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INTERNAL MORPHOLOGY OF THE HYPOUS OF LARDOGLYPHUS KONOII, A TYROGLYPHID PEST ON DRIED STORED FISH

BY

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ABSTRACT.

The internal morphology and histology of the hypopial stage of Lardoglyphus konoi is described from paraffin sections cut at 6 microns and viewed under immersion lens. The cuticle is considerably thicker and provided with pore canals. The parenchyma is different in appearance and compositions from those of the adult and developmental stages. Some well formed muscles are present. Oral opening and pharynx are not present, lumen of oesophagus is occluded. The other parts of the alimentary tract present in the adult and developmental stages are recognisable in hypopus also. Only on type of epithelial cells, is present in any region and the cytoplasm within the cells appears degenerative. The supra oesophageal ganglion shows signs of decentralisation. In other regions of the nervous system it resembles that of the nymph. The gonadal tissue is paired, but rudimentary and insufficiently developed to determine sex. Anatomical differences between hypopus and adult, and hypopus and other developmental stages of the species are pointed out. Anatomical differences between the hypopi of other species are also pointed out.

INTRODUCTION.

Eventhough it is fairly well established by now, that hypopus forms essentially the dispersal phase of the mite, very little is known about the internal morphology of this stage. The fragments of information available in the literature are from the works of HUGHES (1939) on Glycyphagus domesticus, WALLACE (1960) on G. domesticus, G. distructor and Histiostoma and a fairly detailed account by Kuo and NESBITT (1971) on Caloglyphus mycophagus.

PILLAI (1957) has described the external morphology of the hypopus of L. konoi. During a study on the biology of this species it was possible to obtain satisfactory results with paraffin sections and observations made on the hypopus under immersion lens are presented here. An obvious curtailment became necessary in describing the musculature because of the minute size of the animal.

MATERIAL AND METHODS.

All hypopi were grown on dried anchovy kept under preferred conditions of temperature and humidity. Active hypopi were removed from culture, fixed in Bouin's fluid, embedded in Acarologia, t. XV, fasc. 2, 1973.
paraffin and sections of 5 to 6 microns thickness were cut. Sections were stained with Iron Haematoxylin and Azan. At least 30 complete sets of serial sections either in the transverse or longitudinal planes were cut.

**Observations.**

**Body wall:**

Three layers can be distinguished in the body wall, two outer most structureless layers, and an inner cellular layer. The external among the structureless layer ie. the epiostracum (fig.1 EPI) is comparatively thin and slightly receptive to stain. Beneath this is a broad non staining layer the ectostracum (Fig. 1 ECT). These two outer most layers are invested with vertical striations (Fig. 2 V.S) or "pore canals" (Kuo and Nesbitt, 1971).

Inner to these layers is the hypoderm (fig. 1. HY) which is cellular in appearance. It is one cell thick, and the cells are short and squamous. They are rich in cytoplasm which is lightly basophilic. The cells contain a spherical centrally located nucleus.

**Parenchyma:**

The haemocoel between the body wall and internal organs is filled by parenchyma (Fig. 3 PAR). It is a spongy network lacking the cellular demarcation present in the adult or post embryonic developmental stages. The strands of the net work are invested all along with small granules (see Fig. 3) which are slightly basophilic. Some of adherents to the strands are crystalline and pale yellow in appearance.

**Digestive system:**

At the anterior end the external cuticle is slightly invaginated but not open towards the inner side. So, a mouth opening is absent. The associated pharynx is also absent. The tract occupied originally by the oesophagus of the protonymph and situated within the brain is present (Fig. 6. OES), but the lumen is not prominent. The longitudinal muscle band apposed to the sides of the oesophagus in the nymphal and adult stages are present in hypopus also.

The alimentary canal is reduced to a tubular canal situated medially in the body cavity. This tubular tract can however be clearly demarcated into three regions representing the stomach, colon, and rectum of the adult and the developing stages. Of these the stomach region is so much squeezed that its lumen is almost reduced to nullity (Fig. 3 ST). Also, possibly by the shortening of the body in the anteroposterior axis, the stomach is slightly telescoped into the anterior end of the next region ie. the colon.

On the wall of the stomach an epithelium is present, but it shows signs of degeneration. The cytoplasm is nonstaining and holds no inclusions within. Nuclei are not visible nor cellular demarcations within the epithelium. Towards the outer margin in each cell the cytoplasm is slightly more dense, but distally it is more thin and transparent.

The caeca are visible only as two cylindrical chords of tissue on either side of the colon and rectum. The caeca have no lumen (Fig. 4 CAE), and the tissue forming the chord cannot be demarcated into individual cells.

The colon is wider than the stomach and contains a lumen (Fig. 4 CO). The lumen is surrounded by an epithelium. Cellular demarcations are faintly visible in the epithelium and the cells are wedge shaped. Only the basal halves of the cells are filled with cytoplasm. In the distal halves only strands are present. Strands from adjacent cells are confluent and they appear to
FIGS. 1-6: 1) Sagital section of hypopus showing the different layers of the body wall; 2) Transverse section showing the vertical striations in the body wall; 3) Transverse section of hypopus through the region of the stomach; 4) Transverse section through the region of the colon; 5) Sagital section of hypopus showing the rectum; 6) Transverse section through the anterior end of the body.
hold vacuoles within them towards the lumen. Both the strands as well as the dense region have no affinity for the usual histological stains. No nuclei could be discerned within the epithelium.

The rectum retains the shape of a triangular sac as in the developmental stages and adult. But the walls are feeble. A lumen is present, but it is very much reduced (Fig. 5 R.E). The lumen is surrounded by a layer of conical cells whose apices project into the lumen. The cytoplasm within the cells is hardly stainable, and sparsely present towards the distal halves. A small basaly, situated nucleus (Fig. 5 N.U) is visible in some cells. In addition the projecting apex is capped by a thick band (Fig. 5 B.G) of faintly grey material. The bands over adjacent cells are confluent so that in some regions it forms a continuous layer. This material has a shrivelled and inert appearance and in many cells the bands appear to have lost organic connections with them.

The rectum descends obliquely downwards and backwards and opens by a slit like opening, the anus, in the median ventral body wall. For a short distance before the anal opening, a chitinous lining is visible around the lumen as in the adult.

Nervous System: The central nervous system consists of a dorsal half, the supra-oesophageal ganglion, and a ventral half the sub-esophageal ganglionic mass. The two halves can be demarcated by a dent on either side running longitudinally between them. Along the length of the dorsal half a median furrow is present (Fig. 6 F.U), so that two lateral halves can be demarcated in the supra-oesophageal ganglion of the nervous system. In transverse sections each lateral half of the supra-oesophageal ganglion can be seen to contain at least three discrete neuropiles (see Fig. 6). On the dorsal and outerside each half of supra-oesophageal ganglion is capped by ganglionic cells (Fig. 6 COR). These cells are several layers thick on the dorsal side but one or two layers on the sides. The cells on the dorsal sides are also segregated into clusters and at least two such clusters can be seen in each half of the supra-oesophageal ganglion.

The supra-oesophageal ganglion is connected to the upper surface of the anterior end of the sub-oesophageal ganglionic mass, around the oesophagus as in the nymphs and adult. These circum-oesophageal arms (Fig. 6 C.A.) are narrow and slender compared to the region of the supra-oesophageal ganglion. Though they form a continuation of supra-oesophageal ganglion, they can be demarcated from it because the ganglionic cells present on the sides of the ganglion do not descend downwards along the two arms (see fig. 6).

The subo-esophageal ganglionic mass extends horizontally backwards upto the ventral muscle mass. It is roughly pear shaped, with the anterior and posterior ends tapering. The ventral surface of this ganglionic mass is capped by nerve cells or cortex. The outer surface of this cortex is entire and not interrupted by gaps or furrows as in the adult. So the number of additional ganglia which have fused with the sub-oesophageal ganglion proper to form the composite mass could not be determined in the hypopus.

At the posterior end the ganglionic mass continues into a slender median nerve which cannot be traced long. In addition, the hypopus possesses a pair of nerves to the developing palpi and another four pairs, one each to the legs.

Reproductive system:

Sexes are not separate in hypopus.

Towards the median line immediately after the ventral muscle mass there is a longitudinal furrow on each side. The inner edge of this furrow bears a median fused sclerotised valve-like
structure and the outer edge an independent sclerotized structure on each side. These are probably the rudiments of external genitalia.

Immediately above these rudiments and within the body cavity a chord of tissue different from the adjacent parenchyma and cylindrical in outline is present on either side. The tissue within the chord is undifferentiated and homogeneous. It is slightly basophilic. No cellular demarcation or nuclei are visible within the tissue. These chords may represent rudiments of the gonadal tissue.

Musculature: Based on the terminology used by Kuo and Nesbitt (1971) the following muscles groups could be identified.

1) Anterior oblique muscles

These are 3 pairs; with the partners of each pair situated symmetrically on either side of the median line, anterior to the dorsal transverse groove. They run obliquely forwards and downwards.

2) Dorsal muscles:

These are three pairs running parallel to the dorsal integument. They run between the anterior and posterior ends of the body.

3) Dorsoventral muscles:

These are five pairs running between the dorsal and the ventral body wall. The first pair runs between the dorsal integument at the level of the first coxa, and its base. The second also arises from the dorsal integument more or less at the same level and extends to the posterior border of the first coxa. The third pair extends between the lateral sides of the dorsal muscle and inner margin of the third coxa, on the ventral side. The fourth arises from the posterior dorsal body wall lateroventrally and extends anteriorly and downwards upto the hind margin of the third coxa. The fifth arises dorsally at the level of the rectum and extends downwards, backwards and lateroventrally to the ventral body wall.

4) Longitudinal muscles:

Consists of a pair and runs between the ventral muscle mass and the anterior edge of the endosternum, closely apposed to the sides of the oesophagus.

5) Transverse muscle:

This is a single muscle band running transversely at the level of the third coxa between the ventral ganglionic mass and the gut. At the two ends it bifurcates, with each arm ending in front and behind the third coxa of that side.

Discussion.

Except for the reproductive system which does not develop before adult hood, the internal anatomy of the adult and the post-embryonic developmental stages of L. Konoi are fundamentally similar, with well differentiated epithelium in the alimentary tract, a functional pharynx and mouth opening. In the hypopus there is an invagination on the ventral side as in G. domesticus (Hughes and Hughes 1939). But it does not open to the inside. Thus there is no mouth opening in the hypopus under discussion as in any hypopus that has been described. The lumen
of the oesophagus and caeca are occluded. Similarly even though the different regions of the alimentary tract are recognisable in the hypopial stage, the epithelium in the different regions is different from those of the adult or developmental stages. The epithelium in the hypopus appears to be non functional and cells do not at all differentiate into different functional types evident in the adult or the nymphal stages. This indicates that as Kuo and Nesbitt (1971) have suggested, the internal anatomy of the hypopial stage is strikingly different from the adult. The rudimentary lumen of the alimentary tract, absence of salivary gland, pharynx, and mouth opening, all these evidences suggest that the hypopial stage is nonfeeding and the alimentary tract nonfunctional.

In the inert hypopus of G. domesticus there is no anal opening, nor in the intermediate type of G. destructor (Wallace 1960). The hypopus under study is mobile and it has an anal opening and vacuolated rectal lumen as in G. mycophagus (Kuo and Nesbitt 1971). A pale staining material appearing at the apices of the rectal cells of G. mycophagus has been suggested by Kuo and Nesbitt to resemble the developing brush border. Evidences in the present species do not subscribe to this view. Firstly a brush border is not present in the adult epithelium and secondly as already pointed out, this material has only an inert appearance and appear to have no organic connection with the cells.

From the studies on G. mycophagus (Kuo and Nesbitt, 1971) have contended that the central nervous system unlike other internal organs is not modified in this peculiar stage and that the short duration of molt which could preclude any extensive rearrangement of the tissues may be the reason for this. In the present species, in none of the developmental stages or the adult, lateral halves of the supra-oesophageal ganglion are so separate, and so much number of neuropiles and separate ganglionic cell groups of the cortex evident, as in the hypopus. This is a case of decentralisation and shows that the nervous system undergoes changes during this stage. In L. konoi in all the stages before the hypopial molt the brain is more fused and centralised. This would suggest that what is taking place in the species is " decentralisation together with development " or a case of " biogenetic law reversed " (Beklemishav 1969) as in the Diptera larva Syrphus.

Wallace (1960) claimed that a new parenchyma is formed in the hypopial stage. Kuo and Nesbitt (1971) found the haemocoel and fat body similar in the adult and hypopus. Evidences present for L. konoi suggest that a new parenchyma is formed in the hypopial stage. In the nymphal stages the parenchyma has definite cellular demarcation which are totally absent in the hypopial stage. The parenchyma in hypopus is studded with basophilic granules which are also not evident in the nymphal stages. Histo chemical runs have also shown that there is reserve of fat only in the parenchyma of hypopus. The composition of parenchyma was different in the protonymph.

Kuo and Nesbitt (1971) have suggested that the thick sclerotised cuticle in the hypopus may aid water conservation. In the present species it appears that its cuticle is highly resistant to the entry of water from outside also, because, they wade through fixatives for three to four days continuously before they die, as against minutes by which the adults will die in the same fixative. The presence of pore canals in such a case becomes interesting. Lee (1947) suggested that cytoplasmic filaments within the pore canals are important in the intake of water in ticks. But, for hypopus their presence do not seem to be of help in intake. In insects such canals are related to the presence of a wax layer (Locke 1964) which is essential in preventing desication. In C. mycophagus a wax layer could not be established on the cuticle of hypopus by Kuo and Nesbitt. In the present species a wax layer was seen on the surface of cuticle by histochemical studies. Only further studies may help to know how the hypopus is able to respire in the absence
of trachea and spiracle and in the presence of thick cuticle with a wax coating over it. A pair of oil vesicles as seen in *C. mycophagus* is present in the present species also.

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**References**


**Abbreviations used in figures**

- BG: Grey band at the apices of cells; CA: Circum oesophageal arm.
- CO: Colon; COR: Cortex; CAE: Caecum; ECT: Endostracum; EPI: Epiostracum.
- FU: Dorsomedian furrow; HY: Hypodermis; NU: Nucleus; OES: Oesophagus; PAR: Parenchyma.
- RE: Rectum; ST: Stomach; VS: Vertical striations.