

POLLEN MORPHOLOGY OF SOME TURKISH *AJUGA* L. (LAMIACEAE) AND ITS TAXONOMIC VALUE

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Abstract

Pollen morphological structures of eight Turkish species of *Ajuga*, namely *A. bombycina* Boiss., *A. chamaepitys* (L.) Schreber ssp. *chia* var. *chia* (Schreber) Arcangeli, *A. chamaepitys* (L.) Schreber ssp. *chia* var. *ciliata* Briq., *A. chamaepitys* (L.) Schreber ssp. *cuneatifolia* (Stapf) P. H. Davis, *A. genevensis* L., *A. laxmannii* (L.) Benthum, *A. orientalis* L. and *A. reptans* L. have been studied under light and scanning electron microscopes for the first time. It is revealed that the pollen grains of *Ajuga* taxa are more or less suboblata-subprolata and tricolpatae. The exine sculpture is granulate in *A. chamaepitys* subsp. *chia* var. *chia*, *A. chamaepitys* subsp. *cuneatifolia*, *A. genevensis*, *A. laxmannii*, *A. orientalis* and *A. reptans*, but it is reticulate in *A. bombycina* and *A. chamaepitys* subsp. *chia* var. *ciliata*.

Introduction

The Lamiaceae is a large family and show world-wide natural distribution having approximately 250 genera, 7000 species in the world and 45 genera, 574 species in Turkey. Most of species belonging to this family are shrubby and herbaceous, trees extremely rare (Heywood 1978). This family has great importance due to its economic value (Koyuncu *et al.* 2010).

The genus *Ajuga* L. consists of about 90 species, mostly distributed in the north temperate zone of the old world. The genus also occurs in South Africa and Australia. In flora of Turkey *Ajuga* represented by 14 species and 27 subspecific taxa (Davis 1982,1988, Baytop 1999). Some *Ajuga* species have been widely used for their aromatic, diuretic, antipyretic, tonic, diaphoretic, astringent, bitter and homeopathic properties in the Turkish folk medicine (Baytop 1999) and in many official and unofficial medicine (Stuart 1979, Launert 1981, Werker *et al.* 1985, Bown 1995).

Very few anatomical studies is existed on *Ajuga reptans* L. and *Ajuga chamaepitys* (L.) Schreber ssp. *chia* (Schreber) Arcangeli var. *chia* in Turkey (Akçin *et al.* 2006, Potoglu Erkara and Koyuncu 2009). The pollen characters of some Turkish *Ajuga* species have yet studied to be in detail. Pollen structures can be used both to distinguish related taxa and integrate them into a common group.

The purpose of light microscopy (LM) and scanning electronic microscopy (SEM) study on the pollen morphology of Turkish *Ajugas*, one of which is endemic species to solve problematic aspects of taxonomy and evolution.

Materials and Methods

Pollens were obtained from the authenticated voucher specimens deposited at the Faculty of Pharmacy of Anadolu University Herbarium (ESSE). For LM, pollen grains were processed from herbarium materials following Erdtman (1960). The pollen dimensions of all species were measured in such amounts that the resulting data followed Gaussian curves. These measurements

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are shown in Table 2. For SEM, the unacetolyzed pollen grains were directly placed on stubs, sputter-coated with gold plate, and examined under a Jeol 5600 LV-SEM (Walker 1974a,b). The terminologies for pollen morphology proposed by Skvarla (1966), Erdtman (1969), Walker (1974a,b), Charpin *et al.* (1974) and Faegri and Iversen (1975) were employed.

Specimens investigated

Taxa of <i>Ajuga</i>	Herbarium No.	Origin
<i>A. bombycina</i> Boiss. (Endemic)	ESSE 14511	C4 Antalya, Alanya, kale çıkışı, yamaçlar, 102 m, 36° 32' 21.1'' N 31° 59' 669'' E, 24/03/2010.
<i>A. chamaepitys</i> (L.) Schreber subsp. <i>chia</i> var. <i>chia</i> (Schreber) Arcangeli	ESSE 14508	C3 Antalya, Akseki, Güzelsu yolu, yol kenarı, kayalık, 1017 m, 36° 54' 32.2'' N 31° 49' 29.7'' E, 07/07/2008.
<i>A. chamaepitys</i> (L.) Schreber subsp. <i>chia</i> var. <i>ciliata</i> Briq.	ESSE 14505	A1 (E) Kırklareli, Kofcaz-Ahmetli köyü yolu, 5. km, <i>Quercus</i> ormanı, 683 m., N 41° 58' 08.2'' E 27° 09' 38.6'', 17/06/2008.
<i>Ajuga chamaepitys</i> (L.) Schreber subsp. <i>cuneatifolia</i> (Stapf) PH Davis	ESSE 14507	C2 Burdur, Bucak, Çobanbeli, kayalık, 847 m, 37° 10' 21.2 N 30° 29' 85.2'' E, 08/07/2008.
<i>A. genevensis</i> L.	ESSE 14510	A1 (E) Kırklareli: Dereköy yolu, Dereköy'e 10 km kala, Meşe koruluğu, 449 m, 41° 50' 6.13'' N 27° 18' 3.18'' E, 22/04/2009.
<i>A. laxmannii</i> (L.) Benth	ESSE 14503	A1 (E) Kırklareli, Kıyıköy-Vize arası, bozuk <i>Quercus</i> ormanı, 298 m, 41° 39' 36.2'' N 27° 53' 41.9'' E, 16/06/2008.
<i>A. orientalis</i> L.	ESSE 14504	A2 (A) Bursa, Uludağ, Oteller bölgesi, açık alan, 1773 m., 40° 06' 23.2'' N 29° 08' 11.1'' E, 19/06/2008.
<i>A. reptans</i> L.	ESSE 14509	A2 (A) İstanbul: Sarıyer, İstanbul Ü. Orman Fak. Araştırma Ormanı, Fındık suyu, Gürgen ormanı, 41° 09' 77.7'' N 29° 00' 98.3'' E, 20/04/2009.

Results and Discussion

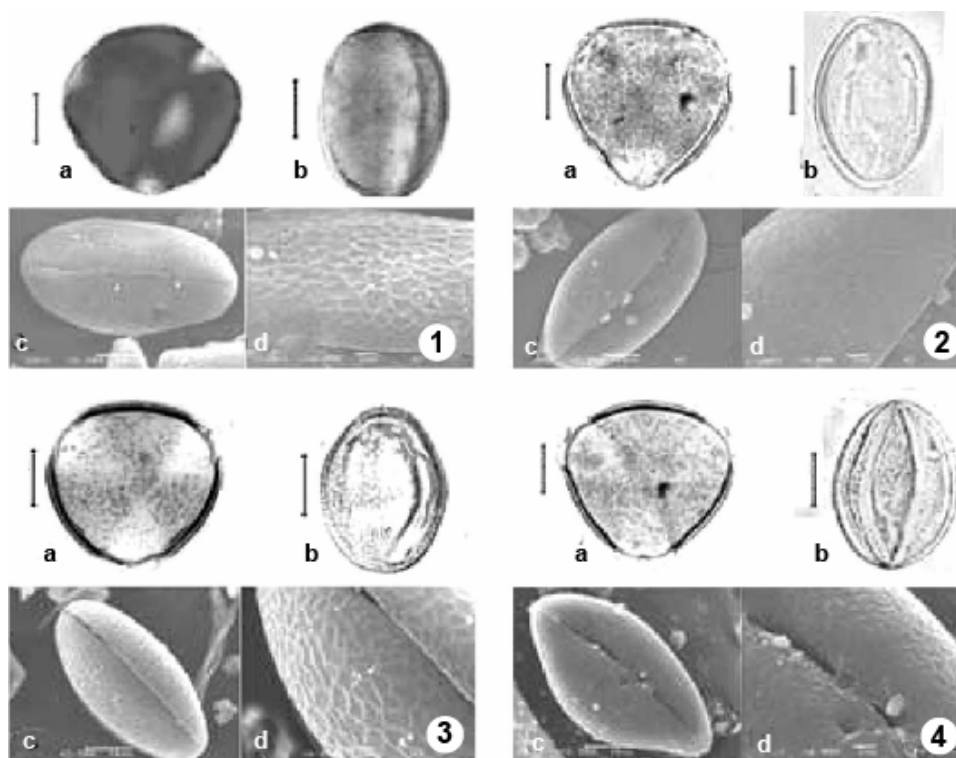
LM and SEM investigations show that the pollen grains of eight *Ajuga* taxa are more or less suboblata-subprolata and tricolpatae. The exine sculpture is granulate in *A. chamaepitys* subsp. *chia* var. *chia*, *A. chamaepitys* ssp. *cuneatifolia*, *A. genevensis*, *A. laxmannii*, *A. orientalis* and *A. reptans*, but reticulate in *A. bombycina* and *A. chamaepitys* ssp. *chia* var. *ciliata*. It has been reported that aperture features and exine structures are among the essential criteria for the determination of the phylogenetic relationships of the species of *Ajuga* (Kuprianova 1967, Cronquist 1968, Walker 1974a, b, Takhtajan 1980). The palynomorph of each of the species is described below:

A. bombycina (endemic): Pollen grains are suboblata-subprolata and tricolpatae, P/E = 1,27 (A); ornamentation is tectatae-reticulatae; exine 1.04 µm (A); tectum reticule (Fig. 1A-D, Table 1).

A. chamaepitys ssp. *chia* var. *chia*: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 1,32 (A); ornamentation is tectatae-granulatae; exine 1.42 µm (A); tectum granule (Fig. 2A-D, Table 1).

A. chamaepitys subsp. *chia* var. *ciliata*: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 1.62 (A); ornamentation is tectatae-reticulatae; exine 1.02 μm (A); tectum reticule (Fig. 3A-D, Table 1).

A. chamaepitys ssp. *cuneatifolia*: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 1,24 (A); ornamentation is tectatae-granulatae; exine 1.1 μm (A); tectum granule (Fig. 4A-D; Table 1).



Figs 1-4. Pollen photomicrography. 1. *Ajuga bombycina*, 2. *A. chamaepitys* subsp. *chia* var. *chia*, 3. *A. chamaepitys* ssp. *chia* var. *ciliata*, 4. *A. chamaepitys* ssp. *cuneatifolia*, Polar view of an acetolysed pollen in light microscope (A). Equatorial view of a acetolysed pollen in light microscope (B). Scanning electron micrographs of pollen grains in equatorial view (C). Close up of pollen grains (D). Bars = 10 μm .

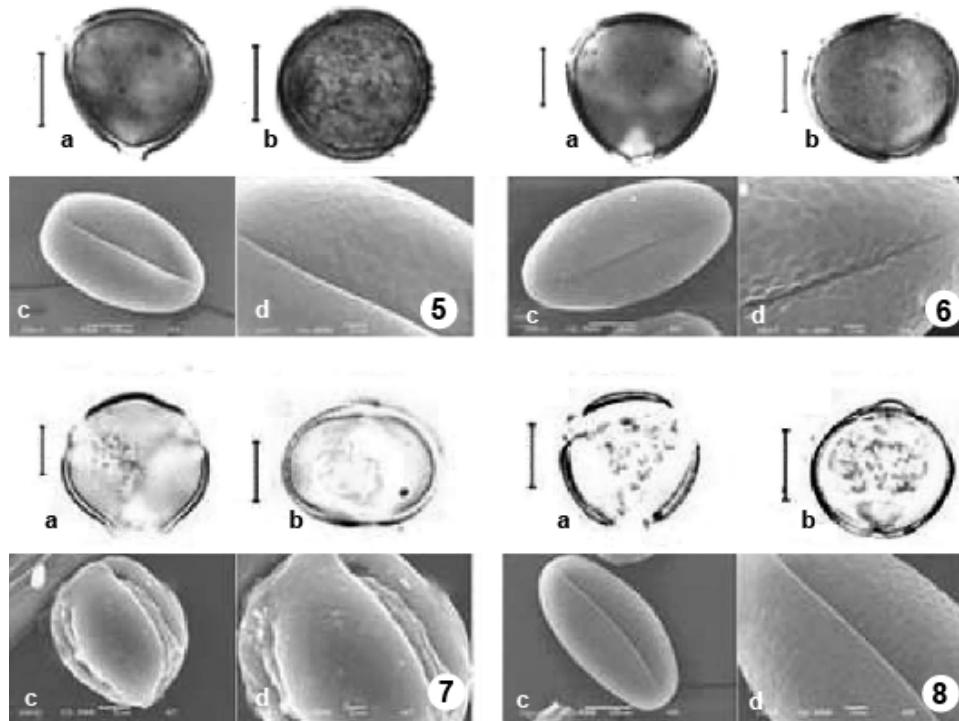
A. genevensis: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 1.1 (A); ornamentation is tectatae-granulatae; exine 1 μm (A); tectum granule (Fig. 5A-D, Table 1).

A. laxmannii: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 1,11 (A); ornamentation is tectatae-granulatae; exine 1.24 μm (A); tectum granule (Fig. 6A-D; Table 1).

A. orientalis: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 0.87 (A); ornamentation is tectatae-granulatae; exine 1.64 μm (A); tectum granule (Fig. 7A-D, Table 1).

A. reptans: Pollen grains are suboblata-subprolata and tricolpatae, P/E = 0.89 (A); ornamentation is tectatae-granulatae; exine 1.46 μm (A); tectum granule (Fig. 8A-D, Table 1).

The morphological features of exine layers in *Ajuga* have been reported as the features that best explain the nature of the phylogenetical relationship between taxa (Kuprianova 1967, Cronquist 1968, Walker 1974a, b, Takhtajan 1980). These results seem to suggest that the granulate and reticulate formation in the species of *Ajuga* could be a genotypic characteristic.



Figs 5-8. Pollen photomicrography. 5. *Ajuga genevensis*, 6. *A. laxmannii*, 7. *A. orientalis* and 8. *A. reptans*. Polar view of an acetolysed pollen in light microscope (A). Equatorial view of a acetolysed pollen in light microscope (B). Scanning electron micrographs of pollen grains in equatorial view (C). Close up of pollen grains (D). Bars = 10 μ m.

Table 1. Morphometrical parameters and an identifying key of the pollen morphological features of investigated *Ajuga* taxa.

Taxa	P	E	P/E	L	clg	clt	t	Exine	Tectum
<i>A. bombycina</i>	39.92 \pm 2.38	31.36 \pm 3.24	1.27	37.84 \pm 2.58	10.75 \pm 1.53	6.1 \pm 1.79	4.0 \pm 0.60	1.04 \pm 0.2	Reticule
<i>A. chamaepitys</i> ssp. <i>chia</i> var. <i>chia</i>	36.76 \pm 2.87	27.8 \pm 3.85	1.32	33.64 \pm 3.2	24.57 \pm 4.1	4.92 \pm 1.32	3.92 \pm 0.86	1.42 \pm 0.47	Granule
<i>A. chamaepitys</i> ssp. <i>chia</i> var. <i>ciliata</i>	29.88 \pm 1.83	18.44 \pm 1.35	1.62	27.92 \pm 1.93	25.37 \pm 3.34	4.96 \pm 0.89	4.64 \pm 0.92	1.02 \pm 0.17	Reticule
<i>A. chamaepitys</i> ssp. <i>cuneatifolia</i>	37.52 \pm 4.13	30.32 \pm 3.87	1.24	35.28 \pm 4.21	8.86 \pm 2.54	5.9 \pm 3.01	3.93 \pm 0.70	1.1 \pm 0.2	Granule
<i>A. genevensis</i>	23.56 \pm 1.8	21.6 \pm 1.93	1.1	21.56 \pm 1.8	10.3 \pm 2.61	4.7 \pm 1.34	3.83 \pm 0.71	1.0 \pm 0	"
<i>A. laxmannii</i>	29.76 \pm 1.45	26.8 \pm 3.77	1.11	27.28 \pm 1.62	13.73 \pm 4.1	5.84 \pm 2.44	3.92 \pm 1.32	1.24 \pm 0.41	"
<i>A. orientalis</i>	21.18 \pm 2.10	24.14 \pm 1.87	0.87	20.42 \pm 1.51	20.84 \pm 3.54	4.34 \pm 1.13	5.8 \pm 1.96	1.64 \pm 0.46	"
<i>A. reptans</i>	19.02 \pm 2.15	21.32 \pm 2.12	0.89	23.15 \pm 2.64	21.8 \pm 3.10	6.1 \pm 1.94	6.32 \pm 2.83	1.46 \pm 0.42	"

A. Acetolysed pollen (LM); P. Polar axis; E. Equatorial axis; L. Equatorial countour diameter; clg. Length of the colpus; clt. Width of the colpus; t. Apocolpium.

While LM revealed that *Ajuga* only had a granulate structure, detailed SEM showed that they were wrapped in both granules and reticules. We attributed such a difference in measurements to the fact that all the species analyzed had a genetic difference, which seems to comply with the claim that, in taxonomy, the sculpture types of pollens have valid morphological features (Cronquist 1968).

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