**Bartın Orman Fakültesi Dergisi** | Journal of Bartin Faculty of Forestry
2024, 26(1): 110 – 118 | DOI: 10.24011/barofd.1379079

# Wood Anatomical Characteristics of Felty Germander (*Teucrium polium* L. subsp. *polium*) in Two Different Habitats

Esra PULAT[1*], Avni YILDIZBAŞ[2], Barbaros YAMAN[3]

[1*, 3] Bartin University, Faculty of Forestry, Department of Forest Engineering, Bartın, Türkiye
[2] Bartin University, Faculty of Forestry, Department of Forest Industrial Engineering, Bartın, Türkiye

**Article History**
*Received:* 26.10.2023
*Accepted:* 21.02.2024
*Published:* 29.02.2024

***Research Article***

**Abstract** − Ecological wood anatomy is a significant discipline that elucidates the impacts of growth environment conditions on wood formation. By thoroughly examining the relationships between the anatomical features of wood and ecological conditions, the adaptation of taxa to their habitat can be evaluated using certain anatomical characteristics. This study focused on the wood anatomical features of *Teucrium polium* L. (felty germander), a species belonging to the Lamiaceae family, which has a widespread distribution in Africa, Northern Europe, Southwest Asia, and also in Türkiye. Wood samples were collected from two different habitats in Türkiye to assess the adaptation of *T. polium* to its environment. *T. polium* has a semi-ring porous wood. In individuals growing in coastal sand dunes, the radial diameters of vessels in the wide diameter class and both tangential and radial diameters in the narrow diameter class were significantly wider than those growing in the interior. However, the tangential diameters of vessels in the wide diameter class did not show a significant difference between the two habitats. The vessel grouping index in samples from the interior was 41.3% higher compared to those from coastal sand dunes. Xeromorphic values of *T. polium* showed no significant difference between the two different habitats. Individuals growing in coastal sand dunes exhibited heterogeneous structures in the root collar bark, with secretory cavities composed of 6-7 rows of epithelial cells. In contrast, individuals from the interior showed no evidence of secretory cavities.

***Keywords*** − *Ecological wood anatomy, Teucrium polium, secretory cavities, Bartın, Türkiye*

# Acıyavşan'ın (*Teucrium polium* L. subsp. *polium*) Iki Farklı Yetişme Ortamında Odun Anatomisi Özellikleri

[1,*, 3] Bartın Üniversitesi, Orman Fakültesi, Orman Mühendisliği Bölümü, Bartın, Türkiye
[2] Bartın Üniversitesi, Orman Fakültesi, Orman Endüstri Mühendisliği Bölümü, Bartın, Türkiye

**Makale Tarihçesi**
*Gönderim:* 26.10.2023
*Kabul:* 21.02.2024
*Yayım:* 29.02.2024

***Araştırma Makalesi***

**Öz** − Ekolojik odun anatomisi, yetişme ortamı koşullarının odun oluşumu üzerindeki etkilerini ortaya koyan önemli bir disiplindir. Odunun anatomik özellikleri ile ekolojik koşullar arasındaki ilişkileri detaylı inceleyerek bazı anatomik özellikler yardımıyla taksonların bulundukları habitata adaptasyonları değerlendirilebilir. Dünyadaki yayılışını Afrika, Kuzey Avrupa ve Güney Batı Asya'da yapan ve Türkiye'de de genel yayılış gösteren Lamiaceae familyasından *Teucrium* L. cinsine ait *Teucrium polium* L. (acıyavşan) türünün odun anatomik özellikleri iki farklı yetişme ortamından alınan örneklerde incelenmiştir. *T. polium* yarı-halkalı traheli bir odun yapısına sahiptir. Kıyı kumul alanlarında yetişen bireylerde geniş çaplı sınıfta trahe radyal çapları, dar çaplı sınıfta da hem trahe teğet hem de trahe radyal çapları iç kesimde yetişenlere göre anlamlı biçimde daha geniştir. Geniş çaplı sınıftaki trahelerin teğet çapları ise her iki yetişme ortamında anlamlı bir fark göstermemektedir. İç kesime ait örneklerde trahe gruplaşma indeksi kıyı kumul ortamına kıyasla %41.3 daha yüksektir. İncelenen *T. polium* L. türünün iki farklı yetişme ortamındaki kseromorfi değerleri arasında anlamlı bir fark olmadığı belirlenmiştir. Kıyı kumullarında yetişen bireylerde, kök boğazı kabuk kısmında heterojen yapı ve büyüklükte 6-7 sıra epitel hücrelerinden oluşan salgı cepleri tespit edilmesine karşın, iç kesimlerdeki bireylerin hiçbirinde salgı cebine rastlanmamıştır.

***Anahtar Kelimeler*** − *Ekolojik odun anatomisi, Teucrium polium, salgı cebi, Bartın, Türkiye*

[1] esraozkanpulat@gmail.com
[2] avniyildizbas@gmail.com
[3] yamanbar@gmail.com
*Corresponding Author / Sorumlu Yazar: Esra PULAT

## 1. Introduction

Türkiye is a major gene center of the Lamiaceae family, representing by 245 genera and 7886 taxa worldwide. The family of Lamiaceae, known as the mint family or mostly Labiatae, is in position in the third most opulent family in terms of endemism, with a rate of 44.2% at Türkiye (Baser, 1993; Kocabaş and Karaman, 2001; Özcan, 2015). The Lamiaceae family is divided into seven subfamilies: Symphorematoideae Briq., Viticoideae Briq., Ajugoideae Kostel., Prostantheroideae Luerss., Nepetoideae Kostel., Scutellarioideae Caruel and Lamioideae Harley. *Teucrium* L. is the genus containing the most taxa in the Ajugoideae subfamily (Harley et al., 2004). It is a well-known genus, one of the largest genera, with 280 species distributed worldwide (Ecevit-Genç et al., 2018; Harley et al., 2004, WFO plant list, 2023).

*Teucrium* is a polymorphic genus that grows widely in the temperate regions of Europe, North Africa, and Asia (Dinç et al., 2011). *Teucrium* species are grouped into ten sections according to their calyx shape and flowering structure. These sections contain *Teucrium* species; *Teucriopsis* Benth., *Teucrium*, *Chamaedrys* (Miller) Schreber, *Polium* (Miller) Schreber, *Isotriodon* Boissier, *Pycnobotrys* Bentham, *Scorodonia* (Hill) Schreber, *Stachyobotrys* Bentham, *Scordium* Reichenbach, *Spinularia* Boissier. *Teucriopsis* and *Pycnobotrys* are not distributed in Türkiye (Ecevit-Genç et al., 2018). The eight sections of the genus distributed in Türkiye consist of 49 taxa (36 species), 18 of which are endemic and grow naturally in Türkiye (Güner, 2012; Ecevit-Genç et al., 2018; WFO plant list, 2023). *Teucrium polium* L. (felty germander), located in the *Polium* section, is distributed in Africa, Northern Europe, and Southwestern Asia throughout the world and has a general distribution in Türkiye (Özcan, 2015; Royal Botanic Garden KEW, 2023).

In a study conducted in Montenegro and Serbia, morpho-anatomical analysis results showed that *T. polium* is a xerophyte species with a distinctive evergreen, microphyllous semi-shrub-like, and xeromorphic structure. In the stem transverse section, the stem shape of *T. polium* is round and has a hypodermis consisting of 2-3 rows. The central cylinder is not evident. The pericycle is made up of bundles of sclerenchymatic elements and small parenchymal cell groups, and the vascular elements are positioned in the form of a central cylinder (Lakušić et al., 2010). In the stem, the epidermis, consisting of a single layer, comprises rectangular to oval cells and is surrounded by a cuticle layer (Dinç et al. 2011). The collenchyma consists of 6-7 cell rows at the corners of the stem and a single cell row between the corners. The cortex parenchyma consisting of 4-5 rows is observed, and its cells are flattened and rectangular. The endodermis is distinct and consists of 1-2 rows of rectangular cells. A pericycle composed of 1-3 layers of sclerenchymatous cells surrounding the vascular tissue presents between the endodermis and phloem. The cambium is indistinct. The xylem consists of vessel elements and tracheids. Additionally, there are uni- and bi-seriate rays (Dinç et al., 2011), and the rays have axially elongated cells and non-lignified structures (Schweingruber et al., 2013).

The anatomical properties of wood are affected by environmental factors such as temperature, light intensity, water, nutrients in the soil, gravity, photoperiod, climate period, wind, and frost. Divergent ecological conditions predominantly exert varying effects on water-conducting cells (tracheids and vessels), as well as several other wood anatomical attributes (Yaman, 2008). Within the framework of ecological wood anatomy, this study aims to determine the differences in the vascular tissue of root collar of *T. polium* growing in the coastal dunes of Bartın and the inland of Zonguldak located in the Western Black Sea region of Türkiye.

## 2. Material and Method

Sampling areas in A4 square in the P. H. Davis's grid system were selected from the coastal part of Bartın and the inner part of Zonguldak of the Western Black Sea region (Edmondson et al., 1982). Regarding plant geography, they are located in the European Siberian Flora region. A total of 6 samples were collected, 3 from each site. Wood samples were taken from the root collar. All field data about the diameters, altitude, location, and growing environment of the wood materials were recorded (Table 1).

Table 1
Field data about sampled *Teucrium polium*

| Group Number | Species | Diameter (cm) | Altitude (m) | Location | Habitat | Coordinate |
|---|---|---|---|---|---|---|
| 1 | *Teucrium polium* | 0.8 | 100 | Coburlar Village | Inland (Foothills) | 41º 30' 37.89''N 32º 08' 31.61''E |
| 2 | *Teucrium polium* | 0.2 | 0 | Hatipler Village | Coastal dune | 41º 36' 01.41''N 32º 08' 25.12''E |

The photographs of *T. polium*, a shrubby perennial herbaceous plant, taken in sample areas are given in Figure 1. The stems are 10-40 cm long, prostrate or erect, and have white-gray curled hairs. Internodes are shorter than leaves. The leaves are oval, narrow, oblong or linear, apex obtuse, edges crenate with hairy up to the middle. Flowers very shortly pedicellate, borne in heads.

a)  b) 

Figure 1. *T. polium* (Lamiaceae) in its natural distribution area (a) Coastal dunes and (b) Foothills

Transverse, radial, and tangential sections of 25-30 µm thickness were taken from the root collars of the sample plants with a GSL1 sliding microtome. The sections were first kept in 70% ethyl alcohol for two minutes and then in 95% ethyl alcohol for one minute for dehydration. After dying with safranin, 2-3 drops of glycerin were put on the slide, so they were prepared for temporary viewing by covering them with a cover glass at a 45° angle (Gärtner and Schweingruber, 2013).

All measurements for wood anatomical features such as radial and tangential diameters of vessels, vessel frequency, and the number of vessels per group were carried out on the Olympus CX-21 model light microscope, using different objectives (x4, x10, x40) selected according to the purpose. Wood elements were measured and counted directly on the sections between the slide and cover glass, using a micrometer and microgrid attached to the eyepieces (Yaman, 2002). For each feature, the mean, standard deviation, and range of values of 30 randomly selected measurements were calculated (Carlquist, 2001; IAWA Committee, 1989).

Xeromorphy values used in ecological wood anatomy studies were calculated separately for each sample. The following formula was used to calculate xeromorphy values (Yaman, 2008).

$$[\, 2\, x \sqrt{\frac{a^2+b^2}{2}} \,/\, (a\, x\, b) \,]\, x\, f$$

In this formula, a is the tangential vessel radius, b is the radial vessel radius, and f is the vessel frequency (Yaman, 2008). The R program was used to process and statistically evaluate quantitative data (mean, standard deviation, t-test). $p \leq 0.05$ was taken as a statistical significance level.

In addition, vulnerability values (vul) were calculated using the following formula (Carlquist, 2001). Vul = vessel tangential diameter/the number of vessels per $mm^2$.

## 3. Results

*T. polium* has semi-ring to diffuse-porous wood. Annual ring boundaries are distinct (Figure 2a). Vessels are mostly solitary and in various groups. The sizes of earlywood and latewood vessels are quite different (two different diameter classes). As the number of vessels ranges from 1 to 3 per group in coastal dune, it is from 1 to 8 in inland. The vessel grouping index exhibits a mean change between 1 and 2 in coastal dune and inland environments, respectively (Figure 2b). Distinct helical thickenings are present in the vessel elements, and perforation plates are simple (Figure 3). Intervessel piths are diagonal. Diffused apotracheal parenchyma are present. Rays are mostly uniseriate, rarely biseriate (Figure 4), and aggregate rays are uncommonly seen.

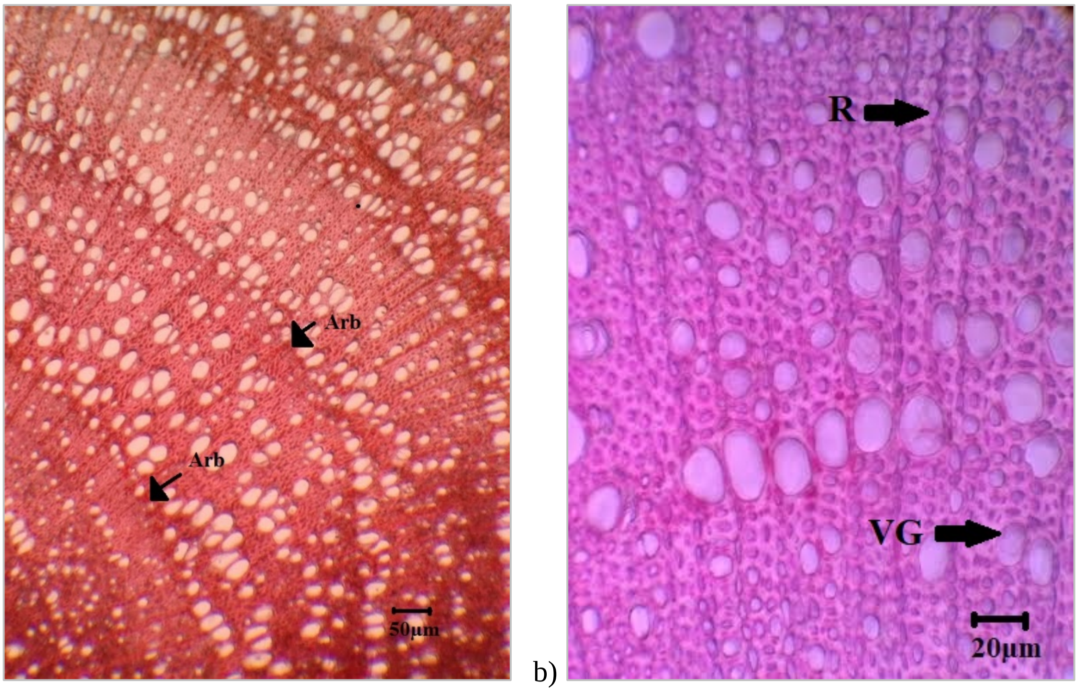



Figure 2. Transverse sections of *T. polium* root collar. a) Annual ring boundaries (Arb) b) Uniseriate rays (R) and vessels groupings (VG)

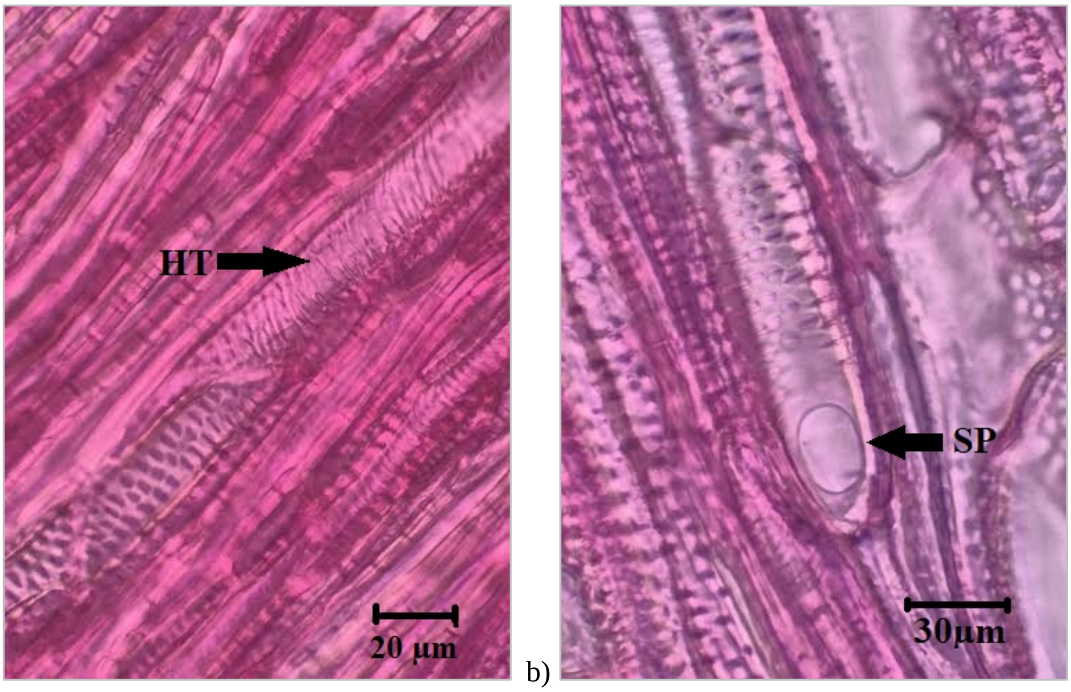



Figure 3. Radial sections of *T. polium* root collar. a) Helical thickenings (HT) in vessel elements b) Simple perforation plate (SP)

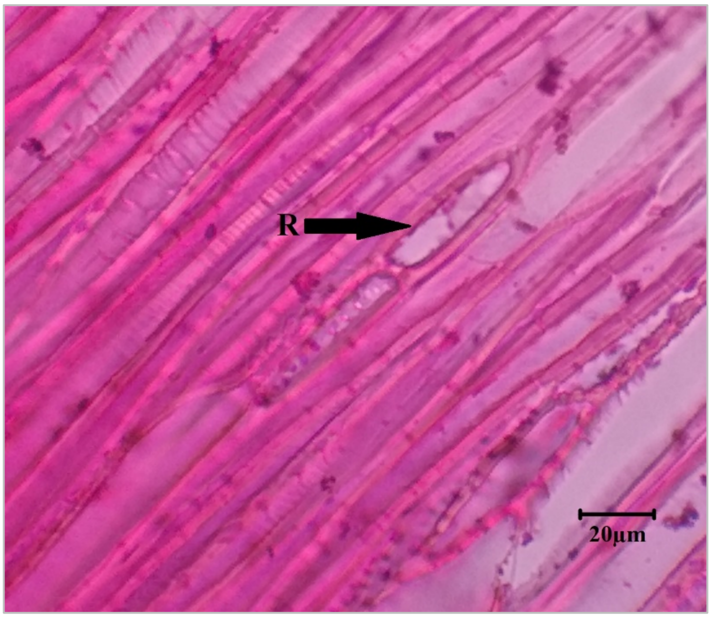



Figure 4. Tangential section of *T. polium* root collar. Uniseriate ray (R)

Secretory cavities were detected in the root collar bark of *T. polium* growing in the coastal dune. Secretory cavities consist of 6-7 rows of epithelial cells of heterogeneous structure and size. On the other hand, secretory cavities were absent in the inland samples (Figure 5).

a)



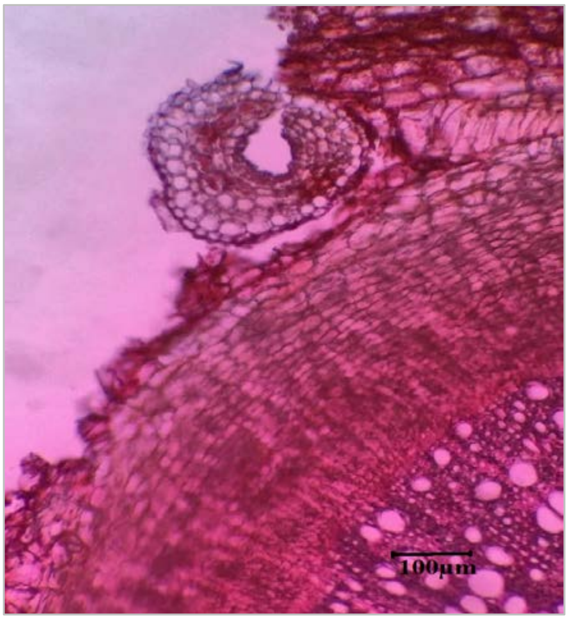
b)



Figure 5. Transverse sections of *T. polium* root collar. a) Secretory cavity b) Bark, secretory cavity, and wood

In the study, some anatomical features of wood samples of *T. polium* were compared in two different growing sites. The anatomical features examined are the tangential and radial diameters of vessel elements (as two different diameter classes), the number of vessels per $mm^2$ (vessel frequency), and the vessel grouping index. The surface-to-volume ratio (S/V) and xeromorphy values used in ecological wood anatomy studies were calculated according to Yaman (2008). The descriptive statistics for each sample group are given in Table 2.

Table 2
Descriptive statistics of anatomical features of *T. polium* wood

| Features | Sample group 1 (Inland) | | | | Sample group 2 (coastal dune) | | | | Significant Level |
|---|---|---|---|---|---|---|---|---|---|
| | Min. | Max. | Mean | Standard deviation | Min. | Max. | Mean | Standard deviation | |
| $VTD_l$ (µm) | 10 | 42.5 | 24.18 | 6.81 | 10.0 | 37.5 | 24.29 | 4.98 | ns |
| $VRD_l$ (µm) | 17.50 | 47.5 | 30.81 | 7.32 | 17.5 | 50.0 | 33.82 | 6.99 | $p<0.05$ |
| $VTD_s$ (µm) | 2.50 | 15 | 9.90 | 2.86 | 6.25 | 22.5 | 12.36 | 3.36 | $p<0.05$ |
| $VRD_s$ (µm) | 2.50 | 18 | 11.49 | 3.27 | 7.5 | 25.0 | 15.54 | 3.76 | $p<0.05$ |
| VN $mm^2$ | 190 | 820 | 491.67 | 131.01 | 250.0 | 1010.0 | 581.56 | 137.65 | $p<0.05$ |
| VGI | 1 | 8 | 1.95 | 1.14 | 1 | 3 | 1.38 | 0.66 | $p<0.05$ |
| VUL | - | - | 0.035 | - | - | - | 0.032 | - | - |
| XSERO | 35.73 | 211.15 | 104.8 | 38.52 | 45.91 | 226.35 | 111.8 | 34.96 | ns |

$VTD_l$: Vessel tangential diameter in the large class, $VRD_l$: Vessel radial diameter in the large class, $VTD_s$: Vessel tangential diameter in the small class, $VRD_s$: Vessel radial diameter in the small class, VN: Number of vessels per mm², VGI: Vessel grouping index, Vul: vulnerability, XSERO: Xeromorphy ratio.

Vessel tangential diameters in the large class are 24.18 µm and 24.29 µm in the inland and coastal dune, respectively. In terms of vessel tangential diameters in the large class, there is no significant difference between the two groups of *T. polium*. Vessel radial diameters in the large class are 30.81 µm and 33.82 µm in the inland and coastal dune, respectively. The radial diameters of vessels in the large class are 9.76% wider in the coastal dune.

Vessel tangential diameters in the small class are 9.90 µm and 12.36 µm in the inland and coastal dune, respectively. The tangential diameter of the vessels in the small class is 24.84% wider in the coastal dune. Vessel radial diameter in the small class are 11.49 µm and 15.54 µm in the inland and coastal dune, respectively. The radial diameter of vessels in the small class is 35.24% wider in the coastal dune.

The number of vessels per $mm^2$ in the inland and coastal dune are 491.7 and 581.6, respectively. The number of vessels is 18.28% higher in the coastal dune. Vessel grouping index is 1.95 and 1.38 in the inland and coastal dune, respectively. The vessel grouping index is 41.3% higher in the inland. The xeromorphy ratio is 104.8 and 111.8 in the inland and coastal dune, respectively. There is no significant difference between the two groups in terms of the xeromorphy ratio. Vulnerability value is approximately the same in both groups.

## 4. Discussion and Conclusion

*T. polium*, widespread in arid habitats, has been observed to have a central cylinder that is usually very narrow and vascular tissues are concentrated around small pith (Lakušić et al., 2010). In this study, it has also been observed that the central cylinder is narrow, and vascular tissues are clustered around a small pith.

Vessel diameter, vessel frequency, vessel grouping, vessel wall thickness, the presence of vascular/vasicentric tracheids, and whether helical thickenings in vessel walls or not are crucial parameters in ecological wood anatomy. In addition, vulnerability, mesomorphy, and xeromorphy values are calculated in these type of studies (Carlquist and Hoekman, 1985; Carlquist, 1988; Yaman, 2008; Akkemik et al., 2018). Merttürk (2021) determined 15.9 µm for vessel tangential diameter, 20.8 µm for vessel radial diameter, and 541 for the number of vessels per $mm^2$. In the present study, while these values were 18.32 µm, 24.68 µm, and 581.56 in the coastal dune, they were 17.04 µm, 21.15 µm, and 491.67 in the inland, respectively. In addition, Merttürk (2021) calculated the mesomorphy value of 5.5 for *T. polium*. In our study, xeromorphy values of this species were found to be 104.8 and 111.8 in the inland and coastal dune, respectively. Both mesomorphy and xeromorphy values indicated that *T. polium* is a xerophytic species. Latewood vessels are smaller in diameter than earlywood vessels. They are more resistant to embolism. Vascular tracheids in *T. polium* wood tend to coexist with vessels in arid habitats and extreme climatic conditions to provide conductive safety (Merttürk, 2021). According to Baas and Schweingruber (1987), *T. polium* has semi-ring to diffuse porous wood. Helical thickenings are present in vessels, and vessels are grouped. Fiber tracheids and vasicentric tracheids are absent, however, vascular tracheids are present. In our study, it was determined that *T. polium* wood is semi-ring porous, however it changes from semi-ring to diffuse-porous in the basis of habitats, and vascular tracheids are also present.

Cihan and Akkemik (2013) reported the tangential diameters of earlywood vessels in wood samples from *Phillyrea latifolia* L., *Myrtus communis* L., *Spartium junceum* L., *Laurus nobilis* L. and *Arbutus andrachne* L. were narrower in the Mediterranean region than that of Black Sea region. Yaman (2009) stated that vessel tangential diameters in woody plants exposed to marine influences in coastal ecosystems were significantly narrower, with some exceptions. In this study, there was no significant difference in vessel tangential diameter of the large class between two different habitats. However, in the coastal dune samples of *T. polium*, the vessel tangential and radial diameters in small classes and the radial diameters of vessels in the large class were wider than the inland samples.

When comparing woody species growing in arid and humid habitats, it is commonly observed that individuals in arid habitats exhibit narrower vessel diameters and a greater number of vessels per $mm^2$ (Carlquist and Hoekman, 1985; Fahn et al., 1986). Cihan and Akkemik (2013) noted a significant adaptation within the wood, particularly in the vessel numbers per $mm^2$, indicating an increased vessel frequency in the Mediterranean region and a decreased frequency in the Black Sea region. Sun and Lin (1997) reported a decrease in vessel frequency with an increase in soil salinity in the wood of River Mangrove (*Aegiceras corniculatum* (L.) Blanco) under varying soil salinity conditions. In this study, the vessel frequency in the wood of *T. polium* was 18.28% higher in the coastal dune than in the inland.

Woody perennial plants in arid environments exhibit numerous xeromorphic features (Rudall, 1980). The xeromorphy ratios of the woody species in the inland and coastal environments ranged from 0.34 to 13.68 and 0.70 to 18.32, respectively (Yaman, 2017). As the xeromorphic ratio of *T. polium* in the inland was 111.17, it was 116.13 in the coastal dune. Although there was no significant difference, the xeromorphy ratio was slightly higher (4.46%) in the coastal areas. Xeromorphy values of *T. polium* are higher than those of shrubs studied by Yaman (2017) and Cihan and Akkemik (2013). This finding could be attributed to the characteristic of *T. polium* as a xerophyte species exhibiting microphyllous semi-shrub morphology. (Lakušić et al., 2010).

In the transverse sections of *T. polium*, secretory cavities were detected in the bark of samples in the coastal dune; however, no secretory cavities were seen in the samples from the inland. The fundamental function of plant secretory structures is associated with structural and induced defense responses against herbivores and pathogens (Lange, 2015). These secretory structures, including the secretory cavities, can be found in leaves, roots, and rhizomes. The secretory cavity in roots or rhizomes could function as reservoirs of volatile oils released due to the physical injury to these organs. The odor emanating from the volatile oils released from these secretory cavities due to physical damage can act as a deterrent or poison for insect larvae or other potential herbivores, similar to the volatile oil cavity in leaves (Pljevljakušić et al., 2012). As far as we know, although the leaves of *T. polium* have trichomes and idioblastic secretory cells (Bosabalidis, 2014; Jurišic-Grubešic, 2007), secretory cavities are absent in its root collar bark. However, the secretory cavities we detected may be a form of adaptation developed by *T. polium* to produce secretions using minerals found in saltwater and dune environments to protect itself against salty conditions, pathogens, and herbivores.

**Acknowledgement**

This study was also presented firstly as oral presentation at the 5th International Symposium on Non-Wood Forest Products, 2023.

**Author Contributions**

Author Esra Pulat: Designed and wrote the article.

Author Avni Yıldızbaş: Literature reviewed and summarized it and took the photos.

Author Barbaros Yaman: Conducted the statistical analysis of the study and wrote the article.

## Conflict of Interest

The authors declared no conflict of interest.

## References

Akkemik, Ü., Bayam, N. N. A., & Akarsu, F. (2018). An approach to compare the environmental conditions of Acer in the Miocene and in the modern flora of Turkey, based on wood anatomy. *Acta Palaeobotanica*, 58(2), 209-217.

Baas, P., & Schweingruber, F. H. (1987). Ecological trends in the wood anatomy of trees, shrubs and climbers from Europe. *IAWA Journal*, 8(3), 245-274.

Baser, K. H. C. (1993). Essential Oils of Anatolian Labiateae: A Profile. *Acta Horticulturae*, 333:217-237.

Bosabalidis, A. M. (2014). Idioblastic mucilage cells in *Teucrium polium* leaf, anatomy and histochemistry. *Modern Phytomorphology, 5*, 49-52.

Carlquist, S., & Hoekman, D. A. (1985). Ecological wood anatomy of the woody southern Californian flora. *Iawa Journal*, *6*(4), 319-347.

Carlquist, S. (1988). Comporative Wood Anatomy, Springer-Verlag, Berlin, 358 p.

Carlquist, S. (1992). Wood anatomy of Lamiaceae. A survey, with comments on vascular and vasicentric tracheids. *Aliso: A Journal of Systematic and Floristic Botany*, *13*(2), 309-338.

Carlquist, S. (2001). Comporative Wood Anatomy, second ed., Springer-Verlag, Berlin, 448 p.

Cihan, C., & Akkemik, Ü. (2013). Ecological wood anatomy of some maquis species naturally grow in both Mediterranean and Black Sea regions of Turkey. *Eurasian Journal of Forest Science*, *1*(1), 20-37.

Edmondson, J. R., Mill, R. R., & Tan, K. (1982). *Flora of Turkey and the East Aegean Islands, Volume 7* (P. H. DAVIS, Ed.; Vol. 7). Edinburgh University Press.

Dinç, M., Doğu, S., Koca, A. D., & Kaya, B. (2011). Anatomical and nutlet differentiation between *Teucrium montanum* and *T. polium* from Turkey. *Biologia*, *66*, 448-453.

Ecevit-Genç, G., Özcan, T., & Dirmenci, T. (2018). Leaf indumentum in some Turkish species of *Teucrium* (Lamiaceae). *Istanbul Journal of Pharmacy*, *48*(1), 6-11.

Fahn, A., Werker, E., & Baas, P. (1986). *Wood anatomy and identification of trees and shrubs from Israel and adjacent regions*. Israel Academy of Sciences and Humanities.

Gärtner, H., & Schweingruber, F. H. (2013). *Microscopic preparation techniques for plant stem analysis.* Verlag Dr. Kessel, Remagen ISBN: 378-3-941300-76-7.

Jurišic Grubešic, R., Vladimir-Kneževic, S., Kremer, D., Kalođera, Z. & Vukovic, J. (2007). Trichome micromorphology in *Teucrium* (Lamiaceae) species growing in Croatia. *Biologia*, *62*, 148-156.

Güner, A. (2012). *Türkiye Bitkileri Listesi-Damarlı Bitkiler. Nezahat Gökyiğit Botanik Bahçesi Yayınları Flora Dizisi-1*, İstanbul.

Harley, R. M., Atkins, S., Budantsev, A. L., Cantino, P. D., Conn, B. J., Grayer, R., M. M. Harley, R. De Kok, T. Krestovskaja, R. Morales, A. J. Paton, O. Ryding, & Upson, T. (2004). Labiatae. In *Flowering Plants· Dicotyledons: Lamiales (except Acanthaceae including Avicenniaceae)* (pp. 167-275). Berlin, Heidelberg: Springer Berlin Heidelberg.

IAWA Committee (1989). List of microscopic features for hardwood identification. *IAWA Bull*, 10(3), 201-232.

Kocabaş, Y. Z. & S. Karaman. (2001). Essential oils of Lamiaceae family from South East Mediterranean Region (Turkey). *Pakistan Journal of Biological Sciences*, 4: 1221-1222.

Lakušić, B., Stevanović, B., Jančić, R., & Lakušić, D. (2010). Habitat-related adaptations in morphology and anatomy of Teucrium (Lamiaceae) species from the Balkan peninsula (Serbia and Montenegro). *Flora*, Volume 205, Issue 10, Page 633-646. https://doi.org/10.1016/j.flora.2010.04.018.

Lange, B. M. (2015). The evolution of plant secretory structures and emergence of terpenoid chemical diversity. *Annual Review of Plant Biology*, *66*, 139-159.

Merttürk, N. (2021). Bazı Lamiaceae Türlerinin Odun Anatomisi Özellikleri (Yüksek Lisans Tezi, Artvin Çoruh Üniversitesi Lisansüstü Eğitim Enstitüsü, Artvin. 63 s.).

Özcan, T. (2015). *Teucrium* L.(Lamiaceae) cinsinin revizyonu (Doktora Tezi, Balıkesir Üniversitesi Fen bilimleri Enstitüsü.472 s.).

Pljevljakušić, D., Rančić, D., Ristić, M., Vujisić, L., Radanović, D., & Dajić-Stevanović, Z. (2012). Rhizome and root yield of the cultivated Arnica montana L., chemical composition and histochemical localization of essential oil. *Industrial Crops and Products*, *39*, 177-189.

Rudall, P. (1980). Wood anatomy in the Hyptidinae (Labiatae). *Kew Bulletin*, 735-741.

Royal Botanic Garden KEW, (2023). https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:460631-1#distributions

Schweingruber, F. H., Börner, A., & Schulze, E. D. (2013). Monographic Descriptions. *Atlas of Stem Anatomy in Herbs, Shrubs and Trees*: *Volume 2, 5-291.*

Sun, Q., & Lin, P. (1997). Wood structure of Aegiceras corniculatum and its ecological adaptations to salinities. *Hydrobiologia*, 52: 61–66,1997

Yaman, B. (2002). Türkiye'nin Euro-Siberian (Euxine) Bölgesinde Doğal Olarak Yetişen Yabani Kiraz (*Cerasus avium* (L.) Moench)'ın Morfolojik, Anatomik ve Palinolojik Özellikleri (Doktora Tezi, ZKÜ Fen Bilimleri Enstitüsü).

Yaman, B. (2008). Variation in quantitative vessel element features of *Juglans regia* wood in the western black sea region of Turkey. *Agrociencia*, 42(3): 357-365.

Yaman, B. (2009). Türkiye'nin Batı Karadeniz Kıyı Ekosistemlerinde Deniz Suyu Etkisine Maruz Kalan Bazı Odunsu Bitkilerin Ekolojik Odun Anatomisi. Tarım, Ormancılık ve Veterinerlik Araştırma Grubu, TÜBİTAK Proje No: 107886. Bartın.

Yaman, B. (2017). Batı Karadeniz Kıyı Ekosistemlerinde Deniz Suyu Etkisinde Kalan Bazı Odunsu Bitkilerin Su İletim Sistemindeki Anatomik Değişimler. *Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi*, *13*(1), 1-17.

WFO plant list, (2023). https://wfoplantlist.org/taxon/wfo-4000038030-2023-12?page=1