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POLLEN MORPHOLOGY OF SOME *DELPHINIUM* L. (*RANUNCULACEAE*) TAXA IN TURKEY

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Abstract:

This study seeks to explain the pollen morphology of some *Delphinium* L. (*Ranunculaceae*) taxa in Turkey. Palynological observations have covered 21 taxa. Pollen morphology of 21 *Delphinium* L. (*Ranunculaceae*) taxa has been examined by light microscopy. Pollen grains are 3-colpate; oblate-sphaeroidal, prolate-sphaeroidal, subprolate and prolate. intersubangular or interangular in polar view. Nexine is equal to sexine or thicker than sexine, and ornamentation is micro-echinate. Colpi membrane with many granules. The pollen grains show stenopalynous features. The aim of the article is to obtain palynological data of some *Delphinium* L. taxa.

Key Words: *Delphinium*, *Ranunculaceae*, Pollen morphology, Turkey.

Introduction

Taxonomic studies of the genus *Delphinium* L. (*Ranunculaceae*) in Turkey have been carried out by Mısırdalı et al. (1) and İlarslan (2).

The genus *Delphinium* L. belongs to the family *Ranunculaceae* and 31 taxa of *Delphinium* L. were found in Turkey (2).

The morphological features of the pollen in some genus of *Ranunculaceae* have been treated by several authors (3-19).

Erdtman has provided a short description of pollen grains of *Ranunculaceae*. Pollen grains of *Ranunculaceae* have pore or colpi. Pollen grains of *Ranunculus arvensis* L., *Ranunculus liyalli* L., *Paeonia* L. and *Souliea vaginata* Franch. were examined by Erdtman (3). Pollen grains of many ranunculaceous taxa were studied and the large size of pantoporate *Ranunculus arvensis* L. type was introduced by Erdtman et al. (4 -5).

A palynological study of the tribe *Ranunculaceae* was made by Santisuk (6).

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Chester and Raine prepared a pollen key including pollen grains of *Ranunculaceae* family (7).

Pollen morphology of *Delphinium peregrium* L., *Consolida raveyi* Boiss., *Consolida hellespontica* Boiss. was determined by Bozdoğan and Pehlivan (8).

Palynological characters of *Delphinium elatum* L. were shown in a palynological database by Oberschneider et al. (9).

Pollen morphology of *Ranunculus constantinopolitanus* Urv. was described by Aytuğ (10).

Pollen morphology of *Helleborus* L. belongs to the family *Ranunculaceae* was examined by Nowicke and Skvarla (11).

Pollen morphologies of many *Ranunculaceae* taxa and *Delphinium verdunense* were studied by Clarke et al. (12).

To determine the taxonomic identities of Korean Adonis, the pollen morphology of 18 taxa were studied by Lee et al. (13).

Pollen grains of *Hydrastis* L., *Paeonia* L. and *Trollius* L. were investigated by Lee and Blackmore (14).

Pollen grains of Indian specimens were studied by Nair (15).

Pollen morphology of Australian *Anemone* L. was examined by Huynh (16)

Pollen morphology of the Bulgarian representatives of the family *Ranunculaceae-Adonis* L was studied by Petrov et al. (17).

Morphological features of the pollen of 62 species of *Aconitum* L. was investigated and pollen characteristics among the species were evaluated by XI (18).

Exine structure of *Nigella* L. was examined by Nowicke and Skvarla. According to this study pollen grains of *Nigella* L. have unusual exine stratification (19).

This investigation was initiated to describe pollen morphology of some *Delphinium* L. taxa, occurring in Turkey.

Materials and Methods

All the pollen samples were taken from herbarium specimens at Ankara University, Faculty of Science (ANK) and Hacettepe University, Faculty of Science (HUB). In this study, collection areas, date of collections and collectors of *Delphinium* L. taxa were given in Table 1.

The pollen slides for light microscopy were prepared using the method described by F. ... (20)

standard deviations of measurements (S), variations obtained with the formulas of Sokal and Rohlf (21)

SPSS packet programme was used for drawing graphs. Datas concerning size are based upon the measurements of a minimum 100 pollen grains for each taxa. Orthomatw device which was bounded to Life Phan Photo microscope was used for photographing. Light micrographs of pollen grains were taken considering optic cross section and ornemanation at high focus, in polar view and equatorial view. Terminology mainly follows Erdtman (4).

Table 1. Collection areas, date of collection, collectors, and herbaria of *Delphinium* L. taxa.

Taxa	Collection Areas	Date	Collectors and Herbaria
<i>D. peregrinum</i>	B-7 Malatya, Doğanşehir, 30 km to Malatya, Hampınar Plantation Forestry Area, 1150 m.	08.07.1986	R. İlarşlan 1664-ANK
<i>D. virgatum</i>	C-3 Antalya, Termessos National Park, Scrubs and stony slopes, 450-500 m.	18.07.1987	R. İlarşlan 1645-ANK
<i>D. venulosum</i>	C-5 Niğde, Çaykavak Pass, Hasan Hill, Calcareous slopes, 1600 m.	28.07.1984	R. İlarşlan 1613-ANK
<i>D. davisii</i>	A-4 Zonguldak, Karabük, Eğriova, Güneyören Town, Rocky places, 850 m.	07.08.1984	R. İlarşlan 1618-ANK
<i>D. staphisagria</i>	C-3 Antalya, Kumluca, Above the Adrasan Bay, Calcareous area, North Slope, 120 m.	08.06.1979	H. Peşmen 4410-HUB
<i>D. albiflorum</i>	A-9 Kars, Sarıkamış, Kemaltepe, Sarıkamış-Karakurt Road, from Sarıkamış 10 km, Çıplak Mount, Protected area, 2050 m.	27.07.1986	R. İlarşlan 1657-ANK
<i>D. dasystachyum</i>	B-7 Erzincan, Üzümlü (Cimin), Keşiş Mountain, Büyük Mezire, under the Orta yol, Çifte Dereleler, 2200-2300 m.	19.08.1984	R. İlarşlan 1605-ANK
<i>D. schmalhauseni</i>	A-9 Kars, Ardahan, Yalnızçam, Bağdaşan Town, Rum Stream, Near stream, 2400 m.	27.08.1984	R. İlarşlan 1620-ANK
<i>D. ilgazense</i>	A-4 Kastamonu, Ilgaz, National Park Area, Kuşkayası Place, northwest slopes, Rocky places, 1600-1700 m.	16.08.1984	R. İlarşlan 1611-ANK
<i>D. fissum</i> subsp. <i>anatolicum</i>	A-4 Ankara, Çubuk, Karagöl, Rocky slopes.	15.08.1973	S. Erik 349-HUB
<i>D. kitianum</i>	C-4 Konya, Ermenek, Kazancı Town, Cevizli Tarla, Above the Büyükyer Place, Northwest slope, 1300 m.	10.07.1985	R. İlarşlan 1639-ANK
<i>D. carduchorum</i>	B-9 Van, Başkale, 80 km, Güzeldere Pass, 2680 m.	04.07.1985	R. İlarşlan 1633-ANK
<i>D. munzianum</i>	A-8 Erzurum, Tortum-Oltu, From Tortum 20 km, Calcareous stony slopes, 1900-2000 m.	17.07.1996	R. İlarşlan 1663-ANK
<i>D. nydeggeri</i>	C-5 Niğde, Çamardı, Demirkazık Village, Cımarın Ağızı, South slopes, 1600 m.	27.07.1984	R. İlarşlan 1616-ANK
<i>D. gueneri</i>	C-3 Isparta, Eğirdir, Aksu Town, Yaka Village, Kapız, Stream, Derin Valley, 1350-1400 m.	12.07.1985	R. İlarşlan 1641-ANK
<i>D. petrodavisianum</i>	C-4 Konya, Ermenek, Hadım Road, 5 km, Rocky slopes, 1300-1400 m.	11.07.1985	R. İlarşlan 1642-ANK
<i>D. vanense</i>	B-9 Bitlis/Van, Above the Kuzgunkıran Pass, Stony mount slopes, 2400-2650 m.	04.07.1986	R. İlarşlan 1635-ANK
<i>D. macrostachyum</i>	C-8 Mardin, Bakırkırı, Rocky slopes, 1500-1600 m.	05.07.1985	R. İlarşlan 1631-ANK
<i>D. buschianum</i>	A-9 Kars, Ardahan, Tunçoğlu (Panik) town, Kısır Mount, Rocky of Ramis, 2400-2500 m.	27.08.1984	R. İlarşlan 1621-ANK
<i>D. formosum</i>	A-8 Rize, Çamlıhemşin, between Çat-Hisarçık, Mixed forest, Deep metamorphical valley, 1200-1600 m.	08.08.1981	Güner 4023-HUB
<i>D. flexuosum</i>	A-9 Artvin, Ardanuç, Kutul yaylası, Karanlık Quercus Forest, Müezzinler Town, Under the plateau, 2150-2200 m.	28.08.1984	R. İlarşlan 1603-ANK

Results

General Pollen Morphology of *Delphinium* L. Genus

Pollen grains of taxa belonging to *Delphinium* L. genus are tricolpate. Average polar axis diameter of pollen grains of taxa ranging from 21.15-37.81 μm , average equatorial diameter ranging from 19.88-27.97 μm . The shape of the pollen grains is oblate-sphaeroidal, prolate-sphaeroidal, subprolate and prolate. Apocolpia is between 2.51-9.92 μm . Ornamentation of exine is microechinate. Exine thickness is between 0.62-1.98 μm at mesocolpia. Nexine is equal to sexine or thicker than sexine. The pollen grains have long or short colpi, with acute apices. Colpi membrane with many granules.

Pollen Description

Section : *Delphinium* DC.

Delphinium peregrinum L. (Figure 1)

Pollen grains 3-colpate, subprolate. Polar axis 24.26 μm . Equatorial diameter 20.50 μm . Amb interangular or intersubangular. Apocolpia 3.16 μm . Exine 1.86 μm thick at mesocolpia. Sexine 0.62 μm , nexine 1.24 μm . Ornamentation of exine is micro-echinate. Colpi 19.84 μm long with acute apices. Wideness of colpi 3.72 μm . Colpi membrane with many granules.

Delphinium virgatum Poir. (Figure 2)

Pollen grains 3-colpate, oblate-sphaeroidal. Polar axis 21.71 μm . Equatorial diameter 22.88 μm . Amb intersubangular. Apocolpia 3.51 μm . Exine 1.75 μm thick at mesocolpia. Sexine 0.62 μm , nexine 1.13 μm . Ornamentation of exine is micro-echinate. Colpi 23.43 μm long with acute apices. Wideness of colpi 3.78 μm . Colpi membrane with many granules.

Delphinium venulosum Boiss. (Figure 3)

Pollen grains 3-colpate, prolate-sphaeroidal. Polar axis 25.88 μm . Equatorial diameter 23.07 μm . Amb intersubangular. Apocolpia 2.66 μm . Exine 1.96 μm thick at mesocolpia. Sexine 0.98 μm , nexine 0.98 μm . Ornamentation of exine is micro-echinate. Colpi 19.77 μm long with acute apices. Wideness of colpi 3.72 μm . Colpi membrane with many granules.

Delphinium davisii Munz (Figure 4)

Pollen grains 3-colpate, subprolate. Polar axis 31.99 μm . Equatorial diameter 24.53 μm . Amb intersubangular. Apocolpia 6.20 μm . Exine 1.24 μm thick at mesocolpia. Sexine 0.62 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 25.42 μm long with acute

Section : **Staphisagria** DC.

Delphinium staphisagria L. (Figure 5)

Pollen grains 3-colpate, prolate. Polar axis 37.81 μm . Equatorial diameter 27.54 μm . Amb intersubangular. Apocolpia 4.96 μm . Exine 1.82 μm thick at mesocolpia. Sexine 1.20 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 28.21 μm long with acute apices. Wideness of colpi 5.89 μm . Colpi membrane with many granules.

Section : **Oligophyllon** DC.

Delphinium albiflorum DC. (Figure 6)

Pollen grains 3-colpate, prolate. Polar axis 27.94 μm . Equatorial diameter 20.32 μm . Amb intersubangular. Apocolpia 6.20 μm . Exine 1.24 μm thick at mesocolpia. Sexine 0.62 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 26.66 μm long with acute apices. Wideness of colpi 5.58 μm . Colpi membrane with many granules.

Delphinium dasystachyum Boiss. & Bal. (Figure 7)

Pollen grains 3-colpate, subprolate. Polar axis 24.29 μm . Equatorial diameter 20.77 μm . Amb interangular or intersubangular. Apocolpia 2.97 μm . Exine 1.25 μm thick at mesocolpia. Sexine 0.47 μm , nexine 0.78 μm . Ornamentation of exine is micro-echinate. Colpi 18.71 μm long with acute apices. Wideness of colpi 3.96 μm . Colpi membrane with many granules.

Delphinium schmalhausenii Albov (Figure 8)

Pollen grains 3-colpate, subprolate. Polar axis 25.67 μm . Equatorial diameter 19.88 μm . Amb intersubangular. Apocolpia 4.96 μm . Exine 1.44 μm thick at mesocolpia. Sexine 0.51 μm , nexine 0.93 μm . Ornamentation of exine is micro-echinate. Colpi 21.26 μm long with acute apices. Wideness of colpi 3.97 μm . Colpi membrane with many granules.

Delphinium ilgazense P. H. Davis (Figure 9)

Pollen grains 3-colpate, prolate. Polar axis 29.36 μm . Equatorial diameter 21.57 μm . Amb intersubangular. Apocolpia 8.86 μm . Exine 0.93 μm thick at mesocolpia. Sexine 0.31 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 22.70 μm long with acute apices. Wideness of colpi 3.10 μm . Colpi membrane with many granules.

Delphinium fissum subsp. ***anatolicum*** Chowdhuri & P. H. Davis (Figure 10)

Pollen grains 3-colpate, prolate-sphaeroidal. Polar axis 24.68 μm . Equatorial diameter 21.99 μm . Amb intersubangular. Apocolpia 8.51 μm . Exine 1.25 μm thick at mesocolpia. Sexine 0.48 μm , nexine 0.77 μm . Ornamentation of exine is micro-echinate. Colpi 23.43 μm long with acute apices. Wideness of colpi 3.88 μm . Colpi membrane with many granules.

Delphinium kitianum İlarıslan (Figure 11)

Pollen grains 3-colpate, subprolate. Polar axis 27.71 μm . Equatorial diameter 22.88 μm . Amb intersubangular. Apocolpia 6.20 μm . Exine 1.47 μm thick at mesocolpia. Sexine 0.78 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 26.66 μm long with acute apices. Wideness of colpi 5.58 μm . Colpi membrane with many granules.

Delphinium carduchorum Chowdhuri & P. H. Davis (Figure 12)

Pollen grains 3-colpate, subprolate. Polar axis 30.80 μm . Equatorial diameter 24.26 μm . Amb intersubangular. Apocolpia, 9.92 μm . Exine 0.62 μm thick at mesocolpia. Sexine 0.31 μm , nexine 0.31 μm . Ornamentation of exine is micro-echinate. Colpi 25.42 μm long with acute apices. Wideness of colpi 4.71 μm . Colpi membrane with many granules.

Delphinium munzianum P. H. Davis & Kit Tan (Figure 13)

Pollen grains 3-colpate, subprolate. Polar axis 26.87 μm . Equatorial diameter 22.19 μm . Amb interangular or intersubangular. Apocolpia, 3.16 μm . Exine 1.24 μm thick at mesocolpia. Sexine 0.62 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 24.67 μm long with acute apices. Wideness of colpi 4.15 μm . Colpi membrane with many granules.

Delphinium nydeggeri Hub.-Mor. (Figure 14)

Pollen grains 3-colpate, subprolate. Polar axis 27.88 μm . Equatorial diameter 23.60 μm . Amb interangular or intersubangular. Apocolpia 3.90 μm . Exine 1.45 μm thick at mesocolpia. Sexine 0.83 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 23.25 μm long with acute apices. Wideness of colpi 4.27 μm . Colpi membrane with many granules.

Delphinium gueneri P. H. Davis (Figure 15)

Pollen grains 3-colpate, subprolate. Polar axis 27.97 μm . Equatorial diameter 22.30 μm . Amb interangular or intersubangular. Apocolpia 6.20 μm . Exine 1.24 μm thick at mesocolpia. Sexine 0.62 μm , nexine 0.62 μm . Ornamentation of exine is micro-echinate. Colpi 24.64 μm long with acute apices. Wideness of colpi 4.57 μm . Colpi membrane with many granules.

Delphinium petrodavisanum İnarşlan (Figure 16)

Pollen grains 3-colpate, subprolate. Polar axis 26.80 μm . Equatorial diameter 22.81 μm . Amb intersubangular. Apocolpia, 2.48 μm . Exine 1.30 μm thick at mesocolpia. Sexine 0.63 μm , nexine 0.67 μm . Ornamentation of exine is micro-echinate. Colpi 21.26 μm long with acute apices. Wideness of colpi 3.97 μm . Colpi membrane with many granules.

Delphinium vanense Rech. (Figure 17)

Pollen grains 3-colpate, oblate-sphaeroidal. Polar axis 21.15 μm . Equatorial diameter 17.97 μm . Amb interangular or intersubangular. Apocolpia 2.60 μm . Exine 1.65 μm thick at mesocolpia. Sexine 0.65 μm , nexine 1.00 μm . Ornamentation of exine is micro-echinate. Colpi 13.25 μm long with acute apices. Wideness of colpi 3.96 μm . Colpi membrane with many granules.

Delphinium ...

μm , nexine $0.62 \mu\text{m}$. Ornamentation of exine is micro-echinate. Colpi, $21.08 \mu\text{m}$ long with acute apices. Wideness of colpi $3.84 \mu\text{m}$. Colpi membrane with many granules.

Section: *Pogonanthus* W.T. Wang

***Delphinium buschianum* Grossh. (Figure 19)**

Pollen grains 3-colpate, prolate-sphaeroidal. Polar axis $23.15 \mu\text{m}$. Equatorial diameter $21.15 \mu\text{m}$. Amb interangular or intersubangular. Apocolpia, $6.20 \mu\text{m}$. Exine $1.30 \mu\text{m}$ thick at mesocolpia. Sexine $0.43 \mu\text{m}$, nexine $0.87 \mu\text{m}$. Ornamentation of exine is micro-echinate. Colpi $18.41 \mu\text{m}$ long with acute apices. Wideness of colpi $4.34 \mu\text{m}$. Colpi membrane with many granules.

***Delphinium formosum* Boiss. & Huet (Figure 20)**

Pollen grains 3-colpate, subprolate. Polar axis $28.62 \mu\text{m}$. Equatorial diameter $24 \mu\text{m}$. Amb interangular or intersubangular. Apocolpia $5.58 \mu\text{m}$. Exine $1.24 \mu\text{m}$ thick at mesocolpia. Sexine $0.62 \mu\text{m}$, nexine $0.62 \mu\text{m}$. Ornamentation of exine is micro-echinate. Colpi $23.00 \mu\text{m}$ long with acute apices. Wideness of colpi $4.58 \mu\text{m}$. Colpi membrane with many granules.

***Delphinium flexuosum* M. Bieb. (Figure 21)**

Pollen grains 3-colpate, prolate-sphaeroidal. Polar axis $23.64 \mu\text{m}$. Equatorial diameter $20.78 \mu\text{m}$. Amb interangular or intersubangular. Apocolpia $3.10 \mu\text{m}$. Exine $1.64 \mu\text{m}$ thick at mesocolpia. Sexine $0.62 \mu\text{m}$, nexine $1.02 \mu\text{m}$. Ornamentation of exine is micro-echinate. Colpi $20.95 \mu\text{m}$ long with acute apices. Wideness of colpi $3.72 \mu\text{m}$. Colpi membrane with many granules.

— 10 μm

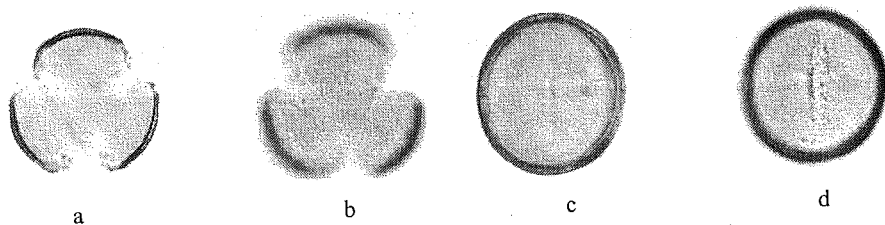


Figure 1. *D. peregrinum*



— 10 μ m

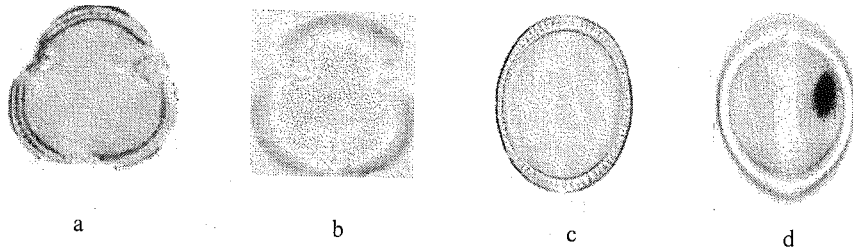


Figure 3. *D. venulosum*

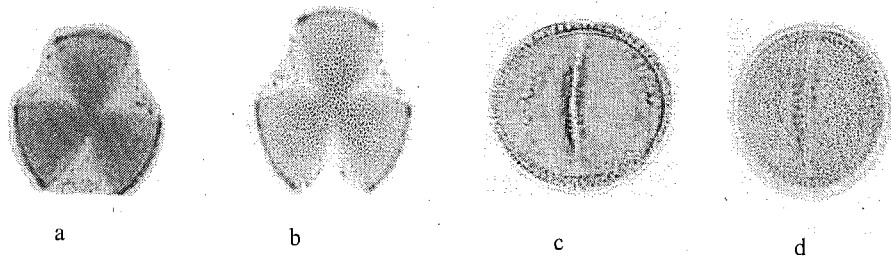


Figure 4. *D. davisii*

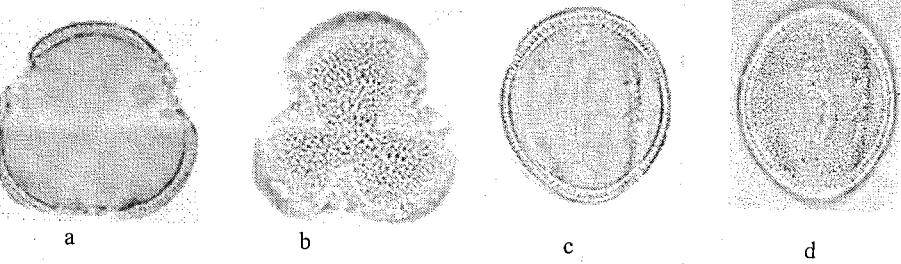


Figure 5. *D. staphisagria*

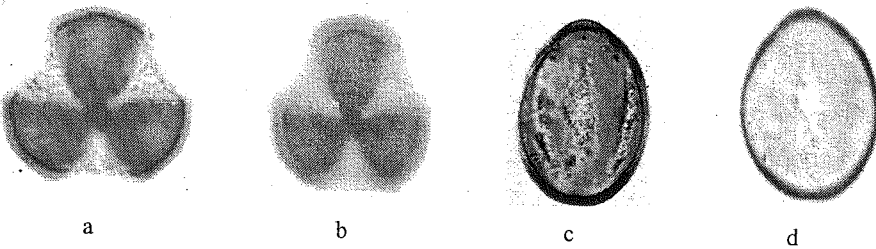


Figure 6. *D. albiflorum*



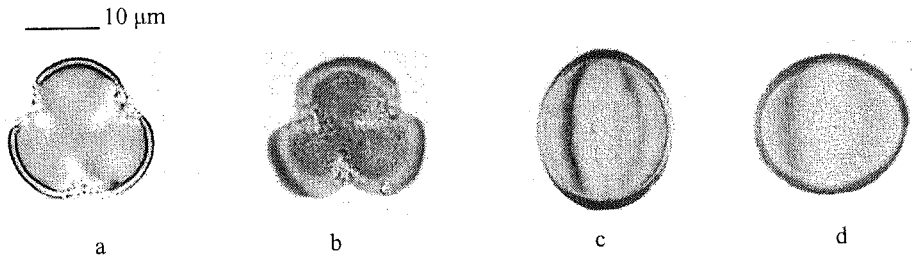


Figure 8. *D. schmalhauseni*

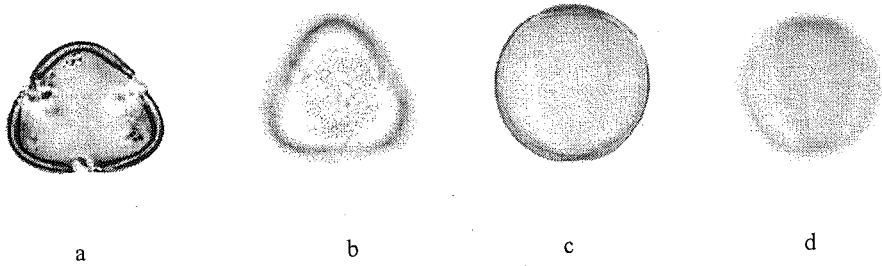


Figure 9. *D. ilgazense*

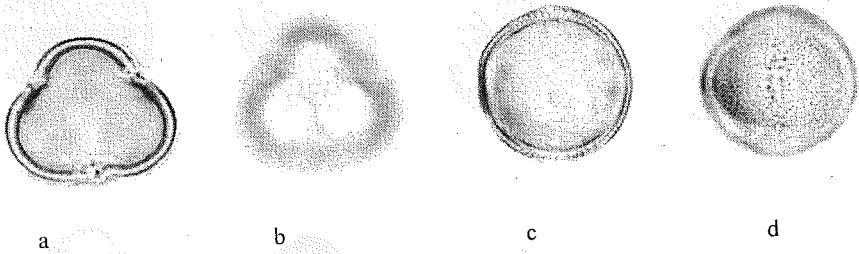


Figure 10. *D. fissum* subsp. *anatolicum*

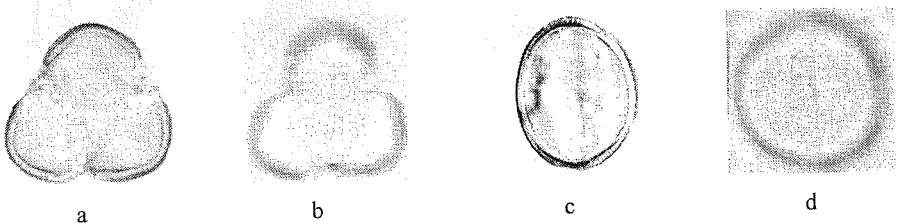
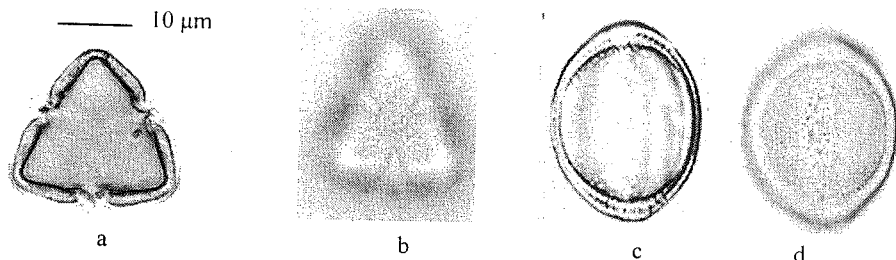
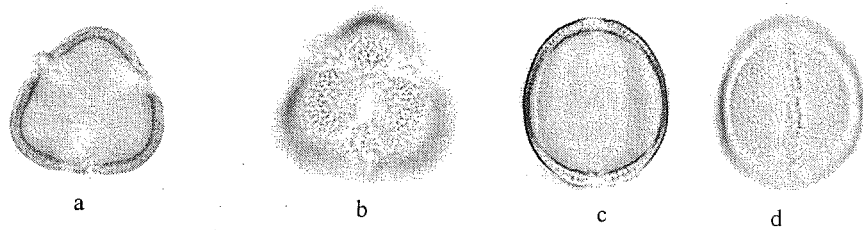
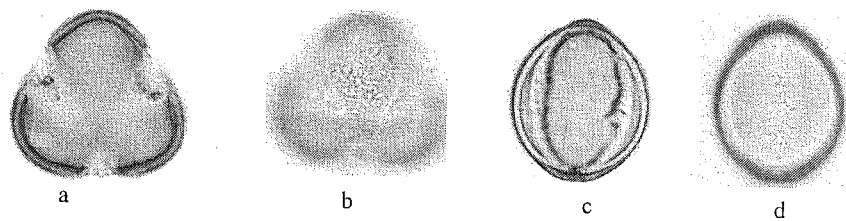
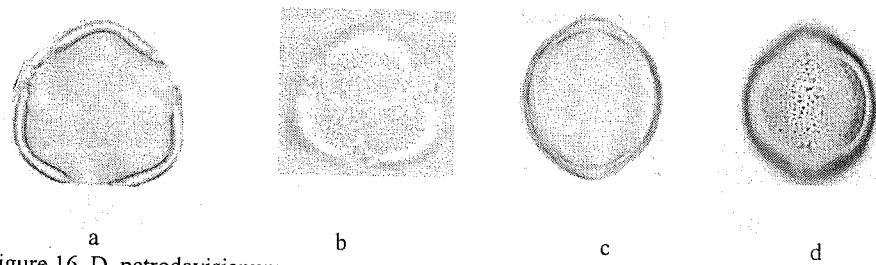
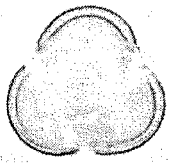


Figure 11. *D. kitianum*

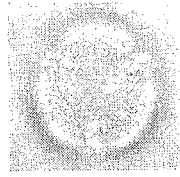


Figure 13. *D. munzianum*Figure 14. *D. nydeggeri*Figure 15. *D. gueneri*Figure 16. *D. petrodavisianum*

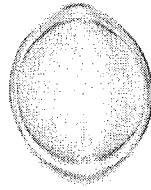
— 10 μ m



a



b

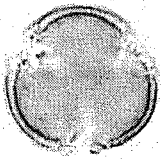


c

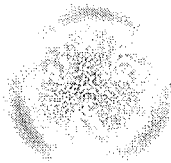


d

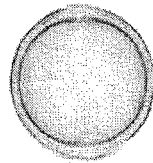
Figure 18. *D. macrostachyum*



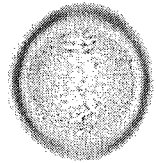
a



b

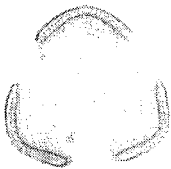


c

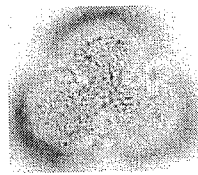


d

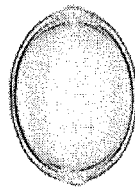
Figure 19. *D. buschianum*



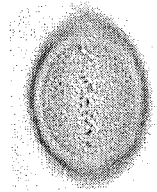
a



b

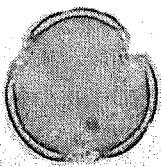


c

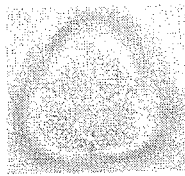


d

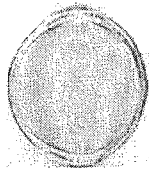
Figure 20. *D. formosum*



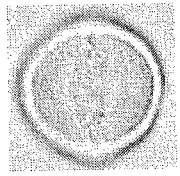
a



b



c



d

Figure 21. *D. flexuosum*

Figure 1-21. Light micrographs of *Delphinium* L. taxa
a - Polar view ; optic cross section

Discussion

The pollen grains of belonging to *Delphinium* L. genus are 3-colpate. AMB shape is intersubangular or angular in polar view. The shape of the pollen grains are oblate-sphaeroidal, prolate-sphaeroidal, subprolate and prolate. Exine ornamentation is micro-echinate. The pollen grains have long or short colpi, with acute apices. Colpi membrane with many granules.

The pollen grains of taxa belonging to *Delphinium* L. taxa show stenopalynous features.

According to SPSS graphs, there are variations and similarities among the pollen grains of taxa existing in the same section (Figure 22-24). According to palynological data, polar axis diameter, equatorial diameter and AMB shape of all pollen grains are not equal.

D. peregrinum and *D. virgatum* exist in the *Delphinium* DC. section. Morphologically *D. peregrinum* is different from *D. virgatum*. *D. peregrinum* L. has obovate petals, upper leaves are linear lanceolata, claw is approximately equal to lamina (2). *D. virgatum*, *D. venulosum*, *D. davisii* pollen grains have approximately same equatorial diameter and polar axis and exist in the *Delphinium* DC section.

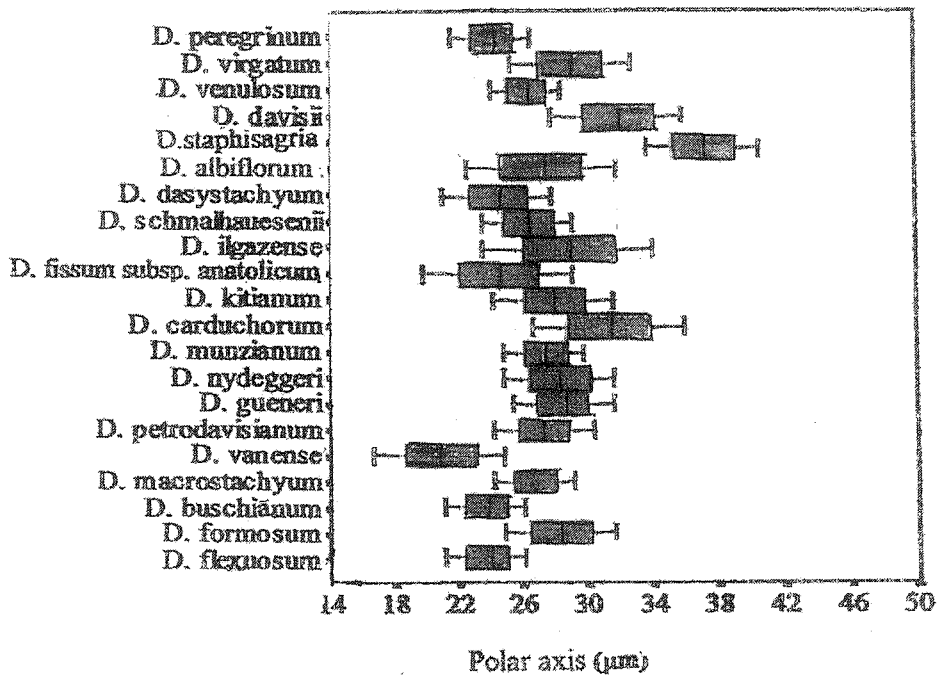
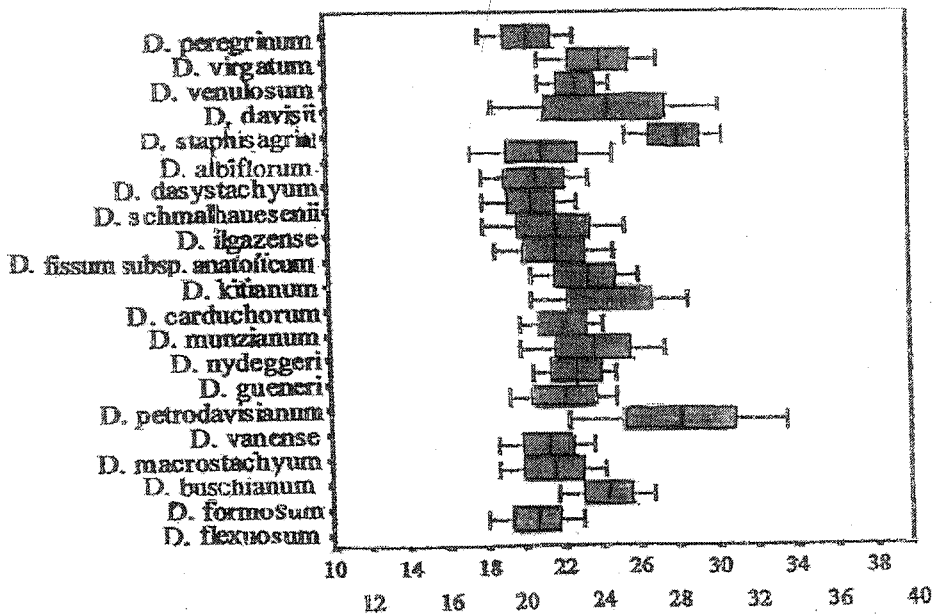
Davis (22) explained that the most of the taxa belonging to *Delphinium* L. were probably hybrid. According to palynological knowledge, when abnormal pollen grains amount is more than % 50, pollen grains are hybrid. (23) Diameters of hybrid pollen grains can be rather various. In this study, pollen grain diameters of 21 *Delphinium* L. taxa diameters are not very different. Pollen grains of 21 *Delphinium* L. taxa are homogenous.

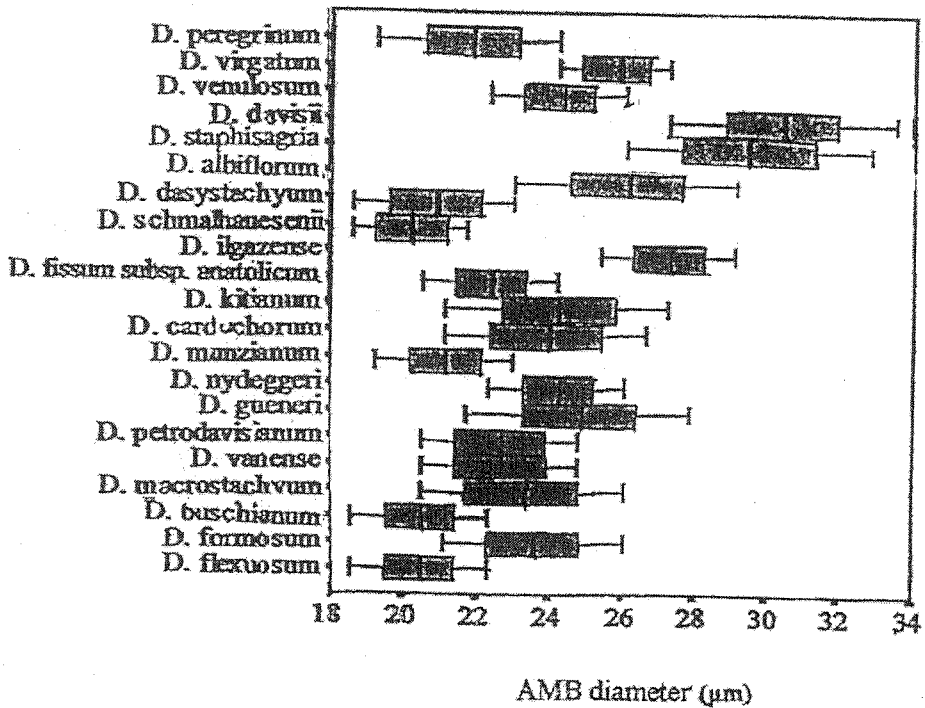
İlarslan described *Delphinium* L. taxa occurring in Turkey and he found variations among the taxa. The pollen grains of the genus *Delphinium* L. show variation between the species that sometimes corresponds with the morphologic features (2).

Pollen characteristics can use to distinguish *Staphisagria* section. *D. staphisagria* L. was separated from other taxa distinctly by İlarslan (2). *D. staphisagria* L. has long, hairy stem and swollen fruit. Diameters of pollen grains of *D. staphisagria* L. are wider than the other species too. But the pollen characteristics can not used to distinguish all the *Delphinium* L. sections and subsections. The variations can be used to distinguish between some closely related species.

Our observations with light microscope have revealed the taxa of the *Delphinium* L. genus.

The investigated taxa are homogenous with respect to their pollen morphology, but a closer studies carried out by SEM and TEM will reveal new data for a better grouping.

Figure 22. Polar axis diameters of *Delphinium* L. taxa



24. AMB diameters of *Delphinium* L. taxa

Variation
 Min | | Max
 ↳ Average Value

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