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ABSTRACT

This paper presents further results of studies on pollen morphology of the family Caprifoliaceae. Besides detailed descriptions of 6 species of genera Linnaea and Lonicera, series of LM and SEM microphotographs are included. All examined species have pollen grains of medium- or large-sized, with oblate forms, echinate (microechinate) ornamentation and short ektaperture, often margined by costa. Length of spines and density of their distribution on the tectum allow to distinguish Linnaea and Lonicera subtypes. The key for determination of 11 Caprifoliaceae species, based on pollen morphology is proposed too.

KEY WORDS: Caprifoliaceae, Linnaea, Lonicera, pollen morphology, SEM, LM.

INTRODUCTION

The results of studies on pollen morphology of 6 Caprifoliaceae species occurring in Poland are presented in this paper. Beside native species, as Linnaea borealis L., Lonicera nigra L., L. periclymenum L., L. xylosteum L., locally running wild species, as Lonicera caprifolium L., L. tatarica L., have been also observed.

Pollen from mature anthers was collected from natural localities and sometimes from herbarium. For native species 7-8 samples were examined. In case of Linnaea borealis, Lonicera periclymenum and L. tatarica 2-3 samples were studied. All samples have been determined by herbarium specimens. Detailed information about collected material is given below pollen diagnosis of each species. The using methods have been described in first part of article.

POLLEN DIAGNOSIS

Linnaea borealis L. (Figs 1-4)
Size: medium; P 38.9 μm (36.0-43.2 μm), E (longest axis) - 44.4 μm (40.8-48.0 μm)\(^1\).

P/E ratio: 0.88 (0.81-0.98), shape of grains are suboblate (46.7% of observed pollen grains) or oblate spheroidal (53.3%)\(^2\).

Outlines:
  - Polar view - circular to triangular, with convex sides, equatorial view - mainly elliptic, sometimes circular.

Exine:
  - 2.4 μm thick (up to 3.2 μm); there is no difference in its thickness between apocolpsia and mesocolpsia. Exine consists of two layers visible in LM. Sexine somewhat thicker than nexine (mean thickness of sexine - 1.23 μm, of nexine - 1.21 μm)\(^3\).

Ornamentation:
  - Microechinate (scabrate); wide, cone-shaped short spines, variable in size (0.5-1 μm), densely spaced, about 80 per 100 μm\(^2\) of tectum. Surface of tectum slightly wrinkled, with minute, poorly visible perforations.

Pollens class:
  - Trizonocolporate\(^5\).

Apertures:
  - Compound.

Ektaperture:
  - Colpus short or medium, narrow, fissured or boat-shaped, with acute ends.

Endaperture:
  - Lalongate colpus\(^6\). Endocolpus margins underlined by costa only at the polar sides of apocolpsia.

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\(^1\) According to Kuprianova & Alyoshina (1972) pollen grains of this taxon have been decidedly large-sized.

\(^2\) In accordance with Punt, Reitsma & Reuvers (1976) grains with prolate polar axis were also noticed.

\(^3\) According to the study of Stachurska, Szczypek & Sadowa (1963) exine may has been up to 5 μm thick. Others authors determined thickness of exine as about 3-4 μm (Bassett & Crompton 1970, Kuprianova & Alyoshina 1972, Punt, Reitsma & Reuvers 1976).

\(^4\) According to Weberling (1966) and Punt, Reitsma & Reuvers (1976) pollen grains of Linnaea borealis were crassisections. Similar observations were noted by Stachurska, Szczypek & Sadowska (1963) and Bassett & Crompton (1970), who considered ectexine of L. borealis always thicker than endexine.

\(^5\) Pollen grains with 4 or 5 apertures were occasionally noted (Kuprianova & Alyoshina 1972, Punt, Reitsma & Reuvers 1976, Stachurska, Szczypek & Sadowska 1963).

\(^6\) ± Icosidiametric apertures were also observed (Kuprianova & Alyoshina 1972, Punt, Reitsma & Reuvers 1976, Stachurska, Szczypek & Sadowska 1963).
Caprifoliaceae pollen, LM and SEM photographs. On photo the bar refers to magnification.
Figs 1-4. Linnaea borealis L.:
1 (LM) – Outline in polar view.
2 (LM) – Outline in equatorial view; marked exine layers.
3 (SEM) – Microechinate ornamentation of apocolpium.
4 (SEM) – Microechinate ornamentation; marked exine layers.

Remarks:
Owing short spines, densely set on the tectum, pollen grains of Linnaea borealis are very characteristic and easy to recognize. Superficially they are similar to grains of Lonicera species.

Analysed samples of Linnaea borealis:
1. Near Olejnica (prov. Leszno), W coast of Olejnicky lake, 29.06.1977, K. Boratyńska, A. Boratyński, KOR.
2. Panasówka near Zwierzyniec (prov. Zamość), 23.06.1993, K. Oklejewicz, POZ.

Lonicera caprifolium L. (Figs 5-8)
Size:
Large, P = 58.4 μm (52.8 to 64.8 μm), E (the longest one) = 64.2 μm (56.8-70.4 μm)\(^7\).
P/E ratio:
0.91 (0.84-1.0); grains usually oblate spheroidal (77.8% of observed pollen grains), sometimes suboblate (16.7%) and only occasionally subpulate (5.6%).

Outlines:
Polar view – triangular with convex sides, equatorial view – elliptic\(^8\).

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\(^7\) According to Stachurska and co-authors (1970) for Polish population of this species, length of polar axis was up to 54 μm, length of equatorial axis = 61 μm. Somewhat larger pollen grains were observed in the Northwest-European populations (P = 60-72 μm; E = 68-77 μm; Punt, Reitsma & Reuvers 1976).

\(^8\) They can be sometimes obtusely acuminate in equatorial view (Punt, Reitsma & Reuvers 1976).
Figs 5-8 Lonicera caprifolium L.
5 (LM) – Outline in polar view.
6 (LM) – Outline in equatorial view; composite aperture visible, endoaperture marked by costa.
7 (SEM) – Echinulate ornamentation of apocolpium.
8 (SEM) – Ornamentation of tectum in details; marked exine layers.

Exine:
about 3.1 µm thick⁹; becoming thicker near apertures; formed by two layers. Sexine ± as thick as nexine or up to 1.5 times thicker¹⁰.

Ornamentation:
Echinulate, Echinae – cylindrical, with slightly widened base and obtuse apex, relatively short, up to about 1 µm long (maximally 2 µm), about 10 per 100 µm² of tectum. Surface of tectum variable; undulate or wrinkled, covered with scarce granula and sometimes with fine, shallow perforations.

⁹ In previous studies on the Lonicera caprifolium pollen exine thickness was about 4-5 µm (Punt, Reitsma & Reuvers 1976, Stachurska et al. 1970).
¹⁰ According to Punt, Reitsma & Reuvers (1976) sexine was rather much thicker. Similar observation was noted by Stachurska and co-authors (1970), in accordance to this ectexine was much thicker than endexine.

Pollens class:
Trizonocolporate¹¹

Apertures:
Compound.

Ectoaperture:
Colpus short, narrow, slit-like; with acute ends.

Endoaperture:
Lalongate porus or lalongate colpus, underlined by costae only at the polar sides. Polar axis of endo- and ectoaperture of similar length.

Remarks:
Pollen grains of Lonicera caprifolium resemble very much the grains of L. periclymenum. The main feature differing pollen of these species is the nature of costa. In the grains of L. capri-

¹¹ Pollen grains with two apertures as well as with four apertures were observed only occasionally (Punt, Reitsma & Reuvers 1976, Stachurska et al. 1970).
Figs 9-13. *Lonicera periclymenum* L.:

9 (LM) - Outline in polar view.
10 (LM) - Outline in equatorial view.
11 (LM) - Composite aperture; endoaperture marked by costa.
12 (SEM) - pollen grains in polar and equatorial views.
13 (SEM) - Ornamentation of tectum in details; marked exine layers.

*folium* it is visible only at the sides of the polar area, while in the grains of *L. periclymenum* it is also marked at the sides of mesocolpia. Besides, pollen grains of *L. caprifolium* are usually smaller and their spines are somewhat shorter and widened at the base.

**Analysed samples of Lonicera caprifolium:**
1. Between Lubiechów Dolny and Markocin (prov. Szczecin), Biełinek reserve by Odra river, 18.06.1958, F. Celiński, M. Filip, POZ.
2. JANOWIEC (prov. Lublin), over Wisła, 25.06.1973, A. Boratyński, J. Zieliński, POZ.
3. Bulgaria, Rhodopi Mts., above Sokolovo, distr. Momcilgrad, 08.06.1971, J. Koeva, KOR.

*Lonicera periclymenum* L. (Figs 9-13)

**Size:**
Large; P - 67.09 μm (59.2 to 76.8 μm), E (longest axis) - 74.37 μm (65.6 to 83.2 μm)\(^{12}\).

**P/E ratio:**
0.9 (0.8 to 1.04), grains with prolate equatorial axis prevail (suboblate - 24.6% of observed pollen grains, oblate spheroidal - 74.2%), prolate spheroidal ones are observed much rarer (1.3%).

**Outlines:**
Polar view - triangular with straight or convex sides\(^{13}\), equatorial outline - mainly elliptic.

\(^{12}\) According to data in literature length of polar axis has been up to 76 μm, equatorial - 83 μm (Punt, Reitsma & Reuvers 1976).

\(^{13}\) Pollen grains with polar view of quadrangular forms, with convex sides have been noticed too (Stachurska et al. 1970).
Exine: 3.17 μm thick (2.4-4 μm)\(^{14}\); becomes thicker in the zone of apertures; formed by two layers. Sexine as thick as nexine, rarely thicker\(^{15}\).

Ornamentation: Echinulate. Echinae – straight, 1.5 μm (up to 2 μm) long, not widened at base; 5-9 per 100 μm\(^2\) of tectum. Surface of tectum gently undulate, with fine, sparse granulations and perforations.

Pollen class: Trizonocolporate\(^{16}\).

Apertures: Compound.

Ectoaperture: Colpus short, slit-like, with acute ends.

Endoaperture: Lalongate colpus or lalongate porus. Polar axis of ectoaperture distinctly longer than polar axis of endoaperture. Costa around the endoaperture well marked, both in polar and equatorial area.

Remarks: See diagnosis of Lonicera caprifolium.

Analysed samples of Lonicera periclymenum:
3. Świnoujście (prov. Szczecin), 27.06.1993, P. Rogalski, POZF.
4. I. km S of Stary Kraków (prov. Słupsk), 08.09.1977, A. Boratynska, KOR.
7. Czelmek Wołowski (prov. Legnica), 8 km SW of Ścinawa by Odra river, 20.05.1993, G. Bobrowicz, POZF.

Lonicera xylosteum L. (Figs 14-18)

Size: Medium, rarely large; P = 45.1 μm (40-53.6 μm), E (longest axis) – 50.6 μm (43.2-59.2 μm).

P/E ratio: 0.89 (0.78-1.0), shape of grains includes suboblate (36.2% of observed pollen grains), oblate spheroidal (63.3%) and exceptionally prolate spheroidal forms (0.5%).

Outlines: Polar view – circular or triangular, with convex sides, equatorial view – circular to elliptic.

Exine: 1.7 μm thick (1.6-2.4 μm)\(^{17}\); becomes thicker in the zone of apertures, formed by 2 layers. Sexine as thick as nexine\(^{18}\).

Ornamentation: Echinulate. Echinae – about 3 μm high\(^{19}\), gently becoming narrower, with obtuse apex; 5-7 per 100 μm\(^2\) of tectum. Surface of tectum variable, almost smooth, with minute, sparsely placed granulations or wrinkled, with rather hardly visible perforations.

Pollen class: Trizonocolporate\(^{20}\).

Apertures: Compound.

Ectoaperture: Colpus short, slit-like, with acute ends.

Endoaperture: Lalongate porus, sometimes also lalongate colpus. Polar axis of ectoaperture longer than polar axis of endoaperture. Costa only at polar area of endoapertures.

Remarks: Pollen of Lonicera xylosteum may be hardly distinguished because of variable surface of tectum and significant similarity to pollen of L. tatarica and L. nigra. In comparison to L. tatarica, however, its pollen grains are smaller, beside their polar axis of ectoaperture is longer than polar axis of endoaperture (both axes are of similar lengths in L. xylosteum). On the other hand grains of L. xylosteum have distinct costae at the polar sides, while such costae are absent in grains of L. nigra.

Analysed samples of Lonicera xylosteum:
1. Wolin National Park, between Międzyzdroje and Warna (prov. Szczecin), 08.05.1993, D. Wrońska-Pilarak, POZF.
2. Gorzeń (prov. Bydgoszcz), 05.05.1993 I. Maciejewska, D. Wrońska-Pilarak, POZF.
3. Zielonka forest, near Bolechowo (prov. Poznań), 03.05.1993, I. Maciejewska, POZF.
4. Żelazne Mts., near Stary Waliszów (prov. Walbrzych), c. 300 m, 17.05.1993, I. Maciejewska, D. Wrońska-Pilarak, POZF.
5. Between Żmigród and Mały Lasek (prov. Rzeszów) 10.05.1959, M. Gostyńska, KOR.
6. Tatra Mts., Kościeliska valley (prov. Nowy Sącz), c. 300 m, 12.05.1993, I. Maciejewska, D. Wrońska-Pilarak, POZF.

Lonicera tatarica L. (Figs 19-23)

Size: Medium to exceptionally large; P = 47.5 μm (40-48 μm), E (longest axis) – 52 μm (44-56 μm).

P/E ratio: 0.91 (0.81-1.0) ± spheroidal forms predominate (suboblate – 18.3% of observed pollen grains, oblate spheroidal – 78.2%, prolate spheroidal – 3.5%).

Outlines: Polar view circular or triangular, with convex sides, equatorial view – elliptic or circular.

Exine: about 1.6 μm thick, usually the thickest near apertures, formed by 2 layers. Sexine as thick as nexine\(^{21}\).

\(^{14}\) According to Punt, Reitsma & Reuvers (1976) and Stachurska and co-authors (1970) exine has been up to 5 μm thick.

\(^{15}\) Punt, Reitsma & Reuvers (1976) considered sexine thicker than nexine, as in pollen grains of Lonicera caprifolium.

\(^{16}\) Pollen grains with 2 apertures have been observed sporadically (Punt, Reitsma & Reuvers 1976).

\(^{17}\) According to Punt, Reitsma & Reuvers (1976) up to 5 μm.

\(^{18}\) In previous studies thicker ectexine than endexine was observed (Kuprianova & Alyoshina 1972, Punt, Reitsma & Reuvers 1976, Stachurska et al. 1970).

\(^{19}\) According to Stachurska and co-authors (1970) up to 4 μm.

\(^{20}\) Pollen grains with 2 or 4 apertures were noticed much rarer (Punt, Reitsma & Reuvers 1976).

\(^{21}\) According to Stachurska and co-authors (1970) ectexine has been thicker than endexine.
Figs 14-18. *Lonicera xylosteum* L.:
14 (LM) – Outline in polar view, marked echinate ornamentation.
15 (SEM) – Outline in equatorial view; composite aperture; endoaperture marked by costa.
16 (SEM) – Echinulate ornamentation of apocolpium.
17, 18 (SEM) – Ornamentation of tectum in details.

**Ornamentation:**
Echinulate. Echinæae 3-4 μm high, with swelling base, about 8 per 100 μm² of tectum. Surface of tectum wrinkled, without perforations.

**Pollen class:**
Trizonocolporate.

**Apertures:**
Compound.

**Ectoaperture:**
Colpus short, slit-like, with acute ends.

**Endoaperture:**
Lalongate porus. Polar axis of ecto- and endoaperture ± equal. Costae distinct only at the polar sides.

**Remarks:**
Pollen grains of *Lonicera tatarica* show some affinities to pollen grains of *Lonicera nigra* and *L. xylosteum*. Main differences between *L. nigra* and *L. tatarica* are to be observed in size, lack (*L. nigra*) or presence (*L. tatarica*) of perforations in tectum and nature of costae (generally endoapertures of *L. nigra* have no marked edges). In comparison with *L. xylosteum* pollen grains of *L. tatarica* are somewhat larger and its polar axis of ectoaperture and polar axis of endoaperture are of similar length.

**Analysed samples of Lonicera tatarica:**
1. Owilska by Warta river (prov. Poznań), 15.05.1993, I. Maciejewska, POZF.
2. Russian Republic, Novosibirsk region, Iskitimsk district, 19.06.1971, A.A. Chramov, KOR.

**Lonicera nigra** L. (Figs 24-28)

**Size:**
Medium, occasionally large. P = 43.8 μm (39-53 μm), E (longest axis) = 50.7 μm (44-59 μm).22

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22 According to Punt, Reitsma & Reuvers (1976) pollen grains of *Lonicera nigra* were of similar size as those of *L. xylosteum* (P = 42-60 μm, E = 46-66 μm); according to Stachurska and co-authors (1970) they were smaller (P = 34-43 μm, E = 40-48 μm).
P/E ratio: 0.87 (0.75-1.03), mostly observed suboblate grains (55.0%), relatively frequent – oblate spheroidal (44.6%) and very rare prolate spheroidal (0.4%).

Outlines: Polar view – circular or triangular with convex sides, equatorial view – mainly circular, sometimes elliptic.

Exine: 1.64 μm thick (1.6-2.4 μm), formed by 2 layers. Sexine as thick as nexine.

Ornamentation: Echinata. Echinate. Echinate – about 2-3 μm high, gradually becoming narrower, but without acuminate apex, 5-7 per 100 μm² of tectum. Surface of tectum with minute, irregularly placed striae, divided by distinct perforations.

Pollen class: Trizonocolporate.

Apertures: Compound.

Ectoaperture: Colpus short, slit-like, with acute ends.

Endoaperture: Porus lalongate, wide. Polar axis of ectoaperture as long as polar axis of endoaperture. Costae around endoapertures indistinct.

Remarks: See diagnosis about Lonicera xylosteum and L. tatarica pollen.

Analysed samples of Lonicera nigra:
1. Karkonosze Mts. (prov. Jelenia Góra), Wielki Staw, c. 1180 m, 05.06.1964, K. Browicz, KOR.
2. Izerskie Mts., between Chmielen and Pasiecznik (prov. Jelenia Góra), 480-490 m, 13.05.1981, A. Boratyński, KOR.
3. Szklarska Poręba (prov. Jelenia Góra), about 1 km to Szklarka waterfall, c. 500 m, 15.05.1993, I. Maciejewska, T. Maliński, POZF.
4. Babia Góra Mt. (prov. Bielsko Biała), c. 1150 m, 24.06.1952, W. Bugała, KOR.
5. Slope of Szymbierka Mt. (prov. Bielsko Biała), 10.05.1993, M. Gancarczyk, POZF.
6. SE end of Chwaniów Mt., between Jureczkowo and Liskowate (prov. Rzeszów), c. 600 m, 10.06.1966, K. Browicz, KOR.
7. Tatra Mts., Strążyska Valley (prov. Nowy Sącz), c. 600 m, 11.06.1993, I. Maciejewska, D. Wrońska-Pilarek, POZF.
8. Bieszczady Mts., slope of Kruzień (prov. Krosno), c. 500 m, 26.05.1993, T. Maliński, D. Wrońska-Pilarek, POZF.
CONCLUSION

Pollen grains of *Lonicera* and *Linnaea* species represent similar morphological type. All grains are medium- or large-sized, with oblate forms, echinate (microechinate) ornamentation and short ectoaperture. Length of spines and density of their distribution on tectum allow however to distinguish *Linnaea* and *Lonicera*.

Pollen grains of *Lonicera* species can be only correctly determined, when combination of features is taken into account. Size of grains, arrangement of tectum, length and shape of spines, their density on tectum and character of compound apertures have essential, diagnostic value. Pollen with the most variable quality features (mainly connected with the ornamentation) has been observed in samples of *L. xylosteum*. Its range of variability overlaps with pollen variability of *L. tatarica* and *L. nigra*.

KEY TO THE POLLEN GRAINS OF *CAPRIFOLIACEAE* SPECIES OCCURRING IN POLAND

1a. Polar axis usually longer than equatorial axis. Grains semitectate, with reticulate ornamentation

1b. Polar axis shorter than equatorial axis. Grains tectate, with echinate (or microechinate) ornamentation

2a. Muri in reticulum with only partly fused capita of collumellae. Ridges of muri beaded

2b. Muri in reticulum with completely fused capita of collumellae. Ridges of muri psilate

3a. Muri in reticulum at least 0.5 μm wide

3b. Muri in reticulum up to 0.4 μm wide

4a. *Viburnum lantana* L.

4b. *Viburnum opulus* L.
MORFOLOGIA ZIAREN PYŁKU KRAJOWYCH GATUKÓW
Z RODZINY CAPRIFOLIACEAE. CZĘŚĆ 2.

STRESZCZENIE

W pracy przedstawiono wyniki badań nad morfologią ziarn pyłku 6 krajowych gatunków z rodzajów Linnaea i Lonicera (rodzina Caprifoliaceae). Obserwacje przeprowadzono w oparciu o różne typy mikroskopów świetlnych oraz skaningowych. Opisy morfologiczne ziarn poszczególnych gatunków zostały ilustrowane seriami zdjęć spod obydwu rodzajów mikroskopów. Badane gatunki z rodzajów Linnaea i Lonicera charakteryzują się ziarnami o średnich, względnie dużych rozmiarach, spłaszczonej kształcie, kolczastym urzębeniu dąska oraz o krótkiej brudźce zewnętrznej, często podkreślonej przez ożebranie. Cechami odgromagującymi te dwa taksony oraz zarażącymi pozytywnie na wyróżnienie dla nich podtypów ziaren są gęstość rozmieszczenia kolców na powierzchni dąska oraz ich wysokość. Ponadto w pracy zamieszczono klucz do oznaczania 11 krajowych gatunków ziarn pyłku z rodziny Caprifoliaceae (rodzaj Linnaea, Lonicera, Sambucus, Viburnum).

SŁOWA KLUCZOWE: Caprifoliaceae, Linnaea, Lonicera, morfologia, ziarna pyłku, SEM, LM.