

Supporting Information for:

Infrared spectroscopy of pollen identifies plant species and genus as well as environmental conditions

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Estimation of pollen lipid content

The EMSC and baseline corrected spectra were used for the estimation of relative lipid content in pollen belonging to *Pinus*, *Quercus* and *Iris* genera. The analyses were based on the three vibrational bands: lipid band at $\sim 1740\text{ cm}^{-1}$, amide II band at $\sim 1545\text{ cm}^{-1}$, and sporopollenin band at 833 cm^{-1} . The average transmission spectra (based on three measurements per species) were scaled to amide II band (with sporopollenin band serving as a double-check for scaling), followed by spectral deconvolution (multipeak fitting of Gaussian and Lorentzian curves), and application of Beer–Lambert law, i.e. the linear correlation of absorbance (area under the curve with the lipid band as a centre) and quantity (Fig. S1). The obtained relative lipids content for the three genera are presented in Table 2.

The estimation of relative content of pollen lipids is based on the following approximations: 1) all congenital species have pollen grains with identical morphology, 2) sporopollenin and protein content in pollen for all congenital species is quantitatively invariant, 3) lipids content of pollen can be estimated by applying Beer–Lambert law on transmission spectra of the KBr sample pellets. Although the third approximation is quite far off due to diffuse reflection and saturated absorption, similar pollen morphology of congenital species will result in comparable deviations from Beer–Lambert law. The maximal values (Table 2) are probably underestimated regarding that saturated absorption is higher for samples with elevated lipids content. Different fitting parameters were assessed and the results typically varied approximately 10 % from the values reported in the Table 2.

Parameters used for spectral deconvolution:

For *Pinus* species: spectral range: $1900\text{--}1496\text{ cm}^{-1}$; No. of curves: 6; Fitting constrains (function, FWHM, approx. position of peak value): Lorentzian (20, 1515 cm^{-1}), Lorentzian (50, 1545 cm^{-1}), Lorentzian (20, 1600 cm^{-1}), Gaussian (110, 1635 cm^{-1}), Gaussian (130, 1660 cm^{-1}), Lorentzian (25, 1745 cm^{-1}).

For *Quercus* species: spectral range: $1900\text{--}1481\text{ cm}^{-1}$; No. of curves: 5; Fitting constrains (function, FWHM, approx. position of peak value): Lorentzian (50, 1510 cm^{-1}), Lorentzian (50, 1545 cm^{-1}), Gaussian (150, 1620 cm^{-1}), Gaussian (100, 1660 cm^{-1}), Lorentzian (25, 1745 cm^{-1}).

For *Iris* species: spectral range: $1900\text{--}1481\text{ cm}^{-1}$; No. of curves: 5; Fitting constrains (function, FWHM, approx. position of peak value): Lorentzian (50, 1510 cm^{-1}), Lorentzian (50, 1545 cm^{-1}), Gaussian (100, 1635 cm^{-1}), Gaussian (150, 1660 cm^{-1}), Lorentzian (25, 1745 cm^{-1}).

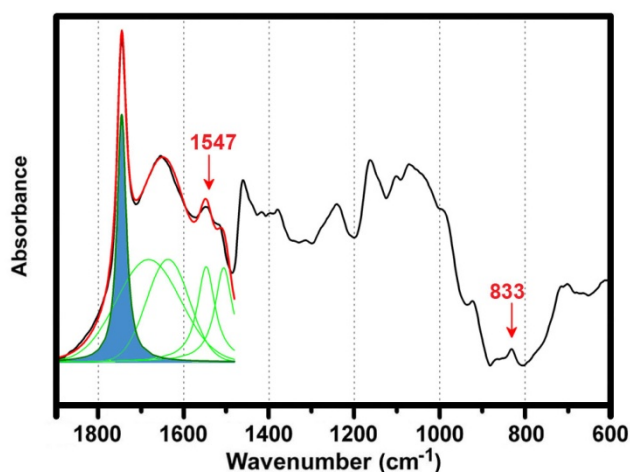


Fig. S1. Estimation of pollen lipid content for *Iris pallida* depicting bands for the normalization of transmission spectra (amide II band at 1547 cm^{-1} , and sporopollenin band at 833 cm^{-1} that was used as the secondary standard), spectral deconvolution (multipeak fitting of three Lorentzian and two Gaussian curves), and application of Beer–Lambert law, i.e. the linear correlation of absorbance (blue area under the curve with the peak center at $\sim 1745\text{ cm}^{-1}$) and lipid quantity.

Carbohydrate-to-protein ratio in pollen

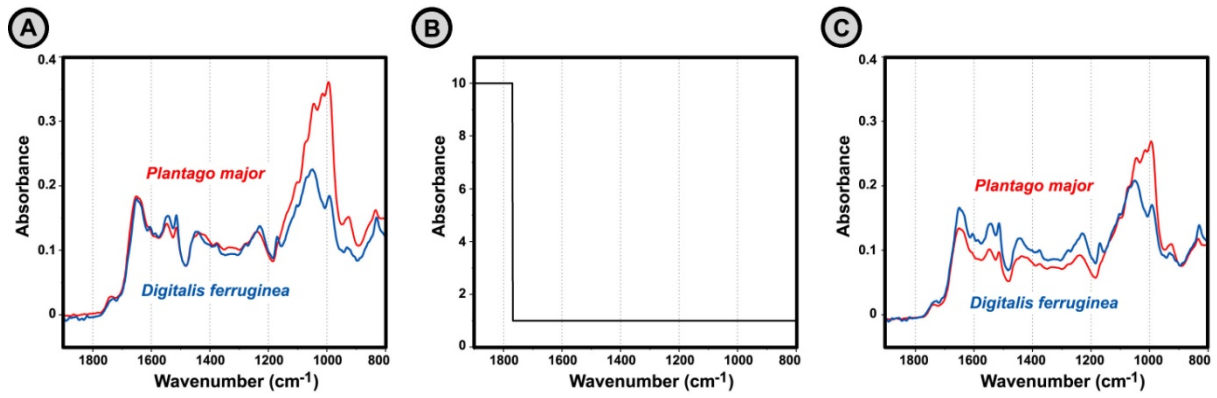


Fig. S2. (A) Reflectance IR spectra of *Plantago major* and *Digitalis ferruginea* (raw data). (B) Weighting vector for the MSC correction. (C) MSC corrected spectra of *Plantago major* and *Digitalis ferruginea*.

Pollen grain wall composition

Pollen grain has double-layered outer wall made of the cellulose-rich intine layer, and the highly resistant exine composed predominantly of a complex biopolymer sporopollenin. As a result of thick cellulose intine wall pollen grains of *Cupressaceae* family have unique and outlying spectral features (Fig. S3A). While *Cupressaceae* pollen grains have thick intine and thus increased relative amount of cellulose, pollens of *Pinaceae* family have a large hollow projection (saccus) from the central body of pollen grain composed only by the exine, resulting with increased relative amount of sporopollenin in the grains. For that reason the vibrational bands associated with the sporopollenin dominate to a larger extent in *Pinaceae* reflectance spectra than is the case with *Cupressaceae* spectra (Fig. S3D).

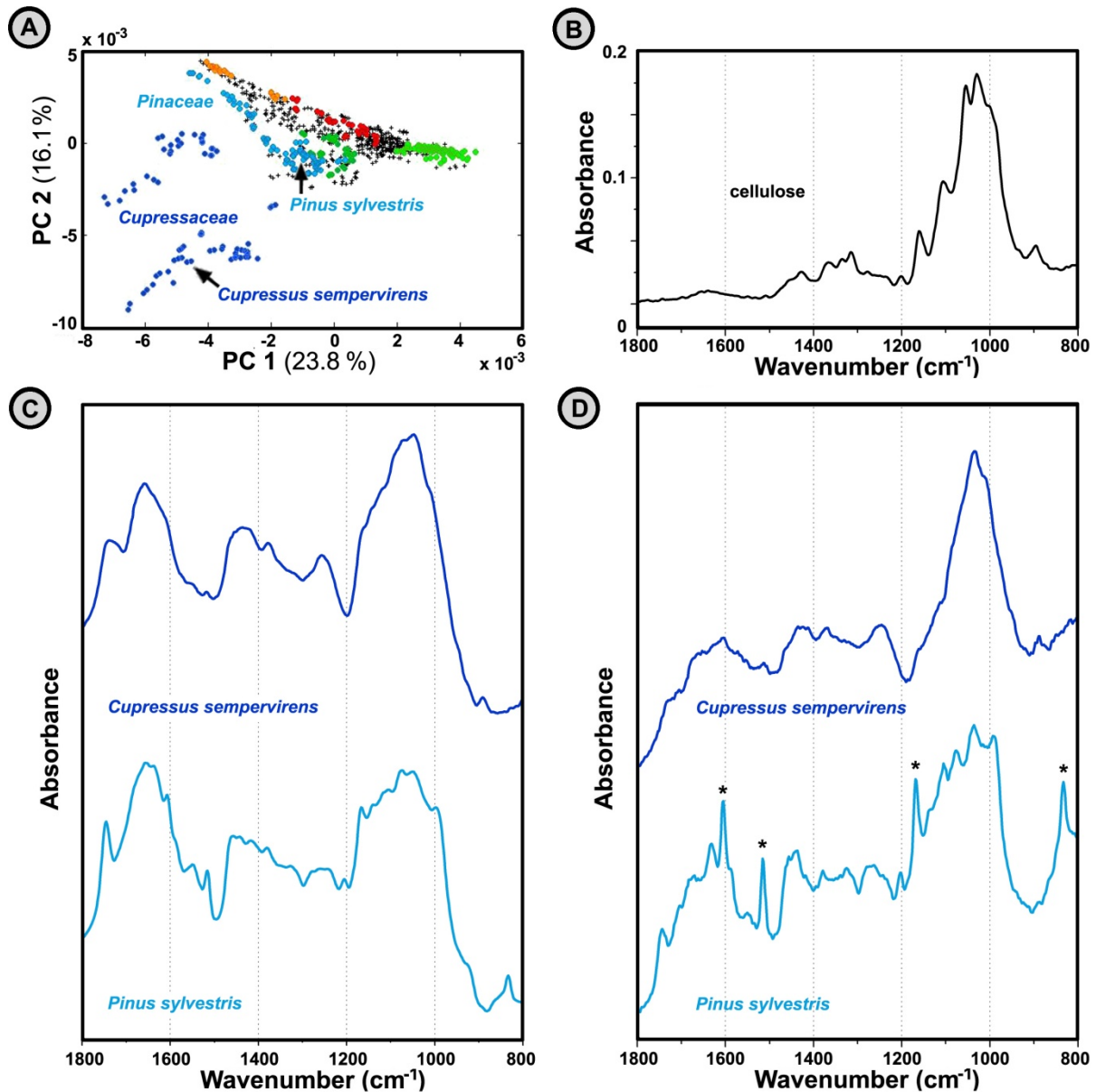


Fig. S3. (A) PCA plot of transmission IR spectral data set (300 species, three spectra per specie; second derivative and EMSC corrected spectra) with depiction of plant families: *Pinaceae* (light blue), *Cupressaceae* (dark blue), *Poaceae* (light green), *Cyperaceae* (dark green), *Betulaceae* (red), and *Juglandaceae* (orange). The percent variances for the first five PCs are 23.83, 16.13, 11.30, 6.11, and 5.24. (B) reflectance IR spectra of cellulose. EMSC corrected transmission (C) and reflectance (D) IR spectra of *Cupressus sempervirens* (Mediterranean cypress, *Pinales* order, *Cupressaceae* family) and *Pinus sylvestris* (Scots pine; *Pinales* order, *Pinaceae* family) pollen. For better viewing the spectra are offset; the vibrational bands associated with sporopollenin are denoted with asterisks.

Correlation between spectroscopic data and taxonomy

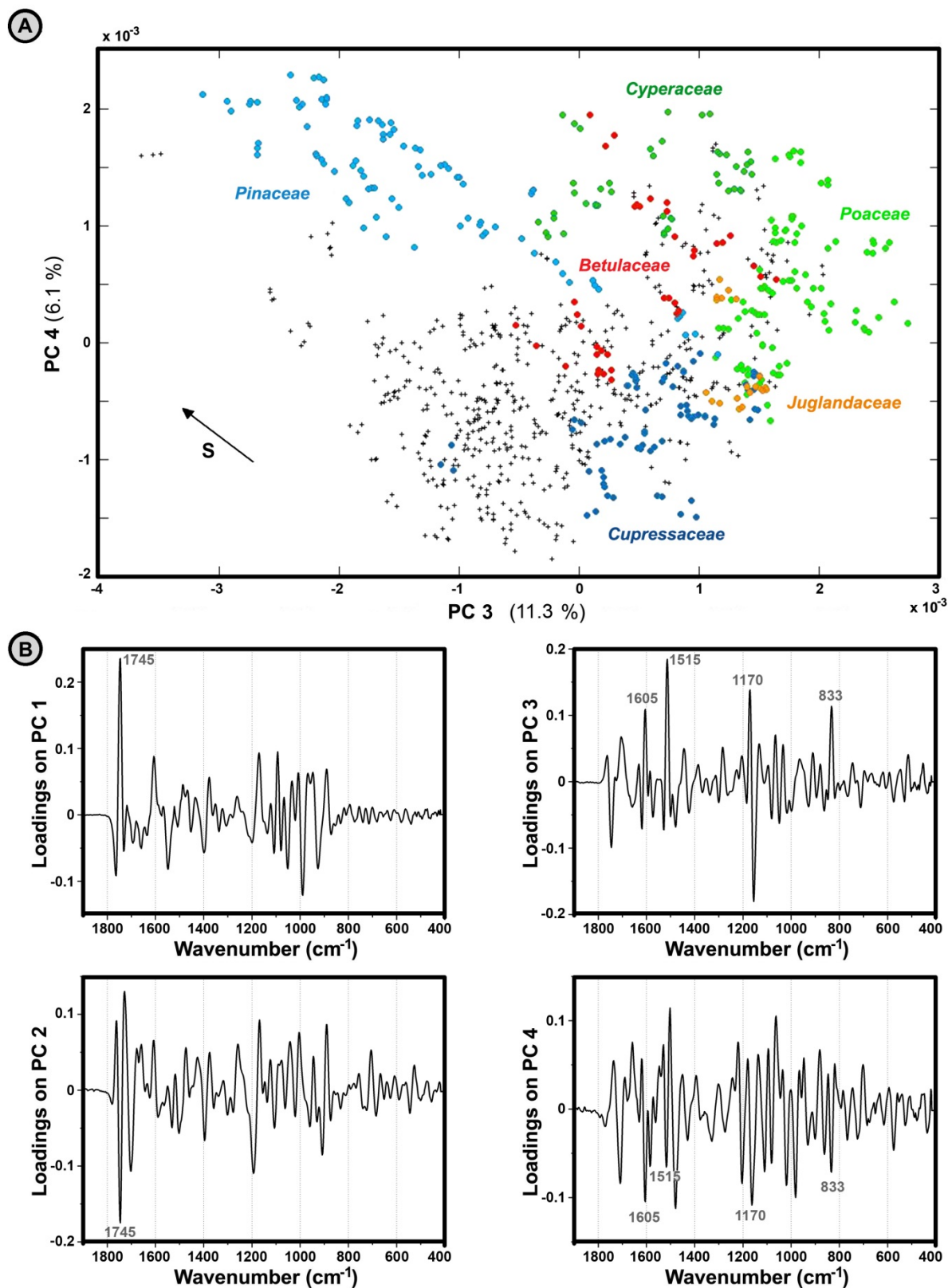


Fig. S4. (A) PCA plot of transmission IR spectral data set (300 species, three spectra per species; second derivative and EMSC corrected spectra) with depiction of plant families: *Pinaceae* (light blue), *Cupressaceae* (dark blue), *Poaceae* (light green), *Cyperaceae* (dark green), *Betulaceae* (red), and *Juglandaceae* (orange). The percent variances for the first five PCs are 23.83, 16.13, 11.30, 6.11, and 5.24. (B) Loadings plot on the first four principal component of the PCA.

Fagales order pollen samples

All pollen samples depicted in Fig. S5 were sampled in 2011 within the area of 100 m radius. The timeframe of the sampling was the following (expressed in weeks): *Corylus* (W denotes first week of March), *Alnus* (W), *Betula* (W+4), *Ostrya* (W+4), *Carpinus* (W+4), *Pterocarya* (W+4), *Juglans* (W+4 till W+6), *Quercus* (W+4 till W+7), *Fagus* (W+5) and *Carya* (W+10; i.e. third week of May).

Pollen samples depicted in Fig. S6 were sampled in 2010, in the first week of March. Five *Corylus avellana* samples (depicted in different shades of red) were collected from different individuals, all growing several meters apart on a same location.

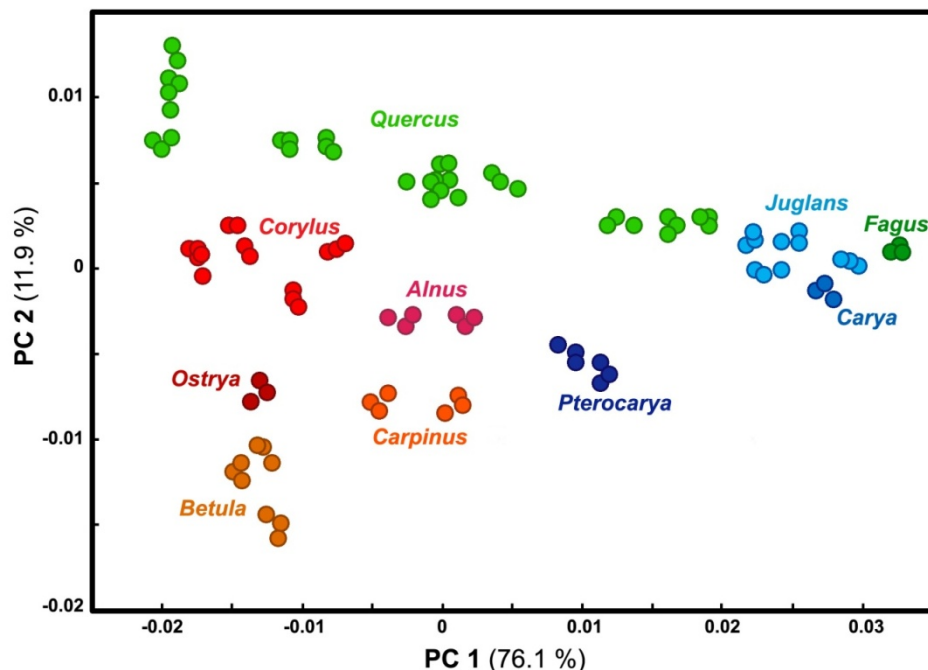


Fig. S5. (A) PCA plot of transmission IR spectral data set containing pollen samples of *Fagales* order in the 2011 pollination season (33 species, three spectra per specie; first derivative and EMSC corrected spectra) with depiction of plant families: *Betulaceae* (red: *Corylus* (hazel), *Alnus* (alder), *Betula* (birch), *Carpinus* (hornbeam) and *Ostrya* (hop-hornbeam)), *Fagaceae* (green: *Fagus* (beechnut) and *Quercus* (oak)), and *Juglandaceae* (blue: *Juglans* (walnut), *Pterocarya* (wingnut) and *Carya* (hickory)). The percent variances for the first five PCs are 76.05, 11.85, 3.78, 2.75, and 1.24.

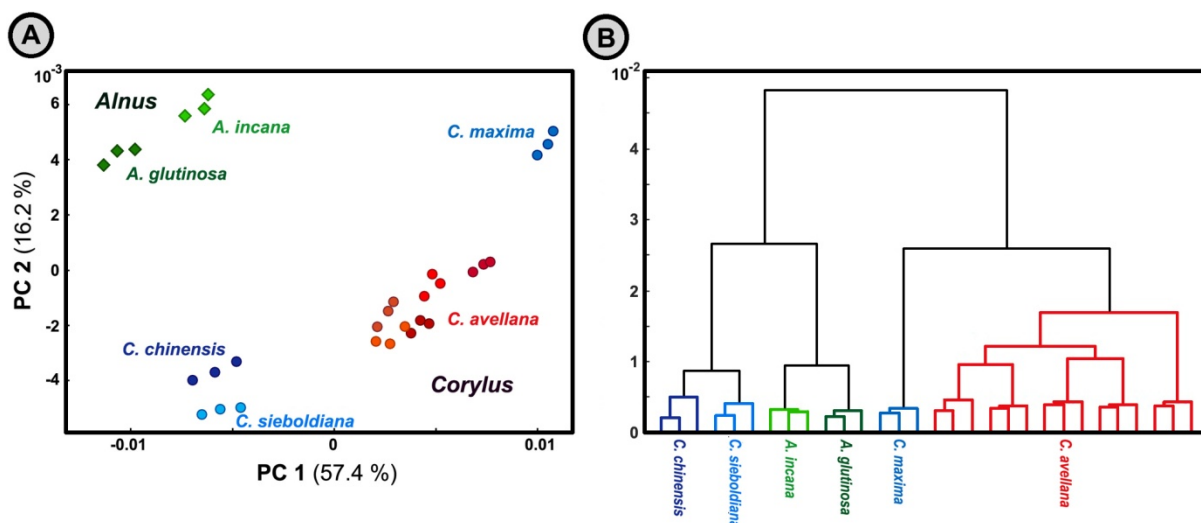


Fig. S6. Reflectance IR spectral data set containing pollen samples of *Betulaceae* family in the 2010 pollination season (10 samples, three spectra per sample; first derivative and EMSC corrected spectra) with depiction of plant genera and species (two *Alnus* and four *Corylus* species). (A) PCA plot of spectral data; The percent variances for the first five PCs are 57.39, 16.19, 11.33, 6.06, and 1.93. (B) HCA dendrogram.

Triglycerides content of pollen

The spectral variability caused by the specific biochemicals can be extracted from the rest of the data (Fig. S7). That way, the influence of specific biochemical components on spectral variability, such as triglycerides, can be evaluated.

The data matrix containing complete set of transmission spectra was deflated by using either 1) the PC 1q vector (the first principal component obtained by PCA on quercus subset; i.e. set of transmission spectra obtained by measuring pollen samples of *Quercus* genus), or 2) reflectance spectra of tristearin (Fig. S7D). For the deflation the data matrix was centred while the vectors were normalized. The PC 1q vector accounts for the maximal spectral variance in congenital pollen samples of *Quercus* genus. Since both deflation procedures resulted with the similar reduced data sets, as seen by the PCA plots of this sets (Figs. S7B and C), it is clear that congenital differentiation of *Quercus* pollen, as well as *Pinus* and *Iris* pollen, can be based on the relative content of triglycerides. The impact of triglycerides on spectral variance can be more directly estimated from spectral differences of congenital pollen samples (Fig. S7E)

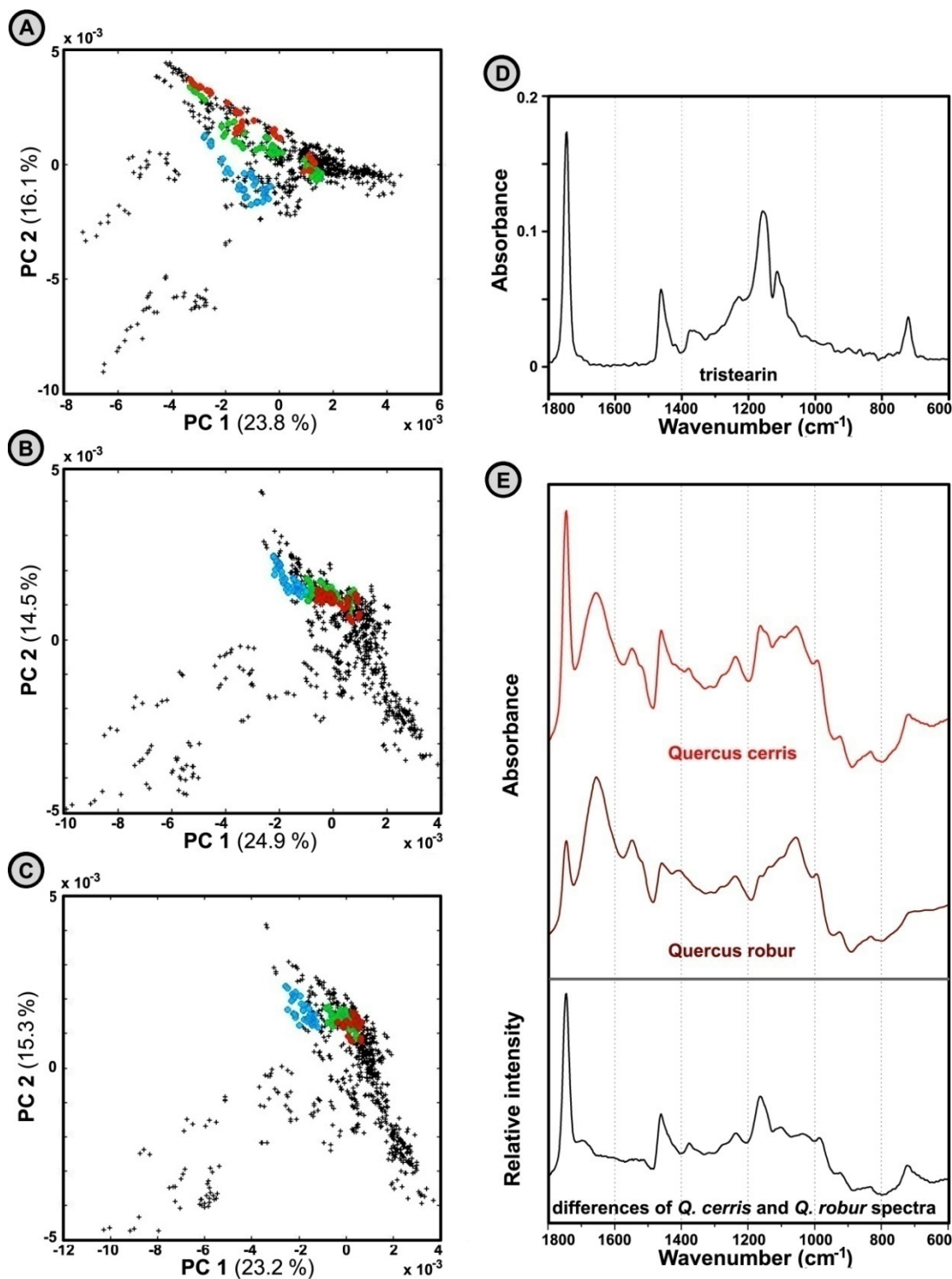


Fig. S7. PCA plots of transmission IR spectral data set (300 species, three spectra per specie; second derivative and EMSC corrected spectra) with depiction of plant genera: *Pinus* (blue), *Iris* (green) and *Quercus* (red). (A) Original data. The percent variances for the first five PCs are 23.83, 16.13, 11.30, 6.11, and 5.24. (B) Modelling spectral contribution of triglycerides, approximated by tristearin spectrum. The percent variances for the first five PCs are 24.87, 14.48, 9.40, 7.17, and 5.91. (C) Modelling spectral contribution of PC1q obtained by PCA on quercus subset. The percent variances for the first five PCs are 23.19, 15.27, 7.43, 6.22, and 5.71. Note the similarity between figures B and C: It is clear that triglyceride content is responsible for the majority of congenital spectral variations. (D) reflectance IR spectra of tristearin (amorphous phase). (E) Transmission IR spectra of *Quercus cerris* (Turkey oak) and *Quercus robur* (pedunculate oak) pollen, and spectral differences of the two transmission spectra. For better viewing the spectra are offset.

Table S1. List of analyzed pollen taxa (part I): eudicots.

ORDER	FAMILY	GENUS	SPECIES	COMMON NAME		
Fagales	Betulaceae	Alnus	<i>A. incana</i>	Grey Alder		
			<i>A. glutinosa</i>	Black Alder		
		Corylus	<i>C. maxima</i>	Filbert		
			<i>C. avellana</i>	Common Hazel		
			<i>C. chinensis</i>	Chinese Hazel		
			<i>C. colurna</i>	Turkish Hazel		
			<i>C. sieboldiana</i>	Asian Beaked Hazel		
		Ostrya	<i>O. carpinifolia</i>	European Hop-hornbeam		
		Betula	<i>B. ermanii</i>	Erman's Birch		
			<i>B. pendula</i>	Silver Birch		
			<i>B. papyrifera</i>	Paper Birch		
		Carpinus	<i>C. orientalis</i>	Oriental Hornbeam		
			<i>C. betulus</i>	European Hornbeam		
		Fagaceae	Quercus	<i>Q. robur</i>	Pedunculate Oak	
	<i>Q. coccinea</i>			Scarlet Oak		
	<i>Q. rubra</i>			Northern Red Oak		
	<i>Q. petraea</i>			Sessile Oak		
	<i>Q. ilex</i>			Holly Oak		
	<i>Q. coccifera</i>			Kermes Oak		
	<i>Q. faginea</i>			Portuguese Oak		
	<i>Q. cerris</i>			Turkey Oak		
	<i>Q. pubescens</i>			Downy Oak		
	<i>Q. libani</i>			Lebanon Oak		
<i>Q. shumardii</i>	Shumard's Oak					
<i>Q. frainetto</i>	Hungarian Oak					
Fagus	<i>F. sylvatica</i>			European Beech		
Juglandaceae	Juglans			<i>J. regia</i>	Persian Walnut	
		<i>J. ailanthifolia</i>	Japanese Walnut			
		<i>J. mandshurica</i>	Manchurian Walnut			
		<i>J. nigra</i>	Eastern Black Walnut			
	Carya	<i>C. illinoensis</i>	Pecan Hickory			
	Pterocarya	<i>P. stenoptera</i>	Chinese Wingnut			
		<i>P. fraxinifolia</i>	Caucasian Wingnut			
Malpighiales	Salicaceae	Salix	<i>S. babylonica</i>	Peking Willow		
			<i>S. alba</i>	White Willow		
			<i>S. caprea</i>	Goat Willow		
		Populus	<i>P. nigra</i> *	Black Poplar		
			<i>P. alba</i> *	White Poplar		
			Euphorbiaceae	<i>R. communis</i>	Castor Bean	
Proteales	Platanaceae	Platanus	<i>P. x hispanica</i>	Hybrid (London) Plane		
			<i>P. orientalis</i>	Oriental Plane		
Lamiales	Oleaceae	Fraxinus	<i>F. excelsior</i>	European Ash		
			<i>F. pennsylvanica</i>	Red Ash		
			<i>F. ornus</i>	Manna Ash		
			<i>F. chinensis</i>	Chinese Ash		
			Olea	<i>O. europeae</i>	Olive	
		Plantaginaceae	Plantago	<i>P. lanceolata</i>	Ribwort Plantain	
				<i>P. media</i>	Hoary Plantain	
				<i>P. major</i>	Greater Plantain	
			Digitalis	<i>D. purpurea</i>	Common Foxglove	
				<i>D. grandiflora</i>	Big-flowered Foxglove	
		<i>D. lutea</i>		Yellow Foxglove		
		Scrophulariaceae	Paulownia	<i>P. tomentosa</i>	Empress Tree	
		Acanthaceae	Acanthus	<i>A. balcanicus</i>	Balkan Bear's Breeches	
		Saxifragales	Altingiaceae	Liquidambar	<i>L. orientalis</i>	Oriental Sweetgum
					<i>L. styraciflua</i>	American Sweetgum
Paeoniaceae	Paeonia			<i>P. mascula</i>	Wild Peony	
				<i>P. officinalis</i>	European Peony	

Note on Table S1: Species denoted with asterisks were measured in transmission mode only.

Table S1. List of analyzed pollen taxa (part II): eudicots.

ORDER	FAMILY	GENUS	SPECIES	COMMON NAME			
<i>Carvophyllales</i>	<i>Polygonaceae</i>	<i>Rumex</i>	<i>R. acetosa</i>	Common Sorrel			
			<i>R. longifolius</i>	Dooryard Dock			
			<i>R. patientia</i>	Patience Dock			
			<i>R. aquaticus</i>	Western Dock			
			<i>R. alpinus</i>	Alpine Dock			
	<i>Portulacaceae</i>	<i>Cistanthe</i>	<i>C. grandiflora</i>	Big-flowered Pussypaws			
<i>Sapindales</i>	<i>Sapindaceae</i>	<i>Aesculus</i>	<i>A. hippocastanum</i>	Common Horse Chestnut			
			<i>A. flava</i>	Yellow Buckeye			
			<i>Acer</i>	<i>A. opalus</i>	Italian Maple		
			<i>A. negundo</i> *	Boxelder Maple			
			<i>A. cissifolium</i>	Vineleaf Maple			
		<i>Anacardiaceae</i>	<i>Pistacia</i>	<i>P. lentiscus</i>	Mastic Tree		
				<i>P. terebinthus</i>	Terebinth		
		<i>Rutaceae</i>	<i>Dictamnus</i>	<i>D. albus</i>	White Dittany		
	<i>Dipsacales</i>	<i>Adoxaceae</i>	<i>Sambucus</i>	<i>S. nigra</i>	Black Elder		
				<i>Viburnum</i>	<i>V. rhytidophyllum</i>	Leatherleaf Viburnum	
<i>V. carlesii</i>					Korean Spice Viburnum		
<i>V. lantana</i>					Wayfaring Tree		
<i>V. opalus</i>					Guelder Rose		
				<i>Dipsacaceae</i>	<i>Scabiosa</i>	<i>S. caucasica</i>	Caucasian Scabious
		<i>Cephalaria</i>	Tatarian Cephalaria				
<i>Asterales</i>		<i>Asteraceae</i>	<i>Ambrosia</i>	<i>A. artemisifolia</i>	Common Ragweed		
				<i>Taraxacum</i>	<i>T. officinale</i>	Common Dandelion	
				<i>Artemisia</i>	<i>A. absinthium</i>	Absinthe Wormwood	
					<i>A. dracunculus</i>	Tarragon	
					<i>A. vulgaris</i>	Common Wormwood	
		<i>Campanulaceae</i>	<i>Platycodon</i>	<i>P. grandiflorus</i>	Chinese Bellflower		
				<i>Campanula</i>	<i>C. persicifolia</i>	Peach-leaved Bellflower	
	<i>Rosales</i>	<i>Rosaceae</i>	<i>Prunus</i>	<i>P. cerasifera</i>	Cherry Plum		
				<i>P. padus</i>	Bird Cherry		
				<i>P. laurocerasus</i>	Cherry Laurel		
			<i>Rosa</i>	<i>R. pendulina</i>	Alpine Rose		
				<i>R. canina</i>	Dog Rose		
				<i>R. dumetorum</i>	Corymb Rose		
			<i>Rubus</i>	<i>R. fruticosus</i>	Common Blackberry		
			<i>Mespilus</i>	<i>M. germanica</i>	Common Medlar		
			<i>Sanguisorba</i>	<i>S. minor</i>	Salad Burnet		
			<i>Potentilla</i>	<i>P. atrosanguinea</i>	Ruby Cinquefoil		
			<i>Geum</i>	<i>G. x heldreichii</i>	Copper Avens		
			<i>Fragaria</i>	<i>F. moschata</i>	Musk Strawberry		
			<i>Filipendula</i>	<i>F. vulgaris</i>	Fern-leaf Dropwort		
			<i>Urticaceae</i>	<i>Parietaria</i>	<i>P. officinalis</i>	Upright Pellitory	
					<i>Urtica</i>	<i>U. pilulifera</i>	Roman Nettle
					<i>U. dioica</i>	Stinging Nettle	
<i>Buxales</i>			<i>Buxaceae</i>	<i>Buxus</i>	<i>B. sempervirens</i>	Common Box	
					<i>B. microphylla</i>	Japanese Box	
<i>Malvales</i>			<i>Malvaceae</i>	<i>Abutilon</i>	<i>A. grandifolium</i>	Hairy Indian Mallow	
	<i>Kitaibelia</i>	<i>K. vitifolia</i>			Vine-leaved Kitaibelia		
	<i>Althaea</i>	<i>A. officinalis</i>			Common Marshmallow		
		<i>A. cannabina</i>			Palm-leaf Marshmallow		
<i>Geraniales</i>	<i>Geraniaceae</i>	<i>Geranium</i>	<i>G. phaeum</i>	Dusky Cranesbill			
<i>Fabales</i>	<i>Fabaceae</i>	<i>Bauhinia</i>	<i>B. purpurea</i>	Purple Orchid Tree			
<i>Brassicales</i>	<i>Brassicaceae</i>	<i>Bunias</i>	<i>B. orientalis</i> *	Turkish Wartycabbage			
			<i>Tropaeolaceae</i>	<i>Tropaeolum</i>	<i>T. majus</i>	Garden Nasturtium	
<i>Cucurbitales</i>	<i>Cucurbitaceae</i>	<i>Ecballium</i>	<i>E. elaterium</i>	Squirting Cucumber			

Note on Table S1: Species denoted with asterisks were measured in transmission mode only.

Table S1. List of analyzed pollen taxa (part III): eudicots and magnoliids.

ORDER	FAMILY	GENUS	SPECIES	COMMON NAME	
<i>Solanales</i>	<i>Solanaceae</i>	<i>Nicandra</i>	<i>N. physalodes</i>	Apple of Peru	
		<i>Nicotiana</i>	<i>N. alata</i>	Winged Tobacco	
			<i>N. tabacum</i>	Common Tobacco	
		<i>Datura</i>	<i>D. innoxia</i>	Downy Thorn-apple	
		<i>Brugmansia</i>	<i>B. suaveolens</i>	White Angel's Trumpet	
<i>Ranunculales</i>	<i>Ranunculaceae</i>	<i>Pulsatilla</i>	<i>P. montana</i>	Mountain Pasque Flower	
		<i>Aquilegia</i>	<i>A. nigricans</i>	Bulgarian Columbine	
			<i>A. vulgaris</i>	European Columbine	
			<i>A. chrysantha</i>	Golden Columbine	
			<i>A. fragrans</i>	Fragrant Columbine	
		<i>Anemone</i>	<i>A. coronaria</i>	Poppy Anemone	
			<i>A. sylvestris</i>	Snowdrop Windflower	
		<i>Caltha</i>	<i>C. palustris</i>	Marsh Marigold	
		<i>Ranunculus</i>	<i>R. repens</i>	Creeping Buttercup	
			<i>R. acris</i>	Meadow Buttercup Žabnjak	
			<i>R. lanuginosus</i>	Woolly Buttercup	
		<i>Clematis</i>	<i>C. recta</i>	Erect Clematis	
		<i>Papaveraceae</i>	<i>Nigella</i>	<i>N. damascena</i>	Love-in-a-Mist
			<i>Papaver</i>	<i>P. lapponicum</i>	Lapland Poppy
				<i>P. orientale</i>	Oriental Poppy
				<i>P. nudicaule</i>	Iceland Poppy
				<i>P. rhoeas</i>	Field Poppy
			<i>Glaucium</i>	<i>G. flavum</i>	Yellow Hornpoppy
			<i>Eschscholzia</i>	<i>E. californica</i>	California Poppy
		<i>Chelidonium</i>	<i>C. majus</i>	Greater Celandine	
		<i>Magnoliales</i>	<i>Magnoliaceae</i>	<i>Magnolia</i>	<i>M. x sonlangiana</i>
<i>Liriodendron</i>	<i>L. tulipifera</i>			American Tulip Tree	

Table S1. List of analyzed pollen taxa (part IV): monocots.

ORDER	FAMILY	GENUS	SPECIES	COMMON NAME	
Poales	Cyperaceae	<i>Holoschoenus</i>	<i>H. romanus</i>	Round-headed Club-rush	
		<i>Carex</i>	<i>C. dipsacea</i>	<i>C. dipsacea</i>	New Zealand Sedge
			<i>C. pendula</i>	<i>C. pendula</i>	Pendulous Sedge
			<i>C. muskingumensis</i>	<i>C. muskingumensis</i>	Muskingum Sedge
			<i>C. flacca</i>	<i>C. flacca</i>	Blue Sedge
			<i>C. divisa</i>	<i>C. divisa</i>	Divided Sedge
			<i>C. ferruginea</i>	<i>C. ferruginea</i>	Rusty Sedge
			<i>C. morrowii</i>	<i>C. morrowii</i>	Variegata Sedge
			<i>C. riparia</i>	<i>C. riparia</i>	Great Pond-Sedge
			<i>C. ornithopoda</i>	<i>C. ornithopoda</i>	Birdsfoot Sedge
			<i>C. grayi</i>	<i>C. grayi</i>	Gray's Sedge
			<i>C. sylvatica</i>	<i>C. sylvatica</i>	Forest Sedge
			<i>C. ovalis</i>	<i>C. ovalis</i>	Eggbract Sedge
			<i>Cladium</i>	<i>C. mariscus</i>	<i>C. mariscus</i>
	<i>Eleocharis</i>	<i>E. palustris</i>	<i>E. palustris</i>	Common Spikerush	
	Poaceae	<i>Secale</i>	<i>S. cereale</i>	<i>S. cereale</i>	Rye
		<i>Zea</i>	<i>Z. mays</i>	<i>Z. mays</i>	Maize
		<i>Alopecurus</i>	<i>A. pratensis</i>	<i>A. pratensis</i>	Meadow Foxtail
		<i>Brachypodium</i>	<i>B. retusum</i>	<i>B. retusum</i>	Mediterranean False-brome
			<i>B. pinnatum</i>	<i>B. pinnatum</i>	Heath False-brome
		<i>Piptatherum</i>	<i>P. miliaceum</i>	<i>P. miliaceum</i>	Smilgrass
		<i>Festuca</i>	<i>F. filiformis</i>	<i>F. filiformis</i>	Fine-Leaved Sheep's Fescue
			<i>F. ovina</i>	<i>F. ovina</i>	Sheep Fescue
			<i>F. pratensis</i>	<i>F. pratensis</i>	Meadow Fescue
			<i>F. drymeja</i>	<i>F. drymeja</i>	Mountain Fescue
			<i>F. amethystina</i>	<i>F. amethystina</i>	Tufted Fescue
			<i>F. arvernensis</i>	<i>F. arvernensis</i>	Field Fescue
			<i>F. heterophylla</i>	<i>F. heterophylla</i>	Various-leaved Fescue
		<i>Melica</i>	<i>M. ciliata</i>	<i>M. ciliata</i> *	Hairy Melic
			<i>M. altissima</i>	<i>M. altissima</i>	Siberian Melic
			<i>M. nutans</i>	<i>M. nutans</i>	Mountain Melic
		<i>Poa</i>	<i>P. badensis</i>	<i>P. badensis</i>	Baden's Bluegrass
			<i>P. pratensis</i>	<i>P. pratensis</i>	Smooth Meadow-grass
			<i>P. nemoralis</i>	<i>P. nemoralis</i>	Wood Meadow-Grass
			<i>P. compressa</i>	<i>P. compressa</i>	Flattened Meadow-grass
		<i>Anthoxanthum</i>	<i>A. odoratum</i>	<i>A. odoratum</i>	Sweet Vernal Grass
		<i>Arrhenatherum</i>	<i>A. elatius</i>	<i>A. elatius</i>	Tall Oat-grass
		<i>Sesleria</i>	<i>S. tenuifolia</i>	<i>S. tenuifolia</i>	Thin-leaved Moor Grass
			<i>S. nitida</i>	<i>S. nitida</i>	Nest Moor Grass
		<i>Dactylis</i>	<i>D. glomerata</i>	<i>D. glomerata</i>	Orchard Grass
		<i>Pennisetum</i>	<i>P. orientale</i>	<i>P. orientale</i> *	Oriental Fountain Grass
		<i>Bromus</i>	<i>B. erectus</i>	<i>B. erectus</i>	Erect Brome
		<i>Briza</i>	<i>B. media</i>	<i>B. media</i>	Common Quaking Grass
		<i>Lolium</i>	<i>L. perenne</i>	<i>L. perenne</i>	Perennial Ryegrass
	<i>Holcus</i>	<i>H. lanatus</i>	<i>H. lanatus</i>	Common Velvet Grass	
	<i>Phalaris</i>	<i>P. canariensis</i>	<i>P. canariensis</i>	Phalaris canariensis	
	<i>Coix</i>	<i>C. lacryma-jobi</i>	<i>C. lacryma-jobi</i>	Job's Tears	
Juncaceae	<i>Luzula</i>	<i>L. luzuloides</i>	<i>L. luzuloides</i>	White Wood-Rush	
		<i>L. sylvatica</i>	<i>L. sylvatica</i>	Great Wood-Rush	
Typhaceae	<i>Typha</i>	<i>T. latifolia</i>	<i>T. latifolia</i>	Broadleaf Cattail	
Arales	Acoraceae	<i>Acorus</i>	<i>A. calamus</i>	Sweet Flag	
Zingiberales	Cannaceae	<i>Canna</i>	<i>C. orchoides</i>	Orchid Canna	
Arecales	Arecaceae	<i>Chamaerops</i>	<i>C. humilis</i> (stak)	Mediterranean Fan Palm	

Note on Table S1: Species denoted with asterisks were measured in transmission mode only.

Table S1. List of analyzed pollen taxa (part V): monocots.

ORDER	FAMILY	GENUS	SPECIES	COMMON NAME		
Asparagales	Hyacinthaceae	Hyacinthus	<i>H. orientalis</i>	Garden Hyacinth		
		Hyacinthoides	<i>H. hispanica</i>	Spanish Bluebell		
	Iridaceae	Iris	<i>I. illyrica</i>	<i>I. illyrica</i>	Illyrian Iris	
			<i>I. pseudacorus</i>	<i>I. pseudacorus</i>	Yellow Iris	
			<i>I. japonica</i>	<i>I. japonica</i>	Japanese Iris	
			<i>I. germanica</i>	<i>I. germanica</i>	German Iris	
			<i>I. sikkimensis</i>	<i>I. sikkimensis</i>	Sikkim Iris	
			<i>I. versicolor</i>	<i>I. versicolor</i>	Larger Blue Flag	
			<i>I. pseudopallida</i>	<i>I. pseudopallida</i>	South Adriatic Iris	
			<i>I. sibirica</i>	<i>I. sibirica</i>	Siberian Iris	
			<i>I. sanguinea</i>	<i>I. sanguinea</i>	Blood Iris	
			<i>I. graminea</i>	<i>I. graminea</i>	Grass-Leaved Iris	
			<i>I. spuria</i>	<i>I. spuria</i>	Blue Iris	
			<i>I. crocea</i>	<i>I. crocea</i>	Crosier Iris	
			<i>I. unguicularis</i>	<i>I. unguicularis</i>	Algerian Iris	
			<i>I. aphylla</i>	<i>I. aphylla</i>	Stool Iris	
			<i>I. bulleyana</i>	<i>I. bulleyana</i>	Bulley's Iris	
			<i>I. pallida</i>	<i>I. pallida</i>	Dalmatian Iris	
			<i>I. bucharica</i>	<i>I. bucharica</i>	Corn Leaf Iris	
			<i>I. orientalis</i>	<i>I. orientalis</i>	Yellow-banded Iris	
		Gladiolus	<i>G. italicus</i>	Italian Gladiolus		
	Asphodelaceae	Asphodelus	<i>A. aestivus</i>	Summer Asphodel		
	Xanthorrhoeaceae	Hemerocallis	<i>H. lilioasphodelus</i>	<i>H. lilioasphodelus</i>	Yellow Daylily	
			<i>H. minor</i>	<i>H. minor</i>	Dwarf Daylily	
			<i>H. citrina</i>	<i>H. citrina</i>	Citron Daylily	
			<i>H. esculenta</i>	<i>H. esculenta</i>	Japanese Daylily	
			Aloe	<i>A. grandidentata</i>	<i>A. grandidentata</i>	Dwarf Soap Aloe
				<i>A. capitata</i>	<i>A. capitata</i>	Capitate Aloe
				<i>A. striata</i>	<i>A. striata</i>	Coral Aloe
			Kniphofia	<i>K. angustifolia</i>	<i>K. angustifolia</i>	Thin-leaved Tritoma
				<i>K. uvaria</i>	<i>K. uvaria</i>	Red Tritoma
				<i>K. triangularis</i>	<i>K. triangularis</i>	Triangle Tritoma
		Gasteria	<i>G. obliqua</i>	Bicolor Gasteria		
	Asphodeline	<i>A. lutea</i>	Yellow Asphodel			
Asparagaceae	Hosta	<i>H. plantaginea</i>	<i>H. plantaginea</i>	Fragrant Hosta		
		<i>H. sieboldiana</i>	<i>H. sieboldiana</i>	Sieboldiana Hosta		
		<i>H. kikutii</i>	<i>H. kikutii</i>	Rock Hosta		
Liliales	Liliaceae	Fritillaria	<i>F. imperialis</i>	Crown Imperial		
		Lilium	<i>L. bulbiferum</i>	<i>L. bulbiferum</i>	Orange Lily	
			<i>L. carniolicum</i>	<i>L. carniolicum</i>	Carniolan Lily	
			<i>L. pumilum</i>	<i>L. pumilum</i>	Siberian Lily	
			<i>L. martagon</i>	<i>L. martagon</i>	Martagon Lily	
			<i>L. regale</i>	<i>L. regale</i>	Regal Lily	
			<i>L. monadelphum</i>	<i>L. monadelphum</i>	Caucasian Lily	
			<i>L. candidum</i>	<i>L. candidum</i>	Madonna Lily	
			<i>L. japonicum</i>	<i>L. japonicum</i>	Bamboo Lily	
			<i>L. henryi</i>	<i>L. henryi</i>	Tiger Lily	
			<i>L. henryi</i>	<i>L. henryi</i>	Tiger Lily	

Table S1. List of analyzed pollen taxa (part VI): conifers and ginkos.

ORDER	FAMILY	GENUS	SPECIES	COMMON NAME	
<i>Pinales</i>	<i>Cupressaceae</i>	<i>Platycladus</i>	<i>P. orientalis</i>	Chinese Arborvitae	
		<i>Thuja</i>	<i>T. dolabrata</i>	Thuja	
		<i>Chamaecyparis</i>	<i>C. lawsoniana</i>	Lawson's Cypress	
			<i>C. obtusa</i>	Hinoki Cypress	
			<i>C. pisifera</i>	Sawara Cypress	
		<i>Juniperus</i>	<i>J. chinensis</i>	Chinese Juniper	
			<i>J. virginiana</i>	Eastern Juniper	
			<i>J. sabina</i>	Savin Juniper	
			<i>J. phoenicea</i>	Phoenicean Juniper	
			<i>J. communis</i>	Common Juniper	
			<i>J. oxycedrus</i>	Prickly Juniper	
		<i>Calocedrus</i>	<i>C. decurrens</i>	California Incense-cedar	
		<i>Cupressus</i>	<i>C. sempervirens</i>	Mediterranean Cypress	
			<i>C. x leylandii</i>	Leyland Cypress	
			<i>C. lusitanica</i>	Mexican Cypress	
			<i>C. sargentii</i>	Sargent Cypress	
		<i>Cunninghamia</i>	<i>C. lanceolata</i>	China Fir	
		<i>Cryptomeria</i>	<i>C. japonica</i>	Japanese Cedar	
		<i>Thuja</i>	<i>T. occidentalis</i>	Eastern Arborvitae	
			<i>T. standishii</i>	Japanese Thuja	
		<i>Taxodium</i>	<i>T. distichum</i>	Bald Cypress	
		<i>Sequoia</i>	<i>S. sempervirens</i>	Coast Redwood	
		<i>Metasequoia</i>	<i>M. glyptostroboides</i>	Dawn Redwood	
		<i>Taxaceae</i>	<i>Taxus</i>	<i>T. baccata</i>	European Yew
				<i>T. cuspidata</i>	Japanese Yew
		<i>Cephalotaxaceae</i>	<i>Cephalotaxus</i>	<i>C. harringtonia</i>	Japanese Plum Yew
			<i>Torreya</i>	<i>T. californica</i>	California Torreya
		<i>Pinaceae</i>	<i>Tsuga</i>	<i>T. canadensis</i>	Eastern Hemlock
				<i>Cedrus</i>	<i>C. atlantica</i>
					<i>C. deodara</i>
		<i>Abies</i>		<i>A. koreana</i>	Korean Fir
				<i>A. pinsapo</i>	Spanish Fir
				<i>A. alba</i>	Silver Fir
				<i>A. cephalonica</i>	Greek Fir
		<i>Picea</i>		<i>P. abies</i>	Norway Spruce
				<i>P. asperata</i>	Dragon Spruce
				<i>P. omorika</i>	Serbian Spruce
				<i>P. chihuahuana</i>	Chihuahua Spruce
				<i>P. orientalis</i>	Caucasian Spruce
				<i>P. smithiana</i>	Morinda Spruce
		<i>Pinus</i>		<i>P. pungens</i>	Blue Spruce
				<i>P. pinea</i>	Stone Pine
				<i>P. mugo</i>	Mountain Pine
<i>P. sylvestris</i>	Scots Pine				
<i>P. tabuliformis</i>	Chinese Red Pine				
<i>P. banksiana</i>	Jack Pine				
<i>P. pinaster</i>	Maritime Pine				
<i>P. densiflora</i>	Japanese Red Pine				
<i>P. nigra</i>	European Black Pine				
<i>P. ponderosa</i>	Ponderosa Pine				
<i>P. resinosa</i>	Red Pine				
<i>P. wallichiana</i>	Himalayan pine				
<i>P. bungeana</i>	Lacebark Pine				
<i>P. peuce</i>	Macedonian Pine				
<i>P. strobus</i>	Eastern White Pine				
<i>P. heldreichii</i>	Bosnian Pine				
	<i>Podocarpaceae</i>	<i>Podocarpus</i>	<i>P. neritifolius</i>	Brown Pine	
<i>Ginkgoales</i>	<i>Ginkgoaceae</i>	<i>Ginkgo</i>	<i>G. biloba</i>	Ginkgo	