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# Pollen morphology of Polish species of the genus *Rosa* – I. *Rosa pendulina*

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**Abstract:** The morphology and variability of pollen of *Rosa pendulina* L. were studied. The material came from 10 native localities of this species. 300 pollen grains were examined. It was established that the diagnostic features of pollen grains of *R. pendulina* L. were: an elongated, narrow operculum, a poorly developed exine sculpture, long ectocolpi (a low value of the apocolpium index), and the predominance of grains elongated in shape. The results obtained usually correspond to data supplied by other palynologists. A statistical analysis of 10 quantitative grain characteristics showed their variability to be rather low. The highest variability was found to occur in two traits connected with d (the distance between the apices of two ectocolpi). Statistical studies revealed dependences among the grains from the 10 analysed localities

**Additional key words:** alpine rose, LM, SEM, variability, multivariate analysis

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## Introduction

Pollen grains of taxa from the family *Rosaceae* L. have a similar morphological structure. Their most important features are their membership of the trizonocolporate class (most species) and exine sculpturing. The operculum, costae colpi, pore structure, and to a lesser degree, grain shape and size are the important traits too. The diagnostic features of pollen grains of the individual taxa of the genus *Rosa* L. include exine sculpture, characteristics of apertures, and the structure of the operculum (Teppner 1965; Reitsma 1966; Eide 1981; Fedoronchuk and Savitsky (1987); Hebda et al. 1988; Faegri and Iversen 1989; Hebda and Chinappa 1990; Moore et al. 1991; Popek 1996; Ueda 1992; Zhou et al. 1999). The diagnostic value of these features requires further studies because data on the structure of pollen grains of roses are incomplete.

Pollen grains of *Rosa pendulina* have been studied and described extremely rarely, using light microscopy (Teppner 1965; Stachurska et al. 1976) or light and scanning microscopy (Savitsky et al. 1987). The authors of the few palynological surveys of the genus *Rosa* containing scanning photographs focus on the exine sculpture (Ueda 1992) or examine the exine sculpture and the structure of the operculum only (Popek 1996). Another route in palynological research is represented by Flory (1950) and Jičinska et al. (1976). They examined the proportion of correctly built grains. Flory (l.c.) reports that in *R. pendulina* they constitute 78.5–89.7%, while according to Jičinska et al. (l.c.), about 80%. Grain survival amounts to about 80% (Jičinska et al. l.c.).

*Rosa pendulina* displays considerable morphological variability. Keller (1931) reports about 80 taxa within *R. pendulina* for Central Europe alone. In the systematics of the genus *Rosa* L., Zieliński (1987) does not distinguish lower-ranking taxa in *R. pendulina*, as against Popek (1996), who differentiates among 5 varieties and 11 forms.

This paper is one of the series of the articles connected with pollen morphology of native species of the genus *Rosa* L. – family *Rosaceae* L. The object of the studies will consist of 16 species from 3 different sections. These are from section *Rosa* – *R. gallica* L., from section *Cinnamomeae* DC. – *R. majalis* Herrm. and *R. pendulina* L. and from section *Caninae* DC. em. H. Christ. – *R. agrestis* Savi, *R. canina* L., *R. dumalis* Bechst., *R. inodora* Fr., *R. jundzillii* Besser., *R. kostrakiewiczii* Popek, *R. micrantha* Borrer ex Sm., *R. mollis* Sm., *R. rubiginosa* L., *R. sherardii* Davies, *R. tomentosa* Sm., *R. villosa* L. and *R. zalana* Wiesb.

Authors assume that pollen morphology may be an important criterion of genus *Rosa* taxonomy. The first article described pollen of *Rosa gallica* L., from section *Rosa* (Wrońska-Pilarek and Boratyńska 2005). The present article shows a research on pollen grains of *R. pendulina* L., from section *Cinnamomeae*, and the next ones will characterize pollen of roses from section *Caninae*. A detailed description of the pollen grains and a key to identify the native rose species on the basis of their pollen grains' features, will be presented as the conclusion of the research.

The principal aim of the present research was to describe the morphology of pollen grains of *Rosa pendulina* on the basis of a large number of them and to assume an attitude towards the opinion of the other authors concerning the meaning of the diagnostic features of grains of the species under study. Another major goal was to analyse the intraspecific variability of *R. pendulina* pollen grains, as represented by 10 individuals coming from a variety of places in Poland.

## Material and methods

The pollen grains come from 3 herbaria, and its collected by various botanists in 10 natural localities (Table 1). The sample it's a pollen grains collected by one flower and one shrub. Each sample was represented by 30 pollen grains; 300 pollen grains were examined in total. They were analysed for 10 quantitative features and the following qualitative ones: shape and outline, type of grain sculpture, and structure of the operculum (Table 2). Only correctly built grains were measured.

All samples were acetolysed according to Erdtman's method (1952), with insignificant modifications (Wrońska-Pilarek 1998). The polen terminology follows Erdtman (l. c.), Reitsma (1970) and Punt et al. (1999). The classes of exine thickness were determined on the basis of the thickness in selected species of the *Rosaceae* ((Eide 1981): thin, 0.82–1.45 $\mu$m; medium, 1.46–2.09 $\mu$m, and thick > 2.10 $\mu$m. Relative exine thickness is the ratio of exine thickness measured along the P (Exp) axis to the length of the P axis, and along the E (Exe) axis to the length of the E axis. The observations were carried out both with LM (Biolar 2308, Nikon HFX-DX) and SEM (ISI 60, Jeol JSM 6300).

The empirical data from grain measurements embraced quantitative features listed in Table 2. The pollen representing particular individuals we compared statistically using descriptive statistics and correlation coefficients, univariate analysis of variance and Tukey's procedure, agglomerative grouping by Ward's method (dendrogram), discriminant analysis and Mahalanobis distances and F statistics and minimum spanning tree constructed on the basis of the shortests Mahalanobis distances (Caliński and Kaczmarek 1973; Karoński and Caliński 1973; Dobosz 2001).

Table 1. Location of studied pollen samples of *Rosa pendulina* (Herbaria: KRAM – Institute of Botany, Kraków, UW – Warszawski University, PZNF – Department of Forest Botany Agricultural University, Poznań)

| No of sample | Locality | Longitude E | Latitude N | Collector, date of collection |
|---|---|---|---|---|
| 1. | Prov. Małopolskie, Babia Góra | 19°31' | 49°35' | Kulczyński W. 1801.KRAM |
| 2. | Prov. Małopolskie, Cyrlowa Skałka, Pieniny Mts | 20°23' | 49°24' | Zarzycki K. 18.05.1967. KRAM |
| 3. | Prov. Małopolskie, Cicha Dolina, Tatra Mts | 19°58' | 49°14' | Czeczotowa H. KRAM |
| 4. | Prov. Małopolskie, Dolina Koprowa, Tatra Mts | 19°58' | 49°14' | Heiteman W. 09.07.1924. KRAM |
| 5. | Prov. Małopolskie, Gzawa, Orawa | 19°44' | 49°34' | Kobendza R. 07.1933. UW |
| 6. | Prov. Dolnośląskie, Mały Staw under Śnieżka, Karkonosze Mts | 15°44' | 50°44' | Krawiecowa A. 10.07.1956. KRAM |
| 7. | Prov. Dolnośląskie, Borowice | 15°41' | 50°47' | Wrońska-Pilarek D. 26.05.2003. PZNF |
| 8. | Prov. Podkarpackie, Połonina Caryńska, Bieszczady Mts | 22°43' | 49°04' | Jasienica A. 13.06.1961. KRAM |
| 9. | Prov Małopolskie, Nosal, Tatra Mts | 19°58' | 49°14' | Wrońska-Pilarek D. 26.05.2003. PZNF |
| 10. | Prov Podkarpackie, Tarnica, Bieszczady Mts | 22°43' | 49°04' | Purkis M. 10.07.1987. KRAM |

Table 2. Pollen grains traits analysed

| No | Traits |
|---|---|
| 1. | Length of polar axis (P) |
| 2. | Length of equatorial axis (E) |
| 3. | Thickness of exine along polar axis (Exp) |
| 4. | Thickness of exine along equatorial axis (Exe) |
| 5. | Length of ectocolpi (Le) |
| 6. | Distance between the apices of two (d) |
| 7. | P/E ratio |
| 8. | Polar area index – PAI (d/E ratio) |
| 9. | Relative thickness of exine (P/Exp ratio) |
| 10. | Relative thickness of exine (E/Exe ratio) |

# Results

## Pollen morphology of *Rosa pendulina* L.

A description of the pollen grain morphology of *Rosa pendulina* is given below and illustrated with a few SEM photographs (Figs 1–6).

Pollen class: 3 – zonocolporate.

Tectum: perforate.

Pollen size: medium: P – 33.09 (28–38) $\mu$m, E – 27.55 (20–32) $\mu$m.

P/E ratio: 1.2 (1.06–1.65). Shape of grains: subprolate (57%), prolate spheroidal (33,3%), prolate (9,7%).

Outline: in polar view – mostly circular or triangular with obtuse apices, more rarely elliptic or quinquangular with obtuse apices. In equatorial view – elliptic.

Exine: two-layered, well marked in LM. Ectexine and endexine of about the same thickness. Thickness of exine – average (99,66%), very rarely thin (0.17%) or thick (0.17%). Mean exine thickness 1.94 $\mu$m and its range: 1.4 – 2.2 $\mu$m. The relative thickness of the exine measured along P (Exp) averaged 0.06 (0.04–0.07), and along E (Exe) – 0.05 (0.07–0.1).

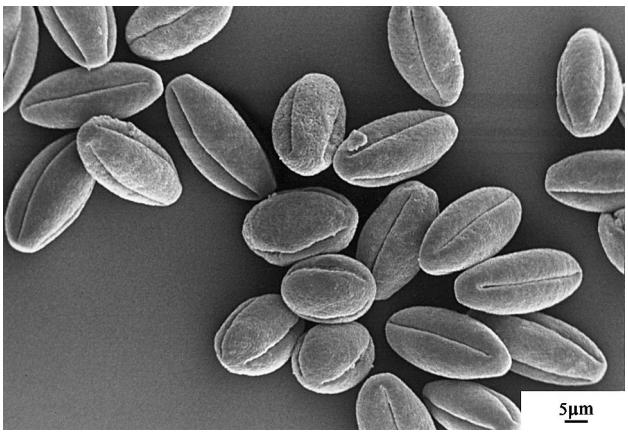


Fig. 1. (SEM). Pollen grains of *Rosa pendulina* in polar and equatorial view; unripe pollen grain visible (× 750)

Exine sculpture: striate. Sculpture not well-defined. Muri not high, cylindrical, ± bifurcating, elongated, running ± parallel to the polar axis. Striae usually rather shallow, more rarely deeper. On their bottom, readily visible, numerous elliptic or circular perforations of varying, relatively substantial diameters.

Apertures: 3 ectocolpi and 3 endopores. Ectocolpi arranged meridionally, regularly, more or less evenly spaced. Usually long, elliptic in outline, deeply set into the exine, ending sharply. Margins of ectocolpi irregular, reinforced by costae colpi. Mean length 26.49 $\mu$m (ranging from 18 to 34 $\mu$m), width variable, usually greatest in equatorial region. Sculpturing of ectocolpus membrane approaching rugulate. Operculum in central part of ectocolpus, partially covering it. Operculum elongated (about 1/3 length of ectocolpus), narrow (not wider than ectocolpus), and rather flat, psilate or more rarely rugulate in sculpture.

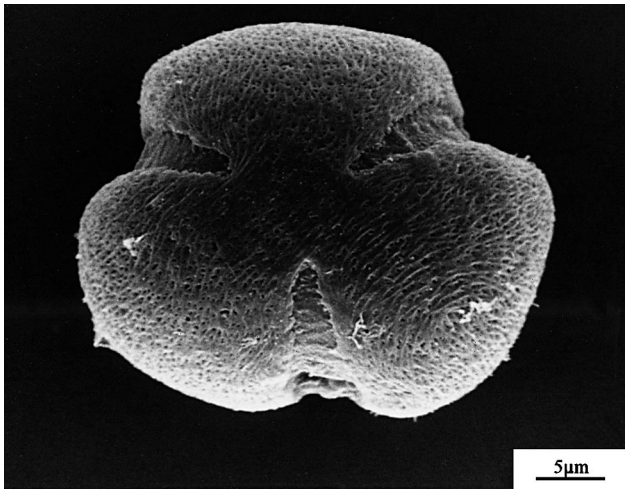


Fig. 2. (SEM). Pollen grain of *Rosa pendulina* in polar view; exine sculpture and 3 ectocolpi visible (× 3500)

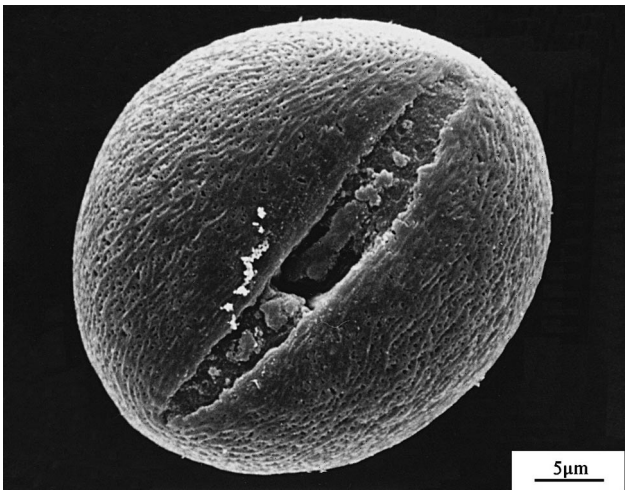


Fig. 3. (SEM). Pollen grain of *Rosa pendulina* in equatorial view; elongated, narrow ectocolpus with operculum and opened pore visible (× 3500)

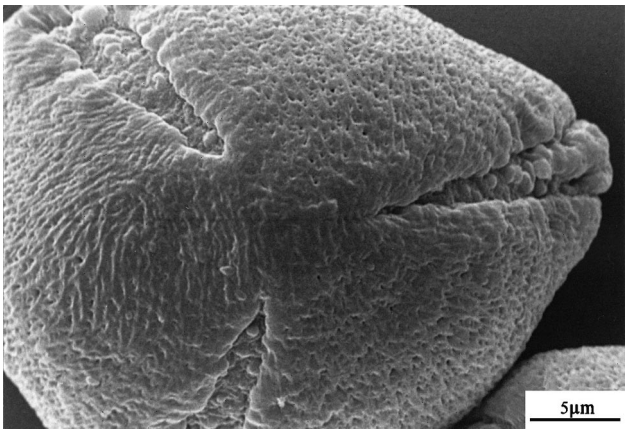


Fig. 4. (SEM). Pollen grain of *Rosa pendulina* in polar view; polar area with 3 ectocolpi visible (× 5000)

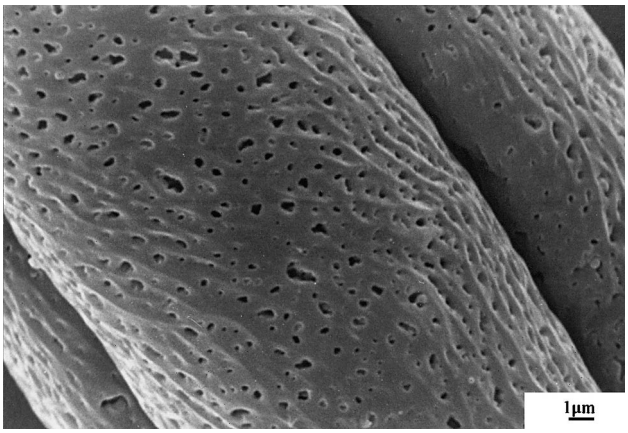


Fig. 5. (SEM). Pollen grain of *Rosa pendulina*; 2 ectocolpi and exine sculpture visible (× 7500)

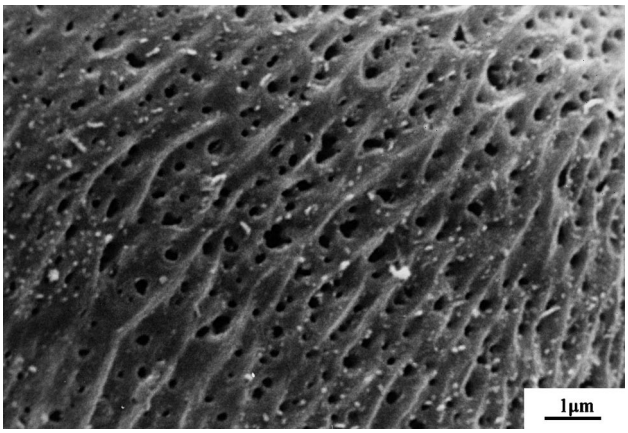


Fig. 6. (SEM). Exine sculpture of pollen grain of *Rosa pendulina*; striae, muri and perforations visible (× 15000)

Endopores usually located in the middle of ectocolpi, readily visible after opening, with irregular margins. Fastigium present.

Apocolpium index (PAI): 0.21 (0.13–0.40).

Proportion of correctly built grains: 80–85%.

## Intraspecific variability

Features P, E, P/E ratio, Exp, Exe, Lb, Exp/P and the Exe/E ratio (cf. Table 2) showed low variability (6.5, 6.7, 7.5, 6.1, 6.0, 9.0, 8.7 and 8.7%, respectively), while the variability of d and the d/E ratio was decidedly greater and attained a middle level (25.3 and 26.0%, respectively). The variability of the features within the *Rosa pendulina* individuals under study did not exceed 12% (for P, E, P/E ratio, Exp, Exe, Lb, Exp/P, Exe/E ratio), and for d and the d/E ratio it ranged between 13.6 and 22.3% (Table 3).

On the basis of an analysis of the diagonal elements of the inverse of the R correlation matrix for all the characteristics, those selected for further study were ones with low values of the diagonal element, which is indicative of a weak correlation between the given characteristic and the others. In this way the following arrangement of traits was chosen: P with the diagonal element value of 2.94, E – 1.27, Exp – 1.17, Exe – 1.17, Lb – 3.08, and d – 1.17.

To verify the hypothesis about the effect of the location of 10 analysed individuals on the pollen grain traits under study, a univariate analysis of variance was carried out. The assumption of distribution normality was verified by the Shapiro-Wilk test, and of variance uniformity, by Levene's test. Since the traits showed no uniformity, a logarithmic transformation was employed. When analysing the empirical value of *F* statistic and probability *p*, for each feature under study the differences were found to be significant at the 5% significance level (feature P – $F_{calc}$ = 15.48 and p = 0.000, feature E – $F_{calc}$ = 6.26 and p = 0.000, feature Exp – $F_{calc}$ = 8.27 and p = 0.000, feature Exe – $F_{calc}$ = 6.26 and p = 0.000, feature Lb – $F_{calc}$ = 21.42 and p = 0.000, feature d – $F_{calc}$ = 30.21 and p = 0.000). In analysing the particular individuals (1–10), a lack of significant differences was marked by two points joined with a dashed line (Table 4).

In order to distinguish the most homogeneous clusters of pollen grains collected in individuals 1–10 by the criterion of the features under study (P, E, Exp, Exe, Lb and d), an agglomerative grouping by Ward's method was carried out to obtain a dendrogram (Fig. 7). The grouping revealed the greatest similarity to hold among the grains from Dolina Koprowa (Tatra Mts), Nosal (Tatra Mts), Gzawa (Orawa) and Cyrlowa Skałka (Pieniny Mts), and the greatest differences to occur between them and those collected from Połonina Caryńska (Bieszczady Mts) and Mały Staw under Śnieżka (Karkonosze Mts).

In the set of 6 parameters chosen for analysis, parameter d (distance between the apices of two ectocolpi) turned out to be a bit more discriminating, because it had a lower value of partial Wilks' lambda (0.5285). The remaining traits displayed very similar

Table 3. Numeral characteristics of traits of studied pollen grains

| Traits | P | | | | E | | | | P/E | | | | Exp | | | | Exe | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locality | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) |
| Babia Góra | 30 | 34.7 | 38 | 6.9 | 26 | 28.1 | 31 | 5.7 | 1.07 | 1.24 | 1.41 | 7.3 | 1.4 | 1.93 | 2.0 | 7.8 | 1.6 | 1.88 | 2.2 | 9.5 |
| Cyrlowa Skałka | 30 | 32.0 | 35 | 4.1 | 26 | 27.9 | 30 | 5.7 | 1.07 | 1.15 | 1.31 | 5.7 | 1.8 | 1.94 | 2.0 | 4.8 | 1.8 | 1.93 | 2.0 | 5.1 |
| Cicha Dolina | 28 | 31.3 | 36 | 5.4 | 22 | 26.5 | 30 | 7.6 | 1.07 | 1.19 | 1.36 | 6.5 | 1.8 | 1.96 | 2.0 | 4.2 | 1.8 | 1.97 | 2.0 | 3.5 |
| Dolina Koprowa | 30 | 32.8 | 35 | 3.9 | 24 | 26.9 | 28 | 5.1 | 1.14 | 1.22 | 1.42 | 5.0 | 1.8 | 1.97 | 2.0 | 3.5 | 2.0 | 2.00 | 2.0 | 0.0 |
| Gzawa | 32 | 34.2 | 36 | 4.8 | 26 | 27.6 | 30 | 4.7 | 1.14 | 1.24 | 1.38 | 5.0 | 1.8 | 1.99 | 2.0 | 2.6 | 1.8 | 1.95 | 2.0 | 4.4 |
| Mały Staw under Śnieżka | 32 | 34.8 | 38 | 5.5 | 24 | 28.0 | 32 | 5.5 | 1.06 | 1.25 | 1.46 | 7.7 | 1.6 | 1.80 | 2.0 | 8.8 | 1.6 | 1.85 | 2.0 | 8.5 |
| Borowice | 32 | 34.2 | 37 | 4.4 | 24 | 27.1 | 30 | 4.7 | 1.14 | 1.26 | 1.42 | 6.0 | 1.8 | 1.99 | 2.0 | 1.8 | 1.8 | 1.99 | 2.0 | 2.6 |
| Połonina Caryńska | 28 | 31.5 | 38 | 8.7 | 20 | 26.4 | 30 | 10.6 | 1.07 | 1.20 | 1.65 | 11.0 | 1.6 | 1.91 | 2.0 | 8.5 | 1.6 | 1.91 | 2.0 | 7.6 |
| Nosal | 31 | 32.9 | 35 | 3.4 | 26 | 28.4 | 31 | 4.9 | 1.07 | 1.16 | 1.27 | 4.4 | 1.8 | 1.99 | 2.0 | 2.6 | 1.8 | 1.99 | 2.0 | 1.8 |
| Tarnica | 30 | 32.7 | 36 | 5.6 | 24 | 28.6 | 32 | 6.1 | 1.06 | 1.14 | 1.42 | 5.9 | 1.6 | 1.93 | 2.0 | 6.4 | 1.6 | 1.93 | 2.0 | 6.4 |

| Traits | Lb | | | | d | | | | d/E | | | | Exp/P | | | | Exe/E | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locality | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) | minimum | means | maximum | variability coefficient (%) |
| Babia Góra | 22.0 | 26.6 | 31.0 | 8.7 | 4.0 | 5.50 | 8.0 | 18.9 | 0.14 | 0.20 | 0.29 | 17.9 | 0.04 | 0.06 | 0.07 | 9.4 | 0.05 | 0.07 | 0.08 | 10.3 |
| Cyrlowa Skałka | 24.0 | 26.7 | 30.0 | 5.2 | 4.0 | 4.87 | 7.0 | 20.0 | 0.13 | 0.18 | 0.25 | 21.4 | 0.05 | 0.06 | 0.07 | 6.2 | 0.06 | 0.07 | 0.08 | 6.5 |
| Cicha Dolina | 22.0 | 24.5 | 28.0 | 6.3 | 4.0 | 5.00 | 8.0 | 22.3 | 0.13 | 0.19 | 0.31 | 21.5 | 0.06 | 0.06 | 0.07 | 6.3 | 0.06 | 0.07 | 0.09 | 7.9 |
| Dolina Koprowa | 24.0 | 26.7 | 28.0 | 5.7 | 4.0 | 5.07 | 6.0 | 19.3 | 0.14 | 0.19 | 0.25 | 21.0 | 0.05 | 0.06 | 0.07 | 5.3 | 0.07 | 0.07 | 0.08 | 5.3 |
| Gzawa | 24.0 | 27.9 | 32.0 | 7.1 | 4.0 | 5.23 | 6.0 | 14.8 | 0.13 | 0.19 | 0.23 | 16.6 | 0.05 | 0.06 | 0.06 | 5.8 | 0.06 | 0.07 | 0.08 | 4.8 |
| Mały Staw under Śnieżka | 26.0 | 29.3 | 34.0 | 6.0 | 4.0 | 5.60 | 8.0 | 16.0 | 0.13 | 0.20 | 0.25 | 16.3 | 0.04 | 0.05 | 0.06 | 10.6 | 0.06 | 0.07 | 0.08 | 9.1 |
| Borowice | 24.0 | 26.7 | 30.0 | 6.2 | 5.0 | 7.13 | 8.0 | 13.6 | 0.19 | 0.26 | 0.33 | 14.6 | 0.05 | 0.06 | 0.06 | 4.3 | 0.07 | 0.07 | 0.08 | 4.9 |
| Połonina Caryńska | 18.0 | 23.7 | 30.0 | 11.8 | 4.0 | 7.63 | 10.0 | 20.2 | 0.15 | 0.29 | 0.40 | 20.9 | 0.05 | 0.06 | 0.07 | 10.1 | 0.06 | 0.07 | 0.10 | 11.8 |
| Nosal | 24.0 | 26.8 | 29.0 | 4.7 | 4.0 | 4.97 | 6.0 | 17.9 | 0.13 | 0.18 | 0.23 | 18.7 | 0.06 | 0.06 | 0.06 | 3.8 | 0.06 | 0.07 | 0.08 | 4.9 |
| Tarnica | 22.0 | 25.9 | 30.0 | 8.0 | 6.0 | 7.53 | 10.0 | 13.8 | 0.21 | 0.26 | 0.32 | 11.5 | 0.05 | 0.06 | 0.07 | 8.2 | 0.06 | 0.07 | 0.08 | 8.9 |

Table 4. Multiple comparisons by Tukey's procedur

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Locality: | 3 | 8 | 2 | 10 | 4 | 9 | 5 | 7 | 1 | 6 |
| Measurement of trait P | 31.33 | 31.47 | 32.00 | 32.67 | 32.77 | 32.87 | 34.17 | 34.20 | 34.70 | 34.77 |
| Locality: | 8 | 3 | 4 | 7 | 5 | 2 | 6 | 1 | 9 | 10 |
| Measurement of trait E | 26.40 | 26.53 | 26.87 | 27.10 | 27.63 | 27.87 | 28.00 | 28.10 | 28.40 | 28.60 |
| Locality: | 6 | 8 | 10 | 1 | 2 | 3 | 4 | 5 | 9 | 7 |
| Measurement of trait EXP | 1.80 | 1.91 | 1.93 | 1.93 | 1.94 | 1.96 | 1.97 | 1.99 | 1.99 | 1.99 |
| Locality: | 6 | 1 | 8 | 2 | 10 | 5 | 3 | 7 | 9 | 4 |
| Measurement of trait EXE | 1.853 | 1.880 | 1.913 | 1.927 | 1.927 | 1.953 | 1.973 | 1.987 | 1.993 | 2.000 |
| Locality: | 8 | 3 | 10 | 1 | 2 | 4 | 7 | 9 | 5 | 6 |
| Measurement of trait Lb | 23.67 | 24.47 | 25.93 | 26.63 | 26.67 | 26.73 | 26.73 | 26.83 | 27.90 | 29.30 |
| Locality: | 2 | 9 | 3 | 4 | 5 | 1 | 6 | 7 | 10 | 8 |
| Measurement of trait d | 4.87 | 4.97 | 5.00 | 5.07 | 5.23 | 5.50 | 5.60 | 7.13 | 7.53 | 7.63 |

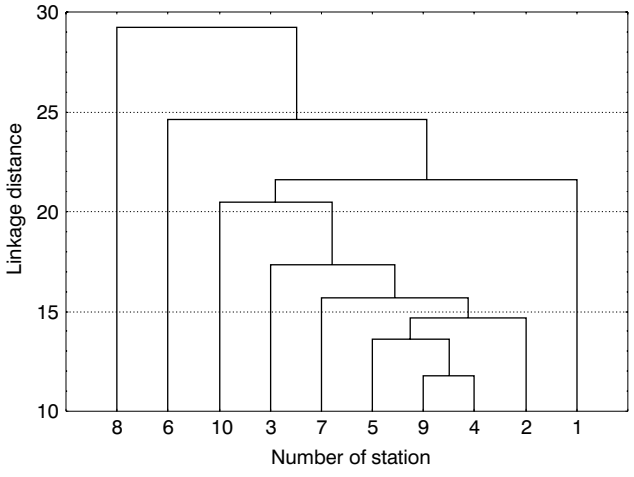


Fig. 7. Dendrogram of 10 localities of *Rosa pendulina* constructed by Ward's method

values of partial Wilks' lambda (from 0.7176 to 0.8881, Table 5).

When analysing Table 6, one can find that the Mahalanobis distances are statistically insignificant for the following pairs of localities: Cyrlowa Skałka (Pieniny Mts), Nosal (Tatra Mts) and Dolina Koprowa (Tatra Mts), Gzawa (Orawa). Besides, between individuals from those localities the Mahalanobis distances were the shortest (Fig. 8). In

Table 5. Results of discriminant analysis in 6 analysed traits

| Traits | Partial Wilk's lambda | F statistics | Probability p |
|---|---|---|---|
| P | 0.7292 | 11.76 | 0.000 |
| E | 0.8306 | 6.46 | 0.000 |
| Exp | 0.8511 | 5.54 | 0.000 |
| Exe | 0.8881 | 3.99 | 0.000 |
| Lb | 0.7176 | 12.46 | 0.000 |
| d | 0.5285 | 28.25 | 0.000 |

Table 6. Mahalanobis distances

| No of locality | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | $D_{obl}$ | 2.48 | | | | | | | | |
| | $F_{obl}$ | 15.11 | | | | | | | | |
| | p | 0.000 | | | | | | | | |
| 3 | $D_{obl}$ | 2.20 | 1.64 | | | | | | | |
| | $F_{obl}$ | 11.88 | 6.58 | | | | | | | |
| | p | 0.000 | 0.000 | | | | | | | |
| 4 | $D_{obl}$ | 2.26 | 1.34 | 1.30 | | | | | | |
| | $F_{obl}$ | 12.56 | 4.41 | 4.15 | | | | | | |
| | p | 0.000 | 0.000 | 0.001 | | | | | | |
| 5 | $D_{obl}$ | 1.79 | 1.51 | 1.88 | 0.93 | | | | | |
| | $F_{obl}$ | 7.85 | 5.57 | 8.68 | **2.13** | | | | | |
| | p | 0.000 | 0.000 | 0.000 | 0.050 | | | | | |
| 6 | $D_{obl}$ | 2.42 | 2.36 | 3.16 | 2.48 | 2.03 | | | | |
| | $F_{obl}$ | 14.35 | 13.72 | 24.50 | 15.05 | 10.08 | | | | |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | | |
| 7 | $D_{obl}$ | 2.36 | 3.01 | 2.59 | 2.21 | 2.09 | 2.94 | | | |
| | $F_{obl}$ | 13.65 | 22.30 | 16.53 | 11.98 | 10.68 | 21.25 | | | |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | | |
| 8 | $D_{obl}$ | 2.97 | 3.40 | 2.67 | 3.09 | 3.27 | 3.71 | 1.99 | | |
| | $F_{obl}$ | 21.60 | 28.48 | 17.46 | 23.50 | 26.32 | 33.78 | 9.69 | | |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | | |
| 9 | $D_{obl}$ | 2.18 | 0.90 | 1.50 | 1.04 | 1.14 | 2.56 | 2.64 | 3.36 | |
| | $F_{obl}$ | 11.64 | 1.98 | 5.55 | 2.64 | 3.17 | 16.13 | 17.18 | 27.80 | |
| | p | 0.000 | 0.068 | 0.000 | 0.017 | 0.005 | 0.000 | 0.000 | 0.000 | |
| 10 | $D_{obl}$ | 2.69 | 2.67 | 2.74 | 2.71 | 2.64 | 2.89 | 1.86 | 1.66 | 2.62 |
| | $F_{obl}$ | 17.77 | 17.53 | 18.38 | 18.02 | 17.09 | 20.54 | 8.47 | 6.77 | 16.81 |
| | p | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

turn, the longest distances in the set were characteristic individuals of the localities of Mały Staw under Śnieżka (Karkonosze Mts) and Połonina Caryńska (Bieszczady Mts).

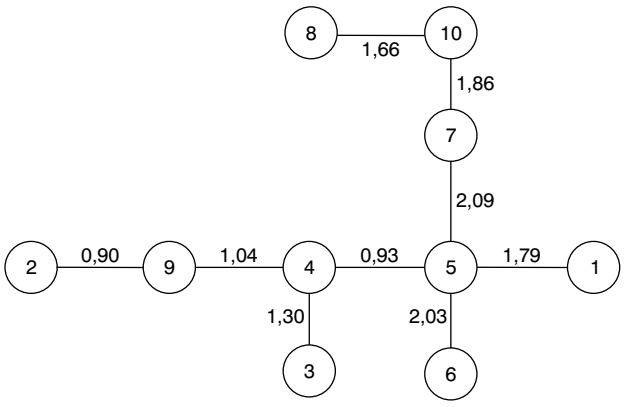


Fig. 8. Minimum spanning tree constructed on the basis of the shortest Mahalanobis distances for 10 localities

## Discussion

The presented description of the pollen grains of *Rosa pendulina* L. and their sizes are usually similar to the characteristics given by Teppner (1965), Stachurska et al. (1976), Savitsky et al. (1987), Ueda (1992) and Popek (1996).

There are slight differences among the authors as far as the length of the P axis is concerned. Its value as a diagnostic feature raises doubts resulting from the variability of the *Rosaceae* grains (Moore et al. 1991) and the way acetolysis is performed (Reitsma 1969). A similar length of the polar axis (P) of pollen grains was observed by Stachurska et al. (1976). The figure reported by Savitsky et al. (1987) is greater by 2 $\mu$m.

According to Ueda (1992), the exine microsculpture of *Rosa pendulina* and some dozen other rose species stands out for its large, distinct perforations. Popek (1996) is of the opinion that the pollen grains of the species under study display a sculpture of the *R. canina* type, i.e. with the muri of varying length, usu-

ally narrower than the striae in which perforations of various sizes and shapes are found. Our results show the muri and striae to be poorly developed, hence the sculpture is rather indistinct.

In his key, Teppner (1965) gives a general description of grains common to *Rosa pendulina* and several other species. He emphasises the importance of the operculum for a diagnosis of rose pollen grains. In his description the operculum is narrow and short (the latter observation has not been corroborated by the present research). According to Popek (1996), the operculum covers the central part of the ectocolpus membrane and assumes the form of a substantial swelling with a sculpture as a rule similar to that of the mesocolpium. Our research has shown it to be narrow, fairly long, and not as sizable and convex as in *R. canina*. The sculpture of the operculum differs from the mesocolpium (which is striate) and is usually psilate or rugulate.

The proportion of correctly built grains (80–85%) is very similar to results obtained by Flory (1950) – 78,5–89,7% and Jičinska et al. (1976) – 80%

## Conclusions

1. The most crucial traits of the pollen grains of the species under study include: an elongated, narrow operculum; a usually poorly developed exine sculpture (usually flat muri, shallow striae, and large, distinct perforations); long ectocolpi, hence a relatively short distance between them (a low value of the apocolpium index); and the predominance of grains elongated in shape.
2. The statistical analysis showed that the quantitative features of *Rosa pendulina* pollen grains were not highly variable. The highest variability was found in two traits: d (the distance between the apices of two ectocolpi) and the d/E ratio (polar area index); the remaining eight features displayed rather low variability.
3. Statistical studies revealed dependences among the grains from the analysed localities. On the one hand, the greatest similarity was found to occur among the grains collected in the neighbouring Tatra Mts, Orava and Pieniny Mts, which differed most from those collected in the distant Bieszczady and Karkonosze Mts; on the other hand, a set of grains with characteristics similar to the first group were those from the equally distant Lower Silesia region.

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