Comparative Studies Based on Fruit Anatomy and Palynology of the Genus *Heptaptera* (Apiaceae) in Turkey

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**Abstract**—The aim of the present study is to contribute to the classification of the genus *Heptaptera* using pollen and mericarp features. This genus is represented by five species in Turkey. The *Heptaptera* species, which grow naturally in Turkey, were investigated comprehensively in terms of fruit anatomy and palynology. Anatomical and palynological features of *Heptaptera cilicica*, *Heptaptera anisoptera*, *Heptaptera anatolica*, *Heptaptera triqueta*, and *Heptaptera syriaca* were investigated. Anatomical characters are very important for distinguishing closely related species and genera, especially in the family Apiaceae. The anatomy of Apiaceae fruits varies even among closely related species in the same genus.

In anatomical studies, cross-sections of fruit have been examined. Mature mericarps of *Heptaptera* species were collected from natural habitats in Turkey. These materials were kept in 70% ethanol for use in the anatomical studies. Each mature mericarp was rehydrated and placed in formalin-acetic acid-alcohol (1:1:8) for a minimum of 24 h, and rehydrated materials were embedded into paraffin blocks following traditional paraffin sectioning methods. Transverse sections 5-10 µm thick were cut using a Thermo microtome and stained with safranin solution. Micrographs were taken using a Nikon AZ100M microscope.

The pollenmorphologies of *Heptaptera* species from Turkey have been examined by light (LM) and scanning electron microscope (SEM). The morphological characters of pollen grains were obtained by measurements and photographic observations. LM pollen preparations of the specimens set up according to the Wodehouse method were examined by using an Olympus BX 51 investigation microscope. During SEM examination of the pollen, taxonomically important micro-characters were assessed in distinguishing the taxa. Dried herbarium materials with flowers were used to obtain pollen. The pollens were mounted on stubs using double-sided adhesive tape under a stereo-microscope. For SEM studies, each pollen sample was coated five times with a 9 Å thick layer of gold by using a Poleron SC7620 Sputter Coater and scanned with Zeiss a LS-10 SEM at 20 kv accelerating voltage.

Pollen grains of *Heptaptera* species are radial symmetry and isopolar. Pollen shape is prolate or subprolate. Pollens are tricolpate, aperture is colporate, and surface ornamentation is rugulate. Colpi length (Clg) is 22-29 µm, colpi width (Clt) is 6-18 µm.

Exine thickness ranges from 0.3 µm to 2 µm. Exine is tektat. Ectexine is thicker than endexine. Intine thickness ranges from 0.3 to 1.5 µm. Fruit is dorsally compressed except for *H. syriaca*, and the mericarps of the *H. syriaca* are ventrally compressed. *H. triqueta* and *H. syriaca* have homomorphic mericarps, and *H. cilicica*, *H. anatolica*, and *H. anisoptera* have heteromorphic mericarps. Primary ribs are aliform or poorly developed wings. Wings are clearly undulate or straight. In the mature mericarp of all *Heptaptera* taxa observed, the characters of vittae are different from each other at the species level. In addition, vascular bundles in the mesocarps are located below each primary rib and surrounded by parenchyma cells.

**Keywords**—*Heptaptera*, pollen, Oenantheae, Umbelliferae.

I. INTRODUCTION

The family Apiaceae includes approximately 450 genera and 3700 species [1]. The Asian countries with the greatest Apiaceae diversity are China, Turkey, Iran, Russia, and Kazakhstan. Among these countries, Asiatic Turkey has the highest concentration of species-level Umbelliferae diversity in Asia, and probably in the world [2, 3, 4, 5, 6, 7]. Many members of the Apiaceae family are readily characterized by umbellate inflorescences, specialized fruits consisting of two mericarps (with one-seed) suspended from a split central column (carpophore), and numerous, minute epigynous flowers. The Apiaceae family is represented by 486 species of 104 genera in Turkey. These species are 37% endemic for Turkey [8]. In Turkey, with a considerably smaller area than Asia countries, Apiaceae occupies second place in our list (486 species in 104 genera) [2, 8]. There are four endemic genera in Turkey: *Aegokeras* Raf., *Ekimia* H.Duman, *Microsciadium* Boiss. and *Crenosciadium* Boiss. & Heldr. The number of endemic species is high; there are 182 species in 42 genera [2, 8, 9]. *Heptaptera* Marg. & Reut. is especially widespread in Southeastern Anatolia, Thrace, the Mediterranean and Aegean regions of Turkey. The genus is distributed in Bulgaria, Macedonia, Iran, Iraq, Syria, and Jordan. The genus *Heptaptera* is represented by 10 species in the world and 4 species in *Flora of Turkey*. The Turkish name of *Heptaptera*, “çağır” is used in the Turkey Plant List (Vascular Plants) [9]. According to our study results, *Petroedmondia syriaca* (Boiss.) Tamamsch. was transferred to *Heptaptera* genus as *Heptaptera syriaca* (Fig. 1). Based on recent arrangements the *Heptaptera* genus is represented by five species in Turkey and 11 species in the world.

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II. MATERIALS AND METHODS

During field trips between the 2012 and 2013 vegetation periods, all specimens belonging to the genus Heptaptera were collected from different localities in Turkey. The Heptaptera species, which naturally grows in Turkey, was investigated comprehensively in terms of fruit anatomy and palynology. Anatomical and palynological features of Heptaptera cillicica, Heptaptera anisoptera, Heptaptera anatolica, Heptaptera triqueta, and Heptaptera syriaca were investigated.

A. Fruit Anatomy

In anatomical studies, cross-sections of fruit have been examined. Mature mericarps of Heptaptera species were collected from natural habitats in Turkey. These materials were kept in 70% ethanol for use in anatomical studies. Each mature mericarp was rehydrated and placed in formalin-acetic acid-alcohol (1:1:8) for a minimum of 24 h, and rehydrated materials were embedded into paraffin blocks following traditional paraffin sectioning methods. Transverse sections about 5-10 µm thick were cut using a Thermo microtome, and stained with saffranin solution. Micrographs were taken using a Nikon AZ100M microscope.

B. Palynology

Palynological investigations were conducted with both light microscope and scanning electron microscope (SEM). For light microscope studies, the pollen slides were prepared by using the Wodehouse technique [10]. The descriptive terminology in Punt et al. was employed [11]. For shape classes (P/E), the definitions of Nilsson and Praglowski were used [12]. For SEM investigations, pollen grains were directly mounted on prepared stubs and coated with gold for SEM studies. Photographs were taken with a Zeiss LS-10 after being coated with a Poleron SC7620 Sputter Coater in SEM studies.

III. RESULTS AND DISCUSSION

Heptaptera species, which naturally grows in Turkey, were investigated with both light microscope and scanning electron microscope (SEM). All species of pollen were photographed with 10 x 4 magnification in the light microscope. When these images are analyzed, the Heptaptera syriaca pollens were identified as the subprolate type, while in other species the pollens were identified as perprolate. Light microscopy data support the taxonomic differences of the five Heptaptera species in Turkey. However, according to the data between the pollen ornamentation of Heptaptera species there are no extreme differences. Also, the pollens of Heptaptera species were investigated in the scanning electron microscope (SEM). According to the SEM photographs of Heptaptera species, pollen surface ornamentations are rugulate-striate at H. cillicica, whereas other species were identified as rugulate (Figs. 2-3).

Fig. 1. General view of Heptaptera syriaca.
The Turkish *Heptaptera* taxa can be separated into two groups according to the characteristics of their fruit wings (homomorphic or heteromorphic). The first group (*H. syriaca* and *H. triquetra*) has homomorphic fruit. The second group (*H. ciliarica*, *H. anatolica*, and *H. anisoptera*) has heteromorphic fruit. *H. anisoptera* and *H. syriaca* have double row circular vittae, but their morphological characters differ from each other. Although *H. ciliarica* and *H. triquetra* are close to each other in terms of morphological features, their anatomical characteristics are different. *H. syriaca* has unusual anatomical characteristics such as regularly double row circular vittae (Fig. 4).

As a consequence fruit anatomical characteristics are important for *Heptaptera* taxonomy and help clarify the differences between the species.

**REFERENCES**