

## ***Fruit Anatomical Features of the Genus Caropodium Stapf & Wettst. ex Stapf (Apiaceae) in Türkiye***

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**ABSTRACT:** Fruit anatomy is extremely important in terms of taxonomic studies in the Apiaceae family. The genus *Caropodium*, whose taxonomic position in the family has been revealed by recent studies, is represented by 5 taxa in Türkiye. The endemism rate of the genus was recorded as 60 %. In this study, the fruit anatomy of the genus was examined in detail with the sections taken from fruit samples belonging to the taxa and evaluated in terms of both qualitative and quantitative characteristics. The general anatomical features of the species belonging to the genus are similar, all fruits are winged and there are a total of nine vascular bundles in the dorsal, lateral and vallecular regions. However, significant differences are observed in the dimensions of the mericarp, vascular bundles and vittae.

**Keywords:** Anatomy, Apiaceae, *Caropodium*, winged fruit.

### ***Türkiye'de Caropodium Stapf & Wettst. ex Stapf (Apiaceae) Cinsinin Meyve Anatomik Özellikleri***

**ÖZ:** Meyve anatomisi, Apiaceae ailesinde taksonomik çalışmalar açısından son derece önemlidir. Son yıllarda yapılan çalışmalar sonucunda familyadaki taksonomik yeri tam anlamıyla ortaya konabilmiş olan *Caropodium* cinsi, Türkiye'de 5 takson ile temsil edilir. Cinsin endemizm oranı % 60 olarak kaydedilmiştir. Bu çalışmada, taksonlara ait meyve örneklerinden alınan kesitlerle cinsin meyve anatomisi ayrıntılı olarak incelenmiş, hem kalitatif hem de kantitatif özellikler açısından değerlendirilmiştir. Cinsine ait türlerin genel anatomik özellikleri benzer olup, tüm meyveler kanatlıdır ve dorsal, lateral ve vallecular bölgelerde toplam 9 iletim demeti bulunmaktadır. Fakat mericarp, iletim demetleri ve yağ kanallarının boyutlarında belirgin farklılıklar göze çarpmaktadır.

**Anahtar Kelimeler:** Anatomi, Apiaceae, *Caropodium*, kanatlı meyve.

## INTRODUCTION

One of the most important classifications of the Apiaceae which is generally based on fruit anatomy, was made by Drude (1898), who divided the family in three subfamilies as Apioideae, Saniculoideae and Hydrocotyloideae. However, in many of the recent phylogenetic studies, the classification of the family has been modified (Pimenov and Leonov 1993, Downie *et al.*, 1996; Downie and Katz-Downie 1996; Plunkett *et al.*, 1996; Plunkett and Downie, 1999). According to the latest studies, there are four accepted subfamilies namely Apioideae, Saniculoideae, Azorelloideae and Mackinlayoideae (Heywood *et al.*, 2007). There are also many studies about the taxonomic hierarchy of the genus (Bornmueller, 1906; Koso-Poljansky, 1915; Schischkin, 1923; Tamamschian, 1968; Tamamschian and Vinogradova, 1969; Vinogradova, 1970; Hedge and Lamond, 1972; Vinogradova, 1995). *Caropodium* Stapf et Wettst. was initially established as a new genus in 1886 (Stapf and Wettstein 1886). Later it was considered as a subgenus under genus *Grammosciadium* DC. sl. (Tamamschian and Vinogradova 1969a, b, 1970, Vinogradova, 1995). According to a recent phylogenetic study, this taxon was again increased to genus level (Bani *et al.*, 2016; Koch *et al.*, 2017). The genus is represented by five taxa namely *C. haussknechtii* (Boiss.) Schischkin, *C. pterocarpum* subsp. *pterocarpum* (Boiss.) Schischkin, *C. pterocarpum* subsp. *sivasicum* (Bani) Bani & M.A.Koch, *C. pterocarpum* subsp. *bilgii* (Bani) Bani & M.A.Koch and *C. platycarpum* (Boiss. & Hausskn.) Schischkin (Hedge and Lamond, 1972; Koch *et al.*, 2017).

All taxa of the genus have winged fruits. Presence, size and location of the mericarp wings, have been accepted as diagnostic characters in Apiaceae by many researchers (Pimenov and Leonov, 1993; Liu *et al.*, 2006; Liu *et al.*, 2007; Calvino *et al.*, 2008). There are also several studies including fruit anatomy which indicate the importance of other fruit anatomical characters besides mericarp wings

for taxonomy of the Apiaceae (Van Wyk and Tilney, 1994; Menemen and Jury, 2001; Khajepiri *et al.*, 2010; Akalın Uruşak and Kızırlarlan, 2013; Özdemir and Kültür, 2014; Yeşil and Akalın, 2014). Yembaturova *et al.* (2010) studied the fruit morphology and anatomy of the genus *Alepidea* Delaroché (Apiaceae, subfamily Saniculoideae) and emphasized that surface sculpture and the presence of regular vittae are taxonomically valuable. In another study, Akalın Uruşak and Kızırlarlan (2013) compared 27 *Ferulago* species using fruit anatomical characters such as size, shape, location or number of vittae and clarity and size of winged or smooth dorsal ribs. Furthermore, Çil (2010) studied anatomy and morphology of the *Heracleum* L. (Apiaceae) and indicated the importance of the size of mericarps, vascular bundles, wings and vittae.

Because fruit anatomy is important in the taxonomy of Apiaceae, in this study, the detailed fruit anatomy of *Caropodium* was investigated using both qualitative and quantitative characters.

## MATERIALS and METHODS

Fruits were collected from natural habitats between 2014 and 2016 from different localities of Türkiye (Ulusoy *et al.*, 2017). After the dry fruits were kept in hot water and softened, they were sectioned via Thermo Shandon Finesse325 microtome from their middle using the paraffin embedding method (Johansen, 1944). The slices were dyed using the double staining technique with safranin and fast green (Algan, 1981). The slices were then photographed with a Leica DFC295 camera attached to a Leica DM3000 microscope. All the measurements were gathered from three different fruits and 10 different slices of each. For each character, a minimum of 30 values were obtained to calculate average values. The terminology for the characters is described in previous studies (Tamamschian and Vinogradova, 1969; Kızırlarlan-Hançer and Akalın-Uruşak, 2017; Kljuykov *et al.*, 2004). Some data from a previous master's thesis were revised and used in this study (Ulusoy, 2017).

## RESULTS and DISCUSSION

It was clearly seen that all the taxa belonging to the genus have winged, homomorphic fruits. In addition, there are totally 9 vascular bundles; 3 of which are dorsally, 2 of which are laterally and 4 of which are vallecularly located in the fruits' transverse sections (Figure 1). Tamamschian and Vinogradova (1969) studied the detailed fruit anatomy by discussing the qualitative characters of *C. haussknechtii*, *C. platycarpum* and *C. pterocarpum*. In this study, the fruit anatomy of *C. pterocarpum* subsp. *sivasicum* and subsp. *bilgilitii* are discussed with both the qualitative and quantitative characters for the first time. In each taxon of the genus, the width of the dorsal and lateral vascular bundles were found to be greater than their length. Moreover, on the continuation of the lateral vascular bundles of these taxa, there are wings of different length (Table 1). Liu *et al.* (2006) discussed the genera of Apiaceae according to the location of the wings. Moreover, Calvino *et al.* (2008) grouped the fruits of the family into three types according to the development of the wings. From these points of view, the mericarps of the genus *Caropodium* have apparently two marginal wings, with a vascular bundle at the base of each. Also the wings include the exocarp and mesocarp, but not endocarp.

It is obviously seen from the sections that a single-row epidermis layer is surrounded by a thick cuticle at the outermost. Epidermal cells can be observed more clearly in *C. pterocarpum* compared to the other taxa. Under the epidermis, there are vascular bundles and vittae located dorsally, laterally and vallecularly. Between epidermal cells and the dorsal vittae there are 2-4 layered chlorenchyma cells in each mericarp. Also funiculus, clearly distinguished carpophore and commissural vittae are located in the region where the two mericarps are placed opposite each other for each fruit of the taxa. In each mericarp of the taxa there is a small vascular bundle in the funicular region. There are also funicular vittae in the mericarps of *C. platycarpum* and *C.*

*pterocarpum* subsp. *sivasicum*. The pericarp layer ends with a single row of endepidermis cells innermost. Moreover, the endosperm is surrounded by the epithegma and the fragmented integumentary layer. In a morphological and anatomical study, Yeşil and Akalın (2014) indicate crystals in the endosperm of *Lecokia cretica* (Apiaceae) mericarps. Crystals also have been found in the sections of the mericarps of *C. platycarpum* and *C. pterocarpum* subsp. *pterocarpum* in this study.

In general, while the vittae located on dorsal and lateral vascular bundles are orbicularly shaped, the vallecular vittae that are located under the vallecular bundles are elliptically shaped. This property can be seen easily from the measurements such that the width / length ratio of the dorsal vittae is close to 1. However, the width of the vallecular vittae is much greater than their length (Table 1). In addition, there are two vittae in the commissural area of each mericarp. Yılmaz and Tekin (2013) evaluated the anatomical and palynological properties of two species from the family Apiaceae and pointed out the resemblance of vittae numbers, but differences of their sizes in each taxon. When evaluated in this way, it is clear that the smallest dimensions of the vallecular vittae are observed in the mericarps of *C. haussknechtii*, whereas the largest dimensions are in the mericarps of *C. platycarpum* and *C. pterocarpum* subsp. *bilgilitii* (Table 1).

Khajepiri *et al.* (2010) studied the fruit anatomy of *Pimpinella* taxa in Iran and emphasized diagnostic characters such as the sizes of mericarp, endosperm, vascular bundles and the number of vascular bundles and vittae. In the sections of the mericarps of *Caropodium*, it is obvious that the taxa with the thinnest endosperms are *C. pterocarpum* subsp. *pterocarpum*, subsp. *sivasicum* and subsp. *bilgilitii*. However, these three taxa have the largest mericarps and the smallest mericarp is in *C. haussknechtii*. Also *C. haussknechtii* has the least width of commissural area and the least distance between the dorsal vittae. Menemen and Jury (2001) studied the macromorphology and

anatomy of some taxa in Apiaceae and indicated the importance of wing length and the number of dorsal vittae. The longest wings were measured in

the mericarps of *C. pterocarpum* subsp. *pterocarpum*, subsp. *sivasicum* and subsp. *bilgiliti* in this study.

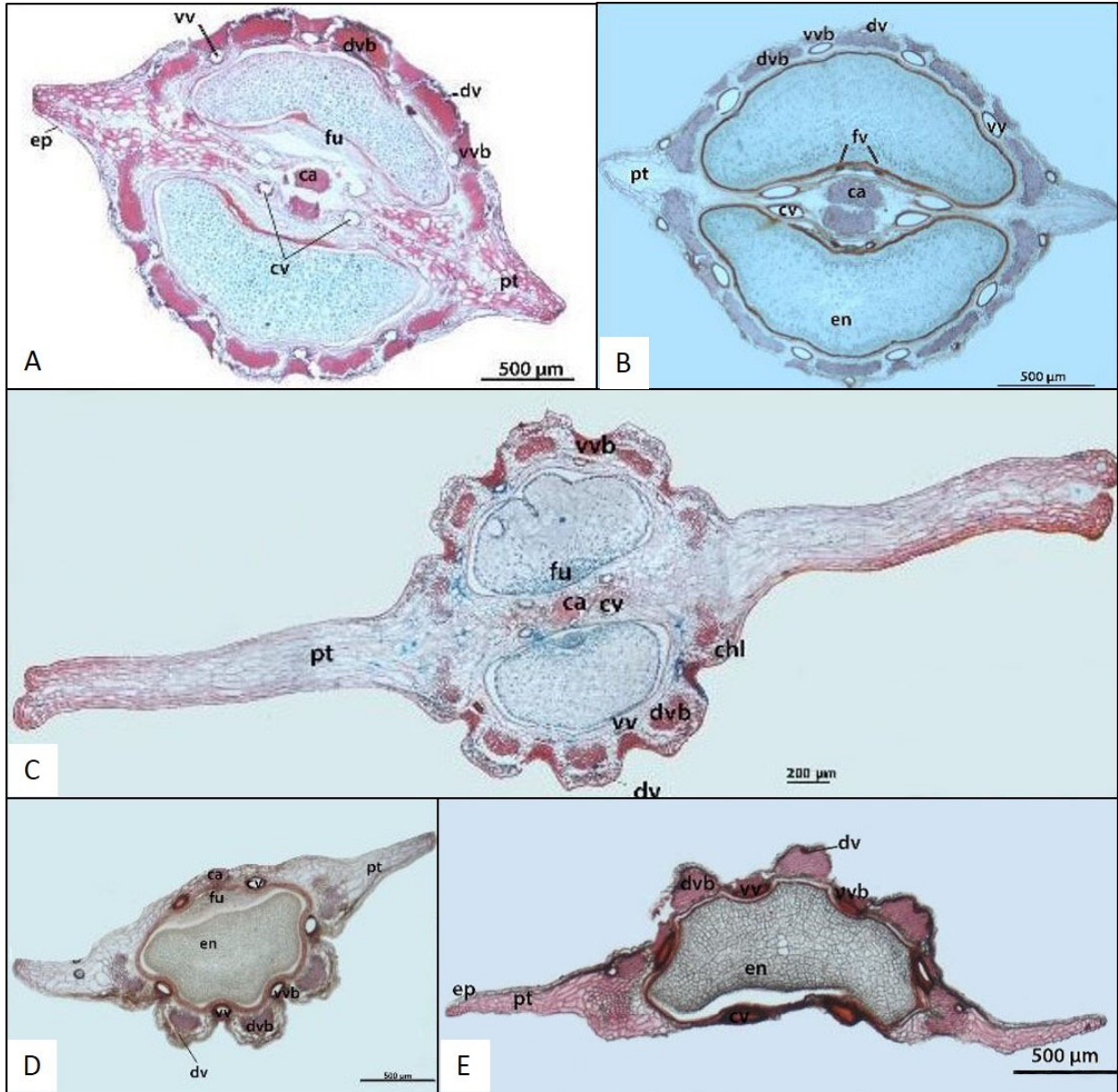


Figure 1. Fruit cross sections of the genus *Caropodium* A) *C. haussknechtii* B) *C. platycarpum* C) *C. pterocarpum* subsp. *pterocarpum* D) *C. pterocarpum* subsp. *sivasicum* E) *C. pterocarpum* subsp. *bilgiliti* ca: carpophore, chl: chlorchyma, cv: commissural vitta, dv: dorsal vitta, dvb: dorsal vascular bundle, en: endosperm, end: endepidermis, ep: epidermis, ept: epitegma, fu: funiculus, fv: funicular vitta, int: fragmented integument, pt: pterenchyma, vv: vallecular vitta, vvb: vallecular vascular bundle.

Şekil 1. *Caropodium* cinsinin meyve kesitleri A) *C. haussknechtii* B) *C. platycarpum* C) *C. pterocarpum* subsp. *pterocarpum* D) *C. pterocarpum* subsp. *sivasicum* E) *C. pterocarpum* subsp. *bilgiliti* ca: karpafor, chl: klorenkima, cv: kommisural vitta, dv: dorsal vitta, dvb: dorsal iletim demeti, en: endosperm, end: endepidermis, ep: epidermis, ept: epitegma, fu: funikulus, fv: funikular vitta, int: parçalı integüment, pt: pterenkima, vv: vallekular vitta, vvb: vallekular iletim demeti.

Table 1. Some measurements from fruit cross sections of the genus (mm).  
Çizelge 1. Cinsin meyve kesitlerinden bazı ölçümler (mm).

Measured parameter Ölçülen parametre	<i>C.</i> <i>haussknechtii</i>	<i>C.</i> <i>platycarpum</i>	<i>C. pterocarpum</i> subsp. <i>pterocarpum</i>	<i>C. pterocarpum</i> subsp. <i>sivasicum</i>	<i>C.</i> <i>pterocarpum</i> subsp. <i>bilgilitii</i>
Dorsal bundle width Dorsal demet eni	0.29 ± 0.013	0.28 ± 0.110	0.21 ± 0.056	0.22 ± 0.015	0.25 ± 0.015
Dorsal bundle length Dorsal demet boyu	0.08 ± 0.012	0.09 ± 0.011	0.08 ± 0.038	0.12 ± 0.033	0.16 ± 0.053
Lateral bundle width Lateral demet eni	0.32 ± 0.007	0.30 ± 0.083	0.26 ± 0.101	0.28 ± 0.036	0.26 ± 0.021
Lateral bundle length Lateral demet boyu	0.05 ± 0.009	0.12 ± 0.014	0.08 ± 0.044	0.11 ± 0.012	0.17 ± 0.037
Width of commissure area Kommissural alanın eni	0.05 ± 0.004	0.18 ± 0.037	0.14 ± 0.069	0.16 ± 0.016	0.13 ± 0.018
Vallecule length (with vittae) Vallekül boyu (demetle birlikte)	0.08 ± 0.006	0.22 ± 0.066	0.13 ± 0.047	0.11 ± 0.017	0.91 ± 0.011
Distance between dorsal vittae Dorsal damarlar arası mesafe	0.11 ± 0.029	0.40 ± 0.087	0.53 ± 0.157	0.49 ± 0.056	0.53 ± 0.031
Endosperm width Endosperm eni	1.43 ± 0.013	1.41 ± 0.081	1.14 ± 0.403	1.24 ± 0.019	1.23 ± 0.018
Endosperm length Endosperm boyu	0.47 ± 0.014	0.58 ± 0.029	0.59 ± 0.147	0.84 ± 0.141	0.50 ± 0.017
Dorsal vitta (oil duct) length Dorsal vitta (yağ kanalı) boyu	0.02 ± 0.069	0.04 ± 0.021	0.03 ± 0.011	0.03 ± 0.007	0.03 ± 0.004
Dorsal vitta (oil duct) width Dorsal vitta (yağ kanalı) eni	0.02 ± 0.003	0.04 ± 0.017	0.02 ± 0.013	0.03 ± 0.007	0.02 ± 0.005
Vallecular vitta width Vallekular vitta eni	0.06 ± 0.009	0.13 ± 0.023	0.10 ± 0.036	0.10 ± 0.008	0.13 ± 0.014
Vallecular vitta length Vallekular vitta boyu	0.02 ± 0.003	0.08 ± 0.015	0.04 ± 0.019	0.05 ± 0.008	0.04 ± 0.006
Mericarp width (without wing) Merikarp eni (kanat hariç)	2.16 ± 0.017	2.23 ± 0.039	3.50 ± 1.806	2.27 ± 0.035	2.37 ± 0.022
Mericarp length Merikarp boyu	0.65 ± 0.014	1.13 ± 0.031	1.00 ± 0.294	1.18 ± 0.027	0.83 ± 0.039
Integument thickness İntegüment kalınlığı	0.02 ± 0.004	0.03 ± 0.012	0.02 ± 0.006	0.03 ± 0.002	0.19 ± 0.003
Wing length (between the tip of the wing and the last vascular bundle) Kanat boyu (kanat ucu ile son iletim demeti arası)	0.48 ± 0.060	0.48 ± 0.046	1.09 ± 0.592	0.72 ± 0.025	0.69 ± 0.025
Number of vascular bundles İletim demeti sayısı	9	9	9	9	9

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