
<i>P. fraxinifolia</i>	30,6 — 43,2	38,0
<i>P. insignis</i>	33,8 — 43,5	38,6
<i>P. forrestii</i>	35,6 — 46,3	39,2
<i>P. rhoifolia</i>	37,8 — 46,8	45,0

Number of pores and way of their arrangement. These two characteristics are shown in the following table:

Number and arrangement of pores (of one hundred grains)

Species	Pores									Arrangement of pores			
	3	4	5	6	7	8	9	10	all arranged equatorially	one outside the equator	within six-pored grains		
											equally spaced	converging in pairs	
<i>P. paliurus</i>	4	83	13	—	—	—	—	—	100	1	—	—	
<i>P. hupehensis</i>	—	4	65	30	1	—	—	—	98	2	66	34	
<i>P. stenoptera</i>	—	—	3	64	26	7	—	—	91	9	100	—	
<i>P. fraxinifolia</i>	1	1	10	52	35	1	—	—	98	2	99	1	
<i>P. insignis</i>	—	—	6	64	29	1	—	—	100	—	99	1	
<i>P. forrestii</i>	—	5	60	33	2	—	—	—	99	1	99	1	
<i>P. rhoifolia</i>	—	—	—	10	36	39	14	1	25	75	100	—	

Engelhardtia Leschen.

Grains three-pored, slightly flattened, circular, rounded-triangular, triangular or hexagonal in outline. Pores elliptical or circular. Exine fine

granular or smooth, relatively thick (to 2μ), Grains $14,24$ to $31,5\mu$ in diameter.

The six discussed species can be divided into three groups depending on the most frequent forms appearing in the given species.

Group I

Grains generally rounded-triangular in outline, sometimes circular, exceptionally hexagonal, $19,2$ to $31,5\mu$ in diameter.

Engelhardtia colebrookiana Lindl.

Plate XII, fig. 1—4

Geographical distribution: Indo-Malayan Archipelago, China.

Material from the Herbarium of the Royal Botanic Garden in Edinburgh.

Grains 21 to $31,5\mu$ in diameter.

Engelhardtia acerifolia Blume

Plate XII, fig. 13—16

Geographical distribution: Indo-Malayan Archipelago, China.

Material: Herbarium of the Royal Botanic Garden, Edinburgh.

Diameter $19,2$ to $24,5\mu$.

Pollen grains of these two species are so similar that their recognition even in the recent material does not seem to be possible. The only difference is larger size of some grains of *E. colebrookiana*.

Group II

The hexagonal forms with characteristic wavy sides more frequent than circular and rounded-triangular ones. Diameter $15,7$ to $24,27\mu$.

Engelhardtia philipinensis A. C. D. C.

Plate XII, fig. 5—8

Geographical distribution: the Philippines.

Material: Herbarium of the Royal Botanic Garden, Edinburgh.

Grains $19,58$ to $24,9\mu$ in diameter.

Engelhardtia parvifolia A c. D C.

Plate XII, fig 9—12

Geographical distribution: the Philippines.

Material: British Museum, London

Diameter 19,58 to 24,9 μ .

Engelhardtia spicata Blume

Plate XIII, fig. 1—4

Geographical distribution: Indo-Malayan Archipelago, China.

Material: Herbarium of the Royal Botanic Garden in Edinburgh.

Grains 15,7 to 22,7 μ in diameter.

Pollen grains of *E. spicata* differ from two previously described species only by slightly smaller size. This minute difference cannot be sufficient to recognize this species with regard to great variability in size of all mentioned species.

Group III

All grains regularly triangular or rounded-triangular in outline. Diameter 14,24 to 17,28 μ .

Engelhardtia chrysolepis Hance

Plate XIII, fig. 5—9

Geographical distribution: Indo-Malayan Archipelago, China.

Material: Herbarium of the Royal Botanic Garden, Edinburgh.

Relatively small size and complete lack of circular and hexagonal forms common in the remaining previously described species allow clearly to distinguish *E. chrysolepis* from other species included in the two former groups.

Platycarya Sieb. et Zucc.

Monotypic genus with a single species:

Platycarya strobilacea Sieb. et Zucc.

Plate XIII, fig. 10—20

Geographical distribution: North China, Japan.

Material: Botanic Institute in Wrocław and Herbarium of the Royal Botanic Garden in Edinburgh.

Grains generally three-pored, triangular in outline, uniform in shape. Pores narrow, slit-shaped, distinct exineous thickenings of small extent around them. Exine 1 to $1,5\mu$ thick, coarsely granular, always crossed by few characteristic, rough edged, deep and broad arcoid grooves.

In pollen material from Lauterbach's Herbarium of the Botanic Institute in Wrocław there are only typical triangular forms. In the material from Edinburgh besides the numerous triangular forms occur few (about 5%) four-pored varying in shape and size, and very rarely (about 0,5%) regular five-pored grains, always with characteristic grooves running somewhat differently and less regularly than in typical three-pored forms.

Diameter of three-pored grains	— 18,7 to 22 μ ,
four-pored	— 22,0 to 27 μ ,
five-pored	— 24,0 to 27 μ .

The four- and five-pored grains closely resemble those of *Pterocarya paliurus* and *Pterocarya hupehensis* but always differ by smaller size and, above all, by very characteristic arcoid grooves never appearing in grains of genus *Pterocarya*.

Pollen grains of the *Juglandaceae* often found in Tertiary formations are not easily recognizable excepting the conspicuous grains of *Juglans* and *Carya*.

Grains of *Pterocarya*, *Engelhardtia* and *Platycarya* closely resemble the grains of the *Betulaceae* and *Myricaceae*, but they can be distinguished by certain minor characters:

Pterocarya — *Alnus*

Pterocarya can be distinguished from *Alnus* by larger size, different character of pores and lack of the connecting bands so characteristic for grains of *Alnus*.

Engelhardtia and *Platycarya* — *Betula*, *Corylus*, *Myrica*

Engelhardtia, closely related to these three genera, differ by less protruding pores and smaller size,

Platycarya — by less protruding slit-shaped pores, smaller size and characteristic arcoid grooves.

According to Erdtman (1952) the grains of *Juglandaceae* have several characteristic in common also with those in *Casuarinaceae* and *Rhoipteleaceae*.

STRESZCZENIE

Autorka opracowała morfologię 32 gatunków należących do pięciu rodzajów rodziny *Juglandaceae*. Materiał pyłkowy pochodził z zielników: Lauterbacha z Instytutu Botanicznego we Wrocławiu, Instytutu Botanicznego U.J. w Krakowie, British Museum i Kew Gardens w Londynie oraz z Royal Botanic Garden w Edynburgu.

Materiał przygotowano do badań metodą acetolizy Erdtmanna (1954). Górną i dolną granicę wielkości oraz wielkość modalną ustalono na podstawie pomiarów stu normalnie wykształconych ziarn pyłku. Do zdjęć wybierano ziarna o najczęściej występujących cechach. Zamieszczone zdjęcia są w tysiąckrotnym powiększeniu. Klucz do rodzajów oparto w dużej mierze na kluczu Wodehouse'a (1935).

Ziarna pyłku *Juglandaceae* odznaczają się prostą budową: kuliste albo mniej lub bardziej spłaszczone, bez wyraźnej rzeźby powierzchni, bez bruzd, egzyna gładka lub ziarnista, wokoło por tworzy zgrubienia. Liczba por 3 do 17.

Różnice między pyłkiem poszczególnych rodzajów wyraźne, między gatunkami przeważnie trudne do uchwycenia. W braku wyraźnie odróżniających cech w poszczególnych gatunkach autorka poprzestała przeważnie na utworzeniu prowizorycznych grup, łącząc te gatunki, które wykazują największe do siebie podobieństwo.

Juglans L.

Ziarna pyłku w kształcie spłaszczonej kuli, w zarysie zwykle regularnie wieloboczne. Liczba por 5—17, około $\frac{2}{3}$, rozmieszczone na linii równikowej ziarna, reszta na jednej z półkul. Wokoło por wyraźne zgrubienia nie zlewające się ze sobą. Średnica ziarn 31 do 58 μ .

Z opracowanych ośmiu gatunków utworzono cztery grupy:

I. Zarys ziarn regularnie wieloboczny, egzyna gruba, liczba por 11—17, pory wystające. Średnica 33,2 do 56,2 μ .

Włączono tu trzy północnoamerykańskie gatunki:

Juglans rupestris Engelm. (tabl. I, 1—3).

Juglans nigra L. (tabl. I, 4—6).

Juglans mollis Engelm. (tabl. 1, 7, 8).

II. Zarys ziarn mniej regularny, egzyna cieńsza, pory mniej wystające. Liczba por 10—15; średnica 36,7 do 58 μ .

Tu zaliczono dwa gatunki azjatyckie:

Juglans sigillata Dode (tabl. II, 1, 2)

Juglans regia L. (tabl. II, 3, 4)

III. Osobno omówiono *Juglans neotropica* Diels (Ameryka Południowa), który z powodu odrębnych cech podobny jest bardziej do pyłku *Carya* niż *Juglans*. Pory (8—10) wgłębione, średnica 34,3 do 43,7 μ (tabl. II, 5—7).

IV. Zarys regularnie wieloboczny, por 5—10, wszystkie lub prawie wszystkie na obwodzie. Pokrój podobny wskutek tego do pokroju ziarn pyłku *Pterocarya*. Średnica 31,2 do 50 μ .

Juglans Sieboldiana Maxim. — Japonia (tabl. II, 1—4).

Juglans cinerea L. — Ameryka Północna (tabl. III, 5—6).

Różnice między grupami są wyraźne, lecz rozróżnienie gatunków wchodzących w skład jednej grupy wydaje się autorce niemożliwe, nie tylko w materiale kopalnym, lecz i współczesnym.

Carya Nutt.

Ziarna pyłku kuliste lub lekko spłaszczone, w zarysie zwykle koliste lub trójkątne. Pory przeważnie trzy, nie wystające lub wgłębione. Wołoko por wyraźne zgrubienie zlewające się ze sobą. Średnica 36,4 do 96,5 μ .

Wszystkie opracowane gatunki występują w Ameryce Północnej.

Podobnie, jak w poprzednim rodzaju, utworzono kilka prowizorycznych grup, łącząc podobne gatunki.

I. Ziarna trójporowe, koliste i kolisto-trójkątne w zarysie. Średnica 36,4 do 56 μ :

Carya aquatica (Michx.) Nutt. (tabl. IV, 1—3).

Carya Pecan (Marsh.) Engl. i Graebner (tabl. IV, 4—6).

II. Zwykle trzy pory, rzadkiej cztery lub pięć. Zarys ziarn nieregularny. Średnica 40,2 μ do 59,5 μ :

Carya cordiformis (Wangh.) K. Koch (tabl. V, 1—3).

Carya tomentosa (Lam.) Nutt. (tabl. V, 4—6).

III. Ogromna różnorodność form, wyraźne zgrubienie egzyny rozciągające się na całej niemal powierzchni ziarna. Trzy pory rozmieszczone na linii równoległej do obwodu, lecz nieco bliżej bieguna, widoczne wyraźnie na powierzchni jednej z półkul. Średnica 38,5 do 61,2 μ :

Carya ovata (Mill.) K. Koch (tabl. VI, 1—3).

Carya glabra (Mill.) Sweet. (tabl. VI, 4—6).

Średnica 53 do 96,5 μ .

IV. Znacznie większe rozmiary i grubsza egzyna (do 5μ). Pory zwykle trzy, rzadziej cztery, pięć lub sześć. Ziarna o większej liczbie por zwykle większe od trzyporowych: 53 do $96,5\mu$.

Carya ovalis (W a n g h.) S a r g. (tabl. VII, 1—3).

Carya pallida A s h e (tabl. VII, 4—5).

Osobno omówiono dwa ostatnie gatunki, których nie udało się włączyć do żadnej z poprzednich grup, ani połączyć razem:

Carya myristicaeformis (M i c h x.) N u t t. (tabl. VIII, 1—4).

Carya laciniosa (M i c h x.) L o u d. (tabl. VIII, 5—6).

Pterocarya K u n t h.

Ziarna pyłku silnie spłaszczone, zwykle regularnie wieloboczne w zarysie. Pory 3 do 10, wszystkie lub prawie wszystkie na linii równikowej ziarna. Wokoło por niewielkie tarczowate zgrubienie egzyny. Stopień wystawiania por różny: od zupełnie nie wystających (tabl. VIII, fig. 4 i tabl. IX, fig. 9) do silnie wystających (tabl. VIII, fig. 1, 2, 6, tabl. IX, fig. 5, 8, tabl. X, fig. 6). Średnica $25,4$ do $46,8\mu$.

W siedmiu opracowanych gatunkach nie wyróżniono cech, które dałyby podstawę do utworzenia prowizorycznych bodaj grup. W każdym gatunku występują wszystkie wyróżnione przez autorkę typy por, co łącznie z dużymi wahaniami w wielkości średnicy, uniemożliwia pewne oznaczenie gatunku.

Przy opisie poszczególnych gatunków podkreślano następujące charakterystyczne cechy:

Pterocarya fraxinifolia (L a m.) S p a c h. — Kaukaz (tabl. IX, 1—5):

Najwięcej ziarn z silnie wystającymi porami. Prawie zawsze wszystkie pory rozmieszczone na obwodzie,

Pterocarya rhoifolia S i e b. et Z u c c. — Japonia (tabl. IX, 6—8):

Dużo ziarn 7- i 8-porowych. 75% ziarn z jedną lub dwiema porami poza obwodem.

Pterocarya insignis R. et W. — Chiny (tabl. X, 1—3).

Większość ziarn pyłku 6-porowych, regularnie wielobocznych. Wszystkie pory na obwodzie.

Pterocarya forrestii W. W. S m i t h — Chiny (tabl. X, 4—6).

Ziarna przeważnie 5- i 6-porowe, regularne w zarysie, pory zwykle wystające.

Pterocarya stenoptera D C. — Chiny (tabl. X, 7—9).

Ziarna przeważnie 6- i 7-porowe, zwykle wszystkie pory na obwodzie.

Pterocarya paliurus Batal. — Chiny (tabl. XI, 1—6).

Liczba por. 3—5, najwięcej ziarn czteroporowych. Wszystkie pory na obwodzie. Formy 3- i 4-porowe bardzo różnorodne w zarysie.

Pterocarya hupehensis S k a n — Chiny (tabl. XI, 7—11).

Liczba por 4—7, najczęściej 5 lub 6, zwykle wszystkie na obwodzie. Pośród 6-porowych, oprócz regularnie sześciobocznych, występuje ponad 30% ziarn o porach ustawionych parami.

Engelhardtia L e s c h e n

Ziarna pyłku trójporowe, lekko spłaszczone, w zarysie kolistе, kolisto-trójkątne, trójkątne i sześcioboczne z charakterystycznie wydętymi bokami. Średnica 14,24 do 31,5 μ .

Zależnie od tego, które z wymienionych cech występują najczęściej, połączono opracowane gatunki w trzy grupy:

I. Ziarna pyłku przeważnie kolistе i kolisto-trójkątne w zarysie. Średnica 19,2 do 31,5 μ .

Engelhardtia Colebrookiana Lindl. — Chiny, Indomalaje (tabl. XI, 1—4).

Engelhardtia acerifolia Blume. — Chiny, Indomalaje (tabl. XII, 13—16).

II. Ziarna sześcioboczne występują znacznie częściej niż kolistе i kolisto-trójkątne. Średnica 15,7 do 24,9 μ .

Engelhardtia philippinensis A c. D C. — Filipiny (tabl. XII, 5—8).

Engelhardtia parvifolia A c. D C. — Filipiny (tabl. XII, 9—12).

Engelhardtia spicata Blume — Indomalaje: Chiny (tabl. XIII, 1—4).

III. Ostatni z opracowanych gatunków, *Engelhardtia chrysolepis* H a n c e — Indomalaje, Chiny (tabl. XIII, 5—9), różni się od pozostałych mniejszymi rozmiarami (14,24 do 17,8 μ) i zupełnym brakiem form kolistych i sześciobocznych. Wszystkie ziarna są w zarysie trójkątne z łagodnie zaokrąglonymi bokami.

Platycarya Sieb. et Zucc.

Rodzaj obejmujący jeden gatunek współczesny *Platycarya strobilacea* Sieb. et Zucc.

Platycarya strobilacea Sieb. et Zucc. — Japonia, północne Chiny (tabl. XIII, 10—20).

Ziarna pyłku najczęściej trójporowe, jednakowego kształtu, pory szczelinowate, zgrubienia wokoło por w postaci wyraźnych niewielkich

krążków. Egzyna szorstka, brodawkowata, z przebiegającymi kilku charakterystycznymi łukowatymi bruzdami o poszarpanej, nierównej linii brzegu.

Poza typowymi, ziarnami trójkątnymi w zarysie, stwierdzono w materiale zielnikowym z Edynburga występowanie około 5% ziarn czteroporowych i 0,5% ziarn pięcioporowych, zwykle regularnie pięciobocznych. Średnica ziarn trzyporowych 18,7 do 22 μ , pięcioporowych 24 do 27 μ .

*

W wyniku przeprowadzonych badań autorka dochodzi do przekonania, że oznaczanie rodzajów w rodzinie *Juglandaceae* w materiale współczesnym jest łatwe i może być przeważnie zupełnie pewne, lecz oznaczenie do gatunku jest tylko w wyjątkowych przypadkach możliwe.

W materiale kopalnym, oznaczenie rodzaju *Juglans* i *Carya* nie stanowi również trudności. Pozostałe trzy rodzaje wykazują dużo podobieństwa do pyłku rodzin *Betulaceae* i *Myricaceae*. Różnią się jednak zawsze pewnymi drugorzędnymi cechami i na tej podstawie mogą być bez trudu oznaczone.

Według Erdtmanna (1952) pyłek *Juglandaceae* ma również niektóre cechy podobne do pyłku *Casuarinaceae* i *Rhoiptelaeaceae*.

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3 — lateral view
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view

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