

**SEED MORPHOLOGY AND HISTOLOGY OF SOME *PARONYCHIA* TAXA  
(CARYOPHYLLACEAE) FROM TURKEY**

**AYŞE KAPLAN<sup>\*</sup>, HATİCE ÇÖLGEÇEN AND H. NURHAN BÜYÜKKARTAL<sup>1</sup>**

*Department of Biology, Faculty of Arts and Science, Zonguldak Karaelmas University,  
67100 İncivez, Zonguldak, Turkey*

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**Abstract**

Seed morphology and histology of 12 taxa (nine species, two subspecies, one variety) of *Paronychia* Miller (Caryophyllaceae) by light and scanning electron microscopes revealed that seeds are laterally compressed, reniform, and hilums are linear. Testa surface structures are alveolate-scalariform, colliculate, reticulate-alveolate, rugose and ruminant. Differences in cuticle and papillae properties of epidermal cells have been observed. A dichotomous key has been developed for *Paronychia agryloba* Stapf, *P. angorensis* Chaudri, *P. arabica* (L.) DC. subsp. *euphratica* Chaudri, *P. carica* Chaudri, *P. cataonica* Chaudri, *P. condensata* Chaudri, *P. davisii* Chaudri, *P. dudleyi* Chaudri, *P. galatica* Chaudri, *P. kurdica* Boiss subsp. *kurdica* var. *kurdica*, *P. kurdica* Boiss subsp. *montis-munzur* Chaudri and *P. mughlaei* Chaudri.

**Introduction**

The genus *Paronychia* Miller (Caryophyllaceae) is distributed in warm and dry regions of the world (Willis 1966, Perveen and Qaiser 2003, Soltis *et al.* 2005). In Turkey the plants are found in Irano-Turanian and East-Mediterranean phytogeographic regions and is represented by 28 species, 20 of which are endemic to Turkey & East Aegean Islands (Davis 1967, Güner *et al.* 2000). In the Red data book of Turkish plants, the status of 12 endemic *Paronychia* species has been described (Ekim *et al.* 2000).

Seed morphology of some genera of Caryophyllaceae have been studied (Yıldız 2002) In *Arenaria uniflora*, seed surface was smooth with entire cell margins in this species grown in wet regions, whilst seed surface was corrugate with sinuate testa cell margins when plants grown in dry regions (Wyatt 1984). Seeds of *Silene* species were generally tuberculate (Yıldız and Çırpıcı 1998, Yıldız 2005). In some species of *Saponaria*, seed surface structures were colliculate or flat tuberculate (Ataşlar 2004, Çinbilgel *et al.* 2007). Seed morphology of 15 species of *Sagina* was studied by Crow (1979). There was variation in particular surface features within some members of the genus. Two basic seed types occurred in this genus and were diagnostic at the sectional level. The saginoid seed, characteristic of section *Sagina*, was obliquely triangular in outline, was grooved along the two dorsal ridges, and had slightly concave lateral surfaces. The crassuloid seed, characteristic of section *Maxima*, was obliquely reniform, lacked dorsal grooves and had shallowly convex lateral surfaces (Crow 1979). Study of the Turkey's species *Paronychia* is limited. Only pollen morphology was studied by Kaplan (2008). In the present study, seed morphology and histology of 12 endemic taxa of the genus *Paronychia*, present in Turkey were investigated.

**Materials and Methods**

Seed samples of 12 endemic *Paronychia* taxa, such as *P. agryloba* Stapf, *P. angorensis* Chaudri, *P. arabica* (L.) DC. subsp. *euphratica* Chaudri, *P. carica* Chaudri, *P. cataonica* Chaudri, *P. condensata* Chaudri, *P. davisii* Chaudri, *P. dudleyi* Chaudri, *P. galatica* Chaudri, *P. kurdica* Boiss subsp. *kurdica* var. *kurdica*, *P. kurdica* Boiss subsp. *montis-munzur* Chaudri and

<sup>\*</sup>Correspondence author. E-mail: aysekaplan2003@hotmail.com <sup>1</sup>Department of Biology, Faculty of Science, Ankara University, 06100 Tandoğan, Ankara, Turkey.

*P. mughlaei* Chaudri were collected from Herbarium specimens of Gazi University (GAZI) and Hacettepe University (HUB). Detailed information of these are given in Table 1. Samples were placed on double cellotape on the aluminum stabs, coated with gold by means of Polaron SC500 Sputter Coater and coating was restricted to 30mA for 4 min. They were investigated by JEOL GSM 5600 and LEO 435 VP SEM's.

**Table 1. Detail of herbarium specimens of *Paronychia* Miller considered in the present study, along with the status<sup>a</sup>.**

Sl. No.	Herbarium specimens and status <sup>a</sup>	Collector(s)	Herbarium number(s)
1.	<i>P. agryloba</i> Stapf (LR)	H. Sümbül, 1981	GAZI, 1124, HUB 1124
2.	<i>P. angorensis</i> Chaudri (VU)	R.D.Reeves & U. Kramer	GAZI, 1606
3.	<i>P. arabica</i> (L.) DC. subsp. <i>euphratica</i> Chaudri (VU)	H. Peşmen & A. Güner	HUB, 2237
4.	<i>P. carica</i> Chaudri (VU)	Z. Aytaç & N. Adıgüzel	GAZI, 1995
5.	<i>P. cataonica</i> Chaudri (VU)	H. Duman & Z. Aytaç	GAZI, 51976
6.	<i>P. condensata</i> Chaudri (LR)	M. Vural, Ü. Kol, N. Adıgüzel	GAZI, 4876
7.	<i>P. davisii</i> Chaudri (EN)	H. Özçelik, 1995	GAZI, H. Özçelik-7107
8.	<i>P. dudleyi</i> Chaudri (LR)	Z. Aytaç & H. Duman, 1994	GAZI, 5197a
9.	<i>P. galatica</i> Chaudri (LR)	E. Hamzaoğlu, 1992	GAZI, EH-477
10.	<i>P. kurdica</i> Boiss subsp. <i>kurdica</i> var. <i>kurdica</i> (VU)	Ü. Güler, 1993	GAZI, 1157
11.	<i>P. kurdica</i> Boiss subsp. <i>montis-munzur</i> Chaudri (VU)	Ş. Yıldırım	HUB, 3492
12.	<i>P. mughlaei</i> Chaudri (VU)	H. Peşmen & A. Güner	HUB, 1686

<sup>a</sup>EN= Endangered, VU= Vulnerable, LR= Low risk.

Seeds were soaked in distilled water for 12 h for taking semi-thin sections. These were then fixed at 3% glutaraldehyde buffered with 0.1 M phosphate (pH 7.2) for 3 h at room temperature. They were then post-fixed with buffered 1% osmium tetroxide for 3 h at room temperature. The materials were dehydrated through a graduated ethanol series and embedded in Epon 812 (Luft 1961). Semi-thin (1.5 or 2 µm) sections were cut and stained with 1% methylene blue or 1% safranin. These sections were photographed by Leica DFC 280 digital camera. The terminology described by Stearn (2004) was used to describe seed coat surface sculpturing.

## Results and Discussion

Seeds of 12 taxa of *Paronychia* are laterally compressed, reniform and the hilums are linear. Seed coat surface characteristics of the taxa are given in Table 2. Of the 12 taxa *P. agryloba*, *P. angorensis* and *P. arabica* were with non-papillate epidermis, rest of the taxa are papillate (Figs 2a-e). Ornamentations of the testa are categorized into five types such as alveolate-scalariform, colliculate, reticulate-alveolate, rugose and ruminant, distribution of which among the 12 taxa is shown in Table 2 and SEM of ornamentations in Figs 1a-l.

Among the 12 taxa of *Paronychia*, ruminant and colliculate seed surface ornamentations were common. Alveolate-scalariform and reticulate-alveolate seed surface ornamentations are reported for the first time in the family Caryophyllaceae. Photomicrographs of papillate and non-papillate testa among the 12 taxa are given in Figs 2a-e and 3a-g, respectively.

*Paronychia* taxa is distributed in Inner and West Anatolia regions of Turkey as well as in the Mediterranean region. *P. dudleyi*, *P. arabica* subsp. *euphratica*, *P. condensata* and *P. angorensis* are Irano-Turanien elements, and *P. davisii* and *P. mughlaei* are East-Mediterranean elements

(Davis 1967). The thickest cuticle is present in *P. arabica* subsp. *euphratica* (10  $\mu\text{m}$ ) while thinnest cuticle is present in *P. mughlai* (1.3  $\mu\text{m}$ ). Considering the relationship between seed morphological properties and growing areas of studied taxa, it can be said without generalization that *Paronychia* taxa growing in the Mediterranean region have thin cuticle, while those growing in Inner and East Anatolia have thick ones.

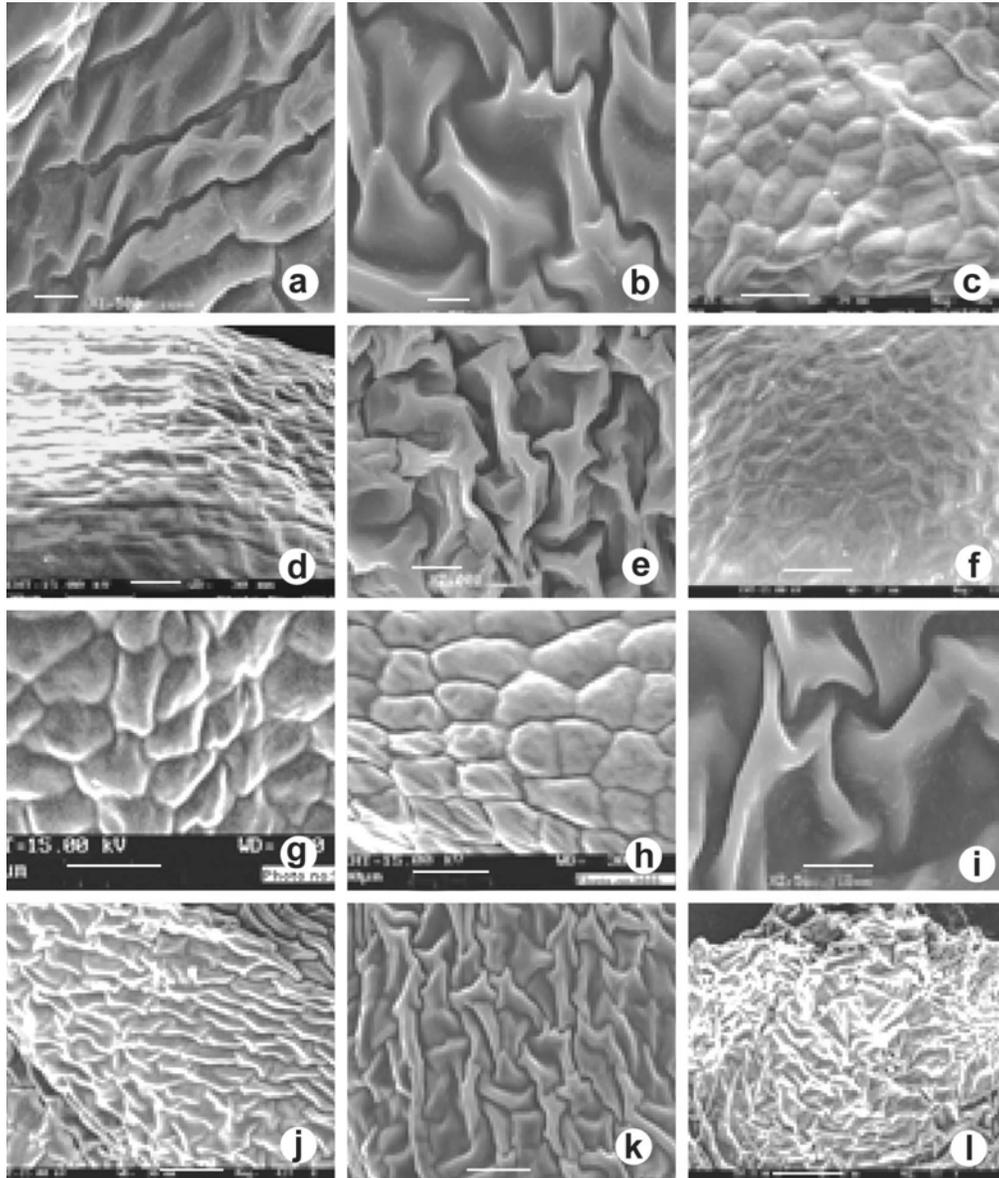


Fig. 1 a-l. Surface ornamentations (SEM) of testa of *Paronychia* taxa. (a) *P. agryloba*, (b) *P. angorensis*. (c) *P. arabica* subsp. *euphratica*, (d) *P. carica*, (e) *P. cataonica*, (f) *P. condensata*, (g) *P. davisii*, (h) *P. dudleyi*, (i) *P. galatica*, (j) *P. kurdica* subsp. *kurdica* var. *kurdica*, (k) *P. kurdica* subsp. *montis-munzur*, (l) *P. mughlai*.

**Table 2. Morphological and histological properties of seed 12 of *Paronychia* taxa.**

Taxa	Seed coat surface	Cuticle thickness ( $\mu\text{m} \pm \text{s.d.}$ )	Papilla	Epidermis
<i>P. agryloba</i>	Rugose	$3.4 \pm 0.4$	absent	Epidermis smooth
<i>P. angorensis</i>	Ruminata	$1.4 \pm 0.2$	absent	Epidermis convex
<i>P. arabica</i> subsp. <i>euphratica</i>	Colliculate	$10 \pm 0.3$	absent	Epidermal cells have dense cytoplasm
<i>P. carica</i>	Alveolate-sclariiform	$2.9 \pm 0.2$	present	Epidermal cells have dense cytoplasm
<i>P. cataonica</i>	Ruminata	$2.3 \pm 0.0$	absent	Outer layer of epidermis is compressed
<i>P. condensata</i>	Reticulate-alveolate	$2.7 \pm 0.0$	present	Epidermis convex
<i>P. davisii</i>	Colliculate	$2.0 \pm 0.1$	absent	Epidermis smooth, cells with dense cytoplasm
<i>P. dudleyi</i>	Colliculate	$2.4 \pm 0.1$	present	Epidermis with acute papillae
<i>P. galatica</i>	Ruminata	$1.5 \pm 0.2$	present	Epidermal cells are big
<i>P. kurdica</i> subsp. <i>kurdica</i> var. <i>kurdica</i>	Ruminata	$3.1 \pm 0.4$	absent	Epidermis convex
<i>P. kurdica</i> subsp. <i>montis-munzur</i>	Ruminata	$2.1 \pm 0.3$	absent	Epidermis convex and zigzag
<i>P. mughlaii</i>	Rugose	$1.3 \pm 1.1$	present	Epidermis has acute papillae

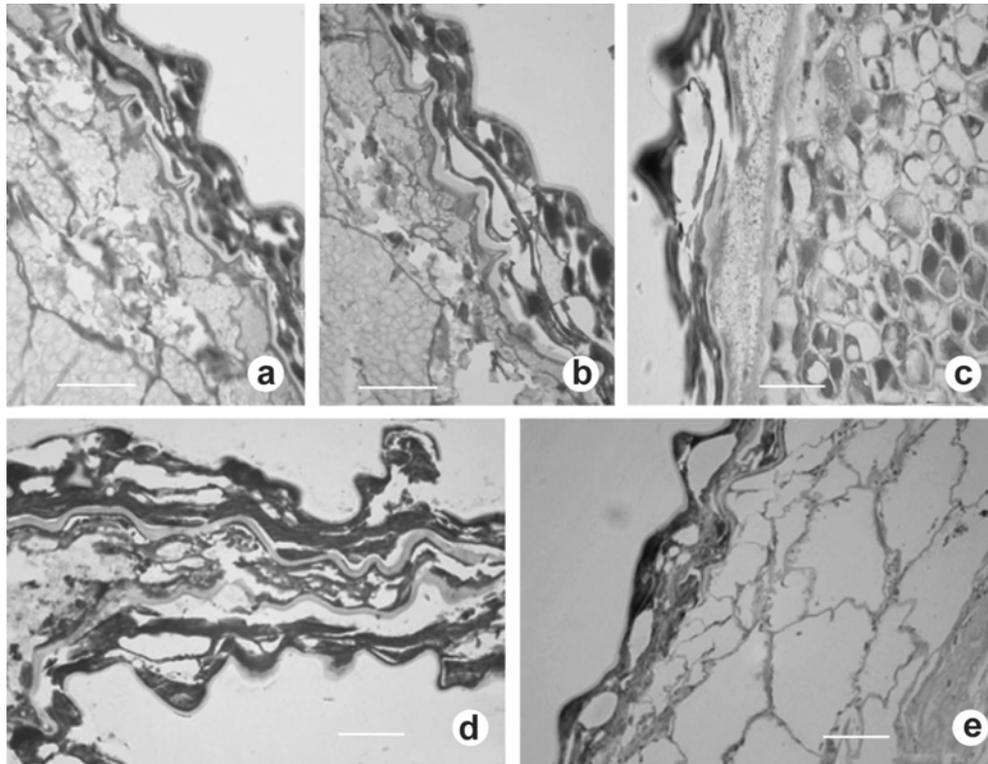


Fig. 2 a-e. Cross-sections of papillate testa of *Paronychia* taxa. a. *P. dudleyi*, b. *P. carica*, c. *P. condensata*, d. *P. galatica*, e. *P. mughlaii*. Bars = 20  $\mu\text{m}$ .

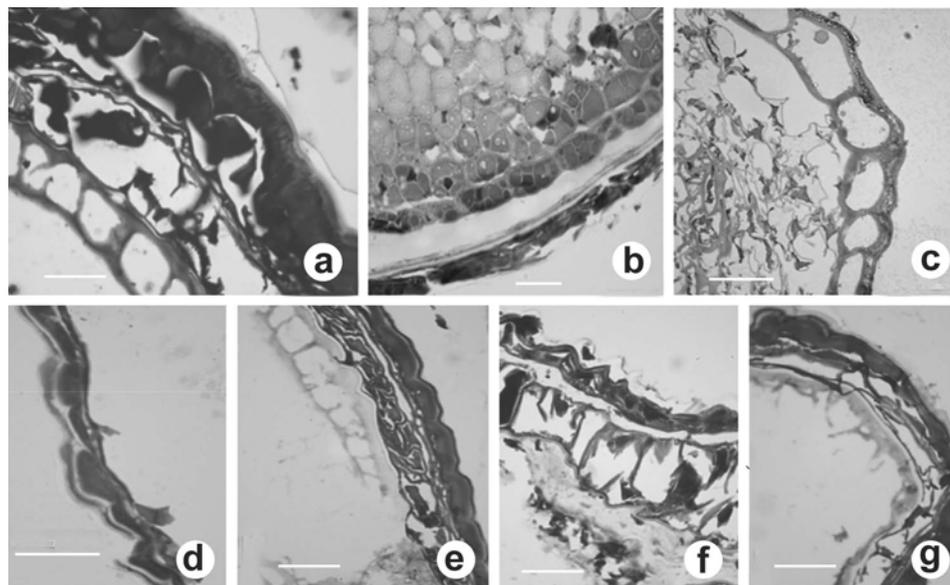


Fig. 3 a-g. Cross-sections of non papillate testa of *Paronychia* taxa. a. *P. arabica* subsp. *euphratica*, b. *P. davisii*, c. *P. agryloba*, d. *P. kurdica* subsp. *kurdica* var. *kurdica*, e. *P. cataonica*, f. *P. kurdica* subsp. *montis-munzur*, g. *P. angorensis*. Bars = 20  $\mu$ m.

Seed coat characters, such as cuticle layer, papillae features of epidermis, ornamentations of testa surface, etc. of *Paronychia* have been found to be useful taxonomic characters in the identification of species. Based on these taxonomic characters, a dichotomous key has been prepared for 12 *Paronychia* taxa as follows:

**Key to 12 taxa of *Paronychia* based on coat characters:**

1	Upper surface of epidermis has papillae	2
1	Upper surface of epidermis has no papillae	6
2	Seed surface colliculate, cuticle thickness about 2.40 $\mu$ m	<i>P. dudleyi</i>
2	Seed surface otherwise	3
3	Cuticle more than 1.50 $\mu$ m	4
3	Cuticle 1.50 $\mu$ m or less	5
4	Seed surface alveolate-scalariform	<i>P. carica</i>
4	Seed surface reticulate-alveolate	<i>P. condensata</i>
5	Seed surface ruminant	<i>P. galatica</i>
5	Seed surface rugose	<i>P. mughlai</i>
6	Seed surface colliculate	7
6	Seed surface otherwise	8
7	Cuticle very thick about 10 $\mu$ m	<i>P. arabica</i> subsp. <i>euphratica</i>
7	Cuticle thickness about 2.00 $\mu$ m	<i>P. davisii</i>
8	Seed surface rugose cuticle thickness about 3.40 $\mu$ m	<i>P. agryloba</i>
8	Seed surface ruminant	9
9	Epidermal cells convex	10
9	Epidermal cells otherwise	11
10	Cuticle thickness about 3.10 $\mu$ m	<i>P. kurdica</i> subsp. <i>kurdica</i> var. <i>kurdica</i>
10	Cuticle thickness about 1.40 $\mu$ m	<i>P. angorensis</i>
11	Epidermal cells compressed	<i>P. cataonica</i>
11	Epidermal cells convex and zigzag in shape	<i>P. kurdica</i> subsp. <i>montis-munzur</i>

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