

ANATOMY AND HISTOLOGY OF THE ALIMENTARY CANAL OF ADULT *PAPILIO POLYTES POLYTES* L. (LEPIDOPTERA: PAPILIONIDAE)

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ABSTRACT

The present study provides the description of the anatomy and histology of the alimentary canal of adult *Papilio polytes polytes*. The alimentary canal consists of long foregut and hindgut and short midgut. Histologically foregut and hindgut showed outer muscularis, middle folded epithelium and inner chitinous intima. Midgut consists of outer muscularis and inner columnar epithelium and peritrophic membrane surrounding gut content. The epithelium of fore gut and ileum is syncytial and epithelium of colon and rectum is cuboidal. The epithelium of colon shows characteristic six folds. The crop shows well developed spines internally.

INTRODUCTION

The alimentary canal is concerned with the digestion of consumed food and absorption of it. Since the time of Pyle (1940), the study of the digestive system of adult lepidopteran insects attracted the attention of the anatomists. Burgess (1880) was probably the first worker to give a scientific account of the digestive system of adult milkweed butterfly, *Danais archippus*. Bordas (1920) have studied comparative account of the gross anatomy and histology of the digestive system of the adults of several species of Papilionidae, Nymphalidae, Satyridae, Notodontidae and Saturniidae. Pyle (1940) described the anatomy and histology of the digestive tract of the adult moth, *Callosomia promethean* in detail. Mortimer (1965) published a comprehensive account on the anatomy and histology of the alimentary canal of six species of lepidoptera. The morphology of the digestive tract of various lepidopterous species was also studied by many workers, viz. Chauthani and Callahan (1967), Le Grice (1968), Judy and Gilbert (1970), Beals and Berberet (1976) and Gongalves (1981). Anatomy and histology of alimentary canal were studied in *Diacrisia obliqua* (Kabir and Ameen, 1986) and *Papilio demoleus* (Goyle, 1990).

The butterfly *Papilio polytes polytes* is a serious and regular pest of curry leaf, *Citrus* spp. and other plants of rutaceae (Haribal, 1992; Gunathigalraj, 1998). The caterpillar is a foliage feeder prefers blossoms and young nurseries of host plants. While adult suck the sugary liquid nectar from flowers. The information available indicates that the studies pertaining to anatomy and histology of digestive tract in butterflies is scanty. Therefore, to overcome the lacunae, the anatomy and histology

of digestive tract of adult butterfly *Papilio polytes polytes* are described in the present paper.

MATERIALS AND METHODS

Field collected larvae of *Papilio polytes polytes* were reared up to the adult stages in rearing cages by providing fresh leaves of their host plants under laboratory conditions. The adults were dissected in chilled insect ringer solution under a stereoscopic binocular microscope for anatomical studies and observations were made.

The various regions of alimentary canal were fixed in Bouins fixative for 24 hr. They were washed in water and dehydrated gradually using ethyl alcohol. After dehydration tissues were cleared in xylene, infiltrated and embedded in paraffin wax (54°C). Tissues were sectioned at 5-7 μ . Sections were stained with Haematoxyline-Eosin (Humason, 1962). Observations were made and microphotography was done.

RESULTS AND DISCUSSION

Anatomy

The alimentary canal of *Papilio polytes polytes* adult is typical lepidopteran type. The length of the alimentary canal is 1.64 times longer than its body. It is about 46 mm long, whereas length of the whole body is about 28 mm only. The alimentary canal is long, relatively straight in the region of hindgut (Fig. 1). The two ends of the alimentary canal are attached to the body wall by means of muscles at the oral and anal region, elsewhere it is supported by the tracheal branches and fatty

tissues. Morphologically it is divided into fore gut, mid gut and hindgut.

Foregut

The foregut is long narrow tube 9.5 - 11 mm in length contributes about 23.91% part of the alimentary canal and extends up to the first abdominal segment. It comprises bulb like sucking pump, narrow diverticulum, lateral diverticulum or crop and muscular proventriculus. The sucking pump is composite structure composed of cibarium and pharynx. It is highly muscular structure situated in the head. The functional mouth is situated at the base of the proboscis through which it communicates with the food. The oesophagus is a narrow tube measures about 10 mm in length. Its first differentiated region is the balloon like air-filled crop. It is the lateral diverticulum and it communicates with the esophagus through a small duct, duct of crop. The crop is insulated with air and occupies the entire dorsal portion of first three abdominal segments. Crop measures about 4 mm long and 2 mm in diameter. The crop is followed by a small, slightly swollen proventriculus. It is well developed and distinguished from the rest of the fore gut. Proventriculus is about 1 mm in length.

Midgut

The midgut is short, straight; cylindrical tube extends up to fourth abdominal segment. It is about 8 mm long and contributes about 17.39% part of the alimentary canal. It appears to be segmented externally. The fore gut and mid gut junction is marked by dilation of the mid gut due to shallow invagination of the fore gut into mid gut. It is provided with numerous tracheae and surrounded by fatty tissues.

Hindgut

The hindgut is longest and coiled tube. It is delicate and measures about 27 mm in length contributing 58.69% of the entire tract. It is divisible into two regions, the intestine and rectum. The anterior intestine is divisible into ileum and colon, measures about 24 mm in length. Ileum is short and broad part while colon is long coiled slender part of the intestine. The ileum lies in fourth abdominal segment and colon is restricted in fourth, fifth and sixth abdominal segments. The rectum is wide pear shaped terminal chamber with anterior conical and posterior tubular portion, which opens to the exterior through the anus in tenth abdominal segment. In the middle of the seventh segment, the intestine passes into rectum and the junction is marked by presence of rectal diverticulum measures about 1.5 mm in length.

There are six malpighian tubules arranged in two groups of three each and open laterally at the junction of midgut and hindgut.

Histology

Fore gut

Histologically, the foregut is externally surrounded by muscularis. There are two concentric layers, outer circular and inner longitudinal muscles. The epithelium is single layered structure consists of flattened epithelial cells. The cells have indistinct basement membrane, which usually follows the longitudinal folds of the epithelium. The epithelium of foregut is syncytial with more or less granular cytoplasm and large, oval nuclei. It is lined by intima on the lumen side,

which is thick and shows alternate major and minor folds along with the epithelial layer (Fig. 2). The intima of proventriculus is thrown into number of irregular folds and occupies almost all portion of lumen and proventriculus is with well developed circular muscle layer (Fig. 3). The muscle coats of crop are thin, epithelial resolves into minor folds and lined with intima. In crop, the intima of upper region shows well developed spines (Fig. 4).

The proventriculus opens into the mid gut through a small opening guarded by the stomodeal valve. The stomodeal valve is well developed and extends into the lumen of the midgut (Fig. 10). It is composed of cuboidal epithelial cells along with intima of foregut. At the junction of foregut and midgut there is no any special structure such as proventricular teeth, pads or spines.

Midgut

Midgut consists of thin muscularis of outer longitudinal and inner circular muscle layers. The epithelium comprises transverse and longitudinal folds to provide large absorptive area. The folds are compact in the anterior region, where as they are comparatively loose in the posterior part. The epithelial cells are tall columnar and with large spherical nuclei. The cytoplasm is granular with globular secretion. The midgut epithelium shows secretory globules at the free surface and the secretion is holocrine. The basement membrane is indistinct. The division of regenerative cells located in the crypts basally to the columnar epithelial cells. The food is surrounded by single peritrophic membrane (Fig. 5).

Hindgut

The mid gut opens into the hind gut through an opening guarded by the pyloric valve (Fig. 11). Histologically, hindgut consists of outer muscularis, middle epithelium and inner intima. The epithelium is arranged into several irregular folds in ileum and characteristic six folds in colon. The epithelium of ileum is syncytial lined with thick irregular intima. The epithelium of colon is composed of single layer of cuboidal cells which are vacuolated at some places. The nuclei of epithelium are oval or rounded and basement membrane is prominent. The intima of colon is thin and wrinkled. The circular and longitudinal muscles of the ileum and colon are comparatively thicker than the midgut muscularis (Fig. 6 and 7). Rectal glands were found scattered throughout the rectal epithelium situated below the intima consists of double layer of cuboidal epithelial cells. The nuclei are large, oval, scattered in the cytoplasm but cell boundaries are not clear. Posteriorly, the rectum is tubular and more muscular and it is devoid of rectal glands. The epithelium of rectal diverticulum is composed of cuboidal cells with granular cytoplasm and darkly stained nuclei. The basement membrane limits the epithelium on its outer side and intima on inner side (Fig. 8).

The alimentary canal of adult *Papilio polytes polytes* is differentiated into foregut, midgut and hindgut like that of adult lepidoptera. These three distinct regions of the alimentary canal were also observed in *Danais archippus* (Burgess, 1880), *Serodes inara* (Le Grice, 1968), *Hyalophora cecropia* (Judy and Gilbert, 1970), *Elasmopalas lingnosellus* (Beals and Berberet, 1976), *Pseudaletia sequax* (Gongalves, 1981). The foregut of *Papilio polytes polytes* is composed of a sucking

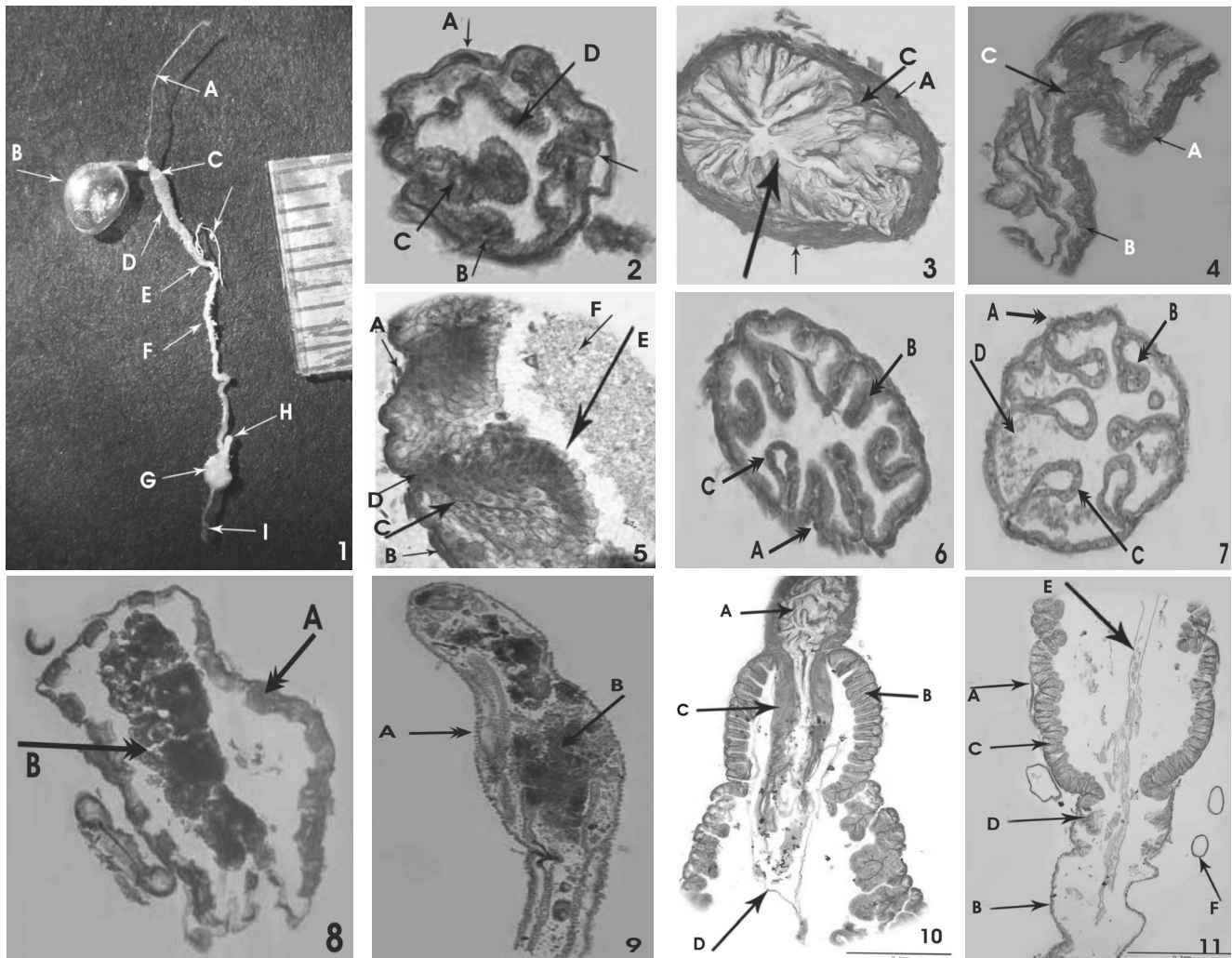


Figure 1: Adult alimentary canal A: oesophagus, B: crop, C: proventriculus, D: mid gut, E: ileum, F: colon, G: Rectum, H: rectal diverticulum, I: anus. **Figure 2: T. S. of oesophagus** A: circular muscles, B: longitudinal muscles, C: epithelium, D: intima. **Figure 3: T. S. of proventriculus** A: Circular muscles, B: proventricular teeth, C: basement membrane **Figure 4: T. S. of crop** A: circular muscles, B: epithelium, C: crop spines, **Figure 5: T. S. of midgut:** A: longitudinal muscles, B: circular muscles, C: epithelium, D: nidi cells, E: Secretary vesicles, F: gut content, **Figure 6 and 7: T. S. of ileim and colon** A: circular muscles, B: eithelial cells, C: intima, D: gut content, **Figure 8: T. S. of rectum** A: epithelium, B: luminal urine **Figure 9: L. S. of rectal diverticulum:** A: epithelium, B: luminal urine. **Figure 10: L. S. of fore gut-mid gut junction:** A: proventriculus, B: epithelium, C: stomodeal valve, D: peritrophic membrane. **Figure 11: L. S. of mid gut-hind gut junction:** A: mid gut, B: hind gut, C: epithelium, D: pyloric valve, E: peritrophic membrane

pump, oesophagus, crop, proventriculus and stomodeal valve. Bordas (1920) reported cibaria-pharyngeal sucking pump, oesophagus and crop in the foregut of several species of adult Lepidoptera. He noted fine denticulations on the epithelial folds of foregut. Pyle (1940) recognized buccal cavity or sucking pump, oesophagus, oesophageal valve and sucking stomach in the foregut of *Callosamia promethean*. He reported that the esophagus is short and narrow with reduced musculature on its wall. Mortimer (1965) noticed similar condition in *Hepialus*. Kabir and Ameen (1986) noted buccopharyngeal cavity, narrow oesophagus, crop and oesophageal valve in *D. obliqua*. They noted that the musculature is not well developed in foregut. These studies are more or less similar with the present findings in *Papilio polytes polytes*.

The crop is a thin walled balloon like air filled lateral

diverticulum. The epithelial layer is lined with thin spiny intima. Similar spiny intima was observed in *Plusia* by Mortimer (1965). Le Grice (1968) also observed some stout spines on the floor of the crop in *Serrodus inara*. The stomodeal valve of *Papilio polytes polytes* adult is well developed and is made up of cuboidal epithelial cells lined with very thin intima. Mortimer (1965) reported similar valve in *Arctia caja*. He noted spiny intima of the valve in *Plusia* and *Hepiatus* where as spines were absent in *Papilio polytes polytes*. Musculature of valve of *Papilio polytes polytes* is well developed agrees the observation Le Grice (1968) and Mortimer (1965). They noted well developed musculature in the oesophageal valve of *Serrodus* and *Plusia* respectively. Earlier Bordas (1920) recorded the columnar cells and replacement cells in the midgut epithelium of adult lepidoptera. Mortimer (1965) observed columnar cells, replacement cells and pavement cells

in the adult midgut epithelium of *Micropteryx*. A well brush border along the lumen side of the epithelial have reported by Le Grice (1968) in *Serrodus inara* and Kabir and Ameen (1986) in *D. obliqua* brush border was not observed but globular secretion was observed on the free border of the mid gut epithelium. According to Van Gehuchtan (1890) in *Ptychoptera* the granular protrusions on the epithelial cells are secretion vesicles and when the globules are present, the cells have no striated border. Present findings strongly support Van Gehuchetan's view that the globular secretion at the free border of mid gut cells of insect under study. In *Papilio polytes polytes* the food is surrounded by single continuous peritrophic membrane. The peritrophic membrane was first reported by (Aubertot, 1938) in butterfly *Pieris brassicae*. Waterhouse (1957) recorded the peritrophic membrane in adult lepidoptera.

The hindgut of adult *Papilio polytes polytes* is divisible into intestine and rectum. The nomenclature used by various authors, however, differed while describing the hindgut in different insects. The intestinal epithelium is arranged into several irregular folds in ileum and characteristic six folds in colon. It is syncytial in colon and in ileum it is composed of single layer of cuboidal epithelial cells lined by intima. Goyle (1990) made similar observations in *P. demoleus* a closely related species of *Papilio polytes polytes*. A large number of typical rectal glands were recorded by several authors (Mortimer, 1965; Le Grice, 1968; Beals and Barberet, 1976) in various species. Mortimer (1965) reported only 3 and 4 rectal glands in *Micropteryx* and *Hepialus* respectively. Judy and Gilbert (1970) found 30-35 rectal pads in *Hyalophora cercropia*. In *Papilio polytes polytes* rectal glands were found scattered in the rectal wall.

The anatomy and physiology of the digestive system have significance in the establishment and confirmation of basic knowledge in the lepidopterous insect. Thus knowledge would be utilized in planning the strategies for management of the population of this species and other related species.

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