



Full Length Article

The Pollen Morphology of some *Lathyrus* Spp. (Fabaceae) Taxa from Turkey

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ABSTRACT

In this study, 10 wild species of genus *Lathyrus* grown in Turkey *L. niger* (L.) Bernh. subsp. *niger*, *L. palustris* L. subsp. *palustris*, *L. tuberosus* L., *L. sphaericus* Retz., *L. setifolius* L., *L. chymenum* L., *L. nissolia* L., *L. aphaca* L. var. *aphaca*, *L. aphaca* var. *affinis* (Guss.) Arc, *L. aphaca* var. *biflorus* Post were examined for pollen morphology. Preparations were made using non-acetolysed and Erdtman methods. The shapes, apertures, structures and sculptures of pollen were observed by using light microscope (LM). The pollen grains were 3-zonocolporate, of spheroidal-subprolate-prolate types ($P/E=1.028-1.573$), medium to large in size. Equatorial view; elliptical-obtuse-convex, polar view; circular to triangular-obtuse-convex. The smallest pollen grains belong to *L. nissolia* ($P=32.791/E=24.747$ in non-acetolysed, $P=40.508/E=28.444$ in Erdtman) and the longest to *L. chymenum* ($P=52.418/E=35.815$ in non-acetolysed, $P=58.604/E=46.332$ in Erdtman) taxa. The ornamentation was reticulate or slightly perforate-foveolate. The pollen morphology of species was also studied using a scanning electron microscope (SEM). In addition, some photographs included in this work were taken using both LM and SEM. © 2011 Friends Science Publishers

Key Words: *Lathyrus*; Pollen morphology; Turkey

INTRODUCTION

Lathyrus belongs to the *Fabaceae* family and tribe *Vicieae* (Adans.) DC. This genus is represented by 13 sections and 150 types worldwide, 10 sections and 62 species in Turkey and 78 taxa (Davis *et al.*, 1970, 1998; Kupicha, 1983; Guner *et al.*, 2000). The species of *Lathyrus*, which are economically high in value, are known for their resistance to drought. *L. sylvestris* is used to prevent erosion on sawn or burnt land in America (Whyte *et al.*, 1953). In the east Anatolian region of Turkey the halberds of the *L. tuberosus* are consumed as food, whereas *L. ochrus* and *L. sativus* are cultivated (Gunes, 2006). Approximately 33 species are used for decorative purposes (Campbell, 1997).

The morphological properties of the pollen of taxa belonging to the *Lathyrus* species have been studied by various researchers both in Turkey and worldwide. In Turkey, *L. digitatus* (Aytug *et al.*, 1971), *L. undulatus*, *L. sylvestris* and *L. ochrus* Gunes and Cirpici (1998), *L. pratensis*, *L. layardii*, *L. laxiflorus* subsp. *laxiflorus*, *L. laxiflorus* subsp. *angustifolius* and *L. czechotianus* (Gunes & Aytug, 2010), *L. annuus*, *L. cicera*, *L. gorgoni* var. *pilosus* and *L. hirsutus* (Gunes & Cirpici, 2010) have been determined for pollen morphology of the taxa. Outside of Turkey e.g., in Russia, *L. niger* by Gapotchka and Chamara (1972) and Gapotchka (1974), *L. palustris* by Faegri and

Iversen (1989), *L. latifolius* and *L. tuberosus* by Halbritter (2000); in France, *L. sylvestris*, *L. pratensis*, *L. maritimus*, *L. nissolia* and *L. montanus* by Moore *et al.* (1991); in Pakistan, *L. emodii*, *L. cicera*, *L. humulis* and *L. pratensis* by Perveen and Qaiser (1998); and in Bulgaria, *L. grandiflorus*, *L. latifolius*, *L. sylvestris*, *L. tuberosus* by Tosheva *et al.* (2004), *L. alpestris*, *L. aureus*, *L. linifolius*, *L. niger*, *L. palustris*, *L. transsilvanicus*, *L. venetus* and *L. vernus* by Tosheva and Tonkov (2005), *L. digitatus*, *L. filiformis*, *L. pallescens*, *L. panicii* and *L. pannonicus* by Tosheva and Tonkov (2007), have determined the morphological properties for pollen belonging to the different species. These researchers provided information on the pollen type (3-zonocolporate), pollen shape (spheroidal, subprolate, prolate), structure (tectate-infrastructurae) and ornamentation (reticulate-perforate-favolate) associated to the taxon belonging to the *Lathyrus* species. Tosheva and Tonkov (2007) *L. filiformis*, *L. pallescens*, *L. panicii* determined a new pollen type seen in taxa called *Lathyrus filiformis*-type. Furthermore, Moore *et al.* (1991) also noted that the endexine thickness 2-3 times around the colpus and the porus and form a large costae formation.

The aim of this study was to determine through the use of LM and SEM, the extent to which morphological differences are well evaluated in 10 Turkish taxa of *Lathyrus*. This study also purpose to throw light on the problematic aspects of taxonomy and evolution.

MATERIALS AND METHODS

Ten taxa of *Lathyrus* were collected from their natural habitats in Turkey between 1996 and 2009. All collected specimens were identified and deposited at the herbarium of Marmara University, Faculty of Arts and Sciences (MUFE), Kafkas University, Faculty of Arts and Sciences, Department of Biology. Initially the samples gathered in European-Turkey were used for this study; however, samples were then collected throughout Turkey. With this reason Erdtman (1960) studies belong to the samples collected from European-Turkey. The observations on fresh pollen were made using preparations from samples collected from localities referred in Table I. The Wodehouse (1935) method was used for measurements carried out on taxa *L. aphaca* var. *aphaca* and *L. aphaca* var. *affinis*. The preparations were made in accordance with the Wodehouse and Erdtman methods. Using an Olympus CH20 light microscope (LM), 13 characteristics belonging to pollen were measured and their photographs were taken at 1000 X. For scanning electron microscopy, the pollen grains were mounted on stubs with double-sided adhesive tape and coated with gold. These coated pollen grains were examined and then photographed using JEOL-JSM-5200 SEM at a magnification of 2000-5000-13000 X. The pollen morphological descriptions followed the terminology of Moore *et al.* (1991) and Punt *et al.* (1994).

RESULTS

The results for these *Lathyrus* species are given in Tables II and III and pictorially presented in Figs. 1-4. However, the detailed results obtained from LM and SEM are given below:

L. niger subsp. *niger*

Pollen class: 3-zonocolporate.

Pollen group: Spheroidal [P/E= 1.135 (Non-acetolysed), subprolate P/E= 1.285 (Erdtman)].

Dimensions: Medium size [PXE= 33.336 X 29.363 µm (Non-acetolysed), 41.288 X 32.136 µm (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, straight, shallow, borders distinct, widened above pori or more widened than pori in mesocolpium, clt < plt, with acute ends, clg: 24.669 µm (Non-acetolysed), 30.097 µm (Erdtman), clt: 2.475 µm (Non-acetolysed), 1.508 µm (Erdtman). Endoapertures-pori: large, lalongate, borders distinct, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 3.48 µm), plg: 7.540 µm (Non-acetolysed), 7.951 µm (Erdtman), plt: 10.324 µm (Non-acetolysed), 9.786 µm (Erdtman) and plt/plg= 0.730 (Non-acetolysed), 0.813 (Erdtman).

Outlines: Equatorial view - elliptic; polar view - circular.

Ornamentation: Reticulate, reticules medium and irregular, Colpus area and apocolpium are psilate or slightly reticulate.

Ex/int (Non-acetolysed): \cong 1/1

Exine (Erdtman): \cong 2.5 µm.

L. palustris subsp. *palustris*

Pollen class: 3-zonocolporate.

Pollen group: Spheroidal [P/E= 1.028 (Non-acetolysed), subprolate P/E= 1.271 (Erdtman)].

Dimensions: Medium size [PXE= 36.917 X 35.902 µm (Non-acetolysed), 45.396 X 35.724 µm (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, nearly reaching the poles, straight, borders distinct, clt < plt, with acute ends, clg: 31.130 (Non-acetolysed), 41.180 (Erdtman) µm, clt: 3.062 (Non-acetolysed), 1.972 (Erdtman) µm. Endoapertures-pori: large, lalongate in non-acetolysed, lalongate in Erdtman, borders distinct, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 3.48 µm), plg: 9.454 (Non-acetolysed), 11.645 (Erdtman) µm, plt: 10.643 (Non-acetolysed), 8.909 (Erdtman) µm and plt/plg= 0.888 (Non-acetolysed), 1.307 (Erdtman).

Outlines: Equatorial view - elliptic to circular; polar view - circular.

Ornamentation: Suprareticulate-foveolate, reticules medium and regular. Apocolpium and aperture area are psilate or slightly reticulate.

Ex/int (Non-acetolysed): \cong 2/1

Exine thickness (Erdtman): \cong 2 µm.

L. tuberosus

Pollen class: 3-zonocolporate.

Pollen group: Spheroidal [P/E= 1.094 (Non-acetolysed), subprolate P/E= 1.263 (Erdtman)].

Dimensions: Medium size [PXE= 34.691 X 31.719 (Non-acetolysed), 46.800 X 37.062 µm (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, straight, with obtuse or acute ends, thin above pori, clt < plt, clg: 24.508 (Non-acetolysed), 29.190 (Erdtman) µm, clt: 3.503 (Non-acetolysed), 1.034 (Erdtman) µm. Endoapertures-pori: not large, borders not distinct, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 4.46 µm), slightly lalongate in non-acetolysed, slightly lalongate in Erdtman, plg: 9.048 (Non-acetolysed), 8.491 µm (Erdtman), plt: 9.605 (Non-acetolysed), 7.656 µm (Erdtman) and plt/plg=0.942 (Non-acetolysed), 1.109 (Erdtman).

Outlines: Equatorial view - elliptic to slightly rectangular-obtuse-convex; polar view - circular.

Ornamentation: Slightly reticulate-perforate, slightly distinct and irregular in mesocolpium. Apocolpium and aperture area are psilate.

Ex/int (Non-acetolysed): \cong 1/1

Exine thickness (Erdtman): \cong 2 µm.

L. sphaericus

Table I: Examined specimens, distribution in the world and locality

Taxa	Section	Distribution in the world	Locality	Herbarium and No
<i>L. niger</i> subsp. <i>niger</i>	<i>Orobis</i>	Eupope, N.W. Africa, Caucasasia	A1 (E) Kırklareli: Babaeski-Yeniköy, shrubs, 100 m, 26.05.1997, <i>F. Güneş</i> (Wodehouse and Acetolysis). A2(A) İstanbul: Sarıyer, Bahçeköy Atatürk Arboretumu, open forest, 115 m, 29.05.1996, <i>F. Güneş</i> (Wodehouse).	MUFE 5416 MUFE 5050
<i>L. palustris</i> subsp. <i>palustris</i>	<i>Orobis</i>	Eupope, C. & E. Asia	A2 (A) İstanbul: Riva stream, reed beds, behind the sports center, at sea level, 14.06.1997, <i>F. Güneş</i> (Wodehouse and Acetolysis).	MUFE 5480
<i>L. tuberosus</i>	<i>Lathyrus</i>	Europe, Caucasasia, Siberia, C. Asia	A1 (E) Tekirdağ: Saray-Vize road, Saray exit, road side, shrubs, 19.06.1998, <i>F. Güneş</i> (Wodehouse). Tekirdağ: Çorlu, Yenimahalle village-Karahalil village road 2. km., stream coast, reed beds, 50 m., 21.06.1997, <i>F. Güneş</i> (Acetolysis). A9 Kars: Melikköy, fields, 1890 m, 02.07.2004, <i>F. Güneş</i> (Wodehouse). B3 Isparta: Eğirdir-Aksu road, 7 th km after junction, 955 m, 12.06.2009, <i>F. Güneş</i> (Wodehouse). A8 Bayburt: Batburt-Gümüşhane road, Akşar village entrance, plantation border, 1614 m, 15.07.2009, <i>F. Güneş</i> (Wodehouse).	MUFE 5769 MUFE 5488 KARS 26 KARS 2337 KARS 2466
<i>L. sphaericus</i>	<i>Orobastrum</i>	Europe, Mediterranean	A1 (E) Kırklareli: Kırklareli-İncece road, 5-6 km., shrubs, 17.05.1997, <i>F. Güneş</i> (Wodehouse). Çanakkale: Gelibolu-Eceabat, pazarlık village road 3. km forest borders, 150 m., 25.04.1998, <i>F. Güneş</i> (Acetolysis). B5 Kayseri: Mount Ali, 1650 m, 09.06.2009, <i>F. Güneş</i> (Wodehouse). C2 Denizli: Sarayköy, Babadağ-Tekçam road, forest border, 937 m, 13.06.2009, <i>F. Güneş</i> (Wodehouse). B7 Erzincan: Tercan-Erzincan road, Tunceli 15 km before the junction, oak forest, 1310 m, 10.07.2009, <i>F. Güneş</i> (Wodehouse).	MUFE 5165 MUFE 5666 KARS 2292 KARS 2355 KARS 2453
<i>L. setifolius</i>	<i>Orobastrum</i>	Medit., Near East	A1 (E) Tekirdağ: Şarköy, Uçmakdere village, on the skirts of cliffs, sl-50-m., 03.05.1998, <i>F. Güneş</i> (Wodehouse and Acetolysis). B8 Siirt: Bitlis-Baykan road, 3 rd km before Baykan, road sides, forest border, rocky shoulders, 704 m, 09.05.2009, <i>F. Güneş</i> (Wodehouse). C1 Muğla: Campus site of Muğla University, 30.03.2008, 54 m, <i>F. Güneş</i> (Wodehouse). C3 Antalya: Kemer-Kumluca road, 24 th km before Kumluca, 375 m, 23.04.2009, <i>F. Güneş</i> (Wodehouse). C6 Hatay: Belen-Hatay road, Belen exit, forest border, 565 m, 18.04.2009, <i>F. Güneş</i> (Wodehouse).	MUFE 5684 KARS 2111 KARS 1521 KARS 2069 KARS 2009
<i>L. clymenum</i>	<i>Clymenum</i>	Mediterranean	A2 (E) İstanbul: Sarıyer, Bahçeköy-Kilyos road 10 km, road side, 100 m., 26.05.1996, <i>F. Güneş</i> (Wodehouse and Acetolysis). B1 İzmir: Narlıdere, military region, 30 m, 20.05.1999, <i>F. Güneş</i> (Wodehouse).	MUFE 5041 MUFE 6131
<i>L. nissolia</i>	<i>Nissolia</i>	Europe, Medit.	A1 (E) Kırklareli: Çağlayık-Dereköy road 2 km, road side, 525 m., 18.05.1997, <i>F. Güneş</i> (Wodehouse). A4 Kırklareli: Çağlayık-Dereköy entrance, by the fountain-road side, 525 m., <i>F. Güneş</i> (Acetolysis). B7 Tunceli: Pülümür-Göneli Kaynak Tuzla road, 1. km., shrubs, 1935 m, 10.07.2009, <i>F. Güneş</i> (Wodehouse). A6 Amasya: Akdağ, Eğribük village entrance, oak oak shrubs, 1183 m, 16.07.2009, <i>F. Güneş</i> (Wodehouse). B3 Ankara: Beypazarı-Karasar ve Kırıbrıcık road 28. km, 2 km before the junction, 1441 m, 17.06.2009, <i>F. Güneş</i> (Wodehouse).	MUFE 5187 MUFE 5189 KARS 2458 KARS 2481 KARS 2387
<i>L. aphaca</i> var. <i>affinis</i>	<i>Aphaca</i>	E. Mediterranean	A2 (E) İstanbul: Silivri-İstanbul road Selimpaşa entrance road side, 80 m., 26.04.1998, <i>F. Güneş</i> & <i>A. Çirpıcı</i> . A1(E) Tekirdağ: Çanakçı village entrance, road side, 01.06.1997, 160 m, <i>F. Güneş</i> . A1(A) Çanakkale: Eceabat-Kilitbayır, military region, plantation border, 24.04.1998, 10 m, <i>F. Güneş</i> . B9 Ağrı: Tazeköy, 1526 m, 06.06.2009, <i>F. Güneş</i> .	MUFE 5678 MUFE 5428 MUFE 5652 KARS 2255
<i>L. aphaca</i> var. <i>aphaca</i>	<i>Aphaca</i>	E. Mediterranean	A2 (E) İstanbul: Atatürk Arboretumu, forest border, 12.05.1996, 115 m, <i>F. Güneş</i> . A1(E) Edirne: Enez-Keşan road, Büyükevren village, aktopraklı site, 85 m., 29.05.1998, <i>F. Güneş</i> . A2(A) İstanbul: Kumburgaz, highway road side, 60 m, 03.05.1998, <i>F. Güneş</i> .	MUFE 5009 MUFE 5700 MUFE 5683
<i>L. aphaca</i> var. <i>biflorus</i>	<i>Aphaca</i>	E. Mediterranean	A2 (E): İstanbul-Çatalca road sides, 115 m., 18.05.1996, <i>A. Çirpıcı</i> and <i>F. Güneş</i> (Wodehouse). A1(E) Kırklareli: Lüleburgaz-Hamitabat village, forest borders plantation borders, 100 m., 22.05.1997, <i>F. Güneş</i> (Acetolysis). A1(E) Edirne: Lalapaşa, Kayapa village, forest border, 24.5.1997, 450 m, <i>F. Güneş</i> & <i>İ. Deniz</i> (Wodehouse). C6 Hatay: Dörtöl, çökek plateau, 500 m, 28.05.2006, <i>F. Güneş</i> (Wodehouse).	MUFE 5014 MUFE 5225 MUFE 5358 KARS 140

Pollen class: 3-zonocolporate.

Pollen group: Spheroidal [P/E= 1.083 (Non-acetolysed), subprolate P/E= 1.338 (Erdtman)].

Dimensions: Medium size [PXE= 33.959 X 31.349 (Non-acetolysed), 46.233 X 34.556 µm (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, straight, with acute ends, nearly reaching the poles, borders distinct, clt < plt, clg: 26.351 (Non-acetolysed), 35.876 (Erdtman) µm, clt: 1.566 (Non-acetolysed), 1.740 (Erdtman) µm. Endoapertures-pori: large, slightly alongate in non-acetolysed, lolongate in Erdtman, borders distinct, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 3.48 µm), plg: 8.404 (Non-acetolysed), 9.090 (Erdtman) µm, plt: 9.048 (Non-acetolysed), 7.445 (Erdtman) µm and plt/plg= 0.929 (Non-

acetolysed), 1.221 (Erdtman) µm.

Outlines: Equatorial view - elliptic to slightly rectangular-obtuse-convex; polar view - circular.

Ornamentation: Reticulate, reticules big, distinct and regular. Apocolpium and aperture area are psilate.

Ex/int (Non-acetolysed): $\cong 2/1$.

Exine thickness (Erdtman): $\cong 2$ µm.

L. setifolius

Pollen class: 3-zonocolporate

Pollen group: Spheroidal [P/E= 1.134 (Non-acetolysed), subprolate P/E= 1.312 (Erdtman)].

Dimensions: Medium size [PXE= 34.394 X 30.334 (Non-acetolysed), 45.098 X 34.367 (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi:

Table II: (Non-acetolysed) Pollen characteristics of the examined taxa. M; arithmetic means, σ ; Standard deviation, var.; variations, P: polar diameter, E: equatorial diameter, P/E: Pollen shape, Ex/int: the ratio of exine to the intin, clg: colpus length, clt: colpus width, plg: porus length regarding the poles, plt: porus width regarding the equatorial diameter, plg/plt: porus shape, t: one edge of polar triangle. Marks (except variations) are in micrometers (μm). Variation numbers are bar numbers in LM

TAXA		P	E	P/E	Ex/int	clg	clt	plg	plt	plg/plt	t
<i>L. niger</i>	M	33.336	29.363			24.669	2.475	7.540	10.324		16.163
	σ	± 1.031	± 0.838	1.135 (W)	$\approx 1/1$	± 1.157	± 0.885	± 0.563	± 0.693	0.730	± 0.895
	var.	11-12	10-11	Subprolate	----	19-23	1-4	6-8	8-10		12-15
<i>L. palustris</i>	M	36.917	35.902			31.130	3.062	9.454	10.643		11.811
	σ	± 1.304	± 1.283	1.028 (W)	$\approx 2/1$	± 1.480	± 1.131	± 0.989	± 0.856	0.888	± 1.798
	var.	12-14	11.5-13.5	Spheroidal	----	24-30	1-5	7-10	7-10		8-15
<i>L. tuberosus</i>	M	34.691	31.719			24.508	3.503	9.048	9.605		13.035
	σ	± 1.141	± 1.264	1.094 (W)	$\approx 1/1$	± 1.611	± 1.194	± 0.804	± 1.161	0.942	± 0.939
	var.	11-13	10-12	Spheroidal	----	19-25	1-5	6-9	7-10		7-15
<i>L. sphaericus</i>	M	33.959	31.349			26.351	1.566	8.404	9.048		14.979
	σ	± 1.127	± 1.447	1.083 (W)	$\approx 2/1$	± 1.931	± 0.553	± 0.887	± 0.758	0.929	± 1.707
	var.	11-12	10-12	Spheroidal	----	20-26	1-2	5-8	6-9		10-16
<i>L. setifolius</i>	M	34.394	30.334			25.520	2.958	7.059	11.335		
	Σ	± 0.964	± 1.190	1.134 (W)	$\approx 1/1$	± 1.591	± 0.858	± 0.643	± 0.881	0.623	non-measured.
	var.	11-12	10-11	Spheroidal	----	19-25	1-4	5-7	8-11		
<i>L. clymenum</i>	M	52.418	35.815			37.623	3.109	7.511	11.629		
	σ	± 2.152	± 2.303	1.464 (W)	$\approx 3/1$	± 1.346	± 0.674	± 0.733	± 0.608	0.646	non-measured.
	var.	16-19.5	11-14	Prolate	----	30-35	1-4	5-8	9-11		
<i>L. nissolia</i>	M	32.791	24.747			21.885	1.889	5.966	8.253		13.147
	σ	± 1.346	± 1.180	1.325 (W)	$\approx 3/2$	± 0.981	± 0.625	± 0.492	± 0.538	0.723	± 1.287
	var.	10-12	8-9	Subprolate	----	16-20	1-3	4-6	6-8		10-13
<i>L. aphaca</i> var. <i>aphaca</i>	M	40.126	26.767			27.701	1.9256	4.369	8.313		
	σ	± 1.637	± 1.054	1.499 (W)	$\approx 2/1$	± 1.104	± 0.611	± 0.491	± 0.903	0.526	non-measured.
	var.	12.5-15	8-10	Prolate	----	22-26	1-3	3-4	6-9		
<i>L. aphaca</i> var. <i>affinis</i>	M	40.144	27.196			34.034	2.459	7.517	10.440		
	σ	± 1.485	± 1.396	1.476 (W)	$\approx 2/1$	± 2.044	± 0.792	± 0.935	± 0.984	0.720	non-measured.
	var.	15-17	10-12	Prolate	----	26-33	1-3	5-8	7-11		
<i>L. aphaca</i> var. <i>biflorus</i>	M	45.604	31.720			31.738	1.879	6.612	10.718		
	σ	± 2.028	± 1.644	1.438 (W)	$\approx 2/1$	± 1.778	± 0.563	± 0.706	± 0.972	0.617	non-measured.
	var.	16-19	11-13	Prolate	----	25-31	1-2	5-7	8-11		

Table III: (Erdtman) Pollen characteristics of the examined taxa. M; arithmetic means, σ ; Standard deviation, var.; variations, P: polar diameter, E: equatorial diameter, P/E: Pollen shape, Ex: exine thickness, Ex/int: the ratio of exine to the intin, clg: colpus length, clt: colpus width, plg: porus length regarding the poles, plt: porus width regarding the equatorial diameter, plg/plt: porus shape, t: one edge of polar triangle, structure: exine, sculpture: ornamentation. Marks (except variations) are in micrometers (μm). Variation numbers are bar numbers in LM

TAXA		P	E	P/E	Ex	clg	clt	plg	plt	plg/plt	Costae	Structure	Sculpture
<i>L. niger</i>	M	41.288	32.136			30.097	1.508	7.951	9.786			Tectate	Reticulate, reticules big and regular
	σ	± 1.615	± 1.539	1.285	≈ 2.5	± 1.816	± 0.423	± 0.465	± 1.032	0.813	3.48	infrastructurae	
	var.	15-17	11-14	Subprolate		24-30	1-2	6-8	7-10				
<i>L. palustris</i>	M	45.396	35.724			41.180	1.972	11.646	8.909			Tectate	Reticules medium and regular
	σ	± 1.960	± 2.132	1.271	≈ 2	± 2.264	± 0.812	± 0.802	± 1.099	1.307	3.48	infrastructurae	
	var.	16-19	13-15	Subprolate		30-40	1-3	9-11	5-10				
<i>L. tuberosus</i>	M	46.800	37.062			29.190	1.034	8.491	7.656			Tectate	Slightly reticulate, Perforate-foveolate, slightly distinct and irregular
	σ	± 1.109	± 2.984	1.263	≈ 2	± 1.591	± 0.756	± 0.541	± 0.656	1.109	4.64	infrastructurae	
	var.	16-20	12-16	Subprolate		23-28	0.5-1.5	7-8	6-8				
<i>L. sphaericus</i>	M	46.234	34.556	1.338		35.876	1.740	9.090	7.445			Tectate	Reticulate, reticules big or medium size, distinct, and regular
	σ	± 1.834	± 1.620	Subprolate-	≈ 2	± 1.875	± 0.519	± 1.008	± 0.904	1.221	3.48	infrastructurae	
	var.	17-19	12-14	Prolate		27-34	1-2	6-9	5-8				
<i>L. setifolius</i>	M	45.098	34.367			35.243	2.404	7.934	12.203			Tectate	Reticulate, reticules distinct and medium size
	σ	± 3.942	± 2.878	1.312	≈ 2	± 1.261	± 0.694	± 0.598	± 0.742	0.650	4.64	infrastructurae	
	var.	14-21	11-15	Subprolate		27-32	1.5-2.5	6-8	10-12				
<i>L. clymenum</i>	M	58.604	46.332			47.166	3.109	8.236	14.245			Tectate	Reticulate, reticules regular, distinct and medium size
	σ	± 3.193	± 3.018	1.265	≈ 1	± 2.096	± 1.420	± 1.740	± 1.540	0.578	1.74	infrastructurae	
	var.	20-26	15-20	Subprolate		37-45	1-5	4-11	10-15				
<i>L. nissolia</i>	M	40.508	28.444			28.490	1.578	6.009	9.094			Tectate	Reticules regular, medium size and distinct
	σ	± 1.808	± 1.832	1.424	≈ 2	± 1.643	± 0.687	± 0.759	± 1.214	0.661	4.06	infrastructurae	
	var.	14-17	10-13	Prolate		22-27	1-3	4-7	6-10				
<i>L. aphaca</i> var. <i>biflorus</i>	M	44.824	32.656			33.269	1.462	6.287	8.770			Tectate	Reticulate and Perforate-foveolate, reticules medium size, distinct
	σ	± 3.058	± 1.957	1.373	≈ 2	± 2.588	± 0.605	± 0.871	± 1.230	0.717	3.48	infrastructurae	
	var.	15-20	11-14	Prolate		25-34	1-3	4-7	5-9				

long, nearly reaching the poles, straight, borders not distinct, with acute to obtuse ends, $clt < plt$, clg : 25.520 μm (Non-acetolysed), 35.243 μm (Erdtman), clt : 2.96 μm (Non-acetolysed), 2.404 μm (Erdtman). Endoapertures-pori: large, lalongate, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 4.64 μm), plg : 7.059 μm (Non-acetolysed), 7.934 μm (Erdtman), plt : 11.335 μm (Non-acetolysed), 12.203 μm (Erdtman) and $plt/plg = 0.623$ (Non-acetolysed), 0.650 (Erdtman).

Outlines: Equatorial view - elliptic; polar view - circular to slightly triangular.

Ornamentation: Reticulate, reticules distinct and medium size. Apocolpium reticulate, aperture area are psilate.

Ex/int (Non-acetolysed): $\cong 1/1$.

Exine thickness (Erdtman): $\cong 2 \mu m$.

L. clymenum

Pollen class: 3-zonocolporate.

Pollen group: Prolate [P/E= 1.464 (Non-acetolysed), subprolate P/E= 1.265 (Erdtman)].

Dimensions: Medium size [PXE= 52.418 X 35.815 (Non-acetolysed), 58.604 X 46.332 (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: very long, nearly reaching poles, straight, borders distinct, with acute ends $clt < plt$, clg : 37.623 μm (Non-acetolysed), 47.166 μm (Erdtman), clt : 3.109 μm (Non-acetolysed), 3.109 μm (Erdtman). Endoapertures-pori: large, lalongate, protruding in mesocolpium, borders distinct, with an annulus (thickness sexine) and costae (thickness nexine: 1.74 μm), plg : 7.511 (Non-acetolysed), 8.236 (Erdtman) μm , plt : 11.629 μm (Non-acetolysed), 14.245 μm (Erdtman) and $plt/plg = 0.646$ (Non-acetolysed), 0.578 (Erdtman).

Outlines: Equatorial view - elliptic; polar view - triangular to slightly circular.

Ornamentation: Reticulate, reticules, regular, distinct and medium size, collumellae are visible inside the lumina. Apocolpium slightly reticulate and aperture area are psilate.

Ex/int (Non-acetolysed): $\cong 1/2$.

Exine thickness (Erdtman): $\cong 1 \mu m$.

L. nissolia

Pollen class: 3-zonocolporate.

Pollen group: Subprolate [P/E= 1.325 (Non-acetolysed), prolate P/E= 1.424 (Erdtman)].

Dimensions: Medium size [P X E= 32.790 X 24.747 μm (Non-acetolysed), 40.508 X 28.444 μm (Erdtman)].

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, not straight, borders slightly distinct, with acute ends, $clt < plt$, clg : 21.885 (Non-acetolysed), 28.490 μm (Erdtman), clt : 1.890 (Non-acetolysed), 1.578 μm (Erdtman). Endoapertures-pori: not large, lalongate,

protruding, borders distinct, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 4.04 μm), plg : 5.966 (Non-acetolysed), 6.009 (Erdtman) μm , plt : 8.253 (Non-acetolysed), 9.094 (Erdtman) μm and $plt/plg = 0.723$ (Non-acetolysed), 0.660 (Erdtman) μm .

Outlines: Equatorial view - elliptic to slightly rectangular-obtuse-convex; polar view - circular.

Ornamentation: Reticulate, reticules regular, medium size and distinct. Apocolpium psilate and aperture area are slightly reticulate.

Ex/int (Non-acetolysed): $\cong 3/2$.

Exine thickness (Erdtman): $\cong 2 \mu m$.

L. aphaca var. *affinis*

Pollen class: 3-zonocolporate.

Pollen group: Prolate (P/E= 1.476).

Dimensions: Medium size (PXE= 40.144 X 27.196 μm).

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, straight, borders distinct, with acute ends, $clt < plt$, clg : 34.034 μm . clt : 2.459 μm . Endoapertures-pori: large, borders distinct, lalongate, protruding in mesocolpium, with an annulus (thickness sexine) and costae can not measured, plg : 7.517 μm , plt : 10.440 μm and $plt/plg = 0.720$.

Outlines: Equatorial view - elliptic; polar view - circular.

Ornamentation: Reticulate, reticules medium size, distinct. Apocolpium and aperture area are psilate.

Ex/int: $\cong 2/1$.

L. aphaca var. *aphaca*

Pollen class: 3-zonocolporate.

Pollen group: Prolate (P/E= 1.499).

Dimensions: Medium size (PXE= 40.126 X 26.767 μm).

Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: not long, straight, borders not distinct, with acute ends, $clt < plt$, clg : 27.701 μm , clt : 1.926 μm . Endoapertures-pori: small, lalongate, borders distinct, with an annulus (thickness sexine) and costae (thickness nexine) can not measured, plg : 4.369 μm , plt : 8.313 μm and $plt/plg = 0.526$.

Outlines: Equatorial view - elliptic; polar view - circular to triangular.

Ornamentation: Reticulate-perforate-foveolate, reticules medium and slightly distinct Apocolpium and aperture area are psilate or slightly reticulate.

Ex/int: $\cong 2/1$.

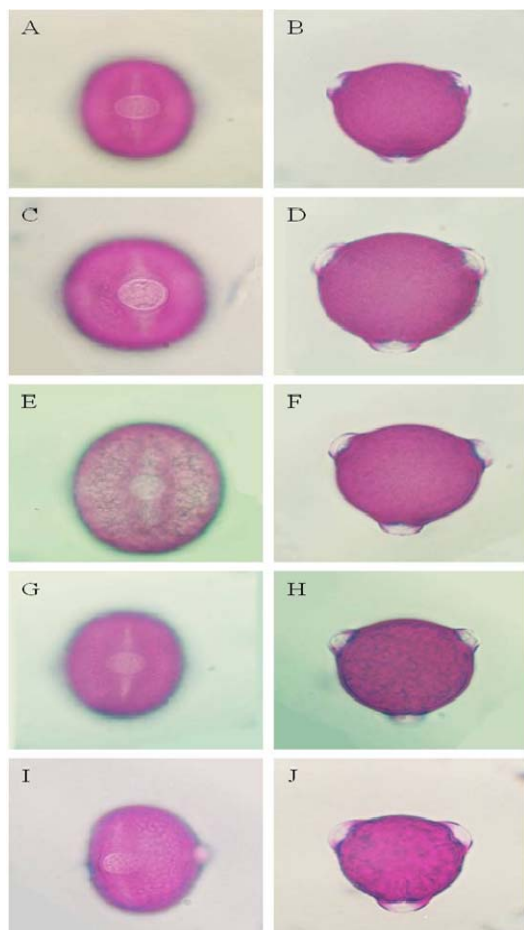
L. aphaca var. *biflorus*

Pollen class: 3-zonocolporate.

Pollen group: Prolate [P/E= 1.438 (Non-acetolysed), prolate P/E= 1.373 (Erdtman)].

Dimensions: Medium size [PXE= 45.604 X 31.720 μm (Non-acetolysed), 44.824 X 32.656 μm (Erdtman)].

Fig. 1: Pollen grains of *Lathyrus niger* (A, B), *L. palustris* (C, D), *L. tuberosus* (E, F), *L. sphaericus* (G, H), *Lathyrus setifolius* (I, J). A, C, E, G, I - equatorial view; B, D, F, H, J - polar view (LM). Bar denotes 15 μ m



Apertures: Apertures with an operculum (thickening of the middle of the aperture membrane). Ectoapertures-colpi: long, straight, borders slightly distinct in non-acetolysed, distinct in Erdtman, with acute ends, $clt < plt$, clg : 31.738 μ m (Non-acetolysed), 32.688 μ m (Erdtman), clt : 1.879 μ m (Non-acetolysed), 6.545 μ m (Erdtman). Endoapertures-pori: large, lalongate, borders distinct, protruding in mesocolpium, with an annulus (thickness sexine) and costae (thickness nexine: 3.48 μ m), plg : 6.612 μ m (Non-acetolysed), 14.887 μ m (Erdtman), plt : 10.718 μ m (Non-acetolysed), 16.427 μ m (Erdtman) and $plt/plg = 0.617$ (Non-acetolysed), 0.717 (Erdtman).

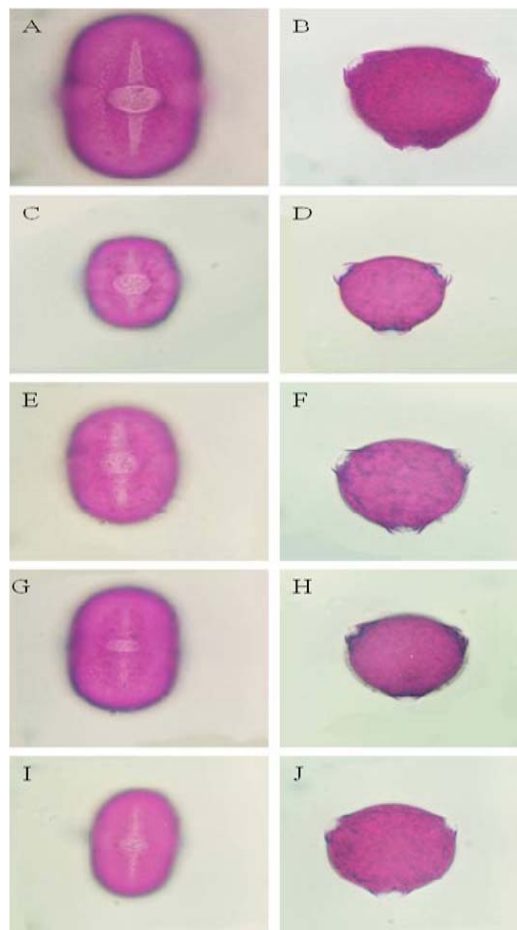
Outlines: Equatorial view - elliptic to slightly rectangular-obtuse-convex; polar view - circular to triangular.

Ornamentation: Reticulate-perforate-foveolate, reticules medium size, distinct Apocolpium and aperture area are psilate or slightly reticulate.

Ex/int (non-acetolysed): $\cong 2/1$.

Exine thickness (Erdtman): $\cong 2 \mu$ m.

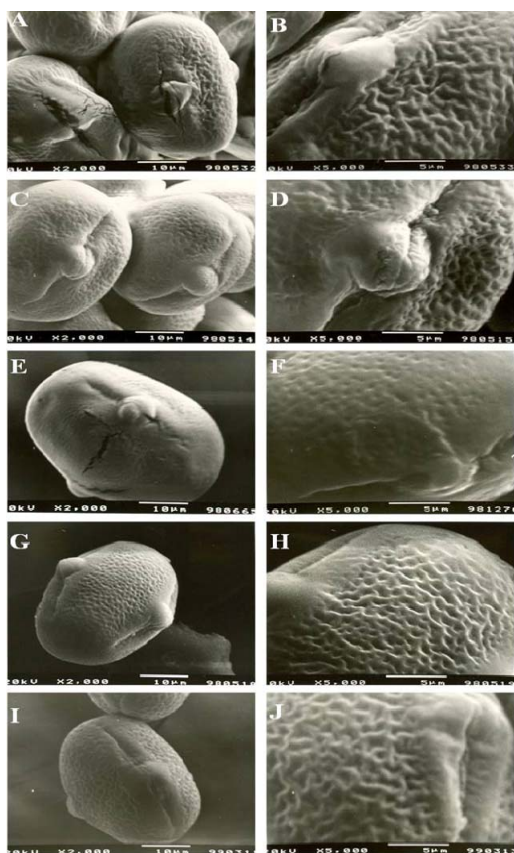
Fig. 2: Pollen grains of *Lathyrus clymenum* (A, B), *L. nissolia* (C, D), *L. aphaca* var. *aphaca* (E, F) *L. aphaca* var. *affinis* (G, H), *L. aphaca* var. *biflorus* (I, J). A, C, E, G, I - equatorial view; B, D, F, H, J - polar view (LM). Bar denotes 15 μ m



DISCUSSION

The pollen of the examined taxa were 3-zonocolpate and its pollen groups were spheroidal, subprolate and prolate. The longest pollen grains belong to *L. clymenum* ($P=52.418/E=35.815 \mu$ m in non-acetolysed & $P=58.604/E=46.332 \mu$ m in Erdtman) and the smallest *L. nissolia* ($P=32.791/E=24.747 \mu$ m in non-acetolysed & $P=40.508/E=28.444 \mu$ m in Erdtman). While pollen belonging to *L. niger* subsp. *niger*, *L. palustris* subsp. *palustris*, *L. tuberosus*, *L. sphaericus* and *L. setifolius* are fresh, when they become fossilized in response to spheroidal they form subprolate. The fresh pollen for *L. clymenum* are prolate and its fossilized pollen are subprolate. The fresh pollen for *L. nissolia* are subprolate and its fossilized pollen are prolate. The fresh pollen and the fossilized pollen for *L. aphaca* var. *biflorus* are prolate. When the pollen for *L. clymenum* are fossilized, they are shorter. The pollen length for *L. aphaca* var. *biflorus* was left unchanged however,

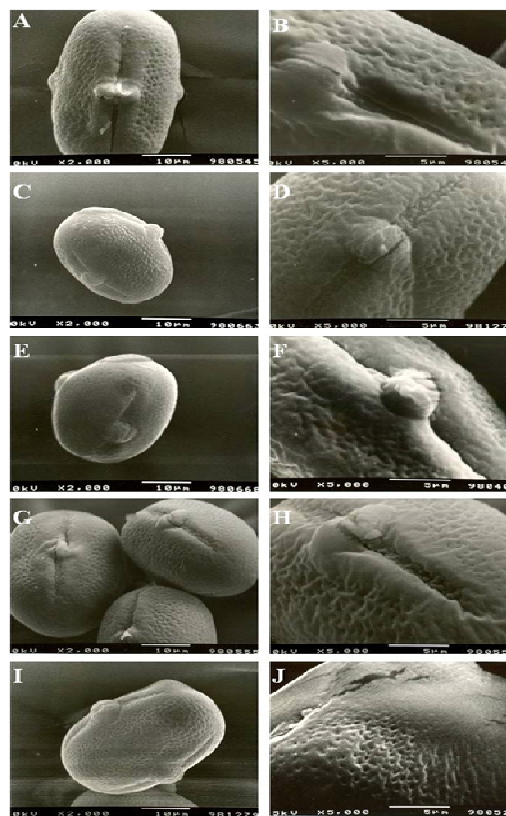
Fig. 3: Ornamentation in pollen grains of *Lathyrus niger* (A, B), *L. palustris* (C, D), *L. tuberosus* (E, F) and *L. sphaericus* (G, H), *Lathyrus setifolius* (I, J). A, C, E, G, I - equatorial view; B, D, F, H, J - polar view (SEM)



the pollen lengths for other taxa lengthened after being fossilized (Table II & III).

The pollen shape in equatorial view is elliptical-obtuse-convex, polar view circular to triangular-obtuse-convex as determined. The aperture system consists of ectoapertures (colpi) and endoapertures (pori). There are operculum above apertures, usually colpus long, borders distinct, with acute ends and thick costae near pori. The longest colpi *L. clymenum* (37.623 μm , in non-acetolysed and 47.166 μm in Erdtman) and the smallest *L. nissolia* (21.885 μm in non-acetolysed and 28.490 μm in Erdtman) was observed in the taxa. The narrowest colpi *L. tuberosus* (1.034 μm in Erdtman, *L. sphaericus* (1.566 μm in non-acetolysed), widest colpi *L. clymenum* (3.109 μm in Erdtman, *L. tuberosus* (3.503 μm in non-acetolysed) observed in the taxa. $\text{clt} < \text{plt}$ in all taxa. The pore shape of examined taxa was lalongate. Even though different figures were observed for pollen types Non-acetolysed and Erdtman, their pore shapes did not change. Pori usually large, borders distinct, annulus distinct, thick costae formed near pori. The biggest pore determined in Erdtman was *L. setifolius* and *L. clymenum*, in non-acetolysed *L. palustris* and *L. clymenum* (Table III).

Fig. 4: Ornamentation in pollen grains of *Lathyrus clymenum* (A, B), *L. nissolia* (C, D), *L. aphaca* var. *aphaca* (E, F), *L. aphaca* var. *affinis* (G, H), *L. aphaca* var. *biflorus* (I, J). A, C, E, G, I - equatorial view; B, D, F, H, J - polar view (SEM)



In the Erdtman method the exine thickness is $\approx 2.5 \mu\text{m}$ for *L. niger* subsp. *niger*, $\approx 1 \mu\text{m}$ for *L. clymenum* and $\approx 2 \mu\text{m}$ in other taxa. Generally, the ornamentation was reticulate. No significant differences were observed in the localities within the comparative study. Aytug *et al.* (1971) stated that the morphological properties of pollen did not change with environmental and geographical conditions. Our findings support the accuracy of this information. *L. tuberosus* (Tosheva *et al.*, 2004), *L. niger* (Gapotchka & Chamara, 1972; Gapotchka, 1974; Moore *et al.*, 1991; Halbritter, 2000; Beug, 2004; Tosheva & Tonkov, 2005) and *L. palustris* Tosheva and Tonkov (2005) are all researches that have carried out studies on the morphological properties of pollen for taxa. The pollen grains of *L. niger* is related to *Lathyrus*-type (Beug, 2004), while Moore *et al.* (1991) assign this pollen grains to *Vicia cracca*-type. Halbritter (2000) reported the presence of psilate ornamentation. Gapotchka and Chamara (1972) and Gapotchka (1974) reported that the grain size is $P \times E = 34.7 \times 26.0 \mu\text{m}$, the ornamentation is perporate.

According to Tosheva and Tonkov (2005) the grain size is $P \times E = 34.6 \times 26.6 \mu\text{m}$, the ornamentation is perporate - foveolate. Our findings, Tosheva and Tonkov (2005) findings

$P \times E = 33.336 \times 29.363 \mu\text{m}$ in non-acetolysed, $41.288 \times 32.136 \mu\text{m}$ Erdtman and the ornamentation show compliance excluding these properties. *L. palustris* is *Lathyrus*-type according to (Beug, 2004), while Moore *et al.* (1991) assign this pollen grains to *Vicia cracca*-type. According to Faegri and Iversen (1989) the pollen grains have distinct reticulum and heavy costae along the colpi. Tosheva and Tonkov (2005) reported that $P \times E = 46.7 \times 36.6$, subprolate. Our results confirm the previous data (Table III). The thickest costae was observed in *L. setifolius* ($4.64 \mu\text{m}$) and the thinnest costae was observed in *L. clymenum* ($1.74 \mu\text{m}$). When researches carried out to date are examined, among the *Lathyrus* taxa (Aytug *et al.*, 1971; Moore *et al.*, 1991; Perveen & Qaiser, 1998; Gunes & Cırpıcı, 1998, 2010; Tosheva *et al.*, 2004; Gunes & Aytug, 2010), for whose pollen morphological properties have been determined (44 taxa), it is observed that the longest pollen belongs to *L. clymenum* and the smallest pollen belongs to *L. nissolia*.

The differences in pollen morphology of 10 *Lathyrus* taxa could be an indication of their genetic differences. Cronquist (1968) reported that pollen sculpture types have valid morphological features in taxonomy. Thus, the taxonomic value of these taxa in *Lathyrus* taxa, as well as their pollen morphology, could be a distinguishing criterion. Thus, morphological structures of pollen seem to be useful for differentiating taxa; thus, it is suggested that they could be of benefit in taxonomical studies.

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