THE DIGESTIVE TRACT OF LONGISTIGMA CARYAE (HARRIS).*

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INTRODUCTION.

This work was undertaken because of the author's interest in Aphididæ, and the desire to become better acquainted with the internal structure. The Sycamore Aphid was chosen because of its large size and availability. All specimens studied were oviparous females containing eggs, collected between October 3rd and November 24th. Due to the unusually dry fall and the lateness of the season, it is doubtful whether even those earliest collected were obtaining much if any sap, which would possibly account for the stomach being closed for most of the distance in all cases. Specimens taken in early October showed signs of recent digestion in the epithelium of the mid-intestine, but those taken later had the cells more normal and showed practically no shedding of the cells. Even in late September the aphids were usually found with the mouth parts attached to the bark, unless they were on the under side of the twigs, ovipositing.

The Author is much indebted to Dr. C. H. Kennedy, under whom this work was carried on, for his suggestions and criticisms as the work progressed.

The digestive tract consists of a rather simple but slightly coiled tube, lying for the most part on the ventral wall of the abdomen (Plate I, Fig. 2). For a short distance the tube is complicated by the anterior end of the mid-intestine doubling back and forming a loop through the muscle wall of the posterior end of the mid-intestine and the anterior end of the hind-intestine (Plate I, Figs. 2 and 3). This loop enters through the muscle wall of the hind-intestine and enlarges (Plate I, Fig. 3 —Oe. V.) where the folds of the œsophageal valve return and join the stomach epithelium (Plate II, Fig. 1). Following the transition from fore- to mid-intestine, the stomach makes an

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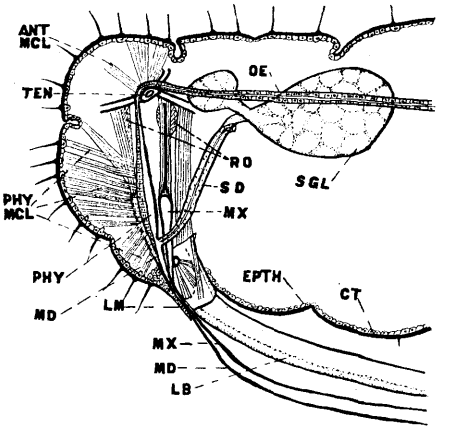
S-shaped turn before enlarging greatly at the termination of the S into the open stomach until it becomes narrowed, except in a few cases, at the point of exit from being encased in the outer covering, formed by the posterior end of the mid-intestine (Plate I, Figs. 1, 2 and 3; Plate II, Figs. 2, 3 and 4.) In this double section the epithelium (Epth.) of the posterior end of the mid-intestine almost surrounds the anterior ensheathed portion of the stomach, although at no point can the fore end be observed to penetrate this epithelium (Plate I, Fig. 1; Plate II, Figs. 1 to 4). All of the coiled portion of the digestive tract is mid-intestine with the exception of the turn made by the anterior end of the hind-intestine at about the point where the œsophagus passes through its muscle layer.



Right half of head cut near median line, showing the mouthparts with some of the muscles, the salivary glands and duct.

THE GROSS ANATOMY OF THE CANAL.

The attachments consist of the invaginated body wall at the two ends, composing the fore and hind-intestines, with the supporting muscles.

The fore-intestine is comparatively simple in the aphid, lacking the crop and gizzard.

The mouth consists of the labium or lower lip which forms the rather long beak, the labrum or pointed upper lip, the stylet like mandibles and maxillæ that are operated by muscles in the head, and the tube connecting the pharynx with the beak, into which the salivary duct empties. (Text Figure of right half of head).

The pharynx is a sucking bulb supplied with numerous muscles from various parts of the head, but especially from in front. This pharynx relaxes into a rather horseshoe shape with the concave side in front. The pharynx extends nearly up to the tentorium apparently, and is flattened and wider in front of the tentorium, enlarging as it extends down towards the mouth. The pharynx lies behind the large brain, and between the two large nerves connecting the brain with the subœsophageal ganglion.

The œsophagus is a long, slender tube leading from the pharynx, over the tentorium to the œsophageal valve which lies under the muscles of the fore end of the hind-intestine, just before the mid- and hind-intestine come together. There is no indication of outpocketing along the œsophagus to form a crop or gizzard. (Plate I, Figure 2 and text figure of right side of head.)

The œsophageal valve is located just under the muscles at the anterior end of the hind-intestine, and is indicated by the enlargement in size just before the first turn, in the stomach which can be seen through the rather structureless hind-intestine. This valve is partly enclosed in the stomach epithelium which folds back around it, but which is not penetrated at any place by the tube. (Plate I, Figures 2 and 3.)

The mid-intestine is a coiled tube longer than the body, usually quite thick-walled, and lacking gastric cœca. Externally the mid-intestine, or stomach, has a mottled appearance when cleared in Carl's solution. For most of its length the stomach is closed or partly closed in the specimens the author examined, although this would not likely be the case in specimens taken when the food supply was abundant. In the portion where the stomach forms a double tube it is usually open in both sections, with the epithelium of the outer tube wrapped most of the way around the walls of the inner, making it appear at first glance that there is epithelium devloped on both sides of the muscle layer. Cross sections show very plainly that this outer epithelium is continuous with the outer tube epithelium, and that the inner tube has not punctured the latter. Food must pass the full length of the digestive tract to reach the anus. (Plate I, Fig. 2.)

The pyloric valve is not present, and the most evident mark of transition from the mid- to hind-intestine is the ending of the

large epithelial cells of the mid-intestine, and the beginning of the rather structureless and nearly transparent sack like hind-intestine, with its scattered prominent pavement-epithelium nuclei. This transition occurs a short distance before the œsophagus penetrates through the muscles of the hind-intestine.

The hind-intestine lacks the Malpighian tubules, and consists of a sack-like portion that is almost transparent for most of the distance, but connecting with the anus by the thick-walled rectum which has only a small opening through the center. (Plate I, Fig. 2.)

The intestinal valve consists of only a fold around the end of the sack-like hind-intestine, just before the beginning of the rectum. (Plate II, Fig. 9.)

The Histology of the Alimentary Canal.

**The "retortenformigen organen"* that Witlaczil explains and pictures from *Aphis pelargonii* are in many respects similar to those found in *Longistigma caryæ*. These organs lie in the sides of the head, one pair in front of the other, and outside of the muscles that retract the mandibles and maxillæ. In the sycamore aphid these are compressed laterally as shown by Whitlaczil, and the large distal end curves back as in *Aphis pelargonii*, but the proximal end tapers to the place it joins the mandibles and maxillæ. In explaining the origin of these organs Whitlaczil states that they develop from the rudiments of the mandibles and first maxillæ, which sink into the head, taking the skin with them, and are surrounded by the body wall. He goes on to explain that "The retort formed organs show in their fully developed condition, an outer layer of flattened cells which are continuous with the epidermis of the body and consist of a compact mass of large nucleated cells, which under this layer secrete a chitinous substance which hardens first on the point of the organ where it comes in contact with the air, and so forms the outgrowing bristle."

There is a small chitinized tube running up through this "retort shaped organ," largest where it joins the base of the mandibles and maxillæ. According to Whitlaczil, Mecznikow wrongly believed that the bristles were thrust out as in the

* Whitlaczil, Dr. Emanuel. Zur Anatomie der Aphiden, with three tables. Arbeiten aus dem zoologischen Institute der Universitat Wien, pp. 397–441, 1882.

Coccidæ, and in the resting stage rolled up in the "retort-shaped organs."

The cellular structure of the "retort-shaped organs" looks much like partly differentiated embryonic muscle in Longistigma caryæ, and the cells are not so large and distinct as pictured for *Aphis pelargonii*, those in the sycamore aphid being longer and narrower in proportion, and are easily distinguished in sections of the head.

The fore-intestine is histologically composed of the same parts throughout its length, but there is some variation in development of the parts. (Right half of head; Plate II, Figs. 1, 5.) The intima is thin and very delicate for most of the distance through the fore-intestine, which it lines throughout. The epithelium is thin, the cells are cuboid, usually clearly defined, the nuclei of medium size, oval to round and quite centrally located. Nucleus and cytoplasm granular, and nucleoli distinct. The basement membrane is delicate and structureless but can be distinguished. The longitudinal muscles are delicate, scattered strands of muscle at irregular intervals. The circular muscles form a rather continuous, fairly thick layer.

The œsophageal valve very clearly marks the transition from fore- to mid-intestine. The valve consists of a fold of epithelium, delicate cuticula and basement membrane from the œsophagus, which extends well into the small fore end of the mid-intestine and around the turn that occurs a short distance from the beginning of the stomach. The folds of epithelium then turn back to join the large stomach digestive epithelium cells at the point where the tube enlarges perceptibly at the end of the œsophagus. Histologically the parts coincide with the same structures in the œsophagus. (Plate II, Fig. 1.)

The mid-intestine is rather long in the aphid and very easily distinguished from the other parts of the tract. The peritrophic membrane, or some membranous tissue is found covering the inner surface of the digestive epithelium cells in the closed and partly closed portion of the stomach, but is not present, apparently in the open stomach except where no signs of recent digestion are in evidence. The digestive epithelium is composed of large, well defined cuboid cells with large oval to flattened nuclei, the nucleoli prominent and quite large, and the cytoplasm as well as the nucleus granular. In specimens taken early in October (Plate I, Fig. 1) the fore-end of the stomach showed

sloughing off of the digestive epithelium to a large extent, although some cells remained intact. In specimens taken late in November the fore-end of the mid-intestine was open, but little evidence of sloughing off of the cells was apparent. In the closed portion of the stomach (Plate II, Fig. 8) the cells are very large, and the intestine also contracted until there is little, if any, passage way left. The basement membrane is a rather thick, structureless membrane and easily distinguished. The circular muscles lie underneath and are delicate muscles in a discontinuous layer over the length of the mid-intestine. The longitudinal muscles are scattered, delicate strands at frequent but irregular intervals on the outside of the circular muscles.

The hind-intestine is sack-like and more than half as long as the aphid ending in a short, thick walled rectum. The intima is delicate, being thickest in the rectum, but hardly distinguishable in the quite structureless sack-like portion of the hind-intestine. The epithelium consists of flattened cells with indistinct nuclei and with the cell walls seldom distinguishable in the sack-like portion. The fold forming the intestinal valve, (Plate II, Fig. 9) and the rectum is composed of thick, cuboid cells with round to oval nuclei very distinct, and the cell walls clearly defined, nucleus and cytoplasm granular. There is only a slight indication of the six-sided rectum usually found in insects. The basement membrane is thin, structureless, not distinguishable as a rule until the rectum is reached. Here it is thin and structureless. The pavement epithelium is recognized by the large flattened nuclei scattered throughout the sack-like hind-intestine, being the most distinct structure in this rather structureless portion, except for the muscles surrounding it. The inner circular muscles form a discontinuous layer of delicate muscles throughout the length of the hind-intestine, and being most numerous around the rectum. The longitudinal muscles are delicate, scattered strands only. The outer circular muscles are present in strands, but do not appear so frequently as the inner circular muscles.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. Longitudinal section through double portion of mid-intestine, showing epithelium wrapped around the inner portion of tract.

Fig. 2. Dorsal view of alimentary canal.

Fig. 3. Double section of intestine much enlarged, showing course of food.

Fig. 4. Cross-section of pharynx with muscles partly relxaed, showing the anterior at A.

PLATE II.

Fig. 1. Oesophageal valve with portion of oesophagus and hind-intestine, and the valve wrapped in the stomach epithelium.

Fig. 2. Cross-section of tube where double, just before emegrence at posterior end of double section. Shows epithelium wrapped around most of inner intestine, and muscles only connecting the folds in one place.

Fig. 3. Cross section through S-shaped portion of mid-intestine and hind-intestine, showing a layer of epithelium surrounding most of the inner folds of the tract.

Fig. 4. Longitudinal section showing emergence of anterior end of mid-intestine from near posterior end of same, where tract is double. Note epithelium pushed back by inner portion of intestine.

Fig. 5. Cross section of oesophagus much enlarged.

Figs. 6 and 7. Cross sections of open mid-intestine.

Fig. 8. Cross section of closed mid-intestine.

Fig. 9. Longitudinal section of posterior end of hind intestine showing end of sack-like portion, intestinal valve and rectum opening at anus.

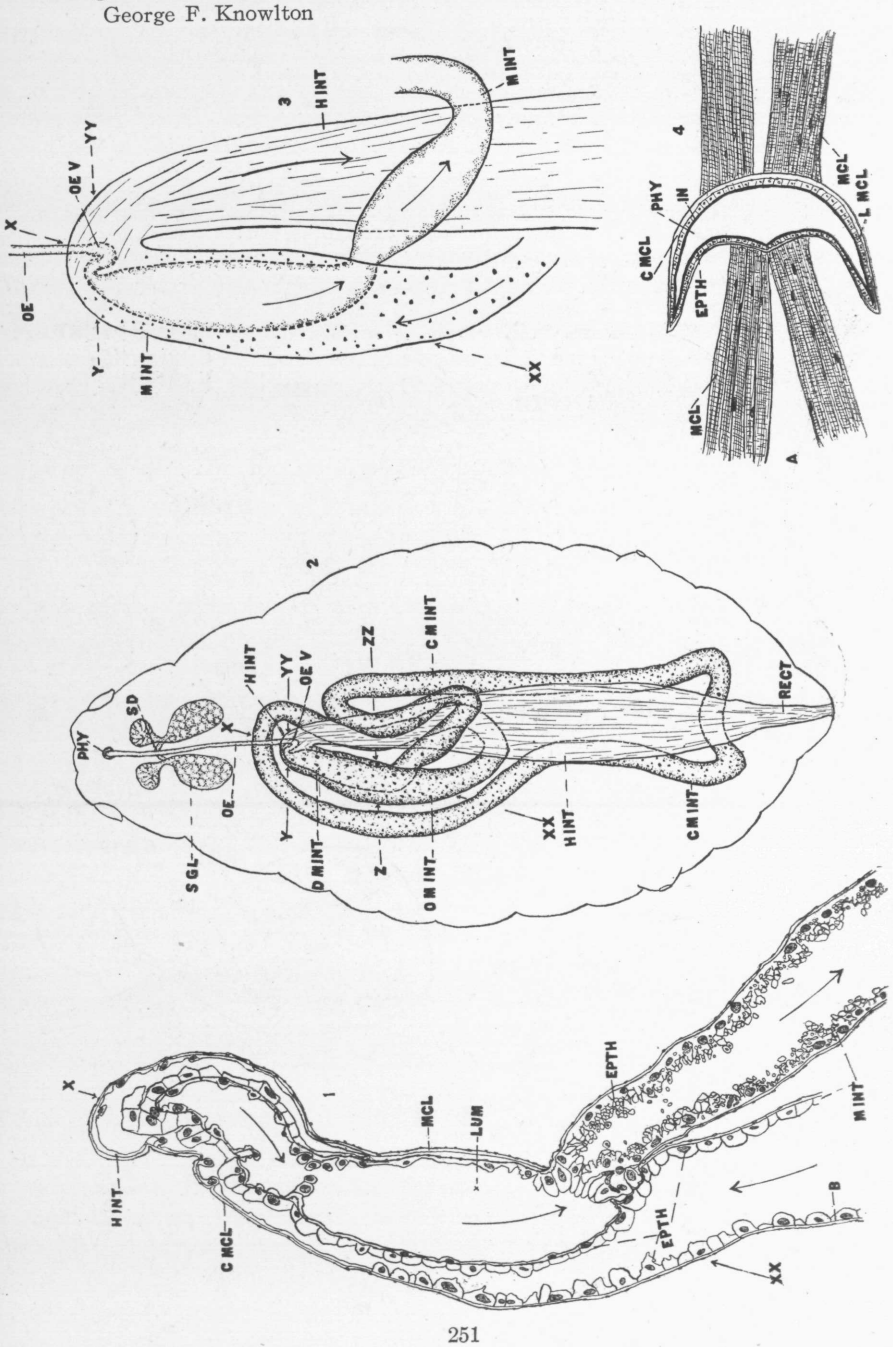
Fig. 10. Salivary glands and duct, showing the cells that stain at different intensities.

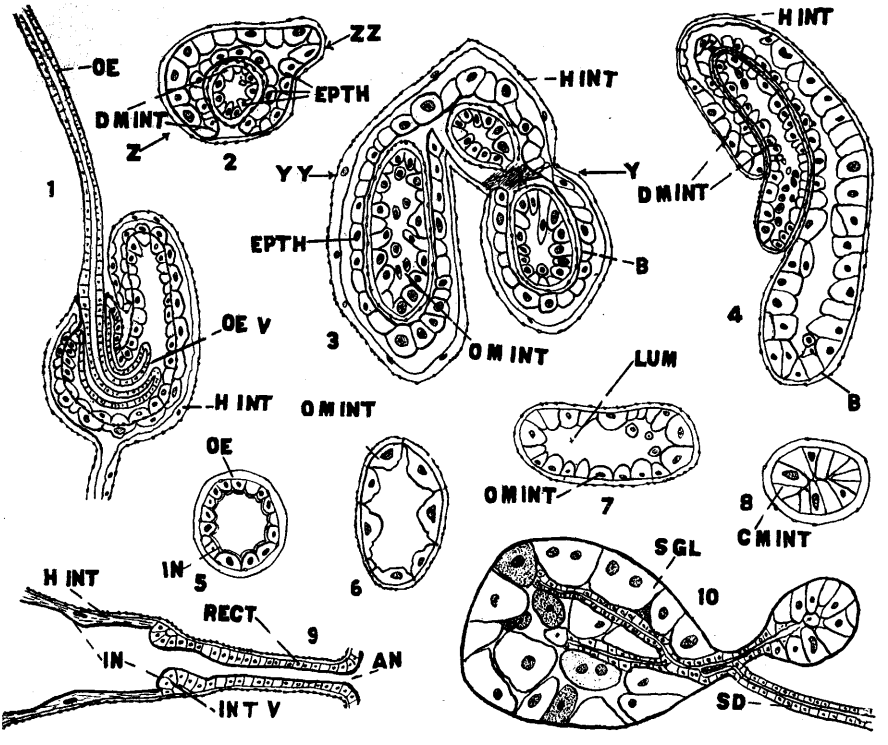
EXPLANATION OF ABBREVIATIONS.

A, anterior.
AN, anus.
ANT MCL, antennal muscle.
B, basement membrane.
C MCL, circular muscle.
C M INT, closed mid-intestine.
D M INT, double mid-intestine.
EPTH, epithelium.
H INT, hind-intestine.
IN, intima.
INT, intestinal valve.
LB, labium.
LM, labrum.
L MCL, longitudinal muscle.
LUM, lumen.
MCL, muscle.
MD, mandible.
MX, maxilla.
OE, oesophagus.
OE V, oesophageal valve.
O M INT, open mid-intestine.
PHY- pharynx.
PHY MCL, pharyngeal muscles.
RECT, rectum.
RO, "retort-shaped organs."
SD, salivary duct.
S L, salivary gland.
TEN, tentorium.

The Digestive Tract of Longistigma,
George F. Knowlton

PLATE I

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