

MORPHOLOGICAL AND ANATOMICAL CHARACTERS FEATURES OF THREE MEDICINAL *SCANDIX* SPECIES (APIACEAE) FROM TURKEY

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Abstract

Genus *Scandix* is represented by 9 taxa in Turkey. They are the medicinal and aromatic plants because of their utility for various medicinal purposes. In this study, morphological, morphometrical and anatomical features of the some *Scandix* species (*Scandix stellata*, *Scandix iberica* and *Scandix aucheri*) from Turkey were investigated to compare and determine the taxonomic importance of these characters in the genus. The description, synonyms, Turkish names, flowering times, habitat characteristics of each taxon were presented. Anatomical investigations, including cross sections taken from stems, root and fruit of each species, were examined using light microscope. For the first time, anatomical as well as morphological studies of *S. stellata* and *S. aucheri* were conducted. The anatomical features of stem, root and fruit structures of these species were quite similar.

Key words: Anatomy, Apiaceae, Morphology, *Scandix*, Turkey.

Introduction

Apiaceae, one of the best known families of flowering plants comprises 300-455 genera and 3000-3700 species, The family Apiaceae is rich in secondary metabolites. The synthesis of essential oils and oleoresin, secreted in schizogenous canals in root, stem, leaves and inflorescence, is a characteristic feature of this family (Constance, 1971; Davis, 1972; Heywood, 1972; Pimenov & Leonov, 1993). The family Apiaceae is cosmopolitan, and particularly abundant in the northern hemisphere, temperate regions but rare in tropics (Downie *et al.*, 2000a, Berenbahum, 1990; Christensen & Brandt, 2006).

The species of the family Apiaceae are aromatic plant and have a distinctive flavor with diverse volatile compounds from their fruits and leaves.

The genus *Scandix* L. consists of 20 species. Fifteen of them are mostly confined to the Mediterranean region (Kubeczka, 1982; Zohary, 1972; Downie *et al.*, 2000b) and only *Scandix pecten-veneris* L. is widely distributed (Cohen, 2002). 8 species and 9 taxa of this *Scandix* genus have been reported in Flora of Turkey. The taxa covered in this study (*Scandix iberica* Bieb., *Scandix stellata* Banks & Sol. And *Scandix aucheri* Boiss.) are annual herbs (Davis, 1972). *Scandix stellata* and *S. iberica* are called as “Dağ kişkişi” and “Atkişnek” in Turkish, respectively (Baytop, 1997). The genus *Scandix* is dibasic ($x=7, 8$) in n and $x=8$ is the most common basic number (Jeelani *et al.*, 2012).

Scandix is mentioned as a pot-herb by Theophrastus and Pliny, and Dioscorides describes the greens as being eaten raw or cooked. Euripides's mother was supposed to have sold wild chervil on the Athenian market (Psaroudaki *et al.*, 2012). According to Dodonoeus, in a writing in 1578, “*Scandix* eaten is good and wholesome, and in times past hath been a common herb amongst the Greeks, but of small estimation and value, and taken but only for a wild wurt or herb” (Hulme, 1902). *Scandix*

species are edible wild green leafy vegetable widely used in the Mediterranean diet (Tsakalidi, 2014). *Scandix iberica* has been used for medical purposes, like genital disorders, liver protecting in Malatya region (Tetik *et al.*, 2013).

Verification of the identity of the common *Scandix* L. species in Israel, locally named as *S. iberica* M. Bieb. revealed that it did not belong to actual *S. iberica* but belonged to an undescribed species. The new species was named as *Scandix verna* O. Cohen. It also included a variety with hirsute fruit var. *eriocarpa*. The species is restricted to the Mediterranean territory of the Levant. Studies of the taxonomic history of the binomial *Scandix iberica*, as well as the distribution of the true *S. iberica* in the Levant, showed that the misapplied name for the Israeli taxon had been used for more than one hundred years.

Many varieties of *S. stellata* are recognized on indumentum, fruit, ray and bracteole characters. *S. aucheri* differs from *S. stellata* from which it may not be specifically distinct, in its entire, lanceolate bracteoles, 1.5-5 mm long. Several specimens of *S. iberica* resembles *S. pecten-veneris* in having bracteoles without membranous margins, and in the comparatively short, thickened rays. It must be noted that bracteole character is a good diagnostic character in this genus and *S. stellata* is easily distinguished from the other members of the genus by pinnate or pinnatifid type of bracteoles (Davis, 1972).

Some morphological features of *S. iberica* have been evaluated in Syria and Iran Flora (Hedhge & Lamond, 1987; Mouterde, 1970; Cohen, 2002), and there are morphological descriptions on the other two *Scandix* species. However, to the best of our knowledge, there is no anatomical research on these three *Scandix* species. In this study, the morphological, morphometrical and anatomical features of the some *Scandix* species from Turkey were investigated to compare and determine the taxonomic importance of these characters in the genus patterns.

Materials and Methods

Plant specimens were collected during the flowering and fruiting period from natural populations in different regions from Turkey. Some individuals were used for morphological and anatomical observations and some of them were dried and stored as herbarium samples. The voucher specimens have been deposited at the Firat University Herbarium (FUH). The taxonomic description of the plant was prepared according to Flora of Turkey (Davis, 1972). Collection localities, collector's number and the habitat of investigated samples are given in Table 1 and their distribution is summarized in Fig. 1. The morphological and morphometrical characters are evaluated in Table 2. The optic images in nature and illustrations of the descriptive characters are shown in Fig. 2. The anatomical studies were carried out on specimens fixed in 70 % alcohol. Cross section of the stem, root and fruits of the plant samples were examined by light microscopy, Olympus BX51. The micro-anatomical measurements are summarized in Table 3 and anatomical features are shown in Fig. 3.

Results

Morphology: The morphological description of *Scandix* species was given in following sections and compared

with the Flora of Turkey (Davis, 1972). Detailed morphological and morphometrical characteristics of these species were presented (Table 2).

Scandix stellata Banks & Sol.

= *S. pinnatifida* Vent., Hort. Cels 14 (1800)

= *Scandicium stellatum* (Banks & Sol.) Thell in Feddes Rep. 16:16 (1919)

Description: Plants almost glabrous, shortly pilose or with long villous hairs on stem and leaves, 18-30 cm high. Cauline leaves narrow-ovate to ovate, deeply 3-1.7-11x 1-5.6 cm, segments almost linear, upper to 2 cm x 0.5 mm, lower shorter. Rays 2-8 mm long, thickening when mature. Bracteoles 0.5 x 6-8 mm, segments linear. Pedicels 0.5-1 mm, thickening in fruit. Number of fruit 11-28 and spreading-stellate when mature, 1.5-2.5 cm x 1 mm, fertile portion dark brown, glabrous or asperous, shorter than and clearly differentiated from dorsally compressed, usually ciliate beak, 0.8- 1.2 cm. Primary ridges filiform.

Fl. Per. 4-6; Habitat; Dry, rocky, hillsides, eroded slopes, igneous scree, road-banks and cornfields, 300-2190 m.; Ir-Tur. Element. Turkish Name; Dağ kişkişi.

Table 1. The locality information of collected *Scandix* species.

Species	Locality
<i>Scandix stellata</i>	B7 Elazığ, Hankendi, Demirpolat 1020; B7 Elazığ, Baskil, Demirpolat 1021; B7 Elazığ, Sivrice Lake Region, Demirpolat 1034; C5 Adana, Pozantı, Gökbez Village, Demirpolat 1026; C6 Gaziantep, Edilli-Koçcağız Village, Demirpolat 1035; B7 Tunceli, Çemişgezek Village, Demirpolat 1028; B6 Kahramanmaraş Pazarcık, Ketiler Village Demirpolat 1037.
<i>Scandix aucheri</i>	B7 Elazığ, Hankendi, Demirpolat 1031
<i>Scandix iberica</i>	B7 Elazığ, Baskil, Demirpolat 1027; B7 Elazığ, Hankendi, Demirpolat 1022; C5 Adana, Pozantı, Gökbez Village, Demirpolat 1025.

Table 2. Morphological and morphometrical characters of *Scandix* species.

Characters	Plants		
	<i>S. stellata</i>	<i>S. iberica</i>	<i>S. aucheri</i>
Plant	18-30 cm	13-32 cm	16-19 cm
Bracteoles	Pinnatifid	Apex of two toothed	Entire
Width of bracteoles	0,5 mm	1-2 mm	1 mm
Length of bracteoles	6-8 mm	3-5 mm	3-4 mm
Leaf shapes	Pinnatisect	Pinnat-Pinnatisect	Pinnat-Pinnatisect
Width of leaf	1-5.6 cm	0.8-7.2 cm	1.5-5 cm
Length of leaf	1.7-11 cm	2.5-5 cm	1.5-9 cm
Length of petal	1-2 mm	3-6 mm	0.5-1 mm
Length of petiole	1.5 mm	0.8 mm	1.5 mm
Hairs of petiole	Simple hairy	Simple hairy	Simple hairy
Number of fruit	11-28	20-40	14-18
Length of mature fruit	1.5-2.5 cm	2-4 cm	1.4- 2 cm
Width of mature fruit	1-1.2 mm	2-3 mm	1-1.5 mm
Colours of dorsally ridges in fruit	Light greenish to brown	Dark brown-green	Dark brown-green
Fruit shapes	Linear	Linear	Linear
Beak length of the fruit	0.8- 1.2 cm	0.7-1.1 cm	0.7-1 cm
Length of pedicel	0.5-1mm	3-5 mm	0.3-1 mm
Number of mature rays	1-3	3-7	1-3
Hairs of mature rays	Scarce hairs	Dense hairs	Scarce hairs

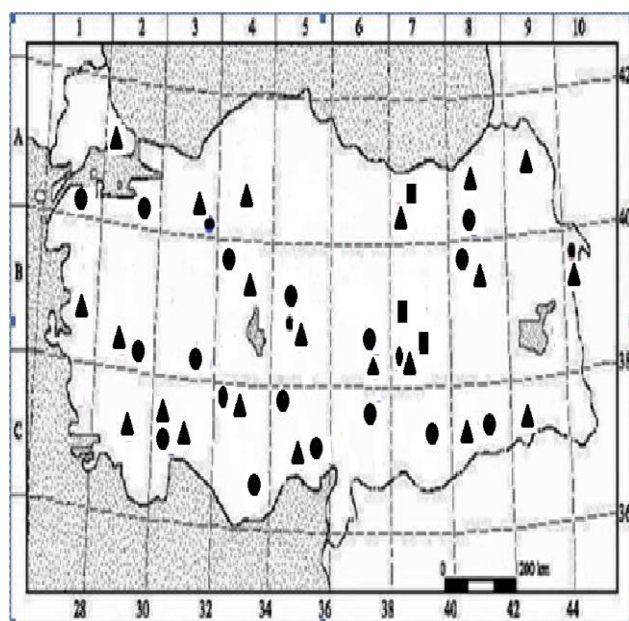


Fig. 1. Distribution of studied *Scandix* species in Turkey (*S. stellata* ●, *S. aucheri* ■, *S. iberica* ▲)

Scandix iberica Bieb.

=*S. pisidica* Boiss., Diagn. 1(10)49 (1849)
= *S. eriocarpa* Stapf and Wettst. ex Stapf in Denkscher. Akad (1886)

Description: Much branched almost glabrous, softly pilose, hispid or sparsely asperous plant, 13-22.5 (-32) cm. Leaves 2-3 pinnate-pinnatisect, 2,5× 0,8 cm linear-

lanceolate to filiform. Rays 4-7, equal or not, 1,5-4 cm. Petiole simple-hairy and 0,8 mm. Bracteoles 4-7, oblong, entire or coarsely 2(-3)-fid from apex, almost reflexed, ciliate, 1-2 × 3-5 mm. Pedicel from apex 3-5 mm. Outer petals clearly radiant, 3-6 mm. Fruit glabrous to densely stigose, 2-4 cm x 2-3 mm, beak always ciliate, 0.7-1.1 cm. Numbers of fruit 20-40, when mature.

Fl. Per. 4-6;

Habitat; Dry and hard top edges eroded slope, stepper volcanic slopes, edge of wheat fields roadsides, 300-2190 m.; Turkish Name; Atkışnekotu.

Scandix aucheri Boiss.

=*Scandicum aucheri* (Boiss.)Manden in Zam. Sist. Geogr.Rast. 10:75 (1941)

Description: Plants 16-17.5(-19) cm high. Leaves linear-tripinnate, lanceolate to filiform, 2 × 2 cm. Rays 1-3, 1-(1.5)-2 mm. Petiole simple-hairy and 0,8 mm. Bracteoles lanceolate, 1× 3-4 mm. Pedicel 0.3-1 mm, when in fruit. Petals white and 1×0.5-1 mm. Fruit glabrous to hispid, 1.4-2 cm x 1 mm. Number of fruit 14-18, when mature, beak 0.7-1 mm.

Fl. Per. 4-6;

Habitat; Dry and tough hillsides, eroded slopes, fields and roadsides, 300-2000 m.; Turkish Name; Karbağ kışkışı.

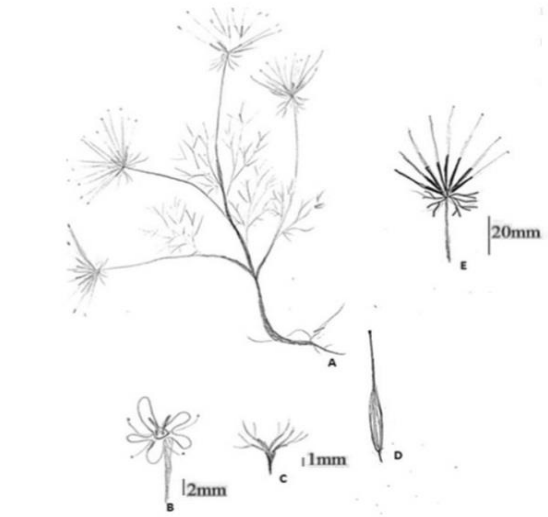
Table 3. Comparative micro-anatomical measurements of various tissues of investigated *Scandix* species.

Stem	<i>S. stellata</i>	<i>S. iberica</i>	<i>S. aucheri</i>
Epidermis cell width(μm)	6-28	5-15	5-10
Epidermis cell length(μm)	4-10	3-8	4-8
Cortex cell width (μm)	6-35	5-25	6-30
Cortex cell length(μm)	7-38	8-20	7-30
Pith cell width(μm)	20-105	20-95	12-98
Pith cell length(μm)	15-102	15-92	25-102
Cortex cell layer(μm)	65-90	45-50	60-75
Root			
Cortex cell width(μm)	10-35	12-15	19-85
Cortex cell length (μm)	8-17	5-17	16-25
Periderma thickness (μm)	9-15	8-11	15-19
Fruit			
Mericarp width(mm)	3-3.5	1-2	4-5
Exocarp thickness(μm)	13-17	6-8	15-17
Mesocarp cell	1-3	1-3	2-3
Mesocarp thickness(μm)	8-10	5-7	9-12
Endocarp thickness(μm)	12	8-11	12
Dorsal vittae number	1	1	1
Dorsal vittae width (mm)	0.8-0.10	0.7-0.8	0.9-0.13
Dorsa-lateral vittae number	2	2	2
Dorsa-lateral vittae width (mm)	0.22-0.25	0.4-0.4	0.25-0.23
Commissural vittae number	2	2	2
Commissural vittae width (mm)	0.29-0.39	0.3-0.4	0.31-0.40
Endosperm width (mm)	2	-	2.2

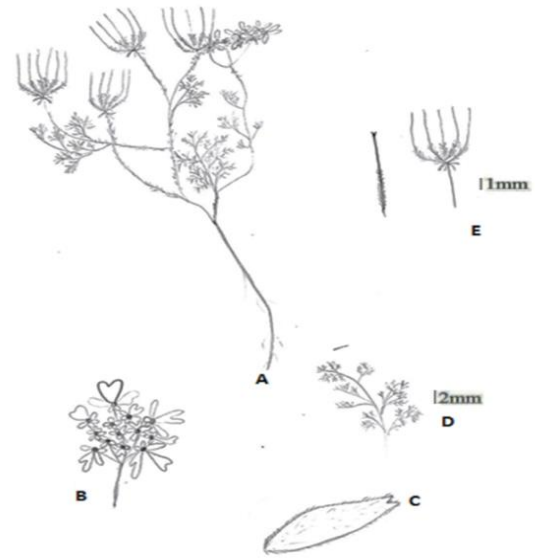
Habitat

Illustration of the characters

S. stellata



S. iberica



S. aucheri

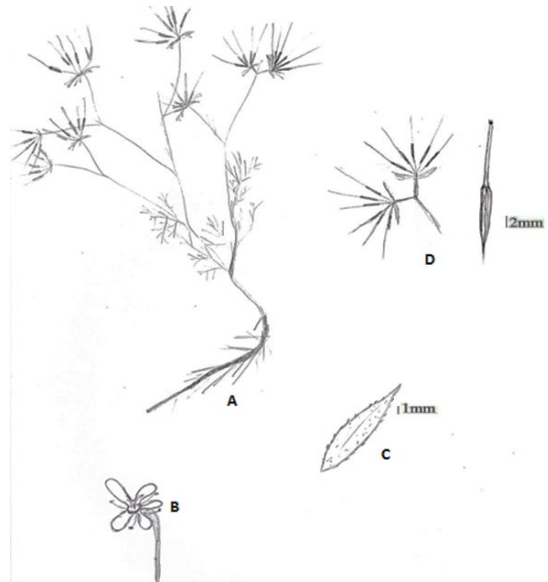


Fig. 2. *Scandix* species A. General appearance B. Flower C. Bracteole D. Fruit.

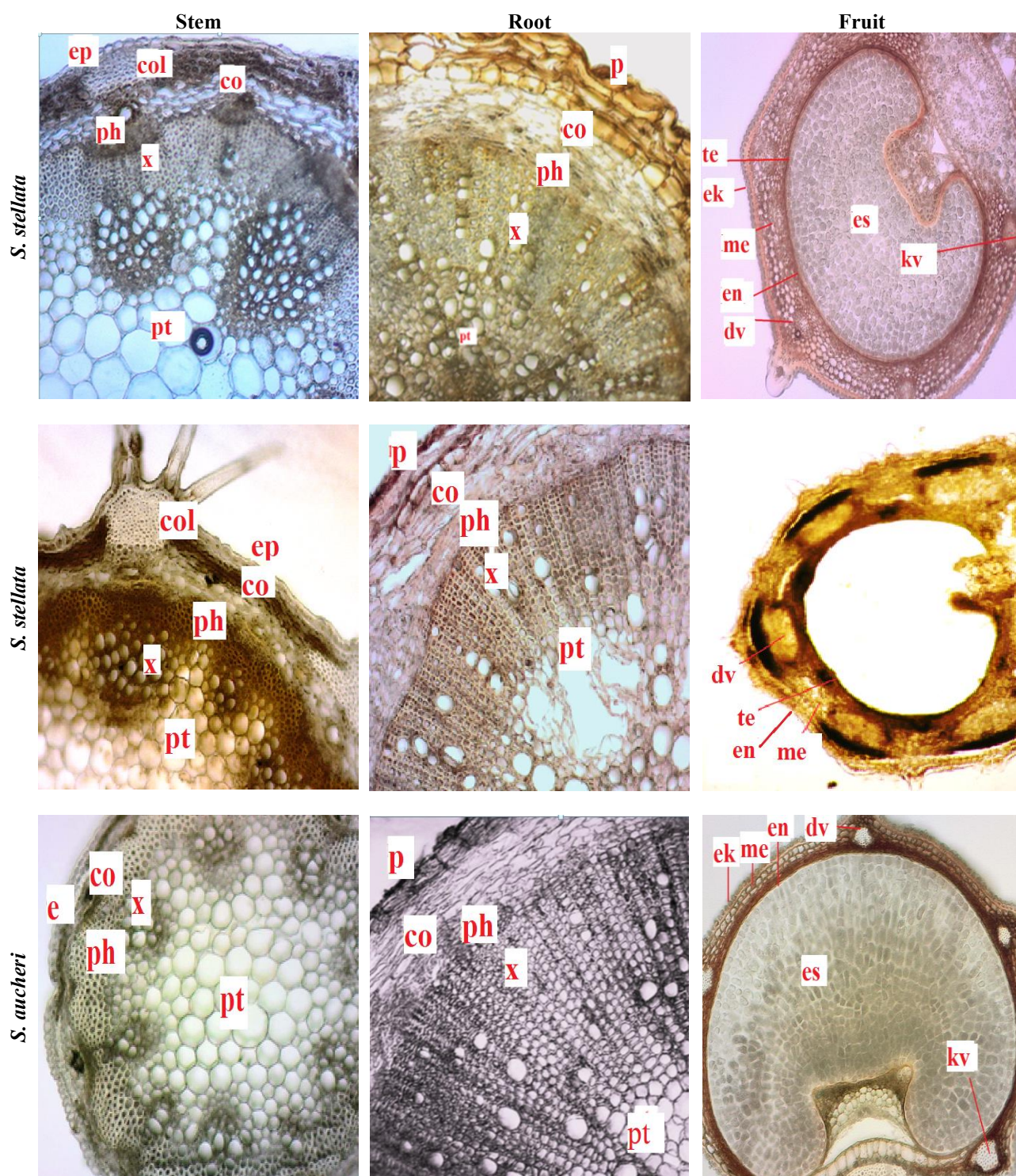


Fig. 3. Light Microscopy: Stem, root and fruit anatomy of the *Scandix* species (ep:epidermis,co:collenchyma, x:xylem, ph:phloem, pt:pith region, p:periderma, ek:ektodermis, en:endodermis, me:mesodermis, dv:dorsal vittae, kv:commissural).

Anatomy

Stem

Scandix stellata: The epidermis is single layered and consists of mostly rectangular or ovoidal rectangular, sometimes square-like cells. The cortex is composed of 4-6 layers and the cells are ovoidal. The first 2-3 layers of cortex cells underneath the epidermis have chloroplasts,

but the small, 3-5 layers of cortex cells close to phloem have few or no chloroplasts. There is collenchyma layer underneath the epidermis that is buried in the cortex at some places. Collenchyma is composed of 6-8 layers. The secretory canal consists of 4-8 secretory cells that is buried in the cortex, underneath the collenchyma layer. A layer below the cortical parenchyma is composed of sclerenchymatic cells with thicker walls. Sclerenchymatic cells consists of 6-12 layers and intercellular spaces

appear between these cells. Phloem is composed of 3-7 layers of cells. Xylem is composed of 4-6 layers of cells. The major part of the stem is occupied by pith region. The parenchymatic cells constitute the pith region are either ovoidal or circular (Table 3).

***Scandix iberica*:** The epidermis is single layered and consists of mostly ovoidal rectangular, sometimes square-like cells. The cortex is composed of 4-5 layers and the cells are ovoidal. The first 2-3 layers of cortex cells underneath the epidermis are small with chloroplasts, but the 3-5 layers of cortex cells close to the phloem have no chloroplasts. There is collenchyma layer underneath the epidermis that is buried in the cortex at some places. Collenchyma is composed of 10-12 layers. Secretory canal consists of 4-8 secretory cells buried in the cortex, underneath the collenchyma layer radially. A layer below the cortical parenchyma is composed of sclerenchymatous cells with thicker walls. Sclerenchymatic cells consist of 3-7 layers and intercellular spaces appeared between these cells. Phloem is composed of 3-5 layers of cells. Xylem is composed of 3-9 layers of cells. The parenchymatous cells constitute the pith region are either ovoidal or circular (Table 3).

***Scandix aucheri*:** The epidermis is single layered and consists of mostly rectangular or ovoidal cells. The cortex is composed of 3-4 layers and the cells are ovoidal. There is collenchyma layer underneath the epidermis, buried in the cortex at some places. Collenchyma is composed of 5-7 layers. Secretory canal consists of 4-7 secretory cells is buried in the cortex, underneath the collenchyma layer radially. There is a layer below the cortical parenchyma composed of sclerenchymatic cells with thicker walls. Sclerenchymatic cells are consists of 5-10 layers and intercellular spaces appeared between these cells. Phloem is composed of 3-6 layers. Xylem is composed of 4-6 layers. The major part of the stem is occupied by pith region. The parenchymatous cells constitute the pith region are either ovoidal or circular (Table 3).

Root

***S. stellata*:** The periderm in the root is composed of 2-5 layered flat rectangular cells. Cortex cells are arranged underneath. Secretory canals consist of 1-2 cells within the cortex and phloem. Phloem and xylem layers are arranged beneath the endodermis. 1-2 layers of cambium is located between phloem and xylem. The major part of the root is occupied by xylem. Trachea and tracheids are regularly arranged within the secondary xylem. Supportive sclerenchymatic cells are located between these cells. The arms of pith are composed of radially arranged parenchymatous cells (Table 3).

***S. iberica*:** The periderm in the root is composed of 1-2 layered flat rectangular cells. Cortex cells are arranged underneath. Secretory canals are located within the cortex and phloem. Phloem and xylem layers are present beneath the endodermis. One layer of cambium is located between phloem and xylem. The major part of the root is occupied by xylem underneath the phloem.

The arms of pith are composed of radially arranged parenchymatous cells (Table 3).

***S. aucheri*:** The periderm in the root is composed of 2-4 layered rectangular cells. Secretory canals consist of 3-9 secretory cells arranged right underneath the periderm and are scattered in the cortex. Cortex cells are located right underneath. No secretory canal is detected in the phloem. Phloem and xylem layers are arranged beneath the endodermis. Phloem consists of 3-5 layers of cells. 1-2 layers of cambium are located between phloem and xylem. The major part of the root is occupied by xylem right underneath the phloem. The pith region is composed of parenchymatous cells (Table 3).

Fruit

***S. stellata*:** Fruits are composed of two mericarps. At the cross-section mericarp appears to be as bean-shaped. The mericarps are attached to each other at the carpophore ventrally. Each mericarp is compressed towards to the wings and its ventral is circle-shaped at the center. Exocarp consists of 1 layer of flat rectangular-like cells. Mesocarp consists of 1-3 layers of elongated ovoidal cells. The different sized parenchymatous cells constitute the mesocarp. Endocarp consists of 2 layered sclerenchymatic cells distally. Testa is composed of flat cells located beneath the endocarp. 1 dorsal vittae and 2 dorso-lateral vittae are present at the dorsal side? of mericarp. 2 commissural vittae are located within mesocarp ventrally. The width of commissural vittae is bigger than dorsal vittae. Resin canals in the commissural side are closed to carpophore. Endosperm is present at the center filling the pericarp. Tightly arranged endosperm cells are ovoidal or circular shaped (Table 3).

***Scandix iberica*:** At the cross-section the mericarp is half circle-shaped and considerably hairy. The mericarps are attached to each other at the carpophore ventrally. Each mericarp is compressed towards to the wings and its ventral is circle-shaped at the center. Exocarp consists of 1 layer of flat rectangular-like cells. Mesocarp consists of 1-3 layers of elongated polygonal-like cells. The mesocarp consists of different sized parenchymatous cells. Endocarp consists of 2 layered sclerenchymatic cells distally, and 3-4 layered flattened and lignified sclereids proximally. Testa is composed of flat cells located beneath the endocarp. 1 dorsal vittae and 2 dorso-lateral vittae are present at the dorsal side of mericarp. 2 commissural vittae are located within mesocarp ventrally. The width of commissural vittae is greater than dorsal vittae. Endosperm is arranged at the center filling the pericarp (Table 3).

***S. aucheri*:** Mericarps are bean-shaped at its cross-section. The mericarps are attached to each other at the carpophore ventrally. Each mericarp is compressed towards to the wings and its ventral is circle-shaped at the center. Exocarp consists of 1 layer of flat rectangular-like cells. Mesocarp consists of 2-3 layers of flat ovoidal cells. The mesocarp is parenchymatous having different sizes of the cells. Testa is composed of flat cells located beneath the endocarp. 1 dorsal vittae and 2 dorso-lateral vittae are

present at the dorsal side of mericarp, 2 commissural vittae are located within mesocarp ventrally. The width of commissural vittae is greater than dorsal vittae. Resin canals in the commissural side are close to carpophore. Endosperm is present at the center filling the pericarp. Tightly arranged endosperm cells are ovoidal or circular shaped (Table 3).

Discussion

In this study, morphological, morphometrical and anatomical features of three species of *Scandix* genus were investigated. This is first report which includes some of the morphologic and morphometric characters not indicated in the Flora of Turkey. Therefore, this study provided some additional characters for the genus *Scandix* including number of mature fruits per ray (11-28), beak length of the fruit (0.8-1.2 cm), the position of the styles in the fruit, pedicel length, width and length of petal (Table 2).

S. stellata is the most widely distributed species in Turkey. The most important and selective morphological feature of *S. stellata* is the bracteole character. The bracteoles of this species are pinnatifid. The size of the bracteoles are 0.5 x 6-8 mm. This species is commonly confused with *S. aucheri*, but it is easily distinguished from *S. aucheri* which has lanceolate bracteoles. Furthermore, other distinct differences are apparent. Plant height of *S. stellata* is up to 30 cm, while it is up to 20 cm in *S. aucheri*. Another difference is that stylus length of *S. stellata* fruit is 0.5-0.7 mm (not more than 1 mm) (Table 2).

S. iberica could be easily distinguished from other species by its dense hairy surface and outer petal with 2 wide lobes at the end. The pedicel length of the fruit is 3-5 mm, while it is 0-1 mm is recorded in the Flora of Turkey. Fruit size is 2-4cm x 2-3 mm, while fruit size is reported to be 1.5-2.5 x 1-1.5 mm in the Flora of Turkey. In a mature individual, fruit number may vary between 20 and 40. Beak length in the fruit is 0.7-1.1 cm but these characters are not detected in the Flora of Turkey. According to Cohen (2002), when taxonomical characters of *S. iberica* are evaluated, bracteole length and width were found to be 2-5 mm and 1-2 mm, respectively and number of rays were observed as 5-9, rarely as 3. Bracteole length and width of *S. iberica* is 3-5 mm, and 1-2 mm, respectively. In addition, number of rays were determined as 3-7. The data collected in our study is considerably in parallel to Cohen's data. Ray number in each umbel may vary as 6-9 according to Schischkin (1950), 3-8 in Flora Iranica (Hedge & Lamond, 1987), 3-9 in Flora of Syria and Lebanon (Mouterde, 1970), and (3-) 4-9 in the Flora of Turkey (Davis, 1972). According to Cohen (2002), the increase and decrease in the number of rays is due to the fact that the climate of the harvesting areas are close to arid and desert climate.

The description of *S. aucheri* in the Flora of Turkey (Davis, 1972), is based upon the one character and it is indicated just the basic difference between *S. aucheri* and *S. stellata*. The results could not be compared in detail. *S. aucheri* with lanceolate bracteol is distinguished from *S. stellata* with its pinnatifid shaped bracteoles. Number of fruits may vary as 14-18 in mature individuals. Beak length in fruit is 0.7-1 cm.

S. stellata is distinguished from *S. aucheri* by some of its anatomical features. Epidermis of stem is 6-28 x 4-10 μm (not 5-10 x 4-8 μm); cortex is 4-6 layered (not 3-4 layered); the width of periderm cell is 9-15 μm and flat rectangular shaped. However, this situation is 15-19 μm and ovoidal rectangular shaped in *S. aucheri*. Mericarp width is 3-3.5 mm (not 4-5 mm), mesocarp is 1-2 layered (not 2-3 layered) in *S. stellata*. The width of dorsal vittae is 0.8-0.10 mm (not 0.9-0.13 mm), smaller than of *S. aucheri*. Although *S. iberica* seems quite different from other species, the data from anatomical characters of this species does not show remarkable differences. The width of periderm layer (8-11 μm) as well as the number of periderm layers of this species is the smallest in all of the *Scandix* species.

Scandix aucheri is distinguished from the other species for some characters. Periderm cells are clearly different from the other *Scandix* species since they are ovoidal-rectangular shaped. Secretory cells were found buried in the root periderm of some of the studied *S. aucheri*. This species is distinguished from the other *Scandix* species that these secretory cells are not found in those species.

In this study, detailed morphological characteristics and anatomical structure of three *Scandix* species are evaluated. The determined morphological characters in our study are generally similar to the Flora of Turkey. But some differences were also be observed. The anatomical features of *Scandix* species are reported for the first time in this study. The anatomical features of the stems, root and fruit of the *Scandix* species have similar characteristics.

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