Zoomorphology
Research Article

ACTA ZOOLOGICA BULGARICA
Acta zool. bulg., 70 (2), 2018: 189-194

Spermathecae Morphology in Some Species of *Tephritis* Latreille, 1804 (Diptera: Tephritidae) from Turkey: A Scanning Electron Microscope Study

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Abstract: Spermathecae of five species of *Tephritis* Latreille**,** 1804 i.e. *T. acanthiophilopsis* (Hering, 1938), *T. carmen* (Hering, 1937), *T. divisa* (Rondani, 1871), *T. hyoscyami* (L., 1758) and *T. postica* (Loew, 1844), are examined using light and scanning electron microscopy (SEM). There are two spermathecae in all studied species. Their structure is characterised by the presence of spermathecal bulb, spermathecal duct, pumping region and pores of the bulb. Spermathecal bulb in *Tephritis acanthiophilopsis*, *T. carmen* and *T. divisa* is cylindrical, corncob-like. Spermathecae of all species are J-shaped. Descriptions and illustrations of the spermathecal structures are presented for each species.

Key words: *Tephritis*, Tephritidae, Spermathecae, SEM

Introduction

The dipteran genus *Tephritis* Latreille, 1804 includes about 170 species and is the sixth largest genus of the Tephritidae and the third largest genus in the Tephritinae. Although the genus is known from all zoogeographic regions, the majority of the species (about 120) are Palaearctic (Norrbom et al. 1999, Korneyev & Dirlbek 2000).

The spermatheca usually consists of a receptaculum seminis (receptacle) and a spermathecal duct (*ductus receptaculus*), which is covered by muscle fibres. While the receptacle stores and nourishes the spermatozoa, the spermathecal duct transports spermatozoa in opposite directions, first to the receptacle at mating and then to the vagina at fertilisation. The structural organisation of the spermatheca reflects these two functions (Dallai et al. 1993). The ejection apparatus is generally located at the middle of the spermathecal ducts and it controls the passage of spermatozoa through contraction of muscle fibers (Theodor 1976, Rodriguez 1994, Pabalan et al. 1996, Yuval et al. 1996, Bloch Qazi et al. 1998, Gschwentner & Tadler 2000, Fritz & Turner 2002).

Sperm storage organs allow females to: temporally separate insemination from fertilisation, manipulate ejaculates and control fertilisation. In the reproductive tract of female fruit flies (Diptera: Tephritidae), sperm is found in two different organs: a pair or triplet of spermathecae and a "fertilisation chamber" (Twig & Yuval 2005).

Most of the Tephritoidea have two spermathecal ducts, of which the right one apically bifurcates and bears two spermathecae. In Pyrgotidae and Tephritidae there are two separate spermathecal ducts on the right side (three in total) that independently connect to the genital chamber. The apical portion of the spermathecal ducts is sometimes dilated (e.g., in Tephritinae), or may be sclerotised, giving the spermathecae the appearance of a figure 8 (e.g., *Enicoptera, Celidodacus,* some Trypetini) (Aluja & Norrbom 1999).

In general, the female reproductive system of fruit flies (Fig. 1) contains the following elements: male advertisement and courtship (consisting of olfactory, auditory and visual displays), copulation,

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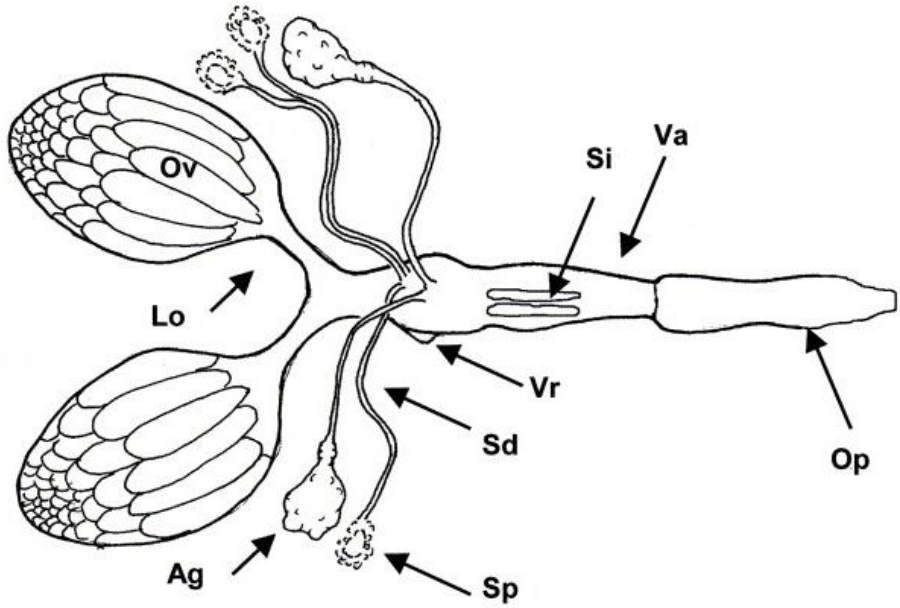

Fig. 1. Line drawing of the gross anatomical structure of the female reproductive tract including the ovaries (Ov), lateral oviducts (Lo), bursa copulatrix (Bc), ventral receptacle (Vr), spermathecae (Sp), spermathecal ducts (Sd), accessory glands (Ag), vagina (Va), signum (Si) and ovipositor (Op) (from Fritz & Turner 2002, modified).

insemination, fertilisation and oviposition (Sivinski & Burk 1989). The first three elements are usually temporally contingent but fertilisation and oviposition may take place hours, days, or even months, after insemination. Some females may mate several times throughout their lives (Prokopy & Hendrichs 1979, Saul & McCombs 1993a, b) and this life pattern significantly enhances their fitness (Whittier & Shelly 1993).

In this study, we have chosen several *Tephritis* spp., i.e. *Tephritis acanthiophilopsis* (Hering, 1938), *Tephritis carmen* (Hering, 1937), *T. divisa* (Rondani, 1871), *T. hyoscyami* (Linnaeus 1758) and *T. postica* (Loew 1844), which were collected by Kütük (2003) and Yaran (2014).

Materials and Methods

Specimens of *Tephritis*, used in the study, were collected from different regions of Turkey between 1998 and 2012. Insect materials were boiled 30-35 min in 10% KOH solution and dissected for obtaining spermathecae using light microscope Olympus SZX12. Dissected spermathecae were cleaned with 96% alcohol and stored in glycerin. Cleaned spermathecae were dehydrated with ascending alcohol series, air dried, mounted using a double-sided tape on SEM stubs, coated with gold using a EMITECH SC7620 Au/Pd and examined with a SEM operated at 10 kV. General spermathecae structure, spermathecal duct, pumping region and pores of bulb were scanned using SEM and compared for differences as systematic characters.

Results

In this study, spermathecae morphology of five species of the genus *Tephritis* were photographed using SEM and the differences between species were thoroughly studied and described. Two spermathecae were distinguished for the reproductive system of *Tephritis*. Width, length and aspect ratio are in the Table 1.

***Tephritis acanthiophilopsis* (Hering, 1938) (Fig. 2)**

End of spermathecal bulb blunt, stenosis in its central parts towards base from ends, then thickening and getting thinner again towards base. All sizes of bulges continuing regularly, completely parallel to each other, and rarely from end to base of bulb. Gland canaliculus and glands extending outward from pores, taking part at the end of digitate bulges. Spermathecal bulb "J"-shaped by flexion at its base, connected to canal. Muscle fibrils in spermathecal canal in the form of barbed wire model. General view of canal like helical structure.

***Tephritis carmen* (Hering, 1937) (Fig. 3)**

Spermathecal bulb with segmental structure, consisting of three parts. End part of the bulb thinner, sharper and oval. End part narrow, with stenosis at central part and extension from the stenosis at mid-

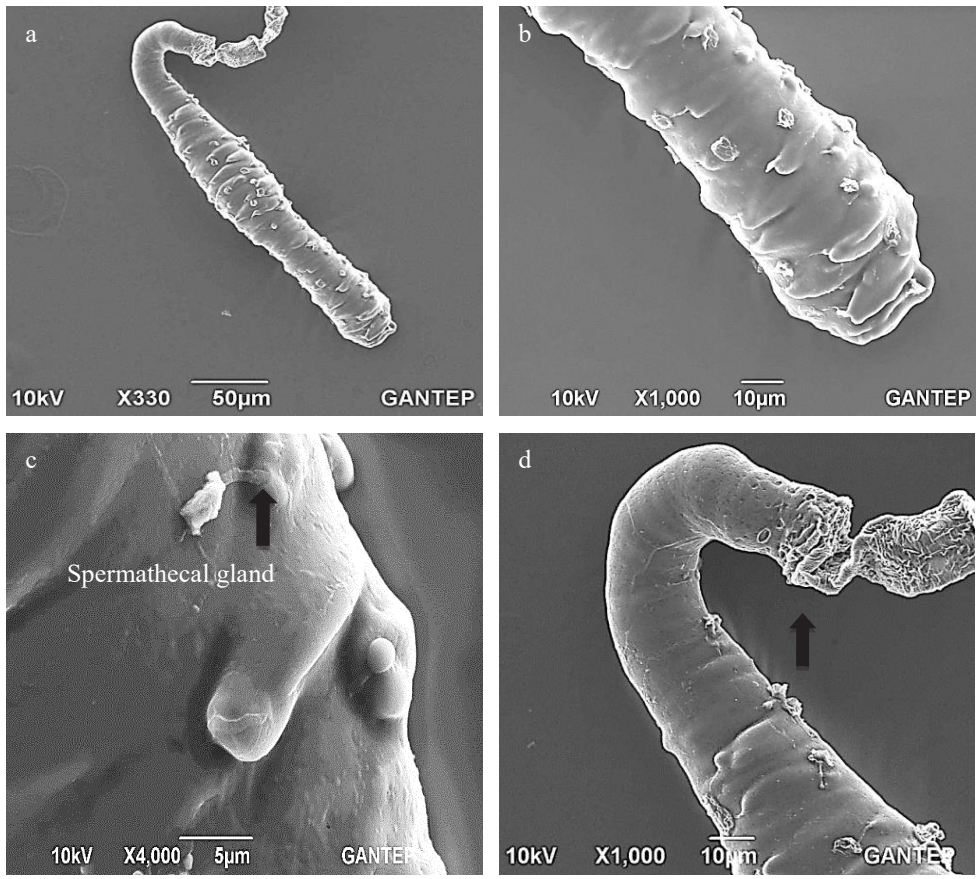

Fig. 2. SEM micrographs of spermathecae of *Tephritis acanthiophilopsis.* **a.** Spermathecal bulb and distal flange of pump. **b.** Pores on the spermathecal bulb. **C.** Spermathecal gland. **d:** Pumping region.

dle part up to base. Digitate bulges on spermathecal bulb quiet small and subclinical, irregular. Pores on bulbs at the end of bulges and surface. Base of spermathecal bulb curled and "J"-shaped. Its base part thin and connected to pumping region and canal; located around the base with irregular distribution.

***Tephritis divisa* (Rondani, 1871) (Fig. 4)**

Spermathecal bulb corncob-shaped, its end part oval and approximately the same size as base. Bulb end connected to canal by curling as "J". Digitate bulges on spermathecal bulb small, irregular, horizontal and parallel to base. There are small pores on the base surface of spermathecal bulb and seen clearly. Pumping region surrounded by muscle parallel fibrils convolved densely and similar to rope.

***Tephritis hyoscyami* (L., 1758) (Fig. 5)**

Spermathecal bulb pear-shaped with large oval end part, narrowing at base. Digitate bulges extending regularly and transversely, parallel to base from end part of the bulb to central part. Ppores at bulb bigger and more significant at the end of digitate bulges, pores on the surface less significant and small. Base of spermathecal bulb in the form of "J" and connecting with canal. Base surrounded by spongy, numerous and scattered pores. Muscle fibrils at spermathecal canal transversely parallel to each other; canal of filament-like and dense muscle fibres.

***Tephritis postica* (Loew, 1844) (Fig. 6)**

Spermathecal bulb swelled from base to end part, sharpening at the end. Pear-shaped at the end part; base "J"-shaped. Spermathecal bulb thinning sharpening; oval and with no digitate bulges at the end. Insignificant and small amount of pores at the end of digitate bulges on the surface of spermathecal bulb. Pumping region wider than canal and base part; surrounded by dense muscle fibrils, characteristic.

Discussion

Studies on the morphology of the spermathecae are increasing in recent years. However, there are not many studies about the spermathecae morphology of fruit flies. Usually they focus on economically significant species (such as *Ceratitis capitata*, *Bactrocera oleae* and *Rhagoletis cerasi*) but there are no comprehensive studies about species of the genus of *Tephritis*.

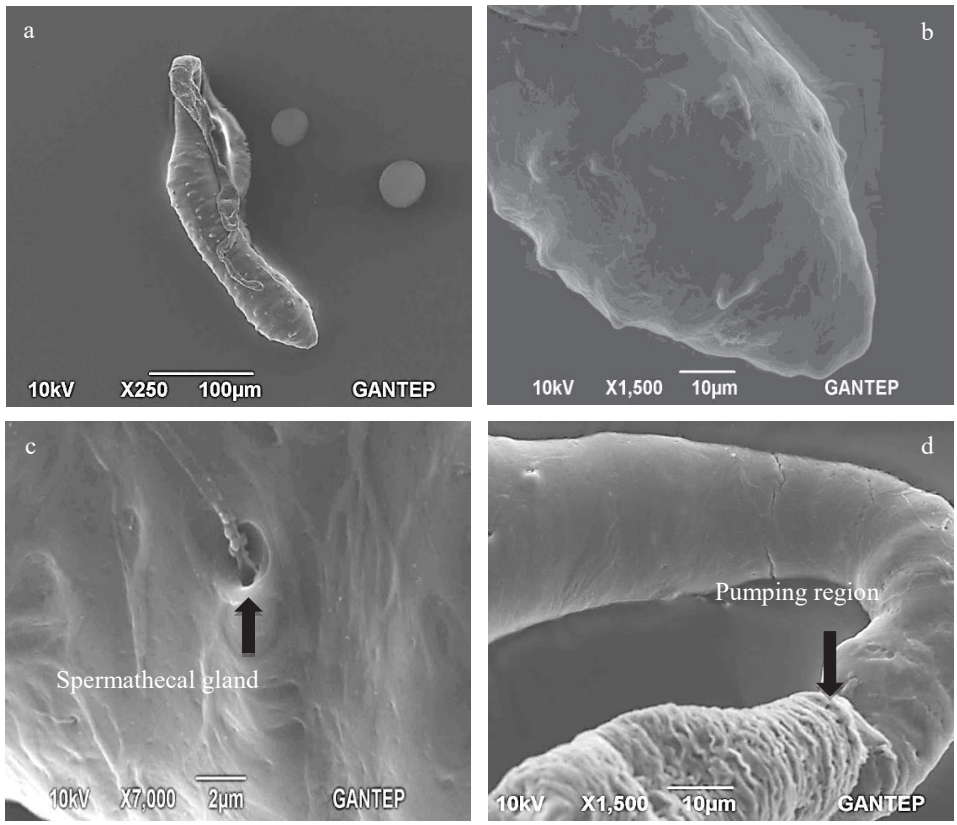

Fig. 3. SEM micrographs of the spermathecae of *Tephritis carmen.* **a.** Spermathecal bulb and distal flange of pump. **b.** Pores on the spermathecal bulb. **c.** Spermathecal gland. **d.** Pumping region.

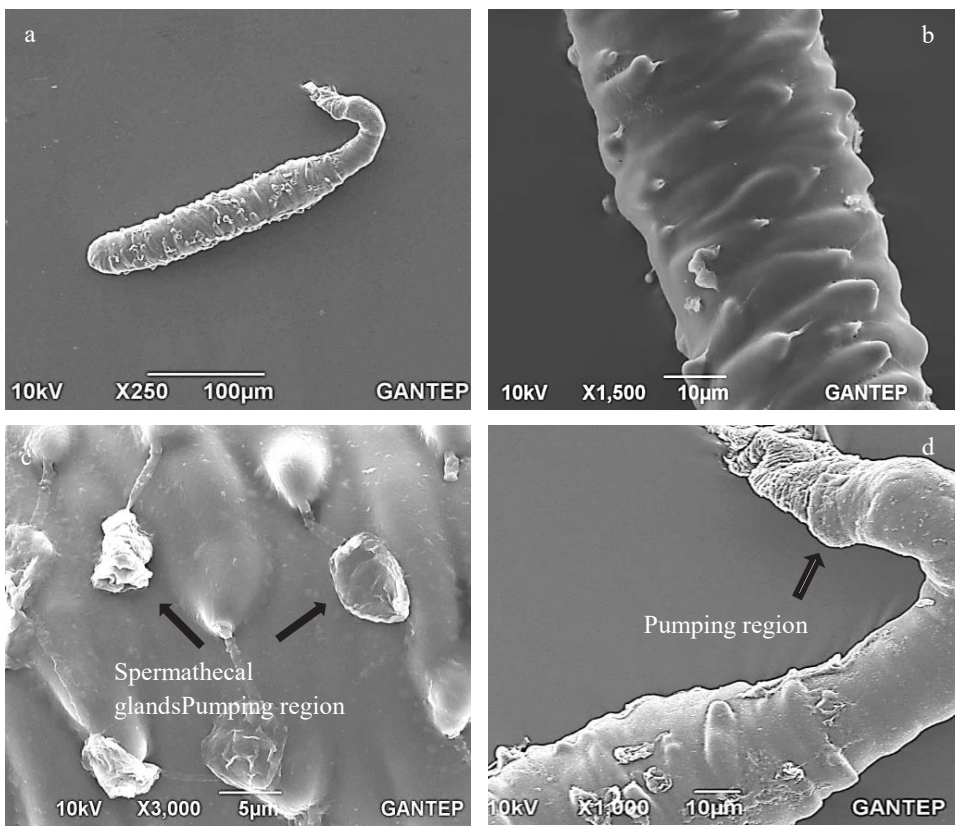

Fig. 4. SEM micrographs of the spermathecae of *Tephritis divisa*. **a.** Spermathecal bulb and distal flange of pump. **b.** Pores on the spermathecal bulb. **c.** Spermathecal gland. **d.** Pumping region.

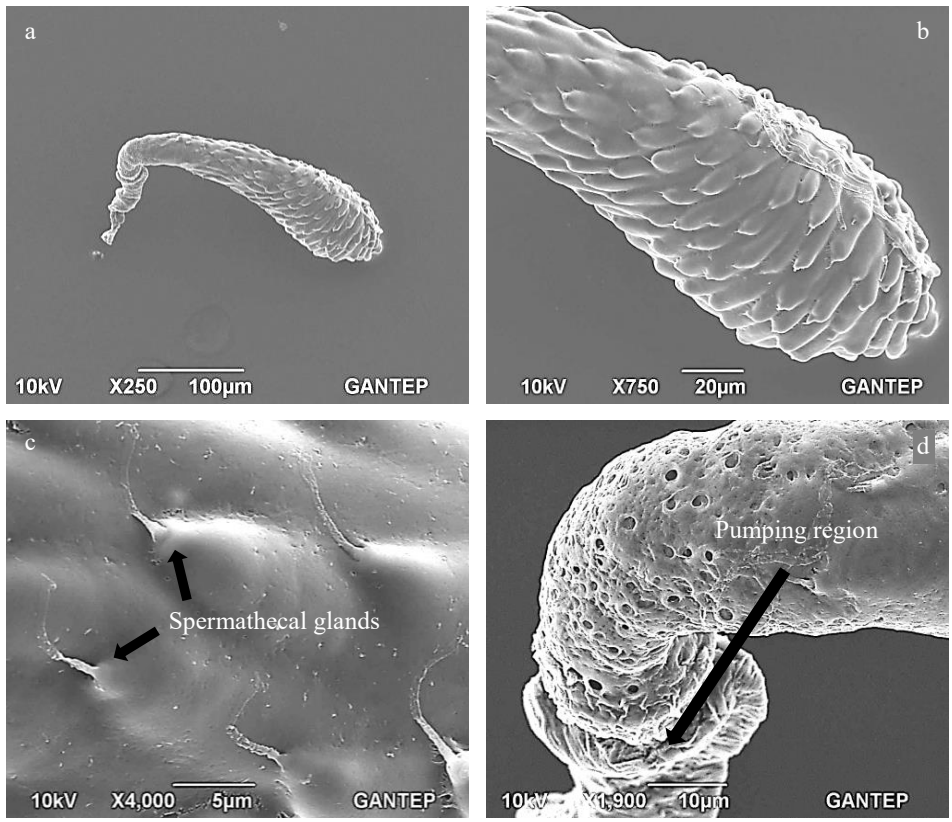

Fig. 5. SEM micrographs of the spermathecae of *Tephritis hyoscyami*. **a.** Spermathecal bulb and distal flange of pump. **b.** Pores on the spermathecal bulb. **c.** Spermathecal gland. **d.** Pumping region.

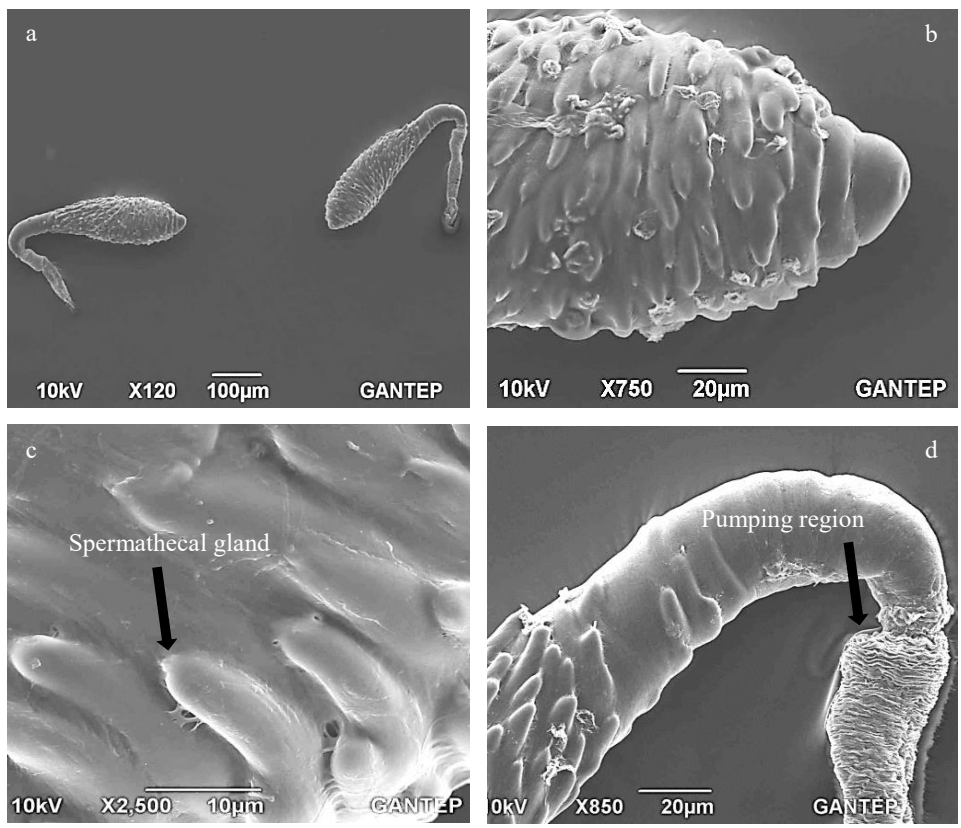

Fig. 6. SEM micrographs of the spermathecae of *Tephritis postica*. **a.** Spermathecal bulb and distal flange of pump. **b.** Pores on the spermathecal bulb. **c.** Spermathecal gland. **d.** Pumping region.

Tephritis acanthiophilopsis, *T. divisa* and *T. carmen* are morphologically separated on the basis of their spermathecae morphology compared to *T. hyoscyami* and *T. postica* (Figs 5, 6). In the former group, the overall appearance resembles corncobs (Figs 2-4) while in the latter group spermathecae are narrowing towards the base. In *T. acanthiophilopsis* and *T. carmen*, spermathecae have narrowing base and tip. In *T. divisa*, there is no narrowing. The aspect ratio in *T. acanthiophilopsis* and *T. carmen* is 0.17 and that in *T. divisa* is 0.19 (Table 1).

Spermathecal canal structures of *T. hyoscyami* and *T. postica* are similar to each other and the parallel cross is covered with dense muscle fibres. *Tephritis hyoscyami* is easily distinguished from *T. postica* owing to its characteristic dense pores around the base. The aspect ratio of these two species is 0.23 (Table 1).

These results demonstrate how the characters of spermathecae in *Tephritis* spp. can be used to classify species belonging to the genus.

Acknowledgements. We thank Gaziantep Scientific Research Projects Department (BAP) for all the support (Project Number: FEF 12.18.). We also thank to Dr. Selami Candan (Gazi University, Science Faculty, Department of Biology, Ankara, Turkey) for useful critical comments on an early version of this manuscript. This study is a part of the second author's MSc thesis.

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Received: 27.02.2017
Accepted: 03.07.2017