

The genus *Astrantia* L. in Turkey: morphology and anatomy

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The genus *Astrantia* L. is a perennial plant which belongs to the Umbelliferae family and is represented by only *A. maxima* Pallas which has two subspecies (subsp. *maxima* and subsp. *haradjianii* (Grintz.) Rech. fil.) in Turkey. Subsp. *haradjianii* is endemic and very common. In this study, *Astrantia* specimens were collected from different localities and investigated for morphological and anatomical differences. The morphological features of various organs of the plant are described in detail. According to our morphological results, subsp. *maxima* is bigger than subsp. *haradjianii*. Bracteoles are large, coloured, surface shapes and length of bracteoles are significant diagnostic characters to separate the subspecies. Inflorescence is simple umbel and fruit oblong-cylindrical. In anatomical studies, the transverse section of the stem and leaf were examined. The stem is almost round, ribbed and the arrangement of vascular bundles has diagnostic value. The number of bundles and rays are different in the subspecies. Leaf is bifacial.

Key words: Umbelliferae, *Astrantia maxima*, morphology, anatomy.

Introduction

The Umbelliferae are represented by three subfamilies, *ca.* 300 genera and 2500–3000 species. *Astrantia* L. is evaluated under subfamily Saniculoideae, with about 10 species, restricted to the Old World (Europe-Asia Minor, Caucasus) (HEYWOOD 1979). Both bisexual and male flowers are present in *Astrantia* (Andromonoecism) (RENDLE 1937). The degree of organization of the inflorescence is one of the most noteworthy features of the Umbelliferae. In some umbels, flowers that are functionally unisexual take on the role of stamens or pistils in *Astrantia*. *A. maxima*, commonly known as masterwort, has shell pink flowers with broad »collars« and attractive foliage. This is really a shame as these plants make excellent ornamentals for the shaded or woodland garden as well as the border (HEYWOOD 1971, 1979). The genus *Astrantia* is a perennial herb and it is represented by only one species under two subspecies; subsp. *maxima* and subsp. *haradjianii* (Grintz.) Rech fil in the Flora of Turkey (HEDGE and LAMOND 1972). Subsp. *maxima* is distributed in North-East Anatolia (Fig.1). It grows in woodlands, lush meadows at 1300–2400 m. and flowering

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time is (June) July–August. On the other hand, subsp. *haradjianii* is widespread in Turkey. It grows in open conifer forests and deciduous scrub, at 700–1750 m. and flowering time is June–July (HEDGE and LAMOND 1972).

In this study, the morphological and anatomical features of *A. maxima* are described in detail and its important diagnostic characters are pointed out.

Materials and Methods

The material used in the present study was collected from Gümüşhane, Trabzon, Bolu and Karabük provinces in Turkey. Voucher specimens are deposited in the Herbarium of the Faculty of Pharmacy of Anadolu University in Eskisehir, Turkey (ESSE 2052, 2064, 2330 and 12492). Morphological features were determined on herbarium materials. Collected living materials were fixed in 70% alcohol for anatomical studies. Transverse sections and surface preparations of stem and leaves were made manually for anatomical studies. A Wild M5 Stereomicroscope with drawing tube and a Leitz SM-LUX binocular microscope with drawing tube were used in morphological and anatomical studies. For SEM study, the specimens were mounted onto SEM stubs using double-sided adhesive tape and coated with gold. Photographs were taken with a Cam Scan S4.

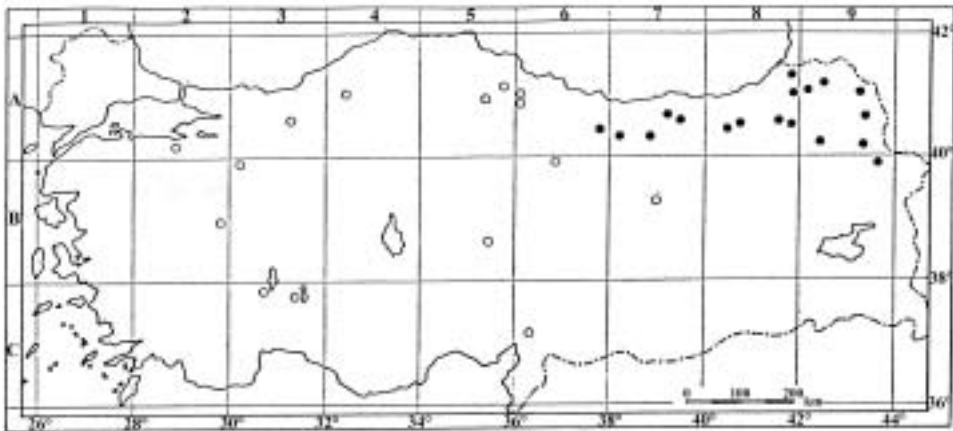


Fig. 1. Distribution of *Astrantia maxima* in Turkey: *A. m.* subsp. *maxima* (●) and *A. m.* subsp. *haradjianii* (○)

Results

Morphological investigations

Astrantia maxima Pallas perennial herb with a short rootstock crowned with a fibrous collar. Stem erect, simple or branched, 44–90 cm long and 1.5–3.5 mm diameter, terete, ridged, hollow and glabrous (Figs. 2–4). Leaves ternate or palmately divided. Basal leaves; 3–5 partite, central 3.3–6.1 × 1.2–2.8 cm, lateral 2.8–8.5 × 1–3.5 cm, segments elliptic,

ovate-lanceolate unequally serrate or crenate with apiculate teeth, petiole much longer than lamina, 4–21 cm, Cauline leaves; 3–5 partite, central $2.8\text{--}7 \times 1\text{--}2$ cm, lateral $3.3\text{--}7.5 \times 1\text{--}3.5$ cm, petiole \pm sessile. Inflorescence simple umbel, flowers 75–140, outer flowers of umbel male, central hermaphrodite, pedicels 7–14 mm, occasionally minutely puberulous. Bracteoles conspicuously nerved, green, white or pinkish, 9–12, elliptic to ovate, acute-acuminate, $0.8\text{--}3 \times 0.2\text{--}1$ cm, \pm connate at base, margin entire below, setose-serrulate above. Sepals conspicuous, $1.5\text{--}2.5 \times 0.2\text{--}0.5$ mm, linear-setaceous persistent. Petals pinkish or white, $2\text{--}2.6 \times 0.5\text{--}0.8$ mm. Fruit oblong-cylindrical, $8\text{--}8.5 \times 1.8\text{--}2.5$ mm, mericarps slightly dorsally compressed, primary ridges crested with 1–2 rows of \pm inflated vesicular scales. Dorsal vittae 5, commissural 0. Carpophore absent (Figs. 3–5).

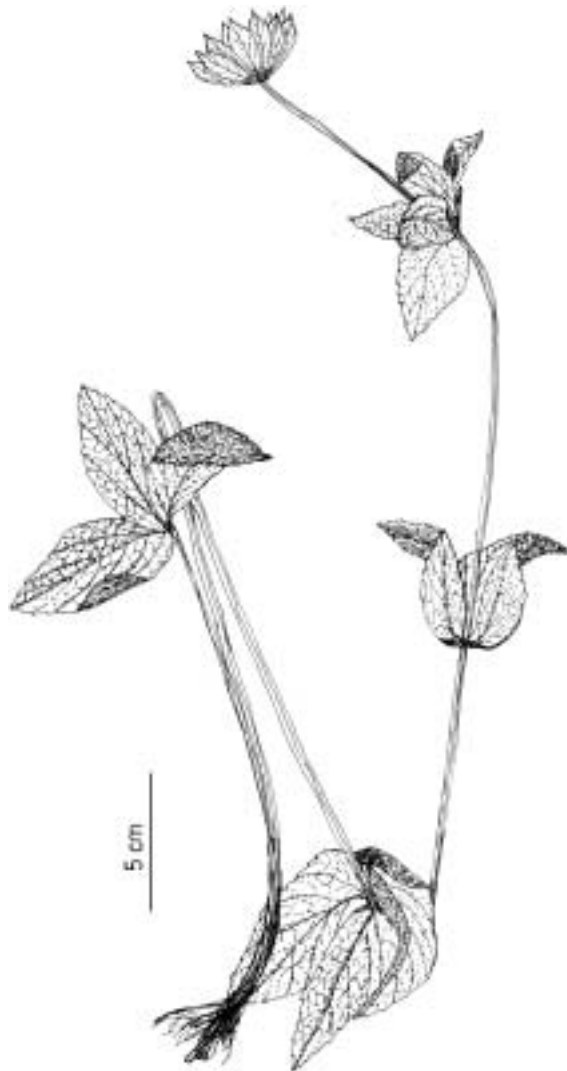


Fig. 2. *Astrantia maxima* subsp. *maxima*, ESSE 2064, habit

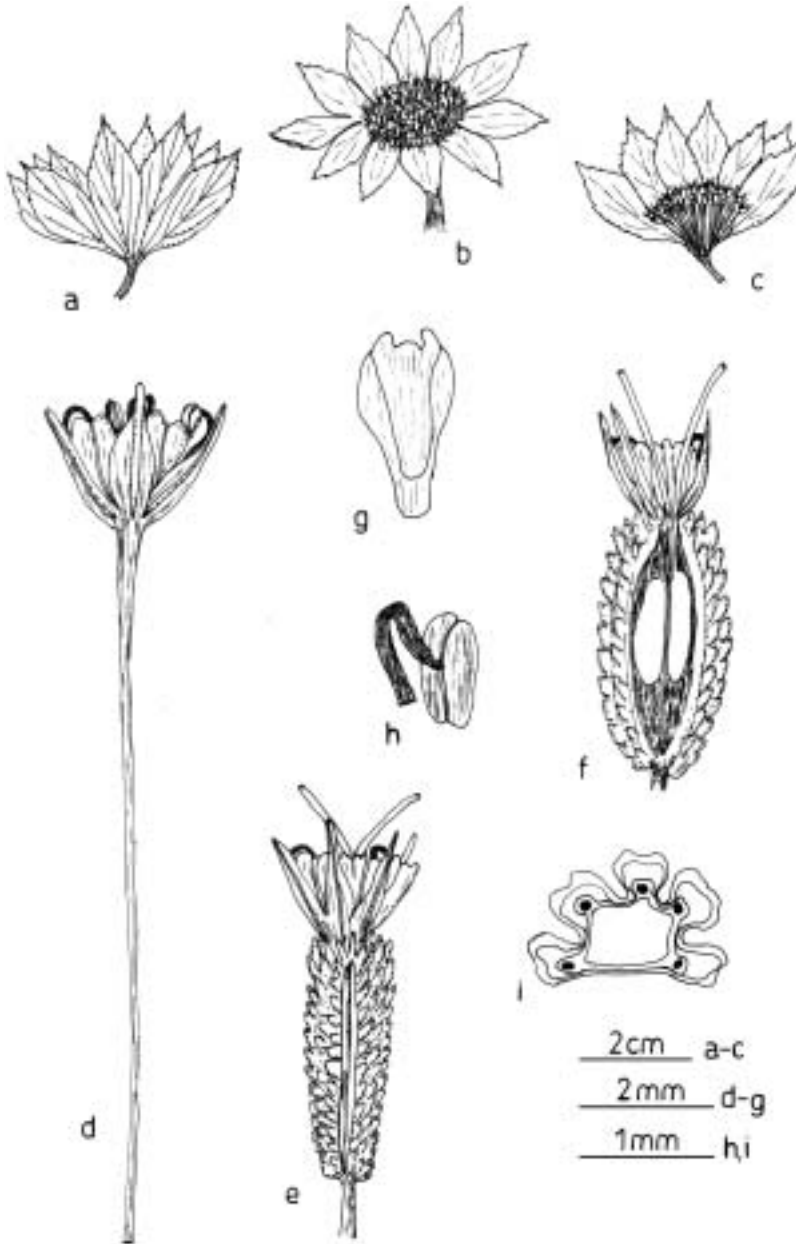


Fig. 3. *Astrantia maxima* subsp. *maxima*, ESSE 2064, a,b-inflorescence, c- inflorescence in vertical section, d-male flower, e-bisexual flower, f- bisexual flower in vertical section, g-petal, h-stamen, i-mericarp cross section

1. Basal leaves 3-partite; flowers $\pm \frac{1}{2}$ length of bracteoles or smaller, bracteoles $1.5-3 \times 0.75-1$ cm, tinged pink, lateral umbels 0-2.

subsp. *maxima*

1. Basal leaves 3-5-partite; flowers at least $\frac{1}{2}$ length of bracteoles or longer (or \pm same level bracteoles), bracteoles $0.8-1.9 \times 0.2-0.8$ cm, tinged white and green, lateral umbels (1-) 3-5.

subsp. *haradjianii*



Fig. 4. *Astrantia maxima* subsp. *haradjianii*, ESSE 12492, habit

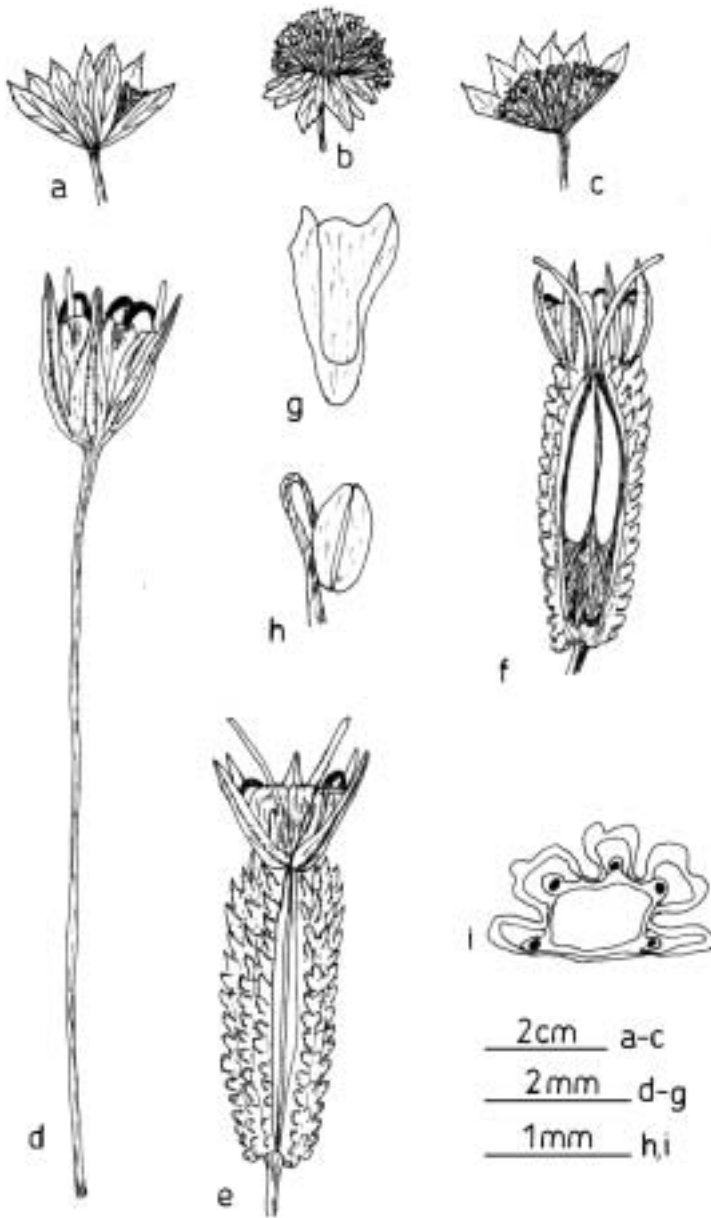


Fig. 5. *Astrantia maxima* subsp. *haradjianii*, ESSE 12492, a, b – inflorescence, c – inflorescence in vertical section, d-male flower, e-bisexual flower, f- bisexual flower in vertical section, g-petal, h-stamen, i-mericarp cross section

Anatomical investigations

Stem: Transverse sections taken from the middle part of the stem and surface preparations were observed as follows;

The stem is almost round, and ribbed. It consists of 8–17 hills and 10–17 hollows in transverse section (Figs. 6, 1 a–b). The epidermis is composed of a single layer of almost square compactly arranged cells in cross section, comprising rectangular shaped cells in surface preparations. The upper surface is generally or partly covered with a thin papillose cuticle. Stomata are observed (Figs. 6, 2 a–b). The collenchyma tissue is located below the epidermis in ribs (hill). The shape of the collenchyma tissue is irregular and 7–10 layered.

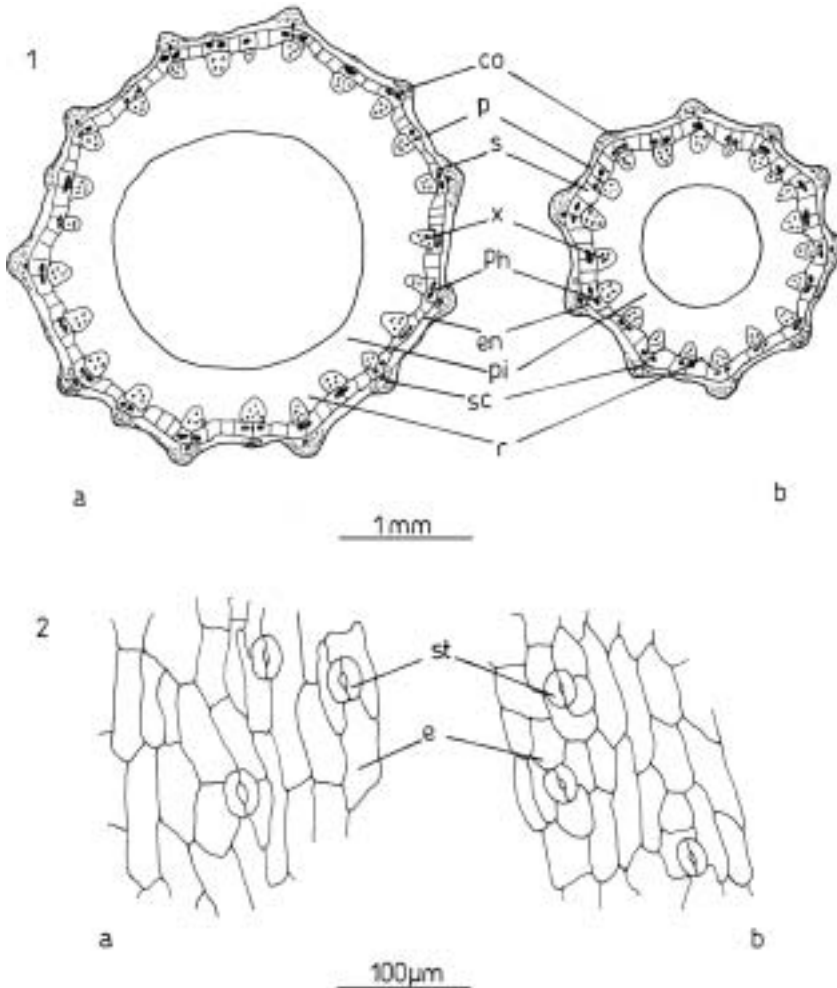


Fig. 6. Stem cross section (schematic): 1a- *Astrantia maxima* subsp. *maxima*, 1b-*A. m.* subsp. *haradjianii* and stem surface preparations: 2a-*A. m.* subsp. *maxima*, 2b-*A. m.* subsp. *haradjianii*: e-epidermis, co-collenchyma, en-endodermis, p-parenchyma, s-sclerenchyma, sc-secretory canal, st- stomata, ph-phloem, x-xylem, r-ray, pi-pith

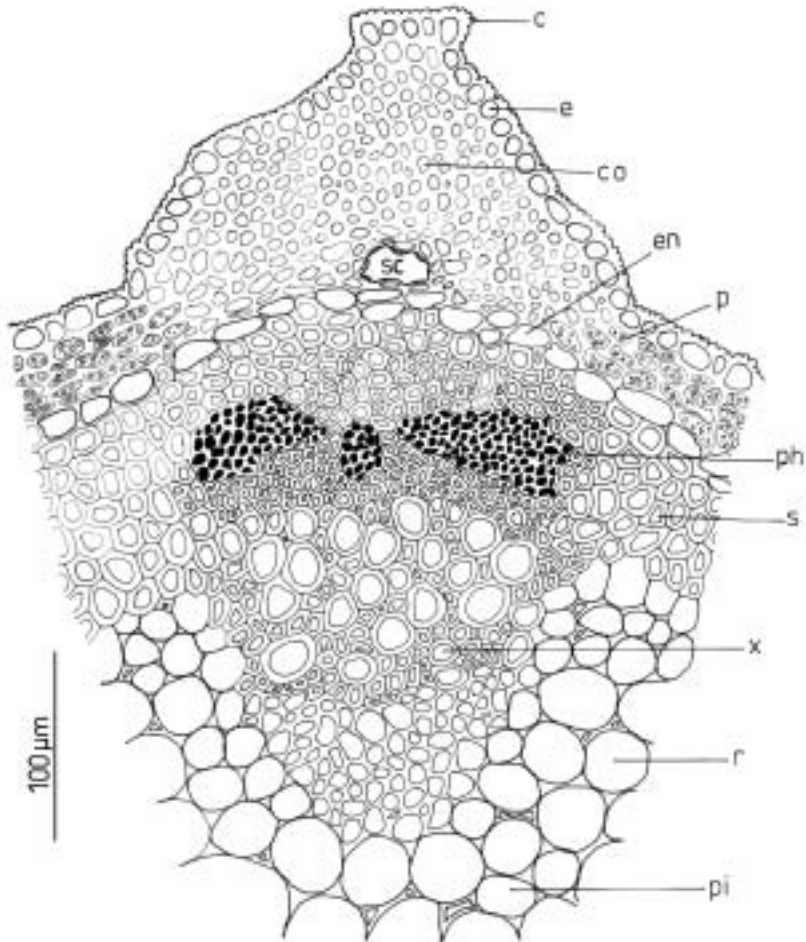


Fig. 7. *Astrantia maxima* subsp. *maxima*, ESSE 2064. Stem cross-section: c-cuticle, e-epidermis, co-collenchyma, en-endodermis, p-parenchyma, s-sclerenchyma, sc-secretory canal, ph-phloem, x-xylem, r-ray, pi-pith

Several layers of collenchyma tissue are also observed between the ribs (hollow) in some preparations. Apart from the collenchyma, the cortex tissue consists of 2–4 layered, usually squashed, chlorenchyma and parenchyma tissue. There are sometimes secretory canals below the collenchyma in the ribs. Single layered endodermis consists of rectangular or ovoid cells. Sclerenchyma tissue is well-developed below the endodermis, forming a ring. Vascular bundles numerous (18–34), arranged in a ring. Phloem and xylem partly separated from one another by sclerenchyma and ground tissue. Phloem is embedded in sclerenchyma tissue as a large group or several narrow groups while xylem is embedded in ground tissue. Xylem consists of vessels and tracheids. Those cells underlying the xylem are narrower and thick walled. All rays are multiseriate, usually 3–9 cells wide. Pith consists of large orbicular or polyhedral parenchymatous cells often with abundant intercellular spaces. The centre of pith is rippled (Figs. 7–8).

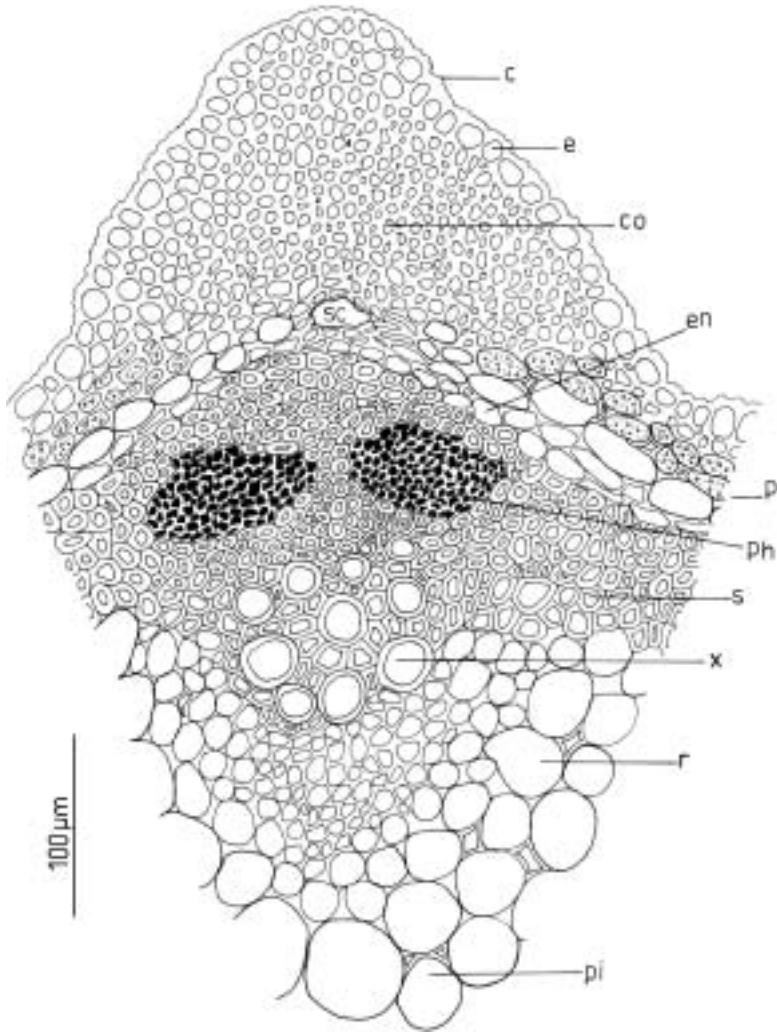


Fig. 8. *Astrantia maxima* subsp. *haradjianii* ESSE 12492. Stem cross-section: c-cuticle, e-epidermis, co-collenchyma, en-endodermis, p-parenchyma, s-sclerenchyma, sc-secretory canal, ph-phloem, x-xylem, r-ray, pi-pith

Leaf: Transverse sections of the lamina and the midrib and surface preparations of both epidermal surfaces revealed the following elements;

In transverse sections (Figs. 9–10), upper and lower epidermis comprise uniseriate square and rectangular cells. Upper walls are usually thicker than lower and lateral walls. Both epidermal surfaces are covered with a thin, rarely papillose cuticle. The lower epidermis is more undulate-walled and smaller than the upper epidermis in the surface preparations. The stomata are usually anomocytic. However, anisocytic stomata are also observed in the same preparations. They only occur on the lower surface of epidermis and they are almost located on the same level with epidermal cells. Leaf is bifacial. Mesophyll is differen-

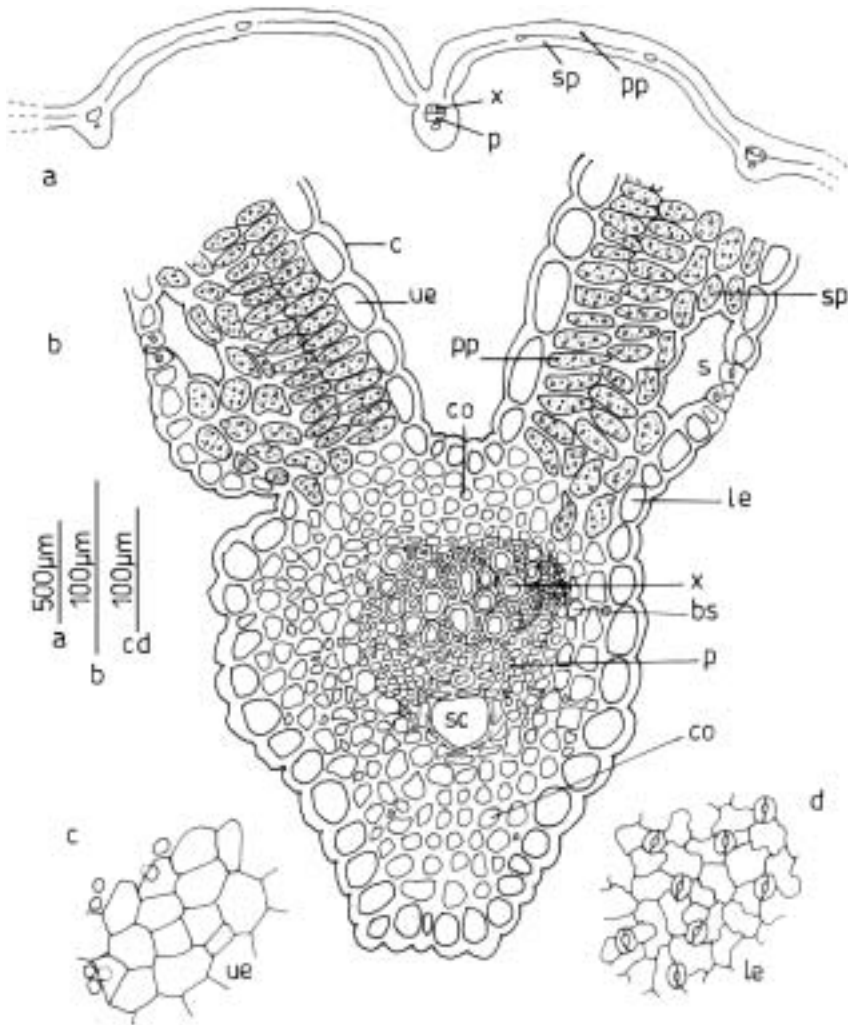


Fig. 9. *Astrantia maxima* subsp. *maxima* ESSE 2064. Leaf cross-section: a-schematic, b-anatomic and surface preparations of leaf epidermis, c-upper, d-lower: c-cuticle, le-lower epidermis, ue-upper epidermis, co-collenchyma, bs-bundle sheath, pp-palisade parenchyma, sp-spongy parenchyma, s-stomata, sc-secretory canal, p-phloem, x-xylem

tiated into 2-seriate palisade and 2-4-seriate spongy tissue. The midrib region forms a projecting part towards the outside. Central vessel is collateral type and less developed. Xylem faces the upper surface as phloem faces the lower epidermis. Vascular bundles are surrounded by a parenchymatous bundle sheath which is sometimes inconspicuous. In the midrib region, the collenchymatous cells are located above and below the vein. Secretory canals are located in below the phloem. There are also several sclerenchymatous cells in the phloem.

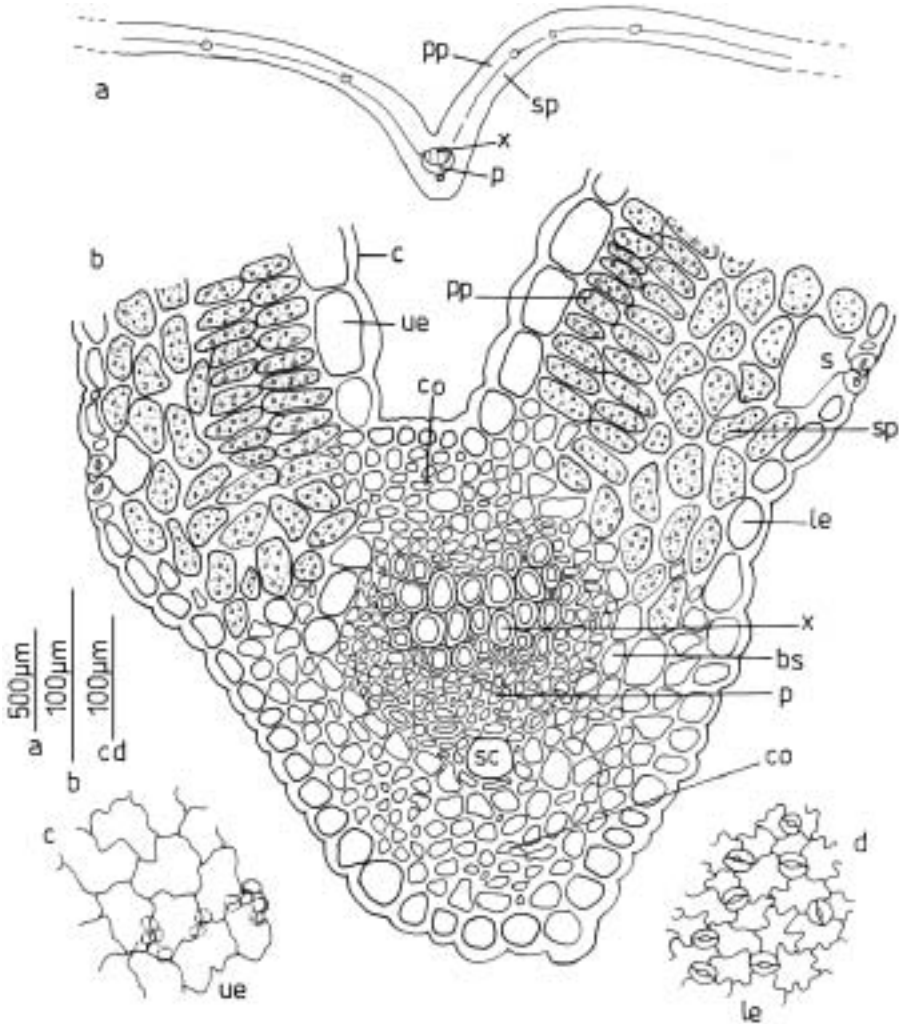


Fig. 10. *Astrantia maxima* subsp. *haradjianii* ESSE 12492. Leaf cross-section: a-schematic, b-anatomic and surface preparations of leaf epidermis, c-upper, d-lower: c-cuticle, le-lower epidermis, ue-upper epidermis, co-collenchyma, bs-bundle sheath, pp-palisade parenchyma, sp-spongy parenchyma, s-stomata, sc-secretory canal, p-phloem, x-xylem

Bracteole: Surface preparations of bracteoles in SEM were observed as follows (Figs. 11–12);

The ventral surface is stellate in the bracteoles of subsp. *maxima*. On the dorsal surface of its numerous characteristic papillate patterns are present. Papillae are rounded. Elongate-papillate patterns are observed on the ventral surface in the bracteoles of subsp. *haradjianii*, but the dorsal surface sculpturing is irregularly tuberculate, with spherical-oval or elongate-oblong shaped.

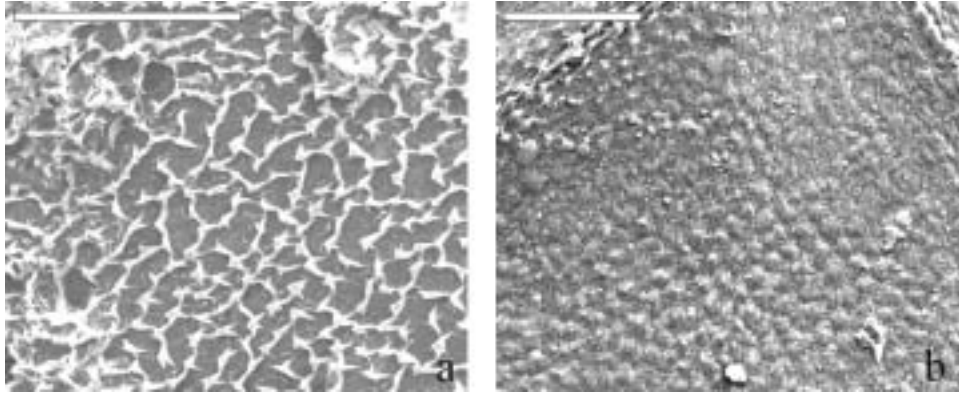


Fig. 11. SEM of bracteole surface in *Astrantia maxima* subsp. *maxima*. a-ventral, b-dorsal. Bars denote 200 μ m.

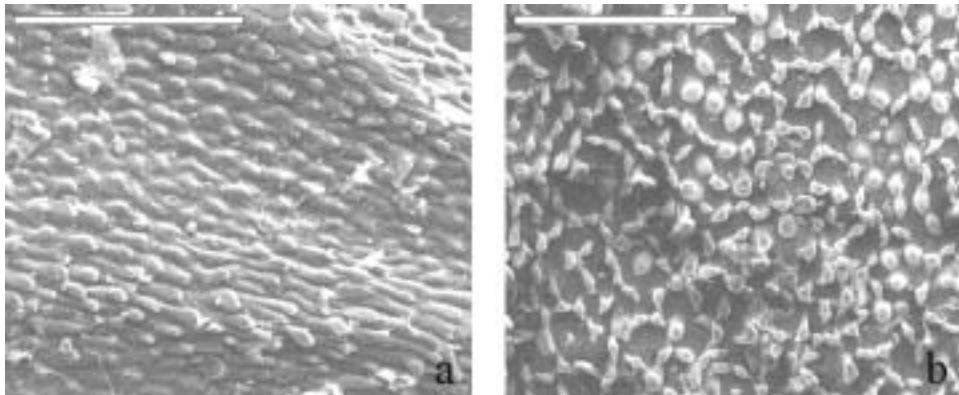


Fig. 12. SEM of bracteole surface in *Astrantia maxima* subsp. *haradjianii*, a-ventral, b-dorsal. Bars denote 200 μ m.

Discussion

Many environmental factors change due to changes in altitude. For instance, daily temperature differences, cloudiness, humidity and effects of wind. On the other hand, evaporation and mean temperature decrease with an altitudinal increase and vegetative phases. All these changes play an important role on the morphological and anatomical characteristics (GÖNÜZ and ÖZÖRGÜCÜ 1999).

Results of the study show that there are some morphological and anatomical variations in *A. maxima*, which is represented by two subspecies (subsp. *maxima* and subsp. *haradjianii*) in Turkey. However, many characters are present in all of them.

A. maxima was summarized in Table 1 according to our morphological observations and the results were compared with the Flora of Turkey.

Tab. 1. A comparison of the distinguishing traits of the subspecies of *A. maxima*

	Subsp. <i>maxima</i> (Euxine Element)	Subsp. <i>haradjianii</i> (Endemic)	Flora of Turkey
Stem length	80–90 cm	44–65 cm	50–90 cm
Stem diameter	3–3.5 mm	1.5–2.5 mm	---
Basal leaves			
Central lobes	3.8–6.1 × 1.6–2.8 cm	3.3–3.8 × 1.2–1.5 cm	2.5–10 × 1.5–5 cm
Lateral lobes	2.8–8.5 × 1–3.5 cm	3.3–4.6 × 1.2–1.5 cm	2.5–11 × 1.5–6.5 cm
Cauline leaves			
Central lobes	3.7–7 × 1–2 cm	2.8–5 × 1–1.7 cm	---
Lateral lobes	4.2–7.5 × 1.4–3.5 cm	3.3–6 × 1–2 cm	---
Bracteoles	1.5–3 × 0.75–1 cm	0.8–1.9 × 0.2–0.8 cm	1.8–3 × 0.7–1.2 cm <i>max</i> 1–1.8 × 0.3–0.8 cm <i>har</i>
Flower numbers	140	75–100	Up to 100
Pedicele	8.5–14 mm	7–11 mm	2–16 mm
Sepal	2.2–2.5 × 0.3–0.5 mm	1.5–2.2 × 0.2–0.4 mm	2–3 mm
Petal	2–2.6 × 0.5–0.8 mm	2.6 × 0.8 mm	1.5–2 mm
Fruit	immature	8–8.5 × 1.8–2.5 mm	5–6 × 2–2.5 mm

According to Table 1 subsp. *maxima* is bigger than subsp. *haradjianii* and our morphological results usually agree with the Flora of Turkey. However; the lengths of basal leaves and pedicel according to the Flora of Turkey are longer than our results while the lengths of petal and fruit in our results are longer than given in the Flora of Turkey. Flowers in subsp. *maxima* are half the length of the bracteoles or smaller; in subsp. *haradjianii* they are half the length of the bracteoles or longer (or ± same level bracteoles). The length of the bracteoles is a significant diagnostic character to distinguish the subspecies and this status is given in the separation key for the subspecies (Figs. 3–5).

The other important difference is observed in the surface shapes of bracteoles. Results clearly show that they are different from each other in the SEM study. (Figs. 11–12).

In the transverse sections of the mericarp no important difference can be observed between the subspecies. Both of them have 5 vittae in the dorsal and 0 in the commissural.

Usual features of Umbelliferae anatomy (METCALFE and CHALK 1965, 712–724) were observed in anatomical studies. The stem is ribbed and composed of hill (rib) and hollow (between the ribs). The number of vascular bundles is different in the stem transverse sections of the subspecies. Subsp. *maxima* has 24–34 vascular bundles which consist of 11–17 hills and 13–17 hollows as subsp. *haradjianii* has 18–27 vascular bundles which are composed of 8–11 hills and 10–16 hollows. The ribs on the stem usually consist of collenchyma. Vascular bundles are arranged in circles and the arrangement of them has diagnostic value. The phloem is wholly embedded in sclerenchyma while the xylem portion of a bundle is embedded in ground tissue. Rays in subsp. *maxima* are 7–8 (–9) cells wide, and (3–) 4–5 (–6) cells wide in subsp. *haradjianii*. The cuticle is conspicuously papillose in the stem of subsp. *maxima*, however the other is inconspicuously papillose or absent. The papillose cuticle is rarely observed in the surrounding of the vascular bundle in the leaf. Secretory canals are usually observed in the stem and leaf.

A. maxima has bifacial type of leaves. The stomata is generally anomocytic. However the anisocytic stomata are also observed in same preparations. The first stomata in young epidermis are recognized of Ranunculaceae type (anomocytic) but, the last ones correspond to the Rubiaceae, Acanthaceae and Cruciferae, respectively (GUYOT 1971). Anisocytic stomata are observed in *Astrantia major* L. in the study of GUYOT (1971). The stomata are sometimes accompanied by variously orientated subsidiary cells according to METCALFE and CHALK (1965). The results clearly show that stomata are only observed on the lower surface and they are of the mesomorph type. The lower epidermis cells in subsp. *maxima* and subsp. *haradjianii* are more undulate than the upper epidermis cells in the leaf surface preparations. In addition, the epidermis cells of subsp. *haradjianii* are more undulate-walled than the other. The bundle sheath is more conspicuous in subsp. *haradjianii* than in the other species.

No important difference is observed between the different localities of the subspecies as morphological and anatomical features.

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