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Stem anatomical survey of the genera *Matricaria* and *Tripleurospermum* (Asteraceae) from Turkey with its taxonomical and ecological implications

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ABSTRACT:
A comparative anatomical study of the stems in 32 taxa assigned in the two related genera; *Matricaria* (4 taxa) and *Tripleurospermum* (28 taxa, 30 accessions), was carried out in Turkey by using cluster analysis (CA) and principal component analysis (PCA) to address generic classification and taxa delimitation. All the studied taxa have the following stem characteristics: one layer of epidermal cells with a sparse distribution of non-glandular trichomes, a cortex composed of interchanging collenchyma and chlorenchyma cells, a number of schizogenous secretory ducts near the bundles, ovate to oblong and open collateral vascular bundles which are arranged in a ring and are variable in size, and parenchymatous pith. The differences among the taxa are mainly the thickness of the xylem in the vascular bundle, the length of the epidermal cells and the pith cell size. The taxonomic and ecological values of the anatomical data are discussed in light of the current framework.

Keywords:
Compositae, chamomile, mayweed, numerical taxonomy

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INTRODUCTION

Asteraceae is a cosmopolitan family divided into 13 subfamilies, 44 tribes (Panero *et al.* 2014), 1600 genera and 24000 species (Funk *et al.* 2009; Mandel *et al.* 2019). Anthemideae, which is one of the important tribes, consists of 111 genera and 1800 species worldwide. The majority of species of Anthemideae are concentrated in Central Asia, the Mediterranean region and the southern regions of Africa (Oberprieler *et al.* 2007).

Many Anthemideae genera of uncertain phylogenetic position or unclear circumscription are distributed along the Mediterranean Basin (Oberprieler *et al.* 2009). *Matricaria* L. and *Tripleurospermum* Sch.Bip. belong to the Mediterreanean genera and share similar morphological habits such as floral architecture and leaf shape with other Anthemideae genera (i.e. *Anthemis* L., *Chamaemelum* Mill., *Chrysanthemum* L., and *Tanacetum* L.). Therefore, they have been confused both taxonomically and nomenclaturally with each other (Jeffrey 1979; Xifreda 1985; Kerguélen *et al.* 1987; Pobedimova 1995; Applequist 2002; Oberprieler & Vogt 2006; Inceer & Hayirlioglu-Ayaz 2014).

Matricaria is a small genus with six species, which are annual and herbaceous (Oberprieler *et al.* 2007), while the genus *Tripleurospermum* has annual and herbaceous perennial species with ca. 32 taxa and is particularly abundant and diverse in Turkey, one of the main centres of diversity (Enayet Hossain 1975; Inceer *et al.* 2018; Inceer & Ozcan 2021). The endemism rate in *Tripleurospermum* is fifty per cent in Turkey. The members of these two genera are distributed mainly in the Mediterranean Basin, including Europe, temperate Asia and North Africa (Oberprieler *et al.* 2007).

The taxa of these two genera are widespread and taxonomically complex. Depending on the authors, several species are classified in either *Matricaria* or *Tripleurospermum* (Inceer 2011). Recent molecular investigations

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based on ITS and ETS ribosomal DNA (rDNA) regions have also clearly supported their delimitation as different clades (Inceer *et al.* 2018).

Cytological studies conducted in *Matricaria* and *Tripleurospermum* have mainly concentrated on chromosome counts (Inceer *et al.* 2018 and the references therein). The basic chromosome number in both genera is x = 9, the most common basic number in the tribe Anthemideae and the family Asteraceae (Inceer & Hayirlioglu-Ayaz 2010). To date, one ploidy level (2*x*) in *Matricaria* and four ploidy levels (2*x*, 3*x*, 4*x*, 5*x*) in *Tripleurospermum* have been reported (Watanabe 2021). In addition, a relationship between ploidy levels and certain anatomical characteristics such as stomatal length, vascular bundle size and palisade sclerenchyma thickness have been noticed by Inceer & Ozcan (2011, 2021) within the genus *Tripleurospermum*.

Anatomical characteristics are useful for the delimitation of taxa regardless of the influence of environmental factors. Therefore, taxonomists have investigated such characteristics in order to select anatomical data which may strengthen the taxonomy of the genera and provide features allowing for better identification of the species (Metcalfe & Chalk 1979; Stace 1980; Dickison 2000; Araújo *et al.* 2010; Inceer & Ozcan 2011, 2021; Inceer *et al.* 2018; Inceer & Bal 2019). Several morphological (Inceer 2012, 2019) and morpho-anatomical studies (Inceer & Ozcan 2011, 2021; Inceer & Bal 2019) have been carried out on the taxa belonging to *Matricaria* and *Tripleurospermum* in recent years. It has been reported that the fruit (especially palisade sclerenchyma in the pericarp) and leaf anatomical characteristics (vascular bundle in particular) of their taxa play an important role in the systematics of the genera (Inceer & Ozcan 2021). Besides, stomatal length and the relative size of the vascular bundle based on the ploidy level have high taxonomic value at interspecific levels in Turkish endemic *Tripleurospermum* taxa (Inceer & Ozcan 2011).

Studies of stem anatomy in the taxa of these two genera are scarce (Uysal 1991; Zarinkamar *et al.* 2013; Khayati *et al.* 2016). Therefore, the present study aims to (1) provide detailed information on the stem anatomy of *Matricaria* (4 taxa) and *Tripleurospermum* (28 taxa) taxa from Turkey so as to determine the anatomical variation between *Matricaria* and *Tripleurospermum*, to (2) evaluate the taxonomic and ecological value of the obtained characters, and to (3) discuss the inter- and intrageneric relationships based on the anatomical data.

MATERIAL AND METHODS

Sampling. We analysed 32 taxa belonging to two relative genera; *Matricaria* (4 taxa) and *Tripleurospermum* (28 taxa, 30 accessions). The plant samples were collected from different natural habitats in Turkey in the flowering and fruiting periods. The species were arranged alphabetically, and the collection data, including species authorship, collector and herbarium, were summarized in Supplementary Table 1. Out of 28 examined *Tripleurospermum* taxa, 12 are endemic to Turkey. Taxa identification and nomenclature follow Enayet Hossain (1975), Grierson (1975), Applequist (2002) and Inceer (2012, 2019). The plant samples have been deposited in the herbarium of Karadeniz Technical University, Department of Biology (KTUB) or H. Inceer collections.

Anatomical examinations. Fresh samples for anatomical studies were fixed in FAA (5 parts formalin: 5 parts acetic acid: 90 parts 70% ethyl alcohol). Transverse sections 18–20 μm thick were taken from the middle parts of the stems by a rotary microtome, stained with safranin-fast green and mounted in Entellan (Algan 1981). For stomatal observations, the epidermal surfaces of the stems were directly peeled by hand, and paradermal sections were prepared. Observations and photographs of the different tissues were made with a Leica DM 4000B microscope and a Leica DFC 490 with a digital camera attachment. Five to ten cells/tissues were measured from at least five slides to assess the consistency of the anatomical characters and to calculate the means and standard error among the different transverse sections using a Nikon binocular microscope with an ocular micrometre.

Statistical analyses. We recognized eleven anatomical characters, and the data were presented as the mean ± the pooled standard error. For all the anatomical characters (11 quantitative characters with mean value) the ploidy levels of the taxa were evaluated, the correlation coefficient was determined, and their grouping was performed using the clustering analysis method (UPGMA, dissimilarity, standardized variable) as well as ordination based on principal component analysis (PCA).

RESULTS

The main anatomical characters of the examined taxa are summarized in Supplementary Table 2. Selected LM micrographs of the anatomical transverse sections are presented in Figs. 1, 2 & 3.

The stems in the transverse section were generally rounded in shape, but were sometimes moderately ridged with 7–9 ribs in *T. caucasicum* (Willd.) Hayek, *T. melanolepis* (Boiss. & Buhse) Pobed., *T. rosellum* var. *album* (Boiss. & Orph.) Hayek (2*x*), *T. parviflorum* (Willd.) Pobed., *T. sevanense* (Manden.) Pobed., *T. transcaucasicum* (Manden.) Pobed., and *T. monticola* (Boiss. and Huet) Bornm. (Figs. 1D, 2B, F & G). In the transverse sections of the stem, the single-layered epidermis is the outermost layer covered by a thin cuticle layer (Fig. 1). The epidermis contains non-glandular (uniseriate, mul-

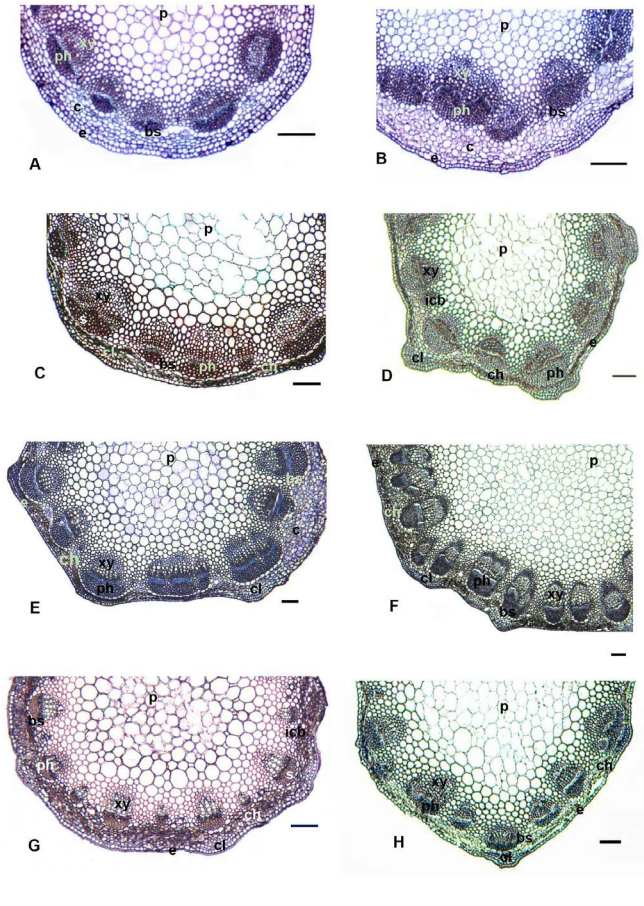

Fig. 1. Transverse section of stem in selected *Matricaria* and *Tripleurospermum* taxa. A – *M. chamomilla*, B – *M. matricarioides*, C – *T. callosum*, D – *T. caucasicum* (2*x*), E – *T. corymbosum*, F – *T. disciforme*, G – *T. fissurale*, H – *T. heterolepis*. bs = bundle sheath, c = cortex, ch = chlorenchyma, cl = collenchyma, e = epidermis, icb = incomplete bundle, p = pith, ph = phloem, s = sclerenchymatous cap, xy = xylem. Scale bars: 100 µm.

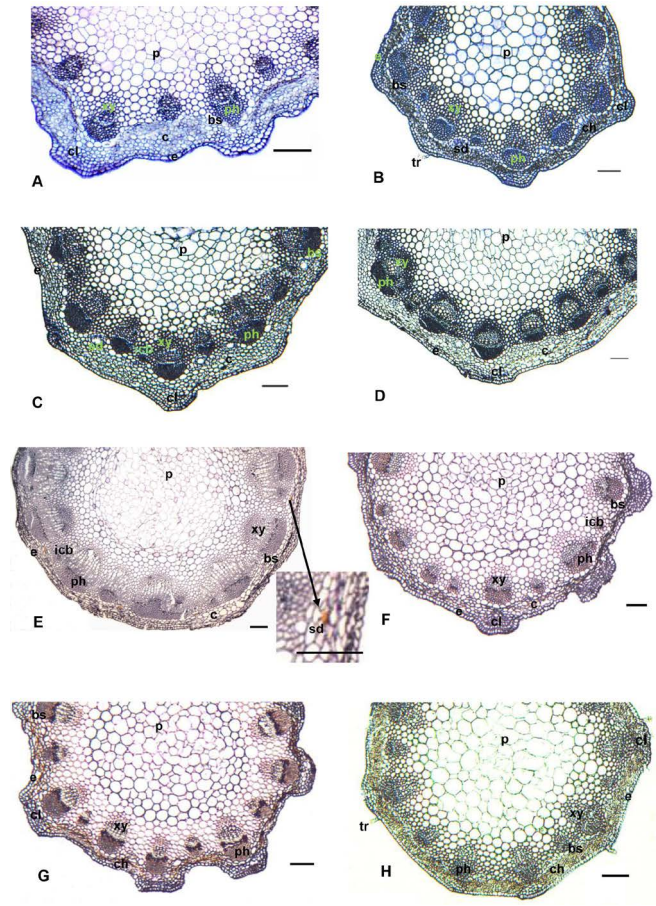

Fig. 2. Transverse section of stem in selected *Tripleurospermum* taxa. A – *T. hygrophilum*, B – *T. inodorum*, C – *T. kotschyi*, D – *T. pichleri*, E – *T. repens*, F – *T. rosellum* var. *album* (4*x*), G – *T. transcaucasicum*, H – *T. ziganaense*. bs = bundle sheath, c = cortex, ch = chlorenchyma, cl = collenchyma, e = epidermis, icb = incomplete bundle, p = pith, ph = phloem, sd = secretory duct, tr = simple trichome, xy = xylem. Scale bars: 100 µm.

ticellular) trichomes with two to three short basal cells and long, fine tails (Figs. 2B, H, 3B, D & H). Anomocytic stomata can be observed in the transverse sections of the stems of some taxa (Figs. 3A & E) in addition to the paradermal section (Figs. 3G & H). The cortex consists of collenchyma, chlorenchyma, and the endodermis. Underneath the epidermis, the thick-walled chlorenchyma is alternated with lamellar collenchyma. The collenchyma tissue (4–6 layered) is located at the corners of the stem. Chlorenchymatous tissue with 3–4 layers covers the area between the corners. The collenchyma tissue at the corners is at its widest in the tetraploid cytotype of *T. rosellum* var. *album* (Fig. 2F) and *T. disciforme* (C.A.Meyer) Sch.Bip., while the thinnest is determined in *M. aurea* (Loefl.) Sch.Bip. (Supplementary Table 2).

The cortex parenchyma tissue has abundant chloroplasts in most of the taxa (chlorenchyma) and the cells are oval or orbicular arranged in 3–6 layers between the corners, with 5–12 rows of oval or orbicular cells throughout the ribs. It consists of several secretory ducts, which range from small to large in diameter near the vascular bundles (Figs. 1B, 2E & 3A-E). Within *Matricaria*, the cortex thickness varies from 65.80 µm in *M. aurea* to 130.70 µm in *M. chamomilla* L. var. *recutita* (L.) Fiori, while it ranges from 54.00 µm in *T. fissurale* E.Hossain to 185.20 µm in *T. conoclinium* (Boiss. & Bal.) Hayek within *Tripleurospermum* (Supplementary Table 2). Underneath the parenchymatous cortex, there is a 1-layered, large, oval or rectangular parenchymatous bundle sheath.

The vascular cylinder presented cambia forming phloem outwards and xylem inwards. The vascular bundles vary in size in all the taxa, are arranged in a circle, ovate to oblong and open collateral per section, and large bundles are mainly visible in the corners. The number of vascular bundles in the stem structures rang-

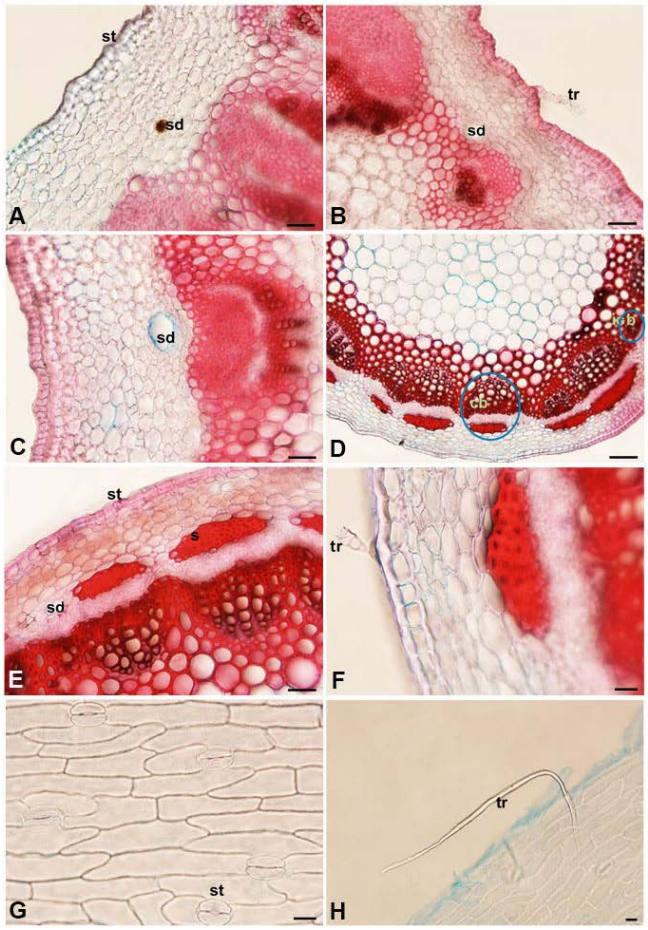

Fig. 3. Special characters in the stems of selected *Matricaria* and *Tripleurospermum* taxa. (A-C) – *M. matricarioides*, (D-H) – *T. fissurale*, A – secretory duct without secretion, B – simple and uniseriate trichome in transverse section, C – secretory duct with secretion material, D – completed and incomplete vascular bundles (blue circles). E – sclerenchymatous cap in vascular bundles, F – simple and uniseriate trichome in transverse section, G – anomocytic stomata in paradermal section, H – simple trichome in paradermal section. cb = completed bundle, icb = incomplete bundle, s = sclerenchymatous cap, sd = secretory duct, st = stomata, tr = simple trichome, ucb = uncomplete vascular bundle. Scale bars: 50 mm (a-e), 20 mm (f-h).

es from 15 to 40 (Figs. 1 & 2). Small and/or incomplete (imperfect, accessory) bundles (Figs. 1D, E, G, 2B, C, D, F, H & 3D) are clearly observed among the large (completed) bundles. The mean size of the completed bundles varies from 124.40 µm in *T. baytopianum* E.Hossain to 379.60 µm in *T. disciforme* within *Tripleurospermum*. The sclerenchymatous interfascicular region is located in between the vascular bundles in some taxa.

The phloem thickness with sclerenchymatous fibre caps (Fig. 3E) ranges from 47.20 µm to 104.0 µm in *Matricaria* taxa and from 47.60 µm to 159.60 µm in *Tripleurospermum* taxa. The sclerenchymatous fibre caps vary from 32.60 µm in *M. aurea* to 92.40 µm in *M. chamomilla* var. *recutita*, and from 32.30 µm in *T. tenuifolium* (Kit.) Freyn to 118.66 µm in *T. disciforme*. The pith is wide and consists of polygonal or orbicular and thickened parenchymatous cells in the centre. The central region contains relatively large ones (Fig. 2B). The pith cavities formed in the centre of the stems of *T. callosum* (Boiss. & Heldr.) E.Hossain, *T. caucasicum* (4*x*), *T. decipiens* (Fisch. & Mey.) Bornm., *T. rosellum* var. *album* (2*x*), and *T. parviflorum* are clearly visible (Fig. 1C).

Parenchymatous cells cover the vascular bundles and the pith. On the other hand, in some of the taxa the central part of the stem was also found to have a cavity formed by the disintegration of the cells, including *T. caucasicum* (both of the two cytotypes), *T. rosellum* var. *album* (both of the two cytotypes), *T. callosum*, *T. decipiens*, *T. elongatum* (Fisch. & Mey.) Bornm., *T. fissurale*, *T. melanolepis* (Boiss. & Buhse) Pobed., *T. parviflorum*, and *T. kotschyi* (Boiss.) E.Hossain.

Multivariate analyses. For the cluster analysis (UPGMA, the unweighted pair group method with arithmetic mean), 11 stem anatomical characteristics of 32 taxa (34 accessions) were analysed, and their intergeneric/ interspecific relationships were observed (Supplementary Table 2, Fig. 4). The dendrogram shows there are mainly two major clusters, and each cluster includes both diploids and polyploids. Moreover, as seen in the dendrogram, the taxa of both genera cannot be separated from each other at a generic level based on the quantitative anatomical characters of the stem.

The results of the PCA ordination for the examined taxa of *Matricaria* and *Tripleurospermum* are presented in Fig. 5. As seen in Fig. 5, the first two PC factors accounted for about 65% of the total variance. In addition, the first three PC factors accounted for about 76% of the total variance. The first factor accounts for about 46% of the total variance, with the mean thickness of the xylem in the vascular bundle having the highest negative correlation ($r > -0.88$). The second factor accounts for about 19% of the total variance, with the epidermal length showing the highest positive correlation ($r > 0.76$). The third factor accounts for about 11% of the total variance, with pith cell size showing the highest negative correlation ($r > -0.67$).

Correlations between the anatomical characters and ploidy level. Details of the correlations between the anatomical characters and ploidy levels are presented in Supplementary Table 3. As seen in Supplementary Table 3, the length and width of the bundle sheath cell, xylem thickness, and trachea size are correlated with ploidy levels in *Tripleurospermum* ($P < 0.05$). However, there is no correlation between the other anatomical characters and ploidy levels in the genus *Tripleurospermum*.

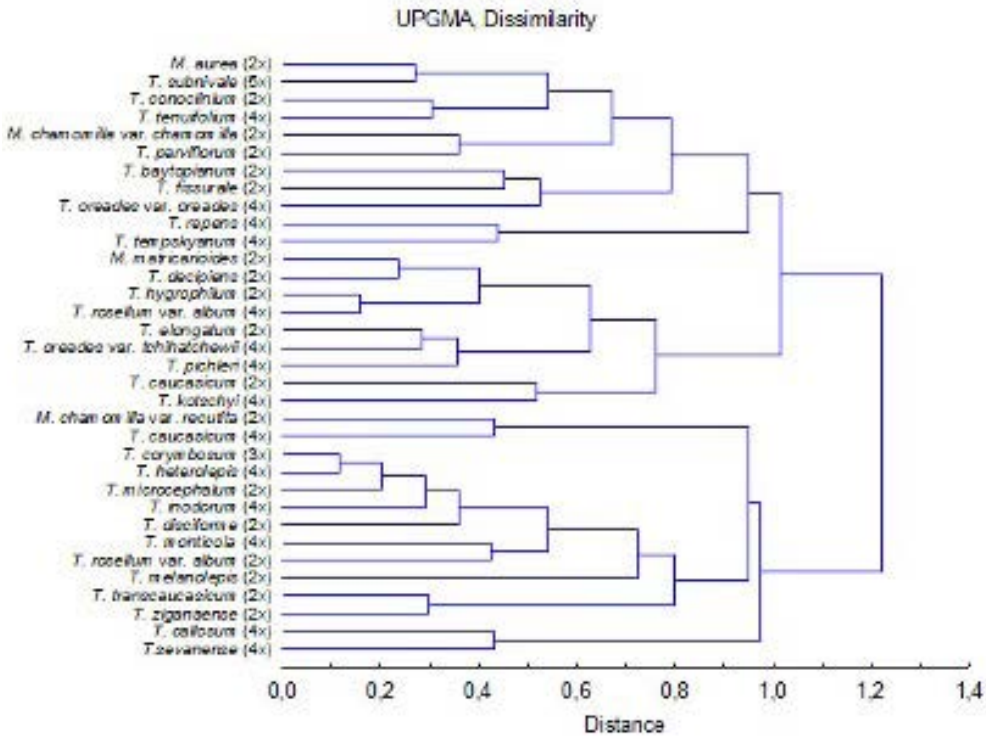

Fig. 4. UPGMA clustering of *Matricaria* and *Tripleurospermum* based on stem anatomical characters.

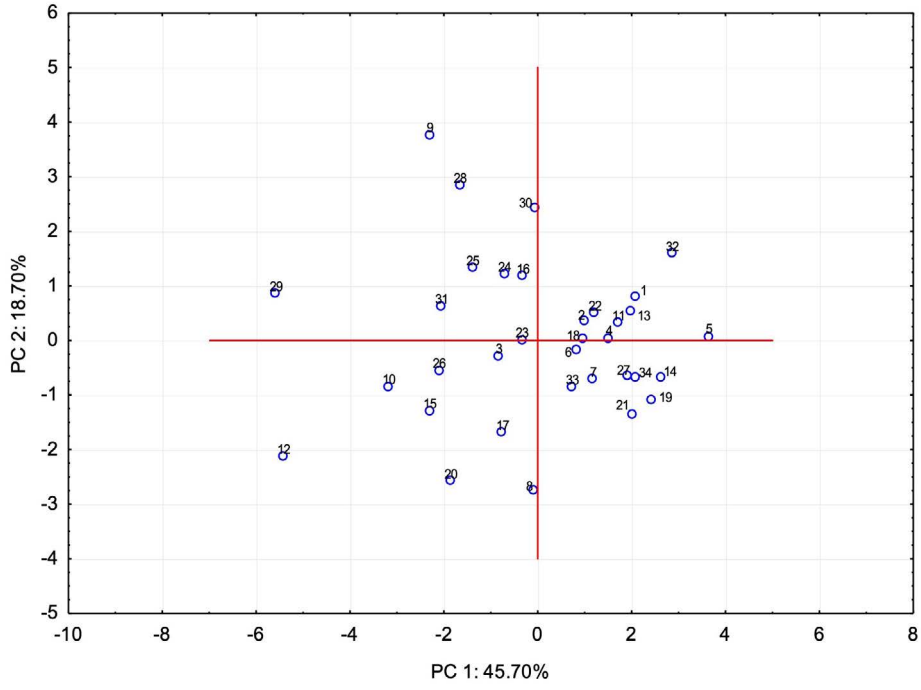

Fig. 5. Results from the principal component analysis of the *Matricaria* and *Tripleurospermum* taxa based on stem anatomical characters. 1 – *M. aurea*, 2 – *M. chamomilla* var. *chamomilla*, 3 – *M. chamomilla* var. *recutita*, 4 – *M. matricarioides*, 5 – *T. baytopianum*, 6 – *T. callosum*, 7 – *T. caucasicum* (2*x*), 8 – *T. caucasicum* (4*x*), 9 – *T. conoclinium*, 10 – *T. corymbosum*, 11 – *T. decipiens*, 12 – *T. disciforme*, 13 – *T. elongatum*, 14 – *T. fissurale*, 15 – *T. heterolepis*, 16 –*T. hygrophilum*, 17 – *T. inodorum*, 18 – *T. kotschyi*, 19 – *T. melanolepis*, 20 – *T. microcephalum*, 21 – *T. monticola*, 22 – *T. oreades* var. *oreades*, 23 – *T. oreades* var. *tchihatchewii*, 24 – *T. parviflorum*, 25 – *T. pichleri*, 26 – *T. repens*, 27 – *T. rosellum* var. *album* (2*x*), 28 – *T. rosellum* var. *album* (4*x*), 29 – *T. sevanense*, 30 – *T. subnivale*, 31 – *T. tempskyanum*, 32 – *T. tenuifolium*, 33 – *T. transcaucasium*, 34 – *T. ziganaense*.

DISCUSSION

In this investigation, the detailed stem anatomical characteristics of 32 *Matricaria* and *Tripleurospermum* taxa, including two polyploid cytotypes, have been presented for the first time by using multivariate analyses. In previous studies, the general stem structure of *M. chamomilla* from Iran (Zarinkamar *et al.* 2013) and the general anatomical characteristics of *T. baytopianum*, and *T. caucasicum*, *T. monticola* and *T. transcaucasicum* have been reported by Uysal (1991) and Khayati *et al*. (2016) from Turkey and Iran, respectively.

The results show that although the stem anatomies were similar in all of the examined taxa, some differences such as rounded to ribbed stem structures and the distributions, densities and size of the vascular bundles were also determined as shown in Figs. 1, 2 & 3. The general structural characteristics of the stems of the examined taxa agree with what has previously been reported by Kadereit & Jeffrey (2007), Metcalfe & Chalk (1979), Zarinkamar *et al.* (2013), Uysal (1991) and Khayati *et al.* (2016) for *Matricaria*, *Tripleurospermum* and other members of the family Asteraceae.

Metcalfe & Chalk (1950) reported that glandular or non-glandular trichomes with a multiseriate stalk and a uniseriate or multiseriate flagelliform terminal cell were the most common trichome types in Asteraceae. On the other hand, unicellular hairs have not been recorded in Asteraceae (Metcalfe & Chalk 1979). In the present study, sparsely distributed simple trichomes have been observed in most of the taxa (Figs. 2B, H, 3B, F & H), except for *T. corymbosum* E.Hossain like its leaf (Inceer & Ozcan 2011). On the other hand, Uysal (1991) previously reported a glabrous stem for *T. baytopianum*. Among the studied taxa, the epidermal surfaces of the stems of *T. fissurale* and *T. ziganaense* Inceer & Hayirlioglu-Ayaz are densely covered in simple trichomes. These species are also characterized by more or less dense trichomes on the leaf surface (Inceer & Ozcan 2011). Besides, the dense indumentum in *T. fissurale* and *T. ziganaense* is associated with their habitats, namely water deficiency, high temperature and intense radiation, and thus, these species can be considered well adapted to arid environments. On the other hand, glandular trichomes have not been encountered in any of the investigated taxa. In contrast to our study, Khayati *et al.* (2016) reported secreting hairs in *T. caucasicum*, *T. monticola* and *T. transcaucasicum* from Iran.

Metcalfe & Chalk (1979) provided information about some of the general anatomical characteristics of the genera of Asteraceae. The authors reported that the stem of the genus *Matricaria* is sometimes ribbed with supporting tissue elements in the angles. Our results obtained from the stem anatomy are similar to this report. The anatomical characteristics of the taxa are also similar to the peculiarities of Asteraceae. *Matricaria aurea*, *M. chamomilla* var. *chamomilla*, *T. conoclinium, T. callosum, T. repens* (Freyn and Sint.) Bornm. and *T. microcephalum* (Boiss.) Bornm. have almost round stems. On the other hand, the other *Tripleurospermum* taxa and *M. chamomilla* var. *recutita* have 6–9 distinctly ribbed ones. Similar to our study, Khayati *et al.* (2016), reported the largest corners in *T. transcaucasium*. Collenchyma tissue protrudes in the corners, and alternates with chlorenchyma tissue, as has been previously reported in *T. baytopianum* by Uysal (1991), in some *Centaurea* L. taxa by Ozcan (2018) and Ozcan *et al.* (2014), and in some *Tanacetum* taxa (Tekin & Kartal 2016). Chlorenchyma cells are clearly visible in most of the *Tripleurospermum* taxa. However, the tetraploid cytotypes of *T. caucasicum* and *T. rosellum* var. *album* do not have chlorenchyma tissue in the corners, unlike the diploid cytotypes. Similarly, the stomata density in the leaves of the tetraploid cytotypes is higher than in the diploid ones (Incer & Ozcan 2011, 2021). These anatomical traits in both taxa may be a result of physiological strategies such as photosynthesis in the adaptation to different environmental conditions.

The stem cortex usually consists of parenchymatic oval cells with thin walls in all of the examined taxa, but it varies from 5 to 12 rows among the taxa (Fig. 1). There were secretory ducts in the cortical parenchyma located near the vascular bundles. Cortical bundles are not present in the taxa. The vascular bundles in the investigated taxa (medullary bundles) are collateral, varying in number and size and arranged in a ring. Similarly, Uysal (1991) reported different sizes of vascular bundles arranged in a circle for *T. baytopianum*. In addition, large (completed) bundles, and incomplete/accessory bundles were observed in *T. caucasicum*, *T. corymbosum*, *T. disciforme*, *T. pichleri*, *T. kotschyi*, *T. fissurale* and *T. rosellum* var. *album* (4*x*). These bundles were also previously reported by Inceer & Ozcan (2011, 2021) in the leaves of the same taxa. Metcafe & Chalk (1979) stated that the incomplete bundles consist of phloem tissue alone, and they contribute to the principal vascular system of the stem. Venning (1947) also reported that individual elements of accessory vascular bundles do not differ in any way from those of the main vascular system. They may serve in a water-storing capacity. Wallace (1990) observed these imperfect bundles in the stem of *Actinostemma biglandulosa* Hemsl. Barykina & Kramina (2006) determined them in *Lotus japonicus* (Regel) K.Larsen and related species as imcomplete additional vascular bundles. A few bundles of different sizes were found in *M. aurea*, while the highest number of vascular bundles (almost 40) was determined in *T. disciforme*. The arrangement of bundles provides valuable information in comparative anatomical studies. Metcalfe & Chalk (1950) noted the importance of the presence of medullary and cortical bundles for taxonomy. Ozcan & Demiralay (2018) re-

ported these types of cortical bundles in the stems of some Turkish *Cirsium* taxa. These bundles have also been reported by Gavrilović *et al.* (2016) in *Xeranthemum annuum* L. from Serbia and by Gavrilović *et al.* (2020) in *Amphoricarpos neumayerianus* (Vis.) Greuter from Montenegro, respectively. On the other hand, Celik *et al.* (2008) and Ozcan *et al.* (2014) described scattered medullary vascular bundles in a circular manner in the stem of some *Centaurea* taxa.

The internal secretory systems are useful for taxonomic evaluations (Appezzato-Da-Glória *et al.* 2008). In the present study, we determined secretory canals of varying diameters in the stem cortex close to the vascular bundles of the examined taxa. The secretory canals were found in the cortex or the endodermis region associated with the vascular bundles. According to Tetley (1925) and Williams (1954), since secretory canals are so close to the phloem, they probably aid the sieve tube in the transfer of organic material. Sizogenous secretory ducts/canals have been reported in the stem anatomies of many members of Asteraceae (Metcalfe & Chalk 1950; Milan *et al.* 2006; Kadereit & Jeffrey 2007; Inceer & Ozcan 2011) like that of the leaves. They have the same features as previously described for the foliar blade of *Tripleurospermum* taxa (Inceer & Ozcan 2011). Similar results have previously been reported in other members of *Tripleurospermum* (Uysal 1991; Inceer & Ozcan 2021) and *Tanacetum* taxa (Tekin & Kartal 2016).

Inceer & Ozcan (2021) noticed that certain anatomical variations such as stomata, phloem, xylem and vascular bundles in the leaf as well as palisade sclerenchyma in the achene were associated with ploidy levels in *Tripleurospermum*. Similarly, the present results show that the length and width of the bundle sheath cell, xylem thickness, and trachea size in the stem are associated with ploidy levels in *Tripleurospermum*. Some polyploid species of *Tripleurospermum,* such as *T. corymbosum* (3*x*), *T. repens* (4*x*) and *T. sevanense* (4*x*), often grow in semi-arid and wet environments. The variations in these anatomical characters in polyploids may play an important role in the efficient transport of water to organs above ground.

The wide range of geographical distributions and the diversity of habitats such as disturbed meadows, vacant lots, areas alongside roads and railroads, waste and dry areas in which *Matricaria* occurs may result in different adaptations to diverse environments (Inceer 2011). Our results indicate that *M. aurea* has smaller conductive elements than the other examined *Matricaria* taxa due to less efficient water transport in its dry habitat, namely water deficiency, high temperature, intense radiation, sands and stony soil. Similarly, the leaf mesophyll is the narrowest in *M. aurea* (Inceer & Ozcan 2011). These anatomical traits in the leaf and stem of this species can prevent water loss in the adaptation to arid environments.

Inceer *et al.* (2018) reported that the genera *Matricaria* and *Tripleurospermum* appeared well separated in different and supported clades based on molecular phylogeny. In addition, both genera are separated from each other based on the anatomical characters of their leaves and achenes (Inceer & Ozcan 2021). Unlike molecular phylogeny, multivariate analyses show no delimitation of these genera based on the quantitative anatomical characters of the stem in terms of similar anatomical traits. It is thus concluded that the stem anatomical structure cannot be used as a marker between phylogenetic lineages.

CONCLUSIONS

The stem anatomical structures of *Matricaria* and *Tripleurospermum* are similar to each other as are their stem morphologies. This anatomical uniformity indicates close relationships among the taxa examined. Therefore, it is difficult to separate both genera based on stem anatomy. On the other hand, *Matricaria* taxa display more or less average values in all the quantitative data, whereas *Tripleurospermum* taxa have the highest and the lowest values. Despite the fact that the stem structure in *Matricaria* and *Tripleurospermum* has a low taxonomic value, the variations in some of the stem characteristics such as conductive elements, chlorenchyma, and indumentum, could play an important role in the adaptation to the diverse environments of some taxa of these genera.

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REZIME

Botanica SERBICA

Anatomija stabljika rodova *Matricaria* i *Tripleurospermum* (Asteraceae) iz Turske sa svojim taksonomskim i ekološkim implikacijama

Melahat Ozcan i Huseyin Inceer

Uporedna anatomska studija stabljika 32 taksona u okviru dva srodna roda; *Matricaria* (4 taksona) and *Tripleurospermum* (28 taksona, 30 uzoraka), sprovedena je na materijalu iz Turske korišćenjem klaster analize (CA) i analize glavnih komponenti (PCA) za rešavanje generičke klasifikacije i razgraničenja taksona. Svi proučavani taksoni imaju sledeće karakteristike stabljike, uključujući jedan sloj epidermalnih ćelija sa retkim rasporedom trihoma bez žlezda, korteks sastavljen od ćelija kolenhima i hlorenhima koje menjaju segmente jedni u drugima, nekoliko šizogenih sekretornih kanala u blizini snopića, jajolike do duguljaste i otvorene kolateralne vaskularne snopiće koji su raspoređeni u jedan prsten i promenljive su veličine, i parenhimatoznu srž. Razlike među taksonima su uglavnom u debljini ksilema u vaskularnom snopiću, dužini epidermalnih ćelija i veličini ćelije srži. Taksonomske i ekološke vrednosti anatomskih karakteristika razmatraju se u svetlu trenutnog okvira.

Ključne reči: Compositae, kamilice, numerička taksonomija