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Pollen Morphology of *Astragalus* L. Section *Alopecuroidei* DC. (Fabaceae) in Turkey

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Abstract: In this study pollen morphological diversity is described for *Alopecuroidei* DC. (*Alopecias* bunge) species belonging to genus *Astragalus* L. (Fabaceae) occurring in Turkey. The study was based on light and scanning electron microscopic observations of pollen grains collected from herbarium specimens. Members of the section studied possess tricolpate subprolate or prolate spheroidal pollen grains with a microreticulate exine ornamentation and semi-angular amb.

Key words: *Alopecias*, *Alopecuroidei*, *Astragalus* L., Palynology, Turkey

INTRODUCTION

Astragalus L. (Fabaceae) is the richest genus of *Angiospermae* in the world, distributed around semiarid steppe regions. It is represented by ca. 2500 taxa in the world and the number of taxa of the genus in USSR is about 1005 and in Flora Iranica is approximately 680^[1]. It is also the largest genus in Turkey, represented by ca. 443 species and 62 sections^[2-5]. Twenty one taxa of the section *Alopecuroidei* of the genus *Astragalus* L. are found in Turkey.

Pollen of a few species has been described in studies on Fabaceae^[6]. Tewari and Nair^[7] studied pollen morphology of some Indian Papilionaceae and there have been few pollen studies on *Astragalus* L.^[8-11].

This research is a part of multidisciplinary study which was done for *Alopecuroidei* section of *Astragalus* L. occurring in Turkey.

MATERIALS AND METHODS

All the pollen samples were taken from herbarium specimens. In this study, 18 taxa belonging to 15 species examined with light and scanning electron microscopes. Flowering specimen from *A. aytachii* and *A. bracteolus* could not be found. For light microscopy, the pollen grains were mounted directly with basic-fuchsin-glycerin jelly^[12]. A Zeiss microscope with an apochromate oil immersion objective (x100) and periplan eyepiece was used for finding the polar and equatorial axis length, exine and intine thickness, amb shapes and mesocolpium diameters. Usually 50 pollen grains of each specimen were measured. The morphological measurements of pollen grains are given in Table 1.

For scanning electron microscopy, the pollen grains were transferred directly to double-sided tape affixed stubs and vacuum-coated with platinum. Photomicrographs were taken with a JEOL 200 CXII scanning electron microscope at the Laboratory of Foundation of Petroleum of Turkey.

In this study Punt *et al.*^[13] terminology was used.

Specimens Investigated

Astragalus crinitus Boiss., Erzincan, H. Akan 1295.
Astragalus decurrens Boiss., Diyarbakir-Elazig, H. Akan 1415.
Astragalus dipsaceus Bunge, Sivas; H. Akan 1269.
Astragalus echinops Aucher ex Boiss., Elazig, H. Akan 1416.
Astragalus elatus Boiss. and Bal., Sivas, H. Akan 1356.
Astragalus gymna-lopecias Rech., Van, H. Akan 1351.
Astragalus macrocephalus Willd. subsp. *cucullaris* (Boiss.) Chamberlain, Mardin, H. Akan 1410.
Astragalus macrocephalus Willd. subsp. *finitimus* (Bunge) Chamb., Konya-Isparta, H. Akan 1241.
Astragalus macrocephalus Willd. subsp. *macrocephalus*, Ankara, H. Akan 1013.
Astragalus maximus Willd., Bayburt-Gumushane, H. Akan, 1187.
Astragalus oocephalus Boiss. subsp. *stachyophorus* Hub.-Mor. and Chamb., Tunceli, H. Akan 1417.
Astragalus oocephalus Boiss. subsp. *oocephalus*, Agri H. Akan 1321.
Astragalus ovabaghensis Akan and Aytac, Diyarbakir, H. Akan 1412.
Astragalus panduratus Bunge, Ankara, H. Akan 1463.
Astragalus ponticus Pall., Kutahya-Afyon, H. Akan 1009.

Table 1: Pollen morphological data (with mean values and standard deviations) of *Astragalus* L. species in Section *Alopecuroidei* growing in Turkey. All measurements are given in μm ; P-Polar axis; E-Equatorial diameter; Clg-colpus length; Clt-colpus width; Plg-pore length; Plt-pore width; t- apocolpium; m- mesocolpium

Species	P	E	P/E	Clg	Clt	Plg	Plt	t	m	Pollen shape
<i>Astragalus ovabaghensis</i> Akan and Aytac	35.2±0.94	28.2±1.01	1.24	25.9±1.27	4.0±0.94	7.0±1.03	11.4±1.01	15.2±0.12	23.2±0.89	Subprolate
<i>A. ponticus</i> Pall.	31.2±1.91	28.0±1.99	1.11	27.8±2.43	4.4±0.70	6.9±0.91	11.4±0.50	9.0±1.27	20.8±1.20	Prolate-spheroidae
<i>Auhtwormians</i> Freyn and Bornm.	30.3±0.80	27.8±0.60	1.08	24.2±1.00	4.4±0.40	7.5±0.70	-	12.5±0.60	26.7±1.10	Prolate-spheroidae
<i>A.maximus</i> Wild.	32.5±1.80	28.6±2.90	1.13	24.6±1.90	3.7±0.70	7.5±0.80	9.2±0.60	12.3±0.50	21.7±0.60	Prolate-spheroidae
<i>A. elatus</i> Boiss and Bal.	29.7±0.90	25.1±1.00	1.18	22.6±1.10	3.3±0.50	7.1±0.90	9.3±0.80	12.3±0.30	21.4±1.00	Subprolate
<i>A.panduratus</i> Bunge	33.2±1.50	26.1±1.30	1.27	24.8±1.20	3.4±0.60	6.9±0.70	11.0±1.40	12.4±0.30	22.5±1.10	Subprolate
<i>A. ocephalus</i> Boiss. ssp. <i>oocephalus</i>	26.7±1.20	23.5±0.90	1.13	20.6±1.00	3.1±0.50	7.0±0.30	9.4±0.60	12.2±1.50	21.8±1.10	Prolate-spheroidae
<i>A. ocephalus</i> Boiss ssp. <i>stachyophorus</i> Hub.-Mor. and Chamb.	30.4±1.30	26.3±1.20	1.15	23.7±1.20	3.4±0.30	7.0±0.80	10.6±1.80	15.1±0.50	22.7±1.60	Subprolate
<i>A. dipsaceus</i> Bunge	32.4±1.50	27.3±0.80	1.18	23.3±1.30	3.4±0.60	6.7±0.60	10.9±0.30	15.0±0.50	21.4±0.60	Subprolate
<i>A. crinitus</i> Boiss.	33.3±0.90	28.5±0.80	1.16	24.1±0.80	3.9±0.70	7.2±0.70	9.8±0.70	14.8±0.80	23.4±0.90	Subprolate
<i>A. stojani</i> Nab.	30.5±0.90	24.6±0.80	1.24	23.3±1.30	3.6±0.70	6.6±0.70	9.8±0.70	12.1±0.30	21.1±1.30	Subprolate
<i>A. decurrens</i> Boiss.	30.9±1.40	27.0±1.20	1.18	24.0±1.10	4.1±0.50	7.4±1.00	11.3±0.70	11.6±1.00	22.1±1.80	Subprolate
<i>A. trichocalyx</i> Trautv. <i>A. macrocephalus</i>	30.6±1.40	25.6±1.10	1.19	24.0±1.50	4.8±0.70	7.2±0.70	9.7±0.80	13.4±0.50	21.3±0.60	Subprolate
Wild. ssp. <i>macrocephalus</i>	33.5±0.80	28.0±1.00	1.19	25.6±1.40	4.5±0.80	8.1±0.80	9.5±0.60	8.1±0.80	23.1±1.20	Subprolate
<i>A.macrocephalus</i> Wild. ssp. <i>cucullaris</i> (Boiss.) Chamberlain	31.5±1.40	26.4±0.90	1.19	24.1±1.70	4.7±1.00	7.5±0.40	7.9±1.00	13.2±0.80	21.1±1.40	Subprolate
<i>A. macrocephalus</i> Wild ssp. <i>finitimus</i>	32.7±1.00	27.9±1.00	1.17	25.3±1.00	4.5±0.80	7.1±0.60	9.5±1.30	12.0±0.70	21.7±1.20	Subprolate
<i>A. echinops</i> Aucher ex Boiss.	30.1±0.90	26.9±0.90	1.11	23.7±1.20	4.3±0.80	7.6±0.60	9.7±0.50	12.2±0.60	21.1±0.60	Prolate-spheroidae
<i>A. gymnopecias</i> Rech. Fil	30.4±0.90	26.0±0.70	1.17	23.2±1.30	3.5±0.50	7.1±1.00	9.3±0.30	12.4±0.30	21.1±1.10	Subprolate

Astragalus stojanii Nab., Mardin, H. Akan 1460.

Astragalus trichocalyx Trautv., Erzurum, H. Akan 1294.

Astragalus uhlwormianus Freyn and Bornm, Elazig, H. Akan 1425.

RESULTS

Description of pollen grains

Astragalus crinitus Boiss.: Pollen grains radially symmetrical, isopolar, tricolporate, 33.3x28.5 μm subprolate. Amb semiangular. Apocolpia 14.8 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (Pd: 2/3, 3/4) and with clear margins. Clg 24.1 μm , Clt 3.9 μm . Mesocolpia 23.4 μm in diameter. Pores endoaperture, ellipsoid, Plg 7.2 μm , Plt 9.8 μm (Plg/Plt: 0.73) (Fig. 3D and 6D-E).

Astragalus decurrens Boiss.: Pollen grains radially symmetrical, isopolar, tricolporate, 30.9x26.1 μm subprolate. Amb semiangular. Apocolpia 11.6 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 2/3, 3/4) and with clear margins. Clg 24.0 μm , Clt 4.1 μm . Mesocolpia 22.1 μm in diameter. Pores endoaperture, ellipsoid, Plg 7.4 μm , Plt 11.3 μm (Plg/Plt: 0.65) (Fig. 1E and 7C-D).

Astragalus dipsaceus Bunge: Pollen grains radially symmetrical, isopolar, tricolporate, 32.3x27.3 μm subprolate. Amb semiangular. Apocolpia 15.0 μm in

diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 2/3, 3/4) and with clear margins. Clg 23.3 μm , Clt 3.4 μm . Mesocolpia 21.4 μm in diameter. Pores endoaperture, ellipsoid, Plg 6.7 μm , Plt 10.9 μm (Plg/Plt: 0.61) (Fig. 1A and 4C-D).

Astragalus echinops Aucher ex Boiss.: Pollen grains radially symmetrical, isopolar, tricolporate, 30.1x26.9 μm prolate-spheroidal. Amb semiangular. Apocolpia 13.1 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 23.7 μm , Clt 4.3 μm . Mesocolpia 21.1 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.6 μm , Plt 9.7 μm (Plg/Plt: 0.78) (Fig. 3A, 4E and 8A).

Astragalus elatus Boiss. and Bal.: Pollen grains radially symmetrical, isopolar, tricolporate, 29.7x25.1 μm subprolate. Amb semiangular. Apocolpia 12.3 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate and the lumina are beset with micro-bacula. Structure tectate. Intine 0.5 μm thick. Colpi thin and very long (pd: 3/4) and with clear margins. Clg 22.6 μm ; Clt 3.3 μm . Mesocolpia 21.4 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.1 μm , Plt 9.3 μm (Plg/Plt: 0.76) (Fig. 5E-F and 3B).

Astragalus gymnopecias Rech. Fil.: Pollen grains radially symmetrical, isopolar, tricolporate, 30.4x26.0 μm subprolate. Amb semiangular. Apocolpia 12.4 μm in

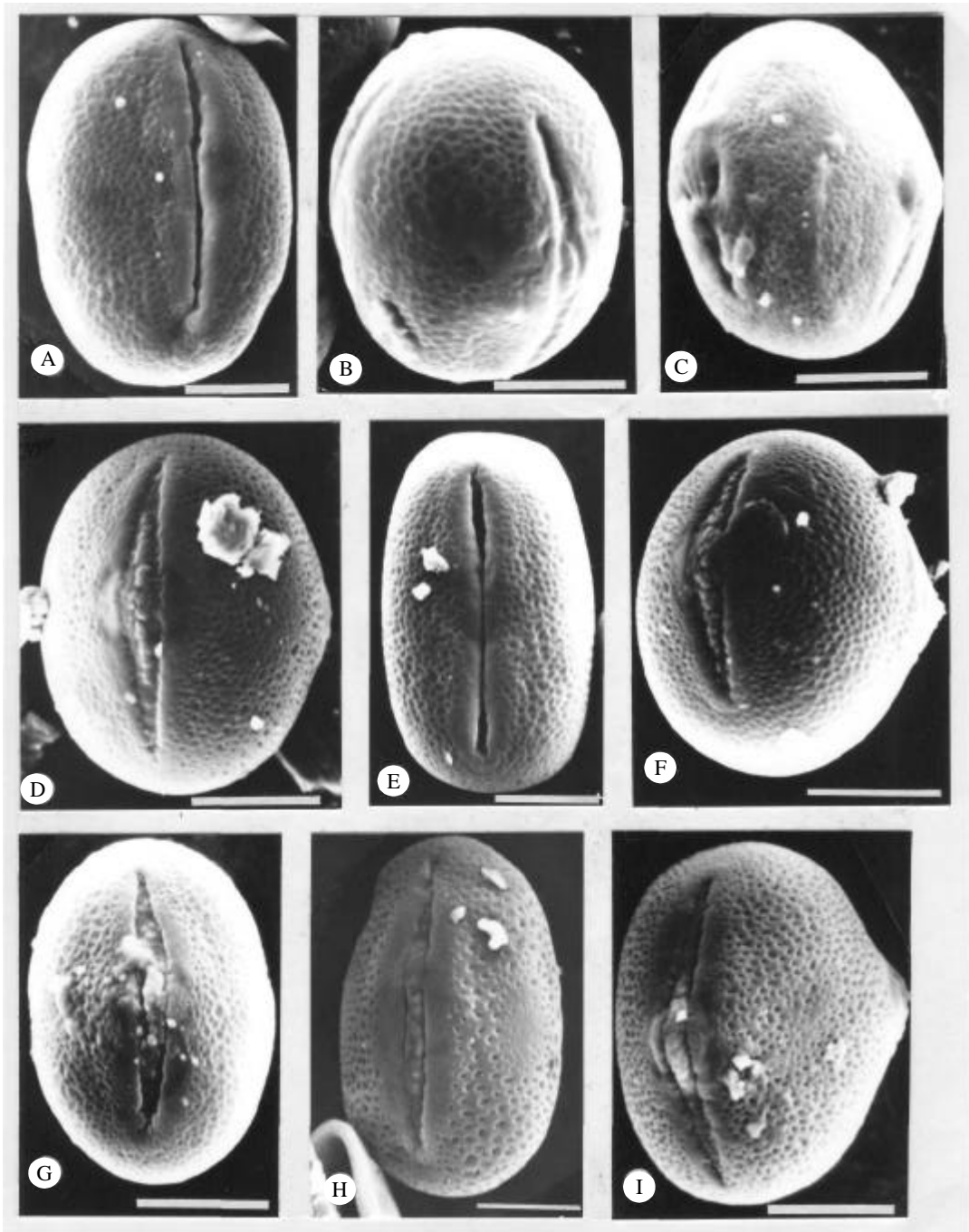


Fig. 1: Scanning electron micrographs of *Astragalus* L. Equatorial views of pollen grains: *A. dipcaceus* (A); *A. oocephalus* ssp. *stachyophorus* (B); *A. maximus* (C); *A. gymnolopecias* (D); *A. decurrens* (E); *A. trichocalyx* (F); *A. stojani* (G); *A. macrocephalus* ssp. *cucullaris* (H); *A. macrocephalus* ssp. *finitimus* (I); scale bar: 10 μ m

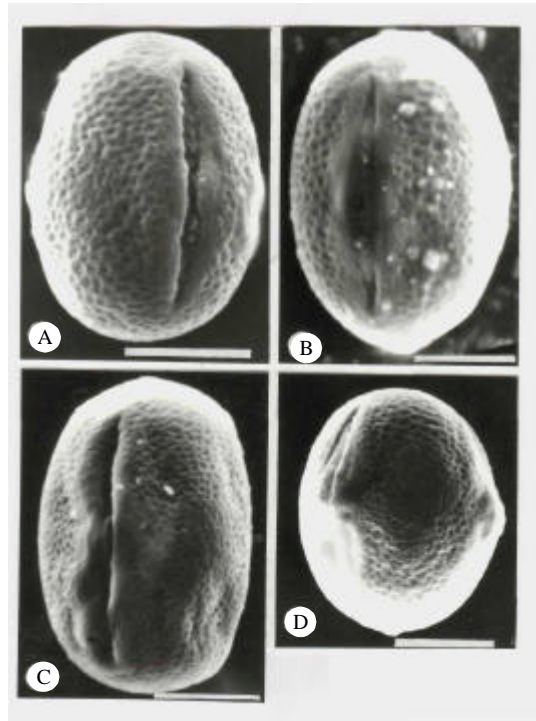


Fig. 2: Scanning electron micrographs of *Astragalus* L. Equatorial views of pollen grains: *A. oocephalus* ssp. *oocephalus* (A); *A. macrocephalus* ssp. *macrocephalus* (B); *A. panduratus* (C); *A. ponticus* (D); scale bar: 10 μ m

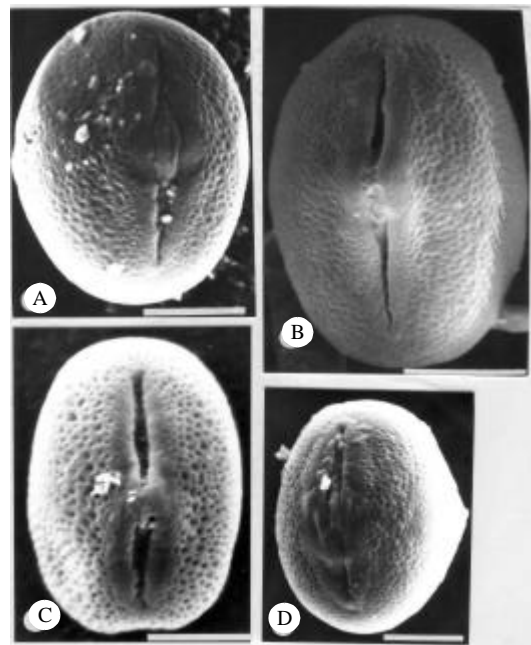


Fig. 3: Scanning electron micrographs of *Astragalus* L. Equatorial views of pollen grains: *A. ovabaghensis* (A); *A. elatus* (B); *A. echinops* (C); *A. crinitus* (D); scale bar: 10 μ m

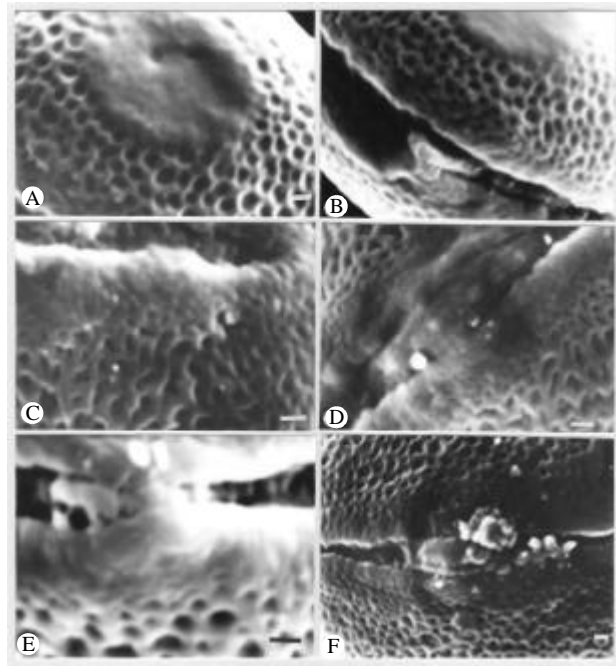


Fig. 4: Scanning electron micrographs of *Astragalus* L. Ornamantation of the tectum of pollen grains: *A. maximus* (A-B); *A. dipcaeus* (C-D); *A. echinops* (E); *A. ovabaghensis* (F); scale bar: 1 μ m

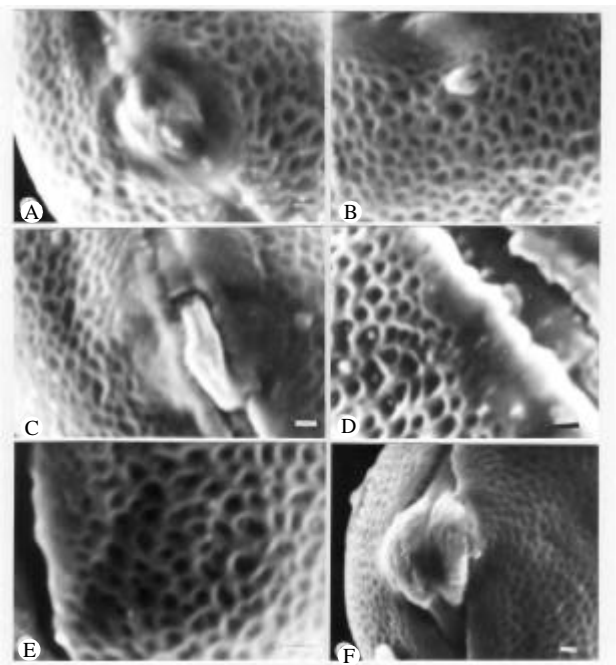


Fig. 5: Scanning electron micrographs of *Astragalus* L. Ornamantation of the tectum of pollen grains: *A. macrocephalus* ssp. *macrocephalus* (A-B); *A. ocephalus* ssp. *stachyophorus* (C-D); *A. elatus* (E-F); scale bar: 1 μ m

diameter. Exine 0.6-0.9 μm thick, microreticulate and the lumina are beset with micro-bacula. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 23.2 μm , Clt 3.5 μm . Mesocolpia 21.1 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.1 μm , Plt 9.2 μm (Plg/Plt: 0.77) (Fig. 1D and 6F).

Astragalus macrocephalus Willd. subsp. **cuellaris** (Boiss.) Chamberlain: Pollen grains radially symmetrical, isopolar, tricolporate, 31.5x26.4 μm subprolate. Amb semiangular. Apocolpia 13.2 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 24.1 μm , Clt 4.7 μm . Mesocolpia 21.1 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.5 μm , Plt 7.9 μm (Plg/Plt: 0.94) (Fig. 1H and 8B).

Astragalus macrocephalus Willd. subsp. **finitimus** (Bunge) Chamberlain: Pollen grains radially symmetrical, isopolar, tricolporate, 32.7x27.9 μm subprolate. Amb semiangular. Apocolpia 12.0 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 25.3 μm , Clt 4.5 μm . Mesocolpia 21.9 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.1 μm , Plt 9.5 μm (Plg/Plt: 0.74) (Fig. 1I and 8D).

Astragalus macrocephalus Willd. subsp. **macrocephalus**: Pollen grains radially symmetrical, isopolar, tricolporate, 33.5x28.0 μm subprolate. Amb semiangular. Apocolpia 8.1 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 25.6 μm , Clt 4.5 μm . Mesocolpia 23.1 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 8.1 μm , Plt 9.5 μm (Plg/Plt: 0.86) (Fig. 2B and 5A-B).

Astragalus maximus Willd.: Pollen grains radially symmetrical, isopolar, tricolporate, 32.5x28.6 μm prolate-spheroidal. Amb semiangular. Apocolpia 12.3 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and very long (pd: 3/4) and with clear margins. Clg 24.6 μm ; Clt 3.7 μm . Mesocolpia 21.7 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 6.7 μm , Plt 9.2 μm (Plg/Plt: 0.73) (Fig. 4A-B and 1C).

Astragalus oocephalus Boiss. subsp. **stachyophorus** Hub.-Mor. and Chamberlain: Pollen grains radially symmetrical, isopolar, tricolporate, 30.4x26.3 μm subprolate. Amb semiangular. Apocolpia 15.1 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate and the

lumina are beset with micro-bacula. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 23.7 μm , Clt 3.4 μm . Mesocolpia 22.7 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.0 μm , Plt 10.6 μm (Plg/Plt: 0.65) (Fig. 1B and 5C-D).

Astragalus oocephalus Boiss. subsp. **oocephalus**: Pollen grains radially symmetrical, isopolar, tricolporate, 26.7x23.5 μm prolate-spheroidal. Amb semiangular. Apocolpia 12.1 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 20.6 μm , Clt 3.1 μm . Mesocolpia 21.8 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.0 μm , Plt 9.4 μm (Plg/Plt: 0.70) (Fig. 2A and 6C).

Astragalus ovabaghensis Akan and Aytac: Pollen grains radially symmetrical, isopolar, tricolporate, 35.2x28.2 μm subprolate. Amb semiangular. Apocolpia 15.2 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 2/3-3/4) and with clear margins. Clg 25.0 μm , Clt 4.0 μm . Mesocolpia 23.2 μm in diameter. Pores endoaperture, ellipsoid, Plg 7.0 μm , Plt 11.4 μm (Plg/Plt: 0.61) (Fig. 4F and 3A).

Astragalus panduratus Bunge: Pollen grains radially symmetrical, isopolar, tricolporate, 33.2x26.1 μm subprolate. Amb semiangular. Apocolpia 12.4 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 2/3, 3/4) and with clear margins. Clg 24.8 μm , Clt 3.4 μm . Mesocolpia 22.5 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 6.9 μm , Plt 11.0 μm (Plg/Plt: 0.62) (Fig. 2C and 6A).

Astragalus ponticus Pall.: Pollen grains radially symmetrical, isopolar, tricolporate, 31.2x28.0 μm subprolate. Amb semiangular. Apocolpia 9.0 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 27.8 μm ; Clt 4.4 μm . Mesocolpia 20.8 μm in diameter. Pores endoaperture, ellipsoid to circular, Plg 6.8 μm , Plt 11.4 μm (Plg/Plt: 0.64) (Fig. 2D and 7G-F).

Astragalus stojanii Nab.: Pollen grains radially symmetrical, isopolar, tricolporate, 30.5x24.6 μm subprolate. Amb semiangular. Apocolpia 12.1 μm in diameter. Exine 0.6-0.9 μm thick, microreticulate. Structure tectate. Intine 0.5 μm thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 23.2 μm , Clt 3.6 μm .

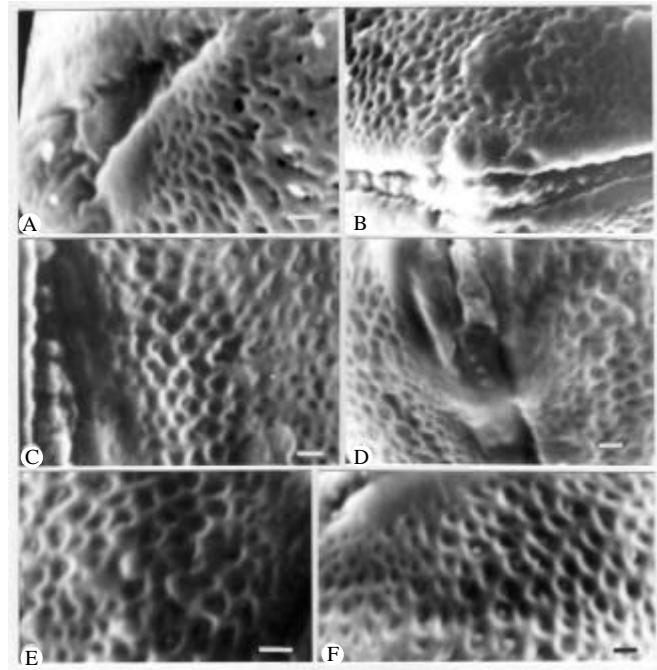


Fig. 6: Scanning electron micrographs of *Astragalus* L. Ornamentation of the tectum of pollen grains: *A. panduratus* (A); *A. trichocalyx* (B); *A. oocephalus* ssp. *oocephalus* (C); *A. crinitus* (D-E); *A. elatus* (E); *A. gymnolopecias* (F); scale bar: 1 μ m

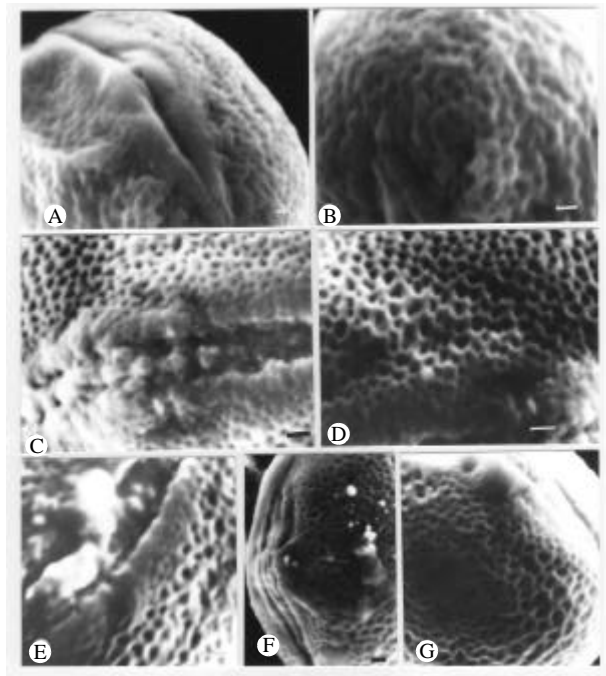


Fig. 7: Scanning electron micrographs of *Astragalus* L. Ornamentation of the tectum of pollen grains: *A. uhlwormianus* (A-B); *A. decurrens* (C-D); *A. stojani* (E); *A. ponticus* (F-G); scale bar: 1 μ m

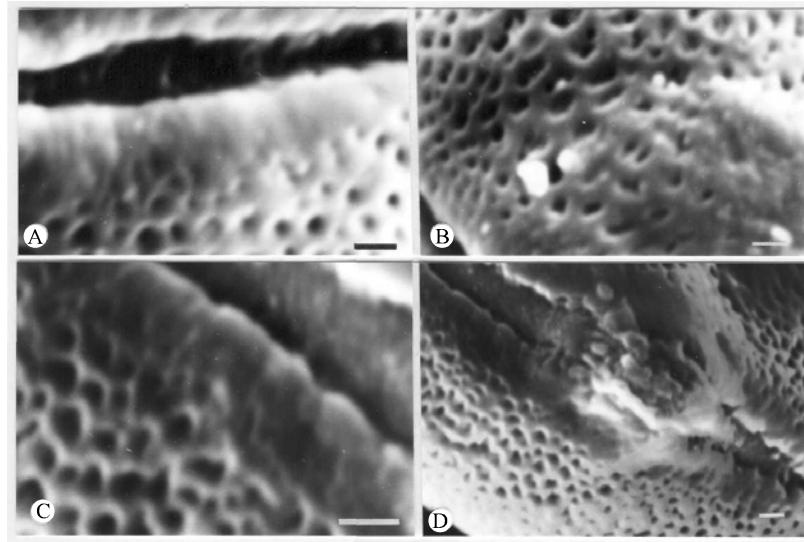


Fig. 8: Scanning electron micrographs of *Astragalus* L. Ornamentation of the tectum of pollen grains: *A. echinops* (A); *A. macrocephalus* ssp. *cucullaris* (B); *A. macrocephalus* ssp. *finitimus* (C); scale bar: 1 μ m.

Mesocolpia 21.1 μ m in diameter. Pores endoaperture, ellipsoid, Plg 6.6 μ m, Plt 9.8 μ m (Plg/Plt: 0.67) (Fig. 1G and 7E).

Astragalus trichocalyx Trautv.: Pollen grains radially symmetrical, isopolar, tricolporate, 30.6x25.6 μ m subprolate. Amb semiangular. Apocolpia 13.4 μ m in diameter. Exine 0.6-0.9 μ m thick, microreticulate. Structure tectate. Intine 0.5 μ m thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 24.0 μ m, Clt 4.8 μ m. Mesocolpia 21.3 μ m in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.2 μ m, Plt 9.7 μ m (Plg/Plt: 0.74) (Fig. 1F and 6B).

Astragalus uhlwormianus Freyn and Bornm.: Pollen grains radially symmetrical, isopolar, tricolporate, 30.3x27.8 μ m prolate-spheroidal. Amb semiangular. Apocolpia 12.5 μ m in diameter. Exine 0.6-0.9 μ m thick, microreticulate. Structure tectate. Intine 0.5 μ m thick. Colpi thin and long (pd: 3/4) and with clear margins. Clg 24.2 μ m; Clt 3.6 μ m. Mesocolpia 26.7 μ m in diameter. Pores endoaperture, ellipsoid to circular, Plg 7.5 μ m, Plt couldn't be measured (Fig. 7A-B).

DISCUSSION

In the Fabaceae family, pollen grains single or united monads usually 3-colporate sometimes provided with 2, 4 or 6 apertures, ranging in shape from peroblate to prolate.

Pollen grains of *Astragalus* species (Fabaceae: Alopecuroidei) occurring in Turkey are stenopalynous.

Pollen grains of studied taxa are radial symmetry, isopolar and 3-colporate.

During this revision, the palynological studies are carried out and pollens of taxa are examined in the light and electron microscope and determined the differences between the morphology of pollens. The identification key for the members of section of Alopecuroidei in Turkey is prepared. It was observed that the pollen type in the members of section is subprolate or prolate-spheroid. The Pollen is tricolporate and ornamentation is microreticulate. The amb type is semiangular.

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