A. M. HAYRAPETYAN

POLLEN OF TREES AND SHRUBS OF ARMENIA (ANGIOSPERMAE. VIII. *Thymeleaceae*, *Tiliaceae, Ulmaceae, Vitaceae, Zygophyllaceae*)

With the help of light (LM) and scanning electron (SEM) microscopes investigations of pollen morphology of 15 species of Armenian trees and shrubs from the families *Thymeleaceae* Juss., *Tiliaceae* Juss., *Ulmaceae* Mirb., *Vitaceae* Juss. and *Zygophyllaceae* R.Br. have been carried out.

Pollen morphology, trees, shrubs, LM, SEM

Հայրապետյան **Ա. Մ. Հայաստանի ծառերի և թփերի ներկայացուցիչների ծաղկափոշու ուսումնասիրությունը (Angiospermae. VIII. *Thymeleaceae, Tiliaceae, Ulmaceae, Vitaceae, Zygophyllaceae*):** Լուսային (ԼՄ) և սկաներային էլեկտրոնային (ՍԷՄ) մանրադիտակների օգնությամբ ուսումնասիրվել է Հայաստանի դենդրոֆլորայի *Thymeleaceae* Juss., *Tiliaceae* Juss., *Ulmaceae* Mirb., *Vitaceae* Juss., *Zygophyllaceae* R.Br. ընտանիքներին պատկանող 15 տեսակների ծաղկափոշու մորֆոլոգիան:

Ծաղկափոշու մորֆոլոգիա, ծառեր, թփեր, ԼՄ, ՍԷՄ

Айрапетян А. М. **Морфология пыльцы деревьев и кустарников Армении (Angiospermae. VIII. *Thymeleaceae, Tiliaceae, Ulmaceae, Vitaceae, Zygophyllaceae*).** С помощью светового (СМ) и сканирующего электронного (СЭМ) микроскопов изучена пыльца 15 видов деревьев и кустарников Армении из семейств *Thymeleaceae* Juss., *Tiliaceae* Juss., *Ulmaceae* Mirb., *Vitaceae* Juss., *Zygophyllaceae* R.Br.

Морфология пыльцы, деревья, кустарники, СМ, СЭМ

The results of investigation of pollen morphology of 15 representatives of Armenian dendroflora relating to the families *Thymeleaceae* Juss., *Tiliaceae* Juss., *Ulmaceae* Mirb., *Vitaceae* Juss., *Zygophyllaceae* R.Br. are presented.

MATERIAL AND METHODS

The material studied was obtained from the herbaria of the Institute of Botany after A. Takhtajyan NAS Republic of Armenia, Yerevan (ERE) and Botanical Institute, St.-Petersburg, Russia (LE).

The descriptions of the pollen grains with the help of the light microscope are based on the grains stained with basic fuchsine (Smoljaninova, Golubkova, 1950), and also on the simplified acetolysis method (Avetisyan, 1950). Pollen grains for the scanning electron microscopes (Jeol, JSM-35; Jeol, JSM-6390) were vacuum sputter-coated with gold and investigated in the laboratory of electronic microscopy of Botanical Institute, St.-Petersburg, Russia.

Ten pollen grains were examined and measured for each investigated specimen.

Specimens examined:

THYMELEACEAE Juss.: ***Daphne glomerata*** Lam.: Армения, Араилер, субальпийский пояс. Leg. A. T. Асатрян (личные сборы) (Armenia, Arailer, subalpine zone. Leg. A. T. Asatryan (personal collections)); АрмССР, Разданский район, Ахундово, лесной склон. Leg. В. Аветисян (ArmSSR, Hrazdan district, Akhundovo, forest slope. Leg. V. Avetisyan) (ERE, 95193); ***D. mezereum*** L.: Армения, Араилер, верхний горный (субальпийский) пояс. Leg. A. T. Асатрян (личные сборы) (Armenia, Arailer, upper mountain (subalpine) zone. Leg. A. T. Asatryan (personal collections)); Fl. suecica, Vastergotland. Leg. A. Hillestrom (ERE, 15730); ***D. oleoides*** Schreb. (= *D. transcaucasica* Pobed.): АрмССР, Варденисский район, окр. села Гюней, ущелье Севанского хребта. Leg. К. Таманян (ArmSSR, Vardenis district, the vicinity of the Guney village, gorge of the Sevan ridge. Leg. K. Tamanyan) (ERE, 131618); АрмССР, Вединский район, сс. Кярки х Чанахи. Leg. А. Тахтаджян, Я. Мулкиджанян, Э. Габриэлян (ArmSSR, Vedi district, between the villages Karki and Chanakhi. Leg. A. Takhtajan, Ya. Mulkidjanian, E. Gabrielyan) (ERE, 67967);

TILIACEAE Juss.: ***Tilia caucasica*** Rupr.: АрмССР, Головино. Leg. Я. Мулкиджанян (ArmSSR, Golovino. Leg. Ya. Mulkidjanian) (ERE, 64095); Сев.-Зап. Кавказ, Геленджикский район, сев. склон Мархотского хребта, смешанный лес. Leg. Васильев (Northwest Caucasus, Gelendzhik district, northern slope of the Markhot ridge, mixed forest. Leg. Vasiliev) (5, LE); ***T. cordata*** Mill.: Армения, Гугаркский район, ущелье реки Памбак. Leg. В. Манакян (Armenia, Gugark region, gorge of the Pambak river. Leg. V. Manakyan) (ERE, 111348); АрмССР, Гелкенд, липовая роща. Leg. J. Mulkijanian (ArmSSR, Gelkend, linden grove. Leg. J. Mulkijanian) (ERE, 87284);

ULMACEAE Mirb.: ***Celtis caucasica*** Willd.: Kachetia, prope Lagodechy. Leg. Mlokossjevicz (ERE, 15798); Iberiae, Tiflis. Leg. Szovits (LE); C***. planchoniana*** K. I. Chr. (= *C. glabrata* Steven ex Planch., nom. Illeg., non Spreng.): Армения, Мегринский район, с. Шванидзор. Leg. Э. Габриэлян, Ш. Асланян (Armenia, Megri district, Shvanidzor village. Leg. E. Gabrielyan, Sh. Aslanyan) (ERE, 64583); Армения, Мегринский район, с. Шванидзор, Герун-дара. Leg. Э. Габриэлян, Ш. Асланян (Armenia, Megri district, Shvanidzor village, Herun-dara. Leg. E. Gabrielyan, Sh. Aslanyan) (ERE, 65280); In locus abruptis montanum, distr. Elisabetpol. Leg. Hohenack. (LE); ***Ulmus densa*** Litw.: АрмССР, Ереван, Норк, базарная площадь. Leg. А. Тахтаджян (ArmSSR, Yerevan, Nork, market square. Leg. A. Takhtajan) (ERE, 15823); ***U. glabra*** Huds.(= *U. elliptica* K.Koch): АрмССР, Ереван, Бот. сад. Leg. Я. Мулкиджанян (ArmSSR, Yerevan, Bot. garden. Leg. Ya. Mulkidjanyan) (ERE, 31696); ***U. lae-***

vis Pall. (= *U. scabra* Mill.): Армения, Ереванский Бот. сад. Leg. Е. Аветисян (личные сборы) (Armenia, Yerevan Bot. garden. Leg. E. Avetisyan (personal collections)); АрмССР, Ереван, Бот. сад. Leg. Л. Манукян (ArmSSR, Yerevan, Bot. garden. Leg. L. Manukyan) (ERE, 121831); ***U. minor*** Mill. (= *U. suberosa* Moench): АрмССР, Ереван, территория Бот. сада, под перголой. Leg. Я. Мулкиджанян (ArmSSR, Yerevan, territory of Bot. garden, under the pergola. Leg. Ya. Mulkidjanyan) (ERE, 59122); (= *U. suberosa* Moench): Армения, между сс. Иджеван х Узунтала. Leg. Я. Мулкиджанян (Armenia, between the villages Ijevan and Uzuntala. Leg. Ya. Mulkidjanyan) (ERE, 59087); (= *U. densa* Litw.): АрмССР, Эчмиадзинский район. Leg. Я. Мулкиджанян (ArmSSR, Echmiadzin district. Leg. Ya. Mulkidjanyan) (ERE, 78786);

VITACEAE Juss.: ***Vitis sylvestris*** C. C. Gmel.: АрмССР, Сев. Армения, Спитакский район, в окр. села Дебет. Leg. Я. Мулкиджанян (ArmSSR, North Armenia, Spitak region, in the vicinity of the village Debet. Leg. Ya. Mulkidjanyan) (ERE, 101287); Армения, Ереванский Бот сад. Leg. Е. Аветисян (личные сборы) (Armenia, Yerevan Bot Garden. Leg. E. Avetisyan (personal collections)); ***V. vinifera*** L.: АрмССР, бассейн реки Мегри-чай, между сс. Легвас и Агарак. У дна оврага, среди дубового редколесья. Leg. A. Doluchanov (ArmSSR, Meghri-chai river basin, between the villages Legvas and Agarak. At the bottom of the ravine, among the oak woodlands. Leg. A. Doluchanov) (ERE 137181); Caucasus. Leg. Kelenat (1719, LE); Армения, Ереванский Бот. сад. Leg. Е. Аветисян (личные сборы) (Armenia, Yerevan Bot. Garden. Leg. E. Avetisyan (personal collections));

ZYGOPHYLLACEAE R.Br.: ***Nitraria schoberi*** L.: Distr. Nachitschevan, int Dzulfa et Aza. Leg. A. Grossheim (ERE, 29491**);** ***Zygophyllum atriplicoides*** Fisch.et C.A.Mey.: Армения, Арташатский район, с. Суренаван. Leg. Я. Мулкиджанян, В. Манакян (Armenia, Artashat region, Surenavan village. Leg. Ya. Mulkidjanyan, V. Manakyan) (ERE, 80309); АрмССР, Вединский район, с. Дашлу. Leg. Я. Мулкиджанян, В. Манакян (ArmSSR, Vedi district, village Dashlu. Leg. Ya. Mulkidjanyan, V. Manakyan) (ERE, 72651).

THYMELAEACEAE Juss.

The total number of genera in Armenia – 2. The number of genera of trees and/or shrubs in Armenia – 1

Daphne L.

Arkhangelski, 1971; Avetisyan, Mekhakyan, 1973; Valdes et al., 1987; Garg, Rogers, 2011; Khodayari, Faramarzi, Jalilian, 2017

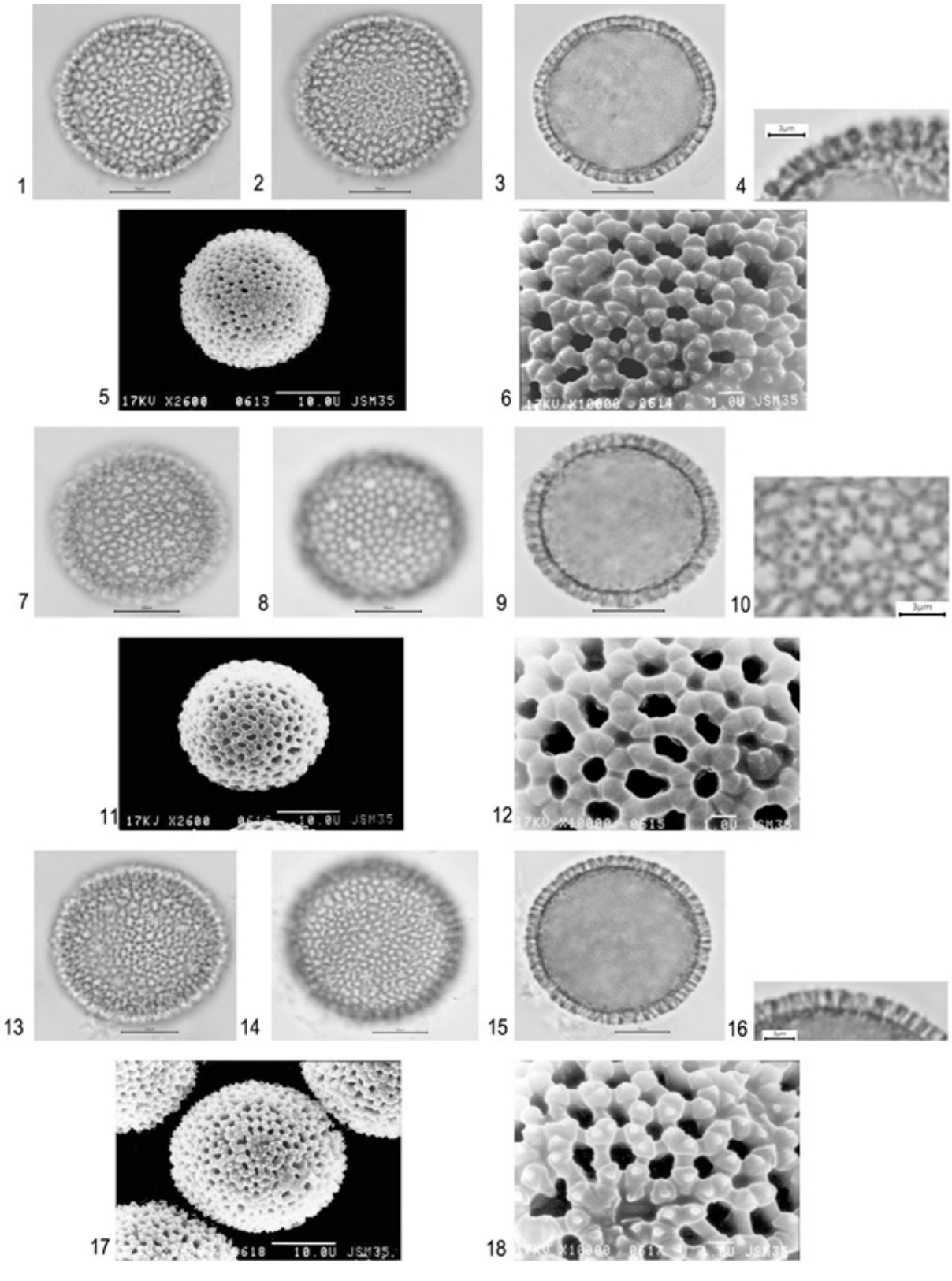
(plate 1, phototable I)

Erect or procumbent shrubs. The number of species in Armenia – 4-5.

Pollen grains are 12-16-pantopore, spheroidal, 21,0-35,0 μm in diameter. Pore lacunae are often larger than poreless ones, with 3-5 rays and 8-11 triangular tectate plates, slightly hanging over the lacunae, which most expressed in the species *D. glomerata* Lam. and *D. oleoides* Schreb. (phototable. I, 6, 18); poreless lacunae are roundish-angular, also with cover plates; supratectal protuberances on the plates are hemispherical (*D. mezereum*) or spinulouse (*D. oleoides* Schreb.) (SEM). Pores are mainly roundish, 2,0-2,5 μm in diameter, pore membrane is smooth. Exine 2,8-3,2 μm, columns are spaced, cylindrical, often with rounded heads. Exine ornamentation is reticulate (lumina of various shapes) with tectate plates and supratectate protuberances (LM, SEM).

Plate 1. Palynomorphological characteristics of some species of the genus *Daphne*

Species	Pollen grains diameter (μm)	Pore number	Exine ornamentation	
			LM	SEM
D. glomerata Lam.	23,2-29,0	16	reticulate	reticulate
D. mezereum L.	21,0-24,0	12	– // –	– // –
D. oleoides Schreb. (= *D. transcaucasica* Pobed.)	31,7-35,0	12-16 (8)	– //	– // –



Phototable I. Pollen grains of some species of the genus *Daphne* L.
1-6 – *D. glomerata* Lam. (1, 2 – overall view, 3, 4 – exine (LM), 5 – overall view, 6 – exine ornamentation (SEM)); 7-12 – *D. mezereum* L. (7, 8 – overall view, 9 – exine, 10 – exine ornamentation (LM), 11 – overall view, 12 – exine ornamentation (SEM)); 13-18 – *D. oleoides* Schreb. (= *D. transcaucasica* Pobed.) (13-14 – overall view, 15-16 – exine (LM), 17 – overall view, 18 – exine ornamentation (SEM)) (scale bar: 1-3, 7-9, 13-15 – 10 μm)

TILIACEAE Juss.

The total number of genera in Armenia – 1. The number of genera of trees and/or shrubs – 1

Tilia L.

Gladkova, 1950; Gubonina, 1952; Jonas, 1952; Erdtman et al., 1961; Praglowski, 1962; Richard, 1970b; Avetisyan, Mekhakyan, 1973; Surova, 1975; Bassett et al., 1978; Kuprianova, Alyoshina, 1978; Christensen, Blackmore, 1988; Trigo & Fernández, 1994; Jones et al., 1995; Dzyuba, Tarasevich, 2001; Beug, 2004; Tokarev, 2004; Dzyuba, 2005; Karpovich et al., 2015

(plate 2, phototable II)

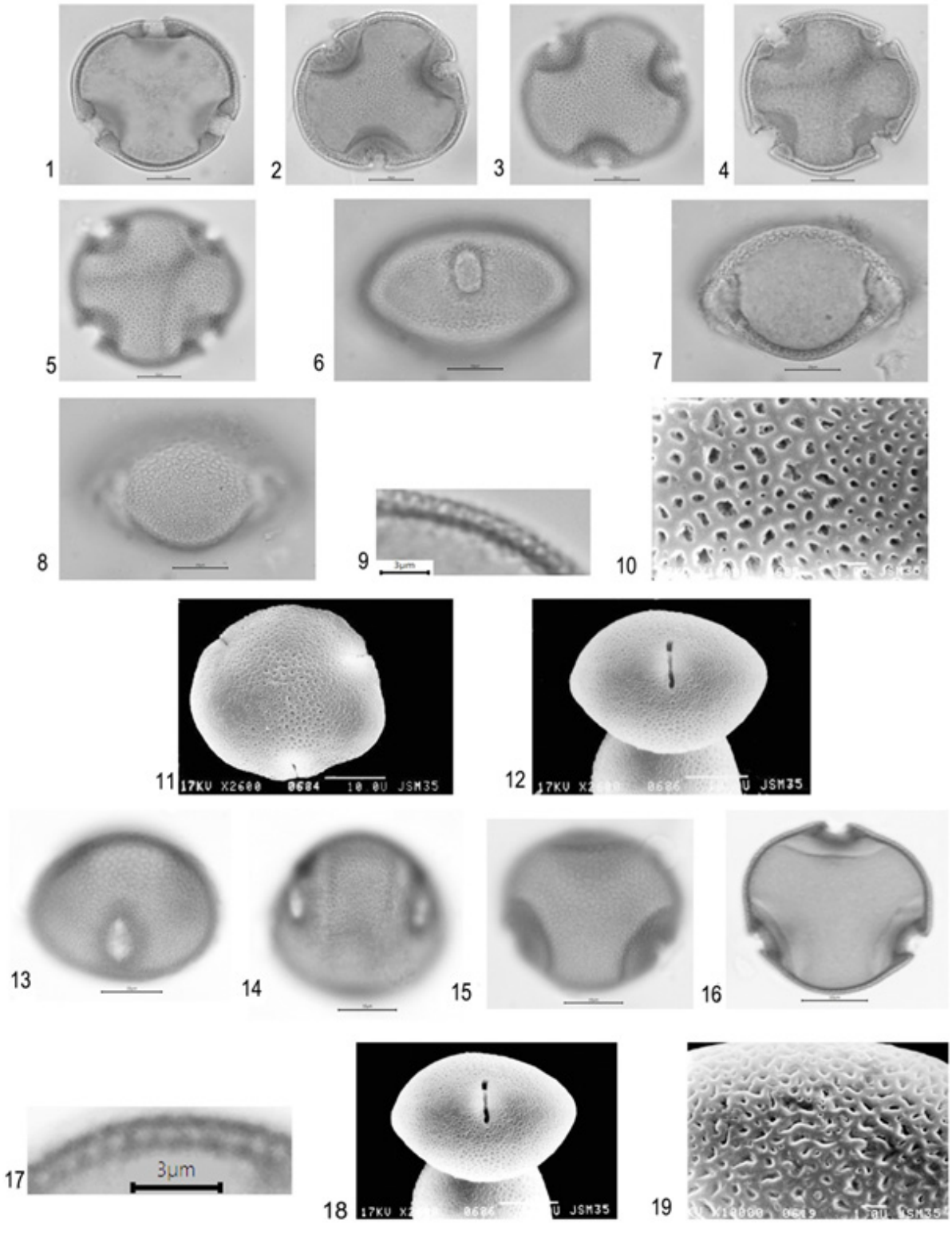
Trees. The number of species in Armenia – 3.

Pollen grains are 3(4)-zonocolp-porate, oblate-spheroidal in shape, outline in polar view is roundish-3(4)-lobed; polar axis 21,0-28,0 μm, equatorial diameter 29,0-38,0 μm. Colpi are short, not wide or narrow, the ends are rounded; apocolpium diameter 15,5-19,5 μm, mesocolpium width 19,2-24,8 μm; exine thickening along the edges of the colpi are noted. Pores are rounded or slightly oblong, vestibulate. Exine 1,3-1,5 μm (*T. caucasica* Rupr.) or 1,2-1,3 μm (*T. cordata* Mill.), with thin tectum, columellae are short, with wide bases, columellae heads are brought together. Exine ornamentation is finely reticulate and foveolate (*T. caucasica*) or reticulate (*T. cordata*) (LM); exine ornamentation is foveolate (*T. caucasica*) or reticulate, close to apertures is perforate-foveolate (*T. cordata*) (SEM).

Plate 2. Palynomorphological characteristics of some species of the genus *Tilia* L.

Species	**Pollen grain size (P x E)**[1] (μm)	**Colpus**		**Exine ornamentation**	
		apocolpium diameter (μm)	**mesocolpium width** (μm)	**LM**	**SEM**
T. caucasica Rupr.	22,4-28,0 x 32,7-38,0	18,0-19,5	20,5-24,8	finely reticulate-foveolate	foveolate
T. cordata Mill.	21,0-23,5 x 29,0-32,5	15,5-17,7	19,2-22,4	reticulate	reticulate, close to apertures perforate- foveolate

[1] P – polar axis, E – equatorial diameter



Phototable II. Pollen grains of some species of the genus *Tilia* L.
1-12 – *T. caucasica* (1-3 – 3-zonocolp-porate pollen grains from polar view, 4, 5 – 4-zonocolp-porate pollen grains from polar view, 6-8 – pollen grains from equatorial view (6 – colpus, 7 – mesocolpium, 8 – mesocolpium, ornamentation), 9 – exine (LM), 10 – exine ornamentation, 11 – pollen grain from polar view, 12 – pollen grain from equatorial view (SEM); 13-19 – *T. cordata* (13, 14 – pollen grains from semiequatorial view, 15-16 – 3-zonocolp-porate pollen grains from polar view, 17 – exine (LM), 18 – pollen grain from equatorial view (colpus), 19 – exine ornamentation (SEM)) (scale bar: 1-8, 13-16 – 10 µm)

ULMACEAE Mirb.

The total number of genera in Armenia – 2. The number of genera of trees and/or shrubs – 2

Celtis L.

Samoilovich, 1950; Erdtman G. 1954; Куприянова, 1965; Richard, 1970b; Kuprianova, Alyoshina, 1972; Avetisyan, Manukyan, 1962; Bassett et al., 1978; Zavada, 1983; Valdes et al., 1987; Takahashi, 1989; Trigo & Fernández, 1994; Jones et al., 1995; Stafford, 1995; Beug, 2004; Tokarev, 2004; Sattarian et al., 2005; Palazzesi et al., 2007; Zarafshar et al., 2010

(plate 3, phototable III)

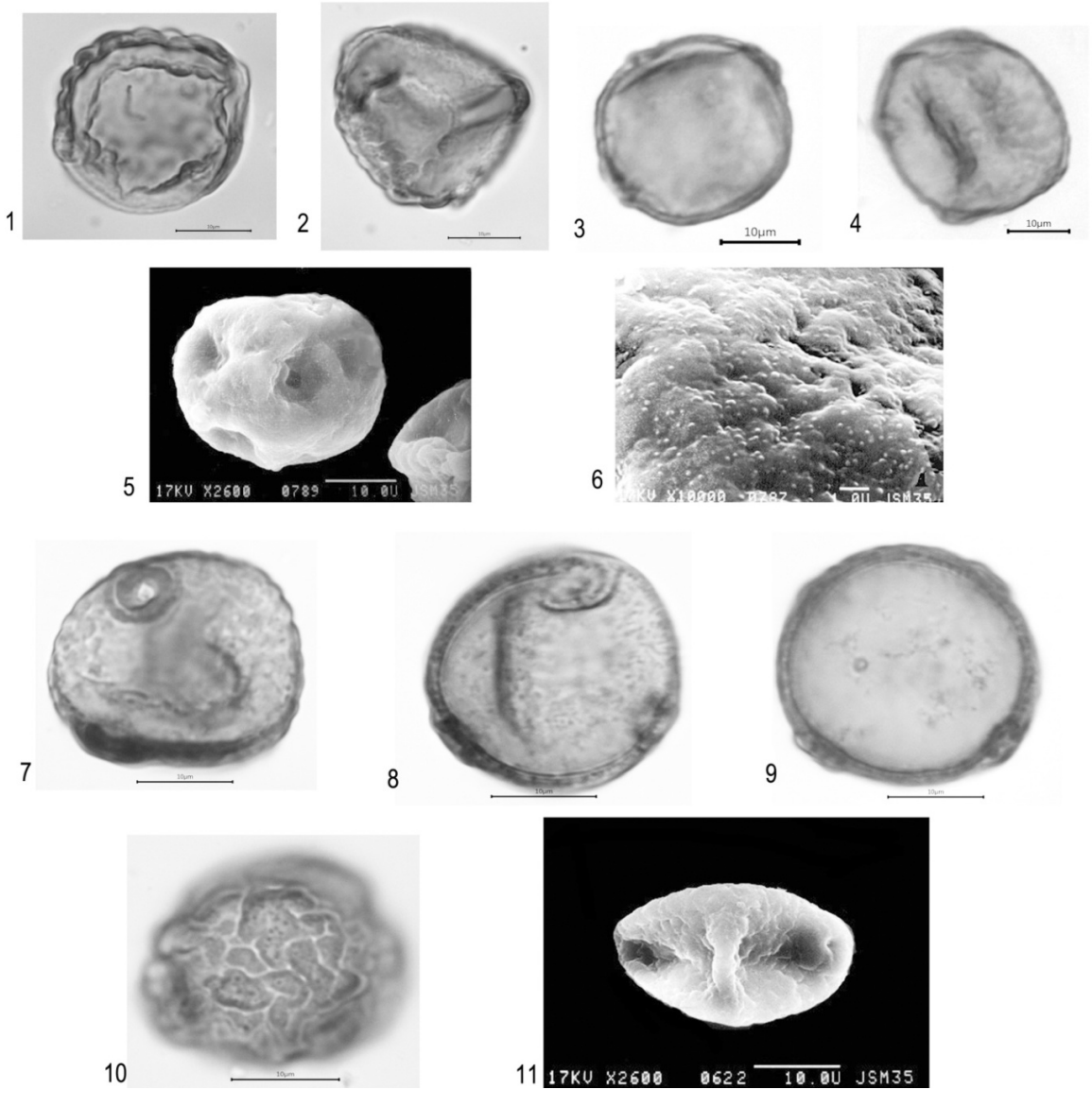
Trees or shrubs. The number of species in Armenia – 2.

Pollen grains are 4-5(3)-pantoporate, spheroidal, rounded polygonal or oblate spheroidal in shape, outline in polar view is roundish or roundish-3(4)-angular[1]; polar axis 15,2-24,1 μm, equatorial diameter 20,2-25,3 μm. Pores are rounded, submerged, rimulate, with operculum, 2,5-5,3 μm in diameter; 3-4 pores are usually located at the equator, the remaining 1-2 ones – on the hemispheres. Exine 1,2-1,4 μm, columellae separate, regularly spaced, with rounded heads (*C. planchoniana* K. I. Chr.); in the species *C. caucasica* Willd. columellae layer is weakly expressed. Exine ornamentation is finely and sinuously spotted (*C. caucasica*) or regularly verrucate (C. *planchoniana* K. I. Chr.), the surface of the pollen grains here divided into separate zones of various shapes and sizes (LM); exine ornamentation is perforate-granulate-plicate; in the species *C. planchoniana*, granules are smaller, located irregularly on the surface of pollen grains (SEM).

late 3. Palynomorphological characteristics of some species of the genus *Celtis* L.

Species	**Pollen grain size (P x E)** (μm)	**Pore diameter**	**Exine ornamentation**	
			LM	**SEM**
C. caucasica Willd.	18,4-21,2 x 20,2-23,1	2,5-3,1	finely and sinuously spotted	perforate-granulate-plicate
C. ***planchoniana*** K. I. Chr. (= *C. glabrata* Steven ex Planch., nom. Illeg., non Spreng.)	15,2-24,1 x 22,2-25,3	4,1-5,3	regularly verrucate, the surface of the pollen grains here divided into separate zones	- // -

1 Slightly deformed pollen grains are quite often founded in samples, also noted by Tokarev (2004).



Phototable III. Pollen grains of some species of the genus *Celtis* L.
1-6 – *C. caucasica* Willd. (1-4 – overall view (LM), 5 – overall view, 6 – exine ornamentation (SEM); 7-11 – C. *planchoniana* K. I. Chr. (7-9 – overall view, 10 – exine ornamentation (LM), 11 – overall view (SEM)
(scale bar: 1-4, 7-10 – 10 μm)

Ulmus L.

Samoilovich, 1950; Jonas, 1952; Erdtman G. 1954; Erdtman et al., 1961; Praglowski, 1962; Avetisyan, Manukyan, 1962; Kuprianova, 1965; Richard, 1970b; Myachina et al., 1971; Stockmarr, 1974 ; Сурова, 1975; Bassett et al., 1978; Kuprianova, Alyoshina, 1978; Zavada, 1983; Valdes et al., 1987; Xin Y.-Qun et al., 1993; Jones et al., 1995; Stafford, 1995; Beug, 2004; Tokarev, 2004; Dzyuba, 2005; Karpovich et al., 2015

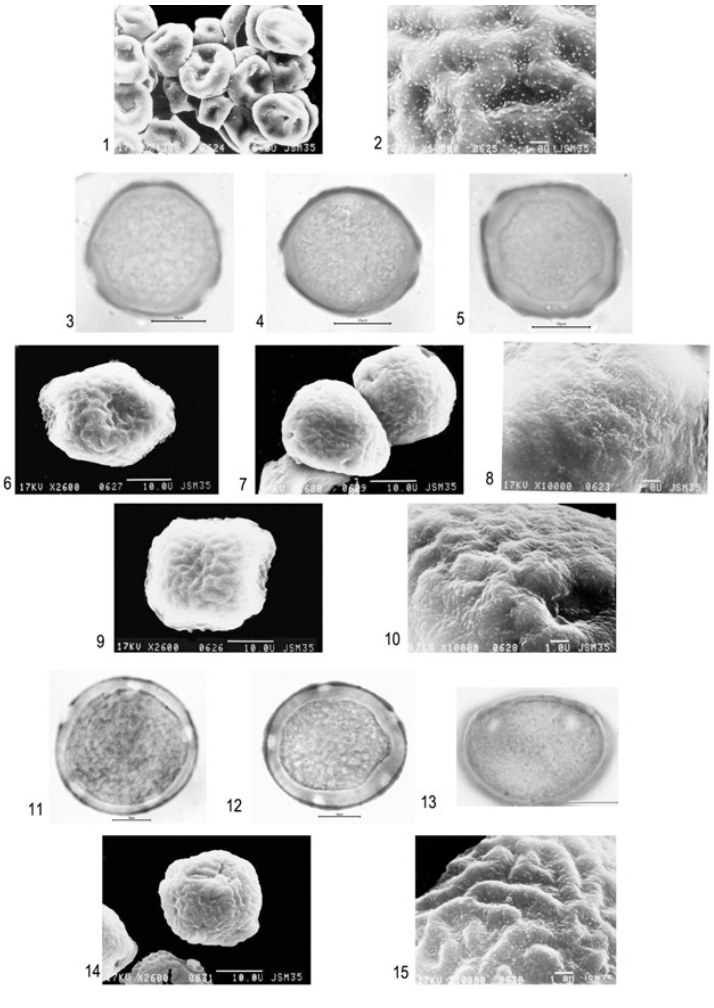
(plate 4, phototable IV)

Trees, less often shrubs. The number of species in Armenia – 4-6.

Pollen grains are 4-5-zonopore, oblate spheroidal, outline in polar view is almost roundish or angular-roundish, the surface of pollen grains are wavy; polar axis 14,3-18,2 μm, equatorial diameter 18,8-25,0 μm. Pores are rounded, narrow-rimmed, sometimes slightly elongated, 2,0-3,7 μm in diameter. Exine 1,5-1,7 μm, columellae layer is weakly expressed. Exine ornamentation is sinuously tuberculate (LM); exine ornamentation is plicate-granulate or sinuously plicate-granulate (*U. minor* Mill.) (SEM).

Plate 4. Palynomorphological characteristics of some species of the genus *Ulmus* L.

Species	Pollen grain size (P x E) (μm)	Exine ornamentation	
		LM	SEM
U. densa Litw.	15,8-18,2 x 20,1-23,0	sinuously tuberculate	plicate-granulate
U. glabra Huds. (=*U. scabra* Mill., *U. elliptica* K.Koch)	15,2-18,1 x 20,2-23,4	– // –	– // –
U. laevis Pall.	14,3-15,7 x 18,8-21,3	– // –	– // –
U. minor Mill. (=*U. foliacea* Gilib.; *U. carpinifolia* Ruppins ex Suckow, *U. suberosa Moench, U. araxina* Takht.)	16,5-18,1 x 21,8-25,0	– // –	sinuously plicate-granulate



Phototable IV. Pollen grains of some species of the genus *Ulmus* L.
1-2 – *U. densa* Litw. (1 – overall view, 2 – exine ornamentation (SEM); 3-8 – *U. glabra* Huds. (= *U. elliptica* K.Koch) (3, 5 – pollen grains from polar view, 4 – pollen grain from equatorial view (LM), 6, 7 – overall view, 8 – exine ornamentation (SEM); 9-10 – *U. laevis* Pall. (pollen grain from polar view, 10 – exine ornamentation (SEM); 11-15 – *U. minor* Mill. (11, 12 – pollen grains from polar view, 13 – pollen grain from equatorial view (LM), 14 – overall view, 15 – exine ornamentation (SEM)) (scale bar: 3-5, 11-13 – 10 μm)

VITACEAE Juss.

The total number of genera in Armenia – 1. The number of genera of trees and/or shrubs – 1

Vitis L.

Erdtman et al., 1961; Avetisyan, Mekhakyan, 1973; Myachina et al., 1971; Kuprianova, Alyoshina, 1978; Valdes et al., 1987; Jones et al., 1995; Sekina et al., 1995; Inceoglu et al., 2000; Punt et al., 2003; Willard et al., 2004; Tokarev, 2004; Perveen, Qaiser, 2008; Karpovich et al., 2015

(plate 5, phototable V)

Climbing shrubs (lianas). The number of species in Armenia – 2.

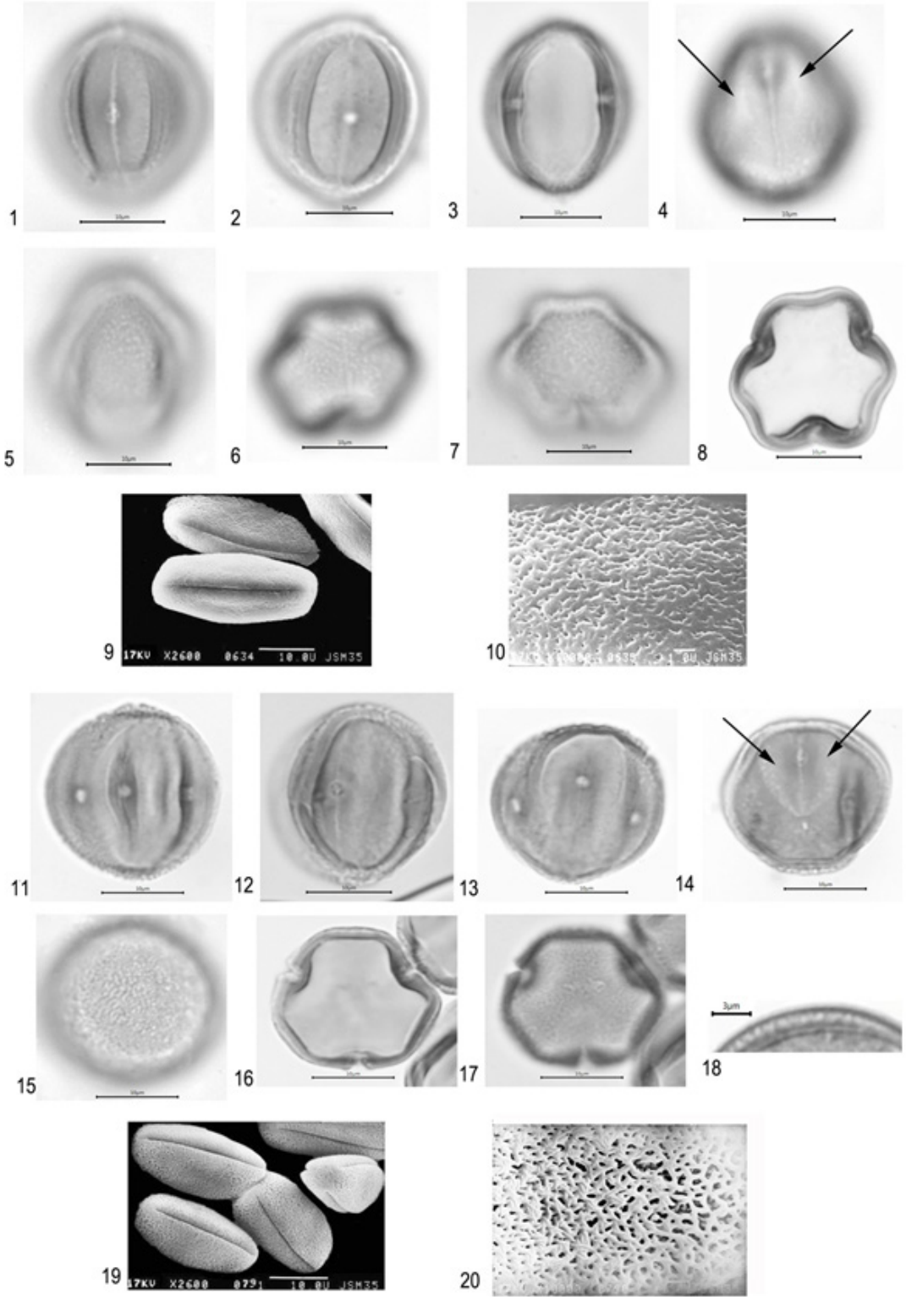
Pollen grains are 3-zonocolp-porate with paracolpi[1], broadly ellipsoidal or almost spheroidal (LM) or ribbed-ellipsoidal (SEM), outline in polar view is 3-lobed (*V. vinifera* L.) or 6-lobed (*V. sylvestris* C.C. Gmel .); polar axis 18,3-20,5 μm (LM) or 22,0-25,2 μm (SEM), equatorial diameter 15,5-19,9 μm (LM) or 10,2-13,4 μm (SEM)[2]. Colpi are long, very narrow, with parallel edges, exine thickening in the equatorial region along the edges of the pores is noted; apocolpium diameter 2,5-5,1 μm, mesocolpium width 9,3-12,3 μm; paracolpi short, crescent. Pores are small, spherical, 1,5-2,0 μm in diameter. Exine 1,3-1,4 μm, columellae are of various shapes. Exine ornamentation is sinuously and finely reticulate (LM); exine ornamentation is sinuously and finely reticulate (*V. vinifera* L.) or perforate-plicate (*V. sylvestris* C.C. Gmel.) (SEM)

Plate 5. Palynomorphological characteristics of some species of the genus *Vitis* L.

Species	**Pollen grain size (P x E)** (μm)	**Colpus**		**Exine ornamentation**	
		apocolpium diameter (μm)	**mesocolpium width** (μm)	**LM**	**SEM**
V. sylvestris C. C. Gmel.	18,8-20,5 – LM (23,0-25,2 – SEM) x 15,5-18,7 – LM (12,5-13,4 – SEM)	2,5-3,2	10,5-12,3	sinuously and finely reticulate	perforate-plicate
V. vinifera L. (cultivated plant)	18,3-20,1 – LM (22,0-23,3 – SEM) x 18,3-19,9 – LM (10,2-12,3 – SEM)	4,2-5,1	9,3-11,5	- // -	sinuously and finely reticulate

[1] Paracolpi – colp-shape parts of thinned endexine, located on both sides of the colpi (Yeramyan, 1971). In our opinion, paracolpi in their structure are homologs of ora.

[2] Due to thin exina, pollen grains of species of the genus *Vitis* L., after treatment for research with LM, often have a wide ellipsoidal or almost spheroidal shape, while untreated pollen used in SEM studies is narrowly ellipsoidal. In this regard, we presented general shape and size of pollen grains, obtained using both light and scanning microscopes.



Phototable V. Pollen grains of some species of the genus *Vitis* L
1-10 – *V. sylvestris* C.C. Gmel. (1-3 – pollen grains from equatorial view, 4, 5 – pollen grains from semiequatorial view (5 - paracolpi (marked by arrows)), 6-8 – pollen grains from polar view (LM), 9 – pollen grains from equatorial view, 10 – exine ornamentation (SEM)); 11-20 – *V. vinifera* L. (11-13, 15 – pollen grains from equatorial view, 14 – pollen grains from semiequatorial view, paracolpi (marked by arrows), 16, 17 – pollen grains from polar view, 18 – exine (LM), pollen grains from polar and equatorial view, 20 – exine ornamentation (SEM)
(scale bar: 1-8, 11-17 – 10 μm)

ZYGOPHYLLACEAE R. Br.

The total number of genera in Armenia – 2. The number of genera of trees and/or shrubs – 2

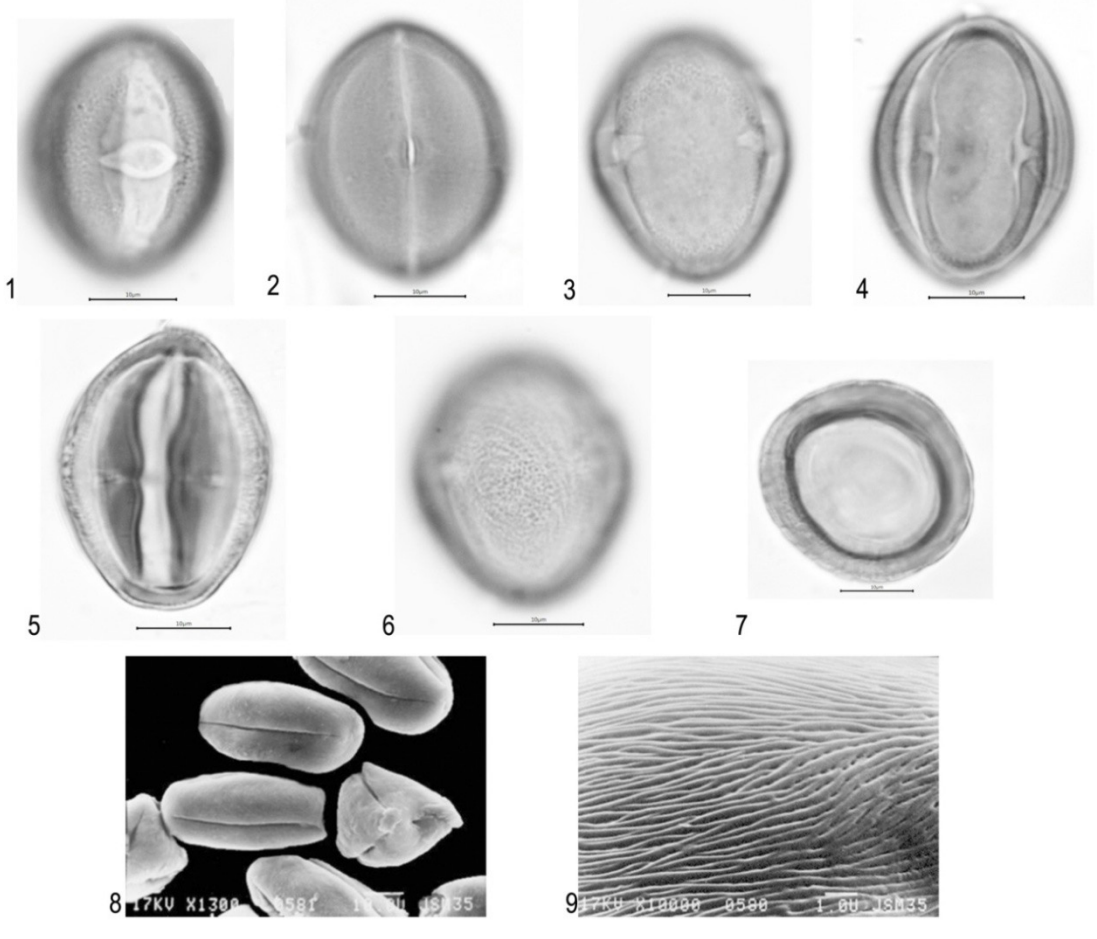
Nitraria L.

Sladkov, 1954; Agababyan, 1964, 1965; Agababian, Tumanyan, 1972; Avetisyan, Mekhakyan, 1973; Ting Su, 1949; Kuprianova, Alyoshina, 1978; Khalkuziev, 1990; Abdusalih, Xiaoling, 2003; Nurbay, Pan, 2003; Perveen, Qaiser M, 2006; Kai-Qing Lu et al., 2018

(phototable VI)

Shrubs with regular simple fleshy leaves. The number of species in Armenia – 1.

N. schoberi L. Pollen grains are 3-zonocolp-orate, broadly ellipsoidal (LM) or narrow ellipsoidal (SEM), outline in polar view is rounded (LM) or rounded-triangular (SEM); polar axis 24,8-31,8 μm, equatorial diameter 20,5-23,9 μm. Colpi are long, usually very narrow, with pointed ends; a thickening of exine along the edges of the colpi, and especially in the corners of the ora at the equator is noted; apocolpium diameter 3,5-4,2 μm, mesocolpium width 11,5-12,8 μm. Ora are elliptical, sharply narrowed to the ends, the ends pointed or slightly rounded; length of os 10,0–11,3.0 μm, maximum width 5,0–5,5 μm. Exine 2,2-2,8 μm, columellae are thin, with rounded heads. Exine ornamentation is finely striate (LM); exine ornamentation is finely striate, finely reticulate-striate (SEM).



Phototable VI. Pollen grains of *Nitraria schoberi L.*
1-6 – pollen grains from equatorial view (1, 2, 5 – colpus, 3, 4 – mesocolpium, 6 – mesocolpium, ornamentation, 7 – pollen grain from polar view (LM), 8 – pollen grain from polar and equatorial view, 9 – ornamentation (SEM)
(scale bar: 1-7 – 10 μm)

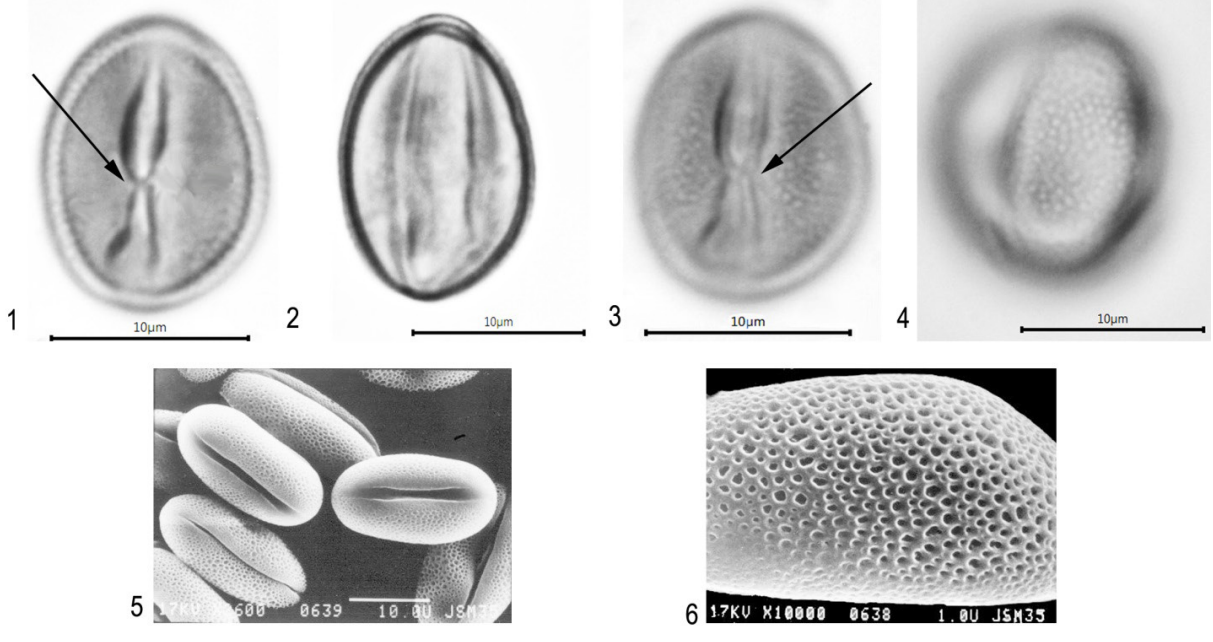
Zygophyllum L.

Ting Su, 1949; Sladkov, 1954; Agababyan, 1964, 1965; Avetisyan, Mekhakyan, 1973; Khalkuziev, 1990; Trigo et al., 1992; Sekina et al., 1995; Perveen, Qaiser M, 2006; Kai-Qing Lu et al., 2018

(phototable VII)

Splayed branchy shrub. The total number of species in Armenia – 2. The number of species of trees and/or shrubs – 1.

Z. atriplicoides Fisch.et C.A. Mey. Pollen grains are 3-zonocolp-porate, widely ellipsoidal, outline in polar view is rounded; polar axis 15,1-16,8 μm, equatorial diameter 11,5-14,0 μm. Colpi are usually geniculate, long, not wide or narrow; apocolpium diameter 3,8-4,5 μm, mesocolpium width 7,5-8,8 μm. Pores are small, rounded, not always clearly defined. Exine 0,7-0,8 μm, columellae are short, thin. Exine ornamentation is regularly reticulate (LM, SEM), along the edges of the colpi reticulum is weakly expressed or absent (SEM).



Phototable VII. Pollen grains of *Z. atriplicoides* Fisch.et C.A. Mey.
1-4 – pollen grains from equatorial view (1, 3 – colpus with geniculum (marked by arrows), 2, 4 – mesocolpium with exine ornamentation (4) (LM), 5 – pollen grains from equatorial view, 6 – exine ornamentation (SEM)) (scale bar: 1-4 – 10 μm)

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REFERENCES

Abdusalih N., Xiaoling P. 2003. Pollen morphology and taxonomy of *Nitraria* and its allied genera in West China // Arid Zone Research, 20, 1: 16-19.

Agababyan V. Sh. 1964. Morphological types of pollen and taxonomy of the family *Zygophyllaceae* // Izv. Akad. Nauk Arm. SSR., Biol. Nauki, 17, 12: 39-45 (in Russ.) (Агабабян В. Ш. 1964. Морфологические типы пыльцы и систематика семейства *Zygophyllaceae* // Известия АН Арм. ССР. Сер. «Биол. науки», 17, 12: 39-45).

Aghababyan V. Sh. 1965. Pollen structure and taxonomy of the family *Zygophyllaceae* // Proceedings of Bot. Institute of the Academy of Sciences of ArmSSR, 15: 66-90 (in Russ.) (Агабабян В. Ш. 1965. Строение пыльцы и систематика семейства парнолистниковых // Труды Бот. института АН АрмССР, 15: 66-90).

Agababian V. Sh., Tumanyan K.T. 1972. Palynomorphology of the genus *Nitraria*. Biolog. Zhurn. Armenii, 25, 4: 38-41 (in Russ.) (Агабабян В. Ш., Туманян К.Т. 1972. К палиноморфологии рода *Nitraria* L. // Биолог. журн. Армении, 25, 4: 38-41).

Arkhangelski D.B. 1971. Palynotaxonomy of *Thymelaeaceae* s. l. // In: Pollen morphology (eds. L.A. Kupriyanova, M.S. Yakovlev). Leningrad. 334 p. (in-

Russ.) (Архангельский Д.Б. 1971. Палинотаксономия *Thymelaeaceae* s. l. // В кн.: Морфология пыльцы (под ред. Л.А. Куприяновой и М.С. Яковлева). Ленинград. 334 с.).

Avetisyan E. M., Mekhakyan A. K., 1973. Description of the pollen of *Aceraceae, Anacardiaceae, Araliaceae, Celastraceae, Cornaceae, Ebenaceae, Elaeagnaceae, Ericaceae, Malvaceae, Nitrariaceae, Punicaceae, Rhamnaceae, Staphyleaceae, Thymeleaceae, Tiliaceae, Vitaceae, Zygophyllaceae* // Flora of Armenia, 6. Yerevan, 485 pp. (in Russ.) (Аветисян Е. М., Мехакян А. К. 1973. Описание пыльцевых зерен сем. *Aceraceae, Anacardiaceae, Araliaceae, Celastraceae, Cornaceae, Ebenaceae, Elaeagnaceae, Ericaceae, Malvaceae, Nitrariaceae, Punicaceae, Rhamnaceae, Staphyleaceae, Thymeleaceae, Tiliaceae, Vitaceae, Zygophyllaceae* // Флора Армении, 6. Ереван. 485 с.)

Avetisyan E.M., Manukyan L.K. 1962. Description of the pollen of *Betulaceae, Corylaceae, Fabaceae, Fagaceae, Moraceae, Ulmaceae*. Flora of Armenia, 4. Yerevan, 436 p. (in Russ.) (Аветисян Е.М., Манукян Л.К. 1962. Описание пыльцевых зерен сем. *Betulaceae, Corylaceae, Fabaceae, Fagaceae, Moraceae, Ulmaceae.* Флора Армении, 4. Ереван. 436 с.)

Basset, I. J., Crompton, C. W., Parmelee, J. E. 1978. An atlas of airborne pollen grains and common fungus spores of Canada. Monogr. 18. Can. Dept. Agric., Ottawa, 321 p.

Beug, H.-J. 2004. Leitfaden der Pollenbestimmung fur Mitteleuropa und angrenzende Gebiete. Verlag Friedrich Pfeil, Munich, 542 pp.

Christensen P.B., Blackmore S. 1988. The Northwest European pollen flora. 40. *Tiliaceae* // Rev. Palaeobot. Palynol., 57: 33-43.

Dzyuba O. F. 2005. Atlas of pollen grains most common in the air basin of Eastern Europe. Nycomed. Moscow. 68 p. (in Russ.) (Дзюба О. Ф. 2005. Атлас пыльцевых зерен наиболее часто встречающихся в воздушном бассейне Восточной Европы. Nycomed. Москва. 68 с.)

Dzyuba O. F., Tarasevich V. F. 2001.Morphological features of pollen grains of *Tilia cordata* Mill. in a modern megalopolis // Pollen as an status indicator of the environment and paleoecological reconstructions. St. Petersburg: VNIGRI. P. 76-90 (in Russ.) (Дзюба О. Ф., Тарасевич В. Ф. Морфологические особенности пыльцевых зерен *Tilia cordata* Mill, в условиях современного мегаполиса // Пыльца как индикатор состояния окружающей среды и палеоэкологические реконструкции. Санкт-Петербург: ВНИГРИ, 2001. С. 76-90).

Erdtman G. 1954. An introduction to pollen analysis. Waltham, Mass., USA. 239 p.

Erdtman G., Berglung B., Praglowski J. 1961. An introduction to a Scandinavian Pollen Flora // Grana Palynol., 2 (3): 3-92.

Garg A., Rogers Z. S. 2011. A palynological investigation of *Daphne papyracea* and *Daphne bholua (Thymelaeaceae)* in India // J. Bot. Res. Inst. Texas 5, 2: 635-641.

Gladkova A. N. 1950. Pollen morphology of the fam. *Araliaceae, Buxaceae, Celastraceae, Tiliaceae* // In: Pollen analysis (ed. A. N. Krishtofovich). Moscow. 570 p. (in Russ.) (Гладкова А.Н. 1950. Морфология пыльцы сем. *Araliaceae, Buxaceae, Celastraceae, Tiliaceae* // В кн.: Пыльцевой анализ (под ред. А. Н. Криштофовича). Москва. 570 с.

Gubonina Z. P. 1952 Pollen description of species of the genus *Tilia* L., growing on the territory of the USSR (for the purposes of pollen analysis) // Proceedings of the Institute of Geography, LI USSR. Vol. 52, no. 7. P. 116-129 (in Russ.) (Губонина З.П. 1952. Описание пыльцы видов рода *Tilia* L., произрастающих на территории СССР (для целей пыльцевого анализа) // Тр. ин-та географии ЛИ СССР. Т. 52, вып. 7. С. 116-129.)

Inceoglu, O., Pinar, N., Oybak-Dönmez, E. 2000. Pollen morphology of wild *Vitis sylvestris* Gmelin (*Vitaceae*) // Turk. J. Bot. 24, 147-150.

Jonas Fr. 1952. Atlas zur Bestimmung ezenter und fissuler Pollen und Spores // Fed. Rep. B. 133. 60 p. (+ 57 tables).

Jones, G. D., Bryant, V. M., Jr., Lieux, M. H., Jones, S. D., Lingren, P. D. 1995. Pollen of the southeastern United States: with emphasis on melissopalynology and entomopalynology. Dallas, TX: Am. Assoc. Stratigr. Palynol. Found. No. 30.76 pp. + 104 plates.

Kai-Qing Lu, Gan Xie, Min Li, Jin-Feng Li, Anjali Trivedi, D. K. Ferguson, Yi-Feng Yao, Yu-Fei Wang. 2018. Dataset of pollen morphological traits of 56 dominant species among desert vegetation in the eastern arid central Asia // Data in Brief, 18: 1022–1046.

Karpovich I. V., Drebezgina Ye. S., Elovikova E. A, Legotkina G. I., Zubova E. N., Kuzyaev R. Z., Khismatullin R. G. 2015. Pollen atlas. The Ural worker: Yekaterinburg. 318 p. (+ 288 plates) (in Russ.) (Карпович И. В., Дребезгина Е. С., Еловикова Е. А., Леготкина Г. И., Зубова Е. Н., Кузяев Р. З., Хисматуллин Р. Г. 2015. Атлас пыльцевых зерен (Pollen atlas). Уральский рабочий: Екатеринбург. 318 с. (+ 288 илл.)).

Khalkuziev P. 1990. On the kinship of some plant families of desert regions. “FAN” Uzbek. SSR. Tashkent. 126 p. (in Russ.) (Халкузиев П. 1990. О родственных связях некоторых семейств растений пустынных

областей. Изд. “ФАН“ Узб. ССР. Ташкент. 126 с.).

Khodayari H., Faramarzi A., Jalilian N. 2017. The morphological, micromorphological and palynological study of the genus *Daphne* L. *(Thymelaeaceae)* in Iran // Taxonomy and Biosystematics, 9, 33: 47-64.

Kuprianova L. A. 1965. Palynology of Amentiferae. Moscow, Leningrad: Nauka. 214 p. (in Russ.) (Куприянова Л. А. 1965. Палинология сережкоцветных (Amentiferae). “Наука”, М.-Л. 2014 с.).

Kuprianova L. A., L. A. Alyoshina, 1972. Pollen and spores of plants of European part of USSR. Nauka, Leningrad, I. Leningrad. 170 pp. (in Russ.) (Куприянова Л. А., Алешина Л. А. 1972. Пыльца и споры растений флоры Европейской части СССР, I. Ленинград. 170 с.).

Kuprianova L. A., Alyoshina L. A. 1978. Pollen and spores of plants from the flora of European part of the USSR. 2. *Lamiaceae-Zygophyllaceae*. Akademia Nauk SSSR, Komarov Bot Inst., Leningrad. 184 pp. (in Russ.) (Куприянова Л. А., Алешина Л. А. 1978. Пыльца двудольных растений флоры Европейской части СССР. Ленинград. «Наука», 183 с.).

Myachina A. I., Kazachikhina L. L., Mamontova I. B., Kalinina V. S. 1971. Atlas of spores and pollen of some modern plants of the Far East. Academy of Sciences of the USSR, Khabarovsk. 85 p. (+ 53 tab.) (in Russ.) (Мячина А. И., Казачихина Л. Л., Мамонтова И. Б., Калинина В. С. 1971. Атлас спор и пыльцы некоторых современных растений Дальнего Востока. АН СССР, Хабаровск. 85 с. (+ 53 табл.)).

Nurbay A, Pan X. 2003. Pollen morphology and taxonomy of *Nitraria* and its allied genera in west China // Arid Zone Research 20, 1: 16-19.

Palazzesi L., Pujana R. R., Burrieza H. P., Steinhardt A. P. 2007. Pollen grain morphology of selected allergenic species native to Southern South America // The Journal of the Torrey Botanical Society, 134, 4, 527-533

Perveen A, Qaiser M. 2006. Pollen flora of Pakistan – XLIX. *Zygophyllaceae*. Pak. J. Bot., 38, 2: 225-232.

Perveen A., Qaiser M. 2008. Pollen flora of Pakistan – LVII. *Vitaceae* // Pak. J. Bot., 40, 2: 501-506.

Potonie R. 1934. Zur Morphologie der fossilen Pollen und Sporen // Arbeiten des Instituts für Paläobotanik und Petrographie der Brennsteine, 4: 5-24.

Praglowski J. R. 1962. Notes on the pollen morphology of Swedish trees and shrubs // Grana Palynol., 3, 2: 45-65.

Punt W., A. Marks, P. P. Hoen. 2003. *Vitaceae*. The Northwest European Pollen Flora, 64 // Rev. Palaeobot. Palyn., 123, 1-2: 67-70.

Punt W., Hoen P. P., Blackmore S., Nilsson S., Le Thomas A. 2007. Glossary of pollen and spore terminology // Rev. Palaeobot. Palynol., 143: 1-81.

Richard, P. 1970a. Atlas pollinique des arbres et de quelques arbustes indigenes du Quebec. III. Angiospermes *(Salicacées, Myricacées, Juglandacées, Corylacées, Fagacées, Ulmacées)* // Naturaliste canadienne, 97: 97–161.

Richard, P. 1970b. Atlas pollinique des arbres et de quelques arbustes indigenes du Quebec. IV. Angiospermes *(Rosacées, Anacardiacées, Acéracées, Rhamnacées, Tiliacées, Cornacées, Oléacées, Caprifoliacées)*. Naturaliste canadienne // 97: 241–306.

Samoilovich S.R. 1950. Pollen morphology of *Berberidaceae, Fagaceae, Moraceae, Platanaceae, Saxifragaceae, Ulmaceae* // In: Pollen analysis (ed. A. N. Krishtofovich). Moscow. 570 p. (in Russ.) (Самойлович С.Р. 1950. Морфология пыльцы сем. *Berberidaceae, Fagaceae, Moraceae, Platanaceae, Saxifragaceae, Ulmaceae* // В кн.: Пыльцевой анализ (под ред. А. Н. Криштофовича). Москва. 570 с.).

Sattarian A, van den Berg, R.G., van der Maesen, L.J.G. 2005. Pollen morphology of *Celtis (Celtidaceae)*. Feddes Repert., 117, 1-2: 34-40.

Sekina, M. Ayyad, P., D. Moore. 1995. Morphological studies of the pollen grains of the semi-arid region of Egypt // Flora, 190: 115-133.

Sladkov A.N. 1954. Morphological description of pollen of *Zygophyllaceae* from Turkmenistan // Proceedings of the Institute of geography. USSR Academy of Sciences, 61: 157-167 (in Russ.) (Сладков А.Н. 1954. Морфологическое описание пыльцы парнолистниковых Туркмении // Тр. ин-та геогр. АН СССР, 61: 157-167)

Stafford P. J. 1995. *Ulmaceae*. The Northwest European Pollen Flora, 53 // Rev. Palaeobot. Palynol., 88: 25-46.

Stockmarr J. 1974. SEM studies on pollen grains of North European *Ulmus* species // Grana, 14, 2-3: 103-107

Surova T. G. 1975. Electron microscope investigation of plants pollen and spores. Nauka. Moscow. 87p. (in Russ.) (Сурова Т. Г. 1975. Электронно-микроскопическое исследование пыльцы и спор растений. Москва. “Наука“. 87 с.).

Takahashi M. 1989. Pollen morphology of *Celtidaceae* and *Ulmaceae*, A reinvestigation. In: Crane P.R., Blackmore S. (eds.) Evolution, systematics, and fossil history of the Hamamelidae, 2. Oxford, Clarendon Press. Pp. 253- 265.

Ting Su. 1949. Illustration of pollen grains of some Chinese plants // Bot. Not., 4: 277-282

Tokarev P. I. 2004. Palynology of woody plants growing on the territory of Russia. Abstract of thesis. Diss...Doct. Biol. Sciences. Moscow. 55 p. (in Russ.)

(Токарев П. И. 2004. Палинология древесных растений, произрастающих на территории России. Автореф. дисс. … докт. биол. наук. Москва. 55 с.).

Trigo M. M., I. Fernández. 1994. Contribución al estudio polínico de especies ornamentales con interés alergógeno cultivadas en Málaga: Dicotiledóneas // Acta Bot. Malacitana, 19: 145-168.

Trigo M. M., Recio M., Cabezudo B. 1992. 10. Sobre palinología de algunas species endémicas e interesantes de Andalucía Oriental, V // Acta Bot. Malacitana, 17: 267-277

Valdés B., Díez M. J., Fernandes I. 1987. Atlas polinico de Andalucia Occidental. Universidad de Sevilla. 451p.

Willard D. A., C. E. Bernhardt, L. Weimer, S. R. Cooper, D. Gamez, J. Jensen. 2004. Atlas of pollen and spores of the Florida Everglades // Palynology, 28: 175–227.

Woutersen, A., Jardine, P.E., Bogotá-Angel, R.G., Zhang, H.X., Silvestro, D., Antonelli, A., Gogna, E., Erkens, R.H., Gosling, W.D., Dupont-Nivet, G. and Hoorn, C., 2018. A novel approach to study the morphology and chemistry of pollen in a phylogenetic context, applied to the halophytic taxon *Nitraria* L. (*Nitrariaceae*) // PeerJ, 6, doi.org/10.7717/peerj.5055

Xin Y.-Qun, Zhang Y.-Long, Xi Y.-Zhen. 1993. Studies on the pollen morphology of the genus *Ulmus* L. in China and its taxonomic significance // Acta Bot. Sin., 35, 2: 91-95.

Zarafshar M., Akbarinia M., Sattarian A., van der Maesen L. J. G. 2010. Pollen morphology of iranian *Celtis (Celtidaceae-Ulmaceae)* // Botanica Serbica, 34, 2: 145-149.

Zavada M. 1983. Pollen morphology of *Ulmaceae* // Grana, 22: 23-30.

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