



Pollen morphology of the genus *Verbascum* L. (Group A) in Turkey

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Abstract

Pollen morphology of 30 taxa belonging to *Verbascum* L. of the family Scrophulariaceae from Turkey has been investigated using light microscope and scanning microscope. It is an eurypalynous family Erdtman (1952). Pollen grains usually radially symmetrical, isopolar, oblate-spheroidal to spheroidal, tricolpate. Tectum reticulate and coarsely reticulate.

Keywords: *Verbascum*, Pollen, Turkey

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Özet

Scrophulariaceae familyasından Türkiye’de yayılış gösteren *Verbascum* L. cinsine ait 30 taksonun polen morfolojisi, ışık ve elektron mikroskobu kullanılarak çalışılmıştır. Scrophulariaceae eurypalynous bir familyadır Erdtman (1952). Polen taneleri genellikle radyal simetrlili, isopolar, oblate-spheroidal’den spheroidal, tricolpate’a kadar. Tectum reticulate ve kabaca reticulate.

Anahtar Kelimeler: *Verbascum*, Polen, Türkiye

1. Introduction

This family is represented by 280 genera and about 3000 species in the world and 30 genera and 466 species in Turkey (Watson & Dallwitz, 1991; Huber-Morath, 1978). *Verbascum* is represented by 360 taxa in the world and 241 taxa in Turkey (Huber--Morath 1978, Davis *et al.* 1988, Vural & Aydoğdu 1993, Karavelioğullari *et al.* 2004, 2006,

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2008, Sutory 2001, 2004 Özhatay 2006, Kaynak *et al.* 2006, Parolly, G. & Tan, K. 2007, 2008). *Verbascum* group A, is could be separated with having 4 stamens from the others groups. This group members are represented by 45 taxa in Turkey and others neighbouring countries (Ferguson, 1972; Fedchenko, 1955; Huber-Morath, 1981; Feinbrun-Dothan, 1978a, 1978b; Meikle, 1985; Täckholm, 1974).

Pollen morphology of the family Scrophulariaceae has been examined by a number of workers such a Erdtman (1952), Moore & Webb (1978). Inceoglu (1982), Vargehese (1986). Argue (1986) Karim & EL-Oqlah (1989). Minki & Eshbaugh (1989). Karavelioğulları *et al.*, (2005)

2. Materials and methods

Material used for study was collected from 30 wild populations in Turkey which belong to 30 taxa in 28 species. Collectors and localities are shown in the Appendix. The list of voucher specimens of the plants are deposited in the herbarium of GAZI. The pollen grains were prepared for light (LM) by the standard methods described by Erdtman (1952). For light microscopy, the pollen grains were mounted in unstained glycerine jelly and observations were made with a Prior microscope under (125, 0.65) and oil immersion (E100, 1.25), using 10x eye piece. For scanning electron microscopy investigations, the polen grains were put on stubs, stutted-coated with gold plate. The S.E.M examination was carried out on a Jeol microscope JSM-6060. The measurements were based on 30 readings from each specimen. Polar axis, equatorial diameter, P/E ratio, exine, colpi long axis, colpi short axis, apocolpium and Amb diameter were also measured. The terminology used is in accordance with Erdtman (1952), Kremp (1965), Faegri & Iversen (1964), Walker & Doyle (1976) and Willis (1973).

3. Results

3.1. General pollen characters of the genus *Verbascum* (Group A)

Verbascum natolicum (Fisch. & C.A.Mey.) Hub.-Mor. Figure. 1. A, B, Table 1.

Measurements: Polar axis P (22.56–) 23.44±0.90 (– 26.04) µm, and equatorial diameter E (18.22–) 20.35±1.57 (–22.56) µm, P/E ratio: 1.15. Colpi (16.49–) 19.82±2.05 (–23.43) µm long. Amb diameter (21.70–) 23.14±1.27 (–26.04) µm. Apocolpium (1.73–) 2.79±0.65 (–4.34) µm. Exine (0.86–) 1.01±0.17 (–1.73) µm thick, ornamentation is coarsely reticulate.

Verbascum spodiotropicum (Hub.-Mor) Hub.-Mor. Figure. 2. A, B, Table 1.

Measurements: Polar axis P (14.75–) 16.23±0.83 (–17.36) µm, and equatorial diameter E (12.15–) 14.20±1.17 (–15.62) µm, P/E ratio: 1.14. Colpi (11.45–) 13.37±1.17 (14.75) µm long. Amb diameter (13.88–) 14.52±0.60 (–15.62) µm. Apocolpium (1.73–) 2.09±0.38 (–2.60) µm. Exine (0.86–) 0.94±0.11 (–1.08) µm thick, ornamentation is reticulate.

Verbascum orientale (L.) All. Figure. 3. A, B, Table 1.

Measurements: Polar axis P (27.77–) 29.97 ± 1.56 (–33.85) μm , and equatorial diameter E (24.30–) 27.28 ± 1.81 (–32.94) μm , P/E ratio: 1.10. Colpi (19.96–) 25.43 ± 2.22 (–29.51) μm long. Amb diameter (25.17–) 27.11 ± 1.42 (–29.51) μm . Apocolpium (3.47–) 5.09 ± 0.73 (–6.07) μm . Exine (1.30–) 1.47 ± 0.21 (–1.73) μm thick, ornamentation is reticulate.

Verbascum brachysepalum (Fisch. & Trautv.) O. Kuntze Figure. 4. A, B, Table 1.

Measurements: Polar axis P (24.30–) 25.87 ± 1.30 (–28.64) μm , and equatorial diameter E (21.70–) 23.63 ± 1.09 (–25.17) μm , P/E ratio: 1.09. Colpi (19.96–) 22.48 ± 1.71 (–26.04) μm long. Amb diameter (23.43–) 25.84 ± 1.56 (–28.64) μm . Apocolpium (2.60–) 3.64 ± 0.70 (–4.34) μm . Exine (0.86–) 0.97 ± 0.11 (–1.08) μm thick, ornamentation is reticulate.

Verbascum cilicium (Boiss. & Heldr.) O. Kuntze Figure. 5. A, B, Table 1.

Measurements: Polar axis P (19.96–) 22.54 ± 1.13 (–24.30) μm , and equatorial diameter E (18.2–) 20.39 ± 1.14 (–22.56) μm , P/E ratio: 1.11. Colpi (15.62–) 17.70 ± 1.55 (–19.96) μm long. Amb diameter (18.22–) 19.75 ± 0.96 (–20.83) μm . Apocolpium (1.73–) 2.47 ± 0.30 (–2.60) μm . Exine (0.86–) 0.94 ± 0.10 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum flabellifolium (Hub.-Mor.) Hub.-Mor. Figure. 6. A, B, Table 1.

Measurements: Polar axis P (20.83–) 22.85 ± 1.35 (–25.17) μm , and equatorial diameter E (17.36–) 20.19 ± 1.04 (–22.56) μm , P/E ratio: 1.11. Colpi (16.49–) 19.76 ± 1.47 (–22.56) μm long. Amb diameter (19.96–) 21.35 ± 0.34 (–22.56) μm . Apocolpium (1.73–) 2.34 ± 0.38 (–2.60) μm . Exine (0.65–) 0.90 ± 0.14 (–1.08) μm thick, ornamentation is reticulate.

Verbascum trapifolium (Stapf.) Hub.-Mor. Figure. 7. A, B, Table 1.

Measurements: Polar axis P (18.22–) 22.74 ± 0.73 (–22.56) μm , and equatorial diameter E (16.49–) 20.54 ± 1.05 (–20.83) μm , P/E ratio: 1.11. Colpi (15.62–) 19.44 ± 1.12 (–21.70) μm long. Amb diameter (17.4–) 21.01 ± 1.06 (–19.96) μm . Apocolpium (2.60–) 3.73 ± 0.70 (–3.90) μm . Exine (0.86–) 0.96 ± 0.11 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum pyroliforme (Boiss. & Heldr.) O. Kuntze Figure. 8. A, B, Table 1.

Measurements: Polar axis P (21.70–) 23.89 ± 1.52 (–26.04) μm , and equatorial diameter E (18.22–) 20.62 ± 1.13 (–21.70) μm , P/E ratio: 1.16. Colpi (16.49–) 20.16 ± 1.47 (–23.43) μm long. Amb diameter (18.2–) 21.78 ± 1.37 (–23.4) μm . Apocolpium (1.73–) 1.97 ± 0.36 (–2.60) μm . Exine (0.65–) 0.81 ± 0.08 (–0.86) μm thick, ornamentation is reticulate.

Verbascum dudleyanum (Hub.-Mor.) Hub.-Mor. Figure. 9. A, B, Table 1.

Measurements: Polar axis P (15.6–) 21.57 ± 1.30 (–22.56) μm , and equatorial diameter E(13.88–) 20.19 ± 0.99 (–19.96) μm , P/E ratio: 1.03. Colpi (12.15–) 18.14 ± 1.39 (–19.96) μm long. Amb diameter (16.49–) 20.63 ± 0.75 (–19.96) μm . Apocolpium (1.73–) 2.80 ± 0.22 (–3.47) μm . Exine (0.65–) 0.86 ± 0.22 (–1.08) μm thick, ornamentation is reticulate.

Verbascum coronopifolium (Boiss. & Balansae) O. Kuntze Figure. 10.A, B, Table 1.

Measurements: Polar axis P (19.96–) 24.38 ± 2.14 (–26.04) μm , and equatorial diameter E (17.36–) 19.21 ± 1.04 (–20.83) μm , P/E ratio: 1.27. Colpi (15.62–) 17.13 ± 0.85 (–18.22) μm long. Amb diameter (17.36–) 19.73 ± 1.14 (–21.70) μm . Apocolpium (2.60–) 3.98 ± 0.60 (–4.34) μm . Exine (0.65–) 0.80 ± 0.09 (–0.86) μm thick, ornamentation is reticulate.

Verbascum serratifolium (Hub.-Mor.) Hub.-Mor. Figure. 11.A, B, Table 1.

Measurements: Polar axis P (19.96–) 22.07 ± 1.08 (–23.40) μm , and equatorial diameter E(18.22–) 20.50 ± 1.50 (22.56) μm , P/E ratio: 1.08. Colpi (16.49–) 18.19 ± 1.10 (19.96) μm long.. Apocolpium (2.60–) 3.80 ± 0.68 (–5.20) μm . Amb diameter(16.49–) 20.02 ± 1.08 (–22.56) μm . Exine (0.86–) 0.93 ± 0.10 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum basivelatum Hub.-Mor. Figure. 12.A, B, Table 1.

Measurements: Polar axis P (17.36–) 19.21 ± 1.32 (–21.70) μm , and equatorial diameter E(15.6–) 17.73 ± 1.20 (–19.09) μm , P/E ratio: 1.08. Colpi (13.88–) 15.79 ± 1.22 (–18.22) μm long. Amb diameter (16.49–) 18.93 ± 1.04 (–19.96) μm . Apocolpium (2.60–) 2.80 ± 0.33 (–3.47) μm . Exine (0.86–) 0.86 ± 0.24 (–1.08) μm thick, ornamentation is reticulate.

Verbascum bourgeauanum Hub.-Mor. Figure. 13.A, B, Table 1.

Measurements: Polar axis P (19.09–) 21.87 ± 1.30 (–24.30) μm , and equatorial diameter E (18.22–) 20.19 ± 0.99 (–22.56) μm , P/E ratio: 1.08. Colpi (16.49–) 18.14 ± 1.39 (–21.70) μm long. Amb diameter (19.96–) 20.63 ± 0.75 (–21.70) μm . Apocolpium (2.60–) 2.80 ± 0.22 (–3.03) μm . Exine (0.65–) 0.86 ± 0.22 (–1.08) μm thick, ornamentation is reticulate.

Verbascum serpenticola Hub.-Mor. Figure. 14.A, B, Table 1.

Measurements: Polar axis P (21.70–) 21.13 ± 1.14 (–26.04) μm , and equatorial diameter E (19.96–) 21.32 ± 0.81 (–22.56) μm , P/E ratio: 0.99. Colpi (16.49–) 18.33 ± 1.03 (–20.83) μm long. Amb diameter (21.70–) 22.91 ± 0.83 (–24.30) μm .

Apocolpium (2.60–) 2.78 ± 0.29 (–3.47) μm . Exine (0.65–) 0.86 ± 0.22 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum sorgerae (Hub.-Mor.) Hub.-Mor. Figure. 15.A, B, Table 1.

Measurements: Polar axis P (19.96–) 21.67 ± 0.92 (–23.43) μm , and equatorial diameter E (17.36–) 19.53 ± 1.16 (–20.83) μm , P/E ratio: 1.11. Colpi (16.49–) 18.14 ± 1.01 (–19.96) μm long. Amb diameter (18.22–) 19.84 ± 1.27 (–21.70) μm . Apocolpium (1.73–) 2.14 ± 0.40 (–2.60) μm . Exine (0.65–) 0.89 ± 0.15 (–1.08) μm thick, ornamentation is reticulate.

Verbascum nudicaule (Wydler) Takht. Figure. 16.A, B, Table 1.

Measurements: Polar axis P (19.96–) 20.97 ± 0.69 (–22.56) μm , and equatorial diameter E (18.22–) 19.18 ± 0.66 (–19.96) μm , P/E ratio: 1.09. Colpi (16.49–) 17.53 ± 0.95 (–19.09) μm long. Amb diameter (17.36–) 19.78 ± 1.13 (–21.70) μm . Apocolpium (2.60–) 3.14 ± 0.26 (–3.47) μm . Exine (0.65–) 0.81 ± 0.10 (–0.86) μm thick, ornamentation is coarsely reticulate.

Verbascum suworowianum (K.Koch) O. Kuntze. var. *suworowianum* Figure. 17.A, B, Table 1.

Measurements: Polar axis P (18.22–) 20.69 ± 0.10 (–21.70) μm , and equatorial diameter E (19.09–) 20.86 ± 1.24 (–22.56) μm , P/E ratio: 0.99. Colpi (14.75–) 18.17 ± 1.72 (–20.83) μm long. Amb diameter (17.36–) 19.73 ± 1.42 (–21.70) μm . Apocolpium (1.73–) 2.69 ± 0.67 (–4.34) μm . Exine (0.65–) 0.91 ± 0.14 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum suworowianum (K.Koch) O. Kuntze. var. *papillosum* (Murb.) Hub.-Mor. Figure. 18. A, B, Table 1.

Measurements: Polar axis P (19.96–) 21.35 ± 0.90 (–22.56) μm , and equatorial diameter E (18.22–) 19.29 ± 0.78 (–20.83) μm , P/E ratio: 1.11. Colpi (15.62–) 17.16 ± 0.71 (–18.22) μm long. Amb diameter (17.36–) 19.06 ± 0.93 (–20.83) μm . Apocolpium (2.60–) 2.67 ± 0.16 (–3.03) μm . Exine (0.65–) 0.86 ± 0.22 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum luciliae (Boiss.) O. Kuntze Figure. 19. A, B, Table 1.

Measurements: Polar axis P (17.36–) 18.89 ± 1.36 (–21.70) μm , and equatorial diameter E (16.49–) 17.55 ± 0.71 (–22.56) μm , P/E ratio: 1.08. Colpi (13.88–) 15.68 ± 1.54 (–18.22) μm long. Amb diameter (17.36–) 17.87 ± 0.81 (–19.96) μm . Apocolpium (1.73–) 1.99 ± 0.36 (–2.60) μm . Exine (0.43–) 0.65 ± 0.19 (–0.86) μm thick, ornamentation is coarsely reticulate.

Verbascum rupicola (Hayek & Siehe) Hub.-Mor. Figure. 20. A, B, Table 1.

Measurements: Polar axis P (19.09–) 20.37 ± 1.01 (–23.43) μm , and equatorial diameter E(14.75–) 16.35 ± 0.76 (–17.36) μm , P/E ratio: 1.25. Colpi (15.62–) 20.08 ± 0.80 (–22.56) μm long. Amb diameter (13.88–) 16.40 ± 1.67 (–19.09) μm . Apocolpium (1.73–) 2.30 ± 0.50 (–3.03) μm . Exine (0.86–) 1.05 ± 0.14 (–1.30) μm thick, ornamentation is reticulate.

Verbascum agrimoniifolium (K.Koch) Hub.-Mor. subsp. *agrimoniifolium* Figure. 21. A, B, Table 1.

Measurements: Polar axis P (17.36–) 18.74 ± 0.98 (–20.83) μm , and equatorial diameter E (15.62–) 17.36 ± 0.68 (–18.22) μm , P/E ratio: 1.08.. Colpi (14.75–) 15.74 ± 0.93 (–17.36) μm long. Amb diameter (14.75–) 17.07 ± 1.08 (–19.96) μm . Apocolpium (1.73–) 2.92 ± 0.78 (–3.47) μm . Exine (0.65–) 0.86 ± 0.22 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum levanticum I.K. Ferguson Figure. 22.A, B, Table 1.

Measurements: Polar axis P (19.96–) 21.60 ± 1.14 (–23.43) μm , and equatorial diameter E (16.49–) 18.45 ± 1.18 (–20.83) μm , P/E ratio: 1.17. Colpi (14.75–) 18.55 ± 0.83 (–20.83) μm long. Amb diameter (17.36–) 18.25 ± 0.83 (–19.96) μm . Apocolpium (1.73–) 1.97 ± 0.33 (–2.60) μm . Exine (0.65–) 0.86 ± 0.22 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum bugulifolium Lam. Figure. 23. A, B, Table 1.

Measurements: Polar axis P (16.49–) 18.60 ± 1.02 (–19.96) μm , and equatorial diameter E(16.5–) 16.66 ± 0.70 (–18.22) μm , P/E ratio: 1.12. Colpi (13.88–) 15.59 ± 1.06 (–17.36) μm long. Amb diameter (16.49–) 17.82 ± 0.81 (–19.09) μm . Apocolpium (2.60–) 3.48 ± 0.60 (–5.20) μm . Exine (0.65–) 0.83 ± 0.07 (–1.08) μm thick, ornamentation is coarsely reticulate.

Verbascum ponticum (Boiss.) O. Kuntze Figure. 24.A, B, Table 1.

Measurements: Polar axis P (17.36–) 18.57 ± 0.98 (–19.96) μm , and equatorial diameter E (14.75–) 16.46 ± 0.83 (–17.36) μm , P/E ratio: 1.13. Colpi (13.88–) 15.06 ± 0.92 (–16.49) μm long. Amb diameter (15.62–) 16.61 ± 1.34 (–21.70) μm . Apocolpium (1.73–) 2.22 ± 0.48 (–3.03) μm . Exine (0.65–) 0.79 ± 0.10 (–0.86) μm thick, ornamentation is reticulate.

Verbascum bornmuellerianum Hub.-Mor. Figure. 25.A, B, Table 1.

Measurements: Polar axis P (17.36–) 19.53±0.99 (–21.70) µm, and equatorial diameter E (16.49–) 18.19±0.87 (–19.96) µm, P/E ratio: 1.07. Colpi (13.88–) 16.43±1.07 (–18.22) µm long. Amb diameter (16.49–) 18.34±1.16 (–19.96) µm. Apocolpium (1.73–) 2.42±0.49 (–3.03) µm. Exine (0.65–) 0.88±0.10 (–1.08) µm thick, ornamentation is coarsely reticulate.

Verbascum oreophilum K.Koch. var. *oreophilum* Figure. 26. A, B, Table 1.

Measurements: Polar axis P (19.09–) 20.71±1.11 (–22.56) µm, and equatorial diameter E (17.36–) 18.92±1.19 (–22.56) µm, P/E ratio: 1.09. Colpi (15.62–) 17.36±0.75 (–18.22) µm long. Amb diameter (19.96–) 21.52±1.10 (–23.43) µm. Apocolpium (1.73–) 2.54±0.40 (–3.03) µm. Exine (0.86–) 0.96±0.11 (–1.08) µm thick, ornamentation is reticulate.

Verbascum oreophilum K.Koch. var. *joannis* (Bordz.) Hub.-Mor. Figure. 27. A, B, Table 1.

Measurements: Polar axis P (19.96–) 21.49±0.90 (–23.43) µm, and equatorial diameter E (15.62–) 17.16±0.54 (–18.22) µm, P/E ratio: 1.25. Colpi (17.36–) 19.17±0.97 (–20.83) µm long. Amb diameter (16.49–) 17.70±0.12 (–19.09) µm. Apocolpium (2.60–) 3.41±0.01 (–4.34) µm. Exine (0.65–) 0.79±0.09 (–0.86) µm thick, ornamentation is reticulate.

Verbascum gaillardotii Boiss. Figure. 28. A, B, Table 1.

Measurements: Polar axis P (15.62–) 18.92±1.43 (–20.83) µm, and equatorial diameter E (14.75–) 17.82±1.11 (–19.09) µm, P/E ratio: 1.06. Colpi (13.02–) 15.01±1.04 (–17.36) µm long. Amb diameter (16.49–) 18.19±1.01 (–20.83) µm. Apocolpium (2.60–) 3.18±0.50 (–4.34) µm. Exine (0.86–) 1.19±0.17 (–1.73) µm thick, ornamentation is coarsely reticulate.

Verbascum freynii (Sint.) Murb. Figure. 29. A, B, Table 1.

Measurements: Polar axis P (19.09–) 21.52±0.92 (–22.56) µm, and equatorial diameter E (18.22–) 20.86±1.52 (–21.70) µm, P/E ratio: 1.03. Colpi (16.49–) 17.79±0.87 (–19.96) µm long. Amb diameter (19.96–) 21.15±0.98 (–22.56) µm. Apocolpium (2.60–) 3.41±0.34 (–5.20) µm. Exine (0.86–) 1.01±0.10 (–1.08) µm thick, ornamentation is reticulate.

Verbascum transcaucasicum Wulf. Figure. 30. A, B, Table 1.

Measurements: Polar axis P (17.36–) 20.36±1.80 (–22.56) µm, and equatorial diameter E (13.88–) 17.78±1.77 (–19.96) µm, P/E ratio: 1.15. Colpi (15.62–) 16.95±0.74 (–18.22) µm long. Amb diameter (17.36–) 18.13±0.69 (–19.09) µm. Apocolpium (1.73–) 2.31±0.41 (–3.03) µm. Exine (0.65–) 0.74±0.11 (–0.86) µm thick, ornamentation is reticulate.

3.2. Key to the species

- 1- Pollen shape oblate*V. suworowianum* var. *suworowianum*
- 1- Pollen shape prolate, subprolate
- 2- Pollen shape subprolate
- 3-Exine diameter 0.79 to 0.86µm
- 4- Polar axis 21µm
- 5- Colpi short axis 2µm.....*V.oreophilum* var. *joannis*
- 5- Colpi short axis 4µm.....*V. levanticum*
- 4- Polar axis 23 to 24µm
- 6- Colpi long axis 17µm.....*V. coronopifolium*
- 6- Colpi long axis 20µm.....*V. pyroliforme*
- 3- Exine diameter 1µm
- 7- Amb diameter 16µm.....*V. rupicola*
- 7- Amb diameter 23µm.....*V. natolicum*
- 2- Pollen shape prolate
- 8- Polar axis 16 to 19µm
- 9- Equatorial diameter 14µm.....*V. spodiotropicum*
- 9- Equatorial diameter 16 to 20 µm
- 10- Colpi short axis 2 µm.....*V. ponticum*
- 10- Colpi short axis 3 to 4.5 µm
- 11- Exine diameter 1 µm.....*V. gaillardotii*
- 11- Exine diameter 0.6 to 0.9 µm
- 12- Amb diameter 17 µm
- 13- Apocolpium 1 to 2 µm
- 14- Colpi short axis 3.66 µm.....*V. luciliae*
- 14- Colpi short axis 3.85 µm
-*V. agrimoniifolium* ssp. *agrimoniifolium*
- 13- Apocolpium 3 µm.....*V. bugilifolium*
- 12- Amb diameter 18 µm
- 15- Colpi short axis 3 µm.....*V. basivelatum*
- 15- Colpi short axis 4 µm.....*V. bornmuellerianum*
- 8- Polar axis 20 to 29µm
- 16- Amb diameter 18 to 20 µm
- 17- Colpi short axis 2 to 3 µm
- 18- Colpi long axis 16 µm.....*V. transcausicum*
- 18- Colpi long axis 18 µm.....*V. borgeauanum* and *V. dudleyanum*
- 17- Colpi short axis 4 to 5 µm
- 19- Colpi long axis 17 µm
- 20- Apocolpium 3 µm.....*V. nudicaule*
- 20- Apocolpium 2 µm
- 21- Polar axis 21 µm.....*V. suworowianum* var. *papillosun*
- 21- Polar axis 22 µm.....*V. cilicicum*
- 19- Colpi long axis 18 µm.....*V. sorgerae*
- 16- Amb diameter 21 to 27 µm
- 22- Polar axis 21 µm
- 23- Colpi long axis 17 µm
- 24- Apocolpium 2 µm.....*V. oreophilum* var. *oreophilum*
- 24- Apocolpium 3 µm.....*V. freynii*
- 23- Colpi long axis 18 to 19 µm
- 25- Apocolpium 2 µm
- 26- Exine diameter 0.86 µm.....*V. serpenticola*
- 26- Exine diameter 1 µm.....*V. flabellifolium*
- 25- Apocolpium 3 µm
- 27- Colpi long axis 18 µm.....*V. serratifolium*
- 27- Colpi long axis 19 µm.....*V. trapifolium*
- 22- Polar axis 25 to 29µm
- 28- Exine diameter 0.97 µm.....*V. brachycephalum*
- 28- Exine diameter 1.47 µm.....*V. orientale*

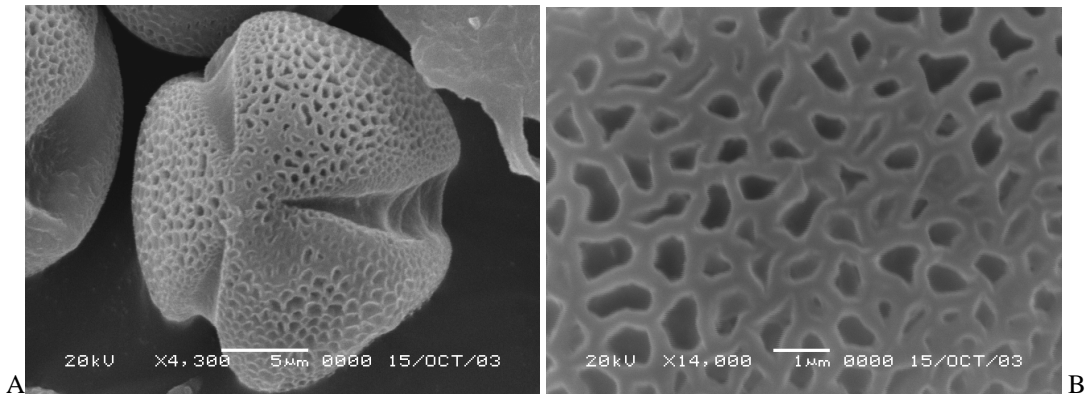


Fig. 1. SEM photos of the pollen grain of *V. natolicum* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 14000. (FAK 3008)



Fig. 2. SEM photos of the pollen grain of *V. spodiotrichum* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 5000, (B) x 16000. (FAK 3318).

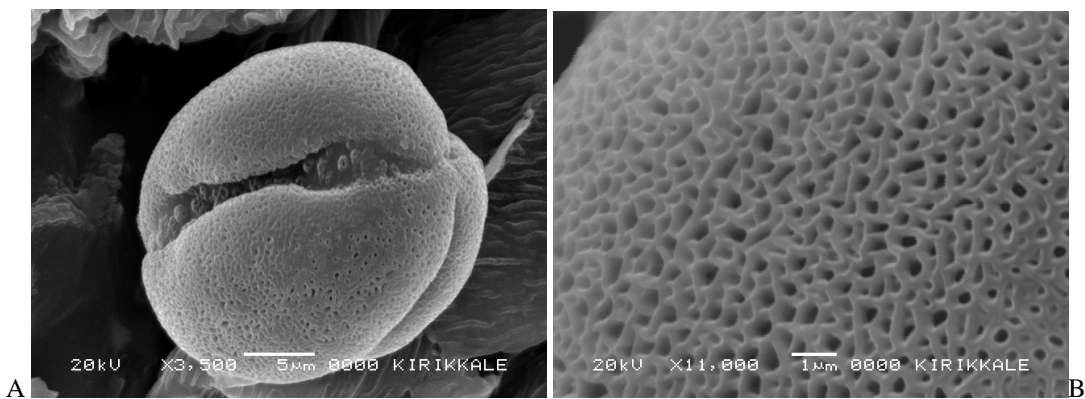


Fig. 3. SEM photos of the pollen grain of *V. orientale* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 3500, (B) x 11000. (FAK 3175)

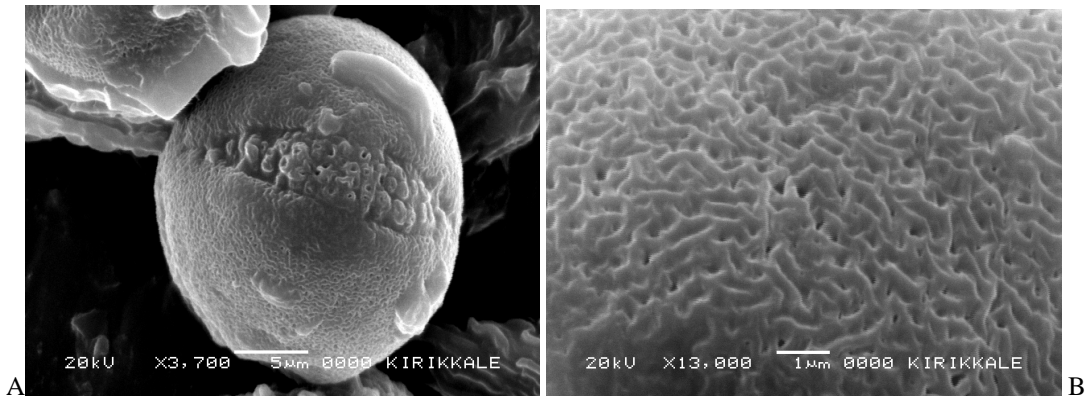


Fig. 4. SEM photos of the pollen grain of *V. brachysepalum* (A) equatorial view and (B) detail of pollen grain.

Magnification: (A) x 3700, (B) x 13000 (FAK 3184).

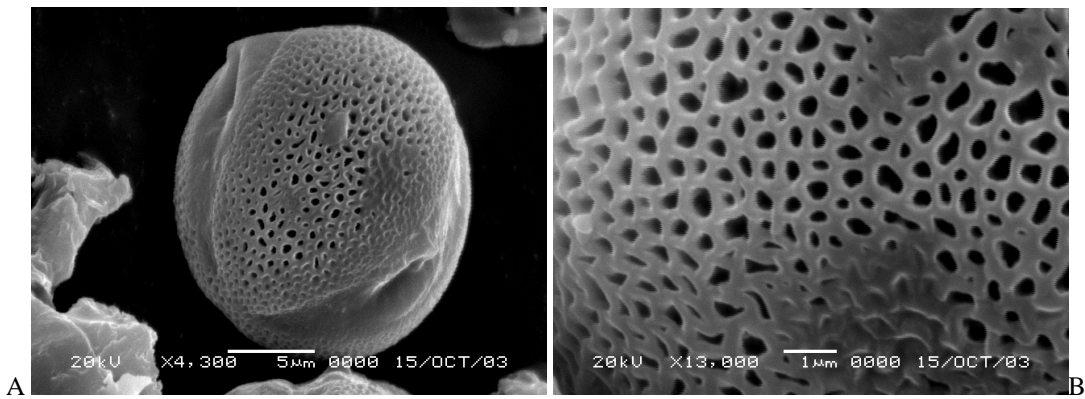


Fig. 5. SEM photos of the pollen grain of *V. cilicium* (A) equatorial view and (B) detail of pollen grain. Magnification:

(A) x 4300, (B) x 13000 (FAK 3262).

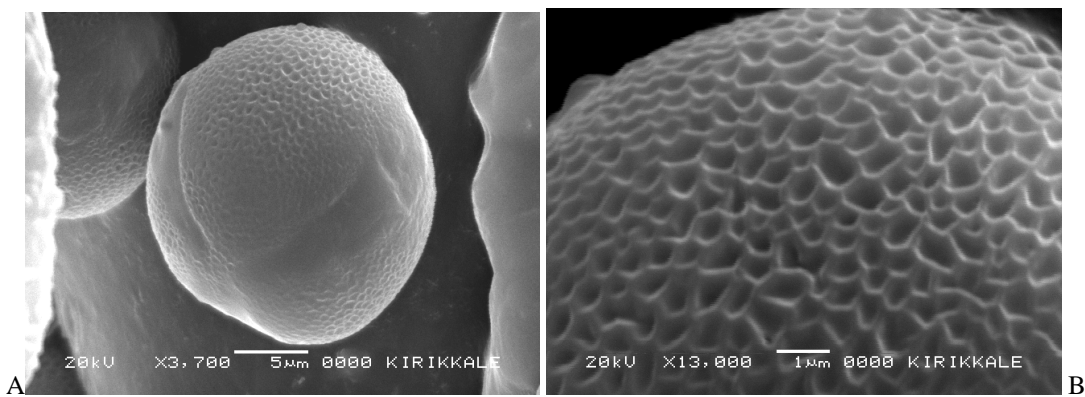


Fig. 6. SEM photos of the pollen grain of *V. flabellifolium* (A) polar view and (B) detail of pollen grain. Magnification:

(A) x 3700, (B) x 13000 (FAK 3238).

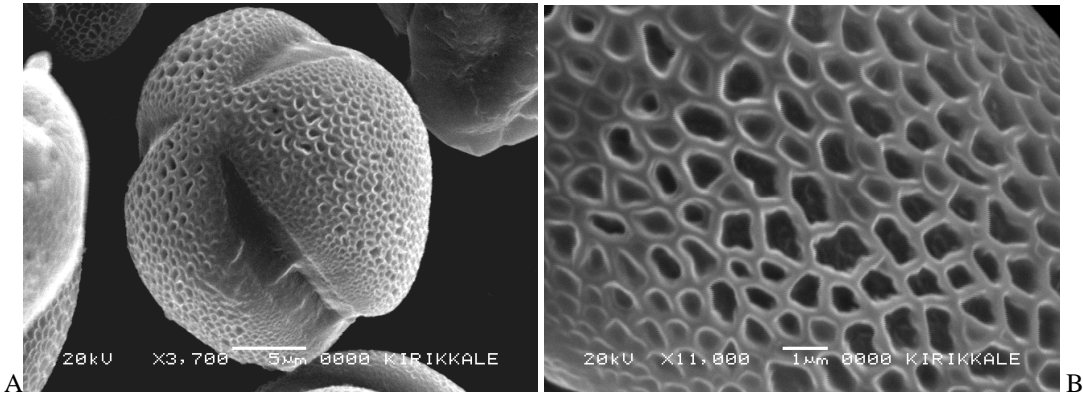


Fig. 7. SEM photos of the pollen grain of *V. trapifolium* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 3700, (B) x 11000 (FAK 3321).

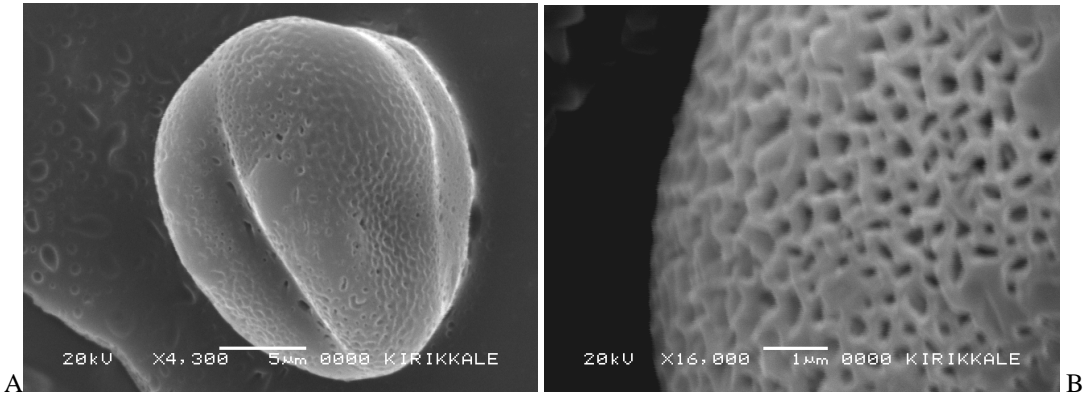


Fig. 8. SEM photos of the pollen grain of *V. pyroliforme* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 16000 (FAK 3359).

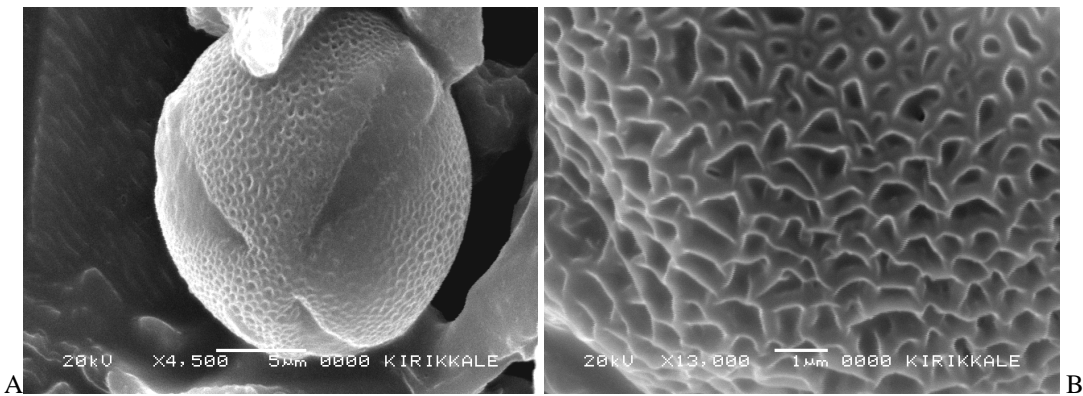


Fig. 9. SEM photos of the pollen grain of *V. dudleyanum* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 4500, (B) x 13000 (FAK 3323).

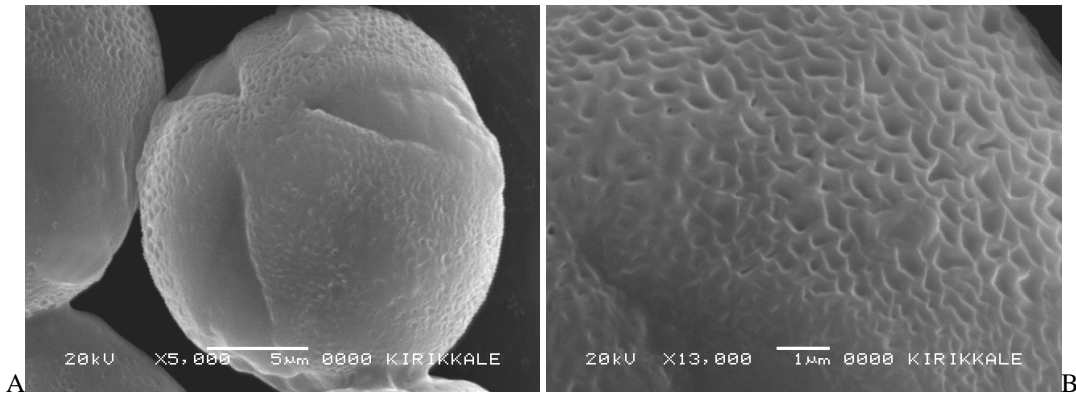


Fig. 10. SEM photos of the pollen grain of *V. coronopifolium* (A) polar view and (B) detail of pollen grain.

Magnification: (A) x 5000, (B) x 13000 (FAK 3388).

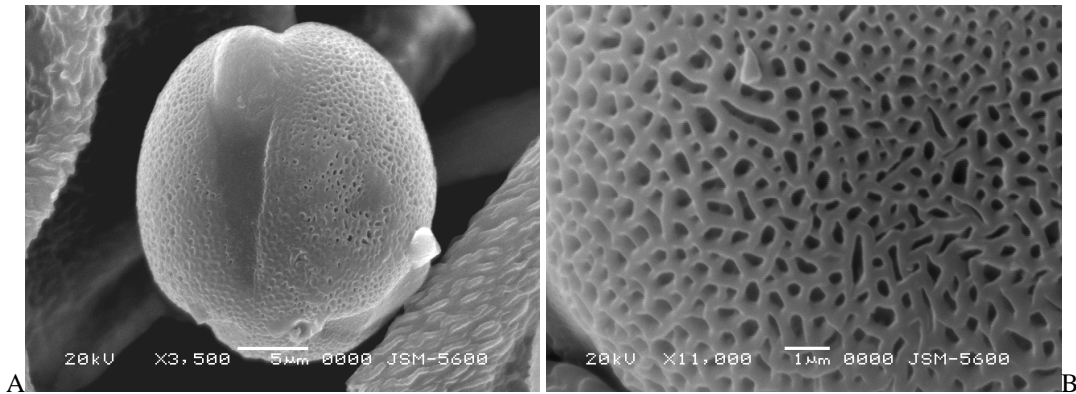


Fig. 11. SEM photos of the pollen grain of *V. serratifolium* (A) polar view and (B) detail of pollen grain. Magnification:

(A) x 3500, (B) x 11000 (FAK 3002).

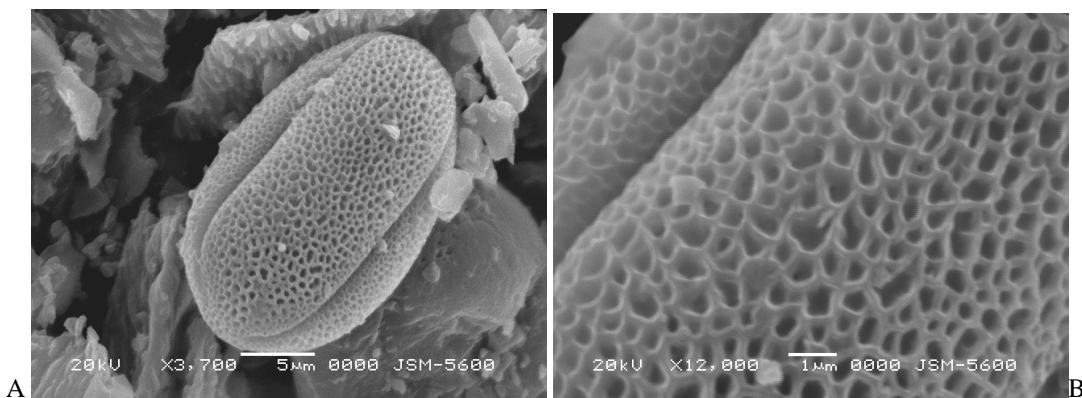


Fig. 12. SEM photos of the pollen grain of *V. basivelatum* (A) equatorial view and (B) detail of pollen grain.

Magnification: (A) x 3700, (B) x 12000 (FAK 3386).

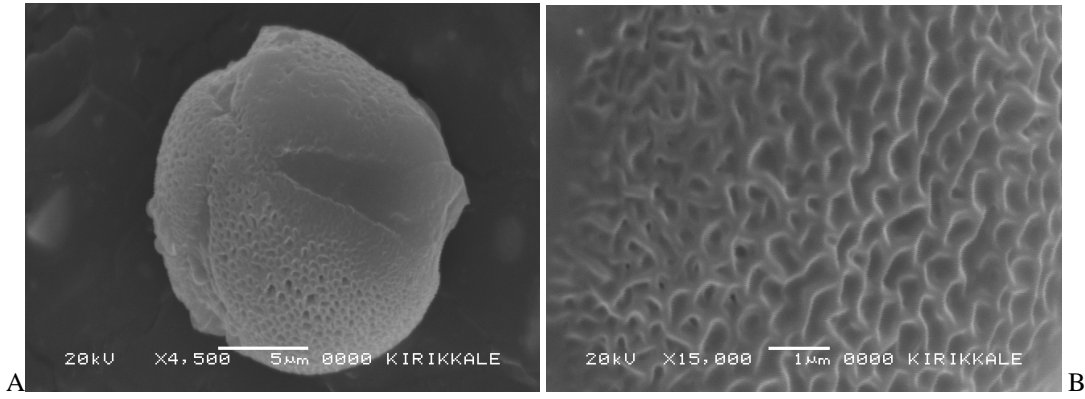


Fig. 13. SEM photos of the pollen grain of *V. bourgeauanum* (A) polar view and (B) detail of pollen grain.

Magnification: (A) x 4500, (B) x 15000 (FAK 3429).



Fig. 14. SEM photos of the pollen grain of *V. serpenticola* (A) polar view and (B) detail of pollen grain. Magnification:

(A) x 4300, (B) x 13000 (FAK 3247).

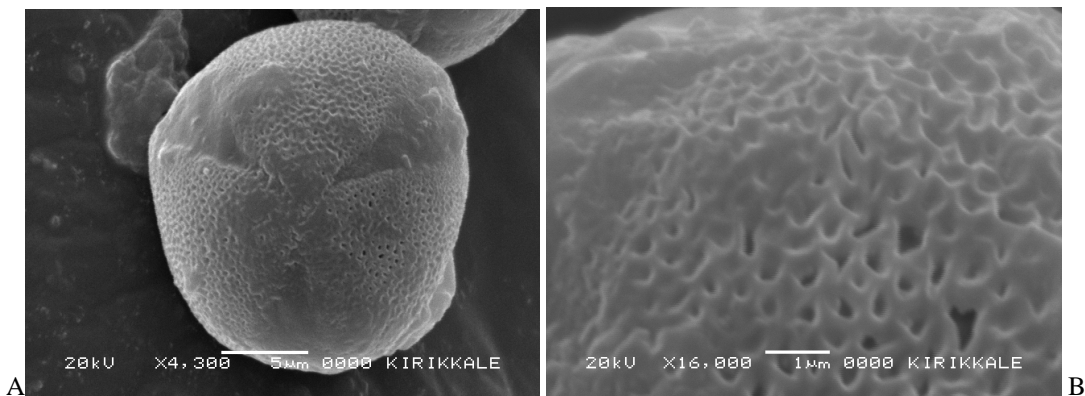


Fig. 15. SEM photos of the pollen grain of *V. sorgerae* (A) polar view and (B) detail of pollen grain. Magnification: (A)

x 4300, (B) x 16000 (FAK 3253).

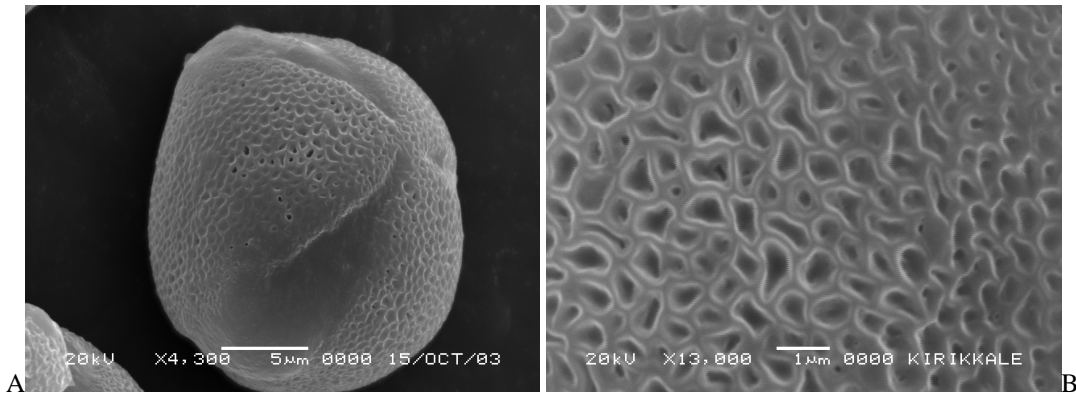


Fig. 16. SEM photos of the pollen grain of *V. nudicaule* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 13000 (FAK 3046).

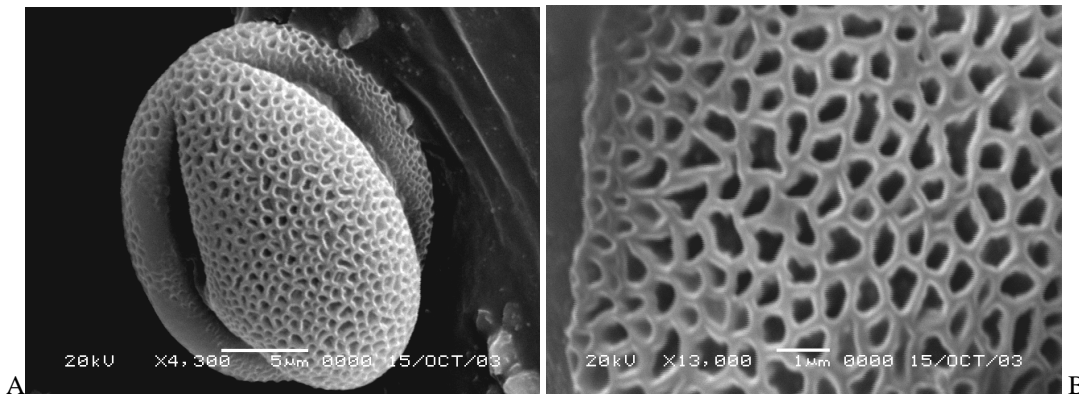


Fig. 17. SEM photos of the pollen grain of *V. suworowianum* var. *suworowianum* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 13000 (FAK 3362).

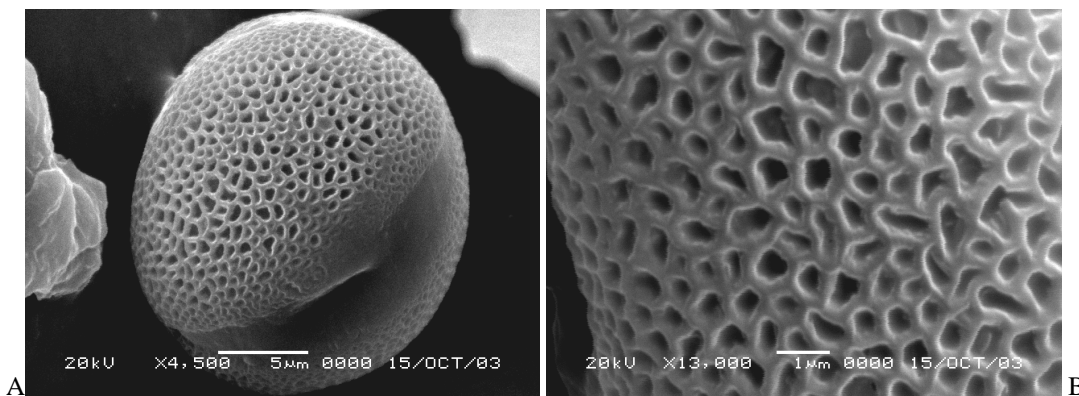


Fig. 18. SEM photos of the pollen grain of *V. suworowianum* var. *papillosum* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 13000 (FAK 3392).

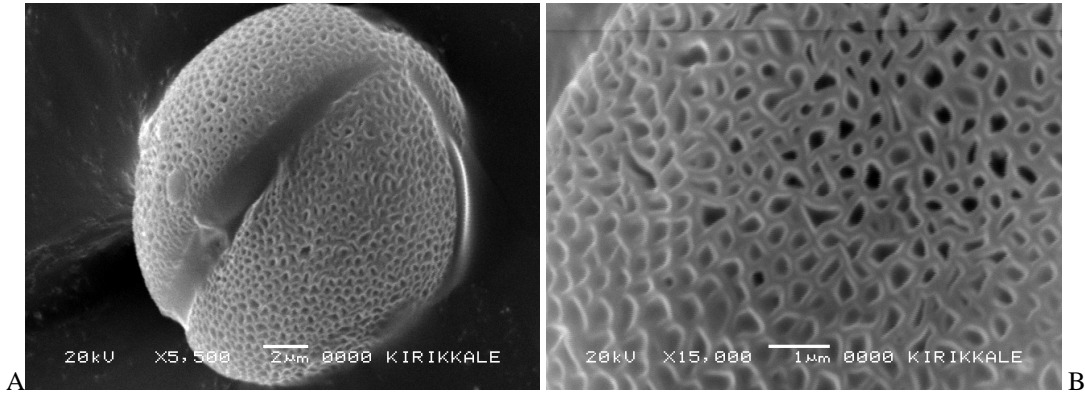


Fig. 19. SEM photos of the pollen grain of *V. luciliae* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 5500, (B) x 15000 (HD 7178).

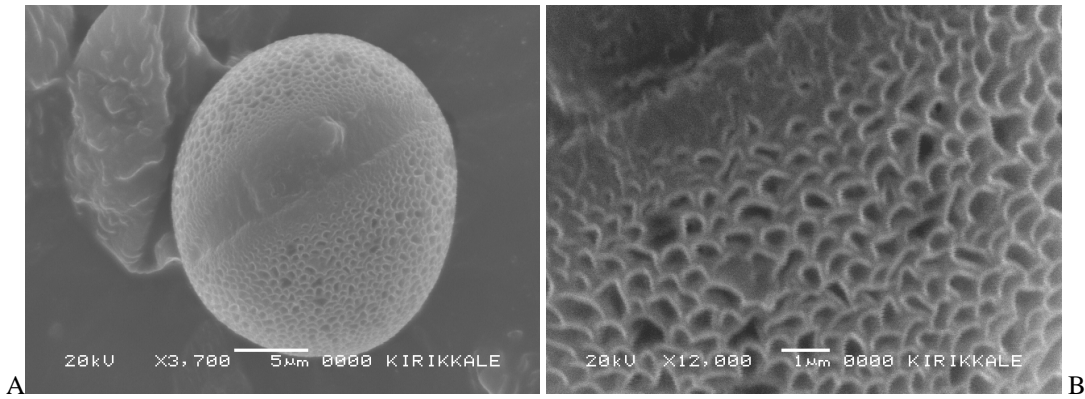


Fig. 20. SEM photos of the pollen grain of *V. rupicola* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 3700, (B) x 12000 (SŞ 3025).

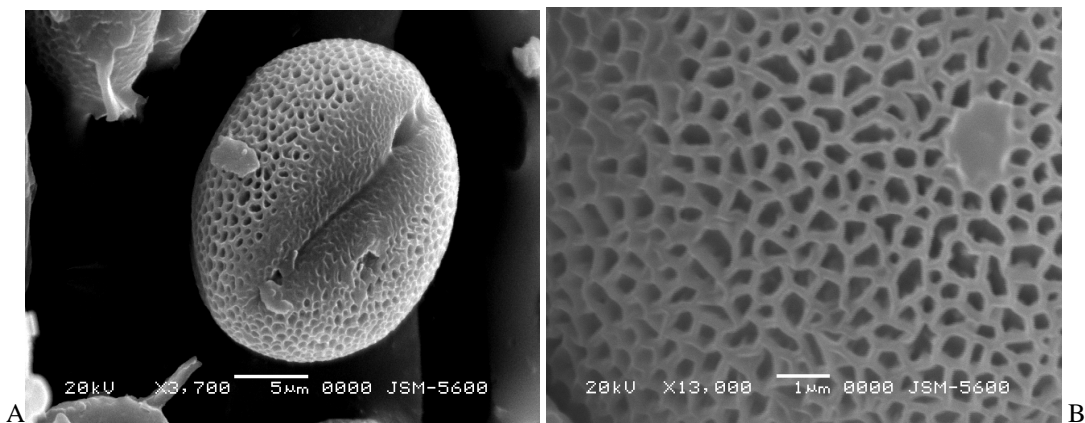


Fig. 21. SEM photos of the pollen grain of *V. agrimoniifolium* subsp. *agrimoniifolium* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 3700, (B) x 13000 (FAK 3031).

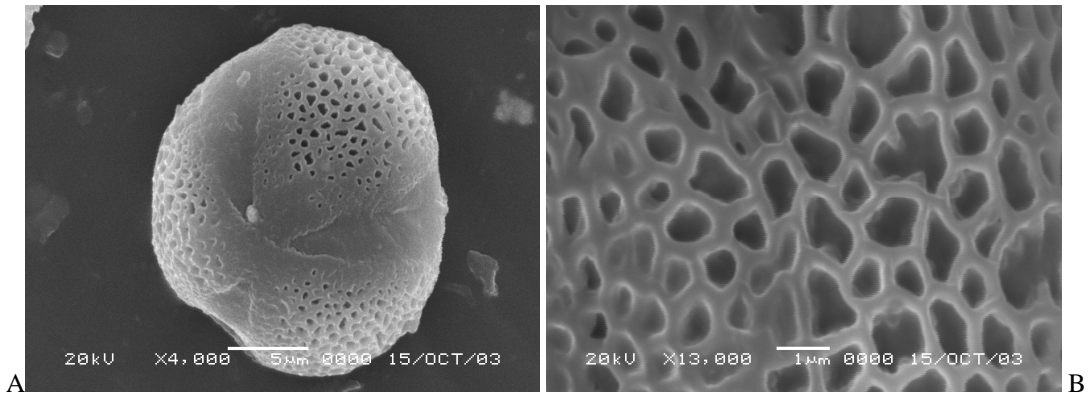


Fig. 22. SEM photos of the pollen grain of *V. levanticum* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 4000, (B) x 13000 (FAK 3158).

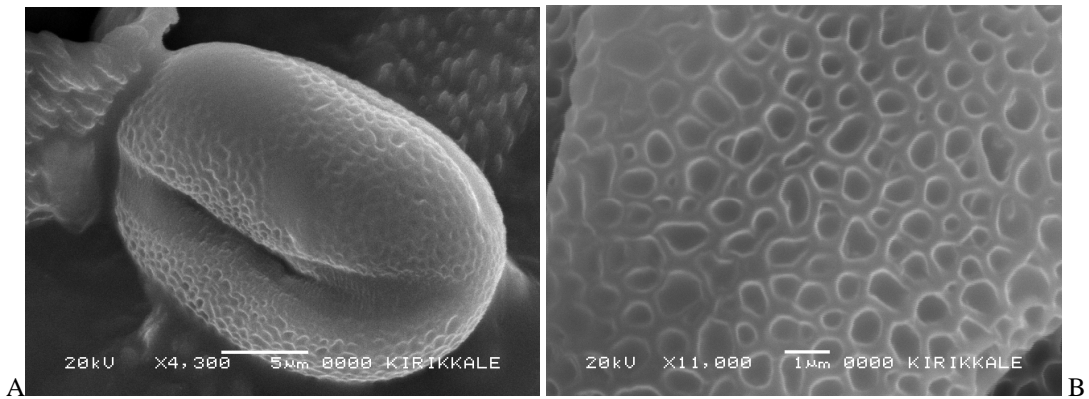


Fig. 23. SEM photos of the pollen grain of *V. bugulifolium* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 11000 (FAK 3411).

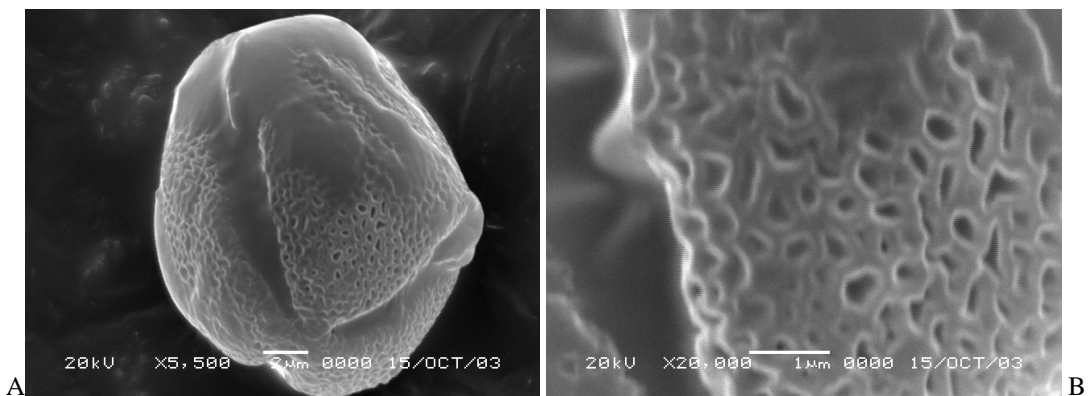


Fig. 24. SEM photos of the pollen grain of *V. ponticum* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 5500, (B) x 20000 (FAK 3110).

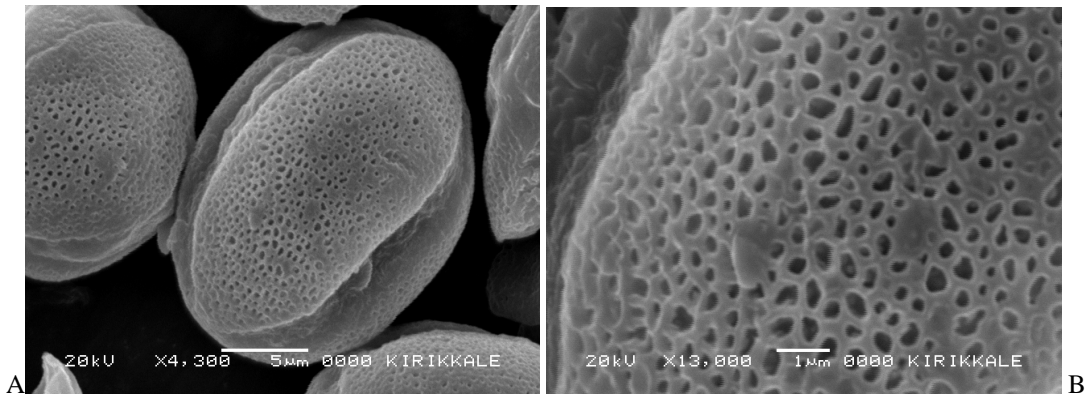


Fig. 25. SEM photos of the pollen grain of *V. bornmuellerianum* (A) equatorial view and (B) detail of pollen grain.

Magnification: (A) x 4300, (B) x 13000 (FAK 3025).

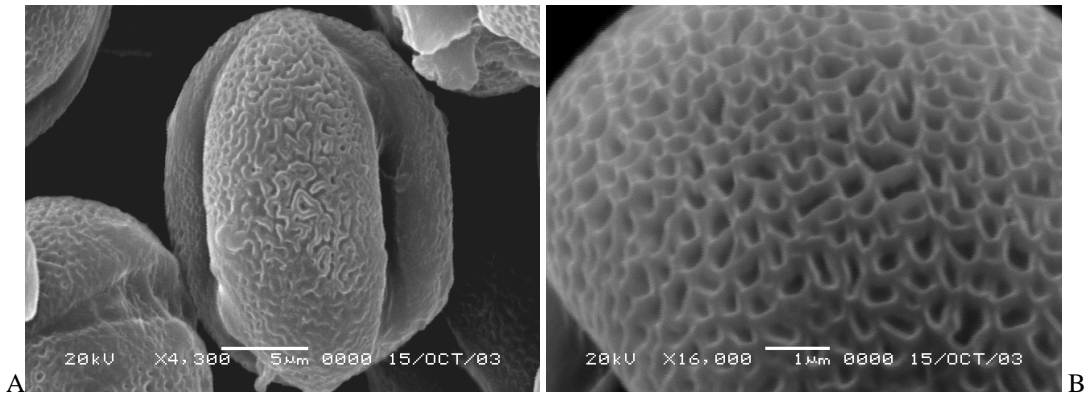


Fig. 26. SEM photos of the pollen grain of *V. oreophyllum* var. *oreophyllum* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 16000 (FAK 3043).

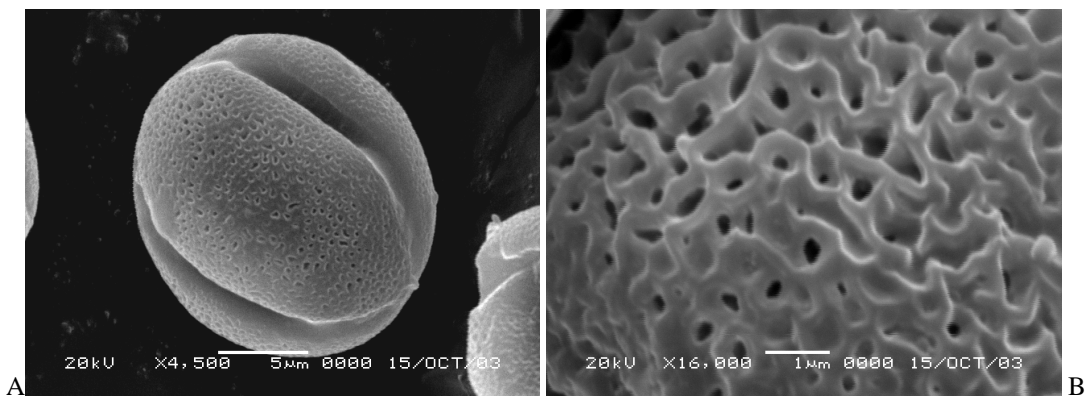


Fig. 27. SEM photos of the pollen grain of *V. oreophyllum* var. *joannis* (A) equatorial view and (B) detail of pollen grain. Magnification: (A) x 4500, (B) x 16000 (FAK 3036).

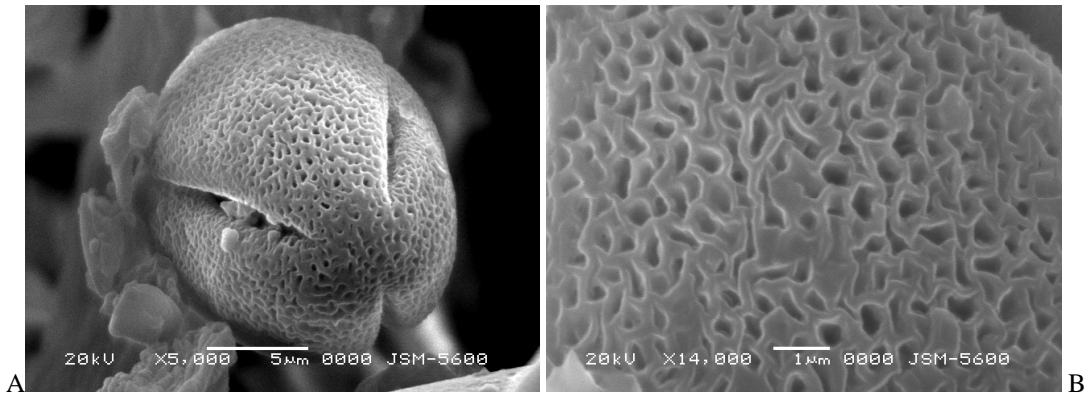


Fig. 28. SEM photos of the pollen grain of *V. gaillardotii* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 5000, (B) x 14000 (FAK 3145).

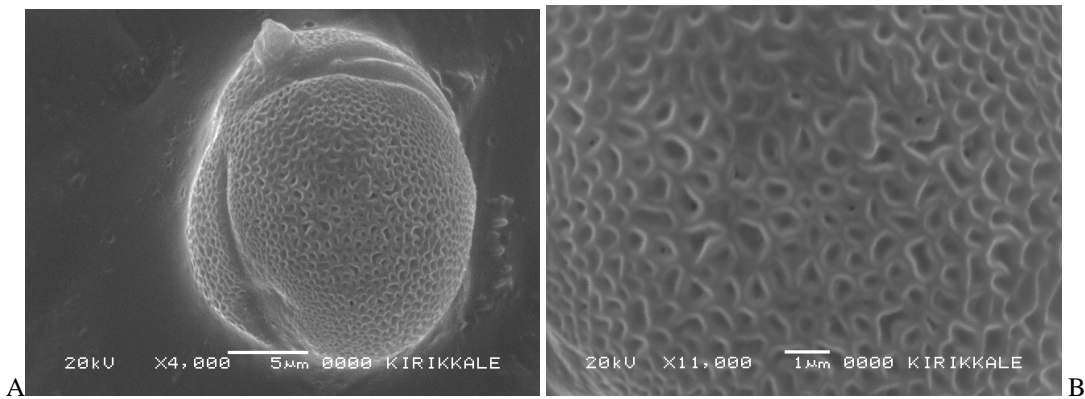


Fig. 29. SEM photos of the pollen grain of *V. freynii* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 4000, (B) x 11000 (FAK 3425).

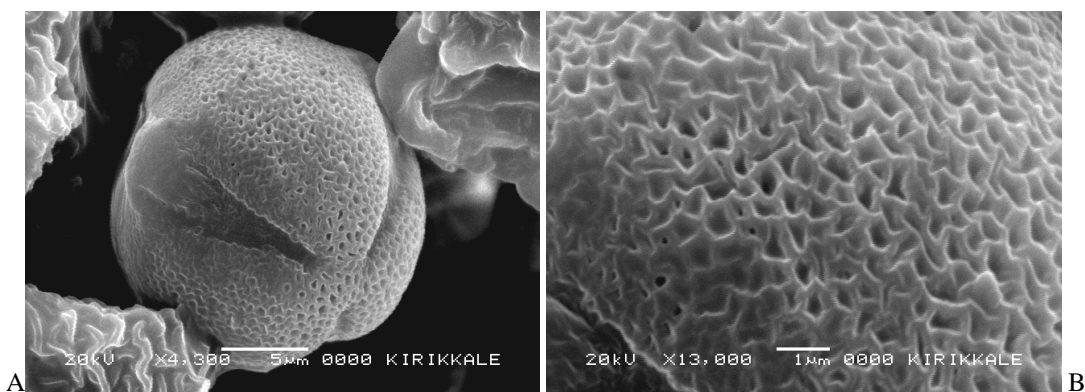


Fig. 30. SEM photos of the pollen grain of *V. trascaucasicum* (A) polar view and (B) detail of pollen grain. Magnification: (A) x 4300, (B) x 13000 (FAK 3137).

Appendix

- V. naticum* B5 Kayseri: Talas, 20.06.2001, 1230-1270 m, FAK 3008.
V. spodiotrichum C3 Antalya: Tekirova, 27.08.1993, 1-400 m, FAK 3318.
V. orientale Adana: Kozan-Feke 35. km, Akkaya village, 850 m, 20.05.2002, FAK 3175.
V. brachysepalum C5 Mersin: Tarsus-Namrun (Çamlıyayla) 35. km, 870 m, 21.05.2002, FAK 3184.
V. cilicium C5 Niğde: Ulukışla-Çiftehan, 1050 m, 25.08.2002, FAK 3262.
V. flabellifolium C2 Burdur: Dirmil-Fethiye, 18.06.2002, 1650 m, FAK 3238.
V. trapifolium C2 Burdur: Dirmil-Göhlhisar 3,5. km, 1250 m, 07.06.2002, FAK 3321.
V. pyroliforme B4 Konya: Konya-Kayacık, 06.09.2001, FAK 3359.
V. dudleyanum C2 Burdur: S. shore of Salda, 1150 m, 11.07.2001, FAK 3323 .
V. coronopifolium B2 Kütahya: Murat mountain, above Gediz, Kesik Söğüt, 1700-1900 m, 21.06.2003, FAK 3388.
V. serratifolium B3 Eskişehir: Sarıcakaya, valley of Sakarya, Gökçekaya dam, 450-500 m, 08.05.1994, FAK 3002.
V. basivelatum B3 Eskişehir: Porsuk dam, Türkmen Dağı, 930 m, 23.07.2003, FAK 3385.
V. bourgeauanum C2 Antalya: Elmalı, Akdağ, Kızlarsıvrısı, 2000-2300 m, 02.08.2003, FAK 3429.
V. serpenticola C2 Burdur: Dirmil, Dirmil passage, 1450-1650 m, 12.07.2003, FAK 3247
V. sorgerae C3 Isparta: Çiçekdağı, Gedikli village, Sindeli, 31.05.2002, 1350 m, FAK 3253.
V. nudicaule B9 Van: Erek mountain, Gemiş Gölü, 2200 m, 20.09.2003, FAK 3046.
V. suworowianum var. *suworowianum* A9 Kars: Kağızman-Iğdır, 26 km W. of Tuzluca, 1080 m, 03.07.1992, FAK 3362.
V. suworowianum var. *papillosum* B10 Ağrı: d. Doğubeyazıt, Topçatan village, 1550 m, 09.06.2001, FAK 3392.
V. luciliae B2 Uşak: Eşme, Gümüskol, Edertepe, 900-1050 m, 20.07.2002, HD 7178.
V. rupicola C1 İzmir: Gümüldür, 100-200 m, 26.06.2003, S. Şenol 3025.
V. agrimoniifolium subsp. *agrimoniifolium* B6 Malatya: Malatya-Pütürge 17. km, 990 m, 03.06.2001, FAK 3031.
V. levanticum C4 Antalya: Alanya, Derince stream, 800 m, 31.08.2002, FAK 3158.
V. bugulifolium A1 (E) Kırklareli: Demirköy-İğneada, Avcılar, 20 m, 13.06.2003, FAK 3411.
V. ponticum A5 Kastamonu: Ilgaz mountain, 1000 m, 19.06.2003, FAK 3110.
V. bornmuellerianum C9 Şırnak: Şırnak, 1450 m, 10.06.2001, FAK 3025.
V. oreophyllum var. *oreophyllum* Kars: Akçay to Cumaçay E. of Kağızman, 2200 m, 17.07.2001, FAK 3043.
V. oreophyllum var. *joannis* A9 Kars: Kağızman, Paşlı-Çilehane, 1600 m, 13.07.2001, FAK 3036.
V. gaillardotii C6 Hatay: Harbiye S.W. of Antakya, 300-400 m, 03.07.2001, FAK 3145.
V. freynii A5 Kastamonu: Tosya, Y. Dikmen, Kilkuyu village, c. 1400-1600 m, 12.06.2003, FAK 3425.
V. trascaucasicum A9 Kars: Akçay-Cumaçay, 14 km, 1950 m, 20.07.2001, FAK 3137.

4. Results and discussion

The Scrophulariaceae is a more or less stenopalynous family Erdtman, (1952). When examined under the light microscope (Table 1) the taxa of *Verbascum* show a more or less uniform pattern of the pollen morphology. At first sight it seems that the pollen characters in this family are of little value for taxonomic studies.

The morphological characteristics of the pollen grains of 30 taxa of *Verbascum* (group A) are shown in Table I. The pollen of all species is radially symmetrical, isopolar, tri-colpate, zonoaperturate, prolate or subprolate, oblate spheroidal in shape and in the P/E ratio (polar axis / equatorial axis), ectoaperture – colpus long, narrow, not sunken Erdtman, (1952). The size of the pollen grains ranged from 16.23-29.97 µm min length (polar axis), 14.20-27.28 µm in width (equatorial axis), P/E ratio 0.99-1.27, colpi long axis 13.37-25.43 µm, colpi short axis 2.39-5.81 µm, apocolpium 1.97-5.09 µm, Amb diameter 14.52-27.11 µm. Exine thickness from 0.65-1.47 µm. Examination of the exine surface of all the species under the SEM gave very good diagnostic characters. Two sculptures of exine showed very good diagnostic characters for separating the taxa into groups based on the sculpturing type: reticulate and coarsely reticulate.

In our study, some remarkable dimensional differences were observed between taxa. Polar axis of *V. spodiotrichum* is the smallest (16.23 µm), *V. orientale* is the largest (29.97 µm). Equatorial diameter of *V. spodiotrichum* is the smallest

(14.20 µm), *V. orientale* is the largest (27.28 µm). Exine of *V. luciliae* is the smallest (0.65 µm), *V. orientale* is the largest (1.47 µm). Colpi long axis of *V. spodiotrichum* is the smallest (13.37 µm), *V. orientale* is the largest (25.43 µm). Colpi short axis of *V. transcaucasicum* is the smallest (2.39 µm), *V. natolicum* is the largest (5.81 µm). Apocolpium of *V. levanticum* and *V. pyroliforme* is the smallest (1.97 µm), *V. orientale* is the largest (5.09 µm). Amb diameter of *V. spodiotrichum* is the smallest (14.52 µm), *V. orientale* is the largest (27.11 µm). *V. orientale* and *V. brachcephalum* is only colpal membrane densely granulated.

In Flora of Turkey, these two species were separated from each other as follows;

- 1. Pedicel thickness, equal or shorter than capsule *V. orientale*
- 1. Pedicel weak, 2-3 times longer than capsule.....*V. brachysepalum*

Also, these two taxa have some differences in their description in the Flora of Turkey. These are lower bract pinnatisect, upper bracts linear corolla with brown spots inside in *V. orientale*. Bracts oblong-linear, linear; corolla without spots inside in *V. brachysepalum*.

As a result of the field studies and investigations on herbaria materials it seen that, the using corolla having brown inside, is not a good character. The specimen of *V. orientale* (FAK 3260) collected from Erzurum had no brown spots and the specimen of *V. brachysepalum* collected from Mersin (FAK 3185) had a few obscur brown spots inside the corolla (Karavelioğulları & Aytaç 2008).

Using other charachters, length of pedicels and structure of bracts. In *V. orientale*, pedicels are 1.5-5 mm long, and lower bracts are pinnatisect; pedicels are 8-20 mm and all bracts oblong-linear to linear in *V. brachysepalum*. Only upper bracts are linear in *V. orientale* (Karavelioğulları & Aytaç 2008).

The morphological characteristics of the pollen grains *Verbascum suworowianum* var. *suworowianum* is oblate, *Verbascum suworowianum* var. *papillosum* is prolate.

These two variaties are growing same area, the basal leaves very important for separation. Otherwise stem hairness is not good charachters, to given in Flora of Turkey, because two of them have glandulare and aglandular hairs.

The morphological characteristics of the pollen grains *V.oreophilum* var. *joannis* is subprolate, *V. oreophilum* var. *oreophilum* is prolate.

In Flora of Turkey, these two species were separated from each other as follows;

- 1. Filaments with purplish-violet hairy; inflorescence stellate-short stalked glandular hairy.....var. *oreophilum*
- 1. Filaments with whitish-yellow hairy; inflorescence stellate-eglandular hairyvar. *joannis*

Shown in key to the species *V. borgeauanum* and *V. dudleyanum* the morphological characteristics of the pollen grains is similar but In Flora of Turkey, these two species is different. *V. borgeauanum* is filament with whitish-yellow hairs up to anthers. *V. dudleyanum* is filament with whitish-yellow wool 2 anterior anthers glabrous near apex

The determination of the taxa pollen morphological structure in the results has led us to think better of the usefulness of pollen studies in distinguishing the characteristics possessed by the taxa.

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Table 1 The morphological characteristics of the pollen grains of *Verbascum* (Group A)

Taxa	P (µm)	E (µm)	P/E	Exine (µm)	Colpi long axis (µm)	Colpi short axis (µm)	Apocolpium (µm)	Amb diameter (µm)	Ornamentation
<i>V. natolicum</i> FAK 3008	23.44±0.90	20.35±1.57	1.15	1.01±0.17	19.82±2.05	5.81±0.65	2.79±0.65	23.14±1.27	Coarsely reticulate
<i>V. spodiotrichum</i> FAK 3318	16.23±0.83	14.20±1.17	1.14	0.94±0.11	13.37±1.17	3.90±0.38	2.09±0.38	14.52±0.60	Reticulate
<i>V. orientale</i> FAK 3155	29.97±1.56	27.28±1.82	1.10	1.47±0.21	25.43±2.22	5.09±0.71	5.09±0.73	27.11±1.42	Reticulate
<i>V. brachysepalum</i> FAK 3185	25.87±1.30	23.63±1.09	1.09	0.97±0.11	22.48±1.71	4.89±0.42	3.64±0.70	25.84±1.56	Reticulate
<i>V. cilicium</i> FAK 3421	22.54±1.13	20.39±1.14	1.11	0.94±0.13	17.70±1.55	4.48±0.60	2.47±0.30	19.75±0.96	Coarsely reticulate
<i>V. flabellifolium</i> FAK 3238	22.85±1.35	20.19±1.04	1.11	0.90±0.14	19.76±1.47	4.28±0.64	2.34±0.38	21.35±0.34	Reticulate
<i>V. trapifolium</i> FAK 3321	22.74±0.73	20.54±1.05	1.11	0.96±0.11	19.44±1.12	4.54±0.63	3.73±0.70	21.01±1.06	Coarsely reticulate
<i>V. pyroliforme</i> FAK 3359	23.89±1.52	20.62±1.13	1.16	0.81±0.08	20.16±1.47	4.45±0.49	1.97±0.36	21.78±1.37	Reticulate
<i>V. dudleyanum</i> FAK 3323	21.87±1.30	20.19±0.99	1.03	0.86±0.22	18.14±1.39	3.44±0.46	2.80±0.22	20.63±0.75	Reticulate
<i>V. coronopifolium</i> FAK 3388	24.38±2.14	19.21±1.04	1.27	0.80±0.09	17.13±0.85	3.88±0.60	3.98±0.60	19.73±1.14	Reticulate
<i>V. serratifolium</i> FAK 3001	22.07±1.08	20.50±1.50	1.08	0.93±0.10	18.19±1.10	4.75±0.62	3.80±0.68	20.02±1.77	Coarsely reticulate
<i>V. basivelatum</i> FAK 3386	19.21±1.32	17.73±1.20	1.08	0.86±0.24	15.79±1.22	3.62±0.33	2.80±0.34	18.93±1.04	Reticulate
<i>V. bourgeanum</i> FAK 3429	21.87±1.30	20.19±0.99	1.08	0.86±0.22	18.14±1.39	3.44±0.46	2.80±0.22	20.63±0.75	Reticulate
<i>V. serpanticola</i> FAK 3320	21.13±1.14	21.32±0.81	0.99	0.86±0.22	18.33±1.03	4.28±0.55	2.78±0.29	22.91±0.83	Coarsely reticulate
<i>V. sorgerae</i> FAK 3253	21.67±0.92	19.53±1.16	1.11	0.89±0.15	18.14±1.01	5.20±0.82	2.14±0.40	19.84±1.27	Reticulate

Table 1. The morphological characteristics of the pollen grains of *Verbascum* (Group A) (Continue)

Taxa	P (µm)	E (µm)	P/E	Exine (µm)	Colpi long axis (µm)	Colpi short axis (µm)	Apocolpium (µm)	Amb diameter (µm)	Ornamentation
<i>V. nudicaule</i> FAK 3046	20.97±0.69	19.18±0.66	1.09	0.81±0.10	17.53±0.95	4.37±0.69	3.14±0.26	19.78±1.13	Coarsely reticulate
<i>V. suworowianum</i> var. <i>suworowianum</i> FAK 3075	20.69±0.10	20.86±1.24	0.99	0.91±0.14	18.17±1.72	4.37±0.58	2.69±0.67	19.73±1.42	Coarsely reticulate
<i>V. suworowianum</i> var. <i>papillosum</i> FAK 3328	21.35±0.90	19.29±0.78	1.11	0.86±0.22	17.16±0.71	4.21±0.99	2.67±0.16	19.06±0.93	Coarsely reticulate
<i>V. luciliae</i> HD 8755	18.89±1.36	17.55±0.71	1.08	0.65±0.19	15.68±1.54	3.66±0.52	1.99±0.36	17.87±0.81	Coarsely reticulate
<i>V. rupicola</i> FAK 3030	20.37±1.01	16.35±0.76	1.25	1.05±0.14	20.08±0.80	3.95±0.50	2.30±0.50	16.40±1.67	Retikulat
<i>V. agrimoniifolium</i> ssp. <i>agrimoniifolium</i> FAK 3125	18.74±0.98	17.36±0.68	1.08	0.86±0.22	15.74±0.93	3.85±0.78	2.92±0.78	17.07±1.08	Coarsely reticulate
<i>V. levanticum</i> FAK 3158	21.60±1.14	18.45±1.18	1.17	0.86±0.22	18.45±1.64	4.17±0.67	1.97±0.33	18.25±0.83	Coarsely reticulate
<i>V. bugulifolium</i> FAK 3028	18.60±1.02	16.66±0.70	1.12	0.83±0.07	15.59±1.06	3.79±0.75	3.48±0.60	17.82±0.81	Coarsely reticulate
<i>V. ponticum</i> FAK 3110	18.57±0.98	16.46±0.83	1.13	0.79±0.10	15.06±0.92	2.84±0.35	2.22±0.48	16.61±1.34	Retikulat
<i>V. bormuellerianum</i> FAK 3025	19.53±0.99	18.19±0.87	1.07	0.88±0.10	16.43±1.07	4.48±0.60	2.43±0.49	18.34±1.16	Coarsely reticulate
<i>V. oreophilum</i> var. <i>oreophilum</i> FAK 3044	20.71±1.11	18.92±1.19	1.09	0.96±0.11	17.36±0.75	4.89±0.42	2.54±0.4	21.52±1.10	Retikulat
<i>V. oreophilum</i> var. <i>joannis</i> FAK 3351	21.49±0.90	17.16±0.54	1.25	0.79±0.09	19.17±0.97	2.91±0.34	3.41±0.01	17.70±1.12	Reticulate
<i>V. gaillardotii</i> FAK 3145	18.92±1.43	17.82±1.11	1.06	1.19±0.17	15.01±1.04	4.24±0.63	3.18±0.50	18.19±1.01	Coarsely reticulate
<i>V. freynii</i> FAK 3425	21.52±0.92	20.86±1.52	1.03	1.01±0.10	17.79±0.87	3.96±0.44	3.41±0.34	21.15±0.98	Reticulate
<i>V. transcaucasicum</i> FAK 3137	20.36±1.80	17.78±1.77	1.15	0.74±0.11	16.95±0.74	2.39±0.39	2.31±0.41	18.13±0.69	Reticulate

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