ISSN 0031-0301, Paleontological Journal, 2006, Vol. 40, Suppl. 5, pp. S590–S594. © Pleiades Publishing, Inc., 2006.

On the Natural Polymorphism of Pollen Grains of *Acer tataricum* L.

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Received March 15, 2006

Abstract—To study natural polymorphism, pollen grains should be collected from ecologically clean sites. Taking the ecological conditions at the end of the 19th century and at the beginning of the 20th century as more favorable than the modern state, herbarium material (LE) was examined. In addition to typical (normally developed) pollen grains, we found two more morphological types within the range of natural polymorphism of pollen grains of *Acer tataricum* L. that were produced at the end of the 19th century and at the beginning of the 20th century.

DOI: 10.1134/S0031030106110062

Key words: Pollen grains, polymorphism, and ecology.

INTRODUCTION

Pollen grains of *Acer* Juss. have repeatedly been studied by many researchers. However, there are few studies recording natural polymorphism of pollen grains in this genus. In particular, Wodehouse (1935) pointed out that in addition to tricolpate and tetracolpate pollen grains, pollen grains with two, five, and six colpi also occur. Stel'mak (1950) described tricolpate and tetracolpate pollen grains of this taxon. Kupriyanova (1972) mentioned the occurrence of tetracolpate pollen grains in *A. negundo* L. and pollen grains greatly varying in size in *A. stevenii* Pojark. In his study of 12 species of *Acer*, Pozhidaev (1993) provided microphotographs and schemes of 11 palynological morphotypes, deviating from typical pollen grains in the number and position of colpi. Using extensive material, Tokarev (1996) showed that pollen grains of this genus are polymorphic in several characteristics, the most important of which concern the apertural type, surface structure, and the shape and size of pollen grains. Nonetheless, natural polymorphism of *Acer* is still an open question. This is because the previous authors did not treat their material statistically, the detection of pollen polymorphism within a species was not among the aims of their studies. They ignored the quality of the environment, where the pollen studied was produced, and provided no information about the time (year) of the reproduction. The last parameter might be very significant because of the continuously increasing anthropogenic technological impact on the biosphere.

Therefore, we decided to study what morphological types of pollen grains (apart from typical, normally developed, pollen grains) may be produced by *A. tataricum* under optimal ecological conditions or, in other words, what morphological types represent natural polymorphism of pollen grains of this species. This paper reports the results of this study.

MATERIAL AND METHODS

For the study of natural polymorphism, pollen grains should be collected from ecologically clean sites. Since nowadays such places are relatively difficult to find (and where found, may not contain the relevant plant taxon), we were forced to study herbarium material collected at the end of the 19th and beginning of the 20th century; ecological conditions before the middle of the 20th century were less damaging than today. We decided to analyze the presence–absence of natural polymorphism, and its variation, using pollen grains of *A. tataricum* from herbarium material from that period. Unfortunately, not all of the available herbarium material contained pollen, and we studied and statistically analyzed pollen from only two samples from Komarov Botanical Institute Herbarium/LE/ (1867, Kiev, and 1921, Leningrad Region). In addition, for comparative purposes we began a study of the polymorphism of modern pollen grains of the same species, from a suburb of St. Petersburg that lacks industry, and from a satellite-town of the Leningrad Nuclear Power Station (table).

Pollen grains were studied under a light microscope (LM) and scanning electron microscope (SEM); some were treated using Erdtman's acetolysis method (Erdtman, 1952), while others were studied untreated (in the natural state).

In transmitted light, pollen grains were studied on both permanent (glycerol jelly) and temporary slides

Some quantitative characteristics of pollen grains of *Acer tataricum* produced in St. Petersburg, Leningrad Region, and Kiev in different years (1886–1924, 1998)

Sample no.	Locality	Date of sampling	Sizes of pollen grains (p.g.), μm		Apertures	Number of p.g.	Percentage of p.g.	
			equatorial diameter	polar axis			normal	teratomorphic
Reproduction of the end of 19th–beginning of 20th centuries								
8g	Petrograd Region, Yamburgskii District (Kingiseppskii area)	1921	26.8 ± 3.5	31.3 ± 3.8	1-, 3-, 4-colpate	200	77%	23%
7g	Kiev	1867	29.7 ± 3.0	31.3 ± 3.8	3-, 4-colpate	100	98%	2%
Reproduction of the end of the 20th century								
161/96	Leningrad Region, village of Ul'yanovka (nonindustrial)	1996			1-, 3-colpate	106	99%	1%
14/SB 98	Town of Sosnovyi Bor, enterprise "Rodon"	1998	29.5 ± 6.8 (19.4–46.8)	34.2 ± 4.3 (26.5–46.8)	1–4, 6, 7-colpate	140	37%	63%, of those 30% are dwarf forms

(glycerol), the latter allowing each pollen grain to be manipulated, and photographed in different positions. One or two hundred pollen grains were studied from each sample. The study and microphotography were accomplished with a LM Leica DMLS camera using the image-analyzing system VideoTesT. For SEM, pollen grains were placed on a double-sided sticky tape, attached to SEM stubs, and gold coated. The study, coating, and microphotography were accomplished under a JSM-T-200SEM.

RESULTS AND DISCUSSION

Before we discuss the polymorphism of pollen grains of *A. tataricum*, it is pertinent to describe typical pollen grains of this species.

DESCRIPTION OF TYPICAL (NORMALLY DEVELOPED) POLLEN GRAINS OF *ACER TATARICUM*

Sample no. 8g. Collected: Petrograd Region (currently St. Petersburg Region), Yamburgskii District (currently Kingiseppskii District). Date of sampling: July 1, 1921; leg., determ.: Sveshnikov, *Acer tataricum* L. (LE).

Pollen grains are isopolar, flattened, spheroidal or ellipsoidal, radial, tricolporate.

In polar position rounded-trilobate.

In equatorial position flattened elliptic, elliptic, or rounded.

Polar axis (P.A.) 31.3 ± 3.8 (21.4–42.8 μm).

Equatorial diameter (E.D.) 26.8 ± 3.5 (17.3–40.8 μm), i.e., normally developed pollen grains of this species vary in shape from flattened, with P.A./E.D.=0.5, to ellipsoid, with P.A./E.D.=1.6.

Apertures are simple (colpi) and combined (colpi and pores), the latter variant is found in 18% of pollen grains studied. Exoapertures, bordered colpi, have margins of about 1 μm wide. In the equatorial position, their width is at most 1.8 ± 1.2 μm (from closed to 6.1 μm wide). In polar position, the colpi are usually wide, 8.3 ± 2.6 (1.5–14.3 μm). The extremities of the colpi become sharply narrowed towards the poles. Their length is 25.0 ± 3.7 (17.3–32.6 μm). Membranes of the colpi are weakly wrinkled. Endoapertures, ores, are rounded or nearly rounded, with uneven margins; they are recognized predominantly in colpi in the equatorial position of a pollen grain. The ore diameter is 4.4 ± 1.3 (2.1–7.1 μm).

The mesocolpium is narrowly rhomboidal; in the center, its width is 20.2 ± 4.4 (9.2–28.6 μm).

The apocolpium. The apocolpium diameter is 5.3 ± 0.9 (3.1–8.2 μm).

Endexine seems bilayered in transmitted light. The ectexine and endexine are equal in thickness (about 1 μm). The exine in both the mesocolpium and apocolpium is 2.0 ± 0.2 μm thick (1.5–2.5 μm). Observations in the polar position show that the apertural exine is at most 1.2 ± 0.3 μm thick (0.5–2.0 μm).

The sculpture (as it appears in transmitted light) is finely granulate–striate. Short or long striae branch, interlacing and weakly twisting. The striation is distinct mostly on the mesocolpium in the equatorial position. The striae are mostly parallel to the polar axis. There are occasional perforations between the striae. Under SEM, long dichotomizing striae are clearly seen, which are densely spaced, with rare perforations between them.

The color ranges from light yellow to dark brown.

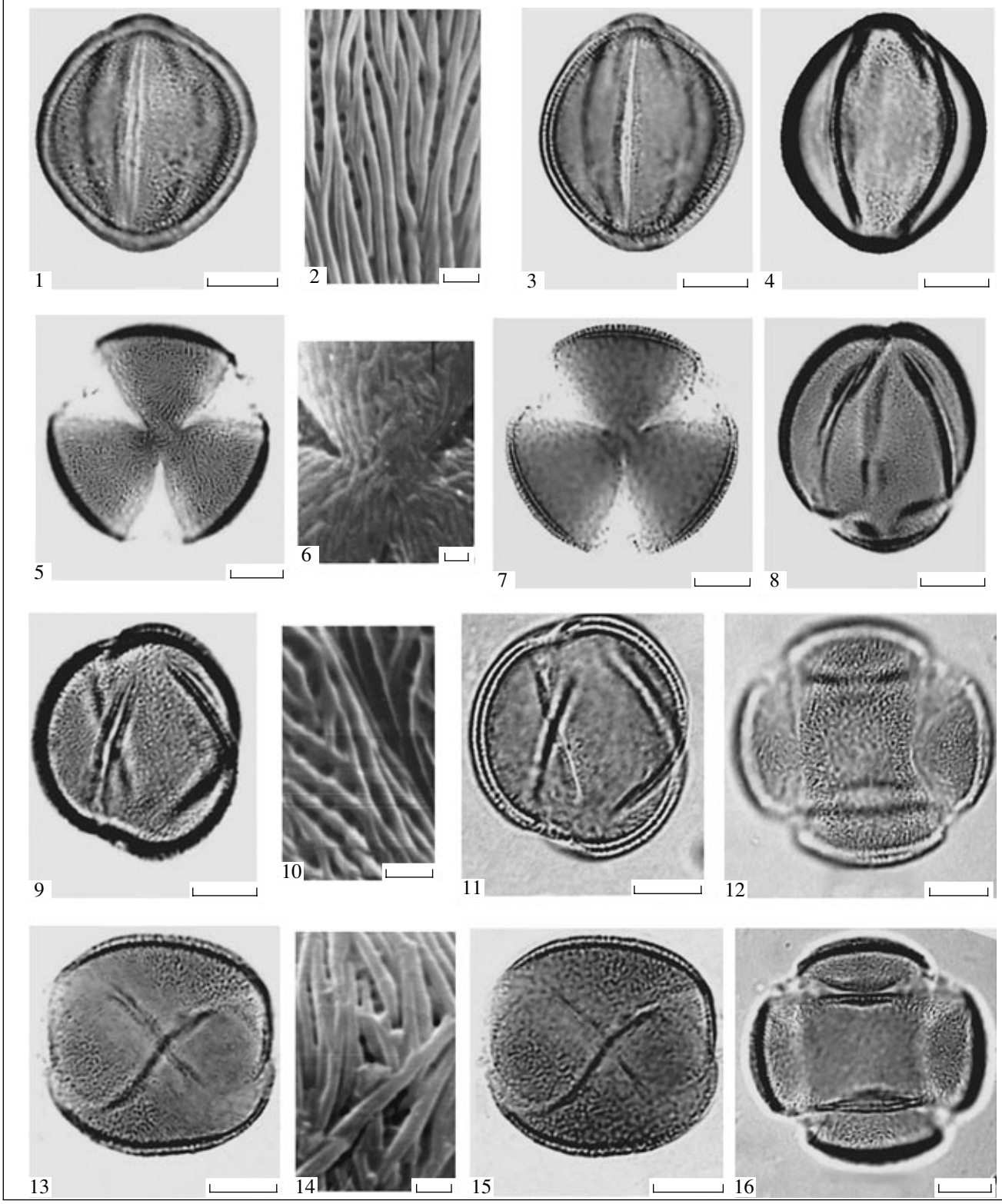
The study showed that, apart from typical (normally developed) pollen grains (Pl. 4, figs. 1–8), the herbarium material contained two more morphotypes: tetra-

colpate pollen grains (Pl. 4, figs. 9–11); and circular monocolpate (disyncolporate) pollen grains with colpi that are situated as in the suture of a tennis-ball (Pl. 4, figs. 12–16).

DESCRIPTION OF TETRACOLPATE POLLEN GRAINS OF *ACER TATARICUM*

Sample no. 8g. Collected in the Petrograd Region (now St. Petersburg Region), Yamburgskii District

Plate 4



(now Kingiseppskii District). Date of sampling: July 1, 1921; leg., determ.: Sveshnikov, *Acer tataricum* L. (LE).

Pollen grains are isopolar, spheroidal or ellipsoidal, radial, and equatorially tetracolpate.

In polar position, such pollen grains were not found.

In equatorial position, pollen grains are elliptical or rounded.

Polar axis (P.A.) is 32.4 ± 4.8 μm long (25.5–40.0 μm).

Equatorial diameter (E.D.) is 27.9 ± 2.9 μm (23.5–31.3 μm).

Apertures are equatorial and simple (colpi). The colpi are bordered (the border is at most 1 μm wide) and narrow. The colpi are 0.7 ± 0.4 μm wide (from closed to 1.0 μm) and 24.0 ± 5.2 μm long (18.4–32.9 μm). The extremities of the colpi sharply narrow towards the poles.

The mesocolpium is narrowly rhomboidal; in the center, it is 15.1 ± 2.2 μm wide (11.4–18.0 μm).

The apocolpium is 5.5 ± 1.1 μm in diameter (4.1–7.2 μm).

The exine consists of two layers (as visible in transmitted light). The ectexine and endexine are equal in thickness (about 1 μm). The exine of the mesocolpium is 2.1 ± 0.2 μm thick (1.6–2.4 μm), and that of apocolpium is 2.1 ± 0.3 μm thick (1.6–2.4 μm). We failed to measure the thickness of the apertural exine.

The sculpture (in transmitted light) is granulate–striate. Short and (or) long striae branch, interlace and twist weakly. The striation is most distinct on the mesocolpium in the equatorial position. The striae are mainly directed along the polar axis. Between the striae, there are occasional perforations. Under SEM, long dichotomizing and crossing striae are clearly seen. They are densely spaced, with rare perforations between them.

The color varies from light yellow to dark brown.

CIRCULAR MONOCOLPATE (DISYNCOLPORATE) POLLEN GRAINS OF *ACER TATARICUM*

Sample no. 8g. Collected: Petrograd Region (now St. Petersburg Region), Yamburgskii district (now Kingiseppskii district). Date of sampling: July 1, 1921; Leg., determ.: Sveshnikov, (LE). *Acer tataricum* L.

Pollen grains are apolar, spheroidal, circular monocolpate, bilaterally symmetrical, and rounded in outline.

The diameter of the pollen grain is 32.5 ± 3.6 μm (25.5–43.9 μm).

Apertures. One continuous aperture, which was apparently formed by two fused meridian colpi, is situated as in the suture of a tennis-ball. The colpus is close or open, in the latter case its width reaches 6.3 ± 1.6 μm (3.4–9.4 μm).

The mesocolpium is narrowly rhomboidal; in the central region, it is 16.3 ± 2.3 μm wide (13.3–22.3 μm).

The apocolpium. The shape of the pollen grains does not allow the determination of the position of the apocolpia.

The exine looks bilayered in transmitted light. It is 2.1 ± 0.3 μm thick (1.5–2.5μm) and 1.1 ± 0.2 μm (1.0–1.5 μm) in the apertural region. The ectexine and endexine are equal in thickness.

The sculpture (in transmitted light) looks finely granulate–striate. Short and (or) long striae branch, interlacing and weakly twisting. The striation is distinct mostly on the mesocolpium in the equatorial position. The striae are mainly directed along the polar axis. Between the striae, there are occasional perforations. Under SEM, long dichotomizing and crossing striae are clearly seen. They are densely spaced, with rare perforations between them.

The color varies from bright yellow to dark brown.

The fact that the sample from 1867 (from Kiev) contains only 2% polymorphic pollen grains, whereas the sample from 1921 (Leningrad Region, Kingiseppskii District) contains 23% polymorphic pollen grains is significant.

We also studied pollen grains of the same species, which were produced in a nonindustrial suburb of St. Petersburg (village of Ul'yanovka) and in a satellite town with a nuclear power station. Pollen grains that were collected from trees of *Acer tataricum* L. growing

Explanation of Plate 4

Figs. 1–8. Typical (normally developed) pollen grains of *Acer tataricum* L.: (1, 3, 4) equatorial position, LM; (2) sculpture of the mesocolpium surface, SEM; (5, 7) polar position, LM; (6) sculpture of the apocolpium surface, SEM; and (8) equatorial-polar position, LM.

Figs. 9 and 11. Tetracolpate pollen grain of *Acer tataricum* L. in equatorial position, with different depths of field, LM.

Fig. 10. Surface sculpture of a tetracolpate pollen of *Acer tataricum* L. in the apertural region, SEM.

Figs. 12 and 16. Circular monocolpate (disyncolpate) pollen grain of *Acer tataricum* L., with different depths of field, LM.

Figs. 13 and 15. One more circular monocolpate (disyncolpate) pollen grain of *Acer tataricum* L., with different depths of field, LM.

Fig. 14. The surface sculpture of circular monocolpate (disyncolpate) pollen grain of *Acer tataricum* L. in interapertural region, SEM.

Figs. 1–16. Sample no. 8g, pollen grains were produced in 1921, Petrograd Region (now St. Petersburg Region), Yamburgskii District (now Kingiseppskii District).

Scale bar: (1, 3–5, 7–9, 11–13, 15, 16) 10 μm; (2, 6, 10, 14) 1 μm.

in the village of Ul'yanovka, where ecological conditions are relatively favorable, show a strikingly uniform morphology. The polymorphism of pollen grains hardly reaches 1%. In contrast, there are 63% of polymorphic pollen grains among pollen grains of *Acer tataricum* that were produced in the satellite town with a nuclear power station (in this case, teratomorphism is a more pertinent term). Dwarf forms (nanism), with an equatorial diameter of 22.6 ± 1.3 μm, prevail among teratomorphs. Apart from typical pollen grains, this sample contains 14 morphological types of pollen grains. The teratomorphism is mostly expressed in size variation in pollen grains, and morphological changes in the apertures and sculptural elements of the exine. The sculpture of different pollen grains varies from smoothed striate to ridgelike.

CONCLUSIONS

This study clearly shows the existence of natural polymorphism in pollen grains of *A. tataricum* and that polymorphism (teratomorphism) increases under unfavorable ecological conditions. This preliminary study should be continued using more comprehensive material. In particular, the possible application of the pollen of *Acer tataricum* as an ecological indicator should be explored.

ACKNOWLEDGMENTS

We are grateful to L. I. Krupkina (Komarov Botanical Institute, Russian Academy of Sciences) for her help in collecting pollen grains from the herbarium.

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