# THE STRUCTURE OF THE DIGESTIVE SYSTEM IN CREOPHILUS VILLOSIS

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## INTRODUCTION.

The beetles used in this study were procured at the Columbus, Ohio, Packing House, where they lived in and around an open shed, "the hair house," where fly larvæ were abundant in masses of hair. Here they were found in large numbers in early fall. Occasionally one or two were obtained from fly larvæ infested meat placed out of doors at the Ohio State University. This large black staphylinid with silvery white markings is usually known as *Creophilus villosis* (Grav.) but is listed by Long as variety *villosis* of the species *Creophilus maxillosis* (L.).

I wish to express my appreciation to Doctor C. H. Kennedy under whose supervision the work has been carried on.

## THE GROSS ANATOMY OF THE ALIMENTARY CANAL OF THE ADULT.

The alimentary tract is relatively short in correlation with the carniverous habits of the beetle. It extends as an almost straight tube only slightly longer than the body itself. (Fig. 1).

The *fore-intestine* begins with a small pharynx limited to the anterior part of the head. This narrows quickly into a slender oesophagus extending into the prothorax where it gradually widens into the gizzard. In the mesothorax the gizzard is constricted at the beginning of the mid-intestine or stomach.

The *mid-intestine* is large in diameter and comprises about one-half the length of the entire tract. At the posterior end it loops back upon itself for a short distance. The stomach is covered from beginning to end with large and conspicuous pipillaform crypts which give a dense white appearance.

The *hind-intestine* is transparent enough so that often the chalky white contents can be seen being moved about by peristaltic action. This action often continues for a number of

minutes after the beetle is chloroformed and placed in normal salt solution. Four Malpighian tubules arise at the beginning of the hind-intestine. They are long and coil about the alimentary tract and fat bodies. The hind-intestine has only two visible regions. The most anterior of these (ileum) is slender and short and is usually looped or folded upon itself. The posterior part (colon) loops once then extends caudad. The rectum is not differentiated to outward appearance from the colon.

Terms such as ileum, colon, and rectum are used rather arbitrarily because these parts vary too much in form, structure, and proportion in various species of beetles to be exactly homologyzed.

## The Histological Structure.

*Pharynx.*—The mouth opens into a short, thickly chitenized, muscular pharynx (Fig. 5). The intima is thick, almost transparent, and has a rough surface from which short hair-like processes of chiten extend in imbricated rows, (Fig. 3). These hairs are found on about one-half the inner surface being lacking on the ventral side. The cuboid epithelial cells secreting the intima are very small. The muscles do not form a definite inner longitudinal layer and an outer circular layer, but show a confusion of pharyngial muscles and attachment muscles. The latter extend diagonally out to the chiten of the head and serve to expand the pharynx.

*Oesophagus.*—The intima of the oesophagus is much thinner than that of the pharynx and is thrown into a number of irregular, shallow folds, (Fig. 6). There are no hairs throughout the length of the oesophagus. The epithelium consists of a layer of small cells. Longitudinal muscles are sparsely distributed. Near the base of the pharynx they form a complete covering of the epithelial cells but further back they become scattered and a cross section may show from one to four. Circular muscles form a complete outer layer two or three muscles thick.

*Gizzard.*—As the oesophagus gradually widens into the gizzard the intima again thickens and hairs appear which are larger and longer than those in the pharynx. These are arranged in rows on and between slight ridges of chiten which encircle the pharynx giving its inner surface a ringed appearance, (Fig. 4). The hairs extend into eight groups which meet in

the center and twirl about, (Fig. 2). They point slightly caudad, probably being pushed back by in-coming food. The epithelium cells are small and often indistinct. Connective tissue joins the epithelium cells with the longitudinal muscles which fill in the eight folds, (Fig. 7). These are of two distinct sizes, the larger muscles being on the outside of each fold, and the smaller muscles filling up the inner part. Two or three layers of large circular muscles surround the whole.

*Oesophageal Valve.*—The end of the fore-intestine is marked by the oesophageal valve, (Fig. 9). Here the eight folds lose their characteristic shape, become more rounded, and are reduced to from five to seven. The intima changes to a smooth, hairless, slightly thickened covering of the valve which ceases rather suddenly at its posterior end. Epithelial cells become large and elongate. The muscles do not retain their distinct layers but intertwine as they form their attachments to the valve.

*Mid-Intestine.*—In Creophilus the mid-intestine is distinct in a number of ways.

The epithelial cells reach out through the muscular wall of the stomach as a loose pyle of long crypts measuring as much as eighty mu in length, (Fig. 10). At the outer end of each crypt is a nidus of cells consisting almost wholly of large nuclei. The cells that originate in the nidi make their way down the crypts and become the large secreting cells. At the extremity each crypt is solid but nearer the inner surface of the stomach the cells do not reach entirely to the center in some places and so form irregular spaces in the middle. Korschelt (*Bearbeitung Einheimischer Tiere. I Monographie. Der Gelbrand Dytiscus Marginalisl*) speaks of these spaces as vacuoles and states that they contain digestive fluids. The epithelial cells not only extend out from the muscle wall but also develop folds into the lumen of the stomach. Secretion is holocrine so that at the inner ends of the crypts cells are constantly being broken down to liberate digestive enzymes, and as they are sloughed off new cells take their place. As is usual with secreting cells the cytoplasm as well as the nucleus stains a deep blue in Delafield's Hemotxylin.

The muscular layer cannot be said to surround the epithelial cells but is sunk in among the crypts forming a perforated structure through whose openings the crypts extend. Back of the oesophageal valve the layers have changed position, the

circular muscles being on the inside and the longitudinal muscles covering them externally. The longitudinal muscles branch occasionally and do not run very regularly because of interference of the crypts. The circular layer is thicker and is matted together with minute branched strands running all through it but which are more concentrated on its inner surface. These small strands show no striations and sometimes seem to extend from the circular muscles and sometimes from cells lying loosely in the layer, (Fig. 11, con.). The first interpretation of this mat of branching hair like fibers was that they were minute branched muscle fibres or perhaps connective tissue cells. Later Mr. Warren Miller found a similar layer in the stomach wall of a Meloid beetle, Meracantha, where they were demonstrated to be tracheoles. This is probably the correct interpretation of this layer in Creophilus. Each crypt has a layer of these strands covering it. Larger fibres (but considerably smaller than the ordinary striated muscle) extend lengthwise, twelve or more running out each crypt. The space between these is filled by very fine strands which encircle the crypt, (Fig. 8). The two together form a complete though thin covering.

*Malpighian Tubules.*—The beginning of the hind-intestine is marked by the Malpighian tubules, (Fig. 14). They are four in number arising close together at the posterior end of the stomach at almost the same level from which the last crypts extend. They are composed of huge cells, large nucleated and of indistinct cell walls, surrounding a lumen and bounded on the outside by a thin membrane of connective tissue.

*Pyloric Valve.*—This valve is composed of a ring of elongate epithelial cells thrown into a number of folds, (Fig. 12). They are covered by a thin intima which begins at the anterior end of the valve and lines the entire hind gut. Here again the muscles intertwine so that there is no distinct inner or outer layer. Muscles branch as they run obliquely to the epithelial cells pulling them out to allow the opening of the valve.

*Ileum.*—In the iluem the intima is also thin and closely applied to the epithelial cells which are fairly small and regular. The epithelium is thrown into many irregular folds, (Fig. 13).

Muscles form a very thick layer about the ileum. There is no definite longitudinal layer but the muscles run more or less obliquely in every direction. Near the anterior end there are many muscles which branch to form narrow attachments to

the epithelial cells, and by contracting serve to pull out the folds, thus enlarging the ileum, (Fig. 12).

*Colon.*—The ileum is very short and suddenly widens into the colon, (Fig. 15). The intima continues as a very thin layer and the epithelial cells become much larger. The folds become more regular. At first there are from five to seven folds but further back these increase to from twelve to fifteen, (Fig. 17). About half way down the colon the folds become less distinct and widen out to form six or seven shallow corregations, (Fig. 16).

Usually in insects the hind-intestine has three layers of muscle, an inner circular layer, a middle longitudinal layer, and an outer circular layer. In Creophilus the longitudinal muscles seem to be lacking so the circular muscles are not differentiated into two layers. Throughout the muscle layer of the colon there are many tracheoles as described in the walls of the stomach, the circular muscles being bound together by them. The layer is also held closely together by branching of the muscles so that they twine about each other.

In the alimentary tract branching of the muscles appears to perform three different functions. In the stomach branching serves to circumvent the crypts. In the pyloric valve and ileum branches multiply the number of attachments to the epithelial cells. While in the colon branching binds the muscles closer together.

*Rectum.*—Near the anus the intestine narrows to form the rectum, (Fig. 18). The intima is very much thickened and roughened at the surface. There are six or seven epithelial folds which are drawn close together. The circular layer of muscles is thicker here than in the colon.

## EXPLANATION OF PLATES.

### PLATE I.

Fig. 1. Entire alimentary tract.
Fig. 2. Cross-section through gizzard.
Fig. 3. Portion of chiten of gizzard showing arrangement of hairs.
Fig. 4. Portion of chiten of pharynx showing arrangement of hairs.
Fig. 5. Longitudinal section through pharynx.
Fig. 6. Cross-section through oesophagus.
Fig. 7. Portion of Fig. 2.
Fig. 8. Cross-section through crypt near base showing covering of connective tissue.
Fig. 9. Longitudinal section through oesophageal valve.
Fig. 10. Longitudinal section through stomach showing one crypt.
Fig. 11. Cross-section through crypts near base, showing muscle and connective tissue.

### PLATE II.

Fig. 12. Longitudinal section through pyloric valve.
Fig. 13. Cross-section through ileum.
Fig. 14. Cross-section through pyloric valve, showing Malpighian tubules.
Fig. 15. Longitudinal section through ileum and colon.
Fig. 16. Cross-section through anterior part of colon.
Fig. 17. Cross-section through posterior part of colon.
Fig. 18. Cross-section through rectum.

*Key to Abbreviations.*

c. Mus.....Circular Muscle.
Con.....Tracheoles.
E.....Epithelium.
Giz.....Gizzard.
Int.....Intima.
L. Mus.....Longitudinal Muscle.
Malp.....Malpighian tubule.
Mus.....Muscle.
Oes.....Oesophagus.
Ph.....Pharynx.
St.....Stomach.
Rect.....Rectum.

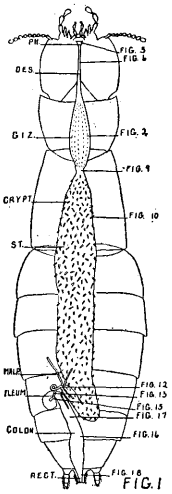
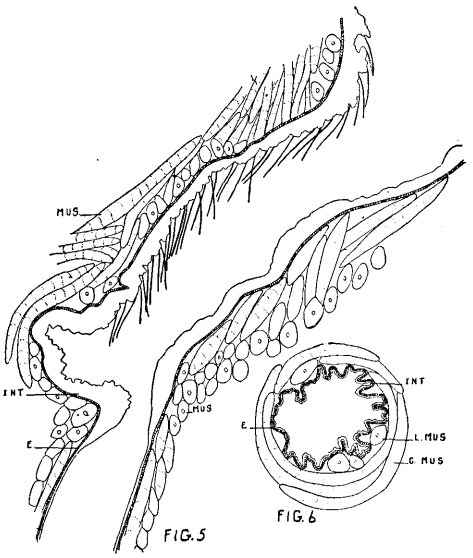
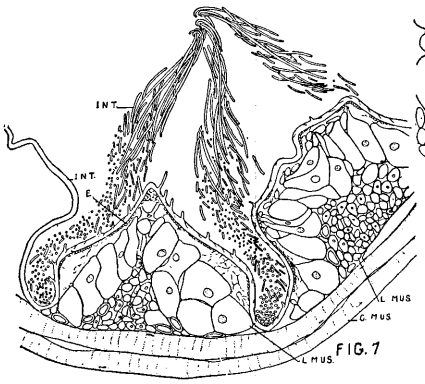

PH
DES
GIZ
CRYPT
ST
MALP
ILEUM
COLON
RECT
FIG. 1


FIG. 2


FIG. 3


FIG. 4


MUS
INT
E
G. MUS
L. MUS
FIG. 5
FIG. 6


INT
INT.
E
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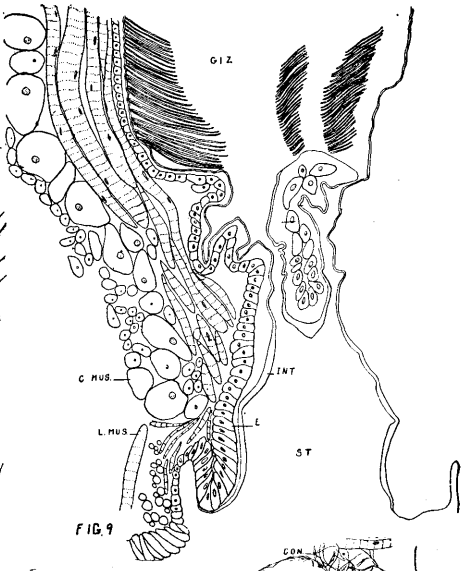
G. MUS
L. MUS
FIG. 7


GIZ
G. MUS.
INT
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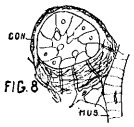
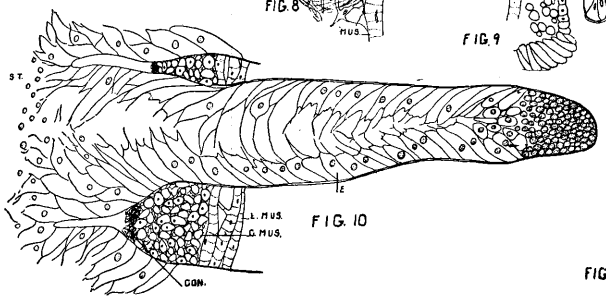
E
ST
FIG. 9


CON.
MUS
FIG. 8


ST.
E
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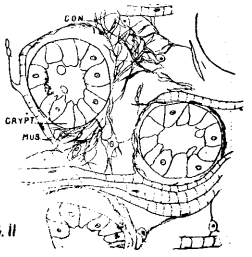
CON.
FIG. 10


CON.
CRYPT
MUS
FIG. 11

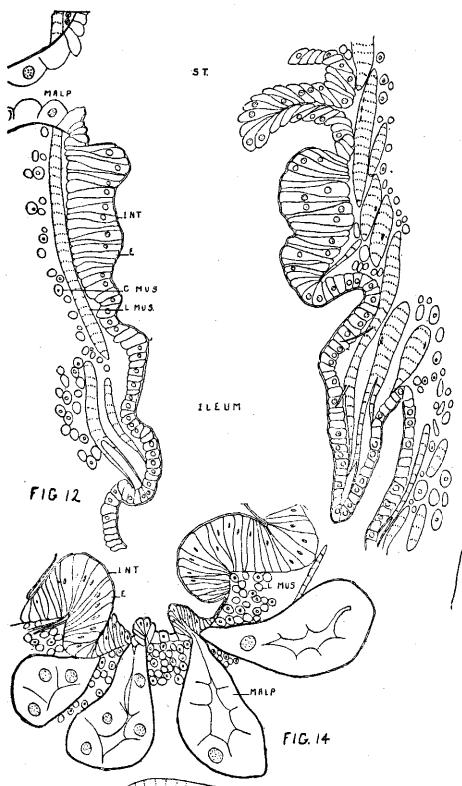



FIG. 12

FIG. 14

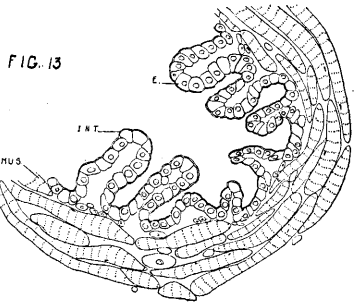



FIG. 13

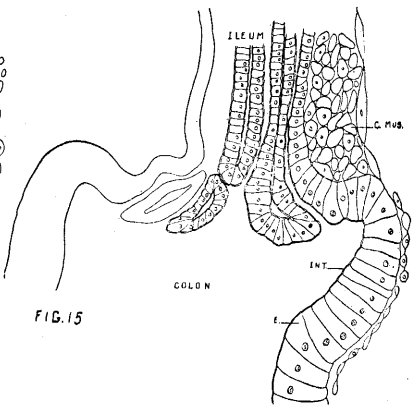



FIG. 15

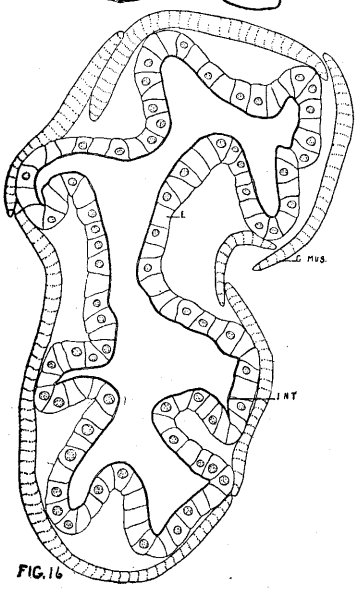



FIG. 16

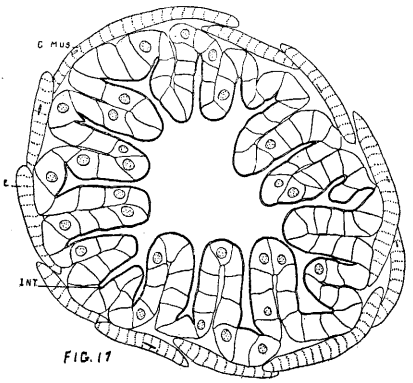



FIG. 17

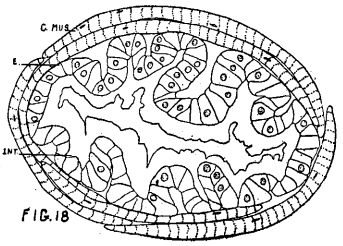



FIG. 18