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# Histomorphology of the Alimentary tract of adult, *Odoiporus longicollis* (oliv.) (Coleoptera: Curculionidae)

**O. Lukhoi Singh and B. Prasad**

**ABSTRACT**

The banana pseudostem borer *Odoiporus longicollis* (Oliv.) is the most serious pest of banana plantation in Manipur. The present study on the anatomy and histomorphology of alimentary tract of adult weevil is one of the striking scientific aspects as the stage has to propagate the pests race. The digestive tract is tubular and coiled structure having 39-42mm in length measuring almost double the length of the body (measuring 18-22mm long). The tract is divisible into Stomodaeum or foregut measuring 9-11 mm. in length, Mesenteron or Midgut is 20-22 mm in length and Proctodaeum or Hindgut measuring 10-11mm in length. These parts are well demarcated by the presence of distinct grooves. Stomodaeum has pharynx, oesophagus, crop and stomodaeum valve having the histological layers like lumen, inner intimal layer, outer intimal, epithelium, basement membrane, musculatures; Mesenteron possees anterior voluminous, middle tubular and posterior with regenerative crypts with histological layers of lumen, peritrophic membrane, epithelium, basement membrane and the last proctodaeum has pylorus, Ilium, Colon and rectum with histological layers namely lumen, intima, epithelium, basement membrane and muscularis repectively.

**Keywords:** Histomorphology, Digestive tract, Stomodaeum, Mesenteron, Proctodaeum.

## 1. Introduction

The banana pseudostem weevil, *Odoiporus longicollis* (oliv.) (Coleoptera: Curculionidae) is one of the major insect pest of indigenous banana plantation in Manipur. The damage is done by both the larval and adult stages, moreover, the larval stages have done maximum destruction in nature before fruiting. The incidences of the pest on the host have been reported from different parts of the world by workers like Leffroy (1909), Lall (1950), Dutta and Maiti (1972) [11, 6] . Of course, the adult stages propagate the race to neighbour healthy plants by oviposition.

The larval stages possess the cutting and chewing type of mouth parts while that of the adult modified into sucking and less cutting type. After hatching, the larval stages start to feed on the inner soft part of the pseudo stem before and during fruiting causing the serious damage to the cropping. Whereas, the adults stay in and around of the putrefied parts or portions of banana plant during and after fruiting however, it has been observed that the laying of eggs inside the small chambers of banana pseudo stem by the mature adult female weevils have been done before fruiting on the healthy plants. Several workers like Mansour [12, 1, 26, 2, 9, 29, 23, 11], Saxena (1951), have studied the anatomical, histological and certain aspects of physiology of digestive tracts of their respective insects in India and abroad Such studies will provide this present study a good ground sources in anatomy as well as histological references. So far, no one from India and abroad had studied about the detail histological aspects of *O. longicollis (Oliv.)*, therefore ,the present study has been made in order to fill up the gap as well as to help for controlling measured of the pest systematically.

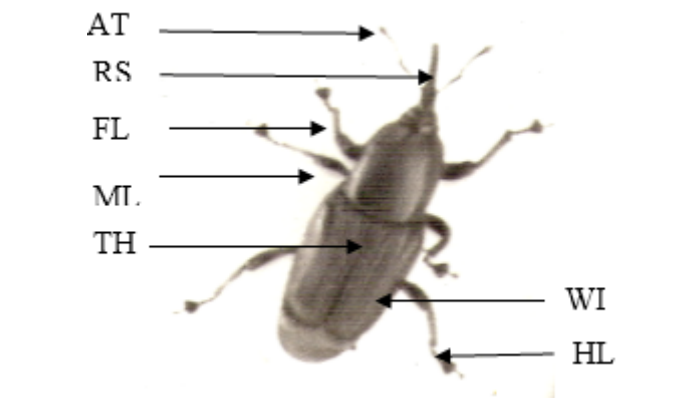


**Fig 1:** Photograph of Adult *Odoiporus longicollis*

## 2. Materials and Methods

The present materials were collected from the banana firm, different places of Manipur like Nambol, Thoubal, Bishnupur, Thanga Moirang Senapati, Urkhrul Tamenglong and Churachandpur respectively. The collected materials thus were brought and reared in the laboratory for practical schedule.

### 2.1 Histological Techniques:

**2.1.1 Materials**-The adults (Fig.1) were used for the process. Before undergoing the practical process, the adult have been starved for 3-4 days so as to enable the insects to clear the food stuffs from their alimentary tracts.

**2.1.2 Techniques**-The techniques adopted here is according to the General Zoological Microtechnique by Weesner [31, 16]. Such prepared slides were dried up for 3-5 days to proceed for further study on the histological aspects.

## 3. Results and Discussions

The alimentary canal (Fig.2) is a coiled tube measuring 39-42 mm. in length against the body length (18-22mm.). It is divisible into 3 distinct division's viz., **Stomodaeum or Foregut (FG), Mesenteron or Midgut (MG**) and **Protodaeum or Hindgut (HG)**. The entire gut is convoluted. The boundaries between these divisions are well marked by respective constrictions. The MG is the longest portion of the gut and it is characterized by the presences of numerous regenerative crypts throughout the length of it. FG is the shortest and flask- shaped with prominent proventriculus. The MG is of coleopteran type. The HG has one and a half convolution in the region of ileum and colon. The malpighian tubules (MTs) comprise of six tubules arranged in two groups of two and four each. These MTs arise from pyloric portion and get reassociated with anterior part of the colon. The alimentary canal is held up properly in the body cavity with fine tracheae.

**3.1 Stomodaeum or Forgut (FG):** The FG is the shortest portion of the adult alimentary canal measuring 9-11 mm. in length. It is divisible into 3 sub-divisions namely-**oesophagus**, **crop** and **proventriculus** (Fig.2). Further, histologically, it can be demarcated into 4 distinct sub-divisions viz., **oesophagus**, **crop**, **proventriculus** and **stomodaeal valve**. The histological observations reveal the presence of these following layers from inside to out namely:-intima, epithelium, basement membrane and musculature. The intima is double layered namely inner intima (IN.IN) and the outer Outer intima (OT.IN).The IN.IN. is highly cuticularised and produced uniform blunt teeth (Fig.3 & 3a).The OT.IN is wider and less cuticularised. The epithelium (EP) is very thin and syncitial. The cells are flattened with almost oval with rounded nuclei. The basement membrane is indistinct throughout this region. The musculature is very distinct, striated and well developed throughout the portion. The outer circular muscle (CM) is composed of 5-6 muscle fibers or sheaths whereas the inner longitudinal muscle is poorly developed locating in the in pushing of the EP. The presence of a well-developed proventriculus forms a characteristic features of it in the adult.

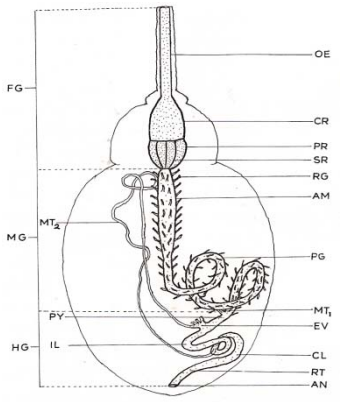


**Fig 2:** Alimentary Tract of Adult, *O.longicollis*
**AM**-Anterior Midgut, **AN**-Anus,**CL**-Colon,, **CR**-Crop, **EV**-Excretory vesicle, **FG**-Foregut **HG**-Hindgut, **IL**-Ileum , **MG**-Midgut, MT1-Anterior set of Malpighian tubules **MT2**-Posterior set of Malpighian tubules, **OE**-Oesophagus, **PG**-Poaterior midgut **PR**-Proventriculus, **PY**-Pylorus, **RG**-Regenerative crypts, **RT**-Rectum, **SR**-Sclerotic ridge.

**3.2 Oesophagus** (OE): It is well developed and extended throughout the length of rostral part measuring 5-6 mm in length and 0.4-0.6 in diameter (Fig.3). Histologically (Fig.3a), it has 4 distinct cellular regions viz., intima, EP, BM and muscularis. The intima is again divisible into two distinct regions as inner (IN.IN) and outer (OT.IN). The IN.IN. Is dark brown, highly denticulate and opaque measuring about 2 μ in thickness. The distance between two consecutive intimal teeth is 2-3 μ.The OT.IN is thick, transparent and unevenly distributed measuring 8-15 μ in thickness. It is attached to the EP. The EP is very thin having flat and distinct cells with well-marked rounded nucleus. It is measuring 13-16 μ in length and 7-10 μ in width. The nucleus is distinct and it has deeply stained bluish nucleolus. A nucleus is measuring 2-4 μ in diameter. The BM is very thin and indistinct. The musculature is well developed comprising of two different layers of scattered inner longitudinal muscle (LM) and outer thick circular muscle (CM). The LM is located in the in pushing portion of EP layer as compact form. It is measuring 3-4 μ in diameter. The CM layer is very thick consisting of 4-5 sheaths with distinct dark bands. It is measured 6-10 μ in thickness.

**3.3 Crop (CR):** From the posterior end of the OE, the gut starts to enlarge so as to form a thick, muscular and voluminous chamber which is known as the **crop.** It is measuring 2-3.5 mm in length and 1-1.5 mm in diameter. Histologically (Fig.4 &4a), the intima is distinct and double layered. The IN.IN. is 3-4 μ in thickness and is deeply stained. It has many distinct ridges and furrows which give

denticulate appearances to it showing like teeth. These are known as toothed spines projecting inside the wide lumen. An individual toothed spine is measured 6-8 µ in thickness and 4-6 µ in width. The OT.IN is also thick but is less stained measuring 6-8 µ in thickness and is closely adhered to the EP layer. The EP layer is located next to intimal layer. The cells of it are flat and sometimes cuboidal with distinct nuclei. It is measuring 14-16 µ in length and 6-9 µ in wide. The boundaries of the cells are not well-marked but the nuclei are rounded with well-stained nucleolus (Fig.4a).A nucleus is 3-4 µ in diameter. The nuclei are located at the basal portion of EP cells. The cytoplasm is granulated with homogenous black granules. The BM is thin on which the EP layer is located. The musculature is made up of two sheaths, the inner LM and the outer CM. The LM muscles are found to present between the folds of the EP. The outer CM is very well developed comprising of 5-6 distinct layers. The collective CM sheath is of 44-50 µ in thickness while individual sheath is measured 8-9 µ in thickness. The nuclei of muscle cells are found to locate in between the layers (Fig.4a).

**3.4 Proventriculus (**PR): It is the terminal part of FG externally. It is highly muscularised , scleotised and lined with 8 distinct rows of sclerotised (SR) reddish brown denticles(Fig.2).The rows are marked externally by thick brown ridges.It is measured 1-1.8 mm in length and 1.8-2 mm in diameter. The PR is broader anteriorly and tapper posteriorly. The constriction at the end of it marks the boundary between the FG and MG.

Histologically, it has a peculiarity. The dominant feature in its structure is the presence of enormous development of chitinous intima and circular muscle fibers (Fig.5 &5a).The intima in the anterior PR is thrown up into 8 longitudinal folding which bear numerous sclerotised teeth. These teeth are not exactly triangular in shaped. Between the bigger teeth, there are smaller and less chitinised secondary teeth. Bases of the main teeth are forked and lodged into the CM fibers. Behind the chitinised intima, a simple layered of cuboidal EP is located. The CM and LM muscles are striated and well developed. The CM muscle sheath surrounds the EP. The LMs are aggregated into 8 groups occupying the bases of the folding. The posterior portion of PR is very short. The epithelial folds become progressively smaller and intima becomes thin. The sclerotised plate of the teeth are set with long yellow spines developing on both sides, hence the LU is reduced in greater extent. The EP and muscular arrangement are the same as in the anterior part.

**3.5 Stomodaeum valve (SV):** It is very distinct (Fig.6).Just after proventricular region, the EP of FG continues up to the fisrt part of MG and forms a distinct double walled of valvular structure. This valve is known as Stomodaeal valve.

**3.6 Mesenteron or Midgut (MG)**: The MG is the longest part of this alimentary tract. Its length is 20-22 mm (Fig.2). The most characteristic feature of it is the presence of numerous regenerative crypts (RG) throughout the entire length. It can be differentiated into 2 regions as the anterior and posterior depending on its volume and number of the RGs. The anterior MG is measured 5-6 mm in length and 2-2.2 mm in diameter at the middle. It is bulging at the middle part and tapering at both the ends. The posterior MG is longer measuring 13-15 mm and has less number of RGs. The crypts are directly originated from the MG. Structurally, each crypt is swollen at the distal ends like pinhead in which the nidi are found to locate. In the middle, it narrows slightly and broads at the base. The junction between the FG and MG is well demarcated. Histologically, the MG can be divisible into 3 regions according to the nature of EP cells viz., **the anterior** (Fig.,7) with thick regenerative cells (RC) and moderate digestive cells (DC**), the middle** (Fig.8) with thickly populated RCs and well developed DCs and **the posterior** (Fig.9) with thick RCs and less DCs. The MG wall is histologically, comprises of **peritrophic membrane** (PM), **epithelium** (EP), **basement membrane** (BM) and **musculature**. A thin membranous structure surrounding the bolus of food in the lumen is the Peritrophic membrane (PM).In most of the MG region, this membrane seems to be broken probably because of the high regenerative and digestive activities of EP cells. Under high magnification, it seems to be made up of several lamellae attached to each other. The EP is the thickest layer consisting of 3 different cells namely-simple columnar, digestive and regenerative cells. An EP cell is measured 17-20 µ in height and 11-15 µ in width in different parts of MG. These cells seem to be varied in their activities like digestion and regeneration. DCs are well developed in the anterior and middle portion while RCs are well distributed throughout the length of MG. But, the goblet cells are entirely lacking from this part. The columnar cells are the ordinary EP cells which form a major portion of MG epithelium. The bases of these cells are narrow and attached to the basement membrane. The cytoplasm is richly granulated. The nuclei are conspicuous and oval shaped measuring 5-7 µ in length and 3-4 µ in width. The nuclei occupy mostly the middle portion of every cell. The inner edge of these cells is closely set with fine filament or striations. These are the digestive cells .The DCs are well developed in anterior and middle portion whereas these are reduced in posterior most parts. The RCs are small with denser cytoplasm and for definite groups termed as nidi sharply distinguished from the surrounding columnar and DCs. This nidi is located at the bottom of the deep EP evaginations. Thus it forms the RGs which are numerous giving a villous structure on the entire external surface of MG. The cells are measured 17-20 µ in length and 12-16 µ in width. The nuclei are rounded structures of 6-9 µ in diameter laying at the basal region. The EP cells are holocrine and sometimes merocrine mode of secretion.The BM is thin. The musculatures lie just next to BM. These are well developed arranging in alternate sheaths of inner CM and outer LM. Individual CM fibre is measured 6.5 µ in diameter while that of LM is 3-4µ in diameter.

**3.7 Proctodaeum or Hindgut** (HG): It is more or less convoluted (Fig.2) of 10-11mm in length. It is the second largest portion of the Alimentary tract. It is divisible into **pylorus** (PY), **ileum** (IL), **colon** (CL) and **rectum** (RT). Histologically, it can further be distinguished into **pyloric valve** (PV), **Pylorus**, **ileum**, **colon** and **rectum**. The HG has the same number of histological layers as those of FG.

**3.8 Pyloric valve** (Fig.8) is characterized by the presence of a valvular structure which regulates the entrance of food from MG to HG. It is made up of double epithelial folds inside the lumen locating at the junction between MG and HG. It consists of one or two transverse folds as a ring of epithelial cells in the pyloric region. The EP is well developed. The cells are elongated to form a valve like structure. The nuclei are situated at the centre.

**3.9 Pylorus** (PY) is the first portion of the HG. It is slightly voluminous and elongated. The malpighian tubules of 6 in numbers arranged into two sets are originated from the left side of this very region (Fig.2). The first set of Malpighian tubules (MT1) is of 2 smaller tubules arising from the anterior part of PY while the second set of it (MT2) if of 4 larger tubules developed posteriorly from a distinct excretory vesicle (EV). These tubules move forward up to the portion of MG and turn back towards the HG. The distal ends are associated with the wall of colon forming a crypto nephridial in nature. The intima is poorly developed. The EP is quite irregular and continues into the malpighian tubules. The CMs are made up of a few bands and the LM fibers are separately situated (Fig.9 &9a).

**3.10 Ileum (**IL) is a short, tubular, U-shaped and bending part. It is measured 2-3mm in length.A cross section of it (Fig.10) reveals its circular feature. The intima is double layered as usual measuring 2-3 µ in thickness. The IN.IN. Layer is smooth and thin while the outer one is thick and less stained. The EP layer is also thin and the cells are almost flat with distinct boundaries (Fig.10a). The EP layer is measured 14-16 µ in length and 13-14 µ in width. The nuclei are rounded measuring 6-8 u in diameter. These are located at the base of the cells. The BM is thin. The musculature consists of inner CM and outer LM fibers. The CM is measured 12-15 µ in thickness while that of LM is 6-8 µ. The LM fibers are assembling of 5-6 bundles.

**3.11 Colon** (CL) is muscular, voluminous, tubular and slightly longer than the ileum. (3-4mm in length). It is interesting to note that the malpighian tubules are reassociated at the anterior part of it. CL portion has 1-2mm in diameter. It leads into the muscular rectum. Histologically (Fig.11), the intima is double layered measuring 3-4 µ in thickness. The IN.IN is thin but the OT.IN is thicker. The EP is flat, granulated and elongated measuring 25-30 µin length and 17-23µ in width. The BM is very thin measuring nearly 1 µ in thickness. The muscularis comprises of inner CM and LM fibers. The CM fibers are grouped into 5-6 sheaths of 9-12 µ in thickness whereas the outer LM fibers are measured 7-10 µ in thickness. All the 6 malpighian tubules are associated independently on a thin peritoneal sheath forming **fiscal chamber** (FC) (Fig.11). The LM fibers are compactly situated in between two consecutive malpighian tubules.

**3.12 Rectum (**RT) is short, highly muscular and slightly bulging portion measuring 2-3 mm in length and 1-2 mm in diameter. There is no rectal pouch, gland and papillae. Histologically, the IN.IN. is smooth and thin measuring 0.8-1 µ in thickness(Fig.12) while the OT.IN. is thick measuring 3-6 µ. The EP is thin with distinct measuring 4-5 µ in width and 6-7 µ in length. The nuclei are rounded structure of 2-3 µ in diameter. The EP and intimal layers are collectively thrown as 6 longitudinal folding into the lumen (Fig.12). The cytoplasm is highly granulated. The BM is thin. The muscularis is well developed. The inner CM fibers comprise of 5-7 sheaths measuring 35-40 µ in thickness. Individual muscle sheath is measured 6-7 µ in thickness. The outer LM fibers are less in number comprising of 4-5 compact fibers. It is measured 7-8 µ in thickness.

The digestive tract of adult *O. longicollis* under investigation is tubular, coiled and cylindrical structure in its gross morphology. It occupies the maximum space in its haemocoel. It is measured 39-42mm in length which is almost double the length of the body (measuring 18-22 mm long). It is coincided with those concepts and findings of Swingle [4, 21]. The entire digestive tract in general is readily distinguished in to three primary sub-divisions viz., stomodaeum or foregut, mesenteron or midgut and proctodaeum or hindgut respectively. These divisions are well-demarcated by the presence of distinct grooves.

**3.13 The Anteriormost, Stomodaeum or Forgut** is the shortest and smallest while the middle midgut is the longest. The malpighian tubules are six in number arranged into two separate groups of two and four sets respectively. Such observations are similar with those of Snodgrass [24, 7]. The larval foregut is thin-walled measuring 9-10 mm in length including the snout. It is cauterized by the presence of a well-developed proventriculus in addition to oesophagus, crop and stomodaeal valve. The adult weevil feeds on the decomposed and decay part of pseudostem with the help of its poorly developed modified piercing and sucking type of mouth parts [33, 14] discussed these concepts. On histological view, the FG possess intima, epithelium, basement membrane and musculatures. The intimal layer is doubled. The inner intimal layer is thrown into numerous denticles and spines throughout the length of FG. These might be playing in splitting and crushing the bigger particles of the food into smaller ones so that the food bolus may enter into the MG. Lewis [10, 32, 20], have also reported similar observations in their respective experimental insects. The single-layered EP with cuboidal and flat cells resting on basement membrane is the characteristic feature of FG. Portier [18] reported the occurrence of even some glandular cells in the esophageal epithelium of *Dystiscus* larvae. No such variations in shape and function of EP cells could be observed during the present study but Morgan [15] reported similar findings. The posterior extremity of the FG gets invaginated into the anterior most part of MG as a valve. Such valves have been name differently like oesophageal, stomodaeal and cardiac by the workers like, Wigglesworth [20]. The two layers of the epithelium have been regarded as adaxial (outer) and adaxial (inner). It is in conformation with that of Henson [5].

**Mesenteron or Foregut** is the longest and broadest portion having a length of 20-22 mm. Its characteristic feature is the presence of numerous regenerative crypts to its entire length. It is broadened anteriorly but becomes tubular to its greater parts posteriorly and gets convoluted. These crypts are more concentrated on the broader anterior area of MG. The MG is divisible into two parts namely anterior voluminous and posterior. The anterior region is straight with thickly growing RGs. The distribution and nature of regenerative crypts in coleopteran have also been observed by workers like Khanna [8] in *Deporaus* and Sundman & king [25] in *Anthonomus* sp. Histologically, the MG has epithelium, basement membrane and muscularis but the peritrphic membrane is absent [17]. However, the present observation regarding the absence of Peritrophic membrane in coleopteran is not in agreement with that of Snodgrass [24]. The EP of Mg is thrown into numerous folds in the anterior part of MG due to the formation of RGs. Such type of crypts develops due to the growth of regenerative cells and exhibit the centre of proliferation of new epithelia [3].

**Fig 3:** T.S. of Oesophagus of x 200


**Fig 3a:** Enlarged a part of T.S Oesophagus.x 450

**Fig 4:** T.S of Crop X 100

**Fig 4a:** Enlarged a part T.S. of Crop. X 400

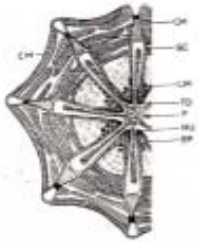

**Fig 5:** Camara Lucida diagram of a part T.S. of Anterior Provetriculus X100

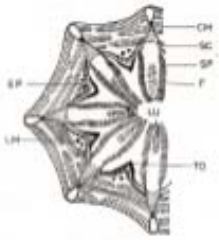

**Fig 5a:** Camera Lucida diagram of a part of T.S. of Posterior Provetriculus X100

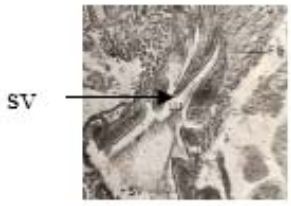


**Fig 6:** L.S. of Stomodaeal valve x 100

**Fig 7:** T.S. of Anterior Midgut x 130

**Fig 7a:** Enlarged a part of T.S of Anterior Midgut x 280

**Fig 8:** T.S of Middle Midgut X 110

**Fig 8a:** Enlarged a part of T.S. of Middle Midgut x 190.

**Fig 9:** T.S. of Posterior Midgut x 140

Fig 9a: Enlarged a part of T.s. of Posterior Midgut x 320

**Fig 10:** L.S. of Pylorus Valve x 130

**Fig 11:** T.S. of Pylorus x 120.

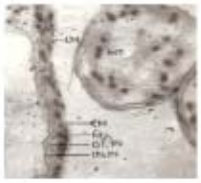

**Fig 11a:** Enlarged a part of T.S. of Pylorus x 500

**Fig 12:** T.S. of Ilium X 150

**Fig 12a:** Enlarged a part of T.S. of Ilium x 700

**Fig 13:** T.S. of Colon x 110

**Fig 13a:** Enlarged a part of T.S. of Colon x 600

**Fig 14:** T.S. of Rectum X180

**Fig 14a:** Enlarged a part of T.S. of Rectum x 400.

**Abbreviations**:-**BM**-Basement membrane, **CB**-Cell boundary, **CC**-Columar Cell, **CM**-Circular muscle, **CW**-Cell wall, **DC**-Digestive cell, **EP**-Epithelium, **EV** -Excretory vesicle, **F**-Food, **FC**-Fiscal Chamber,**FG**-Foregut, **GC**-Granulated cytoplasm **HG**-Hindgut,**IN.IN**-Inner intima, **LM**-Longitudina muscle, **LU**-Lumen ,**MG**-Midgut **MT**1-First set of Malphian tubule,**MT**2-Second set of Malpighian tubules,**NU**-Nucleus **OT.IN**-Outer intima, **PS**-Peritoneal sheath, **PV**-Pyloric valve, **RC**-Regenerative cell**, RG**-Regenerative crypts,**SV**-Stomodaeum valve.

**Proctodaeum or Hindgut** is the posterior most portion of larval alimentary tract. It is coiled tube, presence of malpighian tubules and convoluted portion. The MTs are crypto nephric in nature and arranged into two groups of two and four sets originating from anterior portion and get re associated posteriorly in the hindgut itself. The protodaeal valve is well-developed in the larva than the adult [7]. HG is divisible into pylorus, ilium, colon and rectum. Histological, the EP cells are quite different from those of FG and MG. These are in conformity with those findings of [28]. The musculature comprises of inner CM and outer LM throughout the HG. There are extra muscle sheaths formed by the CM for the re association of MTs. These are also in conformity with that of Talbot (1970).

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