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Surface Morphology of Spermatheca Structure In Some *Terellia* Rob-Des (Diptera: Tephritidae) Species: A Scanning Electron Microscope Study

Murat KÜTÜK[1], Esra DOĞAN[2]
Department of Biology, Faculty of Science and Arts, Gaziantep University, Gaziantep, Turkey
[1]https://orcid.org/0000-0003-1567-1002, [2]https://orcid.org/0000-0003-0267-2700
✉: mkutuk@gantep.edu.tr

ABSTRACT

Spermatheca structures of 6 species [*Terellia fuscicornis* (Loew, 1844), *T. longicauda* (Meigen, 1838), *T. luteola* (Wiedemann, 1830), *T. nigripalpis* Hendel, 1927, *T. serratulae* (Linneaus, 1758) and *T. virens* (Loew, 1846)] belonging to genus *Terellia* Robineau - Desvoidy (Diptera: Tephritidae) were photographed with scanning electron microscopy (SEM). Obtained figures were examined and ultrastructure of the spermatheca for each species were described and differences between species were discussed. Also SEM micrographs of each species were presented.

Research Article

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Bazı *Terellia* Rob-Des (Diptera: Tephritidae) Türlerinde Spermateka Yapılarının Yüzey Morfolojisi: Bir Elektron Mikroskop Çalışması

ÖZET

Terellia Robineau - Desvoidy (Diptera: Tephritidae) cinsine ait 6 türün [*Terellia fuscicornis* (Loew, 1844), *T. longicauda* (Meigen, 1838), *T. luteola* (Wiedemann, 1830), *T. nigripalpis* Hendel, 1927, *T. serratulae* (Linneaus, 1758) and *T. virens* (Loew, 1846)] spermateka yapıları taramalı elektron mikroskobu (SEM) ile fotoğraflanmıştır. Elde edilen görüntüler incelenmiş ve çalışılan her türün spermateka yapısının ultra yüzey yapısı tanımlanmış ve türler arasındaki farklar tartışılmıştır. Ayrıca bu makalede her bir türün SEM görüntüleri sunulmuştur.

Araştırma Makalesi

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INTRODUCTION

Spermatheca (receptaculum seminis) is opened to anterior portion of the oviduct of the female insects which is an ectodermal gland. The spermatheca has many functions e.g.: fertilization, sperm storage, copulation, oviposition (Kocorek and Danielczok-Demska, 2002). After mating, spermatheca save and also to feed the sperms until fertilization process with using energy to keep alive sperms (Pabalan et al., 1996). Sperm storage period could be change in different insects, from hours to months except some species, especially honey bees it may be stored in the spermatheca for years (Candan et al., 2014).

Female genitalia tract in *Terellia* species (ovarian, spermatheca and auxiliary glands) extends over the entire abdomen and there are two of spermatheca which are generally located within 4 or 5 segments of abdomen. And it usually consists of three different parts which are spermathecal bulb (reservoir), pumping region (intermediate part), spermathecal duct (ductus recepteculi) (Pluot and Lis, 2008).

Morphology and surface structure of spermatheca of a variety of *Terellia* species have been reported by many researches using light microscope. Recently, Kütük et al., (2017) have given some information about surface morphology of spermatheca in some *Terellia* species [*T. colon* (Meigen, 1826), *T. gynaecochroma* (Herring, 1937), *T. quadratula* (Loew, 1869) and *T. ruficauda* (Fabricius, 1794)] which examined using SEM.

In this paper, six species of *Terellia* [*T. fuscicornis* (Loew, 1844), *T. longicauda* (Meigen, 1838), *T. luteola* (Wiedemann, 1830), *T. nigripalpis* Hendel, 1927, *T.*

serratulae (Linneaus, 1758) and *T. virens* (Loew, 1846)] were chosen which have hyaline wing pattern.

MATERIAL and METHOD

Six species of *Terellia* (*T. fuscicornis*, *T. longicauda*, *T. luteola*, *T. nigripalpis, T. serratulae* and *T. virens*) dissected for spermatheca strucutres which were collected different regions of Turkey (Table 1) and deposited entomology laboratory of Gaziantep University.

Table 1. Taxa, collection locations and number of specimens examined
Tablo 1. Takson, toplama lokaliteleri ve incelenen örnek sayısı

Number	Species	Location	Specimens examined
1	*Terellia fuscicornis* (Loew,1844)	Kahramanmaraş, Göksun	5 ♀♀
2	*Terellia longicauda* (Meigen,1838)	Kahramanmaraş, Göksun	5 ♀♀
3	*Terellia luteola* (Wiedemann, 1830)	Burdur, Yeşilova	4 ♀♀
4	*Terellia nigripalpis* Hendel,1927	Kahramanmaraş, Çağlayancerit	5 ♀♀
5	*Terellia serratulae* (Linneaus, 1758)	Gaziantep, Araban	7 ♀♀
6	*Terellia virens* (Loew,1846)	Kahramanmaraş, Göksun	8 ♀♀

Specimens were treated into 10% KOH (potassium hydroxide) solution about 3- 4 days. After that, in the petri dish containing 96% ethanol, specimens dissected and spermathecal structures are removed with the help of the fine-tipped tweezers. Thereafter, obtained spermatheca were placed in glycerin. Observations were made using a stereomicroscope (Olympus SZX12). Spermatheca structures were placed on SEM stubs and dried for scanning electron microscopy (SEM) observation. Then, stubs were coated by gold/palladium (Au/Pd). Coating process practiced with the Emitech SC 7620 Sputter Coater. Then, ultrastructure of spermatheca was photographed with a Jeol 6390 LV SEM operated at 10 kV for each species. The preparation of the specimens followed Candan and Erbey, 2006

The terminologies followed for designating parts of the spermatheca were those of McAlpine (1981). Short descriptions of species have been made using by following literatures (White, 1988; Freidberg and Kugler, 1989; Yaran, 2014).

RESULTS and DISCUSSION

In this study, *Terellia fuscicornis*, *T. longicauda*, *T. luteola*, *T. nigripalpis*, *T. serratulae* and *T. virens* were dissected for the spermathecal structures and photographed surface morphology by using SEM. The morphological characteristics of spermathecal structures were described as well as the differences between species were introduced. Also, the dimensions and aspect ratios for each species' spermatheca and wing figures of each species were presented in this paper (Table 2).

Table 2. Size of spermathecal bulb in *Terellia* species (µm)
Tablo 2. Terellia türlerinde spermatekal bulb'un boyutu

Name	Spermathecal Bulb		
	Width	Length	Aspect ratio
Terellia fuscicornis	66.48	158.47	0.41
Terellia longicauda	89.21	179.53	0.49
Terellia luteola	52.69	214.30	0.24
Terellia nigripalpis	71.12	153.85	0.46
Terellia serratulae	67.11	170.47	0.39
Terellia virens	54.98	107.08	0.51

Terellia fuscicornis (Loew,1844)

Short description: Colour yellowish, resemble *Terellia serratulae*, 3th segment of antenna light or dark brown. Wing; hyaline. Measurements: Male body; 4.5-6.7 mm, wing; 3.6-5.5 mm; Female body; 6.3-10.8 mm, wing; 3.8-6.2 mm.

Spermatheca morphology: General view is pear-shaped (Figure 1 a); bulb surface presents long papillose spicules (Figures 1 a, d); apex is like a knob (Figures 1 a, b); few pores present both surface and at the end of the papillose spicules and; gland canaliculus stretched out from pores on the papillose spicules (Figures 1 c, d). Spermathecal duct: Width- 18.84, height- 204.44 µm; aspect ratio 0.09; transverse muscle fibers present regularly (Figures 1 e, f) (Figure 1).

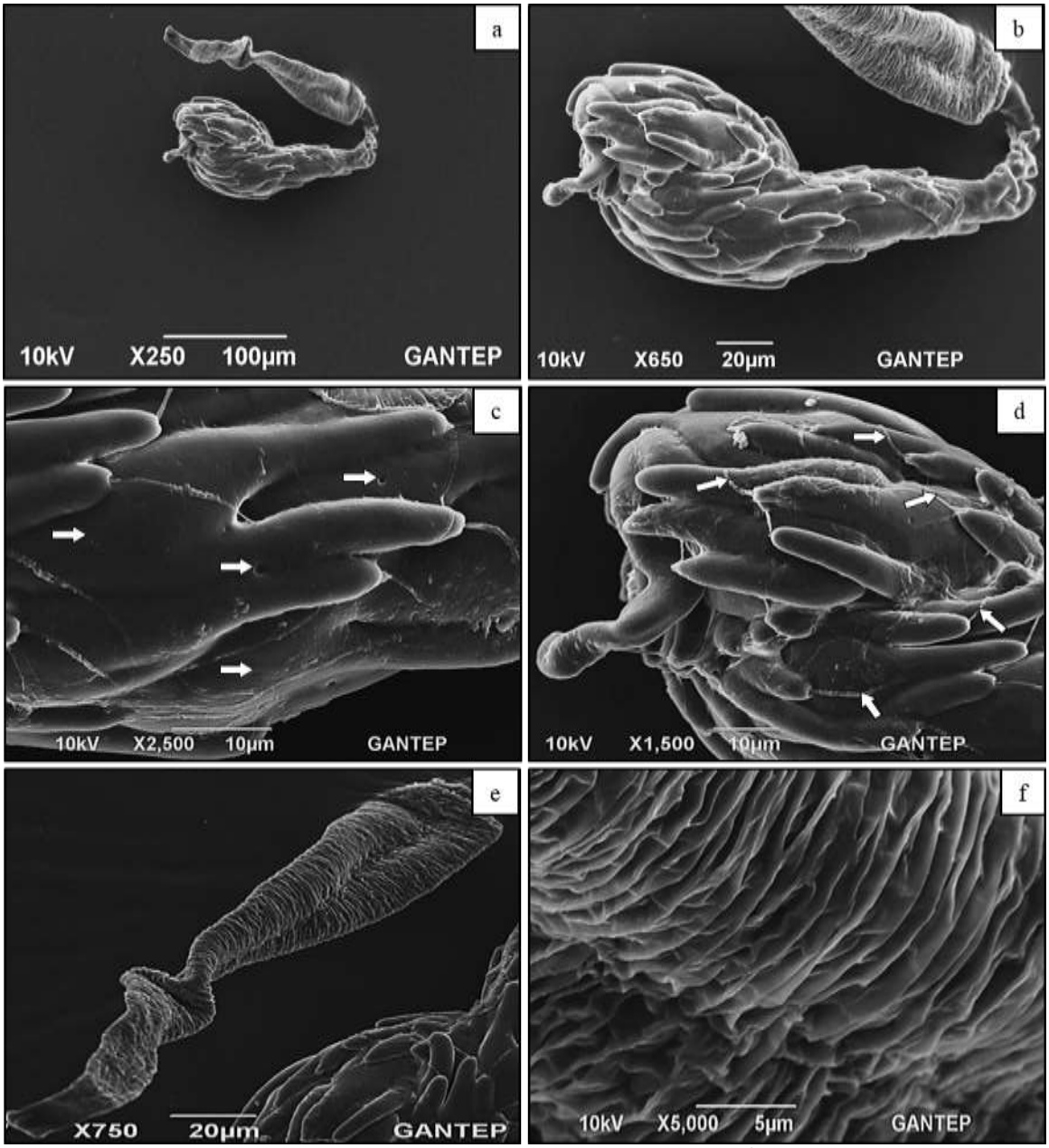

Figure 1. SEM micrographs of the spermatheca of *Terellia fuscicornis* a) General view of spermatheca, b) Spermathecal bulb, c) Pores (White arrows), d) Gland canaliculus (White arrows), e) Dilation part of spermathecal duct, f) Muscle fibers of spermathecal duct.

Şekil 1. Terellia fuscicornis'in SEM mikrografisi a) Spermateka'nın genel görünümü, b) Spermateka haznesi, c) Porlar (Beyaz oklar), d) Bez kanalcıkları (Beyaz oklar) e) Spermatekal kanalın genişleme kısmı, f) Spermatekal kanalın kas fibrilleri.

Terellia longicauda (Meigen, 1838)

Short description: Colour yellowish-green, resemble *Terellia serratulae*. Wing; hyaline, stigma yellowish. Measurements: Male body; 5.5-6.5, mm, wing; 5.1-5.9 mm; Female body; 6.3-7.2 mm, wing; 5.8-6.2 mm.

Spermatheca morphology: Spermathecal duct: Width- 23.53 µm, height- 166.56 µm; aspect ratio 0.14; General view is pear-shaped; too many long papillose spicules exist on apex and base (Figure 2 a), also they form knob-shaped structure on the apex of the bulb (Figure 2 b); apex is similar to a knob; spicules directed transversely spiral on apex (Figures 2 a, b); dense and significant pores present both at the end of the papillose spicules and on the surface (Figure 2 c); gland canaliculus reaches from pores on the papillose spicules (Figure 2 d); transverse muscle fibers present irregularly (Figure 2 f); small cavities formed on surface.

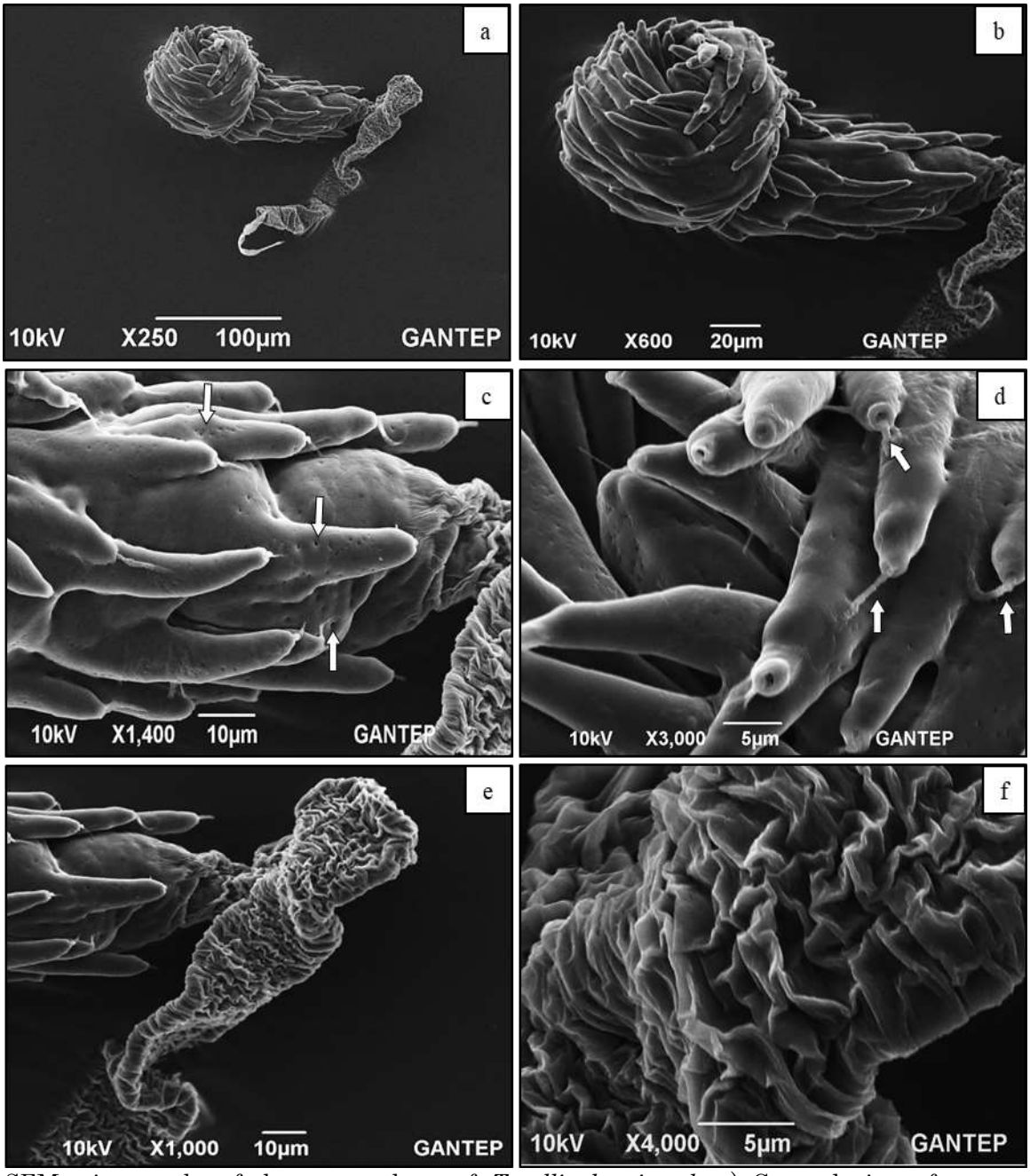

Figure 2. SEM micrographs of the spermatheca of *Terellia longicauda* a) General view of spermatheca, b) Spermathecal bulb, c) Pores (White arrows), d) Gland canaliculus (White arrows), e) Spermathecal duct, f) Muscle fibers of spermathecal duct.

Şekil 2. Terellia longicauda'nın SEM mikrografisi a) Spermateka'nın genel görünümü, b) Spermateka haznesi, c) Porlar (Beyaz oklar), d) Bez kanalcıkları (Beyaz oklar) e) Spermatekal kanal, f) Spermatekal kanalın kas fibrilleri.

Terellia luteola (Wiedemann, 1830)

Short description: Colour yellowish, 3th segment of antenna with black setulae. Wing; hyaline. Abdomen; with black setulae. Measurements: Male body; 4.6-5.1 mm, wing; 4.0-4.2 mm; Female body; 6.0-6.5 mm, wing; 3.7-4.4 mm.

Spermatheca morphology: Spermathecal duct: Width- 75.00 µm, height- 212.25 µm; aspect ratio 0.35; General view is pear-shaped; bone - shaped spicules (Figure 3 a); transverse, irregularly and densely distributed on bulb surface (Figures 2 b, d); apex is similar to a knob (Figure 2 d); pores on the spermathecal bulb are randomly distributed and in different sizes (Figures 2 c, e); some of these pores, gland canaliculus is reaches from them; transverse muscle fibers present regularly (Figure 3 f).

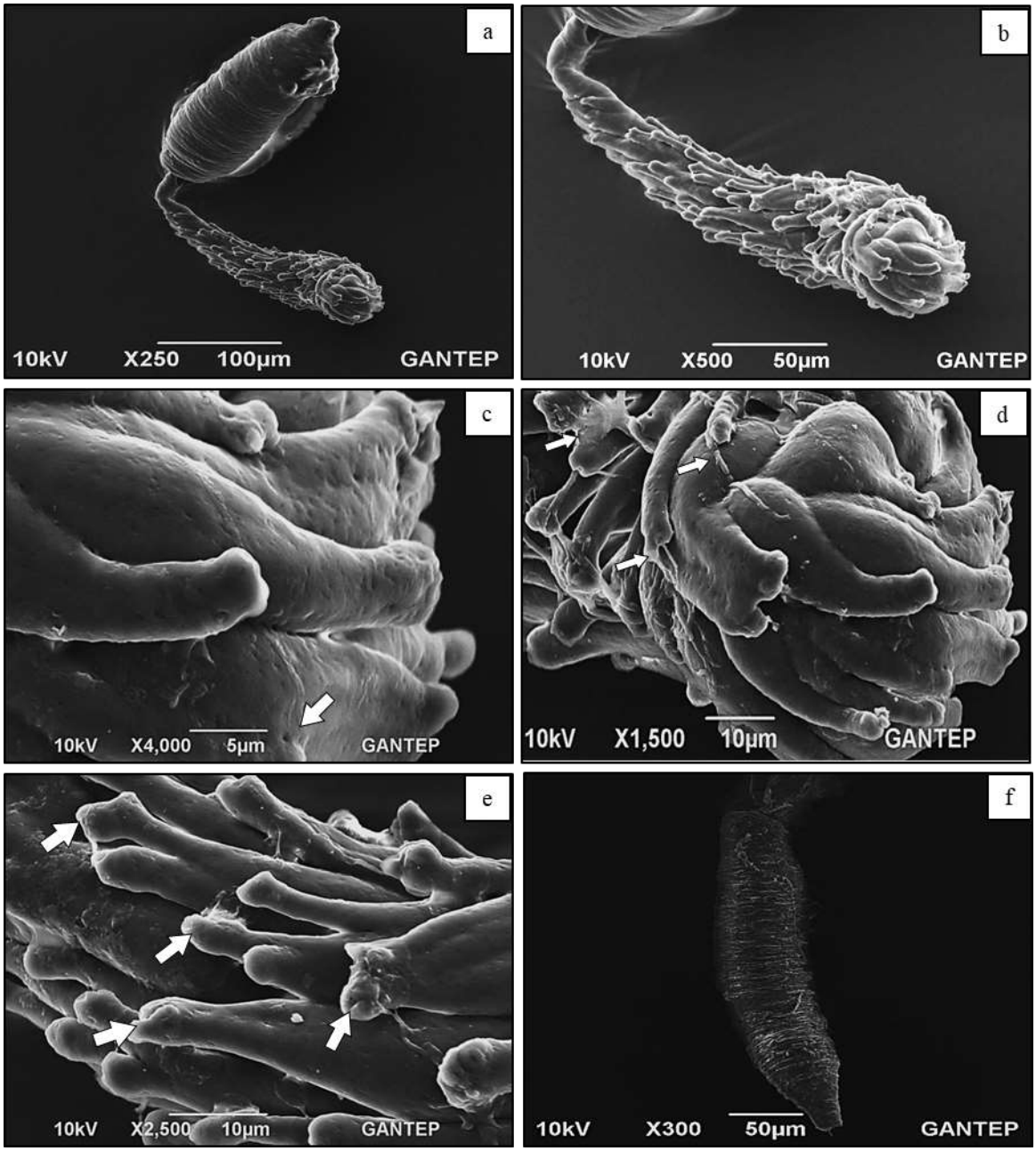

Figure 3. SEM micrographs of the spermatheca *Terellia luteola* a) General view of spermatheca, b) Spermathecal bulb, c) Pores (White arrows), d) Gland canaliculus (White arrows), e) Bone- shaped spicules (White arrows), f) Dilation part of spermathecal duct.

Şekil 3. Terellia luteola'nın SEM mikrografisi a) Spermateka'nın genel görünümü, b) Spermateka haznesi, c) Porlar (Beyaz oklar), d) Bez kanalcıkları (Beyaz oklar) e) Kemik şekilli spiküller (Beyaz oklar), f) Spermatekal kanalın genişleme kısmı.

Terellia nigripalpis (Hendel, 1927)

Short description: Colour yellowish, resemble *Terellia serratulae*. Antenna dark brown or black, palpus dark brown or black. Wing; hyaline. Measurements: Male body; 5.6 – 6.5 mm, wing; 4.2-5.1 mm; Female body; 6.0-7.1 mm, wing; 4.3-5.4 mm.

Spermatheca morphology: Spermathecal duct: Width- 26.68 µm, height- 197.04 µm; aspect ratio 0.13; General view is pear-shaped; papillose shaped spicules (Figure 4 a); apex is similar to a knob (Figure 4 b); pores are frequently distributed and quite apparent (Figures 4 c, d); gland canaliculus reaches from pores on the papillose spicules and formed a funnel-shape and densely present on bulb's surface; transverse muscle fibers present irregularly (Figures 4 e, f); small grooves formed on surface.

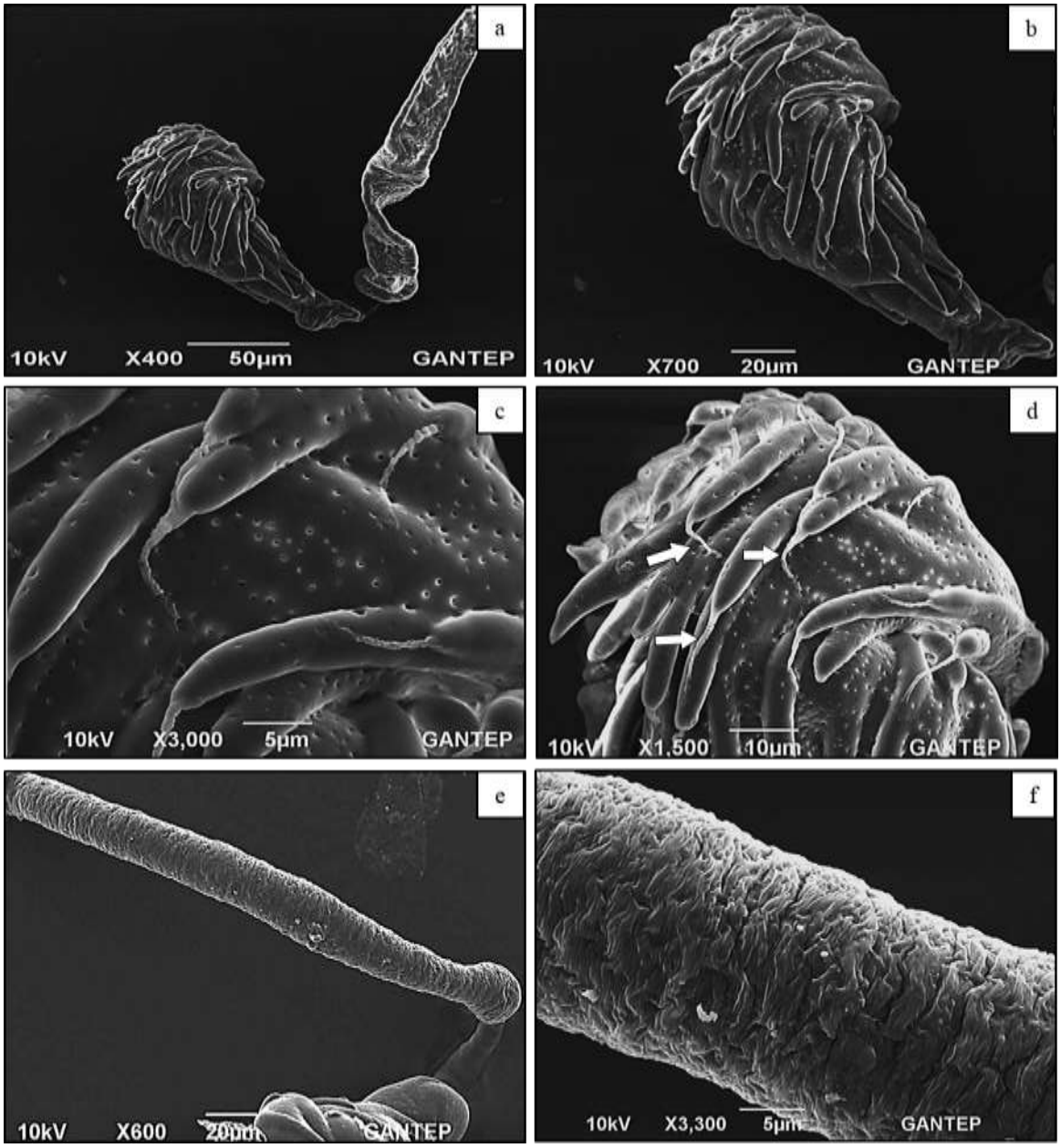

Figure 4. SEM micrographs of the spermatheca of *Terellia nigripalpis* a) General view of spermatheca, b) Spermathecal bulb, c) Pores, d) Gland canaliculus (White arrows), e) Dilation part of spermathecal duct, f) Muscle fibers of spermathecal duct.

Şekil 4. Terellia nigripalpis'in SEM mikrografisi a) Spermateka'nın genel görünümü, b) Spermateka haznesi, c) Porlar, d) Bez kanalcıkları (Beyaz oklar) e) Spermatekal kanalın genişleme kısmı, f) Spermatekal kanalın kas fibrilleri.

Terellia serratulae (Linneaus, 1758)

Short description: Colour yellowish, anterior part of frons, 3th segment of antenna, apical part of palp and proboscis yellow. Thorax; mesonotum flat, about 1.2 times as long as wide. Wing; hyaline. Abdomen; yellow to brown, sometimes greenish. Measurements: Male body; 3.7-6.0 mm, wing; 3.3-5.2 mm; Female body; 4.3-7.5 mm, wing; 3.3-5.2 mm.

Spermatheca morphology: Spermathecal duct: Width- 39.36 µm, height- 328.82 µm; aspect ratio 0.12; General view is pear-shaped (Figure 5 a); papillose shaped spicules; apex is like a knob and no spicules on the apex (Figure 5 b); pores on the spermathecal bulb are distributed and in different sizes (Figures 5 c, d); secretory glands and gland canalicus extend outward from the pores (Figures 5 d); transverse muscle fibers present irregularly; grooves formed on surface transversely (Figures 5 e,f).

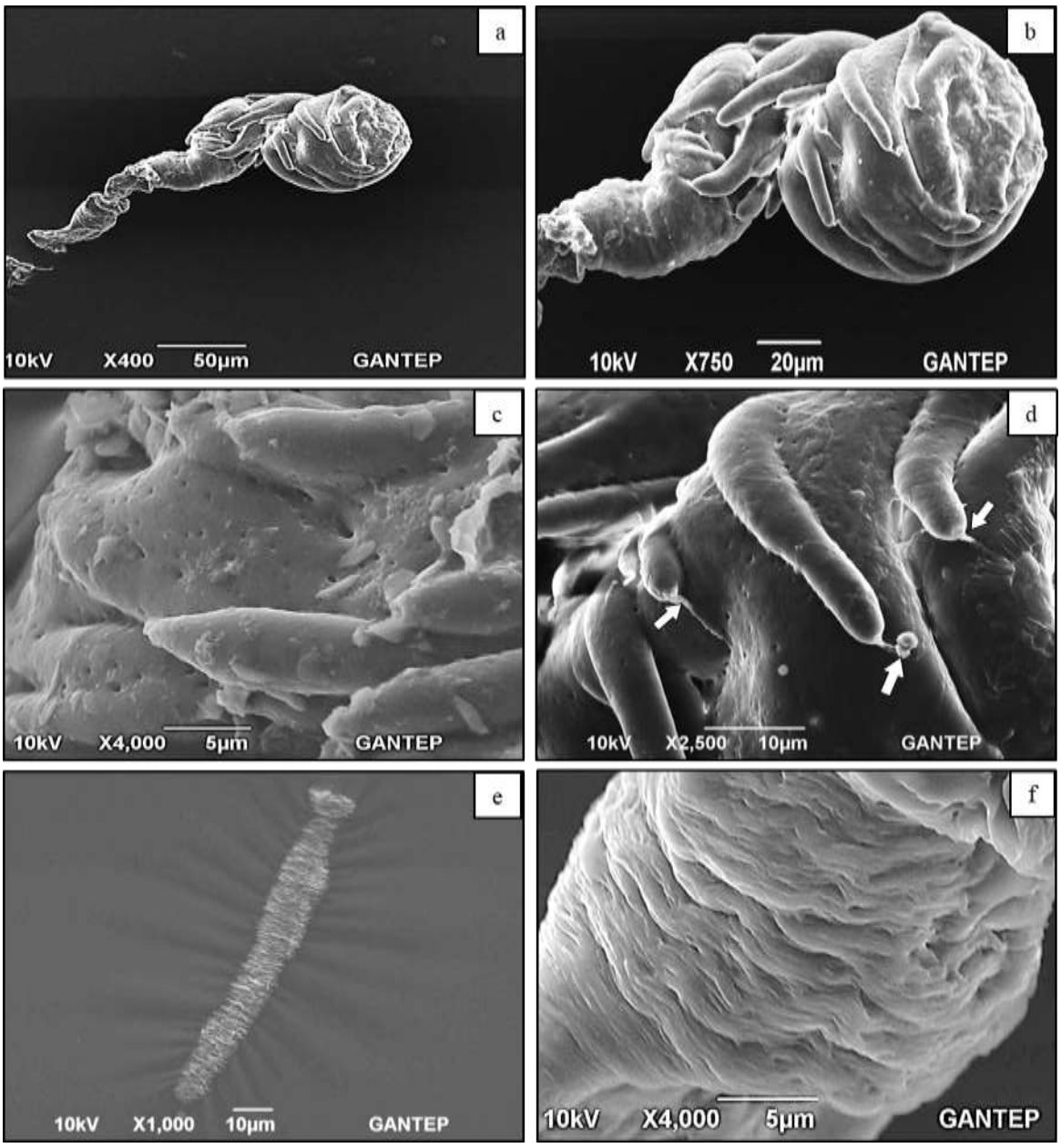

Figure 5. SEM micrographs of the spermatheca of *Terellia serratulae* a) General view of spermatheca, b) Spermathecal bulb, c) Pores and gland canaliculus, d) Secretory glands (White arrows), e) Dilation part of spermathecal duct, f) Muscle fibers of spermathecal duct.

Şekil 5. Terellia serratulae'nin SEM mikrografisi a) Spermateka'nın genel görünümü, b) Spermateka haznesi, c) Porlar ve bez kanalcıkları, d) Salgı bezleri (Beyaz oklar) e) Spermatekal kanalın genişleme kısmı, f) Spermatekal kanalın kas fibrilleri.

Terellia virens (Loew, 1846)

Short description: Coloration as in *Terellia serratulae*. 3th segment of antenna rounded at apex. Thorax; mesonotum as long as wide. Wing; hyaline with yellowish stigma. Abdomen; coloration as in *Terellia serratulae* but black hairs present only on posterior part of 5th and 6th terga. Measurements: Male body; 2.7-4.3 mm, wing; 2.7-3.7 mm; Female body; 3.6-5.4 mm, wing; 2.7-3.8 mm.

Spermatheca morphology: Spermathecal duct: Width- 17.67 µm, height- 200.07 µm; aspect ratio 0.08; General view is papillose shaped spicules (Figure 6 a); same width between apex and base of bulb; pores on the spermathecal bulb are distributed and in different sizes (Figures 6 c, d); secretory glands and gland canalicus extend outward from the pores (Figure 6 d); transverse muscle fibers present regularly; grooves formed on surface transversely (Figures 6 e, f).

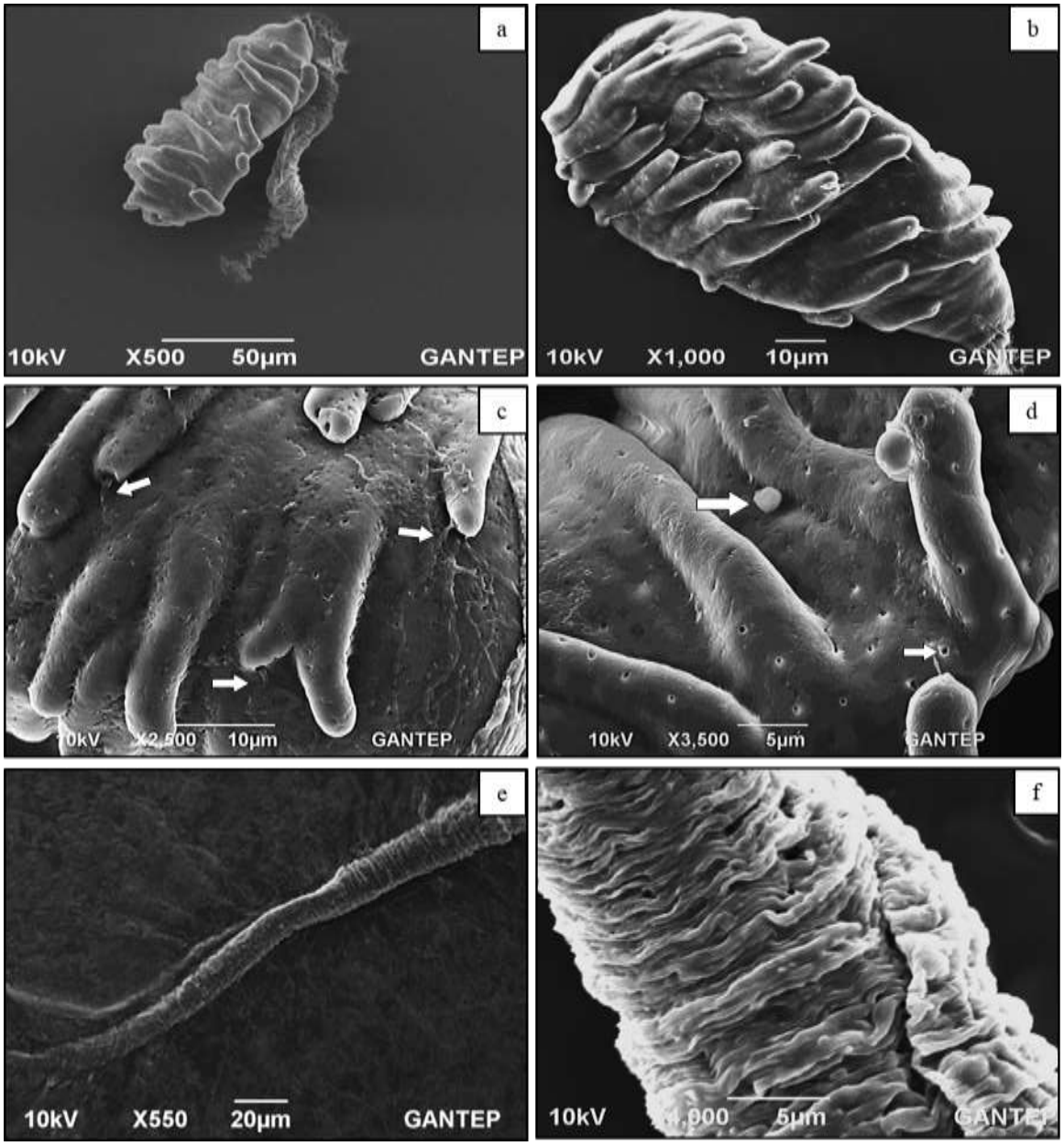

Figure 6: SEM micrographs of the spermatheca of *Terellia virens* a) General view of spermatheca, b) Spermathecal bulb, c) Pores and gland canaliculus (White arrows), d) Secretory glands (White arrows), e) Dilation part of spermathecal duct, f) Muscle fibers of spermathecal duct.

Şekil 6: Terellia virens'in SEM mikrografisi a) Spermateka'nın genel görünümü, b) Spermateka haznesi, c) Porlar ve bez kanalcıkları (Beyaz oklar), d) Salgı bezleri (Beyaz oklar) e) Spermatekal kanalın genişleme kısmı, f) Spermatekal kanalın kas fibrilleri.

DISCUSSION

Studies on the morphology of the spermatheca are increasing in recent years. However, spermatheca morphology of fruit flies poorly known. Recent studies 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 *Terellia* (Kütük et al., 2018).

Korneyev (1985) suggested as synapomorphies of *Terellia* were mostly related to the wing pattern, but also based on the similar shape of the tip of the aculeus and the association with the Asteraceae.

Kütük et al., (2017) were evaluated spermathecaa structures of four species [*Terellia colon* (Meigen, 1826), *Terellia gynaecochroma* (Hering, 1937), *Terellia quadratula* (Loew, 1869) and *Terellia ruficauda* (Fabricius, 1794)] of genus *Terellia* using SEM micrographs. Spermathecal structures, aspect ratio spermathecal bulb and spermathecal duct and the spicules on spermathecal bulb surface were defined. In this study, we examined *Terellia* species which have

similar hyaline wing and compared spermatheca morphology.

The spermathecal bulb structures of the *Terellia fuscicornis, T. longicauda*, *T. luteola*, *T. nigripalpis* and *T. serratulae* species were generally in the form of pears and have formed similar structure with a differentiation of the knob at the apex. Unlike other species, *T. virens*'s length between the apex of the spermathecal bulb and the base was twice the width and flattened. Also, aspect ratios of spermathecal bulb were determined as 0.24 in *T. luteola*, 0.39 in *T. serratulae*, 0.41 in *T. fuscicornis*, 0.46 in *T. nigripalpis*, 0.49 in *T. longicauda* and maximum was 0.51 in *T. virens* respectively. In addition, minimum length of spermathecal bulb was determined 107.08 µm in *T. virens* and respectively 153.85 µm in *T. nigripalpis*, 158.47 µm in *T. fuscicornis*, 170.47 µm in *T. serratulae*, 179.53 µm in *T. longicauda* and maximum length of spermathecal was 214.3 µm in *T. luteola*.

While the spicules on the surface of the spermathecal bulb were in papillose form in all species, *T. luteola*'s were in bone-shape form. The pores were found on the spermathecal bulb surface of all species, they were densely distributed in *T. nigripalpis,* and rarely distributed in *T. fuscicornis*. Gland canalicus was existed in all species. Additionally, secretory glands were investigated in *T. serratulae* and *T. virens*. *T. luteola* can be clearly distinguished from other species in that the spermathecal duct's aspect ratio and muscle fibers were more prominent among the species used in the study. The minimum aspect ratio was 0.08 in *T. virens*, and maximum was 0.35 in *T. luteola* regarding spermathecal duct size. Muscle fibers located in the spermathecal canal of *T. longicauda* were arranged in an irregular manner and were separated by small chambers in the form of cavities. *T. fuscicornis*, *T. luteola* and *T. virens* differ in that they come into the form of grooves extending transversely due to regular fiber structures located in the spermathecal duct structure.

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Statement of Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The contribution of the authors is equal.

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