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ARTICLE

Pollen morphological diversity in the genus *Acer* L. (Sapindaceae) in Iran

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ABSTRACT Pollen grains of 19 specimens (representing 8 species, 6 subspecies, 3 sections) of the genus *Acer* L. distributed in Iran were investigated by scanning electron microscopy. Most of pollen grains were 3-zonocolpate, prolate. Based on exine sculpturing pattern, five types are distinguished: striate (frequent type), rugulate, reticulate, granular and smooth. Twenty-four pollen characters were examined by multivariate analysis. The result of multivariate analysis and exine sculpturing pattern indicated high diversity among different specimens even in specimens of a single species. Due to instability of pollen characters between and within studied specimens, they are not useful in delimitation of species, subspecies and sections. Only three species (*A. velutinum*, *A. negundo*, and *A. mazandaranicum*) were separated from other overlapping species. Pollen morphology does not confirm separation of subspecies and varieties in *A. monspessulanum* and *A. velutinum*.
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Introduction

The genus *Acer* L. belongs to Sapindaceae family and comprises 124-156 species (van Gelderen et al. 1994; de Jong 2004). This genus has 16 sections in recent classification (van Gelderen et al. 1994). The genus is easily recognized by opposite leaves and samaras fruit. However, other morphological characters are highly diversified. Due to morphological diversity, many varieties and forms were generated that makes the genus taxonomically very difficult (Delendick 1990; Park et al. 1993; Judd et al. 2002).

The *Acer* species does not produce large quantities of pollen (de Jong 1994). The pollens are generally tricolpate, isopolar and prolate to nearly spheroidal (de Jong 1994). Several studies have been conducted using light microscopy and SEM in order, to describe pollen grain features in the genus (Philbrick and Bogel 1981; Wodehouse 1935; Erdtman 1952; Praglowsk 1962; Helmish 1963; Biesboer 1975; Pozhidaev 1993; Gogichaishvili 1964; Loma et al. 2015). The results revealed high degree of diversity in pollen morphological characters even in populations of a single species (Philbrick and Bogle 1981). However, Loma et al. (2015) indicated the importance of pollen characters in identification and taxonomy of some *Acer* species in Himalayas. Four pollen types have been recognized in the genus *Acer* based on exine ornamentation including striate, rugulose, granular, and microreticulate (Biesboer 1975). Moreover, Pozhidaev (1995) indicated that pollen characteristics in *Aesculus* correspond to the sectional division. Also, natural polymorphism and deviation from typical forms have been observed in this genus (Dzyuba et al. 2006; Pozhidaev 1993). In Iran, the genus *Acer* comprises of 8 species: 6 species based on Flora Iranica (Murray 1969), one is newly recorded by Maroofi and Sharifi (2006), and another one is newly reported by Amini et al. (2008).

The genus consists of two main centers of distribution in Iran, namely Alborz (Northern Iran) and Zagros (Northwest to Southeast Iran). *A. velutinum* (with two varieties), *A. mazandaranicum*, *A. cappodocicum*, *A. hyrcanum*, *A.campestre*, *A. platanoides* and *A. monspessulanum* (with five subspecies) grow in both Alborz (*A. monspessulanum* subsp. *ibericum* & *turcomanicum*) and Zagros (*A. monspessulanum* subsp. *assyriacum*, *A. monspessulanum* subsp. *persicum*, *A. monspessulanum* subsp. *cinerascence*) (Murray 1969). *A. negundo* (sec. *negundo*) was introduced and cultivated as an ornamental tree.

The Iranian *Acer* species belong to section *Acer* (*A. velutinum*, *A. monspessulanum*, *A. hyrcanum)* and section *Platanoidea (A. cappadocicum*, *A. platanoides*, and *A. campestre)*. These sections are considered highly diverse, regard

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Table 1. *Acer* species and their localities.

Features	Locality*	Voucher number
A. hyrcanum	Gilan pr., Talesh	Pouramini 4028 (HSBU)
A. mazandaranicum	Gilan pr., Talesh	Pouramini 4029 (HSBU)
A. campestre	Gilan pr., Talesh	Pouramini 4022 (HSBU)
A. campestre	Mazandaran pr.	Assadi 78725 (TARI)
A. cappodocicum	Mazandaran pr.	Nikzat 4031 (HSBU)
A. cappodocicum	Gilan pr., Talesh	Poramini 4030 (HSBU)
A. platanoides	Gilan pr., Talesh	Pouramini 4024 (HSBU)
A. velutinum var. *velutinum*	Mazandaran pr.	Nikzat 4036 (HSBU)
A. velutinum var. *velutinum*	Gilan pr., Lahijan	Esfandani 4035 (HSBU)
A. velutinum var. *glabrescense*	Golstan pr., Gorgan	Nikzat 4034 (HSBU)
A. velutinum var. *glabrescens*	Mazandaran pr.	Nikzat 4033 (HSBU)
A. velutinum var. *velutinum*	Gilan pr., Siahkal	Nikzat 4032 (HSBU)
A. monspessulanum subsp. *turcomanicum*	North Khorasan pr., NE Shirvan	Joharchi 4025 (HSBU)
A. monspessulanum subsp. *persicum*	Kerman pr., Deh Bakri, Nayyer Mt.	Assadi 15940 (TARI)
A. monspessulanum subsp. *cinerascens*	Lorestan pr., Delfan	Masoumi 4027 (HSBU)
A. monspessulanum subsp. *cinerascens*	Kermanshah pr.	Masoumi 4026 (HSBU)
A. monspessulanum subsp. *cinerascens*	Isfahan pr., Semirom	Assadi 2044 (HSBU)
A. monspessulanum subsp. *ibericum*	Mazandaran pr., Siah Bisheh	Nikzat 4037(HSBU)
A. negundo	Tehran pr., Shahid Beheshti Univ.	Nikzat 4023 (HSBU)

* pr. = province; Mt. = Mountain

to molecular and morphological characteristics (Grimm and Denk 2013). Given to lack of our knowledge about pollen morphology of Iranian *Acer* species, we aim to: (I) describe pollen characters in Iranian *Acer* and (II) evaluate taxonomic importance of palynological data. We will compare our result with the data available from the earlier investigations in three sections; *Parviflora*, *Rubra* and *Macrantha* (Philbrick and Bogle 1981).

Materials and Methods

Pollen grains of 19 populations were studied by scanning electron microscope (SEM) in the following *Acer* species: *A. campestre* L., *A. velutinum* Boiss (var. *velutinum* & var. *glabrescense*), *A. cappadocicum* Gled, *A. hyrcanum* Fisch & C. A. Mey, *A. monspessulanum* (subsp. *cinerascence*, subsp *ibericum*, subsp. *turcomanicum*, subsp. *ibericum*, subsp. *persicum*), *A. platanoides* L., *A. mazandaranicum*, and *A. negundo* (cultivated species in Iran). The pollen samples were obtained mostly from fresh plant materials as well as from herbarium materials. Voucher specimens have been deposited in Shahid Beheshti University Herbarium (HSBU) and herbarium of Iran's Research Institute of Forests and Rangelands (TARI) (Table 1). Small quantities of pollen were attached to aluminum stubs with double-sided cellophane tape and coated with goal. The specimens were examined with a Phillips × L20 SEM. UTHSCSA Image Tool Version 3.0 was used to carry out required measurements. Statistical analysis including PCOA and PCA were performed using PAST software for plotting variation among populations and species (Hammer et al. 2001).

Ten to 30 fully developed pollen grains were randomly selected for analysis. Eleven quantitative and 13 qualitative palynological features were used for multivariate analysis including pattern of sculpturing (SC), type of branching in lira (BT), situation of lira after branching (SB), width ratio of lira & stria (WR), arrangement of lira to each other (AL), arrangement of lira to polar axis (ALP), shape of pit (SP), size of pit (SZP), distribution of pits (DP), regular of lira arrangement (RL), having resembling leaf venation (LV), width of mesocolpium (WM), width of lira (WL), length of colpus (LC), ratio of width in two ends of mesocolpium (RWE), number of lira in 25 μm^2 area (NL), polar axis length (P), equatorial axis length (E), ratio of polar axis to equatorial axis (P/E), number of branches in 25 μm^2 area (NB), number of pit in 25 μm^2 area (NP), ratio of colpus/P (RCP), shape of pollen (SP) (Table 2). Principal Components Analysis (PCA) was performed among the specimens to determine palynological features useful for separating the species. In order, to group the species, cluster analysis using UPGMA (Unweighted Paired Group with Arithmetic Average) methods and PCA ordination plot were performed using Euclidean and taxonomic distance among the species was calculated (Podani 2000). Exine sculpture elements were measured on the

Table 2. Details of examined characters of *Acer* specimens in this study.

Specimen	SC*	BT*	SB*	WR*	AL*	ALP*	SP	SZP	DP	WM	RL*	LV*LV*
A. hyrcanum	Type I-A	2	1	3	1	2	1	1	1	3	1	1
A. mazandaranicum	Type I-A	2	1	3	3	4	1	1	1	1	2	3
A. campestre	Type I-B-1	2	1	3	2	4	2	2	2	1	1	1
A. cappodocicum	Type I-B-2	1	2	2	3	2	2	3	3	3	2	1
A. cappodocicum	Type I-A	2	1	3	2	2	2	1	1	2	1	1
A. platanoides	Type I-B-1	1	1	3	3	4	1	2	2	4	2	1
A. velutinum var. *velutinum*	Type I-B-2	2	1	2	1	4	2	3	3	4	2	2
A. velutinum var. *velutinum*	Type I-B-2	2	1	1	2	1	3	2	3	3	1	3
A. velutinum var. *glabrescense*	Type I-B-3	1	2	2	3	3	3	2	3	4	2	2
A. velutinum var. *glabrescense*	Type I-B-2	2	2	2	1	1	3	3	3	4	1	3
A. velutinum var. *velutinum*	Type I-B-2	2	1	2	1	1	3	3	3	2	1	3
A. monspessulanum subsp. *turcomanicum*	Type I-B-3	1	1	2	3	4	3	3	3	2	2	1
A. monspessulanum subsp. persicum	Type I-B-1	2	1	3	2	4	3	2	2	4	2	1
A. monspessulanum subsp. *cinerascens*	Type I-B-2	1	2	2	3	2	1	3	3	4	2	2
A. monspessulanum subsp. *cinerascens*	Type I-B-2	1	1	1	2	4	3	2	3	1	2	2
A. monspessulanum subsp. *cinerascens*	Type I-B-2	2	2	1	2	2	1	2	2	2	1	1
A. monspessulanum. subsp. *ibericum*	Type II-B	1	1	3	3	4	1	2	2	1	2	2
A. negundo	Type II-A &III	1	1	3	3	4	1	1	1	1	2	2

Specimen	WMM*	WL	LC	RWE	NL	P	E	P/E*	NB	NP	RCP	SP
A. hyrcanum	13.77±1.7	1.9±0.2	34.08±1.56	0.94	12	41.12±2.17	21.61±1.58	1.9	3	0	0.83	1
A. mazandaranicum	15.43±1.25	1.58±.03	35.04±1.13	0.89	10	42.34±1.84	20.16±2.01	2.1	5	0	0.83	2
A. campestre	19.56±1.56	1.57±0.4	31.76±6.16	0.91	10	43.22±4.49	28.93±3.96	1.49	10	14	0.73	1
A. cappodocicum	18.34±1.61	1.29±0.24	46.52±.55	0.82	9	59.62±2.03	31.99±4	1.86	5	27	0.78	1
A. cappodocicum	35.79±1.73	1.34±0.04	42.4±2.89	0.82	12	50.78±3.56	35.79±2.24	1.41	3	0	0.83	1
A. platanoides	16.76±1.89	0.97±0.08	46.87±3.19	088	11	48.09±3.41	26.66±2.12	1.8	9	25	0.97	1
A. velutinum var. *velutinum*	19.41±1.45	1.21±0.22	45.83±2.94	0.76	12	53.67±3.81	29.66±1.01	1.8	2	39	0.85	1
A. velutinum var. *velutinum*	18.52±1.84	1.24±0.45	43.74±3.30	0.82	13	52.63±2.12	27.18±0.96	1.93	4	33	0.85	1
A. velutinum var. *glabrescense*	19.19±1.55	1.01±0.42	47.64±4.61	0.9	11	64±2.04	29.43±2.72	2.17	9	48	0.74	2
A. velutinum var. *glabrescense*	22.65±2.67	0.95±0.18	47.65±4.61	0.94	14	59.66±3.15	34.81±4.19	1.71	13	29	0.8	1
A. velutinum var. *velutinum*	18.96±1.68	1.32±0.14	48.41±2.48	0.85	11	60.43±1.92	30.65±1.47	1.97	5	43	0.8	1
A. monspessulanum subsp. *turcomanicum*	15.68±1.52	1.01±0.33	43.87±2.58	0.72	10	51.33±3.25	26.14±1.61	1.96	27	80	0.85	1
A. monspessulanum subsp. *persicum*	20.76±2.34	1.15±0.15	47.42±2.03	0.91	12	53.74±1.52	32.94±2.58	1.63	5	10	0.88	1
A. monspessulanum subsp. *cinerascens*	20.23±1.89	1.48±0.62	48.49±1.94	0.69	10	52.31±2.17	28.87±1.22	1.81	5	22	0.93	1
A. monspessulanum subsp. *cinerascens*	13.27±1.87	1.11±0.13	45.7±2.13	0.9	11	52.65±3.14	26.73±1.01	1.96	10	24	0.87	1
A. monspessulanum subsp. *cinerascens*	17.98±1.51	1.4±0.53	45.87±1.84	0.69	13	49.85±1.89	26.45±1.46	1.88	7	35	0.92	1
A. monspessulanum subsp. *ibericum*	9.41±2.19	1.21±0.39	35.91±2.29	0.94	12	43.06±1.58	18.19±1.65	2.36	13	27	0.83	2
A. negundo	13.43±1.16	1.22±0.45	31.07±1.96	0.84	11	38.88±1.62	23.67±1.52	1.64	25	0	0.8	1

SC: Pattern of sculpturing of pollen; BT: type of branching in lira (1: short and branched, 2: long and branched); SB: situation of lira after branching (1: close to each other, 2: far from each other); WR: width ratio of lira & stria (1: equal, 2: stria wider than lira, 3: lira wider than stria); AL: arrangement of lira to each other (1: parallel, 2: semi-parallel, 3: intersection); ALP: arrangement of lira to polar axis (1: parallel, 2: semi-parallel, 3: perpendicular, 4: variously arranged); SP: shape of pit (1: lack pit, 2: roundish, 3: roundish sometime elliptic); SZP: size of pit (1: lack pit, 2: similar diameter, 3: different diameter); DP: distribution of pits (1: lack pit, 2: sparse, 3: numerous); RL: regular of lira arrangement (1: regular, 2: irregular); LV: having resembling leaf venation (1: not having, 2: having in two pole, 3: having in one pole); WMM: width of mesocolpium (1: equal in throughout length, 2: narrow in one pole, 3: equal in two pole (pole acute) and wider in middle, 4: equal in two pole (pole wide) and wider in middle); WL: width of lira (µm); LC: length of colpus (µm); RWE: ratio of width in two ends of mesocolpium; NL: number of lira in 25 µm^2 area; P: polar axis length (µm); E: equatorial axis length (µm); P/E: ratio of polar axis to equatorial axis; NB: number of branches in 25 µm^2 area; NP: number of pit in 25 µm^2 area; RCP: ratio of colpus/P; SP: shape of pollen (1: prolate, 2: preprolate).

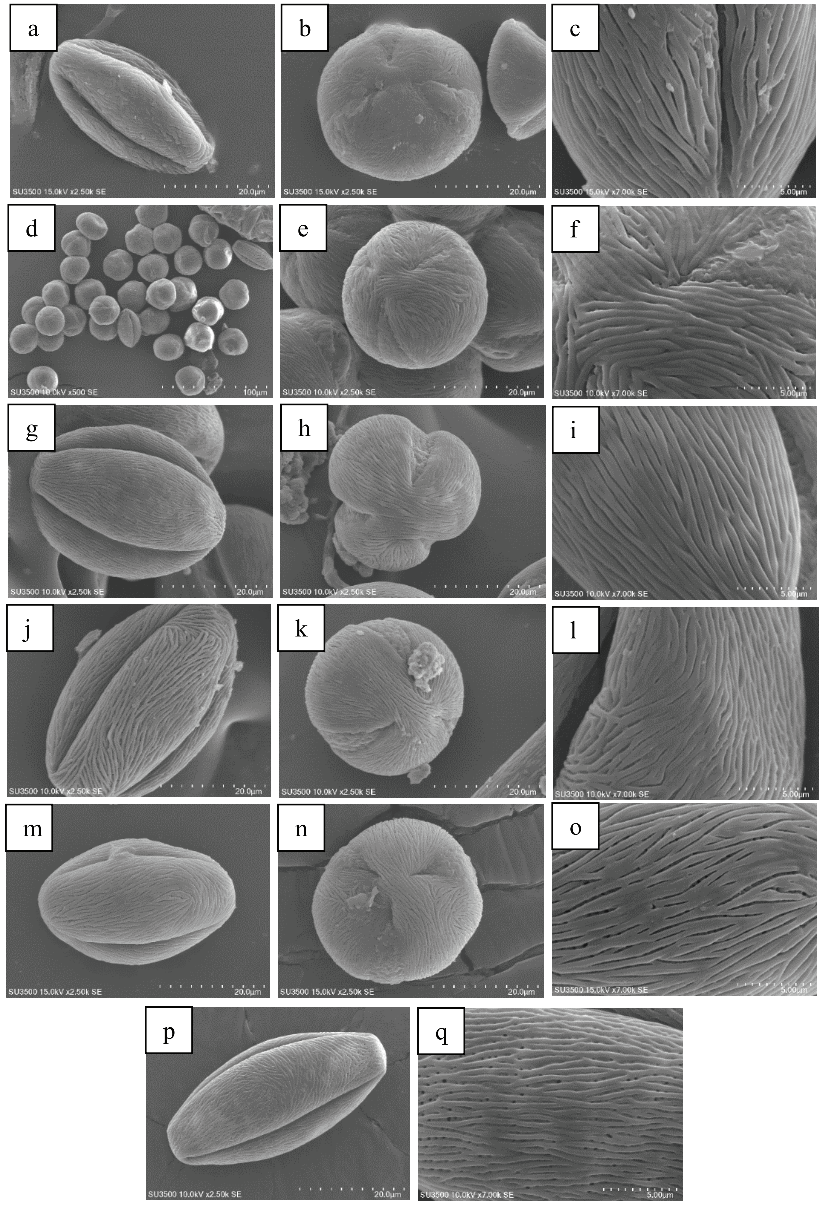

Figure 1. SEM micrographs of pollen grains in *Acer* sp. type I-A: (a-c) *A. hyrcanum*, (d-f) *A. mazandaranicum*, (g-i) *A. cappodocicum* (Talesh specimen). Type I-B-1: (j-l) *A. monspessulanum* subsp. *persicum*, (m-o) *A. campestre* (Talesh), (p,q) *A. platanoides*.

area of 25 µm^2. The terminology follows Hesse et al. (2009) and Erdtman (1952) that lira is a narrow ridge, which forms the murus in a striate pattern and stria is a groove between elongated sculpturing elements.

In addition to studied specimens, the pollen data of *A. spicatum* (sec. parviflora), *A. pensylvanicum* (sec. macrantha), *A. rubra* and *A. saccharinum* (sec. rubra) from other studies were used for sectional analyzes. The common features used for analyzing were shown by asterisks in Table 2.

Results

General pollen grain features

The pollen grain type ranged from prolate (Figs. 1a, j, m, p; 2a, d, g, j, m, p, s, v; 3a, g) to preprolate (Figs.1g; 3d, j) in equatorial view and spheroidal (Figs. 1b, e, h, k; 2b, x; 3b, e, h, n), oblate-spheroidal (Figs. 1n; 2y) to prolate-spheroidal

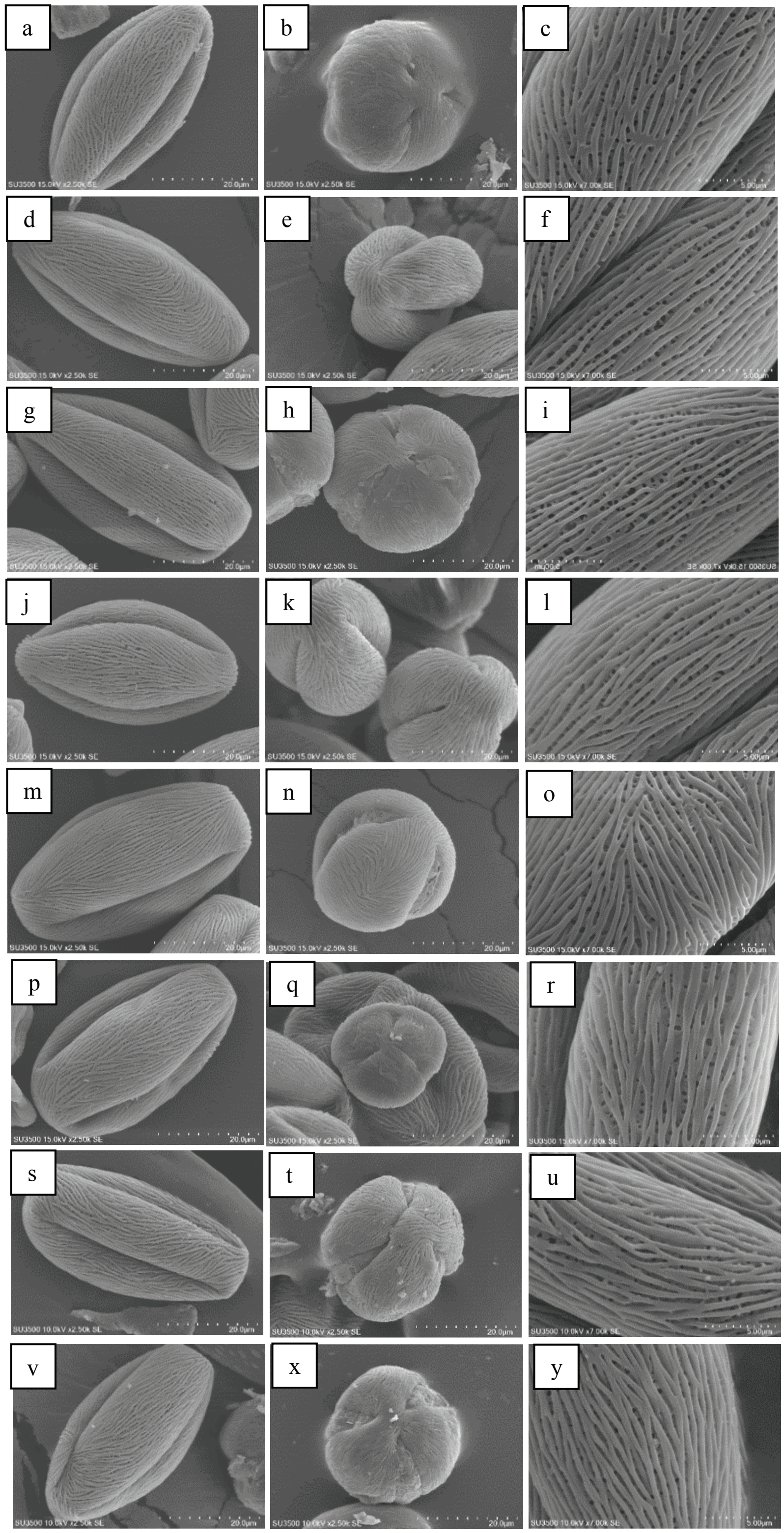

Figure 2. SEM micrographs of pollen grains in *Acer* sp. Type I-B-2: (a-c) *A. cappodocicum* (Toskacheshme specimen), (d-f) *A. velutinum* var. *velutinum* (Toskacheshmeh), (g-i) *A. velutinum* var. *velutinum* (Siahkal), (j-l) *A. velutinum* var.*velutinum* (Lahijan), (m-o) *A. velutinum* var. *glabrescens* (Shirgah), (p-r) *A. monspessulanum* subsp. *cinerascens* (Lorestan), (s-u) *A. monspessulanum* subsp. *cinerascens* (Kermanshah), (v-y) *A. monspessulanum* subsp. *cinerascens* (Esfahan).

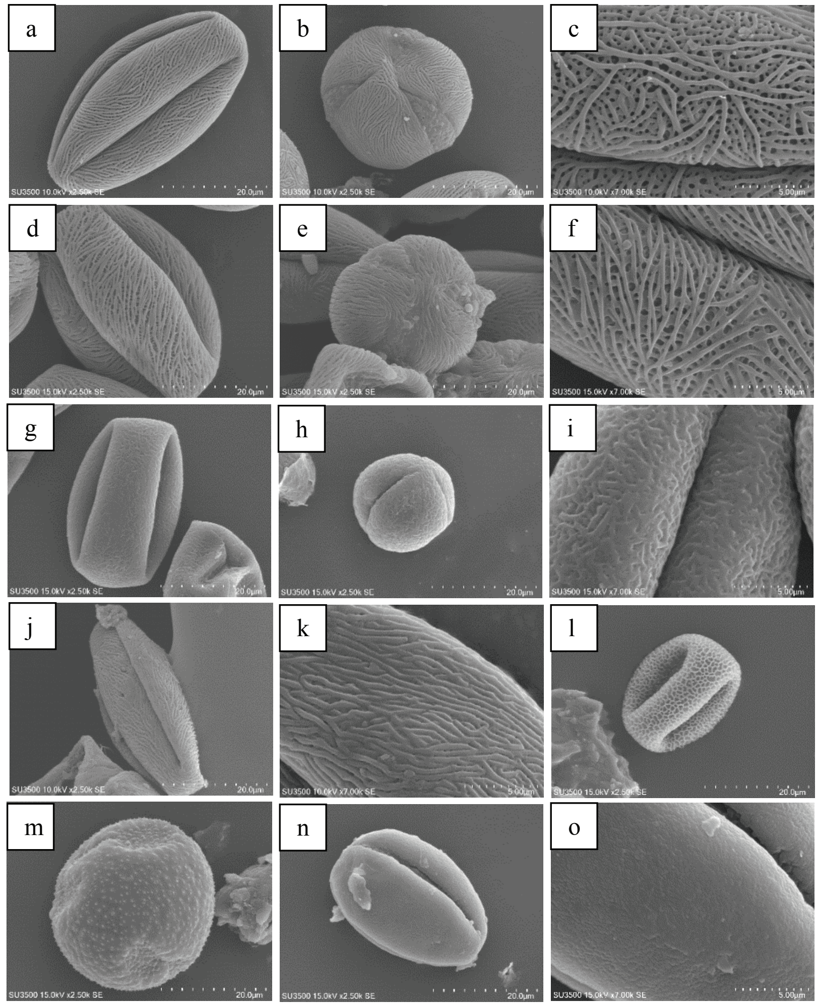

Figure 3. SEM micrographs of pollen grains in *Acer* sp. Type I-B-3: (a-c) *A. velutinum* var. *glabrescens* (Gorgan), (d-f) *A. monspessulanum* subsp. *turcomanicum*, type II-A: (g-i) *A. negundo*, type II-B: (j-l) *A. monspessulanum* subsp. *ibericum*, type III: (m) *A. negundo*, type IV: (n) *A. campestre* (Siahbishe), type V: (o) *A. campestre* (Siahbishe).

(Fig. 2t) in polar view. There were mainly zonocolpate (rarely 3-porate in *A. campestre*) (Fig. 3n) pollen grains with colpus extending the full length of the pollen grain. Mean length of the pollen grains varied from 38.88 µm (*A. negundo*) to 64 µm (*A. velutinum* var. *glabrescense*), while the width varied from 18.9 µm (*A. monspessulanum*. subsp. *ibericum*) to 35.79 µm (*A. cappodocicum*). The main colpus length varied from 31.07 (*A. negundo*) to 48.49 µm (*A. monspessulanum* subsp. *cinerascence*). According to the 8 analyzed species, the P/E ratio varied from 1.41 (*A. cappodocicum*) to 2.36 µm (*A. monspessulanum* subsp. *ibericum*). The main features of the investigated pollen grains are summarized in Table 2.

Three types were recognized based on mesocolpium width: (1) equal throughout the length (Figs. 1m; 2s; 3d, g) (2) narrow in one pole (Figs. 1g; 2g, 2v; 3d) and (3) wider in middle, while equal in two pole (poles acute or wide) (Figs. 1a, j, p; 2a, d, j, m, p; 3a, j).

Infrageneric variation

PCA analysis (Fig. 4) did not support the sectional classification of the studied species. The species of the sections *Acer* and *Platanoideae* were placed intermixed in the PCA plot.

PCOA analysis separated *A. velutinum* from the other studied species (Fig. 5), while *A. monspessulanum*, *A. hyrcanum*, and *A. mazandaranicum* overlapped. *A. hyrcanum*, *A. mazandaranicum*, *A. negundo*, *A. velutinum* and *A. monspessulanum* were separated from each other.

The PCA results, which represented the first three factors comprising about 66% of all the variation, showed that

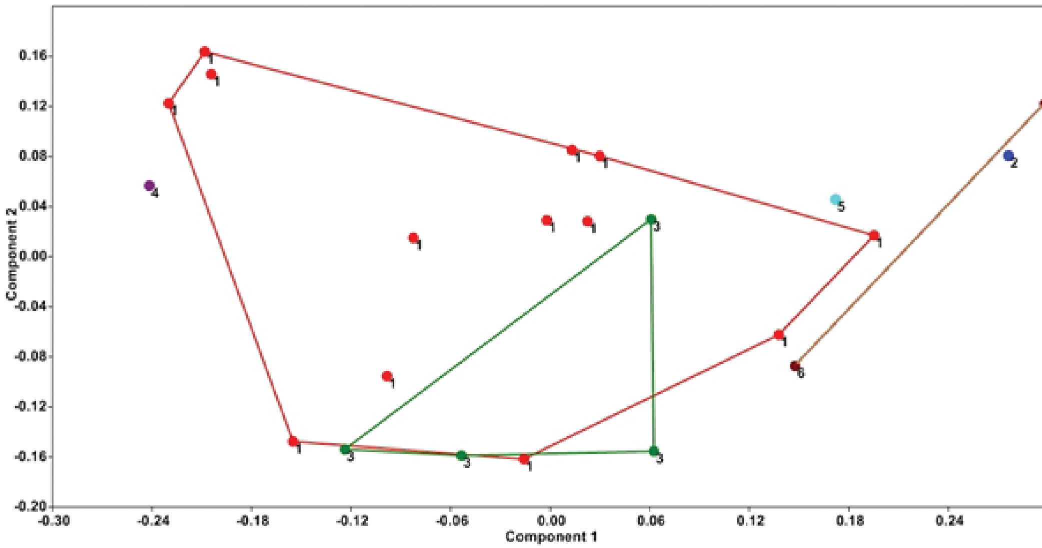

Figure 4. PCOA of *Acer* species studied based on palynological data. 1: sec. *Acer*; 2: sec. *Negundo*; 3: sec. *Platanoideae*; 4: sec. *Parviflora*; 5: sec. *Macrantha*; 6: sec. *Rubra*.

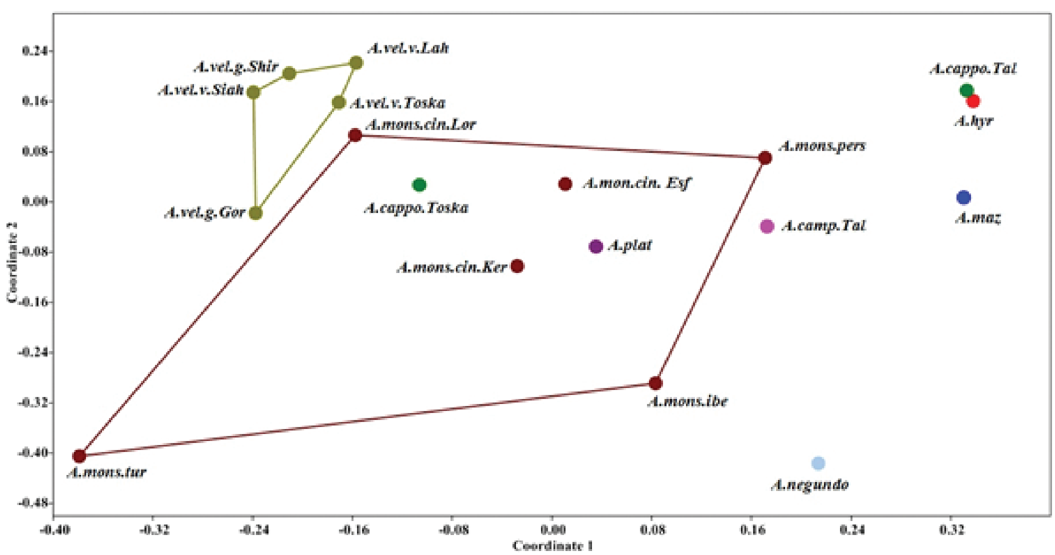

Figure 5. PCOA of palynological characters. Species abbreviations: A. hyr = *A. hyrcanum*, *A. maz* = *A. mazandaranicum*, *A. cappo.* Tal = *A. cappodocicum* (Talesh), A. cappo = *A. cappodocicum* (Toskacheshme), *A. camp*. Tal = *A. campestre* (Talesh), A. vel. v. Toska = *A. velutinum* var. *velutinum* (Toskacheshme), A. vel. v. Lah = *A. velutinum*. var. *velutinum* (Lahijan), *A. vel. v*. Siah = *A. velutinum*. var. *velutinum* (Siahkal), *A. vel. g*. Shir = *A. velutinum*. var. *glabrescence* (Shirgah), *A. vel. var. g.* Gor = *A. velutinum* var. *glabrescence* (Gorgan), *A. mons. Turc* = *A. monspessulanum* subsp. *turcomanicum*, *A. mons. Ibe* = *A.monspessulanum*. subsp. *ibericum*, *A. mons. cin*. Lor = *A. monspessulanum* subsp. *cinerascens* (Lorestan), *A. mons. cin*. Ker = *A. monspessulanum* subsp. *cinerascens* (Kermanshah), *A. mons. cin*. Esf = *A. monspessulanum* subsp. *cinerascens* (Esfahan), *A. mons. pers* = *A. monspessulanum* subsp. *persicum.*

features such as number of pit in 25 μm^2 area, shape, size, distribution of pit and sculpturing pattern, number of branching in 25 μm^2 area, and arrangement of lira to axis were the most variable pollen characteristics. UPGMA tree (Fig. 6) indicated that two varieties of *A. velutinum* overlapped together and pollen features were not useful in their delimitation. Distribution of two subspecies of *A. monspessulanum* (*persicum* and *cinerascens*) were close together and sometimes overlap each other. UPGMA tree based on pollen features, showed that these subspecies have close affinity together, and pollen characteristics are basically in accordance with their taxonomic similarities (Figs. 5, 7).

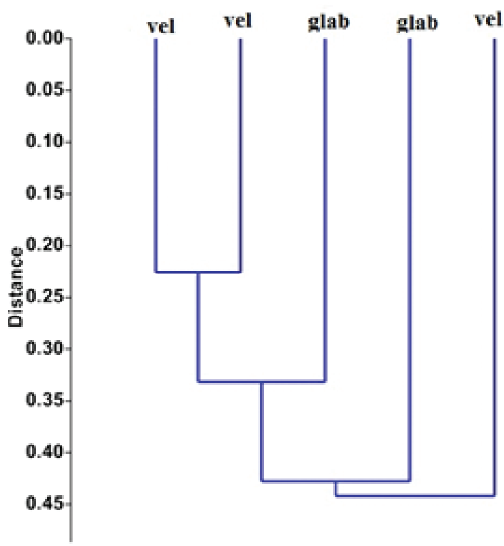

Figure 6. UPGMA tree of *A. velutinum* (vel) with two subspecies: *velutinum* (vel), and *glabrescens* (glab).

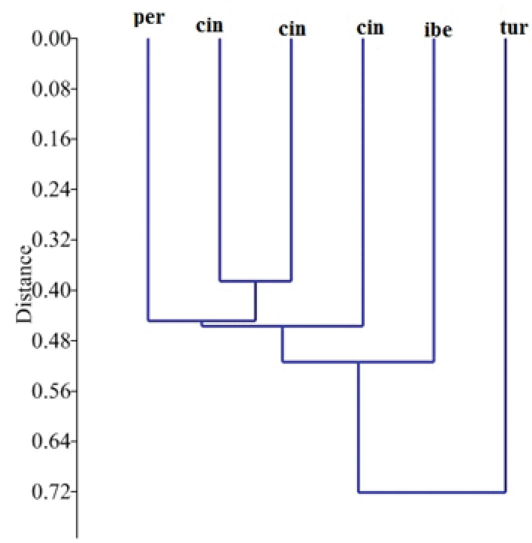

Figure 7. UPGMA tree of four *A. monspessulanum* subspecies: *turcomanicum* (tur), *ibericum* (ibe), *persicum* (per), and *cinerascence* (cin).

Exine sculpture type

On the basis, of differences in exine sculpturing pattern, the following five type are recognized: striate, rugulate, reticulate, granular, and smooth. Most of the specimens belong to striate pattern.

Type (I): striate

This type is recognized by distribution of lira throughout pollen surface. This type is subdivided according to the presence or absence of perforation between lira; type I-A with no perforation (Figs. 1c, f, i) and type I-B with striate perforation. Regarding to density and diameter of perforation, there are three different pattern in type I-B. Type I-B-1 with sparse perforation (Figs. 1l, o, q) and type I-B-2 with abundance and small to moderate perforation (Figs. 2c, f, i, o, r, u, y) and type I-B-3 with dense and large perforation (Figs. 3a, f, i).

Figure 8. Deviated forms (shown by arrows) of typical form of pollen in *A. velutinum* var. *glabrescens* (Shirgah).

Type (II): rugulate

In this type, rugulate are irregularly arranged. This type is intermediate between striate and reticulate pattern. Based on intervals of rugulate, this type is subdivided to type II-A: rugulate with small intervals (*A. negundo*) (Fig. 3g) and type II-B: striate rugulate with large intervals (*A. monspessulanum* subsp. *ibericum*) (Fig. 3j).

Other exine sculpture types

The other patterns observed in this study are uncommon in genus *Acer*. Reticulate type (type III) was only observed in one specimen (*A. negundo*) (Fig. 3m) accompanied with low frequency of type II in the same individual. The granular type (type IV) was only observed in *A. campestre* (Fig. 3n). The smooth type (type V) was reported for the first time in genus *Acer* and co-occurred with type IV in *A. campestre* (Figs. 3o, p).

Irregularities observed

In *A. velutinum* var. *glabrescens* (Shirgah) an irregular form of pollen morphology was detected with low frequency (Fig. 6). This form is characterized by a 4-colpate (syncolpate) pollen with colpi arranged on the edges of a tetrahedron.

Discussion

Acer is a taxonomically diverse genus due to large variation in leaf shape, inflorescence structure and other morphological traits (Delendick 1990; Park et al. 1993). Our study indicated a similar variation in pollen morphological features even in different specimens of the same species. Pollen characters vary among studied material. However, delimitation of *Acer* species is difficult due to instability of these characters within the species. These results are in agreement with Oterdoom and de Jong (in maples of world book, van Gelderen et al. 1994), who suggested a limited application of pollen morphology for delimiting the sections in Aceraceae.

Philbrick and Bogle (1981) indicated inter- and intraspecific instability of important characters in *Acer* (*i.e.* apocolpium area index, P, E, P/E). Similar diversity of pollen morphological characters was reported by Lama et al. (2015) in Eastern Himalaya.

Hybridization provides a possible explanation for the extensive morphological variability in the genus *Acer* (Tirmenstein 1991). In this study, intermediate morphologies found in some specimens (*A. monspessulanum* subsp. *persicum*, *A. campestre* (Talesh), *A. platanoides*) may be due to the high occurrence of hybridization and gene flow inter- and intraspecies. It seems that exine sculpture is important in genus *Acer*, so that Biesboer (1975) distinguished four types among 40 taxa of *Acer*. Also, Clarke and Jones (1978) indicated that European maple belong to two Biesboer types. In this survey, most of taxa belong to Biesboer type I with high diversity regarding distribution, size, density, length and width of pits, distance and arrangement of stria.

According to our study, the common shape of pollen in Iranian distributed species was zonocolpate and prolate. Zonocolpate, subprolate to prolate pollens was reported in native New England species (Philbrick and Bogle 1981) and three colporate, prolate to nearly spheroidal forms were observed in eastern Himalaya species. Two subspecies of *A. monspessulanum* (*persicum* and *cinerascense*) show high similarity in morphological features so that sometimes distinguishing between them is controversial. These subspecies are distributed in Zagros Mountains and approximately distinct from two other subspecies (*trucomanicum* and *ibericum*), which are distributed in Alborz Mountain (Figs 7, 5). However, there is variability in most characters in subspecies of this species, especially in exine sculpture of pollen and there are no significant differences among the subspecies of *A. monspessulanum*.

In *A. velutinum*, the stability of characters related to perforation (size, distribution, shape) separates all specimens of this species from the other species.

High variation in features in two specimens of *A. cappodocicum* nested *A. cappodocicum* (Toskacheshme) among *A. monspessulanum* specimens. *A. hyrcanum* has morphological affinity to *A. monspessulanum*, but this survey indicated that these two species are located far from each other. The pollen type of *A. negundo* (cultivated species in Iran) was reported as regulate in previous studies (Philbrick and Bogle 1981; Kupriyanova and Aleshina 1972). The present study indicated that the reticulate type co-occurs with rugulate type.

The variability of pollen morphological characters is reported in other families such as *Malus* (Nazeri 2008), *Pyrus* (Zamani et al. 2010) and *Sorbus* (Bedworz and Maciejewska-Rutkowska 2005).

In many dicotyledon taxa, the deviated pollen forms can be found in the common forms (Pozhidaev 1993). These forms were reported in *Aesculus* (Pozhidaev 1995), *Acer tataricum* (Dzyuba 2006) and 31 species of 58 studied *Acer* species (Pozhidaev 1993). These uncommon forms vary in the number and arrangement of their typical aperture. We reported two deviated forms (4 colpate with different arrangement of colpus) for the first time in *A. velutinum* (Shirgah). The question of how and why these forms arise presents some difficulty. Pozhidaev (1995) proposed that the polarization in pollen cytoplasm conformation can induce the formation of deviated forms. Dzyuba et al. (2006) suggested that unfavorable ecological conditions increase frequency of these untypical forms.

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