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Full Length Research Paper

Morphology and histology of the alimentary tract of adult palm weevil, *Rhynchophorus phoenicis* Fabricius (Coleoptera: Curculionidae)

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Palm weevil (*Rhynchophorus phoenicis*) is a notorious pest of oil palm trees, worldwide. Investigations were conducted on the alimentary tract of the adult insect. Results of the morphology and histology of the alimentary tract revealed that the alimentary tract consisted of a foregut, which was made up of a buccal cavity, oesophagus, crop and proventriculus. The crop big or small and the proventriculus had bristle teeth which the insect used in the mechanical breakdown of ingested food. The midgut is the longest part of the alimentary tract and most prominent features there are goblet cells, columnar cells, villi, microvilli and intestinal glands. The midgut was well adapted for the digestion and assimilation of food. The hindgut was responsible for the re-absorption of water from undigested food (feaces) because of the presence of rectal pads. The results of these investigations revealed that the alimentary tract of the weevil was structurally and functionally adapted to digest and extract its nutritional requirements from its food.

Key words: Morphology, histology, alimentary tract, adult palm weevil, *Rhynchophorus phoenicis.*

INTRODUCTION

In all living animals the alimentary tract is one of the most important systems in the body because it deals with both the intake of food and its digestion. The alimentary tract of insects generally consist of three primary parts namely, the foregut, midgut and hindgut, however, differences exist among species due to differences in dietary habits. Palm weevil, *Rhynchophorus phoenicis* F. is a notorious pest of oil palm trees, in the tropics and subtropical regions of the world where it causes great economic losses. The insects feed on the trunk of palms thus creating empty cavities in the palm and causing the breaking of the palm trees. The physiology and the structure of the alimentary tract of this insect have not been reported. However, the physiology and the structure of the alimentary systems as well as the midguts of a variety of insects have been documented (Ferreira et al., 1981; Gartner, 1985; Dimitradis, 1991; Lee et al., 1998; Hung et al., 2000). Information on the morphology and histology of the alimentary tract of the adult palm weevil is not available. The purpose of the present study was to provide information on the morphology and histology of the alimentary tract of the insect.

MATERIALS AND METHODS

Collection of insects and the laboratory maintenance of the weevils for this study

The adult palm weevils (50) used for this work were obtained from palm wine tappers at Igbokoda (Latitude 6° 21° N and Longitude 4° 48° E) in Ondo State, Nigeria. The weevils were kept in plastic containers, which were filled to two-third with raphia palm chippings and covered with iron mesh. The containers were transported to the laboratory where the insects were allowed to acclimatize for 48 h before being used.

Morphology of the alimentary system

The guts of the adults palm weevils were prepared according to the methods described by Adedire (2002). The insects were placed in a deep freezer for 30 min to immobilize them before clipping their

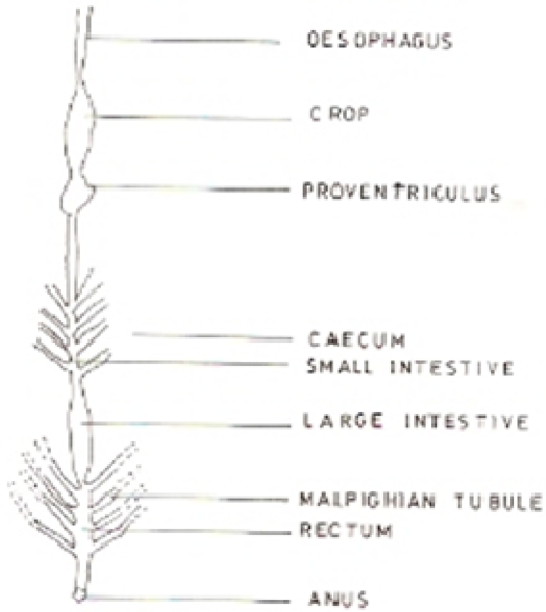

Figure 1. Morphology of the whole gut of adult palm weevil, *Rhynchophorus phoenicis.* X=1/4.

wings and dissect-ting them to remove the alimentary tract. The guts were fixed in Bouins solution for 24 h and then dehydrated for 3 h in 50, 60, 70, 80, 90 and 100% ethanol. The guts were stained with haematoxylin for 5 min and later washed with water for 2 min. The guts were differentiated in acid alcohol for 30 s and rinsed in water for 3 min. The guts were counter-stained with eosin for 3 min and dehy-drated through 50, 60, 70, 80, 90 and 100% ethanol. The guts were cleared in xylene for 30 min and mounted with DPX mountant on glass slides. Morphology of the alimen-tary system was observed under a hand lens and drawing made.

Histology of the sections of the alimentary system

The method described by Adedire (2002) was used in preparing the histological sections of the alimentary tract of the weevil. Adult weevils were immobilized by placing them in a deep freezer for 30 min; their guts were carefully dissected in 0.1 M NaCl and were preserved in Bouins solution for 2 days. The guts were thereafter cut into three distinct sections: foregut, midgut and hindgut. Each section was cleared in xylene for 30 min and infiltrated for 30 min in three changes of paraffin wax. The gut sections were embedded in paraffin wax and allowed to solidify and sectioned serially at 6 microns, using a microtome. The sections were placed on slides, washed with tap water and transferred into warm water (45°C) to allow the wax and the sectioned tissues to spread evenly. The slides were air-dried and transferred into xylene for 5 min to remove wax from the tissues. They were dehydrated in 50, 60, 70, 80, 90 and 100% ethanol for a period of 1 min each. The slides were stained with haematoxylin for 10 min and differentiated in acid alcohol for 30 seconds. The slides were rinsed in tap water for 3 min and counterstained with eosin for 3 min. The slides were rinsed in tap water and the tissues were dehydrated for 1 min each in 50, 60, 70, 80, 90 and 100% ethanol. The slides were cleared in xylene for 5 min and mounted with Canada Balsam and observed on a light microscope. Photomicrographs of the gut sections were taken at ×200 magnification with Leitz camera PM-C attached to Leitz (model ×40) microscope.

RESULTS

Foregut

The foregut of the adult consists of the buccal cavity, oesophagus, crop and the proventriculus. The oeso-phagus is long and it terminates in a small crop at the base of which is the strong proventriculus where food is pulverized (Figure 1).

Transverse section of the oesophagus showed that it consisted of stratified squamous epithelium, exhibiting a characteristic structure and arrangement. The cells are thin, flat and were irregularly shaped. The oesophagus has polyhedral cells, arteries, capillaries, oesophageal glands and squamous cells. Nerves and mucous alveoli are present in the submucosa (Plate 1). The proventriculus was made up of thick walls of circular muscles, longitudinal muscles, capillaries and nerves and it looks more like a star (Plate 2).

Midgut

The midgut was the longest part of the alimentary tract. It was about two times longer than the whole insect length and was situated between the foregut and the hindgut. Its anterior region was straight cylindrical structure located in the thorax and the posterior region was coiled shaped and lied in the abdominal segment. The direction of the coiling was downward and it then turns left where it finally runs downwards and terminates in the hindgut. The distinctive features of the midgut were the villi. The villi were the finger-like projections emanating from the midgut and they are used for food absorption. The transverse section of the midgut showed that the midgut had numerous villi which were well supplied with blood vessels (Plate 3).

The midgut had goblet cells, interstitial glands and columnar cells which form the bulk of the epithelium. The villi had brushlike border of apical microvilli projecting into the lumen. Numerous goblet cells were present while interstitial cells occupy the spaces between the goblet cells. Circular and longitudinal muscles were also present. The villus has central lacteal and capillaries. The villi differ in shape and length.

Hindgut

The hindgut formed the second longest part of the alimentary tract and was one and halve longer than the whole length of the insect. The hindgut, which was found at the posterior part of the alimentary tract, consisted of the rectum and anus. The rectum was the place where undigested food (faeces) stayed while water molecules were being removed from it before it is passed out through the anus. Malpighian tubules which were used to carry out excretion were present towards the posterior part of the hindgut. The same layers are present in the

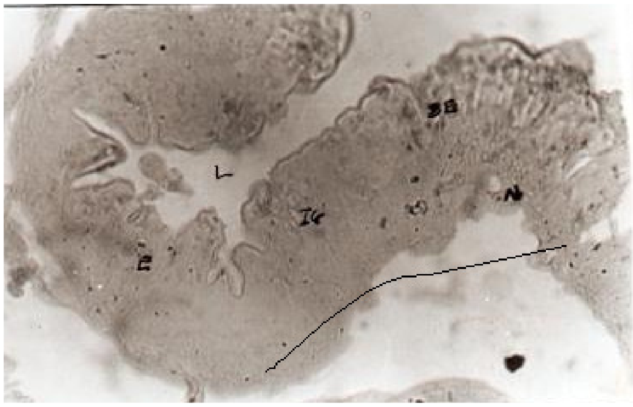

Plate 1. Transverse section of the oesophagus of adult palm weevil E = Epithelium, IG = Intestinal Gland, N = Nerve, SE = Squamous Epithelium, L = Lumen. X=240.

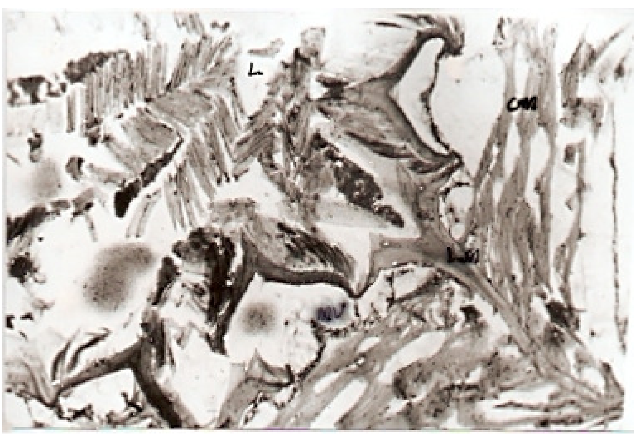

Plate 2. Transverse section of the proventriculus of adult palm weevil CM = Circular Muscle, LM = Longitudinal Muscle, L = Lumen. X=250.

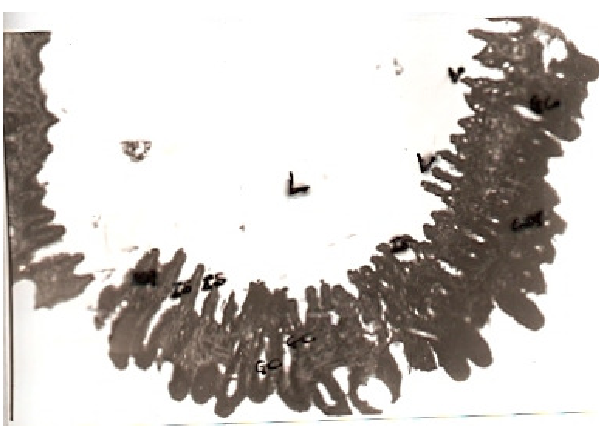

Plate 3. Transverse section of the midgut of adult palm weevil.IS = Inter villus Space, CM = Circular Muscle, GC = Goblet Cell, L = Lumen, V = Villus. X=250.

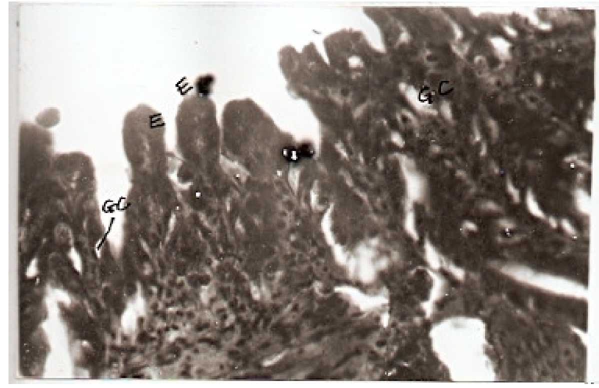

Plate 4. Transverse section of the ileum of adult palm weevil.E = Epithelium, GC = Goblet Cell. X=250.

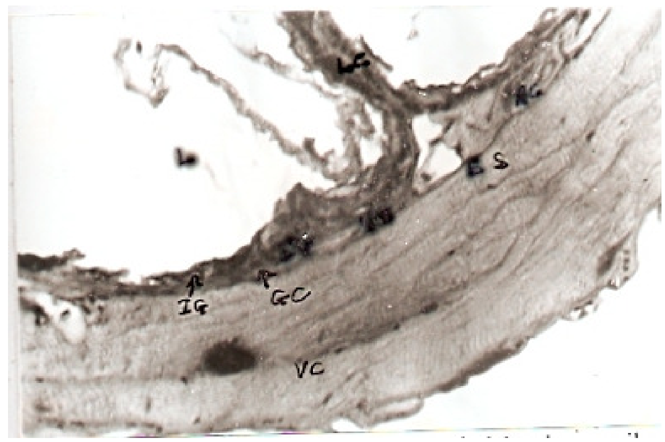

Plate 5. Transverse section of the rectum of adult palm weevilCM= Circular Muscle, GC = Goblet Cell, AC = Adipose Cell, L = Lumen,LM = Longitudinal Muscle, S = Submucosa, IG = Intestinal Gland. X=250.

wall and the same components are found in each layer (Plates 4 and 5).

The rectum had no villi but temporary folds of submucosa and mucosa layers. The rectum consisted of intestinal glands, lamina propria, surface epithelium which was lined by columnar cells, goblet cells, arteries and veins. There were adipose cells, intestinal glands, circular muscles and longitudinal muscles. Longitudinal folds were present and they had a core of submucosa which was covered by mucosa. The longitudinal folds reduce the lumen to small star-shaped spaces.

DISCUSSION

The alimentary tract of palm weevil consisted structurally of three distinct regions from the mouth to the anus. The gut consisted of the foregut, midgut and hindgut. Berridge (1970) reported that the foregut and the hindgut of insects had cuticle and that they were of ectodermal origin while the midgut, which had no cuticular intima, was developed from the endoderm. The foregut of insect begins at the base of the mandible and maxillary and extends to the oesophagus and proventriculus (Tsai and Perrier 1996; Lee et al., 1998). The arrangement of the oesophagus of palm weevil was the same as those reported for oriental fruit fly by Chun-Nu et al. (2000). The larva had a big crop where it stores all its food. Yoloye (1988) and Adedire (2002) reported similar occurrences in the alimentary tract of cockroach, *Periplaneta americana* and kolanut weevil, *Sophrorhinus insperatus* respectively. Backus (1985) had described the ciberial and the oesophageal regions of the mouthparts of several leafhoppers.

The function of the oesophagus of the insect is to pass food downwards to the midgut while the crop serves as a storage depot for ingested food (Wigglesworth, 1965). The oesophageal glands secrete mucous which lubricates food and makes swallowing easy. The oesophagus and the crop of palm weevil must have contained strong elastic muscles which allows peristaltic movement of the food in the oesophegus and makes the distention of the crop possible. Lee et al. (1998) reported similar observation in the foregut of *Bactrocera dorsalis*. The oesophagus of the insect was made up of stratified squamous epithelium. Smith (1968) reported that there may be little or no absorption of nutrients into the haemolymph across the crop wall of insects. The proventriculus plays a very prominent role (grinding) during food digestion in palm weevil. The proventriculus is muscularly built in this insect to withstand the pressure associated with the mechanical grinding of food in the chamber. Chapman (1985) reported that proventriculus was absent in fluid feeders.

The architecture of the midgut of this insect was the same as those reported for other insects (Gartner, 1985; Adedire, 2002). The midgut was the region for both digestion of food and absorption of nutrients. The epithetlium was responsible for both the production of many digestive enzymes and the uptake and transfer of nutrients to the haemolymph (Wigglosworth, 1965; Billen and Buschinger, 2000). Adedire (2002) reported that the larva of *S. insperatus* eats more food because it uses more energy for eclosion and the periodic moulting of its cuticle.

Columnar cells were concerned with the roles of enzymes secretion and the absorption of the products of digestion (Chapman, 1985). Smith (1968) stated that the cytoplasm of columnar in the midguts of insects was richly supplied with cisternae of the rough endoplasmic reticulum as well as the granular cisternae of the golgi complexes. Dimitradis (1991) reported that the anterior and posterior midgut regions of the adult *Drosophila auraria* are probably involved in the absorption of nutrients from the gut lumen to the haemolymph. Both of these regions displayed cells with well-developed villi and microvilli. The midgut epithelium of insects lack permanent uniform cuticle and the food in this part of the digestive system is separated from the peritrophic membranes (Chapman, 1985). There are two types of peritrophic membranes in insects according to their modes of formation. Chapman (1984) reported that the first type of peritrophic membrane occurred in Dipterans in which the membrane is secreted and formed at the anterior end of the midgut while the second type is formed by delamination from the entire surface of the midgut and it occurs in many orders of insects, including Orthoptera and Coleoptera. This structure generally plays a role similar to that of mucous in the vertebrates gut by protecting the midgut cells from mechanical damage caused by abrasive food particles (Richards and Richards, 1971). The peritrophic membrane in palm weevil midgut contained two layers like that reported for oriental fruit fly and *D. auraria* by Chun-Nu et al. (2000) and Dimitriadis (1991) respectively. The presence of endocrine cells around the regenerative cells had been reported in the midgut of *Meliopona quadrifasciata* by Nerves et al. (2003).

The role of the hindgut was very prominent in the alimentary tract of palm weevil. In the rectum more water is removed from the faeces and a somewhat semi-solid material is ejected through the anus. The presence of more goblet cells and intestinal glands in the rectum and anal region lend credence to the fact that more mucous are produced for the lubrication and easy egestion of feacal materials through the anus. These regions are muscularly built to withstand the pressure of defecating. In addition, the presence of more blood vessels in this region may account for the re-absorption of more water and the conveyance of this (that is, water) by the blood.

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