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ANATOMY OF THREE *ONOSMA* SPECIES FROM TURKEY

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Abstract

Three *Onosma* L. species (*O. papillosa* Riedl, *O. rutila* Hub-Mor. and *O. auriculata* Aucher ex DC.) were examined anatomically. All these taxa had secondary root structure and xylem which were composed of sclerenchymatic cells and tracheary elements. *O. papillosa* has crystals and sclereids in the stem and leaf. Sand crystals are seen in the pith region of *O. auriculata. O. papillosa* and *O. auriculata* has bifacial leaf types and *O. rutila* has equifacial type. Stomata are anisocytic, anomocytic and staurocytic. These species have long and short simple eglandular and glandular trichomes. Setae with glabrous tubercles are present in *O. papillosa* and *O. rutila. O. auriculata* has porrect-stellate trichomes. Simple trichomes are unicellular and generally short. They have lignified, ornamental or smooth walls.

Introduction

In Turkey the *Onosma* genus is represented by about 104 species and the endemism rate of species is 52% (Riedl 1978, Davis *et al*. 1988, Riedl *et al*. 2005, Binzet and Orcan 2007, Kandemir and Türkmen 2010, Aytaç and Türkmen 2011, Binzet 2012, Koyuncu *et al.* 2013, Tarımcılar *et al*. 2015, Cecchi *et al*. 2016, Binzet 2016a, and 2016b and Binzet and Eren 2018). Several *Onosma* species are used as herbs, folk medicines and dyes. In folk medicine, these plants are applied for burns, wounds and ailments (Khajuria and Jain 1993, Özgen *et al.* 2003). The flowers of some species are eaten (Öztürk and Özçelik 1991).

Studies on the anatomy of this genus are limited. Metcalfe and Chalk (1979) and Watson and Dallwitz (1991) described the characteristic properties of Boraginaceae. Akçin and Engin (2001, 2005) and Akçin (2004, 2007) studied the anatomical and ecological properties of some *Onosma* species. Binzet and Orcan (2003) investigated the anatomical structure and palynological characteristics of two *Onosma* species. Teppner (1981, 1988) reported the chromosome number of different species of *Onosma*.

The genus has been divided into three sections: *Onosma*, *Protonosma* and *Podonosma*. Most of the species in Turkey belong to section *Onosma*. *Onosma* section was separated in two subsections according to trichome type: *Asterotricha* (Boiss.) Gürke and *Haplotricha* (Boiss.) Gürke. *O. papillosa* H. Riedl and *O. rutila* Hub- Mor. are endemic plants and belong to subsection *Haplotricha*. *O. auriculata* Aucher ex DC. belong to subsection *Asterotricha*. Anatomical features and trichome properties are very important characters in *Onosma*, but there are inadequate data related to the Turkish species. The main aim of this study was to explore and compare the anatomical properties of *Onosma* species belonging to subsection *Haplotricha* and *Asterotricha*.

Materials and Methods

Plant materials were collected from different localities of southern Turkey in 2004-2005 (Table 1). Vouchers specimens are kept at the Mersin University, Biology herbarium. Taxonomical descriptions of the specimens were made according to Riedl (1978). Samples for

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anatomical studies were fixed in 70% alcohol during field work. All measurements were recorded with an ocular-micrometer on a light microscope. Cross and surface sections were prepared from the samples stored in alcohol.

Table 1. Locality information of the *Onosma* taxa.

Taxa	Locality
O. papillosa	B6 Adana: Tufanbeyli- Saimbeyli 5. km, steppe, 1400m, 380 12' N, 360 12' E, 28. 05. 2004, Binzet 20.
O. rutila	C4 Mersin: Silifke- Gülnar, Balandız plataeu, under forest and open forest, roadside, rocky and stoney slopes, 820 m, 360 20' N, 0330 44' E, 14.05.2005, Binzet 13.
O. auriculata	C4 Mersin: Mut – Silifke, 7 km, slopes, 230 m, 360 35' N, 0330 25' E, 06.05.2005, Binzet 16.

Results and Discussion

Onosma papillosa: A transverse section of *Onosma papillosa* taken from the root was studied (Fig. 1). Periderm is multilayered. Cortex is multilayered and parenchymatic. Phloem cells were 20.54 ± 1.39 × 9.81 ± 0.95 µ. Cambium cells were undistinguishable. Xylem was composed of sclerenchymatic cells and tracheary elements. Concentric rings were observed in the xylem. The pith consisted of parenchymatic cells (Table 2).

A transverse section taken from the middle part of the stem was observed (Fig. 2). Epidermal cells consisted of a single layer and orbicular or rectangular. Glandular and eglandular trichomes are present on the epidermis. Crystals and sclereids were clearly seen in the epidermis, trichomes and collenchyma. Collenchyma was 4 - 8 layered. Cortex cells were 67.98 ± 2.60 × 50.52 ± 3.08µ. Endodermis was 1 - 2 layered. Xylem and phloem elements were clear. Cambium was distinguishable and 3 - 4 layered. Pith rays were multilayered. Diameter of vessel members were 35.5 ± 6.4 µ. Pith cells were found to be large and cylindrical and were smashed in places (Table 2).

In transverse section of the leaf, bifacial leaf was observed (Figs 3 and 4). Both epidermises were covered with thick cuticle. Upper epidermis cells were larger than lower cells. There were densely simple trichomes, setae with glabrous tubercles and glandular trichomes on both epidermises. Sclereids were seen in epidermal cells. Mesophyll consisted of 2 - 3 layers of palisade parenchyma cells and 3 - 4 layers of spongy parenchyma cells. Palisade parenchyma cells were 31.37 ± 1.02 × 11.6 ± 1.6 µ. Vascular bundles were solitary in the midrib and surrounded by a parenchymatic bundle sheath. Stomata are anomocytic. Stomata occurred on the both surfaces (Figs 5-10 and Table 2).

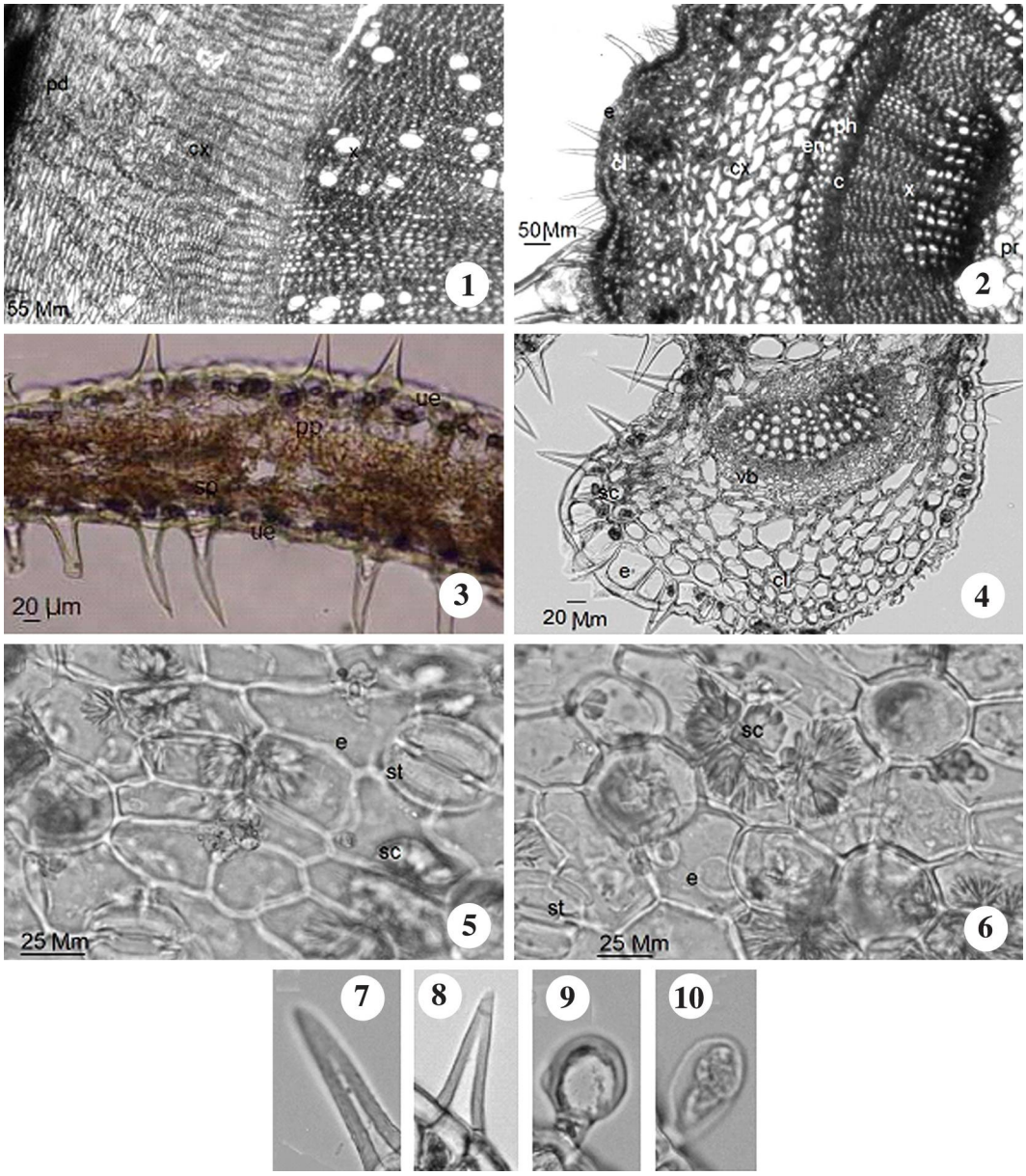
Onosma rutila: A transverse section of *Onosma rutila* taken from the root was observed as follows (Fig. 11). Periderm was multilayered. Fellogen was clear and cortex was multilayered and parenchymatic. Cambium cells were undistinguishable. Xylem was composed of sclerenchymatic cells and tracheary elements. The pith consisted of parenchymatic cells (Table 2).

A transverse section taken from the middle part of the stem was observed (Figs 12 and 13). Cuticle layer was thick. Epidermis cells were 19.98 ± 2.41 × 20.87 ± 1.04 µ. Glandular and eglandular trichomes were present on the epidermis. Collenchyma was multilayered. Collenchymatic cells occupied most of stem cortex. These cells were 47.05 ± 7.08 × 29.85 ± 3.99 µ. Endodermis was distinguishable and 1 - 2 layered. Xylem and phloem elements were clear. Cambium was distinguishable. Sclerenchymatic cells were dense a nd present on upper parts of

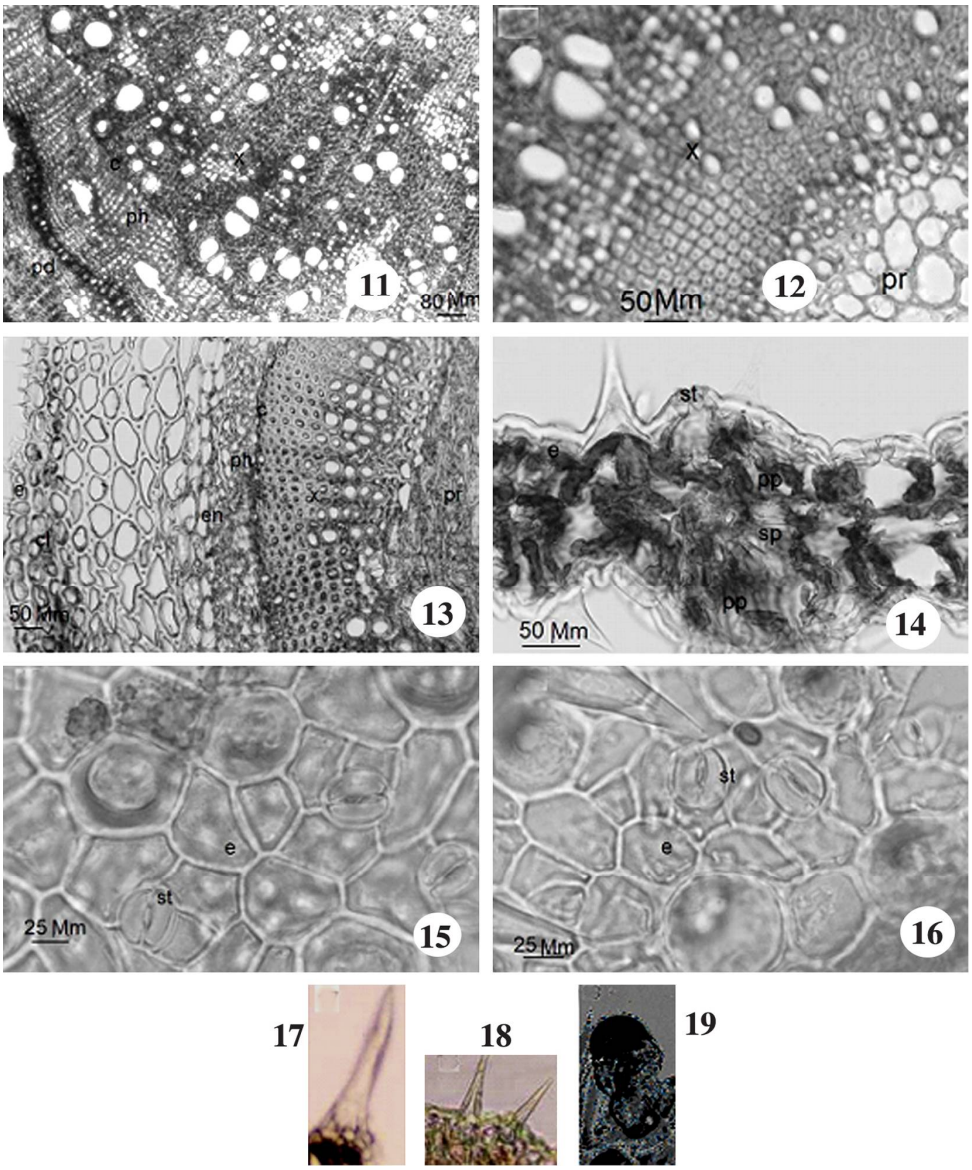
Table 2.Anatomicalmeasurements of studied*Onosma*species

		O. papillosa		*O. rutila*		*O. auriculata*	
		Breath (p) (Mean ±SE)	Lenght (p)	Breath (p) (Mean ±SE)	Lenght (p)	Breath (p) (Mean ±SE)	Lenght (p)
ROOT	Periderm cells	14.04 ±1.47	42.5 ±4.17	10.24 ±0.80	22.77 ± 1.47	9.36 ± 1.00	56.57 ±2..06
	Phyloem cells	9.81 ±0.95	20.54 ±1.39	9.86 ±0.89	15.66 ±0.96	14.16 ± 1.71	20.03 ± 1.86
	Diameter of trachea	54.24 ±2.23	-	49.40 ±3.06	-	67.80 ± 6.42	
	Pith cells	31.26 ±1.59	38.96 ±1.44	44.70 ±3.26	50.72 ±5.00	-	-
STEM	Epidermis cells	24.79 ±0.94	11.73 ±0.97	20.87 ± 1.04	19.98 ±2.41	32.25 ± 1.87	27.19 ± 1.95
	Collenchyma cells	24.28 ±1.67	31.97 ± 1.52	29.85 ±3.99	47.05 ±7.08	39.21 ±3.94	43.21 ±4.45
	Parenchyma cells	50.52 ±3.08	67.98 ±2.60	-	-	-	-
	Endodermis	12.65 ± 1.26	35.72 ±1.95	18.31 ± 1.18	36.55 ±3.25	31.70 ±2.28	57.86 ±2.73
	Phyloem cells	12.90 ±1.92	14.62 ±2.10	9.71 ±0.97	14.47 ± 1.25	11.51 ± 1.99	15.63 ± 1.90
	Cambium cells	9.75 ± 1.146	10.5 ± 1.281	8 ±0.816	6.25 ±0.559	9.75 ± 1.017	10.25 ±0.870
	Diameter of trachea	29.75 ±1.07		20.36 ± 1.45	-	37.95 ±3.30	-
	Pith cells	57.60 ±3.25	67.09 ± 3.76	31.47 ± 1.98	44.42 ±1.70	113.25 ± 19.19	83.49 ±11.68
	Epidermis cells	23.57 ± 1.05	26.10 ±1.78	10.32 ±0.93	30.86 ± 1.57	16.44 ±0.92	31.75 ±2.18
LEAF	Upper epidermis.	20.87 ± 1.04	16.26 ±1.97	7.33 ±0.62	21.37 ±0.92	26.56 ± 1.28	28.71 ± 1.93
	Lower epidermis.	11.60 ±1.60	31.37 ± 1.02	7.28 ±0.71	25.30 ± 1.30	20.49 ± 1.87	46.42 ±2.33
	Palisade parenchyma	6.90 ±0.68	10.80 ±0.93	-	-	22.10 ± 1.61	36.10 ± 1.95
	Spongy parenchyma	14.04 ±1.47	42.5 ±4.17	10.24 ±0.80	22.77 ± 1.47	9.36 ± 1.00	56.57 ±2..06

xylem tissue. Tracheary elements and sclerenchymatic cells were seen in lower part of xylem tissue. Pith cells were large and cylindrical (Table 2).



Figs 1-10. *Onosma papillosa*. 1. Cross-section of root. 2. Cross-section of stem, 3-4. Cross-section of leaf, 5. Upper surface of leaf, 6. Lower surface of leaf, 7-10. Eglandular and glandular trichomes. pd = peridermis, cx = cortex, c = cambium, x = xylem, e = epidermis, cl = collenchyma, sc = sclerenchyma, en = endodermis, ph = phloem, ue = upper epidermis, pp = palisade parenchyma, sp = spongy parenchyma, le = lower epidermis and st = stomata.



Figs 11-19. *Onosma rutila*. 11. Cross-section of root, 12-13. Cross-section of stem, 14. Cross-section of leaf. 15. Upper surface of leaf, 16. Lower surface of leaf, 17-19. Eglandular and glandular trichomes. pd = peridermis, cx = cortex, c = cambium, x = xylem, e = epidermis, cl = collenchyma, sc = sclerenchyma, en = endodermis, ph = phloem, ue = upper epidermis, pp = palisade parenchyma, sp = spongy parenchyma, le = lower epidermis and st = stomata.

In the leaf, both epidermises were covered with thick cuticle. There were densely short simple trichomes, setae with glabrous tubercles and glandular trichomes on both epidermises. Simple trichomes were unicellular and generally short. They had smooth walls. Mesophyll consisted of one layer of palisade parenchyma cells with dense chloroplast on the both epidermises and 2 - 3

layers of spongy parenchyma cells. Palisade parenchyma cells were 31.37 ± 1.02 × 11.6 ± 1.6 µ. Parenchyma cells were found to have large intercellular cavities. Vascular bundles were solitary in the midrib. Collenchymatic cells were observed on the adaxial and abaxial parts of midrib. Leaf was equifacial. Stoma were anomocytic and staurocytic. Stomata occurred on both the surfaces (Figs 14-19, Table 2).

Onosma auriculata: In transverse section of roots of *Onosma auriculata* a secondary structure was observed (Fig. 20). Periderm was multilayered. Cortex was multilayered and parenchymatic and collenchymatic. Cambium cells were undistinguishable. Xylem was composed of tracheary elements and sclerenchymatic cells. The pith consisted of primary xylem (Table 2).

A transverse section taken from the middle part of the stem was observed (Fig. 21). Epidermal cells were 27.19 ± 1.95 × 32.25 ± 1.87 µ. Eglandular trichomes were present on the epidermis. Collenchyma was generally 2 - 3 layered. Multilayered (more than 2 - 3 layers) collenchyma were observed in the cortex. Thick walled paranchymatic cells had definite intercellular area. Endodermis was distinguishable and 1 - 2 layered. Xylem and phloem elements were clear. Cambium was distinguishable. Pith rays were multilayered (2 - 6 layered). Pith cells were large and cylindrical. Sand crystals were seen in the cells of pith and pith rays (Table 2).

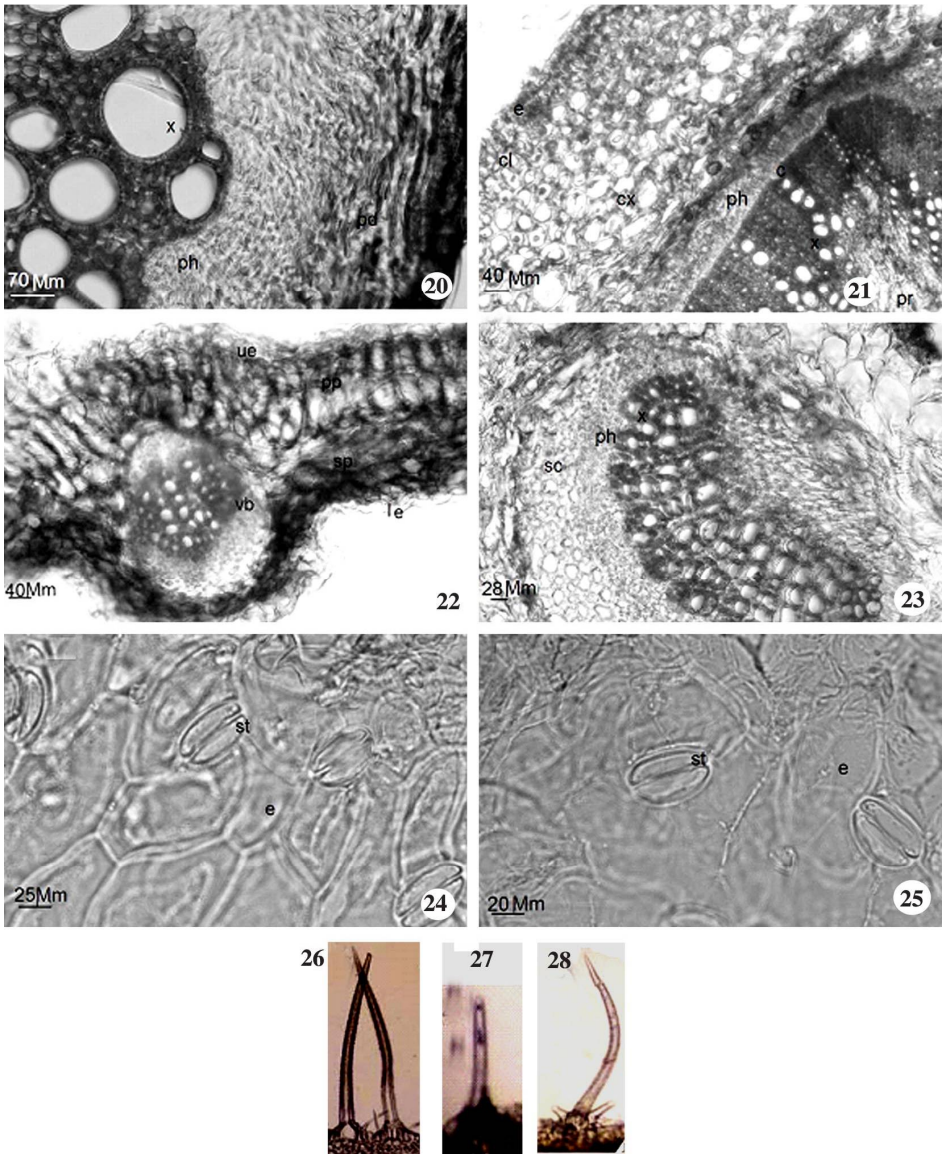
In transverse section of the leaf, bifacial leaf was observed (Figs 22, 23). Both epidermises were covered with thick cuticle. There were short simple trichomes, porrect-stellate trichomes and glandular trichomes on both epidermises. Simple trichomes were unicellular and generally short. They had smooth walls. Porrect-stellate trichomes with both smooth and ornamental cuticle were found on the both surfaces of leaf. Cystoliths like structures were present in trichomes. Mesophyll consisted of 2 (3) layers of palisade parenchyma cells and 2-3 layers of spongy parenchyma cells. Vascular bundles was solitary in the midrib and surrounded by a parenchymatic bundle sheath. Large and small vascular bundles were located in the mesophyll. Fibers were present cells on the xylem and phloem. Stomata were anomocytic and anisocytic. Stomata occured on the both surfaces (Figs 24-28 and Table 2).

In this study, the anatomical properties of *O. papillosa*, *O. rutila* and *O. auriculata* were examined. *O. papillosa* and *O. rutila* are endemic species and belong to subsection *Haplotricha* and *O. auriculata* belongs to subsection *Asterotricha* (Riedl 1978).

Metcalfe and Chalk (1979) and Watson and Dallwitz (1991) explained the characteristic properties of Boraginaceae. All taxa had secondary root structure and xylem were composed of sclerenchymatic cells and tracheary elements. The pith region of root consisted of generally primary xylem elements in *Onosma* species as *O. bracteosum* (Akçin and Engin 2005) and *O. gigantea* Lam. (Binzet and Orcan 2003). *O. auriculata* had primary xylem elements in pith region. Some *Onosma* species have parenchymatic pith region (Binzet and Orcan 2003, Akçin 2007). Binzet and Orcan (2003) explained that lignified parenchyma cells were found in the pith region of *O. roussaei*. The pith region of *O. papillosa* and *O. rutila* composed of parenchymatic cells. The presence of crystals in Boraginaceae family has important features (Metcalfe and Chalk 1979). Crystals and sclereids were clearly seen in the stem and leaf of *O. papillosa*. Sand crystals were seen in the pith region of *O. auriculata.* While the row number of collenchymatic cells varied among species, these cells were present in the stem of studied taxa. Endodermis were seen between cortex and vascular tissue in all species. It was seen that phloem and cambium were more distunguiable.

Metcalfe and Chalk (1979) reported that there are centric or isobilateral mesophyll types in Boraginaceae. It was observed that *O. papillosa* and *O. auriculata* had bifacial leaf types and *O. rutila* had equifacial type. The same feature had been observerd in the leaves of some *Onosma* taxa (Binzet and Orcan 2003, Akçin 2004, 2007). Generally, there is anomocytic and anisocytic

stomata in *Onosma* taxa (Akçin and Engin 2001, Binzet and Orcan 2003, Akçin 2004, 2007). Stomata types were anomocytic in *O. papillosa,* anomocytic and staurocytic in *O. rutila* and anomocytic and anizocytic in *O. auriculata.* Dasti *et al.* (2003) explained that although anomocytic type was dominant type helicocytic, hemiparacytic, staurocytic and brachyparatetracytic stoma were seen in *Onosma stephonia*.



Figs 20-28. *Onosma auriculata.* 20. Cross-section of root. 21. Cross-section of stem, 22-23. Cross-section of leaf, 24. Upper surface of leaf, 25. Lower surface of leaf. 26-28, Eglandular and glandular trichomes. pd = peridermis, cx = cortex, c = cambium, x = xylem, e = epidermis, cl = collenchyma, sc = sclerenchyma, en = endodermis, ph = phloem, ue = upper epidermis, pp = palisade parenchyma, sp = spongy parenchyma, le = lower epidermis and st = stomata.

According to Watson and Dallwitz (1991), eglandular or eglandular and glandular trichomes are usually present in this family. *Onosma* section was separated into two subsection according to trichome type: *Asterotricha* (Boiss.) Gürke. and *Haplotricha* (Boiss.) Gürke. In subsect. *Haplotricha*, the tubercles are glabrous (the haplotrichous state). *Asterotricha*, has tubercular setulae (porrect stellate), spinules or hairs (Riedl 1978). It was found that studied species had long and short simple eglandular trichomes and glandular trichomes. Setae with glabrous tubercles were observed in *O. papillosa* and *O. rutila*. These species belong to subsect. *Haplotricha*. *O. auriculata* had porrect-stellate trichomes (subsect. *Asterotricha*). Simple trichomes were unicellular and generally short. They had lignified, ornamental or smooth walls. Glandulars trichomes were unicellular and multicellular.

The anatomical features of *O. papillosa, O. rutila* and *O. auriculata* were examined in this study. It may be concluded that some anatomical characters are useful for separating studied *Onosma* species.

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