

Palynological data on the genus *Cornus* (Cornaceae)

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Genus *Cornus* L. (Cornaceae) includes, according to various sources, from 4 to about 60 species, growing mainly in temperate regions of the northern hemisphere. *Cornus mas* L. is the most widely used species in the genus, from which numerous semi-cultivated and cultivated forms and sorts were obtained. The wild *C. mas* is of Western Asian origin, distributed in the mountains of the Caucasus, Asia Minor, and Southern Europe, and the genotype of the species shows reliable polymorphism. The purpose of this study was to present a detailed palynomorphological characteristic of the species *C. mas* of the Armenian flora using light microscopy (LM) and scanning electron microscopy (SEM), to clarify the disagreements noted in the literature regarding to the pollen aperture type for the species *C. mas*, as well as to conduct a comparative palynomorphological analysis of the genus *Cornus* as a whole (based on the literary data). The data obtained are consistent with the opinion of a number of authors about the presence in the species *C. mas* of the quite rare compound pollen aperture type. This compound aperture type is formed by a combination of the colpus with a peculiar endoaperture complex, consisting of a small oblong os and paracolpi, located on both sides of the colpi. The os small, elliptical, reaching the paracolpi, forming together butterfly-like or H-shape endexine thinnings. In our opinion, both the os and the paracolpi arose due to the thinning or absence of the internal layers of the exine. Exine 1.3–1.5 μm , columellae separate, thick, capitate. Exine ornamentation verrucate (LM); exine ornamentation densely verrucate with rare perforations, verrucae varying in size (SEM). An extensive analysis of the literature data on pollen of 42 species of the genus *Cornus* revealed the significant differences in the characteristics of the type of apertures not only at the interspecific, but also at the intraspecific level. In terms of size, pollen grains are predominantly large or of medium size, rarely small. The large pollen grains were noted for *C. alba* L., *C. alsophila* W. W. Sm., *C. alternifolia* L.f., *C. amomum* Mill., *C. asperifolia* Michx., *C. controversa* Hemsl., *C. coreana* Wangerin, *C. drummondii* C. A. Mey., *C. excelsa* Kunth, *C. glabrata* Benth., *C. hemsleyi* C. K. Schneid. & Wangerin, *C. monbeigii* Hemsl., *C. paucinervis* Hance, *C. poliophylla* C. K. Schneid. & Wangerin, *C. rugosa* Lam., *C. sanguinea* L., *C. sericea* L., *C. stolonifera* Michx., *C. walteri* Wangerin, *C. wilsoniana* Wangerin. Medium pollen size is typical for *C. boliviana* J. F. Macbr., *C. brachypoda* C. A. Mey., *C. canadensis* L., *C. capitata* Wall., *C. chinensis* Wangerin, *C. controversa*, *C. disciflora* Moc. & Sessé ex DC., *C. floccosa* Wangerin, *C. florida* Hook., *C. foemina* Mill., *C. hongkongensis* Hemsl., *C. kousa* Buerger, *C. longipetiolata* Hay., *C. macrophylla* Wall., *C. mas* L., *C. nuttallii* Audubon, *C. oblonga* Wall., *C. peruviana* J. F. Macbr., *C. sericea*, *C. sessilis* Torr., *C. suecica* L., *C. ulotricha* C. K. Schneid. & Wangerin, *C. unalaschkensis* Ledeb. The largest pollen grains were noted for the species *C. monbeigii* (P x E = 81.0 x 48.5 μm) and the smallest ones for *C. officinalis* (P x E = 20.0 x 21.0 μm). Exine ornamentation as a rule is represented by a number of primitive types, namely, scabrate, rugulate, verrucate, granulate, echinate, etc., sometimes with perforations.

Keywords: comelian cherry; pollen; aperture; light microscopy; scanning electron microscopy.

Introduction

The genus *Cornus* L. (Cornaceae) includes, according to various sources, from 4 to about 60 species, growing mainly in temperate regions of the northern hemisphere (Murrell, 1993; Fan & Xiang, 2001). It was revealed that the phylogeny based on the total evidence tree including fossils supports an origin and early Tertiary diversification of *Cornus* in Europe and multiple trans-Atlantic migrations between Europe and North America by the early Tertiary (Eyde, 1988; Crane et al., 1990; Xiang et al., 2006). The basic chromosome numbers $x = 10$ and $x = 11$ have been reported for the genus *Cornus*. For the species *C. mas*, $2n = 18, 27, 54$ were given (D'Amato, 1946; Ferguson, 1966); for some other species, $2n = 20, 22, 44$ were noted (Janick & Moore, 1975). Fossil plant remains of the genus *Cornus* have been known since the Cretaceous period. According to archaeological data, dogwood stones and wood, used in the manufacture of knife and sword handles, were first discovered in Bronze Age layers starting from the 2nd millennium BC during excavations of Celtic pile settlements on the territory of modern Switzerland.

The most widely used species is *Cornus mas* L. (comelian cherry), from which numerous semi-cultivated and cultivated forms and sorts were obtained. Comelian cherry is a shrub up to 4–5 m high, sometimes a tree up to 8 m high with wood as hard as horn, which is where the Latin name of the genus *Cornus comes* from. The wild *C. mas* is of Western Asian origin (Sinskaya, 1969; Wulff, 1987), distributed in the mountains of the Caucasus, Asia Minor, and Southern Europe, and the genotype of the species shows reliable polymorphism (Morozowska et al., 2013). The species is one of the first to begin flowering (approximately 10.02–03.04), and completes the growing season during October; it is also a good honey plant. The fruits of both wild *C. mas* and its forms and varieties are widely used as food in fresh and processed form (Araratyan, 1959; Klimenko, 2007). In addition, they are used as a medicine and also have a general strengthening, appetite-increasing, anti-cold and increased body resistance effect. In the folk culture of the Slavs, it was considered, on the one hand, as a ritual attribute, a locus of rituals and a folklore image, and on the other hand, as a symbol of health and longevity. On the territory of the Republic of Armenia, *C. mas* is the only representative of the genus (Fig. 1). Spe-

cies usually grows in small tracts in the lower mountain belt up to an altitude of 1000 m above sea level, in broad-leaved forests mainly with birch, beech, hornbeam, oak in the Lori, Ijevan, Zangezour and Megri floristic regions (Mulkidzhanyan, 1973; Gabrielian & Zohary, 2004; Gabrielian & Fragman-Sapir, 2008). In the “Habitats of Armenia” (Fayvush & Aleksanyan, 2016) this species is presented in the categories Eastern Mediterranean deciduous thickets (F3.245), shrub plantations for ornamental purposes or for fruit, other than vineyards (FB.3), oak forests with *Crataegus* spp. and *Cornus mas* (G1.A1D12–AM), oak forests with *Quercus araxina* (G1.A1D3–AM) and oak-hornbeam forests with *Quercus araxina* (G1.A733–AM). Significant work on the study of the culture of *C. mas* in Armenia was carried out by Naroyan (1969), who also collected 28 elite forms. However, at present, in homestead farms, as a rule, no more than 1–2 local forms and a number of introduced sorts of this species were noted, and the harvest is carried out by the population in the forests as well.

Palynological descriptions of pollen of the genus *Cornus* using light microscopy (LM), were given by a number of researchers (Yeramyan, 1967a, 1967b, 1971; Kuprianova, 1972; Avetisyan & Mekhakyian, 1973). Literature data on the study of the pollen morphology of the genus *Cornus* on the level of scanning electron microscopy (SEM), as well as transmission electron microscopy (TEM) were also noted (Ferguson, 1977; Ferguson & Hideux, 1978; Avetisyan et al., 2015).

When researching 19 pollen characters on five early diverging orders of Superasteridae (Berberidopsidales, Caryophyllales, Comales, Ericales, and Santalales) plus Dilleniales, for Comales and Ericales (Asteridae), including the genus *Cornus* also, 3 main characters were noted, namely, compound apertures, smooth aperture membranes, and the presence of costae (Yu et al., 2018). Studies on the pollen of comelian cherry cultivars have also been carried out (Mert, 2009), where the author pointed out the presence of differences in pollen shape, exine and intine thickness, as well as the perception of abnormal pollen grains.



Fig. 1. *Cornus mas*: a – general view, b – flowers, c – fruits

The purpose of this study was to present a detailed palynomorphological characteristic of the species *C. mas* of the Armenian flora using light microscopy (LM) and scanning electron microscopy (SEM), to clarify the disagreements noted in the literature regarding to the pollen aperture type for the species *C. mas*, as well as to conduct a comparative palynomorphological analysis of the genus *Cornus* as a whole (based on the literary data).

Material and methods

Unopened mature flower buds were obtained from the herbarium of the Institute of Botany after A. Takhtajyan of NAS of Republic of Armenia (ERE).

The descriptions of pollen grains by light microscopy (LM) for each investigated species are based on acetolyzed material (Avetisyan, 1950) and also on grains stained with basic fuchsin (Smolyaninova & Golubkova, 1950).

1. Method of staining with basic fuchsin. The essence of the method is the alcohol fixation of pollen grains, followed by the addition of a basic

fuchsin solution in 96% ethyl alcohol (the ratio of fuchsin to alcohol is approximately 1: 6000). After staining, without allowing the preparation to dry, the pollen is placed in glycerin jelly.

2. Simplified acetolysis method. The treatment of pollen grains with a mixture of acetic anhydride and sulfuric acid (in a ratio of 9: 1) is carried out directly on a glass slide, followed by heating until a light brown color appears. After cooling, the pollen is filled with glycerin jelly.

Seven morphological characters, namely the length of polar axis (P), as well as the length of equatorial diameter (E), length of colpi and paracolpi, apocolpium diameter, mesocolpium width and exine thickness, were measured. Measurements of the size of pollen grains and exine thickness were taken under light microscopy (AmScope 2000X LED, China, 2015) on 20 pollen grains for each specimen.

For scanning electron microscopy (SEM), non-acetolysed pollen grains were washed with alcohol and placed on a metal stub and sputter coated with gold (10 nm). Samples were imaged under SEM (JEOL JSM-6390, Japan, 2007), with a 15 kV electron beam. According to The Plant List (www.theplantlist.org), *C. mas* L. is an accepted species. The morphological terminology used in our study mainly follows

(Yeramyan, 1967a; Punt et al., 2007; Halbritter et al., 2018). On the whole, pollen morphological characteristics of two samples of species *C. mas* of the flora of Armenia were analyzed: Armenia: Ijevan distr., Abeghakar, Gabrielyan E., Oganezova G. (ERE, No. 148746); Georgia: Tiflis, in jugo Teleti, Grossheim A. (ERE, No. 3525).

Results

Cornus mas L. (Fig. 2, 3). Pollen grains 3-zonocolp-orate with paracolpi, range in shape from spheroidal to prolate, in outline from polar view triangular or rounded triangular; polar axis 17.2–27.5 μm , equatorial

diameter 21.1–23.7 μm . Colpi narrow, sometimes slit-like, colpus length 2/3–4/5 of polar axis; colpi costate, the maximum thickening of the exine around the colpi was observed in the equatorial region at the intersection of the colpus and os (Fig. 2a–c); colpus membrane irregularly granulate (SEM); apocolpium diameter 4.5–5.7 μm , mesocolpium width 14.9–17.5 μm . Paracolpi colp-shaped, the length of paracolpi approximately 1/2 of colpi. Os small, elliptical, reaching to paracolpi, forming together butterfly-like (Fig. 2d) or H-shape (Fig. 2e) endexine thinnings. Exine 1.3–1.5 μm , columellae separate, thick, capitate. Exine ornamentation verrucate (LM); exine ornamentation densely verrucate with rare perforations, verrucae varying in size (SEM).

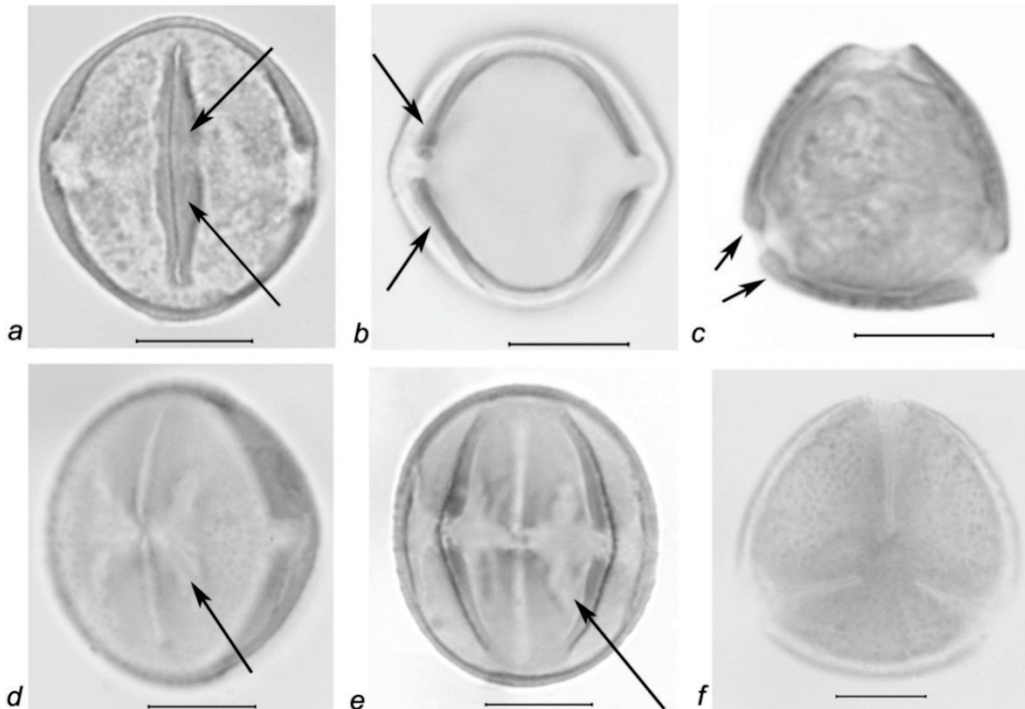


Fig. 2. Pollen grains of *Cornus mas* L. (LM micrographs): *a, b* – equatorial view, costa colpus (marked with arrows); *c* – polar view, costa colpus (marked with arrows); *d, e* – equatorial view (pollen with butterfly-like (*d*) or H-shaped (*e*) endexine thinning complex, marked with arrows); *f* – polar view, exine ornamentation; scale bar 10 μm

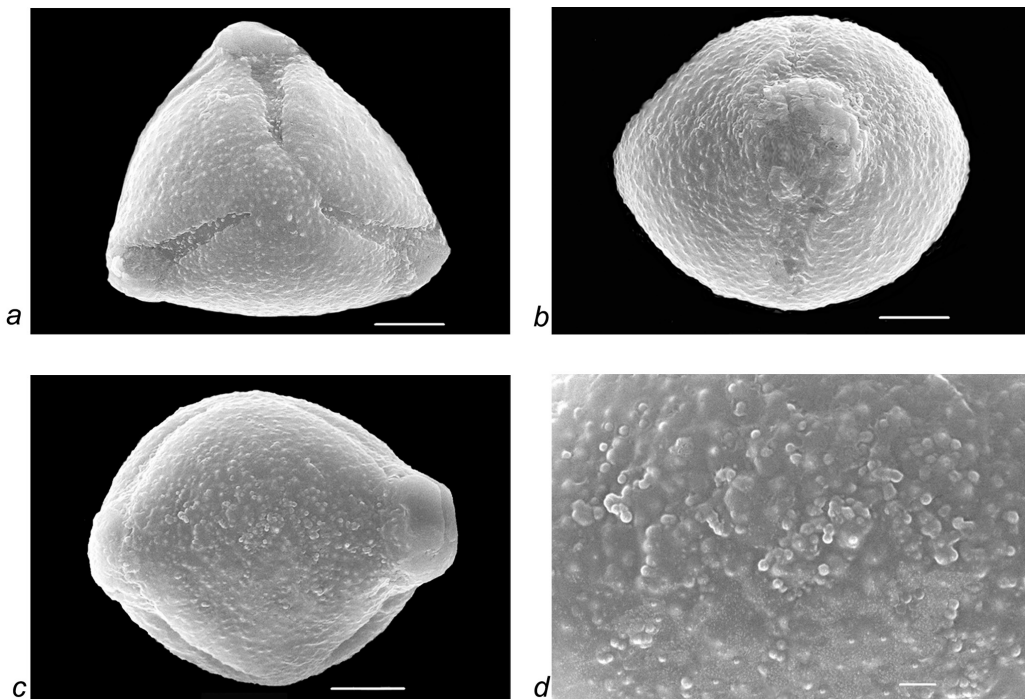


Fig. 3. Pollen grains of *Cornus mas* L. (SEM micrographs): *a* – polar view; *b, c* – equatorial view (*b* – colpus, *c* – mesocolpium); *d* – exine ornamentation; scale bar: *a–c* – 5 μm , *d* – 1 μm

Table 1
Some palynological features of the genus *Cornus* L. (“–” – no data available)

Species	Aperture type	Colpus	Pollen size		Exine, μm	Exine ornamentation		Authors
			P, μm	E, μm		LM	SEM	
<i>C. alba</i> L.	3-colporate	about 55.0 μm	60.0	45.0	1.5–2.5	mainly verrucate	–	Erdtman et al. (1961)
<i>C. alba</i>	3-zonocolporate with indistinct complex H-shaped endoaperture	long, with small fastigium	64.5	43.5	up to 2.0	–	scabrate	Stafford & Heath (1991)
<i>C. alsophila</i> W. W. Sm.	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	70.0	54.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. alternifolia</i> L.f.	same as above	same as above	55.3	42.4	about 1.0	same as above	–	Ferguson (1977)
<i>C. amomum</i> Mill.	3-colporate	–	68.0	49.0	–	–	–	Erdtman (1952)
<i>C. amomum</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	65.8	50.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. asperifolia</i> Michx.	same as above	same as above	54.7	42.3	about 1.0	same as above	–	Ferguson (1977)
<i>C. boliviana</i> J. F. Macbr.	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	48.0	45.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. brachypoda</i> C. A. Mey.	same as above	same as above	44.5	33.7	about 1.0	same as above	–	Ferguson (1977)
<i>C. canadensis</i> L.	tricolpate with germinal aperture	long	28.1	33.1	–	finely granular	–	Chao (1954)
<i>C. canadensis</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	26.8	22.8	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. capitata</i> Wall.	same as above	same as above	25.5	24.2	about 1.0	same as above	–	Ferguson (1977)
<i>C. chinensis</i> Wangerin	tricolpate with germinal aperture	long	25.5	26.4	–	granular	–	Chao (1954)
<i>C. chinensis</i>	3-colp-porate with paracolpi, pores oblate, connected to paracolpi	long	23.1	24.7	1.6	granulate	–	Yeramyan (1967a, 1971)
<i>C. chinensis</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	25.2	22.3	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. controversa</i> Hemsl.	tricolpate with germinal aperture	long	30.6	38.3	–	finely granular	–	Chao (1954)
<i>C. controversa</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	54.7	41.8	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. controversa</i>	tricolporate	–	–	–	–	–	microechinate, perforate	Weber et al. (2020)
<i>C. coreana</i> Wangerin	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	61.0	48.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. disciflora</i> Moc. & Sessé ex DC.	same as above	same as above	28.3	26.6	about 1.0	same as above	–	Ferguson (1977)
<i>C. drummondii</i> C. A. Mey.	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	52.0	41.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. excelsa</i> Kunth	same as above	same as above	62.5	45.5	about 1.0	same as above	–	Ferguson (1977)
<i>C. floccosa</i> Wangerin	same as above	same as above	27.5	26.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. florida</i> Hook.	tricolpate with pore	long, almost from pole to pole	37.0	34.0	subxineous thickening bordering the colpi	finely granular	–	Wodehouse (1935)
<i>C. florida</i>	3-colporate	–	38.0	31.0	–	–	–	Erdtman (1952)
<i>C. florida</i>	tricolpate with germinal aperture	long	30.8	38.3	–	finely granular to nearly smooth	–	Chao (1954)
<i>C. florida</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	33.8	28.4	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. florida</i>	tricolporate	–	25.1	33.0	–	psilate	–	Weber et al. (2020)
<i>C. foemina</i> Mill.	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	48.5	38.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. glabrata</i> Benth.	same as above	same as above	59.0	44.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. hemsleyi</i> C. K. Schneid. & Wangerin	same as above	same as above	68.0	46.5	about 1.0	same as above	–	Ferguson (1977)
<i>C. hongkongensis</i> Hemsl.	tricolpate with germinal aperture	long	25.5	29.3	–	finely granular	–	Chao (1954)
<i>C. hongkongensis</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	26.2	26.5	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)

Species	Aperture type	Colpus	Pollen size		Exine, μm	Exine ornamentation		Authors
			P, μm	E, μm		LM	SEM	
<i>C. kousa</i> Buerger	tricolpate with germinal aperture	long	28.1	30.6	–	finely granular	–	Chao (1954)
<i>C. kousa</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	28.5	26.2	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. kousa</i>	tricolporate	–	25.1	28.0	–	gemmate, verrucate	–	Weber et al. (2020)
<i>C. longipetiolata</i> Hay.	tricolpate with germinal aperture	long	38.3	40.8	–	finely granular	–	Chao (1954)
<i>C. macrophylla</i> Wall.	tricolporate	colpus long	41.6	38.6	2.5	scabrate, subpsilate	–	Perveen & Qaiser (2002)
<i>C. mas</i> L.	3-colporate	–	27.0	21.0	–	–	–	Erdtman (1952)
<i>C. mas</i>	tricolporoidate	–	28.5	27.5	–	scabrate	–	Straka (1954)
<i>C. mas</i>	tricolpate with germinal aperture	long	25.5	26.4	–	granular	–	Chao (1954)
<i>C. mas</i>	3-colporate with paracolpi, pores oblate, connected to paracolpi	long, with costae	24.1 in diameter	24.1 in diameter	0.7	verrucate	–	Yeramyan (1967a, 1971)
<i>C. mas</i>	3-colporate with paracolpi	long, with costae	27.9	25.2	1.7	microreticulate	–	Kuprianova (1972)
<i>C. mas</i>	3-colporate	–	–	–	–	granulate	–	Avetisyan & Mekhakyn (1973)
<i>C. mas</i>	3-zonocolporate with complex H-shaped endoaperture	long, with small fastigium	28.0	21.5	1-2	–	finely scabrate	Stafford & Heath (1991)
<i>C. mas</i>	tricolporate	–	23.0	23.0	–	psilate	microrugulate, microechinate	Weber et al. (2020)
<i>C. monbeigii</i> Hemsl.	tricolpate with germinal aperture	long	51.7	66.7	–	finely granular	–	Chao (1954)
<i>C. monbergii</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	81.0	48.5	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. nuttallii</i> Audubon	same as above	same as above	32.7	28.2	about 1.0	same as above	–	Ferguson (1977)
<i>C. oblonga</i> Wall.	tricolpate with germinal aperture	long	26.9	31.8	–	finely granular	–	Chao (1954)
<i>C. oblonga</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	33.3	31.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. officinalis</i> Sieb. & Zucc.	3-colporate with paracolpi, pores oblate, connected to paracolpi	long	20.0	21.0	1.0	granulate	–	Yeramyan (1967a, 1971)
<i>C. officinalis</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	23.7	22.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. paucinervis</i> Hance	same as above	same as above	71.5	48.5	about 1.0	same as above	–	Ferguson (1977)
<i>C. peruviana</i> J. F. Macbr.	same as above	same as above	35.0	33.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. poliophylla</i> C.K. Schneid. & Wangerin	same as above	same as above	62.0	45.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. rugosa</i> Lam.	same as above	same as above	59.0	41.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. sanguinea</i> L.	3-colporate	–	67.0	54.0	–	–	–	Erdtman (1952)
<i>C. sanguinea</i>	tricolporoidate	–	52.0	44.0	–	weakly verrucate	–	Straka (1954)
<i>C. sanguinea</i>	3-colporate	about 55.0 μm	60.0	45.0	1.5-2.5	mainly verrucate	–	Erdtman et al. (1961)
<i>C. sanguinea</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	73.7	53.0	about 1 μm	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. sanguinea</i>	3-colpate	–	more than 50	–	–	scabrate perforate	–	Faegri & Iversen (1989)
<i>C. sanguine</i>	3-zonocolporate with indistinct complex H-shaped endoaperture	long, with small fastigium	63.0	48.0	up to 2.0	–	scabrate	Stafford & Heath (1991)
<i>C. sanguine</i>	tricolporate	–	75.5	75.5	–	gemmate, verrucate, scabrate	perforate, microechinate	Weber et al. (2020)
<i>C. sericea</i> L.	3-zonocolporate with indistinct complex H-shaped endoaperture	long, with small fastigium	66.0	45.0	up to 2.0	–	scabrate	Stafford & Heath (1991)
<i>C. sericea</i>	tricolporate	–	45.5	45.5	–	scabrate	–	Weber et al. (2020)
<i>C. sessilis</i> Torr.	3-colporate with paracolpi, pores oblate, connected to paracolpi	long	26.0	24.0	0.8	granulate	–	Yeramyan (1967a, 1971)
<i>C. sessilis</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	23.0	24.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. stolonifera</i> Michx.	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	61.5	43.9	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)

Species	Aperture type	Colpus	Pollen size		Exine, μm	Exine ornamentation		Authors
			P, μm	E, μm		LM	SEM	
<i>C. suecica</i> L.	3-colporate	–	30.0	24.0	–	–	–	Erdtman (1952)
<i>C. suecica</i>	tricolpate with germinal aperture	long	25.5	25.9	–	finely granular	–	Chao (1954)
<i>C. suecica</i>	tricolporoidate	–	28.0	23.5	–	scabrate	–	Straka (1954)
<i>C. suecica</i>	3-colporate, ora circular	–	26.0	21.0	0.5-1.0	“granulate”	–	Erdtman et al. (1961)
<i>C. suecica</i>	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	31.3	27.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. suecica</i>	3-colpate	–	less than 25	–	–	microverrucate	–	Faegri & Iversen (1989)
<i>C. suecica</i>	3-zonocolporate with distinct complex H-shaped endoaperture	long, with small fastigium	28.5	22.0	1-2	–	finely scabrate	Stafford & Heath (1991)
<i>C. ulotricha</i> C. K. Schneid. & Wangerin	3(4)-colporate, endoaperture (os) a complex of H-shape thinnings	with costae, 2/3 to 3/4, or \pm equal in length to polar axis	43.0	34.0	about 1.0	granulate or spinulate, sometimes with perforations	–	Ferguson (1977)
<i>C. unalaschkensis</i> Ledeb.	same as above	same as above	31.0	28.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. walteri</i> Wangerin	same as above	same as above	60.3	39.0	about 1.0	same as above	–	Ferguson (1977)
<i>C. wilsoniana</i> Wangerin	same as above	same as above	53.0	41.5	about 1.0	same as above	–	Ferguson (1977)

Discussion

When studying the morphological characteristics of pollen in literary sources, discrepancies in characterizing the type of apertures in the pollen of the genus *Cornus*, including the species *C. mas* were revealed. In particular, the following aperture types were noted: tricolpate with costae colpi (Faegri & Iversen, 1989), tricolpate with germ pore and subexinous thickening bordering the furrows (Wodehouse, 1935), tricolpate with germinal aperture, elliptical in outline (Chao, 1954), 3-zonocolporate (Erdtman, 1952; Stafford & Heath, 1991; Weber et al., 2020), sometimes colpi with vestibula and ora circular distinct (Perveen & Qaiser, 2002), 3-colp-porate (Avetisyan & Mekhakyian, 1973) (Table 1).

On the other hand, for the pollen grains of a few representatives of the family Cornaceae, including the genus *Cornus*, some authors noted the presence of paracolpi, i.e. colp-shape parts of thinned endexine, located on both sides of the colpi (Yeramyian, 1967a, 1967b, 1971). Later, within the limits of the genus *Cornus*, the presence of oncuses under the pores and paracolpi were also revealed (Kuprianova, 1972). When studying the pollen of the Cornaceae family using LM, SEM and TEM, a number of species of the genus *Cornus*, as well as *C. mas*, were included in the *Cornus*-type or *Cornus mas*-subtype (Ferguson, 1977; Ferguson & Hideux, 1978). These species were characterized by more or less spheroidal pollen grains averaging 25.0 μm in diameter, colpi with costae and endoapertures (os) as the “complex H-shape thinning comprised of a “pore” 4–6 \times 4–5 μm , joining two lateral thinning which are parallel to the colpus” (Ferguson, 1977, p. 5). Subsequently, when studying the pollen of 5 species of the genus *Cornus*, two morphological types were identified (Stafford & Heath, 1991). The species *C. mas*, together with the species *C. suecica*, were included into the *Cornus mas* type, which differs from representatives of the *Cornus sanguinea* type (namely *C. alba*, *C. sanguinea*, *C. sericea*) by predominantly smaller pollen grains, as well as by the presence of a distinct H-shaped endoaperture. The results of demarcation were consistent with the previously reported data (Straka, 1954), where the main distinguishing characteristics between the first two species listed above and the species *C. sanguinea* are the size of the pollen grains, as well as the exine ornamentation (Table 1, Fig. 4–9).

It was also revealed that pollen grains to their size (Erdtman, 1952) were predominantly large or of medium size, rarely small. The large pollen grains were noted for *C. alba* L., *C. alsophila* W. W. Sm., *C. alternifolia* L.f., *C. anomum* Mill., *C. asperifolia* Michx., *C. controversa* Hemsl., *C. coreana* Wangerin, *C. drummondii* C. A. Mey., *C. excelsa* Kunth, *C. glabrata* Benth., *C. hemsleyi* C. K. Schneid. & Wangerin, *C. monbeigii* Hemsl., *C. paucinervis* Hance, *C. poliophylla* C. K. Schneid. & Wangerin, *C. rugosa* Lam., *C. sanguinea* L., *C. sericea* L., *C. stolonifera* Michx., *C. walteri* Wangerin, *C. wilsoniana* Wangerin. Medium pollen size is typical for *C. boliviana* J. F. Macbr., *C. brachypoda* C. A. Mey., *C. canadensis* L., *C. capitata* Wall., *C. chinensis* Wangerin, *C. controversa*,

C. disciflora Moc. & Sessé ex DC., *C. floccosa* Wangerin, *C. florida* Hook., *C. foemina* Mill., *C. hongkongensis* Hemsl., *C. kousa* Buerger, *C. longipetiolata* Hay., *C. macrophylla* Wall., *C. mas* L., *C. nuttallii* Audubon, *C. oblonga* Wall., *C. peruviana* J. F. Macbr., *C. sericea*, *C. sessilis* Torr., *C. suecica* L., *C. ulotricha* C. K. Schneid. & Wangerin, *C. unalaschkensis* Ledeb.

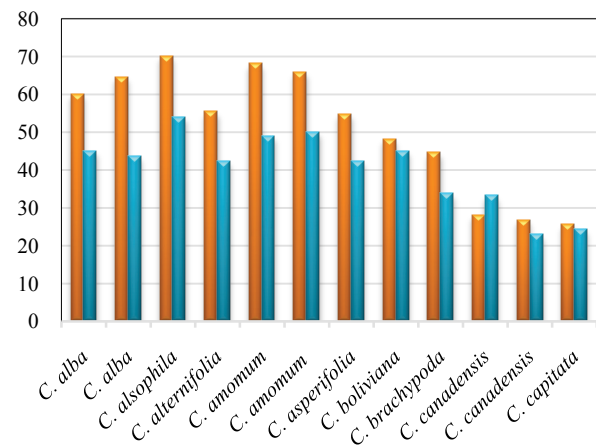


Fig. 4. Pollen grains sizes in the genus *Cornus* L.: orange – polar axis (P), blue – equatorial diameter (E)

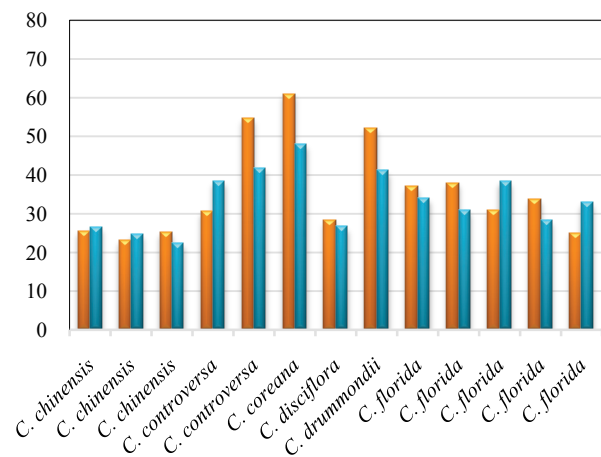


Fig. 5. Pollen grains sizes in the genus *Cornus* L.: orange – polar axis (P), blue – equatorial diameter (E)

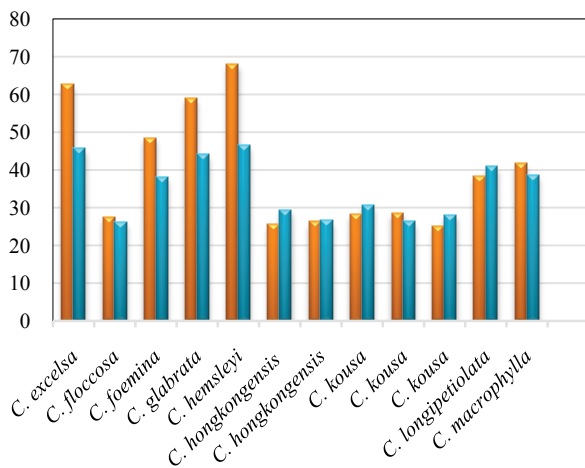


Fig. 6. Pollen grains sizes in the genus *Cornus* L.: orange – polar axis (P), blue – equatorial diameter (E)

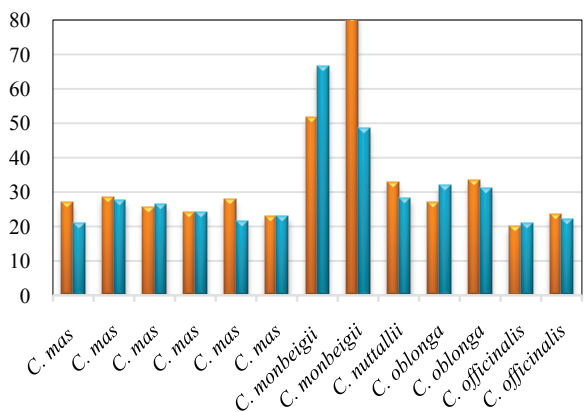


Fig. 7. Pollen grains sizes in the genus *Cornus* L.: orange – polar axis (P), blue – equatorial diameter (E)

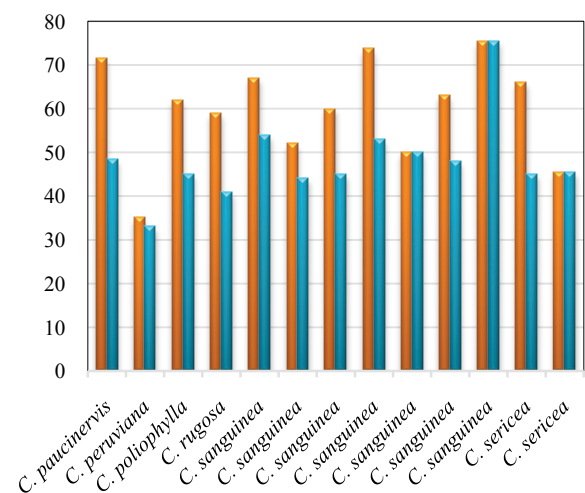


Fig. 8. Pollen grains sizes in the genus *Cornus* L.: orange – polar axis (P), blue – equatorial diameter (E)

The largest pollen grains noted for the species *C. monbergii*, where $P \times E = 81.0 \times 48.5 \mu\text{m}$ (Ferguson, 1977) and the smallest ones for *C. officinalis*, where $P \times E = 20.0 \times 21.0 \mu\text{m}$ (Yeremyan, 1967a, 1971) (Table 1, Fig. 7). It should also be noted that data on the sizes of pollen grains of the widely studied species are generally quite close.

The results of our research on the species *C. mas* of the flora of Armenia are consistent with the data provided by a number of authors (Yeremyan, 1967a; Ferguson, 1977; Stafford & Heath, 1991) about the size of pollen grains (medium or almost medium), as well as the presence of the quite rare compound pollen aperture type. This aperture type is formed by a combination of the colpus with a peculiar endoaperture complex, consisting of a small oblong os and paracolpi, located on both sides of the colpi. In our opinion, both the os and the paracolpi arose due to the thinning or complete absence of the internal layers of the exine.

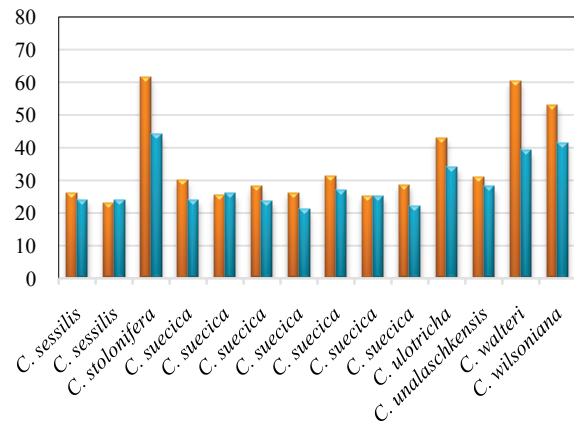


Fig. 9. Pollen grains sizes in the genus *Cornus* L.: orange – polar axis (P), blue – equatorial diameter (E)

On the other hand, an extensive analysis of the literature data on pollen of 42 species of the genus *Cornus* revealed, first of all, the significant differences in the characteristics of the aperture types not only at the interspecific, but also at the intraspecific level. Thus, in a number of the most frequently studied species of the genus *Cornus*, particularly *C. florida*, the presence of 3(4)-colporate apertures with endoaperture as a complex of H-shape thinnings were noted only once (Ferguson, 1977). According to other authors (Erdtman, 1952; Chao, 1954; Weber et al., 2020), pollen of this species is 3(4)-colporate, or tricolporate with germinal aperture. The same was noted for the species *C. kousa*. Most often, the above mentioned compound pollen aperture type with paracolpi was given for the species *C. chinensis* (Yeremyan, 1967a, 1971; Ferguson, 1977), *C. mas* (Yeremyan, 1967a, 1971; Kuprianova, 1972; Stafford & Heath, 1991), *C. sanguinea* (Ferguson, 1977; Stafford & Heath, 1991) and *C. suecica* (Ferguson, 1977; Stafford & Heath, 1991). Exine ornamentation as a rule is represented by a number of primitive types, namely, scabrate, rugulate, verrucate, granulate, echinate, etc., sometimes with perforations.

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