www.biodicon.com Biological Diversity and Conservation

ISSN 1308-8084 Online; ISSN 1308-5301 Print 7/3 (2014) 167-176

Research article/Araştırma makalesi

Morphology and leaf anatomy of some *Euonymus* taxa from Turkey

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Abstract

recently reported as a new record for the flora of Turkey, *Euonymus latifolius*(L.) Mill. subsp. *latifolius*, and *E. latifolius* (L.) Mill. subsp. *cauconis* Coode & Cullen are evaluated. In morphologically, two species resemble each other, but *E. leiophloeus* differs by longer and erect linear wings (10 -15 mm long), smaller capsules (4-5 mm long) and flowers (4-merous). For this examination, several *Euonymus* specimens were examined in morphologically and six *Euonymus* accessions from distinct populations are investigated in anatomically. Dorsiventral (=bifacial) type leaf, hypostomatic stomata (only exist on abaxial epidermis), and cyclocytic stomata cells are observed in all examined accessions here. Detailed measurements were performed in accessions. Populations differ in mainly the shape of midrib vascular bundle, accesssory bundles, and upper and lower epidermal cell shape in surface view.

Key words: Celastraceae; *Euonymus*; Anatomy; Morphology, Turkey

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Türkite'nin bazı *Euonymus* taksonlarının yaprak morfolojisi ve anotomisi

Özet

Bu çalışmada; *Euonymus latifolius* subsp. *latifolius*, *E. latifolius* subsp. *cauconis* ve yakın zamanda Türkiye florası için yeni kayıt olarak rapor edilen *E. leiophloeus* taksonlarının morfolojileri ve karşılaştırmalı yaprak anatomileri değerlendirilmektedir. Morfolojik olarak, *E. leiophloeus* ve *E. latifolius* türleri birbirlerine benzese de; *E. leiophloeus* sahip olduğu uzun ve dik kanatları (10-15 mm uzunlukta), daha küçük kapsül meyveleri (4-5 mm uzunlukta) ve çiçekleri (4-parçalı) ile farklılık göstermektedir. Çalışma için 6 farklı lokaliteden *Euonymus* örnekleri morfolojik ve anatomik olarak incelenmiştir. İncelenen tüm örneklerde dorsiventral (bifasial) tip yaprak, hipostomatik stoma (yalnız alt yaprak yüzeyinde mevcut) ve siklositik stoma hücreleri gözlemlenmiştir. Örnekler üzerinde detaylı ölçümler gerçekleştirilmiştir. Populasyonlar başlıca orta damar iletim demetlerinin şekli, ilave demetler ile yüzeysel görünümde üst ve alt epidermal hücrelerinin şekli ile farklılık göstermektedir.

Anahtar kelimeler: Celastraceae, *Euonymus*, anatomi; morfoloji, Türkiye

1. Introduction

Celastraceae R.Br. family contains about 38 genera, with 375 species of trees and shrubs, many of which are climbing (McNair, 1930). In this family, *Euonymus* L., one of the small genera, belongs to the subtribe *Euonyminae* Benth. & Hook, tribe *Euonymeae* DC., and subfamily *Euonymoideae* (DC.) Arn. (Prokhanov, 1974; Reveal, 2011).

The genus contains deciduous and evergreen species from low growing shrubs, self-clinging climbers to tall shrubs and small trees. There are approximately 130-200 species of the genus distributed in tropical, subtropical and temperate regions of North and Central America, Europe, Asia and Australia (Blakelock, 1951; Eminağaoğlu and Özcan, 2013).

Euonymus taxa investigated in this study commonly distribute in Artvin. There are several floristic studies carried out in localities close to the research area by Eminağaoğlu and Anşin (2003, 2004), Eminağaoğlu et al. (2008), Eminağaoğlu and Akpulat (2010) and Eminağaoğlu et al. (2012). Recently, *Tradescantia fluminensis* Vell. (Eminağaoğlu et al. 2012), *Euonymus leiophloeus* Stev. (Eminağaoğlu and Özcan, 2013), *Scorzonera ketzkhovelii* Grossh. (Hamzaoğlu et al., 2010),

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 BioDiCon. 407-0814

Reseda globulosa Fisch. & C.A.Mey. (Aytaç and Duman, 2010) and ***Lepidium didymum* L. (**Yüzbaşıoğlu and Keskin, 2013) were determined as new taxa or new record to the flora of Turkey from Artvin.

According to recent studies, *Euonymus* is represented 6 taxa at the level of species and subspecies in Turkey (Coode and Cullen, 1967; Eminagaoglu and Özcan, 2013). The fruit and buds are very important characters in this genus (Loesener 1942; Blakelock, 1951; Ma 1997, 2001). While all species have bud scales, their size and shape differ between each other. Few studies have been made to evaluate interspecific relationships within the genus *Euonymus* in USA (McNair, 1930) and China (Yifeng *et al*., 2009) using morphological and anatomical characters. However, there is no report on the anatomy of the investigated taxa in the study.

The present study aims to conduct comparative morphological and leaf anatomical analyses of three *Euonymus* taxa, to support their taxonomic identifications.

2. Materials and methods

2.1. Plant collection

Plant taxa which one of them, *Euonymus leiophloeus,* which was recently determined from Artvin province (Turkey) for the Flora of Turkey, were collected from distinct region of Artvin, Turkey, at different altitudes in August (Table 1). Morphological analyses were carried out in living or herbarium specimens. Plant samples were deposited at the Herbarium of Artvin Coruh University (ARTH), Artvin, Turkey (Figure 1).

2.2. Anatomical preparations

Anatomical observations were performed in the leaf anatomy of six populations. Their collections data are listed in Table 1. The leaves from herbarium specimens were softened by heating up in boiling water. Then the plant parts were stored in 70% alcohol for anatomical studies. Transverse sections and peripheral sections of upper and lower epidermis of leaves were taken by hand using commercial razor blades and stained in Haematoxylin for about 15 min. To remove the excess stain, sections were washed in water several times (Algan, 1981). Semi - permanent slides were mounted in glycerin or permanent slides were covered with glycerin - gelatin (Vardar, 1987). Well stained sections were examined under a light microscopy and photographed using an Olympus BX-53 microscope with digital camera attachment DP 73.

Five cross-sections from at least three different individual plants of each taxon were measured to assess the consistency of anatomical characters and to calculate the means and standard error among different cross-sections. Ten peripheral slides were prepared for each taxon and 50 stomatal lengths were measured on each slide. The length of stomata was measured under x 40 magnification using a light microscope with an ocular micrometer using surface sections obtained from the adaxial and abaxial parts. The stomatal index was calculated according to the method described by Meidner and Mansfield (1968).

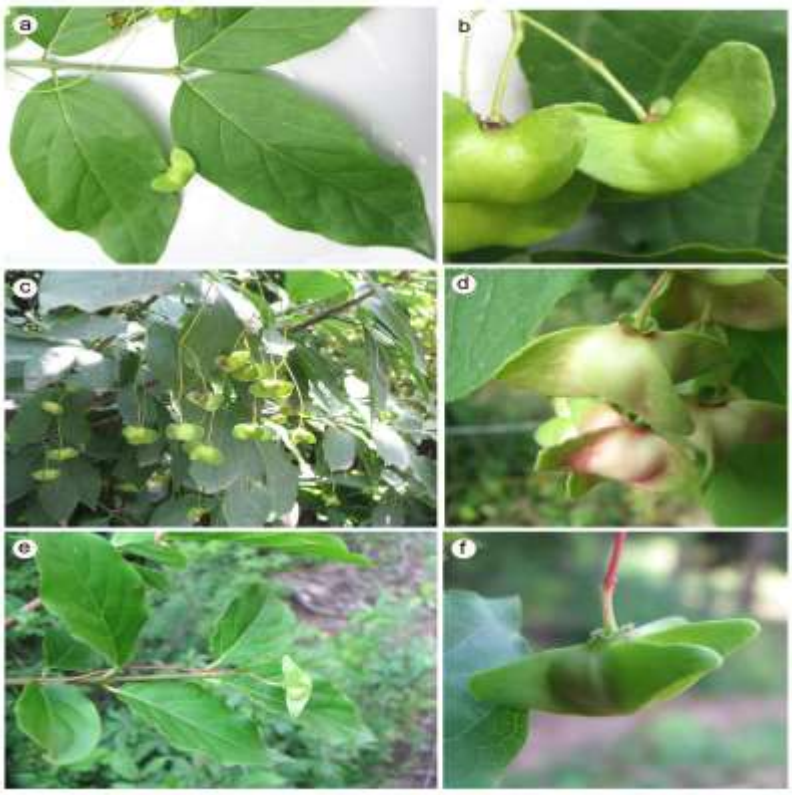

Figure 1. Habits and capsule of *Euonymus* taxa. a, b- *E. leiophloeus*; c, d- *E.latifolius*; e-f- Intermediate form.

Table 1. Collection data of investigated accessions in *Euonymus.*

Taxon	**Locality**	**Voucher**
E. latifolius subsp. *latifolius*	A8 Artvin, Şavşat, Ilıca village, in forest, 1533 m, 03.08.2011,	*Ö.Emin*. 8751
E. latifolius subsp. *cauconis*	A4 Kastamonu, Şenpazar, around the Gürleyik Village, 750 m, 10.08.2011	*Ö.Emin*. 8761
E. leiophloeus	A8 Artvin, Şavşat, Ilıca village, in forest, 1533 m, 03.08.2011,	*Ö.Emin*. 8750
	A8 Artvin, Şavşat, Yeşilce village, in forest, 1443 m, 04.08.2011,	*Ö.Emin*. 8753
Intermediate accesssion	A8 Artvin, Şavşat, Eskikale village, in forest, 1885 m, 05.08.2011,	*Ö.Emin*. 8754
	A8 Artvin, Şavşat, Aşağıkoyunlu village, in forest, 1764 m, 13.08.2011,	*Ö.Emin*. 8760

3. Results

3.1. Morphological analysis

Three taxa (6 populations) were examined. The morphological results of this study showed that *E. leiophloeus* is closely related to *E. latifolius* (L.) Mill. It differs from *E. latifolius* by its capsule and erect linear wings. More differentiating characters among populations are given in the Table 2.

Table 2. Comparison of *Euonymus latifolius* and *E. leiophloeus*

Character	***E. latifolius***	***E. leiophloeus***
Buds	5-18 mm long	2-10 mm long
Leaves	up to 6 (7.5)x16(21) cm	up to 4 x 7 cm
Petioles	5-20 mm	petioles 3-5 mm
Cymes	3-5 rayed; 4-to 12- flowered	5-rayed, many-flowered (up to 21)
Flowers	commonly 5-(rarely 4) merous, 7-9 mm in diameter	4-merous, ca. 5 mm in diameter
Petals	2.5-3.5 mm long	2-2.5 mm long
Capsules	9-15 mm long, (4) 5-lobed	4-5 mm long, 4-(rarely 5) lobed
Wings	laterally compressed passing into narrow orbicular -trapeziform, horizontal, 4-7 mm long	gradually acuminate or sometimes, conversely, tapering at base, erect linear, 10 -15 mm long

E. leiophloeus and *E. latifolius* are morphologically very similar. Both species are distributed in the same areas according to Flora of USSR and our collections. An identification key for these 2 species is provided below:

1. Capsules 4-5 mm long, 4-lobed, with gradually acuminate or sometimes, conversely, tapering at base, erect linear wings (10 - 15 mm long) …… ……***E. leiophloeus***
1. Capsules 9-15 mm long, (4) 5-lobed, with laterally compressed passing into narrow orbicular - trapeziform, horizontal wings (4-7 mm long) ……..……***E. latifolius***
   2. Terminal bud 9-18 mm; leaves 8-17 cm, usually obovate and acuminate ……..subsp. ***latifolius***
   2. Terminal bud 5-8 mm; leaves 5-7 cm, usually elliptic and acute ……subsp. ***cauconis***

3.2. Anatomical analysis

Transverse section of leaf blade, midrib and peripheral sections of leaves were investigated in the present study (Figure 2-4). The main anatomical characters, assessed among the populations studied are summarized in Table 3.

3.2.1. E. leiophloeus

Shape of leaf midrib is more or less protrudes both on the upper and lower sides. There is a single-layered epidermis on both the adaxial and abaxial surfaces of the leaf. It is surrounded by thick cuticle in adaxial and abaxial parts. Trichomes are not present on the both epidermises. In terms of size, upper epidermal cells are slightly taller than those of the abaxial ones.

Large vascular bundle can be seen in the midrib and this bundle is curved and arc shape. Two accessory bundles can be seen in the midrib region through to the upper parts of this bundle. Above, collenchyma tissue forms the ridge which protrudes on the upper surface of the leaf. Compound crystals are found near especially phloem parts of this bundle. Collenchyma layers are present beneath in the both epidermises in the midrib. Lamina is bifacial (dorsiventral) and mesophyll composed a loosely arranged 6 layer of spongy parenchyma and two layers of palisade parenchyma. The palisade cells are quite compactly arranged (Figure 2a, b). The size of the first palisade row is almost equal to the second one. The spongy cells are rounded or slightly elongated paraIlel to the surface.

In peripheral sections, adaxial epidermises are usually irregular shape with repand to sinuous anticlinal cell walls, while abaxial ones are irregular shape and have sinuous cell walls. Stomata occur abundantly on the lower surface only (hypostomatic). Lower surface has cyclocytic stomata cells with 4 or 6 neighboring cells as a circle. Stomata cells are broadly elliptical in outline and are raised above epidermis level (Table 3 and Figure 4a, b). Average of stomatal length and stomatal index is 28.76 ± 0.24 µm and 04.28 ± 0.51, respectively. Number of stomata per 1 mm^2 is 120.0 ± 15 (Table 3).

3.2.2. E. latifolius subsp. *latifolius*

Shape of leaf midrib is distinctly protrudes both on the upper and lower sides. There is a single-layered epidermis on both the adaxial and abaxial surfaces of the leaf. It is surrounded by thick cuticle in adaxial and abaxial parts. No trichomes are present on the upper and lower epidemises. In terms of size, upper epidermal cells are taller than those of the abaxial ones.

The vascular bundle of the midrib is distinctly curved upward and they are bent in at the ends. Above, collenchyma tissue forms the ridge which protrudes on the upper surface of the leaf. Compound crystals are found near especially phloem parts of this bundle. Collenchyma layers are present beneath in the both epidermises in the midrib. Lamina is bifacial (dorsiventral) and mesophyll composed a loosely arranged 4-6 layer of spongy parenchyma and two layers of palisade parenchyma. The palisade cells are quite compactly arranged (Figure 2c-f). The length of upper palisade cell row is three times higher than wide and two times taller than the lower row. The spongy cells are rounded or slightly elongated parallel to the surface.

In peripheral sections, adaxial epidermises are usually irregular shape with repand anticlinal cell walls, while abaxial ones are irregular shape and have sinuous cell walls. Stomata are present on the lower surface only (hypostomatic). Lower surface has cyclocytic stomata cells with 4 or 6 neighboring cells. Stomata cells are broadly elliptical in outline and are raised above epidermis level (Table 3 and Figure 4c, d). Average of stomatal length and stomatal index is 33.99 ± 0.83 μm and 07.99 ± 0.39, respectively. Number of stomata per 1 mm^2 is 145.0 ± 8 (Table 3).

3.2.3. E. latifolius subsp. *cauconis*

Shape of leaf midrib is more or less distinctly protrudes both on the upper and lower sides. There is a single-layered epidermis on both the adaxial and abaxial surfaces of the leaf. It is surrounded by thick cuticle in adaxial and abaxial parts. Trichomes are not present on the both epidemises. In terms of size, upper epidermal cells are slightly taller than those of the abaxial ones.

Large vascular bundle can be seen in the midrib and this bundle is curved and arc shape. Two accessory bundles can be seen in the midrib region through to the upper parts of this bundle. Above, collenchyma tissue forms the ridge which protrudes on the upper surface of the leaf. Compound crystals are found near especially phloem parts of this bundle. Collenchyma layers are present beneath in the both epidermises in the midrib. Lamina is bifacial (dorsiventral) and mesophyll composed a loosely arranged 6 layer of spongy parenchyma and two or sometimes three layers of palisade parenchyma. The palisade cells are quite compactly arranged (Figure 2g, h). The cells of the rows are from two to four times as high as wide. The spongy cells are rounded or slightly elongated parallel to the surface.

In peripheral sections, adaxial epidermises are usually irregular shape with repand to sinuous anticlinal cell walls, while abaxial ones are irregular shape and have sinuous cell walls. Stomata occur abundantly on the lower surface only (hypostomatic). Lower surface has cyclocytic stomata cells with 4 or 6 neighboring cells as a circle. Stomata cells are broadly elliptical in outline and are raised above epidermis level (Table 3 and Figure 4e, f). Average of stomatal length and stomatal index is 30.04 ± 0.58 μm and 05.12 ± 0.52, respectively. Number of stomata per 1 mm^2 is 100.0 ± 18 (Table 3).

3.2.4. Intermediate form

Shape of leaf midrib is slightly protrudes on the upper sides. There is a single-layered epidermis on both the adaxial and abaxial surfaces of the leaf. It is surrounded by thick cuticle in adaxial and abaxial parts. No trichomes are present on the upper and lower epidermises. In terms of size, upper epidermal cells are almost the same size as abaxial ones.

The vascular bundle of the midrib is only slightly curved and they are not bent in at the ends. Compound crystals are found near especially phloem parts of this bundle. Collenchyma layers are present beneath in the both epidermises in the midrib. Lamina is bifacial (dorsiventral) and mesophyll composed a loosely arranged 5-8 layer of spongy parenchyma and two layers of palisade parenchyma. The palisade cells are quite compactly arranged (Figure 3b, d). The cells of the upper rows are from three to four three as high as wide, while the cells of lower ones are twice as high their wide. The cells of the upper row are almost the same size as the lower one. The spongy cells are rounded or slightly elongated parallel to the surface.

In peripheral sections, adaxial epidermises are usually irregular shape with almost straight anticlinal cell walls, while abaxial ones are irregular shape and have sinuous cell walls. Stomata are present on the lower surface only (hypostomatic). Lower surface has cyclocytic stomata cells with 4 or 6 neighboring cells. Stomata cells are broadly elliptical in outline and are raised above epidermis level (Table 3 and Figure 4g, h).

Average of stomatal length and stomatal index is 29.42 ± 0.28 μm and 5.45 ± 0.44, respectively. Number of stomata per 1 mm^2 is 145.0 ± 11 (Table 3).

4. Conclusions

Morphological characteristic of investigated two species are given in Table 2. This study indicated that there were some specific differences between *E. leiophloeus* and *E. latifolius*. As pointed out by Prokhanov (1954), hybridization between these two species is present. All intermediate forms have different charectiristic from parental species in terms of shape and size of leaves buds and fruits.

Anatomical features of leaves are mostly similar in six accessions. The epidermis is surrounded by thick cuticle. In terms of size, adaxial epidermal cells are more or less larger than the abaxial ones in two *Euonymus latifolius* populations and slightly larger in *Euonymus latifolius* subsp. *cauconis* and *E. leiophloeus* population, whereas both epidermis sizes are almost equal each other in two intermediate populations (Table 3). The epidermal cells of all accessions are always broader than tall. Mc Nair (1930) reported the cells of the upper epidermis in all of the nine species studied were broader than tall. Our results are in accordance to this report. According to the shape of anticlinal cell walls, the anticlinal wall patterns are different on both surfaces; irregular cells with undulate (repand) cell walls on the adaxial epidermis and irregular cells with sinuous anticlinal cell walls on the abaxial sides in three taxa, while irregular cells with more or less straight cell walls on the adaxial epidermis and irregular cells with repand anticlinal cell walls on the abaxial sides in *E. leiophloeus* population.

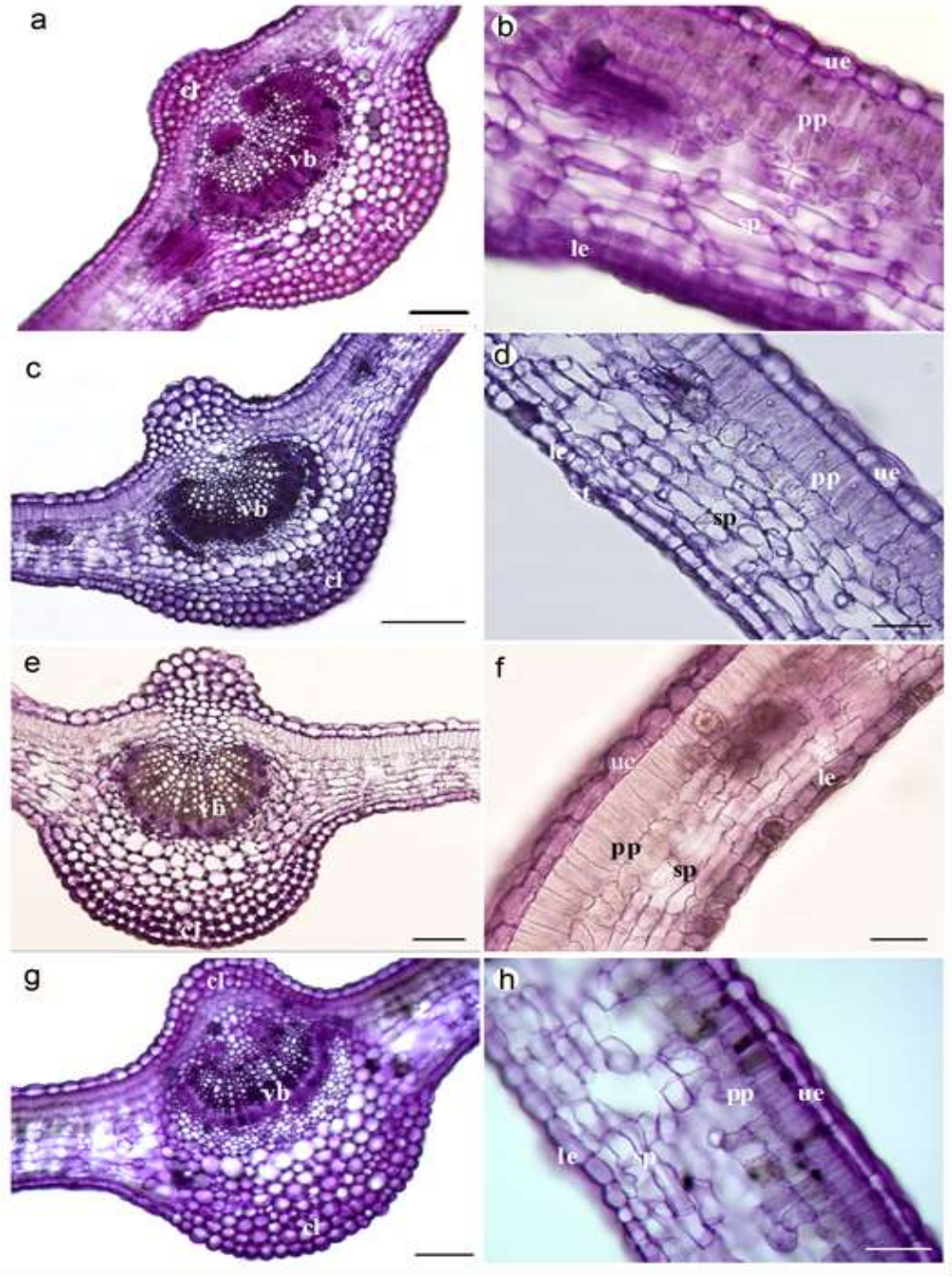

Figure 2. Transverse sections of *Euonymus* samples. a, b - *E. leiophloeus*, c,d,e,f - *E. latifolius* subsp. *latifolius*, g,h - *E. latifolius* subsp. *cauconis*. a,c,e,g - midrib, b,d,f,h - leaf lamina. Scale bars (a,c,e,g): 100 µm, (b,d,f,h): 50 µm

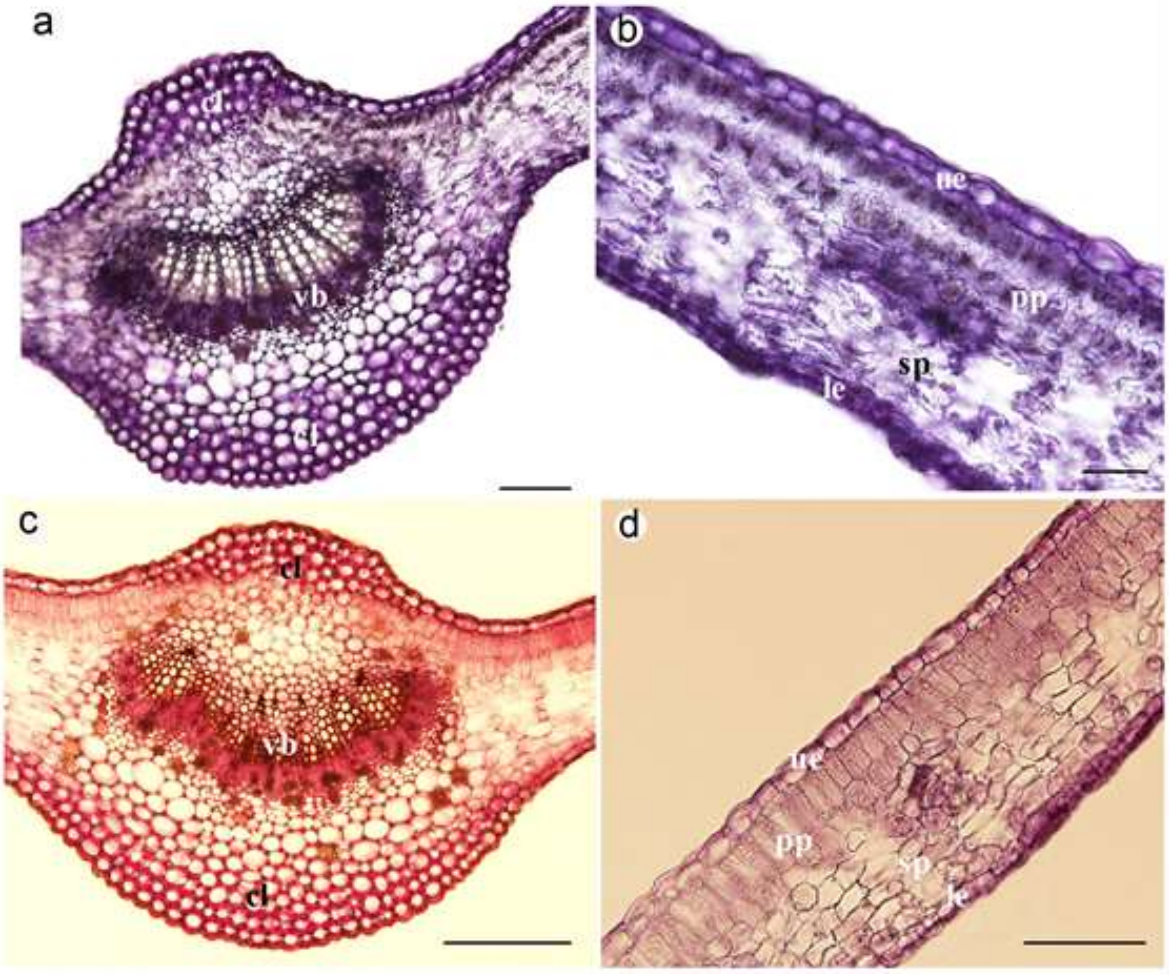

Figure 3. Transverse sections of intermediate form. a,c - midrib, b,d - leaf lamina. Scale bars (a,c): 100 µm, (b,d): 50 µm

In surface view all are irregular or polygonal in shape the sides of the polygon being undulate in *E. leiphloeus* in adaxial parts, while sinuous in abaxial ones. The leaves are hypohystomatic and stomata are found on the abaxial surface only, they protruded below the abaxial epidermis slightly (Figure 2). All samples studied have cyclocytic stomata. On the other hand, Yifeng *et al*. (2009) reported anomocytic, anisocytic, cyclocytic and transitional types among them in some *Euonymus* taxa from China. Trichomes are not present in studied *Euonymus* samples. The palisade layer is mostly two rows of cells high, although in *E. latifolius* subsp. *cauconis* rarely three rows is also observed, and other samples there are two rows. The cells of the upper palisade row are two or three times as tall as broad, those of the lower ones. The rows are the same as high in *E. latifolius* subsp. *cauconis* and *E. leiophloeus*, While the upper row are from three to four times higher than the lower row in *E. latifolius*. McNair (1930) nine stem and leaf anatomy of *Euonymus* species investigated in America. Our results are in accordance with these reports. The author reported that one to three layers of palisade rows and compound crystals were present in studied *Euonymus* samples. In our studied *Euonymus* populations, especially these crystals are clearly visible in peripheral and transverse sections of the leaf in *E. latifolius*.

Collenchyma tissue is quite prominent in the midrib of *E. latifolius* and slightly visible in *E. leiophleous* and *E. latifolius* subsp. *cauconis*, while it is not distinctly prominent in intermediate forms. The midrib distinctly protrudes both above and below the leaf in *E. latifolius*, while more or less flattened in intermediate forms. In all, the vascular bundle is in the form of an arc, varying only in the extent. The arc is broadly open in intermediate accessions. Besides the large vascular bundle, two additional bundles are observed in *E. latifolius* subsp. *cauconis* and *E. leiophloeus* population. According to surface sections, average of stomatal length and stomatal index and stomatal number per $1mm^2$ are similar to each other in *E. latifolius* subsp. *cauconis* and *E. leiophloeus*, while higher values are present in *E. latifolius* subsp. *latifolius*. To sum up, among investigated populations, three main groups can be distinguished; one group is *E. leiophloeus*, the second is *E. latifolius*, and the third is intermediate form. These groups differ in the shape of

midrib vascular bundles, accessories bundles, and upper and lower epidermal cell shape in surface view. We can conclude that our leaf anatomy results support the taxonomic status of *E. leiophloeus* and *E. latifolius*.

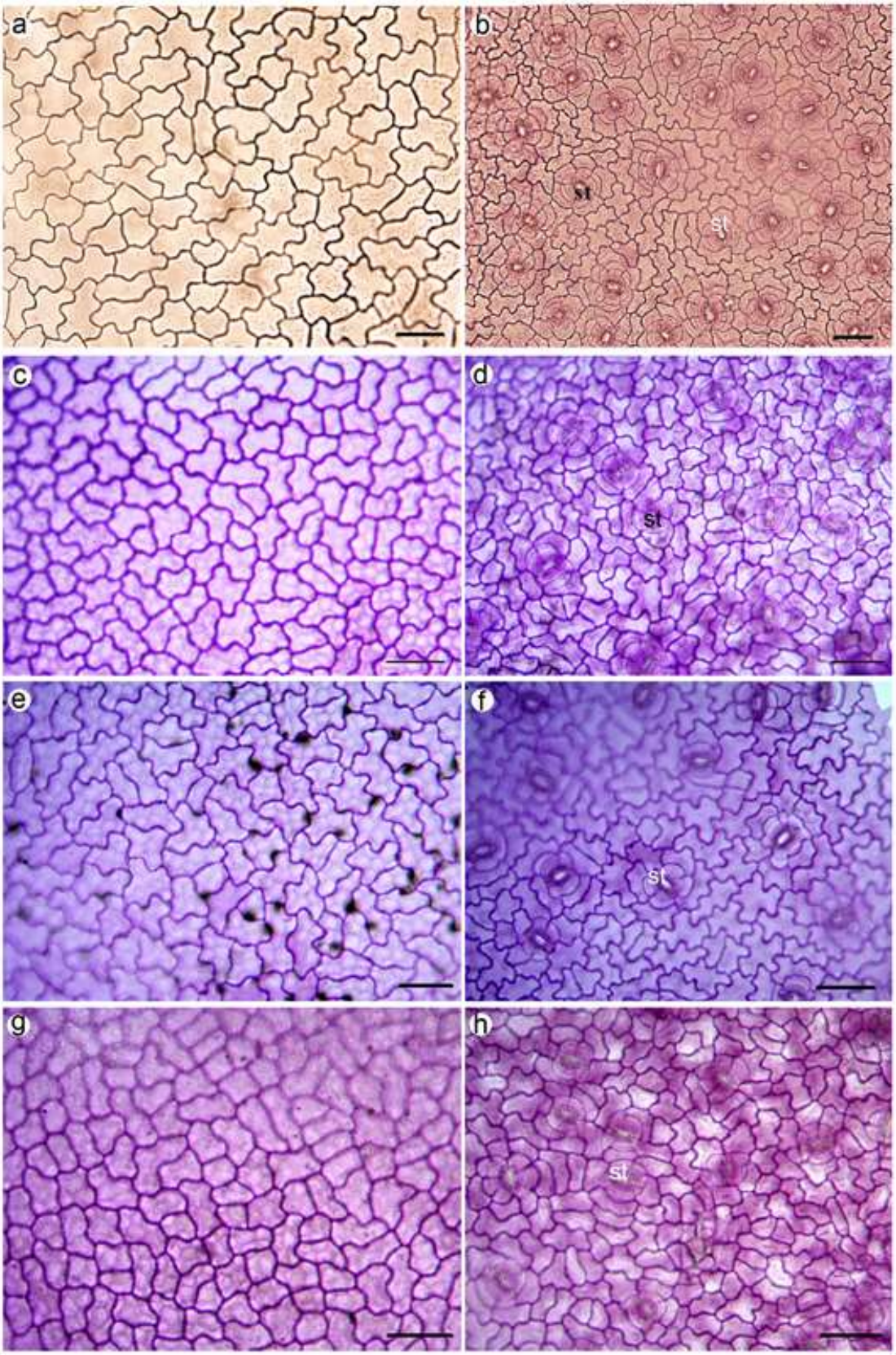

Figure 4. Peripheral sections of *Euonymus* samples. a, b - *E. leiophloeus*, c,d, - *E. latifolius* subsp. *latifolius*, e, f - *E. latifolius* subsp. *cauconis*, g, h: intermediate form. a,c,e,g - midrib, b,d,f,h - leaf lamina. Scale bar: 50 µm

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Table 3. Leaf anatomical characteristics of investigated *Euonymus* accessions

Character			*E. leiophloeus* (*Ö.Emin*. 8750)	*E. latifolius* subsp. *latifolius* (*Ö.Emin*. 8751)	*E.* subsp. *latifolius* (*Ö.Emin*. 8753)
Upper epidermis		length (µm)	16.50 ± 0.79	19.11 ± 0.95	23.45 ± 1.56
		width (µm)	24.53 ± 0.80	28.37 ± 1.39	32.91 ± 4.25
Lower epidermis		length (µm)	12.33 ± 0.71	16.13 ± 0.29	17.14 ± 7.80
		width (µm)	18.23 ± 1.15	22.32 ± 1.79	24.65 ± 2.62
Midrib mesophyll breadth (µm)			614.40 ± 24.92	611.91 ± 10.86	549.13 ± 27.78
Midrib bundle shape			curved	Prominently curved	Prominently curved
Lamina mesophyll breadth (µm)			161.40 ± 04.32	128.81 ± 04.75	169.03 ± 07.16
Palisade thickness			70.45 ± 2.68	66.05 ± 1.82	83.40 ± 4.75
Spongy thickness			83.58 ±2.55	63.39 ± 2.94	97.09 ± 4.45
Trachea size (µm)			16.25 ± 0.47	18.25 ± 0.48	17.99 ± 0.47
Vascular bundle		Length (µm)	229.60 ± 16.15	224.65 ± 09.68	224.38 ± 9.60
		breadth (µm)	428.80 ± 18.66	338.29 ± 21.30	371.35 ± 12.85
Number of the palisade cell line			2	2	2
Number of the spongy cell line			6	4-5	5-6
Adaxial surface	Cuticle thickness (µm)		03.20±0.12	03.24 ± 0.14	03.75 ± 0.09
	Epidermal cell		polygonal shape, repand wall	irregular shape, repand wall	irregular shape, repand wall
	Stomata length (µm)		0	0	0
	Stomatal index		0	0	0
	Number of stomata (1 mm^2)		0	0	0
Abaxial surface	Cuticle thickness (µm)		02.00 ± 0.00	02.61 ± 0.05	03.16 ± 0.12
	Epidermal cell		irregular shape, repand wall	irregular shape, sinuous wall	irregular shape, sinuous wall
	Stomata length(µm)		28.76 ± 0.24	32.13 ± 0.97	35.84 ± 0.30
	width (µm)		24.88 ± 0.44	28.06 ± 0.52	29.67 ± 0.40
	Stomatal index		04.28 ± 0.51	08.02 ± 0.61	07.97 ± 0.47
	Number of stomata (1 mm^2)		120.0 ± 15	135.0 ± 12.73	155.0 ± 09.34

*= mean value ± standard error

Table 3. Continued

Character			*E. latifolius* subsp. *cauconis* (*Ö.Emin.* 8761)	Intermediate form (*Ö.Emin.* 8760)	Intermediate form (*Ö.Emin.* 8754)
Upper epidermis		length(µm)	18.05 ± 0.50	14.87 ± 0.65	17.50 ± 1.57
		width (µm)	28.97 ± 1.47	25.82 ± 0.99	22.26 ± 0.62
Lower epidermis		length(µm)	15.57 ± 0.76	12.23 ± 0.30	12.62 ± 0.51
		width (µm)	20.61 ± 1.56	15.73 ± 0.57	16.81 ± 1.06
Midrib mesophyll breadth (µm)			530.20 ± 27.94	530.20 ± 27.94	578.48 ± 33.72
Midrib bundle shape			Curved	Broadly open, not curved	Broadly open, not curved
Lamina mesophyll breadth (µm)			151.80 ± 09.31	156.62 ± 07.99	147.36 ± 02.42
Palisade thickness			51.75 ± 5.68	62.58 ± 1.42	53.35 ± 2.33
Spongy thickness			83,54 ± 1.60	101.54 ± 6.23	94.92 ± 3.51
Trachea size (µm)			14.38 ± 0.26	17.12 ± 0.50	14.85 ± 0.74
Vascular bundle		Length (µm)	229.60 ± 16.15	212.93 ± 04.59	222.55 ± 18.30
		breadth (µm)	388.80 ± 27.96	441.43 ± 07.54	519.97 ± 52.58
Number of the palisade cell line			2-3	2	2
Number of the spongy cell line			6	5-8	5-7
Adaxial surface	Cuticle thickness (µm)		02.75 ± 0.19	03.08 ± 1.85	03.68 ± 0.27
	Epidermal cell		irregular shape, repand wall	irregular shape, repand wall	irregular shape, repand wall
	Stomata length (µm)		0	0	0
	Stomatal index		0	0	0
	Number of stomata (1 mm^2)		0	0	0
Abaxial surface	Cuticle thickness (µm)		02.10 ± 0.10	02.61 ± 0.07	02.97 ± 0.10
	Epidermal cell		irregular shape, sinuous wall	irregular shape, repand wall	irregular shape, repand wall
	Stomata Length (µm)		30.04 ± 0.58	30.33 ± 0.29	30.72 ± 0.24
	width (µm)		26.40 ± 0.58	26.06 ± 0.19	25.80 ± 0.28
	Stomatal index		05.12 ± 0.52	06.61 ± 0.35	06.44 ± 0.26
	Number of stomata (1 mm^2)		100.0 ± 17.65	170.0 ± 9	145.0 ± 9

(Received for publication 14 November 2014; The date of publication 15 December 2014)