THE GROSS ANATOMY AND THE HISTOLOGY OF THE ALIMENTARY TRACT OF TWO GRASSHOPPERS, OEDIPODA MINIATA (PALL.) AND OEDIPODA COERULESCENS (LINN.) (ORTHOPTERA: ACRIDIDAE)

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ABSTRACT

The anatomy and the histology of the alimentary tract of two orthopteroids subspecies were observed under the light microscopy. The alimentary tract has been anatomically divided into three main parts: Fore-gut, mid-gut and hind-gut. The fore-gut is composed of buccal cavity, pharynx oesophagus, crop and proventriculus. The mid-gut is small.

Between the fore-gut and mid-gut there are six bilobed gastric caeca. The hind-gut include the last three parts of tract: Ileum, colon and rectum. The alimentary tract is covered with a thin chitinous sheath at the internal surface of fore-gut and hind-gut. Beneath this sheath, the epithelial cells are cuboidal and columnar in shape. The epithelium of mid-gut and gastric caeca are ciliated columnar cells. The outside layer of the tract is the muscular layer which are arranged as a circular and a longitudinal layers throughout the digestive tube. It is externally covered by the peritoneal sheath.

1. INTRODUCTION

*O. miniata* and *O. coerulescens* are well known among the orthopteroid insects, but information about their alimentary tract is insufficient. It was not possible obtain earlier works on the subject, but Grassé (1949) and Uvarov (1966) have mentioned it in their own books. It is clear that much more information is needed on the complete gross anatomy and histology of this two related species.

*O. miniata* and *O. coerulescens* are well known and fairly abundant grasshoppers in the Central Anatolia and the other steppe areas of Turkey.

The purpose of this study is to describe comparatively the gross anatomy and the histology of these two species and furnish more information of its structure.
2. MATERIALS AND METHODS

The grasshoppers for this study were caught from the steppe area around Ankara during the summer. They were reared by fresh wheat leaves for a few weeks in the laboratory. For the gross anatomy of the alimentary tract, the specimens were dissected in insect Ringer's solution. Before the histological treatments the grasshoppers were given no food for a few days.

The Parts of the alimentary tract were fixed in Bouin fluid, embedded in parafine, sectioned at 7–8 μm and stained with Hematoxylin–Eosin.

3. OBSERVATIONS

3.1. Gross Anatomy

In general the alimentary tract of the orthopteroid insects has been morphologically divided into three main parts as fore–gut, mid–gut and hind–gut.

3.1.1. Fore–gut

The fore–gut is extended through the thorax segments. It is composed of the buccal cavity, pharynx, oesophagus, crop proventriculus (Fig. 1A, B). All portions of the fore–gut may be distinguished externally.

A pair of salivary glands which are located in the first thorax segment open into the buccal cavity. They look like a bunch of grapes and each one of these has thin duct. The main duct of salivary glands extends to the mouth. Following the short pharynx, the second part of fore–gut is the oesophagus. This part increases in diameter from anterior to posterior. The crop of the alimentary tract is larger than proventriculus. The arrangement of muscle bands on the wall surrounding the crop can be externally distinguishable under the connective tissue sheath. Under the steroscopic microscope these muscle bands are seen as similarly arranged bands in both species from the external view. There is also a bunch of muscle fibers as a band on the ventral side extending throughout the mid–line of the fore–gut. At each side of anterior portion of the fore–gut, the muscle bands extends horizontally parallel to each other.

The proventriculus is distinctive in shape and smaller than the crop in diameter. It joins to the mid–gut cylindrically. On the wall of pro-
ventriculus, the longitudinal and the circular muscles are more compact. The proventriculus nearly occupies the last thoracic segment. The arrangement of muscles causes a cross-lined structure on the proventriculus.

The posterior end of the fore-gut is surrounded by six anterior lobes of the gastric caeca. They are bilobed in shape and the anterior lobes extend forwardly to the mesothorax and the posterior ones extend backwards into the second segment of the abdomen over the mid-gut. The bilobed parts of caeca are set up parallel to the long axis of the alimentary tract. Their total length is nearly 10 mm and they are tapered toward the tips.

The inner surface of fore-gut includes numerous thick chitinized ridges. They are mostly parallel to each others but they way at the different part of the fore-gut and the way is different. They form longitudinal rows, both in the oesophagus and proventriculus, but they are horizontal in the crop. In lateral lobes of the crop they are arranged as elyptoid rows. In the inner surface of oesophagus and proventriculus, the number of ridges are denser than the ones on the crop. Due to the different sizes of the proximal and the distal ends of the proventriculus, the number of the ridges differs. The chitinized ridges are extended nearly 3/4 of the proventriculus. There are six “Y” shaped cardiac sphincters on the inner surface of the proventriculus. Their length is nearly 1 mm and are covered by a dark chitinized shead (Fig. 2).

On the internal surface of fore-gut the arrangement of the chitinized ridges both of O. miniata and O. coeruleiscens are the same.

3.1.2. Mid-gut

The mid-gut (ventriculus, stomach) is the shortest region of alimentary tract. It is joined to the proventriculus by the cardiac sphincters and to the hind-gut by the pylor sphincter or proctodeal sphincter.

The mid-gut extends through the first three abdominal segments. It has a tubular shape and more homogenous in structure than the other parts of the tract. It is very easy to distinguish this portion on the digestive tube. At the posterior end, the mid-gut is surrounded by many Malpighian tubules and, at the anterior part by gastric caeca (Fig. 1).

3.1.3. Hind-gut

The hind-gut is situated from the fourth abdominal segment to the end of abdomen. It is surrounded by numerous tracheoles and connected to the last abdominal segment by the muscle bands.
thin. The epithelial cells nuclei are oval and mostly located in the center (Fig. 11).

3.2.3. Histology of hind–gut

In the sections of ileum of the hind–gut, the epithelium cells are columnnar in shape. The height and the shape of these cells varies throughout the different parts of the hind–gut. Towards the posterior end of ileum epithelium is made of shorter columnar cells. It shows slight folds. A chitoneus intima is extended on it. The most inner structure of the hind–gut is, also, the peritrophic membrane. The longitudinal muscle group extend as six lines on the circular muscle (Fig. 12).

The colon histologically resembles to the ileum. The inner folds of the epithelium layer were much deeper as it is compared to the ileum. The epithelial cells were smaller and more or less cuboidal in shape. Their nuclei are spherical and located more centrally. The longitudinal muscle beneath the epithelium of folding area were well grouped (Fig. 13).

The rectal sac folds are rather large and show separately limited region. The wall of this structure is very thin. Their epithelial cells are small and cuboidal or squamous in shape. The cell surface of this epithelial layer are covered with a thick intima, and it is smoother than that of the fore–gut. The epithelium is consisted of columnar cells. The longitudinal muscles are extended between the rectal sacs and there they are arranged in bundles (Fig. 14).

The foldings of rectum proper occupy nearly all of the lumen. The intima of this region is well recognizable and bears many thiny diverticules on its surface. The epithelium of rectum proper is cuboidal. In the folds, there are delicate retractor muscles. Following the longitudinal muscle bundles, there is a rather thick circular muscle layer (Fig. 15).

There was not any individually characteristic histological structure for this two Oedipoda species, visible under the light microscope.

4. DISCUSSION

The nomenclature for histologic structures was adopted by Uvarov (1966).

The alimentary tract of insects both anatomically and histologically was interested in by many researchers (Snodgres 1935, Hodge 1939–

When one compares the anatomic and histologic features of alimentary tract of *O. miniata* and *O. coerulescens*, with the other orthopteroid forms particularly with the species of Acrididae, the structure seems fairly similar. In the literature less is known about the alimentary tract of these two species.

There are only some remarks about the alimentary tract of *O. coerulescens* by Dufour (1891, in Grassé 1949) who has shown only the crop of alimentary tract which is known today as the fore–gut. In the present paper, the fore–gut is subdivided into the pharynx, oesophagus, crop and proventriculus as it is being done in the last forty years.

The foldings and surface structures of intima are very important in respect to the function of this part. On the internal surface of alimentary tract of both species, there was not any remarkable difference. The internal surface of the fore–gut have taxonomic characteristics at the genus level as pointed out by Uvarov (1966). These characteristic ridges which are on the internal surface of the crop, vary in shape in *Locusta* as it was said by Liu and Leo (1955, in Uvarov 1966) in *Sphingonotus* by Bryantseva (1951, in Unvarov 1966) and in *Oedipoda*. These three orthopteroids genera are in the same subfamily.

The chitinized structures of inner surface of the oesophagus and the proventriculus of *O. coerulescens* are similar with *L. migratoria* as it was shown by Hodge (1936).

The cardiac valves of fore–gut are similar in both *O. miniata* and *O. coerulescens* When it was compared with *L. migratoria* (Hodge, 1939), the cardiac valves are different in shape from *Oedipoda*. It is “Y” shaped in *Oedipoda* and “V” shaped in *Locusta*. It seems to be a characteristic structure at genus level as well.

As compared with the other grasshoppers, the gastric caeca of these *Oedipoda* species resemble to them morphologically but there are differences in length among the species.

The mid–gut of *Oedipoda* has very similar structure with *Locusta* shown by Liu and Leo (1955, in Uvarov 1966).
The all parts of hind-gut have six parallel structures in gross anatomy and histology. Only an undetailed and simple figure of *O. coerulescens* was drawn by Dufour (1941, in Grassé 1949). But these six parallel structures have not been shown in the colon in this figure of Dufour.

The number of Malpighian tubules for *O. coerulescens* was given by Bordas (1898, in Uvarov 1966) as 30–100. But in this paper, in the both *Oedipoda* species, the Malpighian tubules are observed as 70–80 in number.

There are not considerably histologic differences between these two *Oedipoda* species.

The histologic structure of the alimentary tracts of these two *Oedipoda* species shows very close relations in its histological structure with the species of *Melanoplus differentialis* (Hodge, 1939), *Radenotatum carinatum* var. *pennisulare* (Hodge, 1940), *Schistocerca gregaria* (Akhtar and Ashrafi, 1965), *Poecilocerus bufonis* and *Thmehis pulchripennis* (Hafez et. al. 1970), within the Acrididae family.

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and 550–578.


ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
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<tr>
<td>o</td>
<td>Oesophagus</td>
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<tr>
<td>c</td>
<td>Crop</td>
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<td>sg</td>
<td>Salivary gland</td>
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FIGURES

Fig. 1. Ventral view of alimentary tract.
   a- *O. coerulescens* b- *O. miniata*
   A- Males B- Females

Fig. 2. Internal view of fore-gut (*O. coerulescens*).

Fig. Internal view of mid-gut and pyloric valve (*O. miniata*).

Fig. 4. Internal view of colon and rectum (*O. Coerulescens*).

Fig. 5. Transverse section of oesophagus (*O. coerulescens*).

Fig. Intima of oesophagus (*O. miniata*).

Fig. 7. Transverse section through the crop (*O. miniata*).

Fig. 8. a Transverse section through the proventriculus.
   b) Higher magnified portion, (*O. coerulescens*).

Fig. 9. Transverse section through cardiac valve (*O. coerulescens*).

Fig. 10. a) Transverse section through the ventriculus, b) higher magnified portion (right)
   (*O. coerulescens*).

Fig. 11. Transverse section through the caecae (*O. miniata*).
   a) Larger region of anterior lobe, b) End of anterior lobe, c) Posterior lobe.

Fig. 12. Transverse section through the ileum (*O. miniata*).

Fig. 13. Transverse section through the colon (*O. coerulescens*).

Fig. 14. Transverse section through the rectal sac (*O. coerulescens*).

Fig. 15. Transverse section through the rectum proper (*O. miniata*).