

Pollen morphology of *Allium* species (*Liliaceae*) in European Turkey and around Istanbul

Neriman Özhatay & Mine Koçyiğit

Department of Pharmaceutical Botany, Faculty of Pharmacy, Istanbul University, 34116 Beyazıt, Istanbul, Turkey, e-mail: nozhatay@istanbul.edu.tr; minekocyiğit@hotmail.com

Received: May 27, 2009 ▷ Accepted: July 24, 2009

Abstract. Pollen morphology of 23 *Allium* species in European Turkey and around Istanbul, belonging to the sections *Molium*, *Scorodon*, *Brevispatha*, *Codonoprasum*, *Allium*, and *Melanocrommyum*, were investigated under LM (light microscopy) and by SEM (scanning electron microscopy). The pollen grains of genus *Allium* are monosulcate. The pollen shapes (based on LA / SA) are prolate and subprolate. The sulcus extends from distal to proximal in all taxa. The smallest pollen grain belong to *A. guttatum* subsp. *guttatum* ($25.75 \times 19.22 \mu\text{m}$), the largest one to *A. roseum* ($51.19 \times 2.30 \mu\text{m}$).

Key words: *Allium*, *Liliaceae*, LM, morphology, pollen, SEM

Introduction

The genus *Allium* is one of the most diverse and taxonomically difficult groups of the monocots. Formerly regarded as member of the *Liliaceae* s.l., in modern systems of Flowering Plants it is the largest genus

of *Alliaceae* (order *Asparagales*) (Angiosperm Phylogeny Group 2003), comprising about 750-800 species. Most species occur naturally in the northern hemisphere, with a main centre of diversity in the mountains of Southwest to Central Asia and a second but smaller centre of diversity in western North America. The genus *Allium* in the *Flora of Turkey* is represented by 174 species (Özhatay 1983, 1984a, b; Kollmann 1984; Davis & al. 1988; Güner & al. 2000; Özhatay & Kultur 2006; Özhatay & al. 2009).

The *Liliaceae* pollen grains are usually monocolpate. The colpus generally extends fully to the end of the grain, it may be very wide or may have an operculum, which may be ornamented (e.g. reticulate), or thin and scabrate (Dane 1999; Karaca & al. 2007; Özler & Pehlivan 2007).

Material and methods

The investigated 23 *Allium* specimens were collected from European Turkey and around Istanbul (Fig. 1; Annex I). Data for the pollen morphology illustrations of *Allium* species were given by Mohl (1834) and

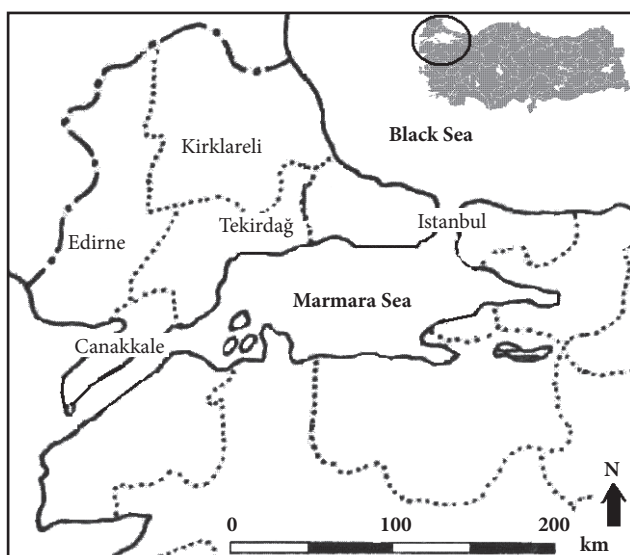


Fig. 1. A map of the studied area.

Annex I. Specimens investigated (deposited in ISTE):**Sect. *Molium***

A. neapolitanum Cirillo – Prov. A2(A) Istanbul: Yusa Hill, coll. N. Özhatay 31505.

A. roseum L. – Prov. A2(E) Istanbul: Belgrad Forest, coll. N. Özhatay 35867.

Sect. *Brevispatha*

A. peroninianum Azn. – Prov. A2(A) Istanbul: Kayisdag, coll. N. Özhatay 30785.

Sect. *Scorodon*

A. moschatum L. – Prov. A1(E) Kırklareli: Derekoy, coll. N. Özhatay 35930.

Sect. *Codonoprasum*

A. paniculatum L. subsp. *paniculatum* – Prov. A2(E) Istanbul: Karacakoy, coll. N. Özhatay 33798.

A. paniculatum L. subsp. *fuscum* (Waldst. & Kit.) Arcang. – Prov. A1(E) Kırklareli: Demirköy, coll. N. Özhatay 30128.

A. rhodopaeum Velen. – Prov. A1(E) Edirne: Baglık deresi, coll. N. Özhatay 33109.

A. pallens L. subsp. *pallens* – Prov. A2(E) Istanbul: Gumusyaka, coll. N. Özhatay 33051.

A. flavum L. subsp. *flavum* – Prov. A1(E) Kırklareli: Derekoy, coll. N. Özhatay 33107.

A. flavum L. subsp. *tauricum* (Besser ex Rchb.) Stearn – Prov. A1 (E) Çanakkale: Arıburnu, coll. N. Özhatay 30129.

A. myrianthum Boiss. – Prov. A2(A) Yalova (formerly Istanbul): Armutlu, coll. N. Özhatay 32075.

Sect. *Allium*

A. ampeloprasum L. – Prov. A2(E) Istanbul: Belgrad Forest, coll. N. Özhatay 33107.

A. atroviolaceum Boiss. – Prov. A1(E) Tekirdağ: Marmara Ereğlisi, coll. N. Özhatay 32097.

A. scorodoprasum L. subsp. *scorodoprasum* – Prov. A1(E) Kırklareli: Igneada, coll. N. Özhatay 30031.

A. scorodoprasum subsp. *rotundum* (L.) Stearn – Prov. A1(E) Kırklareli: Dereköy, coll. N. Özhatay 30077.

A. sphaerocephalon L. – Prov. A1(E) Tekirdağ: Sarkoy, coll. N. Özhatay 30454.

A. proponticum Stearn & Ozhatay – Prov. A1(E) Tekirdağ: Kumbag, coll. N. Özhatay 30435.

A. vineale L. – Prov. A2(E) Istanbul: Belgrad Forest, coll. N. Özhatay 30131.

A. amethystinum Tausch – Prov. A1(E) Tekirdağ: Marmara Ereğlisi, coll. N. Özhatay 32103.

A. guttatum Steven subsp. *guttatum* – Prov. A1(E) Kırklareli: Mahyadag, coll. N. Özhatay 30700.

Sect. *Melanocrommyum*

A. nigrum L. – A2(E) Istanbul: Durusu, coll. N. Özhatay 31841.

A. atropurpureum Waldst. & Kit. – Prov. A1(E) Tekirdağ: Sarkoy-Malkara, coll. N. Özhatay 28440.

A. cyrilli Ten. – Prov. A2(EA) Istanbul: Tuzla, coll. N. Özhatay 35874.

Wunderlich (1936). Furthermore, the detailed pollen morphology of *Allium* was investigated by Koç (2001), Özler (2001) and Güler & Pehlivan (2006).

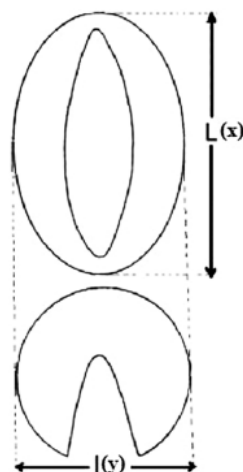
The specimens were compared with those in the Herbarium of Kew (K) and Herbarium of the British Museum (BM) and kept in the Herbarium of the Faculty of Pharmacy of Istanbul University (ISTE).

Our object was to examine the pollen morphology of 23 of the Turkish *Allium* taxa which occur in European Turkey and around Istanbul by using data obtained from LM and SEM observations.

Pollen grains of specimens for LM investigations were prepared according to the methods of Wodehouse (1935) and Erdtman (1960) at Istanbul University, Faculty of Forestry, and Department of Forest Botany.

Pollen shapes and ornamentation were identified according to Halbritter & al. (2007). Pollen dimensions

of all species were measured on Zeiss-Winkel 278943 Light Microscope (1 ocular area = 1.45 μm). The following parameters were registered: long axis (LA) and short axis (SA).



Pollen photographs were taken on SEM in Jodrell Laboratory (England), and on LM in ISTE Laboratory. Preparations are kept in ISTE.

The formula of pollen dimensions:

$$M = n + a \cdot 1/n \sum xy$$

$$\sigma = a \sqrt{1/n \sum x^2 y - u^2}$$

$$u = 1/n \sum xy$$

n = measurement counts

a = differences between classes

σ = standard deviation

M = mean value

Results and discussions

The main palynological features of the examined *Allium* specimens are summarized in Table 1. According to SEM (Plate I, II, III, IV) and LM (Plate V, VI) investigations, the pollen grains are monosulcate. The monosulcate pollen grains, which are regarded as primitive among seed plants, occur widely among the monocotyledons (Furness & Rudall 2001; Özler & Pehlivan 2007; Dönmez Oybak & Işık 2008). The pollen shapes (based on LA/SA ratio) are prolate, subprolate and ellipsoid in distal view, and circular in polar view. The sulcus extends from distal to proximal in sect. *Codonoprasum*, *Molium*, *Brevispatha*, *Scorodon* and *Melanocrommyum*. The sulcus clearly extends both from distal and proximal only in sect. *Allium*. The sulcus membrane is provided with a fragmented operculum only in the sect. *Codonoprasum* (Figs 6, 7, 10, 12, 13, 14, 17).

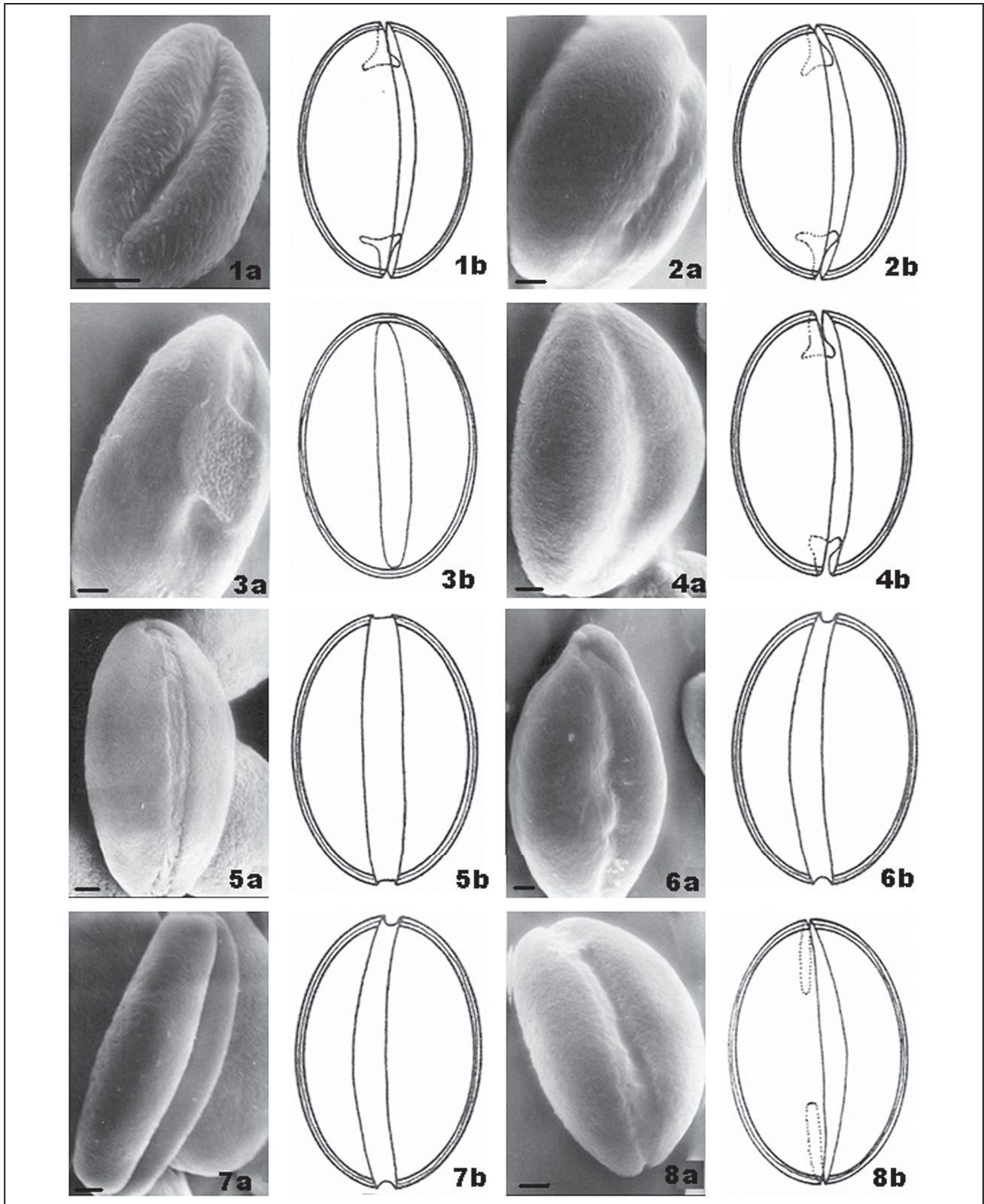
These results correspond to the earlier studies (Güler & Pehlivan 2006). The sulcus ends are narrowed and rounded only in sect. *Molium* (Figs 11, 18). The sulcus ends are broad and rounded in sect. *Brevispatha* and *Scorodon* (Figs 9, 15). The sulcus ends are rounded in sect. *Melanocrommyum* (Figs 3, 5, 56). The exine is semitectate, rugulate perforate (Figs 25, 26, 27, 30, 31, 32, 37, 38, 40, 42), psilate (Figs 28), shadowy rugulate (Figs 34, 35, 36, 39, 43), or rugulate (Figs 23, 24, 29, 33, 41, 44) ornamentation can be distinguished in the investigated *Allium* species. These results show that there are several pollen characters of taxonomic significance in the genus *Allium*. The main palynological differences have been registered at the section level. These results are similar to the earlier studies (Koç 2001 & Özler 2001; Güler & Pehlivan 2006; Bogdanović & al. 2008; Neshati & al. 2009).

Table 1. Palynological features of the examined *Allium* species (Wodhouse).

| Taxa | Pollen shapes (LA/SA) | Dimensions | | | | | |
|---|--------------------------|----------------|-------|-------------|-----------------|-------|-------------|
| | | Long axis (LA) | | | Short axis (SA) | | |
| | | M | SD | Variation | M | SD | Variation |
| <i>Allium roseum</i> | Prolate (1.58) | 51.2 | ±2.52 | 44.95–56.55 | 32.3 | ±2.81 | 26.10–39.15 |
| <i>A. neapolitanum</i> | Prolate (1.44) | 51 | ±1.39 | 47.85–53.65 | 34.24 | ±1.37 | 31.90–37.70 |
| <i>A. moschatum</i> | Subprolate (1.31) | 27.3 | ±1.56 | 23.20–29 | 20.75 | ±1.42 | 18.85–24.65 |
| <i>A. peroninianum</i> | Prolate (1.43) | 27.4 | ±1.97 | 24.65–31.90 | 19.13 | ±1.46 | 14.50–21.75 |
| <i>A. paniculatum</i> subsp. <i>paniculatum</i> | Prolate (1.41) | 30.9 | ±1 | 29–33.35 | 21.75 | ±1.29 | 18.85–26.10 |
| <i>A. paniculatum</i> subsp. <i>fuscum</i> | Prolate (1.39) | 31.1 | ±1.78 | 27.55–36.25 | 22.23 | ±1.58 | 18.85–26.10 |
| <i>A. rhodopaeum</i> | Subprolate (1.26) | 28.5 | ±1.11 | 26.10–31.90 | 22.58 | ±1.21 | 20.30–26.10 |
| <i>A. pallens</i> subsp. <i>pallens</i> | Prolate (1.54) | 34.8 | ±1.58 | 30.45–37.70 | 22.47 | ±1.40 | 20.30–26.10 |
| <i>A. flavum</i> | Prolate (1.61) | 35.6 | ±1.75 | 30.45–37.70 | 22.01 | ±1.10 | 18.85–23.20 |
| <i>A. myrianthum</i> | Prolate (1.56) | 28 | ±0.65 | 27.55–29 | 17.87 | ±0.66 | 17.40–18.85 |
| <i>A. ampeloprasum</i> | Prolate (1.47) | 30.6 | ±1.33 | 27.55–34.80 | 20.72 | ±1.66 | 17.40–23.20 |
| <i>A. atropurpureum</i> | Prolate (1.53) | 29.4 | ±0.91 | 27.55–30.45 | 19.17 | ±0.88 | 17.40–20.30 |
| <i>A. scorodoprasum</i> subsp. <i>scorodoprasum</i> | Prolate (1.44) | 27 | ±2.24 | 23.20–34.80 | 18.75 | ±1.08 | 15.95–23.20 |
| <i>A. scorodoprasum</i> subsp. <i>rotundum</i> | Prolate (1.58) | 36.9 | ±1.21 | 34.80–31.15 | 23.29 | ±1.14 | 21.75–26.10 |
| <i>A. sphaerocephalon</i> | Prolate (1.62) | 31.8 | ±0.95 | 29–33.35 | 19.56 | ±0.71 | 18.85–20.30 |
| <i>A. proponticum</i> | Prolate (1.80) | 32.9 | ±0.84 | 31.90–34.80 | 21.55 | ±1.43 | 18.85–23.20 |
| <i>A. vineale</i> | Prolate (1.40) | 30.6 | ±0.91 | 29–33.35 | 21.7 | ±0.75 | 20.30–23.20 |
| <i>A. amethystinum</i> | Prolate (1.38) | 25.8 | ±0.82 | 24.65–27.55 | 18.62 | ±0.72 | 17.40–20.30 |
| <i>A. guttatum</i> | Prolate (1.47) | 25.8 | ±1.13 | 23.20–27.55 | 17.48 | ±0.78 | 15.95–18.85 |
| <i>A. atropurpureum</i> | Prolate (1.68) | 36.6 | ±1.43 | 33.35–39.15 | 21.71 | ±1.49 | 17.40–24.65 |
| <i>A. nigrum</i> | Prolate (1.47) | 31.9 | ±2.01 | 29–36.25 | 21.66 | ±3.10 | 17.40–29.00 |
| <i>A. cyrilli</i> | Prolate (1.79) | 34.4 | ±1.34 | 30.45–37.70 | 19.12 | ±1.13 | 17.40–20.30 |

Legend: M – Mean value; SD – Standard deviation.

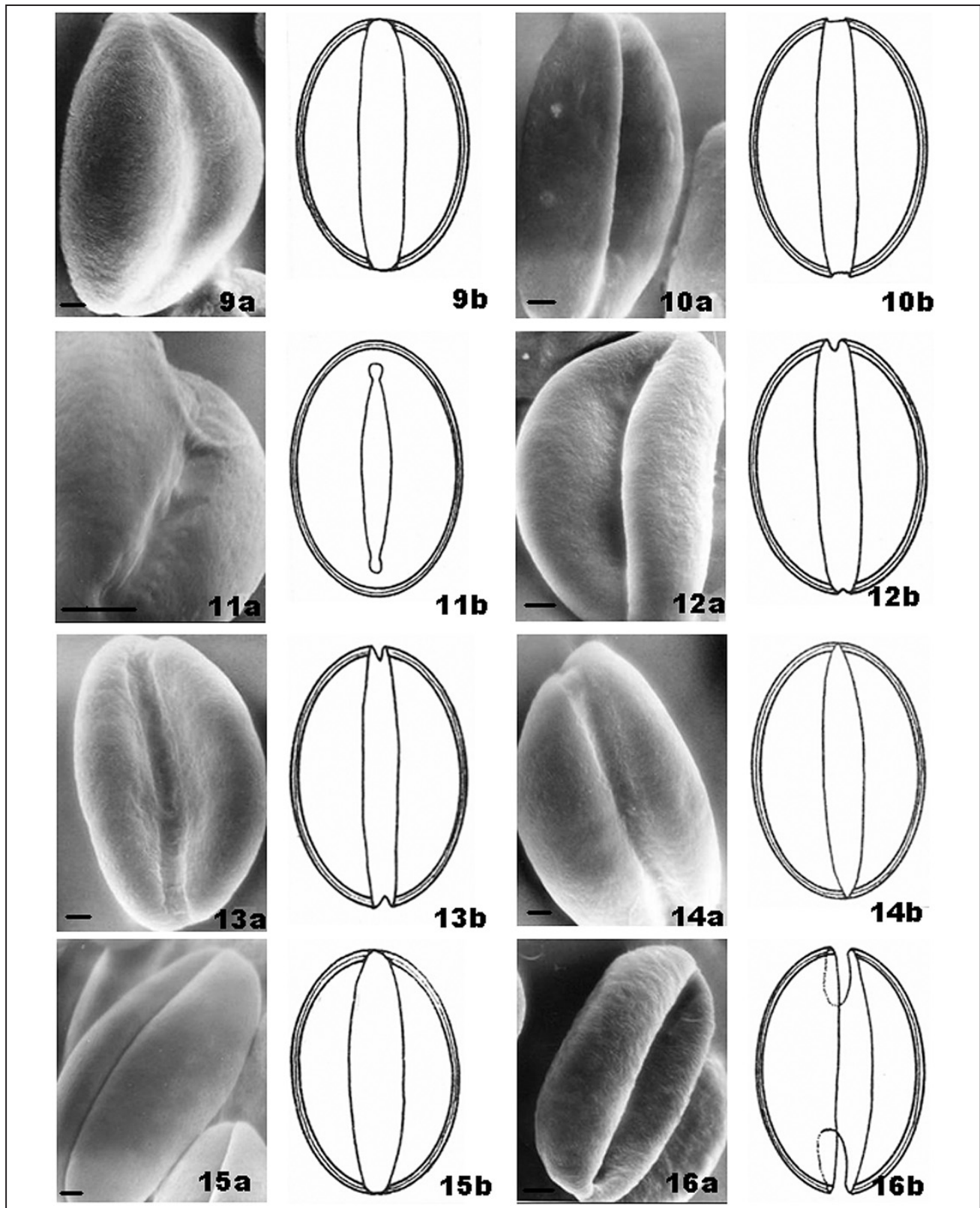
Plate I



Figs 1–8. Pollen grains of *Allium* species (a: SEM photographs; b: drawings):

1, *A. amethystinum* (SEM 3000x); 2, *A. ampeloprasum* (2500x); 3, *A. atropurpureum* (SEM 2500x); 4, *A. atroviolaceum* (SEM 2500x); 5, *A. cyrilli* (SEM 2500x); 6, *A. flavum* subsp. *flavum* (SEM 2500x); 7, *A. flavum* subsp. *tauricum* (SEM 2500x); 8, *A. guttatum* subsp. *guttatu* (SEM 3000x). Scale bar – 10 μ m.

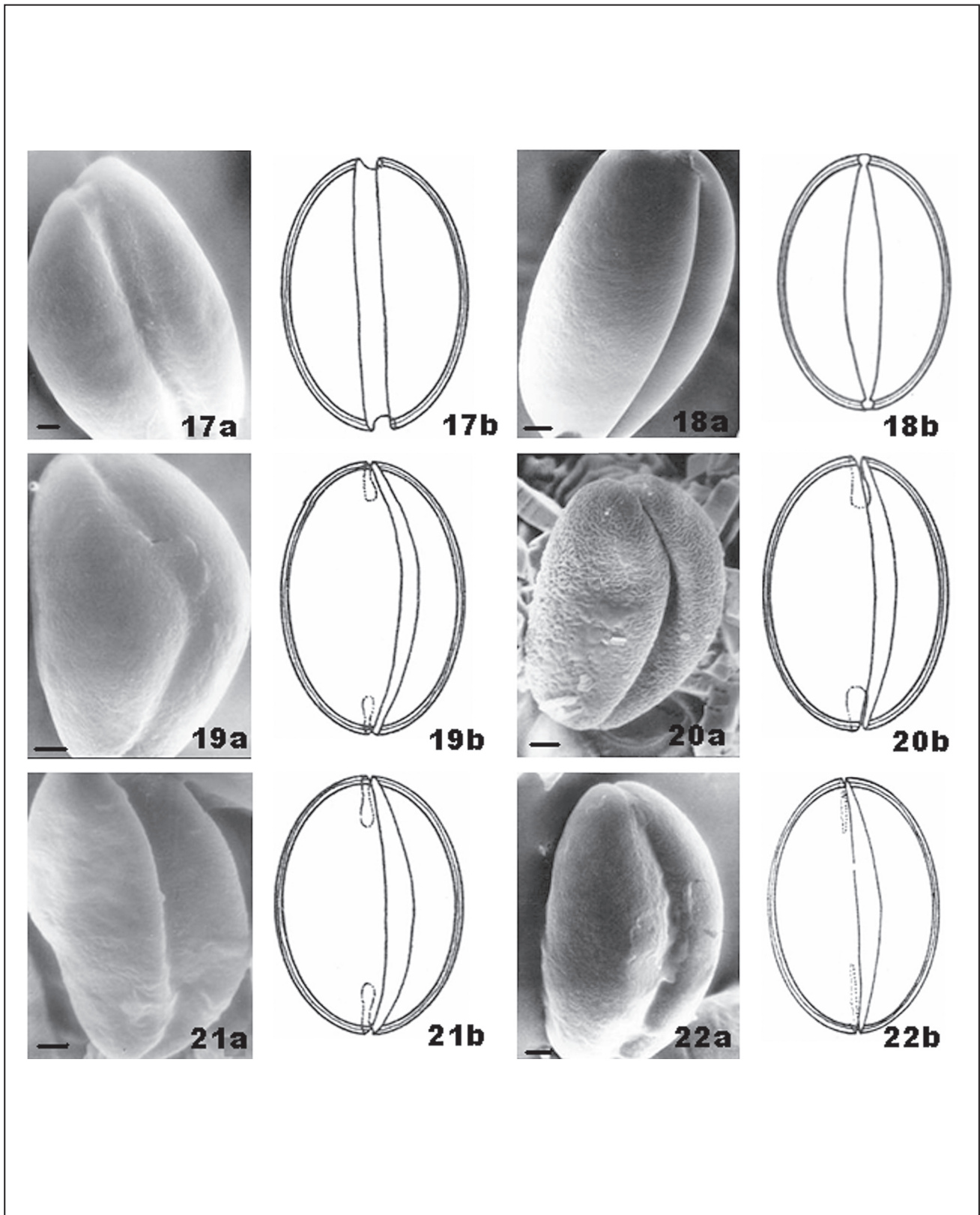
Plate II



Figs 9–16. Pollen grains of *Allium* species (a: SEM photographs; b: drawings):

9, *A. moschatum* (SEM 2500x); 10, *A. myrianthum* (SEM 2500x); 11, *A. neopolitanum* (SEM 2500x); 12, *A. pallens* subsp. *pallens* (SEM 2500x); 13, *A. paniculatum* subsp. *fuscum* (SEM 2500x); 14, *A. paniculatum* subsp. *paniculatum* (SEM 2500x); 15, *A. peroninianum* (SEM 2500x); 16, *A. proponticum* (SEM 2500x). Scale bar – 10 μ m.

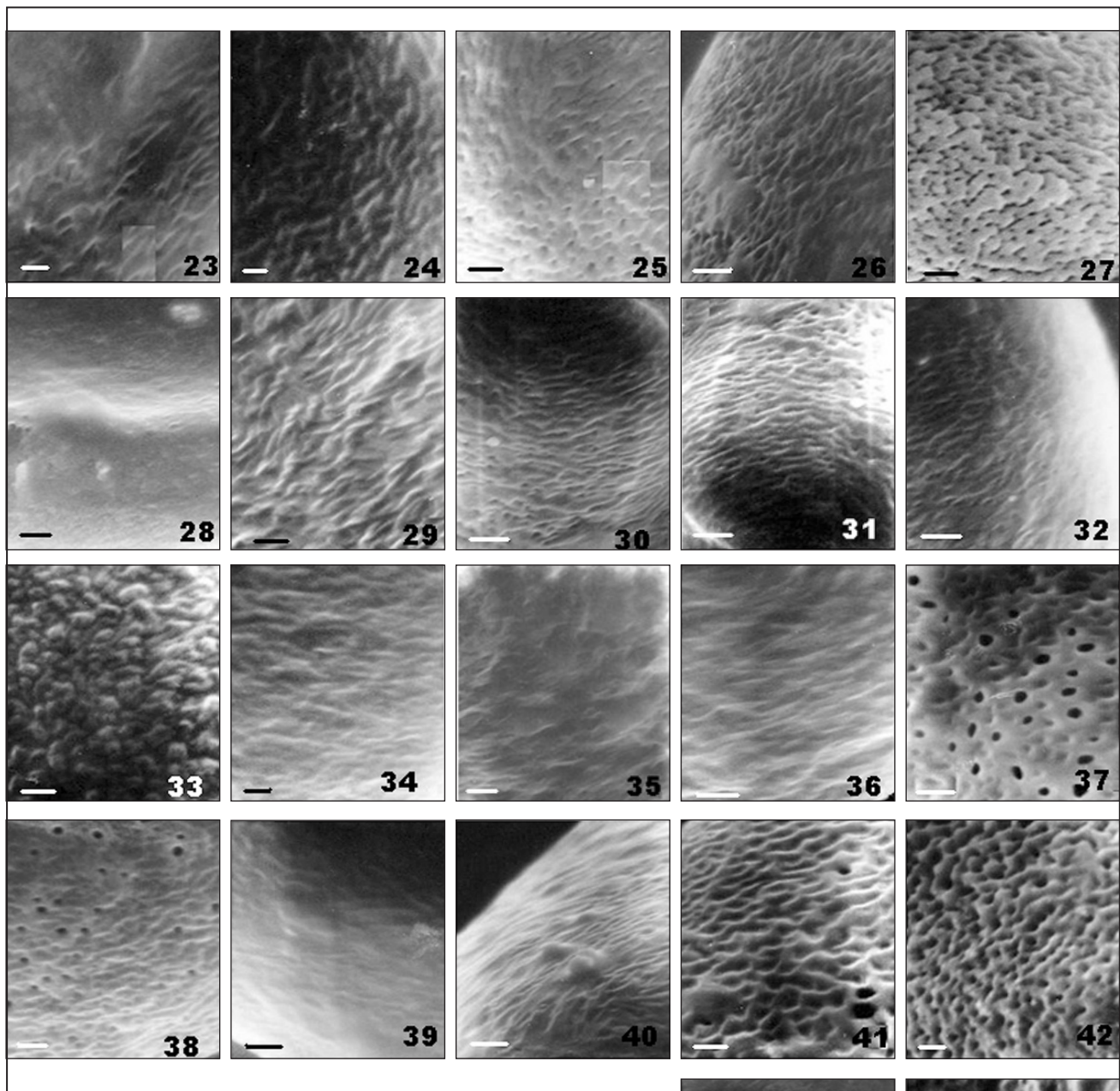
Plate III



Figs 17–22. Pollen grains of *Allium* species (a: SEM photographs; b: drawings):

17, *A. rhodopeum* (SEM 3000x); 18, *A. roseum* (SEM 1500x); 19, *A. scorodoprasum* subsp. *rotundum* (SEM 2500x); 20, *A. scorodoprasum* subsp. *scorodoprasum* (SEM 2500x); 21, *A. sphaerocephalon* (SEM 2500x); 22, *A. vineale* (SEM 2500x). Scale bar – 10 μ m.

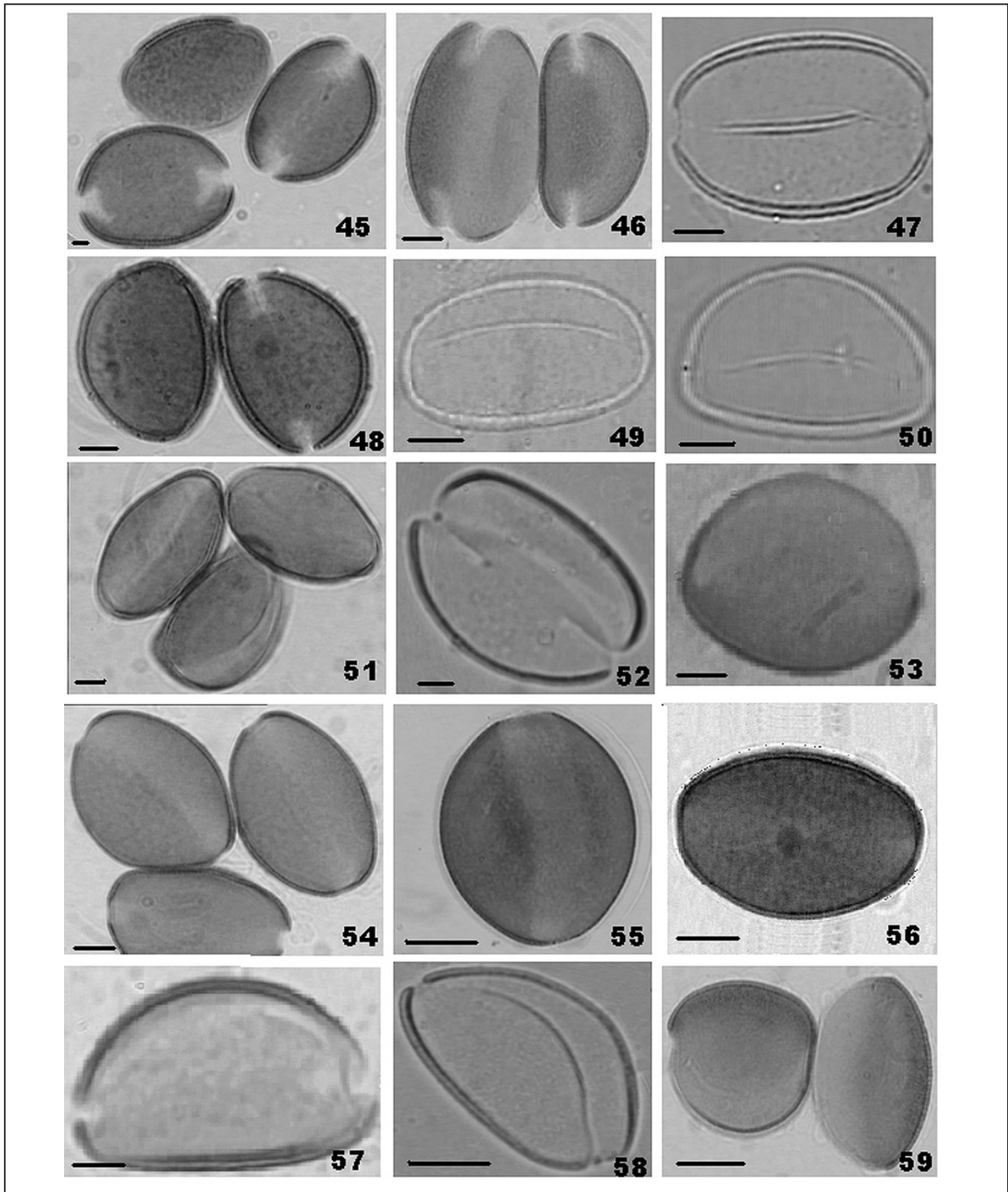
Plate IV



Figs 23–44. SEM photographs of the pollen surfaces of *Allium* species:

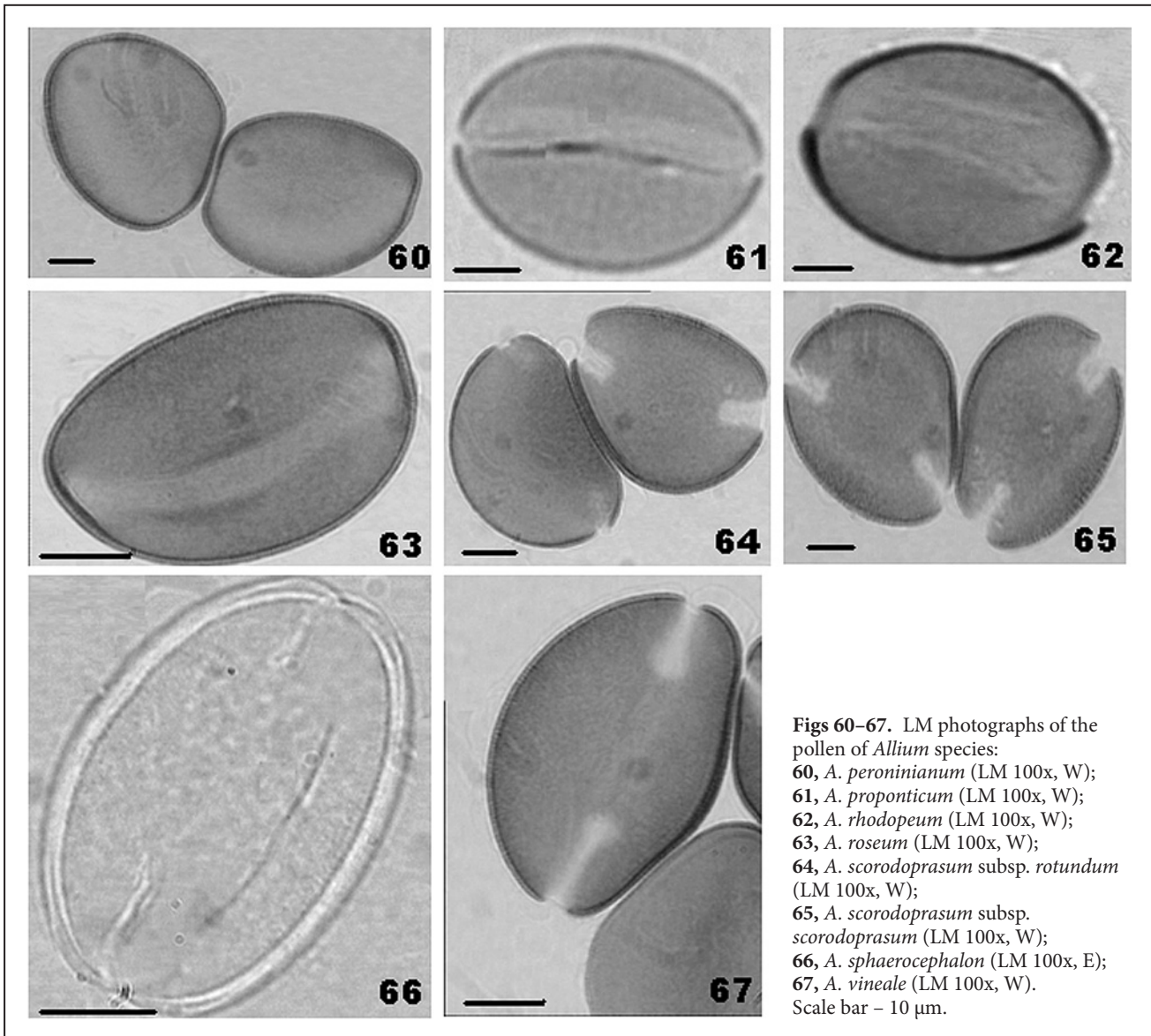
23, *A. amethystinum* (SEM 3000x); 24, *A. ampeloprasum* (SEM 2500);
 25, *A. atropurpureum* (SEM 2500x); 26, *A. atrovioleaceum* (SEM 2500x);
 27, *A. cyrilli* (SEM 2500x); 28, *A. flavum* subsp. *flavum* (SEM 2500x);
 29, *A. flavum* subsp. *tauricum* (SEM 2500x); 30, *A. guttatum* subsp. *guttatum*
 (SEM 3000x); 31, *A. moschatum* (SEM 3000x); 32, *A. myrianthum* (SEM
 2500x); 33, *A. neopolitanum* (SEM 3000x); 34, *A. pallens* subsp. *pallens* (SEM
 3000x); 35, *A. paniculatum* subsp. *fuscum* (SEM 3000x); 36, *A. paniculatum* subsp. *paniculatum* (SEM 2500x); 37, *A. peroninianum*
 (SEM 2500x); 38, *A. proponticum* (SEM 2500x); 39, *A. rhodopeum* (SEM 3000x); 40, *A. roseum* (SEM 1500x); 41, *A. scorodoprasum*
 subsp. *rotundum* (SEM 2500x); 42, *A. scorodoprasum* subsp. *scorodoprasum* (SEM 2500x); 43, *A. sphaerocephalon* (SEM 2500x);
 44, *A. vineale* (SEM 2500x). Scale bar – 10 μ m.

Plate V



Figs 45–59. LM photographs of the pollen of *Allium* species, according to the method of Wodhouse (W) and Erdtman (E): 45, *A. amethystinum* (LM 100x, W); 46, *A. ampeloprasum* (LM 100x, W); 47, *A. atropurpureum* (LM 100x, W); 48, *A. atroviolaceum* (LM 100x, W); 49, *A. cyrilli* (LM 100x, W); 50, *A. flavum* subsp. *flavum* (LM 100x, E); 51, *A. flavum* subsp. *tauricum* (LM 100x, W); 52, *A. guttatum* subsp. *guttatum* (LM 100x, E); 53, *A. moschatum* (LM 100x, W); 54, *A. myrianthum* (LM 100x, W); 55, *A. neopolitanum* (LM 100x, W); 56, *A. nigrum* (LM 100x, W); 57, *A. pallens* subsp. *pallens* (LM 100x, E); 58, *A. paniculatum* subsp. *fusum* (LM 100x, E); 59, *A. paniculatum* subsp. *paniculatum* (LM 100x, W). Scale bar – 10 μ m.

Plate VI



Acknowledgements. This study was supported by the Turkish Scientific and Technical Research Council (Project TBAG 179). The authors are also grateful to Prof. Dr Engin Özhatay, Department of Forest Botany, and to Prof. Dr B. Aytuğ for technical support, and also to the unknown reviewers for the valuable critical comments.

References

- Angiosperm Phylogeny Group.** 2003. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG II. – *Bot. J. Linn. Soc.*, **141**: 399-436.
- Bogdanović, S., Brullo, S., Mitić, B. & Salmeri, C.** 2008. A new species of *Allium* (*Alliaceae*) from Dalmatica, Croatia. – *Bot. J. Linn. Soc.*, **158**: 106-114.
- Dane, F.** 1999. A study of pollen mitosis and pollen morphology in hexaploid ($2n = 24$) *Bellevalia edirnensis* Özhatay & Mathew. – *Turk. J. Bot.*, **23**: 357-368.
- Davis, P.H.** (ed.). *Flora of Turkey and the East Aegean Islands*. Vol. **10**, pp.221-223. Edinburgh Univ. Press, Edinburgh.
- Dönmez Oybak, E. & Işık, S.** 2008. Pollen morphology of the Turkish *Amaryllidaceae*, *Ixioliriaceae* and *Iridaceae*. – *Grana*, **47**: 15-38.
- Erdtman, G.** 1960. The acetolysis method. A revised description. – *Svensk. Bot. Tidskr.*, **54**: 561-564.
- Furness, C.A. & Rudall, P.J.** 2001. Pollen and anther characters in monocot systematics. – *Grana*, **40**: 17-25.
- Güler, Ü. & Pehlivan, S.** 2006. Pollen morphology of some species belonging to *Codonoprasum* and *Allium* sections of *Allium* (*Liliaceae-Alliaceae*) genus. – *Biologia (Bratislava)*, **61**(4): 449-455.

- Güner, A., Özhatay, N., Ekim, T. & Canbaşer, K.H. 2000. Flora of Turkey and the East Aegean Islands (Supplement 2.). Edinburgh Univ. Press, Edinburgh.
- Halbritter, H., Weber, M., Zetter, R., Frosh-Radivo, A., Buchner, R. & Hesse, M. 2007. PalDat–Illustrated Handbook on Pollen Terminology. Society for the Promotion of Palynological Research in Austria, Vienna.
- Işık, S. & Dönmez Oybak, E. 2007. Pollen morphology of Turkish *Romulea* Maratti (*Iridaceae*). – Turk. J. Bot., **31**: 171-182.
- Karaca, Z., Yaşar, A., Vural, E. & Vural, C. 2007. Pollen morphology of certain geophyte plants (*Liliaceae*, *Iridaceae*) in the mountains Erciyes, Kayseri. – Erciyes Üniv. Fen Bilimleri Enst. Dergisi., **23**(1-2): 37-46 (in Turkish).
- Koç, F., 2001. Investigation of pollen morphology of some endemic *Allium* in Turkey. *Ph. D. Thesis*. Inst. Sci. & Technology, Gazi Univ. (in Turkish).
- Kollmann, F. 1984. *Allium* L. – In: Davis, P.H. (ed.), Flora of Turkey and the East Aegean Islands. Vol. **8**, pp. 98-210. Edinburgh Univ. Press, Edinburgh.
- Mohl, H. 1834. Beiträge zur Anatomie und Physiologie der Gewächse. Erstes Heft, Über den Bau und die Form der Pollenkörner. Fischer, Bern.
- Neshati, F., Fritsch, R.M & Zarre, S. 2009. Pollen morphology of some *Allium* L. species (*Alliaceae*) from Iran. – Bot. Jahrb., **127**(4): 433-451.
- Özhatay, N. 1983. Cytotaxonomic studies on the genus *Allium* in European Turkey and around Istanbul I. Sect. *Molium* and *Scorodon*. – Istanbul Üniv. Eczac. Fak. Mecm., **19**: 25-36.
- Özhatay, N. 1984a. Cytotaxonomic studies on the genus *Allium* in European Turkey and around Istanbul II. Sect. *Codonoprasum*. – Istanbul Üniv. Eczac. Fak. Mecm., **20**: 29-42.
- Özhatay, N. 1984b. Cytotaxonomic studies on the genus *Allium* in European Turkey and around Istanbul III. Sect. *Allium* and *Melanocrommyum*. – Istanbul Üniv. Eczac. Fak. Mecm., **20**: 43-65.
- Özhatay, N. & Kultur, Ş. 2006. Check-list of additional taxa to the Supplement Flora of Turkey III. – Turk. J. Bot., **30**: 281-316.
- Özhatay, N., Kultur, Ş. & Aslan, S. 2009. Check-list of additional taxa to the Supplement Flora of Turkey IV. – Turk. J. Bot., **33**: 191-226.
- Özler, H. 2001. Study of pollen morphology structures of some species that belong to *Asparagus* L., *Allium* L., *Muscari* Miller and *Fritillaria* L. *PhD Thesis*. Inst. Sci. & Technology, Gazi Univ. (in Turkish).
- Özler, H. & Pehlivan, S. 2007. Comparison of pollen morphological structures of some taxa belonging to *Asparagus* L. and *Fritillaria* L. (*Liliaceae*) from Turkey. – Bangladesh J. Bot., **36**(2): 111-120.
- Wodehouse, R.P. 1935. Pollen Grains. MacGraw Hill, New York.
- Wunderlich, R. 1936. Vergleichende Untersuchungen von Pollenkörnern einiger Liliaceen und Amaryllidaceen. – Österr. Bot. Z., **80**: 30-55.