Süleyman Demirel Üniversitesi
Fen Bilimleri Enstitüsü Dergisi
Cilt 28, Sayı 2, 167-176, 2024

Süleyman Demirel University
Journal of Natural and Applied Sciences
Volume 28, Issue 2, 167-176, 2024

DOI: 10.19113/sdufenbed.1307574

# Stem and Leaf Anatomies of Some *Globularia* L. (*Plantaginaceae*) Taxa Grown in Türkiye and Their Systematic Value*

**Serhan Koray ÇİFCİ[1], H. Nurhan BÜYÜKKARTAL[*2], Gençay AKGÜL[3]**

[1] Ankara University Institute of Science and Technology, 06110, Ankara, Türkiye
[2] Ankara University, Faculty of Science, Department of Biology 06100, Ankara, Türkiye
[3] Nevşehir Hacı Bektaş Veli University, Faculty of Arts and Sciences, Department of Biology, Nevşehir, Türkiye

(Alınış / Received: 31.05.2023, Kabul / Accepted: 10.06.2024, Online Yayınlanma / Published Online: 23.08.2024)

**Keywords**
*Globularia* sp.,
Stem anatomy,
Leaf anatomy,
*Plantaginaceae*,
Türkiye

**Abstract:** There are 22 species of the genus *Globularia* L. (*Plantaginaceae*) in the world. This genus is represented by 11 taxa in Flora of Turkey. Five of these 11 taxa are endemic to Türkiye. The aim of this study is to examine stem and leaf anatomy of four taxa of *Globularia* (*Globularia davisiana* O. Schwarz, *G. aphyllantes* Crantz, *G. alypum* L. ve *G. orientalis* L.) in Türkiye. Stem and leaf sections of the taxa were taken with a Leica slide microtome. The anatomical features of plants were examined under a light microscope and their photographs were taken with a Leica DFC 290 digital camera attached to the microscope. According to the study results, the studied taxa has the equifacial leaves and anomocytic type of stomas. The stem and leaves of them have covering secretion trichomes. The related anatomic characters on stem and leaf were discussed and the anatomical features of the species were compared with each other according to these characters.

## Türkiye'de Yetiştirilen Bazı *Globularia* L. (*Plantaginaceae*) Taksonlarının Gövde ve Yaprak Anatomileri ve Sistematik Önemi

**Anahtar Kelimeler**
*Globularia* sp.,
Gövde anatomisi,
Yaprak anatomisi,
*Plantaginaceae*,
Türkiye

**Özet:** *Globularia* L. (*Plantaginaceae*) cinsinin dünyada 22 türü bulunmaktadır. Bu cins Türkiye Florasında 11 taksonla temsil edilmektedir. Bu 11 taksonun 5'i Türkiye'ye endemiktir. Bu çalışmanın amacı Türkiye'de *Globularia*'ya ait dört taksonun (*Globularia davisiana* O. Schwarz, *G. aphyllantes* Crantz, *G. alypum* L. ve *G. orientalis* L.) gövde ve yaprak anatomisini incelemektir. Taksonların gövde ve yaprak kesitleri Leica slayt mikrotomuyla alınmıştır. Bitkilerin anatomik özellikleri ışık mikroskobu altında incelendi ve mikroskoba takılan Leica DFC 290 dijital kamera ile fotoğrafları çekilmiştir. Araştırma sonuçlarına göre, incelenen taksonlar eş yüzlü yapraklara ve anomositik tipte stomalara sahiptir. Bunların gövde ve yapraklarında örtücü salgı trikomları bulunmaktadır. Gövde ve yaprakdaki ilgili karakterler tartışılmış ve türün anatomik özellikleri bu karakterlere göre birbirleriyle karşılaştırılmıştır.

*This article is derived from Serhan Koray ÇİFCI's master's thesis.

## 1. Introduction

The genus *Globularia* L. is a member of the *Plantaginaceae* family. Under the old Cronquist system of plant classification, they were treated in their own family, *Globulariaceae*, but genetic evidence has shown that the genus belongs in the family *Plantaginaceae*, nativeto central and southern Europe, Macaronesia, northwest Africa and southwest Asia (1-8) .

The genus *Globularia* L. (*Plantaginaceae*) is represented by approximately 22 species in the

*Corresponding author: *bkartal@science.ankara.edu.tr*

World. The genus is represented by 11 taxa in the Flora of Türkiye. In Türkiye, some woody species belonging to the genus *Globularia* grow naturally and some of them are endemic [1]. And Türkiye hosts the highest number of *Globularia* taxa after the European continent.

The genus is called "Sphere Flower" and members of the genus are seen in the Mediterranean, Euro Siberian and Irano Turanian phytogeographic region in Türkiye. They spread in temperate regions in Türkiye and are generally found in calcareous lands, slopes and rock piles among stone piles. They are usually small shrubs and evergreen perennial herbs (2-9).

Most genus species are known as globe daisies or globularias. The flowers are produced in dense inflorescences (capitula) held above the stem with numerous tightly packed purple, violet, pink or whiteflowers. Some genus species are used as food plants by the larvae of some Lepidoptera species including *Coleophora virgatella*. Several members of the genus, such as *G. cordifolia* and *G. punctata*, are cultivated and sold for garden use (10).

Some of them are traditionally used as diuretics, laxatives, carminatives and tonics and for the treatment of hemorrhoids (11-12) Various publications on this genus in recent years have revealed that there are some taxa that secrete various chemical compounds (13).

An important part of the information about the stem and leaf anatomical features of *Globularia* taxa was given for the first time by Metcalfe and Chalk [14]. The focus of the researchers was especially glandular hairs. Leaf anatomical features were studied by Kupfender [15] and Heckel [16], and their work was particularly valuable for *Globularia*. Luhan [17], in his study, revealed that the arrangement of idioblasts in the shell of stem cells is in the form of a wall mesh. In addition, the stem structure of *G. salicina* was studied by Carlquist [18].

In today, plant taxonomical studies on leaf and stem anatomies have a very important place in defining systematic relationships. As a result of the literature review, no study was found on the leaf and stem anatomy of *Globularia*'s taxa. The aim of this study is to determine the anatomical characters of the *Globularia* species (*G. davisiana, G. aphyllantes, G. alypum and G. orientalis*) and to contribute to the understanding of their kinship relationships and systematic value.

## 2. Materials and Methods

Plants belonging to *Globularia* genus; *G. davisiana*, *G. aphyllantes*, *G. alypum* and *G. orientalis* taxa (Figure 1A-D) were collected from their natural environments (by Associate Professor Dr. G. Akgül) (Table 1). Photographs were taken during the collection.

Anatomical studies were carried out on the samples kept in alcohol 70%. Similarities and differences between the species were revealed in terms of anatomical features according to the characters related to epidermis, stomata, mesophyll tissue, vascular bundles, leaf thickness and trichome types.

Paraffin method was applied to stem and leaf samples in 70% alcohol [19]. 10-12 µm from stem samples and 8 -10 µm thick sections from the leaf samples were taken with a Leica slide microtome. Leaf and stem sections of the taxa were stained with fast green-safranin [19], and the sections were closed with canadian balsam. The anatomical features of plants were examined under a light microscope and their photographs were taken with a Leica DFC 290 digital camera attached to this microscope.

The hard structure and porosity of the woody stems of *G. davisiana*, *G. alypum*, *G. orientalis* and *G. aphyllantes*, which are in the *Globularia* genus, and the inability to saturate with paraffin sufficiently caused the sections to rupture and fragment. Therefore, hand sections were also taken with a razor blade and stained with 10% safranin. In the studies carried out with the sections taken from the surface, 20 superficial sections were taken manually, separately from both surfaces of 5 randomly selected leaf samples from each species, both upper and lower. Stoma index and stoma index ratios were calculated by determining the number of epidermis and stomata in $mm^2$ on both surfaces of the leaf. Leica Application Suite (LAS) v3.4 program was used in the measurements.

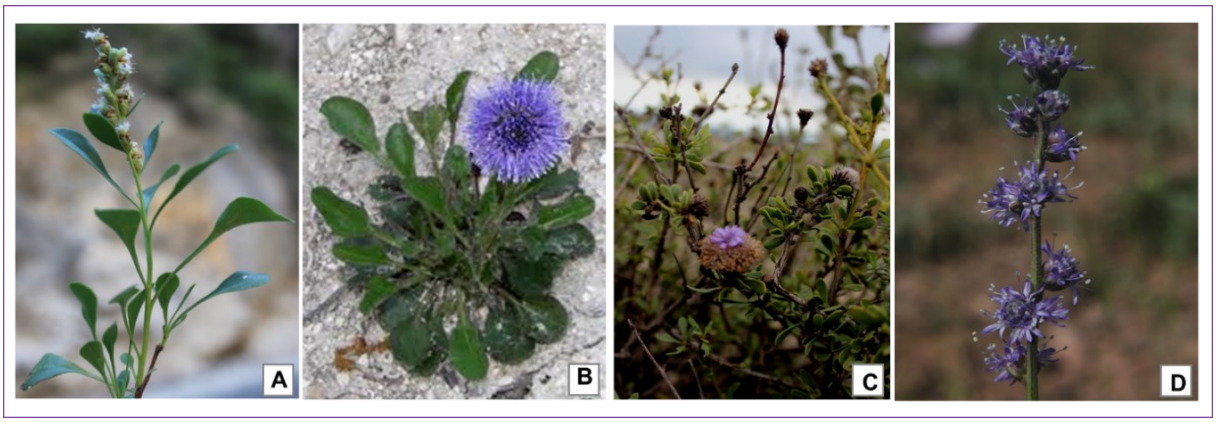


**Figure 1A.** Habitat images of *G. davisiana* **B.** *G. aphyllantes* **C.** *G. alypum* **D.** *G. orientalis* (Photos taken by G. Akgül).

**Table 1.** The localities of *Globularia* taxa.

| Taxon | Locality | Collector |
|---|---|---|
| *G. davisiana* * | Antalya-Kemer | G. Akgül |
| *G. aphyllantes* | İstanbul | |
| *G. alypum* | İzmir: Mordoğan | |
| *G. orientalis* | Nevşehir | |

* Endemic to Türkiye

## 3. Results

### Dicotomic key for the species according to anatomic characters

1.Tracheal elements mostly surrounded by few parenchyma cells and sponge paranchyme contains fewer chloroplast than the palisade
……..***G. aphyllantes***

1. Tracheal elements not as above and sponge paranchyme contains less chloroplast than the palisade

2. Stomatal density greater than 1.***G. Davisiana***

2. Stomatal density less than 1

3. Mesophll thickness 155 µm…..***G. orientalis***

3. Mesophll thickness 83 µm……...***G. alypum***

### 3.1. Leaf and stem anatomical features of *G. davisiana*

In the samples collected from Antalya-Kemer (Table 1), the stem has a secondary structure (Figure 2A). The long rectangular shaped epidermis cells covered with a thick cuticle (Figure 2B). The epidermis has stomata and glandular hairs. In the cortex below the epidermis there are 5-6 rows of cells. The cortex is usually thick-walled and consists of polygon-shaped sclerenchyma cells in groups, with fewer squamous or oval parenchyma cells (Figure 2C). The cambium consists of 2-3 rows of thin-walled cells. Cambial cells are not prominent. The phloem covers a narrower area than the xylem. The stem has a large parenchymatic pith in the center (Figure 2D). The cells are arranged radially on top of each other and are usually rectangular in shape. Although tracheal elements surrounded by parenchyma cells are encountered in the xylem, the majority are sclerenchyma cells (Figure 2E).

The upper and lower epidermal cells are similar to each other (Figure 2F). The stomata are of the mesomorph type (Figure 2G), There are short-stalked peltate glandular hairs on the lower and upper surfaces of the leaves (Figure 2H). The mesophyll consists of sponge parenchyma, which is located irregularly between the two palisade parenchyma. Palisade parenchyma cells are in 4-5 rows. The leaf is isolateral. The cylindrical and long palisade parenchyma contains abundant chloroplasts. Sponge parenchyma occupies less space. It is seen that prominent parenchymatic bundle sheath cells seen in the sponge tissue surround the small vascular bundles arranged in the tissue. The large collateral central vascular bundle is located in the midrib of the leaf (Figure 2I). The average thickness of the mesophyll is 296,851 µm (Table 2).

In the sections taken from the lower and upper surfaces of the leaves, there are epidermal cells with polygonal shape, slightly wavy walls and simple passages that can be easily observed. Amaryllis type stomas are seen in sections taken from the leaf surface (Figure 2J-L). The neighboring cells of the stoma are the same as the epidermal cells and their number varies between 4-5. Stomas are of anamocytic type, with an average of 77,519 on the upper surface and 78,895 on the lower surface in $mm^2$ (Table 2). The leaf is amphistomatic. The average number of epidermis cells on the upper surfaces of the

leaves is 848,708 per mm$^2$, and 887,573 on the lower surface (Table 2). In the section taken from the upper surface of the leaf, it is seen that the palisade parenchyma cells are round and oval in shape (Figure 2K). Chloroplasts are arranged along the cell wall and are dense. Sponge parenchyma cells have more intercellular spaces and contain less chloroplasts than palisade parenchyma (Figure 2M).

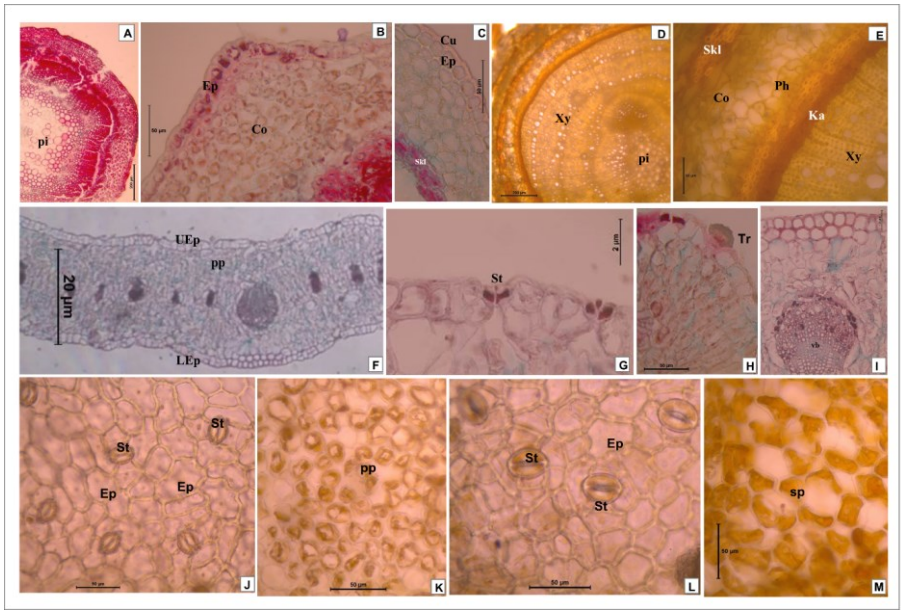


**Figure 2.** *G. davisiana* **A.** Stem in cross section, Bar=200 µm, **B.** epidermal and cortex cells, Bar=50 µm, **C.** scleranchyma cells, Bar=50 µm, **D.** xylem and pith, Bar=200 µm, **E.** cambium, phloem and xylem, Bar=50 µm. **F.** leaf cross-section, Bar= 20 µm **G.** leaf cross-section stomata in epidermis, Bar 2 µm. **H.** leaf peltate glandular hair in epidermis in cross-section, Bar=50 µm. **I.** large vascular bundle (middle vein) in mesophyll tissue in leaf cross-section, Bar=2 µm. **J.** epidermis and stoma in leaf upper tangential section, **K.** palisate parenchyma in upper leaf tangential section, **L.** epidermis and stoma in leaf lower tangential section, **M.** sponge parenchyma in leaf lower tangential section, (J-M) Bars=50 µm.

**Abbreviations :** Ep: Epidermis, Co: Cortex, Cu: Cuticle, Ca: Cambium, Xy: Xylem, Ph: Phloem, Sc: Scleranchyma, St: Stoma, pp: Palisate parenchyma, sp: Sponge parenchyma, LEp: Lower epidermis, UEp: upper epidermis, vb: vascular bundle, Tr: Trichome, pi: Pith.

### 3.2. Leaf and stem anatomical features of *G. aphyllantes*

In the samples collected from Istanbul (Table 1.), the stem is in a secondary structure (Figure 3A). There are 4-6 wing-like protrusions on the stem. A thick cuticle layer covers the rectangular and elongated epidermis cells. Stoma and glandular hairs were occasionally found in the epidermis (Figure 3B-C). There is a cortex with 6-7 cell rows under the epidermis. In the cortex, mostly thick-walled, polygonal shaped sclerenchyma cells are In the transverse section of the leaf, the upper and lower epidermis are similar to each other (Figure 3F). Cells are almost similar in shape and size. The mesophyll consists of sponge parenchyma, which is located irregularly between the two palisade parenchyma. Palisade parenchyma cells are in 4-6 rows. Sponge parenchyma occupies a lesser area (Figure 3G). The average thickness of the mesophyll is 242,389 µm (Table 2). The leaf is equifacial (isolateral). The cylindrical and elongated palisade parenchyma contains abundant chloroplasts. There are a row of parenchymatic bundle sheath cells around the vascular bundle. In the middle mesophyll, there are vascular bundles that appear to be arranged regularly at regular intervals. The bundles are collateral type. Distinct parenchymatic bundle sheath cells surround the small vascular bundles. located in bundles throughout the stem (Figure 3D-E). Phloem is easily distinguished by its thin-walled cells. The phloem consists of thin-walled cells, while the cambium consists of 1-2 rows of thin-walled cells. The xylem covers a larger area than the phloem. Cambial cells are not prominent. The xylem also contains tracheal elements, mostly surrounded by few parenchyma cells (Figure 3E). It is seen that the stem occupies a large space in the center and the pith is parenchymatic (See Figure 3D).

The large collateral central vascular bundle is located in the midrib of the leaf (Figure 3H).

In the upper and lower superficial sections of the leaves, there are polygonal epidermal cells with slightly wavy walls. The stomata seen in the sections taken from the leaf surface are of the amaryllis type (Figure 3I-K). The neighboring cells of the stoma are the same as the epidermis cells and their number varies between 4 and 5. Stomas are of anamocytic type, with an average of 118,343 on the upper surface and 157,790 on the lower surface in mm$^2$ (Table 2). The leaf is amphistomatic. The average number of epidermis cells on the upper surfaces of the leaves is 111,111 per mm$^2$, and 143,459 on the lower surface (Table 2). In the section taken from the upper surface of the leaf, the part with oval and round shaped cells represents the palisade parenchyma (Figure 3J). They have dense chloroplasts arranged along the cell wall. Sponge parenchyma cells contain fewer chloroplasts than the palisade (Figure 3L).

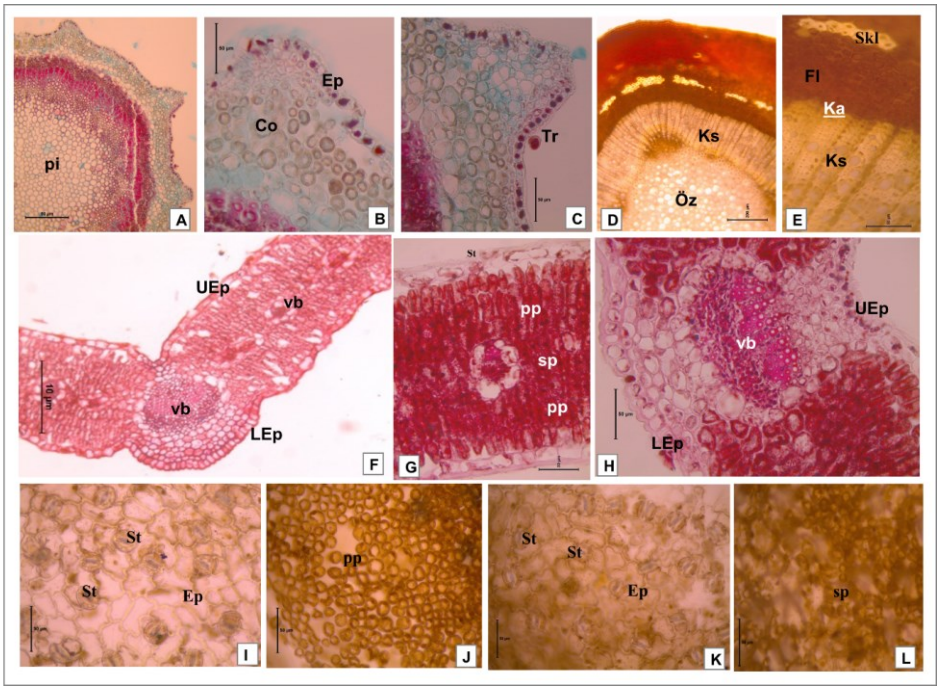


**Figure 3.** *G. aphyllantes* **A.** Stem in cross section, Bar=50 µm, B and **C.** Protrusion regions and cortex cells on stem, Bar=50 µm, **D.** Scleranchyma cells and pith region, Bar=200 µm, **E.** Xylem, Phloem and cambium, Bar=50 µm, **F.** Leaf cross-section, Bar= 10 µm **G.** Mesophilic tissue in leaf cross-section, Bar=50 µm. **H.** Large vascular bundle (middle vein) in mesophyll tissue in leaf cross-section, Bar=50 µm. **I.** Epidermis and stoma in upper leaf tangential section, **J.** Palisade parenchyma in upper leaf tangential section, **K.** Epidermis and stoma in leaf lower tangential section, **L.** Sponge parenchyma in leaf lower tangential section, (I-L) Bars=50 µm.

### 3.3. Leaf and stem anatomical features of *G. alypum*

In the samples collected from İzmir-Mordoğan (Table 1), the stem is in a secondary structure (Figure 4A). There are 4-6 wing-shaped projections on the stem (Figure 4A-E). There is a thick cuticle layer on the long rectangular epidermis cells. The stem has a large parenchymatic pith in the center (Figure 4A-D). There is a cortex with 6-7 cell rows under the epidermis. In the cortex, mostly thick-walled, polygonal shaped sclerenchyma cells are located in bundles throughout the body (Figure 4F). Phloem is composed of thin-walled cells. It is striking that the cells form a radial shape by stacking them on top of each other. The cells forming the cambium appear to have 1-2 rows of thin-walled structures. The area occupied by the phloem is much narrower than the area of the xylem. There is no distinct cambium. In the xylem, a large number of sclerenchyma and a small number of tracheal elements between parenchyma cells are seen (Figure 4G).

In the cross-section of the leaf, the lower and upper epidermis cells are similar (Figure 4H). Mesomorph type stoma is seen on the both surface. The average thickness of the mesophyll is 82,796 µm (Table 2).

The mesophyll consists of sponge parenchyma, which is located irregularly between the two palisade parenchyma. Palisade parenchyma cells are in 4-5 rows (Figure 4H). The leaf is isolateral. The long cylindrical palisade parenchyma contains abundant chloroplasts. Sponge parenchyma occupies less space (Figure 4I). There are short-stalked peltate glandular hairs on the lower and upper surfaces of the leaves (Figure 4.J-K). Bunch sheath cells surrounding the vascular bundles are seen in the sponge tissue. Vascular bundles are seen in the midrib of the leaf (Figure 4L)

In the sections taken from the upper and lower surfaces of the leaves, there are epidermal cells with polygonal shape, slightly wavy walls, and simple passages can be observed. The stomata seen in the sections taken from the leaf surface are of the amaryllis type (Figure 4M-O). The neighboring cells of the stoma are the same as the epidermal cells and their number varies between 4 and 5. The stomata are of anamocytic type, with an average of 157,790 on the upper surface and 198,807 on the lower surface per $mm^2$ (Table 2) The leaves are amphistomatic.

The average number of epidermis cells on the upper surfaces of the leaves is 1527,272 per $mm^2$, and 710,059 on the lower surface (Table 2). In the section taken from the upper surface of the leaf, it was observed that the palisade parenchyma cells were round and oval shaped. (Figure 4N). There are dense chloroplasts lined up along the cell walls. Sponge parenchyma chloroplast amount is less than the palisade (Figure 4P).

### 3.4. Leaf and stem anatomical features of *G. orientalis*

In the samples collected from Nevşehir (Table 1), the stem is in a secondary structure (Figure 5A-B). Epidermal cells have a thick cuticle layer (Figure 5C). There is a cortex with 6-7 cell rows under the epidermis. In the cortex, mostly thick-walled, polygonal sclerenchyma cells are located in bundles throughout the stem (Figure 5D). Phloem is composed of thin-walled cells similar to other species. Cells are mostly rectangular in shape. Tracheal elements can be observed in the xylem, surrounded by a few parenchyma cells, mostly sclerenchyma (Figure 5E). The stem has a large and parenchymatic pith in the center.

In the cross section of the leaf, the upper and lower epidermal cells are similar (Figure 5F). Mesomorph type stoma is present. The mesophyll consists of sponge parenchyma, which is located irregularly between the two palisade parenchyma. Palisade parenchyma cells are in 4-5 rows. The leaf is isolateral. Vascular bundles can be observed in the leaf mesophyll (Figure 5G).

The epidermis cells seen in the sections taken from the upper and lower surfaces of the leaf have a polygonal shape and slightly wavy walls. Amaryllis type stomata are seen in leaf superficial sections (Figure 5H-J). The neighboring cells of the stoma are the same as the epidermis cells and their number varies between 4-5. Stomas are of anamocytic type, with an average of 109,890 on the upper surface and 177,514 on the lower surface in $mm^2$ (Table 2).

The leaf is amphistomatic. The average number of epidermis cells on the upper surfaces of the leaves is 1276,595 per $mm^2$, and 1005,917 on the lower surface (Table 2). In the section taken from the upper surface of the leaf, oval-shaped and rounded palisade parenchyma cells are observed (Figure 5I). Chloroplasts are dense and arranged along the cell wall. Sponge parenchyma contains less chloroplasts than the palisade (Figure 5K). The average thickness of the mesophyll is 155,443 μm (Table 2).

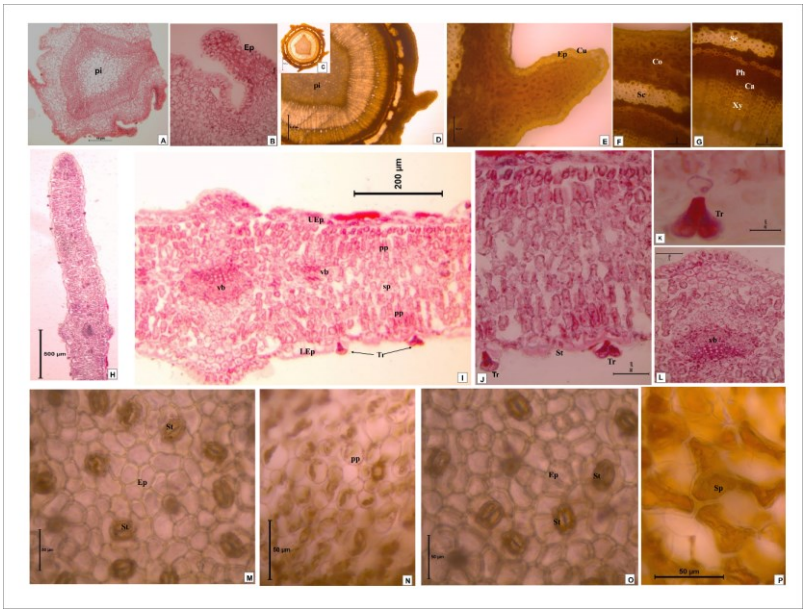

**Figure 4.** *G. alypum* **A-B.** Stem in cross section, (A) Bar=10 µm, (B) Bar=2 µm, **C-D.** Pith region on stem, (C) Bar=500 µm, (D) Bar=200 µm, **E.** Protruding wings on stem Bar=50 µm, **F.** Sclerenchyma cells, Bar=50 µm, **G.** Xylem, phloem and cambium, Bar=50 µm, **H.** leaf cross-section, Bar=500 µm **I.** Leaf cross-section, mesophyll tissue, Bar=200 µm. **J.** Leaf peltate glandular hair in cross-section, Bar=50 µm. Enlarged form of **K.** peltate glandular tricome. Bar=20 µm. **L.** Large vascular bundle (middle vein) in mesophyll tissue in leaf cross-section, Bar=50 µm. **M.** Epidermis and stoma in leaf upper tangential section, **N.** Palisade parenchyma in upper leaf tangential section, **O.** Epidermis and stoma in leaf lower tangential section, **P.** Sponge parenchyma in leaf lower tangential section, (M-P) Bars=50 µm.

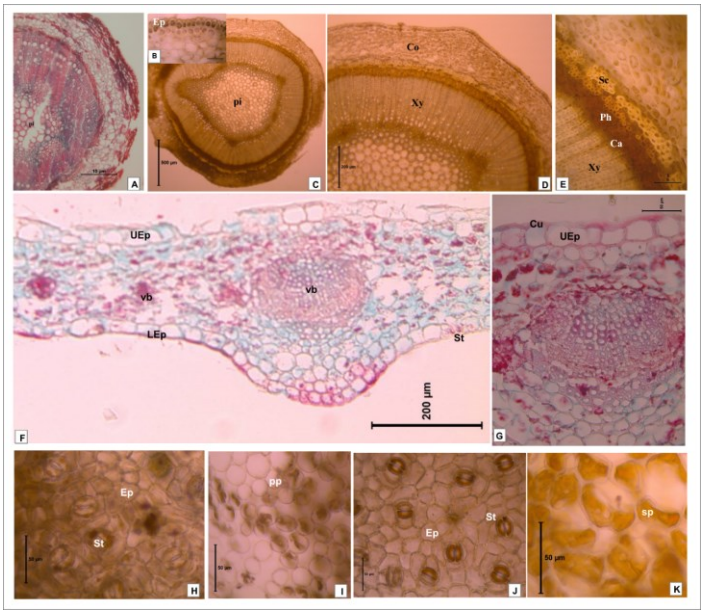

**Figure 5.** *G. orientalis* **A-B.** Stem in cross section, (A), Bar=10 µm, (B), Bar=50 µm, **C.** Epidermis cells in stem, Bar=500 µm, **D.** Cortex and pith, Bar=200 µm, **E.** Xylem, phloem and cambium, Bar=50 µm, **F.** Leaf cross-section Bar=200 µm **G.** Large vascular bundle (middle vein) in mesophyll tissue in leaf cross-section. Bar=50 µm. **H.** Epidermis and stomata in leaf upper tangential section. **I.** Palisade parenchyma on leaf upper tangential section **J.** Epidermis and stoma on leaf lower tangential section **K.** Sponge parenchyma on leaf lower tangential section. (M-K) Bars=50 µm.

**Table 2.** Mesophyll thickness, stoma in mm², epidermis numbers and stoma index, stomatal density in *Globularia* taxa.

| Taxa names | mesophyll Thickness (µm) | Section Surface | Number of Stoma (piece/mm²) | Epidermal cells (piece/mm²) | stomatal index | stomatal density |
|---|---|---|---|---|---|---|
| ***G. davisiana*** | 296.851 | Upper surface | 77,519 | 848,708 | 0,0836 | 1,0245 |
| | | Lower surface | 78,895 | 887,573 | 0,0816 | |
| ***G. aphyllantes*** | 242.389 | Upper surface | 118,343 | 111,111 | 0,5157 | 0,9849 |
| | | Lower surface | 157,790 | 143,459 | 0,5236 | |
| ***G. alypum*** | 82.796 | Upper surface | 157,790 | 1527,272 | 0,0936 | 0,4279 |
| | | Lower surface | 198,807 | 710,059 | 0,2187 | |
| ***G. orientalis*** | 155.443 | Upper surface | 109,890 | 1276,595 | 0,0792 | 0,5283 |
| | | Lower surface | 177,514 | 1005,917 | 0,1499 | |

## 4. Discussion and Conclusion

In this study, stem and leaf anatomies of some *Globularia* L. (*Plantaginaceae*) species distributed in Türkiye were examined for the first time and discussed. The epidermis, stomata, mesophyll tissue, vascular bundles, leaf thicknesses and tricome types of four species (*G. davisiana*, *G. aphyllantes*, *G. alypum* and *G. orientalis*) belonging to the genus *Globularia* were investigated anatomically. According to the results of this study, it was seen that these four species belonging to the genus *Globularia* showed some similarities and differences in terms of leaf and stem anatomies.

In all of the four species examined, it was observed that the epidermis cells were usuallly similar to each other in the cross-sections of the stem and were single-row and rectangular in shape.

Although there are winged protrusions on the stems of *G. aphyllantes* and *G. alypum*, no such protrusions were found in *G. davisiana* and *G. orientalis*.

An important part of the information about the stem and leaf anatomical features of *Globularia*

In the upper and lower superficial sections of the leaves of the four species belonging to the genus

taxa was given for the first time by Metcalfe and Chalk [14]. The focus of the researchers was especially the glandular hairs. Leaf anatomical features were studied by Kupfender [15] and Heckel [16], and their work was particularly valuable for *Globularia*. Luhan [17], in his study, revealed that the arrangement of idioblasts in the shell of stem cells is in the form of a wall mesh. In addition, the stem structure of *G. salicana* was studied by Carlquist [18]. Carlquist's s work is stated *Globulariaceae* proved to have distinctive wood anatomy. In leaf, small glandular hairs with a short stalk cell and a head of two or four cells in one plane are characteristic. Branched sclerenchymatous idioblasts are known from the mesophyll of *G. orientalis*. The structure of the principal vein has been used as a systematic character. The fascicle is either connected to the epidermis on both sides by collenchyma, or it is surrounded by mesophyll (15, 16).

In this study, in leaf cross-section, vascular bundles are collateral type in all the species and the phloem surrounds the xylem. In the conduction bundles, the sclerenchyma has the appearance of an arc. There are covering glandular hairs in all the species. In terms of leaf thickness, *G. davisiana* and *G. alypum* have the smallest value (See Table 2).

*Globularia*, the epidermis cells are slightly wavy-walled or polygonal.

In *G. alypum*, the number of epidermis cells per $mm^2$ on the upper surface was higher than the lower surface, while in other species, the number of epidermis cells per $mm^2$ on the lower surface was higher than the upper surface (See Table 2).

Anatomically, the leaves have some similarities. The leaves of all the taxa have amphistomatic type. It was determined that there were amaryllis type stomata in the species examined, and it was explained that it could be anomocytic type depending on the condition of its neighboring cells. All the taxa have equifacial (isolateral) type leaves.

The taxa are divided into two main groups according to the dichotomic key obtained in the study according to anatomical characters of the stem and leaves. The number of chloroplasts in the sponge parenchyma of *G. davisiana, G. orientalis* and *G. alypum* in the first group is less compared to the palisade, and few in *G. aphyllanthes* in the second group. Three species (*G. davisiana, G. orientalis, G. alypum*) in the first group differ from each other according to stomatal density and mesophyll thickness. This separation and grouping according to the anatomical characters is compatible with the forked key formed according to the morphological characters in the flora of Türkiye [2]. These results show that anatomical characters can be used as well as morphological characters in the differentiation of the species.

In addition, anatomical studies on the species in which *Globularia* taxa are represented, especially in Türkiye, will be very important in defining the differences and similarities between species. It will be useful to understanding the kinship situations in the classification.

It is expected that this study will benefit the future studies especially on this genus and will constitute a source quality.

In conculuation, the data obtained from this study will contribute to better recognition of the genus *Globularia*, to reveal the ancestral characteristics of the species, and thus to the systematics of the genus. An also, this study will create important data for systematic botany and close branches.

**Declaration of Ethical Code**

*In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.*

**References**


[1] Akgül, G., Tunçkol, B. 2018. *Globularia* L. (*Plantaginaceae*) Türkiye'nin Doğal-Egzotik Ağaç ve Çalıları. Orman Genel Müdürlüğü Yayınları, Ankara s:450-452.

[2] Davis, P.H. (ed). 1988. Flora Of Türkiye and The Aegean Islands Suplement II. University Press, Edinburgh.

[3] Güner, A., Özhatay, N., Ekim, T. and Başer K.H.C. 2000. Flora of Türkiye, Volume 11, Edinburgh University Press, Edinburgh.

[4] Duman, H. 2001. A new species of *Globularia* L. (*Globularia*ceae) from South Anatolia. Botanical Journal of Lınnean Society 425-428.

[5] Duran, A., Çetin, Ö. and Öztürk, M., 2009. *Globularia* anatolica sp. nov. (*Globularia*ceae) from the Honaz Mountain National Park, southwest Türkiye. Nordic Journal of Botany 27: 232-237.

[6] Akgül, G. Kılıçkaya, N. 2019. Türkiye florası için yeni bir varyete, *Globularia orientalis* L. var. *nevshehirensis* Akgül, The herb Journal of Systematic Botany (OT Sistematik Botanik Dergisi) 26, (2): 33-38.

[7] Wagenitz, G. 2004. *Globularia*ceae-In: Kubitzki, K.(ed), The families and genera of vascular plants, Springer, Vol. 7, 159-162.

[8] Cronquist, A. 1968-1988. The evolution and classification of flowering plants (2nd ed.). Bronx, NY: New York Botanical Garden.

[9] Davis, P.H. (ed). 1982. Flora of Türkiye and The Aegean Islands, vol, 7. p. 27, University Press, Edinburgh.

[10] https://en.wikipedia.org/wiki/Globularia

[11] Baytop, T. "Therapy with medicinal plants in Türkiye (past and present)" No. 3255, p. 419, Istanbul University Publications, İstanbul (1984).

[12] E. Sezik, M. Tabata, E. Yesilada, G. Honda, K. Goto and Y. Ikeshiro, J. Ethnopharm., 35, 191-196 (1991).

[13] Kırmızıbekmez, H. 2002. *Globularia* tohumları üzerinde formakognozik

çalışmalar, H.Ü., Sağlık Bilimleri Enst., Doktora Tezi.

[14] Metcalfe, C.R. ve Chalk, L. 1950. Anatomy of Dicotiledons, Oxford University Press.

[15] Kupffender, H. 1981. Beitrage Zur Anatomie der *Globularia*ceen und Selaginaceen und Kenntnis des Blattcambiums, Diss. Phill. Kiel, Univ. Erlangen.

[16] Heckel, E. 1984. Etude monographique de la famille des *Globularia*cees au point de vue botanique, chimique et therapeutique. Paris, Annales de la Faculte des Sciences, Marseille Suppl 3.

[17] Luhan, M. 1954. Übes Das Vorkommen von Sklerenchym- İdioblasten bei *Globularia*- Arten. Berichte der Deutschen Botanichen Gesellschaft, 67, 346- 355.

[18] Carlquist, S. 1992. Wood anatomy of sympetalous dicotyledon families: a summary: with comments on systematic relationships and evolution of the woody habit. Annals of the Missouri Botanical. Garden, 79, 303-332.

[19] Algan, G. 1981. Bitkisel dokular için mikroteknik. Fırat Üniversitesi Fen Fakültesi Yayınları. Bot. No:1, Matbaa Teknisyenleri Basımevi, İstanbul.