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Aelia rostrata (Heteroptera: Pentatomidae)'un Sindirim Kanalının Ultrastrüktürü

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ÖZET

Aelia rostrata (Fabricius, 1803) (Heteroptera: Pentatomidae) delici emici ağız tipine sahip olduğu için bitki özsuyu ile beslenmektedir. *Aelia rostrata,* başta buğday olmak üzere yabani Gramineae türleriyle de beslenerek zarar yapmaktadır. Buğday pis böceği (Kımıl) olarak da bilinen zararlı önemli hale gelmiştir. Bu çalışmada, 2014 yılının Ağustos-Ekim aylarında Ankara ili, Bala ilçesi ve civarındaki çeşitli tarımsal ve yabani bitki alanlarından *A. rostrata* örnekleri toplanmıştır. Ardından ışık mikroskobu ve taramalı elektron mikroskobu (SEM) kullanılarak böceğin sindirim kanalının yapısı incelenmiştir. *A. rostrata*'nın sindirim kanalının üç farklı bölgeden oluştuğunu göstermiştir: ön bağırsak, orta bağırsak ve arka bağırsak. Ön bağırsak tükürük bezleri, yutak, yemek borusu ve ön bağırsaktan oluşmaktadır. Orta bağırsakta ön, medyan (orta bağırsağın kanal yapısı), arka orta bağırsak (orta bağırsağın ampul yapısı) bulunmaktadır. Arka bağırsak, ileum ve rektumdan oluşmak tadır. İleum'a bağlı olarak Malpighi tüpleri ve gastrik çekumlar vardır. Ön bağırsakta tükürük bezleri ve mide silindirik epitelden, yardımcı tükürük bezi ve orta bağırsak kanalı kübik epitelden, proventrikulus ise yalancı çok tabakalı epitelden meydana gelmektedir. Orta bağırsakta; orta bağırsak kanalı kübik epitelden, bulb yassı epitelden oluşmaktadır. Arka bağırsakta ileum silindirik epitelden, rektum kübik silindirik epitelden oluşmaktadır. Araştırma böceklerin sindirim kanalı yapısı ile ilgili çalışmalarda bilim dünyasına katkıda bulunacaktır.

Entomoloji

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Bağırsak
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Taramalı elektron mikroskobu

Ultrastructure of Digestive Canal of *Aelia rostrata* (Heteroptera: Pentatomidae)

ABSTRACT

Aelia rostrata (Fabricius, 1803) (Heteroptera: Pentatomidae) has a piercing mouthpiece type that is supplied with a plant sap-absorbing nose type. *Aelia rostrata* mainly consumes wheat but also nourishes wild Gramineae species, making it an important pest known as the wheat stink bug. In this study, A. rostrata samples were collected in August-October 2014 from various fields of agricultural and wild plants in and around the Bala district of Ankara province. Then the structure of the insect digestive canal was investigated using a light microscope and scanning electron microscope (SEM). The results showed that the digestive canal of *A. rostrata* consists of three distinct regions: foregut, midgut, and hindgut. The foregut consists of the salivary glands, pharynx, esophagus, and proventriculus. The midgut has an anterior, median (canal structure of the midgut), and posterior midgut (bulb structure of the midgut). Hindgut has the ileum and rectum. There are Malpighian and gastric caeca depending on the ileum. In the foregut, salivary glands and stomach are composed of cylindrical epithelium, have cylindrical epithelium while the accessory salivary gland and the midgut canal are formed from cuboidal epithelium and also the proventriculus is made from pseudo-stratified epithelium. In the midgut, the cylindrical channel of the midgut causes the cubic epithelium, while the "bulb" causes squamous epithelium. In the hindgut, the ileum occurs as cylindrical epitheliums, and the rectum consists of cubic-cylindrical epithelium. This study will contribute greatly to the scientific world of studies on the digestive tract structure of insects.-

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INTRODUCTION

Pentatomidae is one of the largest families of the Heteroptera suborder, while Heteroptera itself is the largest group of the Exopterygota division of the Pterygota subclass. About 4700 species of the Pentatomidae family are known around the world, grouped into about 900 genera (Rider, 2006). Approximately 170 species belonging to 57 genera from this family are known in Turkey up to date (Rider, 2006; Önder et al., 2006; Fent and Aktaç, 2007; Fent et al., 2010 a,b). Most of the species belonging to this family are phytophagous and have a wide host distribution (Rider, 2006).

Aelia rostrata (Fabricius, 1803), popularly known as Kımıl in Turkish and wheat stink bug in English, is a species belonging to the Pentatomidae family of the Heteroptera order and causes considerable yield loss. The stink bug is known as the most harmful insect species in wheat fields in Turkey (Lodos, 1982). As a phytophagous species that acquires nutrients by absorbing plant sap, it fed primarily on wheat, and other cultivated and wild Gramineae species: oak, even, hedgehog, pine, bear ears, etc. They feed, mate, and lay eggs while living mostly under the leaves. The offspring that emerge from the egg become a new generation of adult insects, and they retreat to the surrounding mountains and forest after the wheat harvest in Turkey (Lodos and Önder, 1986).

The insect digestive system usually has a tube that continues from the mouth to the anus. It is mainly divided into three regions: foregut, midgut, and hindgut (Hood, 1937; Wigglesworth, 1977; Chapman, 1985; Dow, 1986; Gullan and Cranston, 2005; Borges et al.,2015). The foregut (stomodeum), which is of ectodermal origin, usually; consists of the pharynx, esophagus, crop, and proventriculus. Foregut cells are usually flat. These cells are undifferentiated because they do not secrete or absorb. However, the cuticle layer is located in different regions. It usually consists of only the endocuticle and epicuticle. This structure varies from species to species and in different regions of the foregut (Chapman, 1988). The pharynx provides the intake and backward passage of food. The esophagus is usually tubular and provides a connection between the pharynx and the crop. This structure has been described mostly in hemimetabolous insects. Nutrients are stored in the crop. Annular and longitudinal muscles are very well developed in the proventriculus. On the inner side of the proventriculus, the spines, teeth, and many projections of various shapes of the intima are rubbing against each other under the action of the muscles. With this friction, food particles are ground (Chapman, 1998). The midgut is of endodermal origin and is generally not compartmentalized. Digestion usually occurs here. Cells in the midgut are actively involved in the absorption of nutrients as well as enzyme production and secretion (Chapman, 1988). The hindgut (proctodeum), like the foregut, is of ectodermal origin. Removal of waste materials, water, and salt absorption occurs here. It consists of 3 parts: the ileum, colon, and rectum. The anterior part of the hindgut consists of the ileum, the narrow middle part of the colon, and the wider posterior part of the rectum. In many terrestrial insects, the rectum is the only intestinal site where water and solutions in feces are absorbed, but in some insects, the ileum also provides osmoregulation. Malpighi tubes, responsible for excretion, are located at the junction of the midgut and hindgut. It removes nitrogenous waste (especially ammonium ions) from the hemolymph (Chapman, 1988).

To date, the structure of the digestive system of some species belonging to the Heteroptera order has been examined and the structures of the digestive system have been revealed (Çetin, 2014; Metin, 2014; Amutkan et al., 2015; Demirkol, 2016; Candan et al., 2020). Similarly, knowing the structure of the digestive system in detail in *Aelia rostrata*, whose digestive system has not been studied before, and which is an economically important agricultural pest in our country, will shed light on the development of control methods, as well as will be beneficial for systematic and taxonomic studies. In this study, the digestive system of *Aelia rostrata* was examined in detail using light microscopy and scanning electron microscopy.

MATERIALS and METHODS

Adult females and males of *Aelia rostrata* (Heteroptera: Pentatomidae) were collected in the Bala district of Ankara province in August-October 2014. The samples brought to the Gazi University laboratory were preserved in jars containing food plants and moistened cotton.

Preparation of Samples for a Light Microscope (LM)

Live adult *Aelia rostrata* specimens were kept in ethyl acetate vapor in glass containers. The digestive tract of *Aelia rostrata* was dissected under a stereomicroscope in a 70% alcohol medium. The general structure of the removed digestive system was detected in Bouin fixative fluid after being photographed with a stereo-microscope. The detected samples were washed with 70% ethyl alcohol and the digestive system was transferred into paraffin blocks, which were the embedding medium, after dehydration with rising ethyl alcohol series. Sections of approximately 5–7 mm thick were taken from paraffin blocks using a microtome. Sections were stained with Hemotoxylene-Eosin and Mallory 3 staining, closed with Stellan and turned into a permanent prepare. Sections of the parts of the digestive system were examined under an Olympus BX51 light microscope at 4X, 10X, 20X, 40X, and 100X (with immersion oil) magnifications. Photographs were taken after the examination.

Preparation of Samples for Scanning Electron Microscope (SEM)

Samples for scanning electron microscopy were prepared with (0.1-M; pH: 7.2) phosphate buffer with pH: 7.2, fixed in 2.5% Glutaraldehyde for at least 1 day; and washed with phosphate buffer (pH: 7.2) by making two 15-minute changes. Then, it was passed through 70%, 80%, 96%, 100%, and 100% alcohol series for 15 min each. The samples, which were kept in amyl acetate 2 times for 15 min, were dried at the critical point, then they were broken in their entirety or from various parts and attached to the staples with double-sided adhesive tapes. The digestive tracts covered with gold in the Polaron SC 502 coating device were examined in the JEOL JSM 6060 brand scanning electron microscope (SEM) at 5–10 kV and their photographs were taken.

RESEARCH FINDINGS

Gross Morphology of the Alimentary Canal

The digestive system of *Aelia rostrata* is divided into three parts: foregut, midgut, and hindgut (Figure 1). The alimentary canal is long, muscular, and tubular in structure and extends from the mouth to the anus. The foregut consists of the salivary gland, accessory salivary gland, pharynx, esophagus, and proventriculus. Since the pharynx and esophagus parts are not separated from the hard chitin part of the head, they are not examined in this study. The midgut has an anterior, median (canal structure of the midgut), and posterior midgut (bulb structure of the midgut). Hindgut has the ileum and rectum (Figure1).

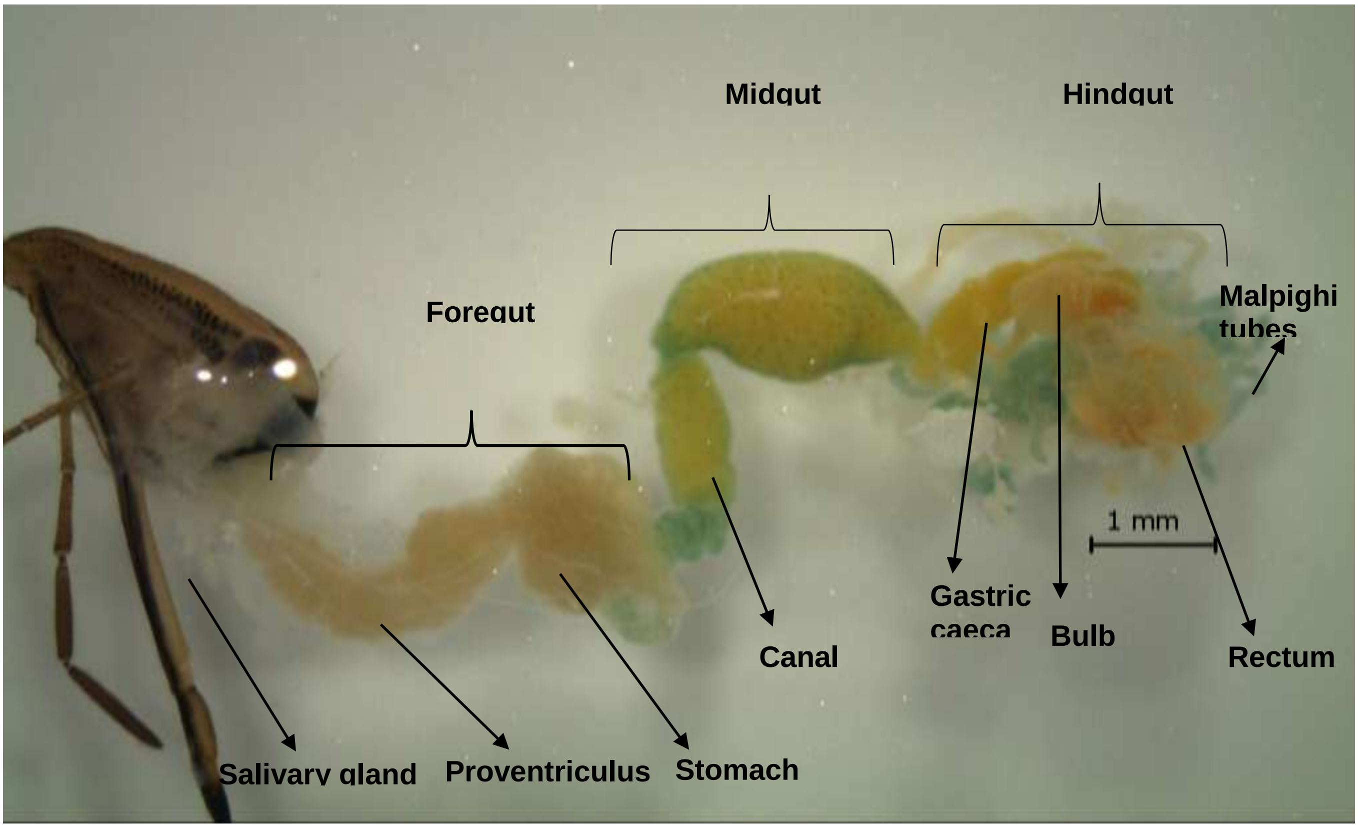

Figure 1. The general view of the alimentary canal of *Aelia rostrata* – Stereomicroscope
Şekil 1. Aelia rostrata sindirim kanalının genel görünüşü-Stereomikroskop

Foregut

The foregut is of ectoderm origin. It begins with the salivary glands opening into the oral cavity. *Aelia rostrata* contains a pair of salivary glands attached to the foregut. Each salivary gland also consists of two parts, posterior and anterior regions (Figure 2a – 2c). Thinning was observed in the region where the posterior part connects with the anterior part (Figure 2a). In SEM images, the folds on the surface of the posterior part connecting to the foregut are less than those on the anterior part (Figure 2b). The outer surface of the anterior part of the salivary glands has the appearance of corn grains (Figure 2c, 2d). The nuclei of the cells are close to the lumen of the cell (Figure 2d). Light and SEM images of the salivary gland showed that the lumen is filled with saliva (Figure 2d, 2e). Each salivary gland also consists of two parts, posterior and anterior (Figure 2a - 2d). The salivary gland is surrounded by a thin monolayer epithelium from the outside in both regions and consists of cubic cells.

Aelia rostrata has an accessory salivary gland attached to each of the two salivary glands attached to the foregut. In the SEM images, it is seen that the accessory salivary gland makes "S"-shaped folds. In the light microscope images, it was observed that the accessory salivary gland consists of a single-layered cuboidal epithelium, and the part facing the lumen is lined with the cuticle layer (Figure 2g, 2h).

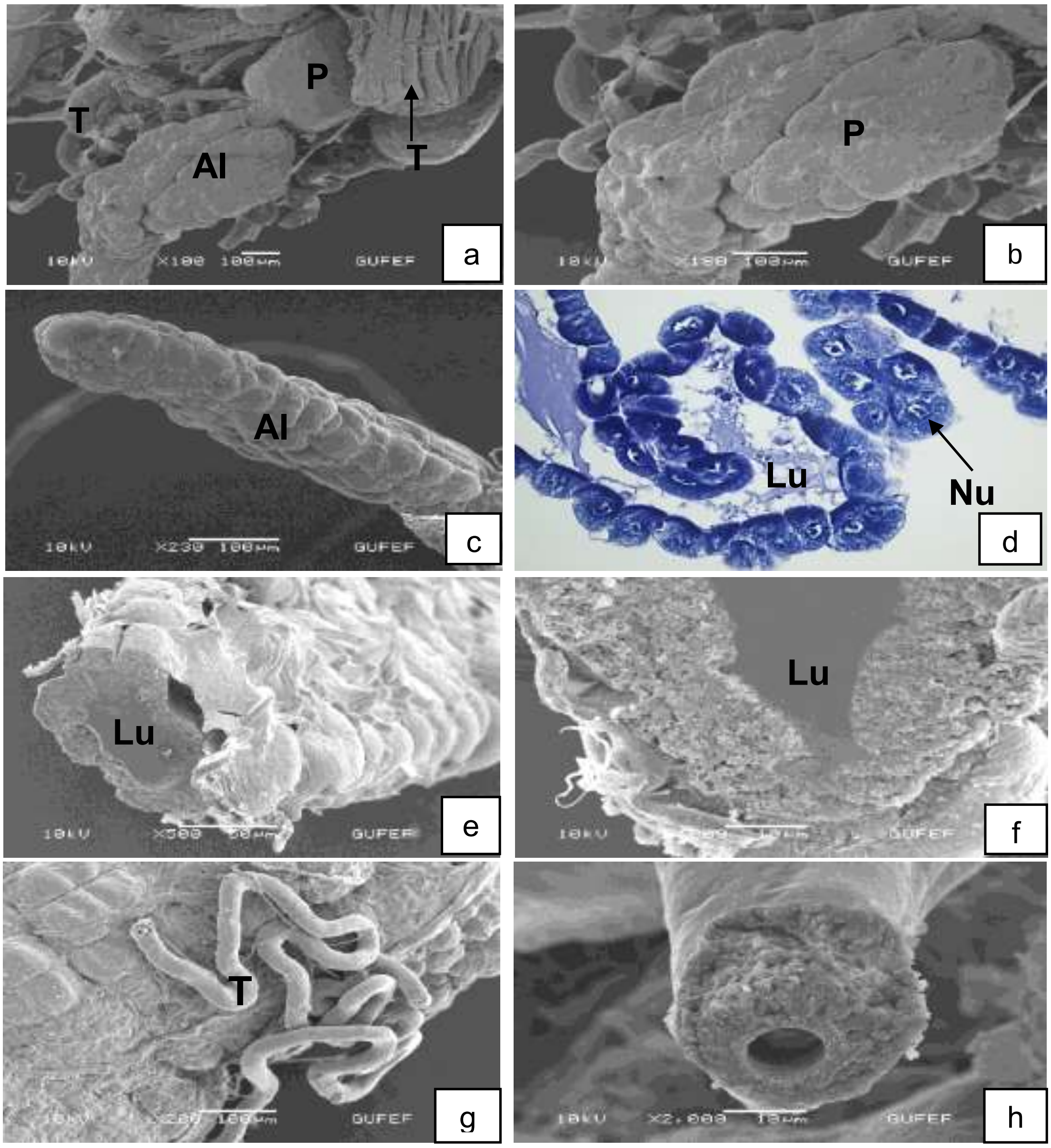

Figure 2. (a) Connecting part of the anterior and posterior region of the salivary gland and trachea (SEM). (b) Posterior region of salivary gland (SEM). (c) Anterior region of the salivary gland (SEM). (d) Longitudinal section view of the salivary gland (LM) (X400). (e,f) Cross-section of the inner surface of the salivary gland (SEM). (g) General view of accessory salivary gland (SEM). (h) Sectional view of the duct of the accessory salivary gland (SEM). Al, anterior lobe; Lu, lumen; Nu, nucleus; Pl, posterior lobe; T, trachea.

Şekil 2. a) Tükürük bezinin ve trakenin ön ve arka bölgesinin birleşen kısmı (SEM). (b) Tükürük bezinin arka bölgesi (SEM). (c) Tükürük bezinin ön bölgesi (SEM). (d) Tükürük bezinin (LM) boyuna kesit görünümü (X400). (e,f) Tükürük bezinin iç yüzeyinin kesiti (SEM). (g) Aksesuar tükürük bezinin (SEM) genel görünümü. (h) Aksesuar tükürük bezi kanalının kesit görünümü (SEM). Al, ön lob; Lu, lümen; Nu, çekirdek; Pl, arka lob; T, soluk borusu.

Proventriculus and Stomach (Ventriculus)

The proventriculus and the stomach, which is the anterior part of the midgut, are parts of the digestive system that help break down food (Figure 3a). Both these regions are externally equipped with a dense tracheal network and longitudinal muscles (Figure 3b). This image shows that the junctions of the monolayer cells are in the pit and the central parts are elevated apically (Figure 3c). The apical membranes of the cells of the single-layered cylindrical epithelial layer are abundant with microvilli, and the basal parts are indented inward. The apical parts of the cells protruded into the lumen. SEM images show that the cells are filled with secretory granules (Figure 3d). The proventriculus and stomach are not completely separated from each other, and the stomach forms the larger part of this structure (Figure 3a). The indentation of the inner surface of the stomach can be seen in SEM images and cross-sections (Figure 3e).

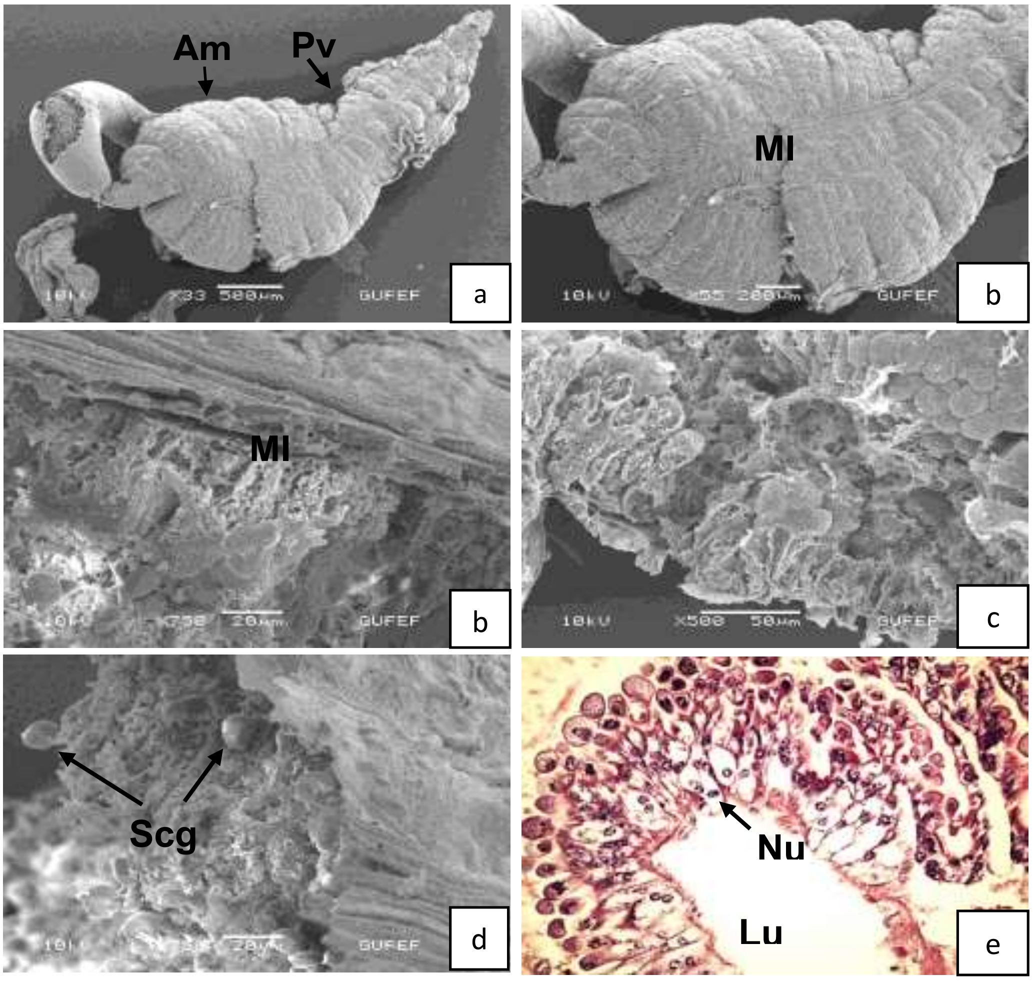

Figure 3. (a) General view of the proventriculus and anterior midgut (SEM). (b) muscle layer on the outer surface of the proventriculus and stomach (SEM). (c) Proventriculus and protrusions on the apical surface of the stomach (SEM). (d) proventriculus and secretory granules in the stomach (SEM). (e) Proventriculus and cells in the stomach and lumen. Am, anterior midgut; L, lumen; Ml, muscle layer; Nu, nucleus; Pv, proventriculus, S, stomach; Scg, secretory granules.

Şekil 3. (a) Proventrikulus ve ön orta bağırsağın genel görünümü (SEM). (b) Proventrikulus ve midenin dış yüzeyindeki kas tabakası SEM). (c) Midenin apikal yüzeyindeki Proventrikül ve çıkıntılar (SEM). (d) Midedeki proventrikulus ve salgı granülleri (SEM). (e) Proventrikül, mide ve lümendeki hücreler. Am, ön orta bağırsak; L, lümen; Ml, kas tabakası; Nu, çekirdek; Pv, proventrikulus, S, mide; Scg, salgı granülleri.

Midgut

The midgut canal (median midgut) is a long tube with one end connected to the stomach and the other to the bulb (Figure 4a-4c). Digestion occurs in this channel. The surface of the midgut canal is surrounded by an abundant tracheal network and muscles (Figure 4d). The cells are composed of a monolayer cubic epithelium. There are microvilli in the lumen-facing part of the epithelial cells (Figure 4e). It consists of a monolayer of cylindrical intestinal epithelial cells of varying heights with abundant trachea and a thin basal lamina (Figure 4f). Cells have microvilli directed toward the lumen side. Epithelial cells contain numerous rough endoplasmic reticulum and secretory granules (Figure 4g).

The short enlarged posterior region of the midgut canal is called the "bulb "posterior midgut. It is attached to the midgut wedge with one end and the ileum with the other end (Figure 4h). This part helps absorb the excess water in the food before it passes to the hindgut. In the SEM images, the outer surface was smooth and surrounded by muscles. Its interior is in the form of a large cavity containing digestive products (Figure 4i). The wall structure is thin, and the epithelial cells are shortened in size, so there are differences in their heights, and there are sometimes cubic or even flat cells. There are microvilli on the apical surface of the cells.

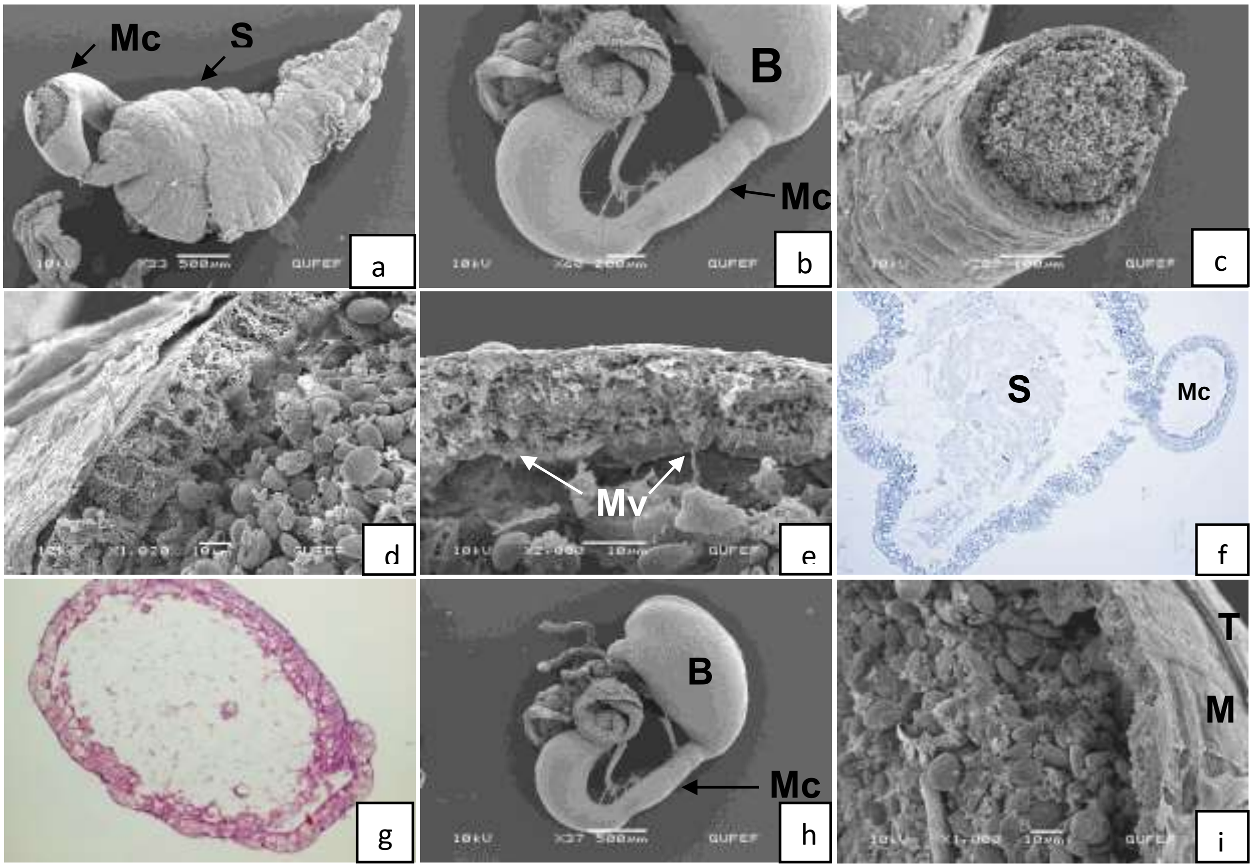

Figure 4. (a) The part where the midgut canal connects to the stomach-SEM. (b) The part of the midgut duct where it attaches to the bulb-SEM. (c) The inner surface structure of midgut cross-sectional canal-SEM. (d) The inner surface structure of the midgut tract-SEM. (e) View of microvilli in the midgut tract-SEM. (f) General view of the stomach and mid-intestinal tract (LM) (X40). (g) Light microscope view of the midgut tract (X40). (h) The part where the bulb structure attaches to the midgut-SEM. (i) Thin cell layer in the bulb and trachea and muscles on the outer surface-SEM. B, bulb; M, muscle; Mc, midgut canal; Mv, microvillus; S, stomach; T, trachea.

Şekil 4. (a) Midgut kanalının mide-SEM'e bağlandığı kısım. (b) Orta bağırsak kanalının ampul-SEM'e bağlandığı kısmı. (c) Orta bağırsak kesit kanalının iç yüzey yapısı-SEM. (d) Orta bağırsak kanalının iç yüzey yapısı-SEM. (e) Orta bağırsak kanalındaki mikrovillusların görünümü-SEM. (f) Mide ve orta bağırsak kanalının genel görünümü (LM) (X40). (g) Orta bağırsak kanalının ışık mikroskobu görünümü (X40). (h) Ampul yapısının orta bağırsağa bağlandığı kısım-SEM. (i) Ampul ve trakedeki ince hücre tabakası ve dış yüzeydeki kaslar-SEM. B, ampul; M, kas; Mc, orta bağırsak kanalı; Mv, mikrovillus; S, mide; T, soluk borusu.

Hindgut

The gastric caeca includes a structure consisting of four channels, one end of which is connected to the rectum and the other end to the midgut. The ileum, which consists of a monolayer cubic-cylindrical epithelium, passes through the middle of the channels in the gastric caeca (Figure 5a, 5c- 5e). In SEM images, it is seen that the caeca has a transverse nodular structure and its outer surface is surrounded by the trachea (Figure 5b, 5e, 5f).

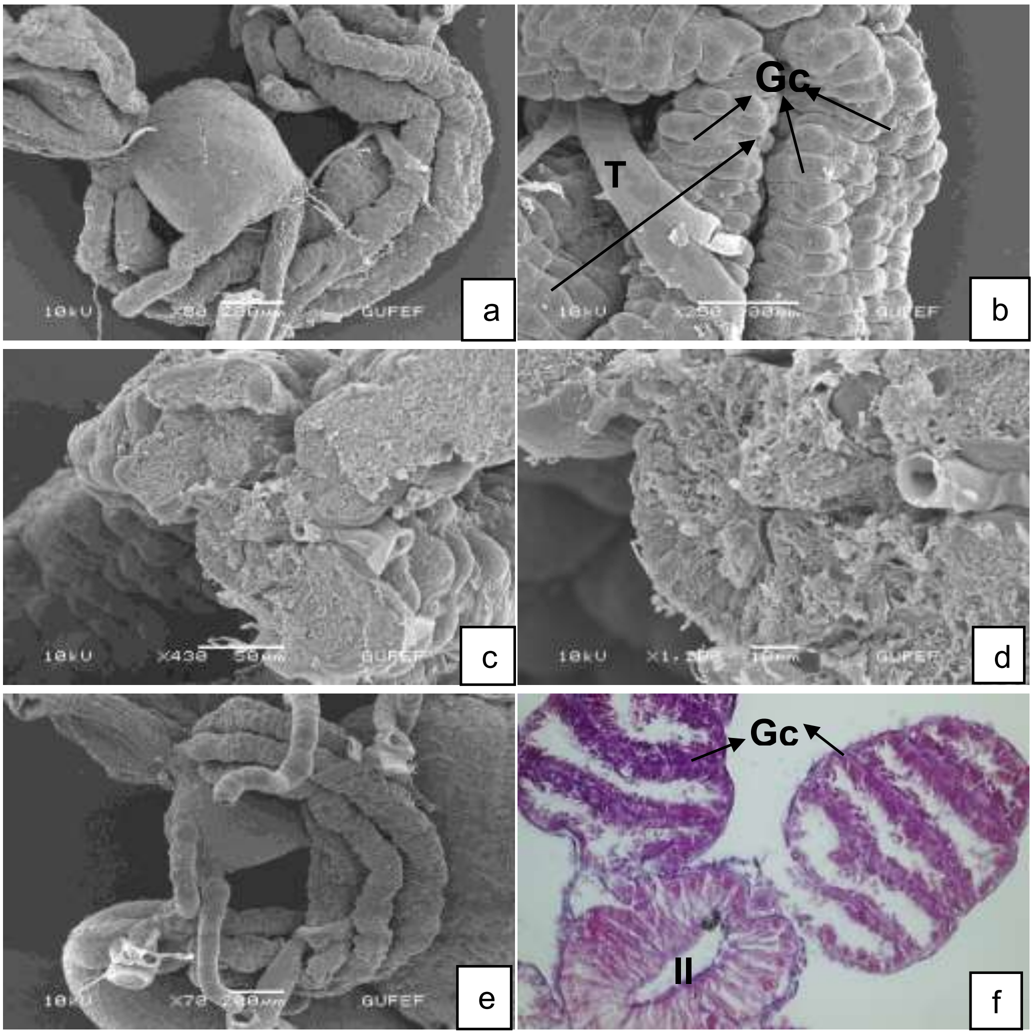

Figure 5. (a) General view of gastric caeca-SEM. (b) Trachea-SEM on the outer surface of the gastric caeca. (c-d) General view of the ducts and ileum in the gastric caeca-SEM. (e) General view of ileum-SEM. (f) View of the gastric cecum and ileum with a light microscope (X40). Gc, gastric caeaca; Il, ileum; T, trachea.

Şekil 5. (a) Gastrik çekumun genel görünümü-SEM. (b) Mide boşluğunun dış yüzeyindeki Trake-SEM. (c-d) Gastrik çekum kanalları ve ileumun genel görünümü-SEM. (e) İleum'un genel görünümü-SEM. (f) Gastrik çekum ve ileumun ışık mikroskobuyla görünümü (X40). Gc, gastrik çekum; Il, ileum; T, soluk borusu.

Malpighian tubules are connected to the digestive canal at the junction of the midgut and hindgut (Figure 5g). One end of the Malpighi tubes, which are found as a pair, is connected to the digestive tract, and the other end is free in the body cavity. While the part connecting to the digestive tract is flatter, the ends are seen as beads (Figure 5h). In the SEM images, the outer surface of the Malpighi tubes is surrounded by the trachea (Figure 5h). Its cells consist of a monolayer cubic epithelium (Figure 5j). The parts of the cells facing the lumen are surrounded by microvilli (Figure 5i, 5j).

The rectum forms the last region of the hindgut (Figure 5k). The surface of the rectum was surrounded by the trachea and muscles (Figure 5l). Intense folds are seen in the parts of the cells facing the lumen (Figure 5m). The cell wall consists of a monolayer cubic epithelium (Figure 5n).

DISCUSSION

Intestinal physiology and morphology differ in insects depending on their nutritional diversity. Insects that feed on solid foods have large, flat, short intestines equipped with strong muscles that protect against abrasion. These structures are very prominent in plant-feeding caterpillars, which consume their food fast and eat solid foods (Harris, 1938; Edmonds 1974, Fontanetti et al., 2002; Silva et al., 2004; Nardi et al., 2009; Metin, 2014; Candan et al. 2019). In contrast, in insects that feed on liquid nutrients such as blood, plant sap, or nectar, the intestine is usually long, narrow, and curved to ensure maximum contact with the liquid food. In this type of nutrition, there is no need to protect the intestine from erosion (Demirsoy, 2003).

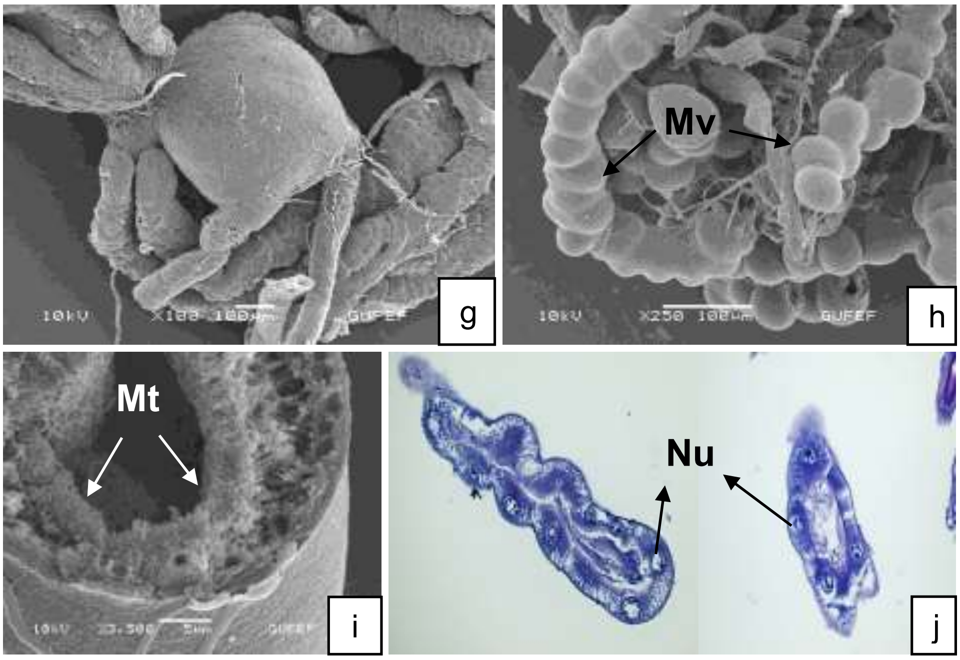

Figure 5. (g) The part where Malpighi tubes connect to the digestive tract-SEM. (h) Bead-shaped structure of Malpighi tubes-SEM. (i) Microvilli in Malpighi tubes-SEM. (j) Longitudinal and cross-section of Malpighi tube-LM (X40) (Mallory). Mt, malpighian tubules; Mv, microvillus; Nu, nucleus; T, trachea.

Şekil 5. (g) Malpighi tüplerinin sindirim sistemine bağlandığı kısım-SEM. (h) Malpighi tüplerinin boncuk şeklindeki yapısı-SEM. (i) Malpighi tüplerindeki mikrovilluslar-SEM. (j) Malpighi tüpü-LM (X40) (Mallory) boyuna ve enine kesiti. Mt, malpighian tübüller; Mv, mikrovillus; Nu, çekirdek; T, soluk borusu.

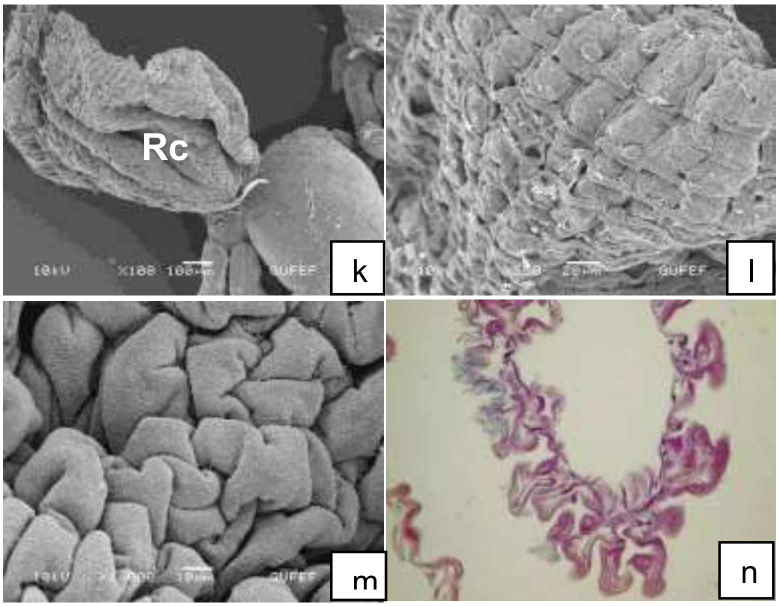

Figure 5. (k) General view of the rectum-SEM. (l) External surface view of the rectum-SEM. (m) Folds on the inner surface of the rectum-SEM. (n) Cubic-cylindrical cell structures of the rectum-LM (X40, HE). Rc, rectum.

Şekil 5. (k) Rektumun genel görünümü-SEM. (l) Rektumun dış yüzey görünümü-SEM. (m) Rektumun iç yüzeyindeki kıvrımlar-SEM. (n) Rektum-LM'nin kübik-silindirik hücre yapıları (X40, HE). Rc, rektum.

The digestive system of *Aelia rostrata*, which consists of the foregut, midgut, and hindgut is similar to the digestive systems of other Heteroptera species (Hamner, 1936; Harris, 1938; Barber, 1980; Pastle and Woodward, 1988; Habibi et al., 2008; Bandani et al., 2010; Çetin, 2014; Metin, 2014; Amutkan et al., 2015; Demirkol, 2016; Candan et al., 2020; Özyurt Koçakoğlu, 2021). The anterior and posterior intestines are of ectodermal origin, and the midgut is of endodermal origin (Candan et al., 2020; Özyurt Koçakoğlu, 2021). The foregut and hindgut are short and the midgut is long. The foregut consists of the salivary glands, pharynx, esophagus, and proventriculus.

There is a pair of salivary glands attached to the foregut. Each salivary gland consists of two parts, posterior and anterior. The salivary glands are surrounded by a thin muscle layer from the outside in both regions and consist of a monolayer of cubic cells. The folds on the surface of the posterior part of the salivary glands are smaller than those of the anterior part. The outer surface of the anterior part of the salivary glands has the appearance of corn grains. Tracheal structures were also observed on the surface and sections of the salivary gland. In terms of possessing a pair of salivary glands, *Dolycoris baccara* (Linneaus, 1758) (Heteroptera: Pentatomidae) (Çetin, 2014), *Carpocoris predicts* (Heteroptera: Pentatomidae) (Metin, 2014), *Lygaeus equestris* (Linneaus, 1758) (Heteroptera: Lygaeidae) (Demirkol, 2016), and *Rhaphigaster nebulosa* (Heteroptera: Pentatomidae) (Bayramova, 2015) show similarity with *Aelia rostrata*. However, Amutkan (2012) showed in his study that there are two pairs of salivary glands attached to the foregut in *Graphosoma lineatum* (Linnaeus, 1758) (Heteroptera: Pentatomidae). In *Aelia rostrata*, the anterior region of the salivary gland has the appearance of corn grains, while it is finger-like protruding in *Graphosoma lineatum* (Amutkan, 2012). *Aelia rostrata* has an accessory salivary gland attached to each of the two salivary glands, which in turn attaches to the foregut. In the SEM images, it is seen that the accessory salivary gland makes "S"-shaped folds. The accessory salivary gland consists of a monolayer cubical epithelium according to light microscope images.

The proventriculus and the stomach, which is the anterior part of the midgut, are parts of the digestive system that help break down food. *Aelia rostrata* does not have tooth-like chitin protrusions as it is fed with plant sap as seen in *Graphosoma lineatum* (Amutkan, 2012), *Carpocoris pudicus* (Metin, 2014), *Dolycoris baccarrum* (Çetin, 2014) and *Rhaphigaster nebulosa* (Bayramova, 2015). It protruded toward the lumen. In Coleoptera, Hymenoptera, and Orthoptera species that feed on solid foods, the structure consists of tooth-like chitin protrusions because the proventriculus is the place where the food is broken down. Because of the studies conducted with the proventriculus, it was observed that this structure changes depending on liquid and solid nutrition. The stomach is in the form of a thin tube, as in *Solube pugnca* Fab. (Heteroptera: Pentatomidae) (Hamner, 1936), *Graphosoma lineatum* (Amutkan, 2012), and *Carpocoris pudicus* (Metin, 2014). Since the is fed with liquid food, no spiny protrusions are observed in the stomach. In *Aelia rostrata*, the inner surface of the stomach is less protruding than the proventriculus.

The midgut canal is in the form of a long tube and consists of a monolayer of cuboidal cells. In *A. rostrata*, the midgut canal is in the form of a long tube, as in *Graphosoma lineatum* (Amutkan, 2012), *Carpocoris pudicus* (Metin, 2014), *Rhaphigaster nebulosa* (Bayramova, 2015), and *Lygaeus equestris* (Demirkol, 2016). Although the midgut canal is composed of monolayered cubic cells in *A. rostrata*, it consists of cylindrical cells in *Carpocoris pudicus* (Metin, 2014). In *A. rostrata* and *Rhaphigaster nebulosa*, the midgut canal is similar in that one end is connected to the stomach and the other to the bulb (Bayramova, 2015).

The short enlarged posterior region of the midgut canal is called the "bulb." It is connected to the midgut wedge with one end and the ileum with the other end. The bulb structure found in *A. rostrata* is similar to that of *Graphosoma lineatum* (Amutkan, 2012) and *Carpocoris pudicus* (Metin, 2014).

In *A. rostrata*, the hindgut consists of the ileum and rectum, whereas *Melanogryllus desertus* (Orthoptera: Gryllidae) consists of the ileum, colon, and rectum (Çakıcı, 2008). Four gastric caeca resembling corn kernels are attached to the ileum. *A. rostrata* is similar to *Carpocoris pudicus* (Metin, 2014) and *Rhaphigaster nebulosa* (Bayramova, 2015) in terms of attachment of gastric caeca and formation of four channels. In *A. rostrata*, the gastric caeca attaches to the hindgut, whereas in *Melanogryllus desertus* it attaches to the midgut (Çakıcı, 2008). Although there are four gastric caeca in A. rostrata, there are two in *Melanogryllus desertus* (Çakıcı, 2008). The gastric caeca is absent in *Pyrrhocoris apterus* (Hemiptera: Pyrrhocoridae) (Koçakoğlu, 2021) and *Lygus hesperus* (Heteroptera: Miridae) (Habibi, 2008).

In *A. rostrata*, the Malpighi tube is connected to the area where the ileum and rectum are connected. Two pairs of Malpighi tubes connected to the ampulla structure branch show a knotty structure and end with closed ends. The presence of constricted and two pairs of malpighi tubes of *A. rostrata* is similar to that of *Carpocoris pudicus* (Metin, 2014) and *Rhaphigaster nebulosa* (Bayramova, 2015) in that the malpighi cells consist of monolayer cubic cells. Although there are 2 pairs of Malpighi tubes in *A. rostrata* and 1 pair in *Pyrrhocoris apterus* (Koçakoğlu, 2021), the Malpighi cells are similar in that they consist of monolayer cubic cells. There are two pairs of Malpighi tubes in *A. rostrata*, *Lygaeus equestris* (Demirkol, 2016), *Oncopeltus fasciatus* (Heteroptera: Lygaeidae) (Hamner, 1936), *Graphosoma lineatum* (Amutkan,2012), *Dolycoris baccarum* (Çetin,2014), and *Psammotettix striatus* (L.)(Hemiptera: Cicadellidae) (Zhang et al., 2012). There are two pairs of Malpighi tubes, as in Zhang et al., 2012). Malpighi tubes *Solubea pugncvc* (Hamner, 1936) 1 pair, *Pezodrymedusa lata* Karadağ (Orthoptera: Tettigoniidae) (Bursalı, 1996) 3 pairs. Ghanim et al. (2001) found that *Besimia tabaci* Gennadius

(Hemiptera: Aleyrodidae) lacks Malpighi tubes, but instead has a special Malpighi-like cell in the inside of the ileum and the filter chamber. In *A.rostrata*, Malpighi cells are nodular, while in *Sarcophaga ruficornis* it consists of principal and star-shaped cells.

The surface of the rectum is surrounded by the trachea and muscles. The cell wall consists of a single layer of cubic cylindrical epithelium. Instead of microvilli, dense folds are seen in the parts of the cells facing the lumen. These features are similar to *Carpocoris pudicus* (Metin, 2014), *Rhaphigaster nebulosa* (Bayramova, 2015), and *Lygaeus equestris* (Demirkol, 2016). Rectal papillae were not observed in *A. rostrata*. Rectal papillae are generally seen in groups with chewing mouth structures such as Orthoptera and Coleoptera. Therefore, the rectal papillae cause the solidification of the waste product with final absorption.

Because of this study on the examined *Aelia rostrata*, it was found that the digestive tract was generally similar to Heteroptera species. However, there are not enough studies on the fine structure of the digestive tract. Due to the structural and morphological similarities of the digestive system of insects, this study will have an important place in future studies and in illuminating insect control studies in terms of agricultural control. It aims to develop mechanisms that will affect the digestive system in the fight against this insect by investigating the structure of the digestive system of *A. rostrata*.

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Author's Contributions

Selami CANDAN planned the study and Şermin GENÇ conducted the study. The findings obtained in the study were analyzed by Selami CANDAN and the article was written by Şermin GENÇ.

Statement of Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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