Some observations on the differing gastrointestinal tracts of Black soldier fly Larvae (BSFL) and Mealworms using a variety of innovative X-ray micro-CT techniques - Implications and a discussion of possible future lines of research

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Introduction

BSFL and mealworms are commonly used feed and food sources. We have observed differences in the anatomy of their GI tracts and wish to draw delegates' attention to some of the possible implications.

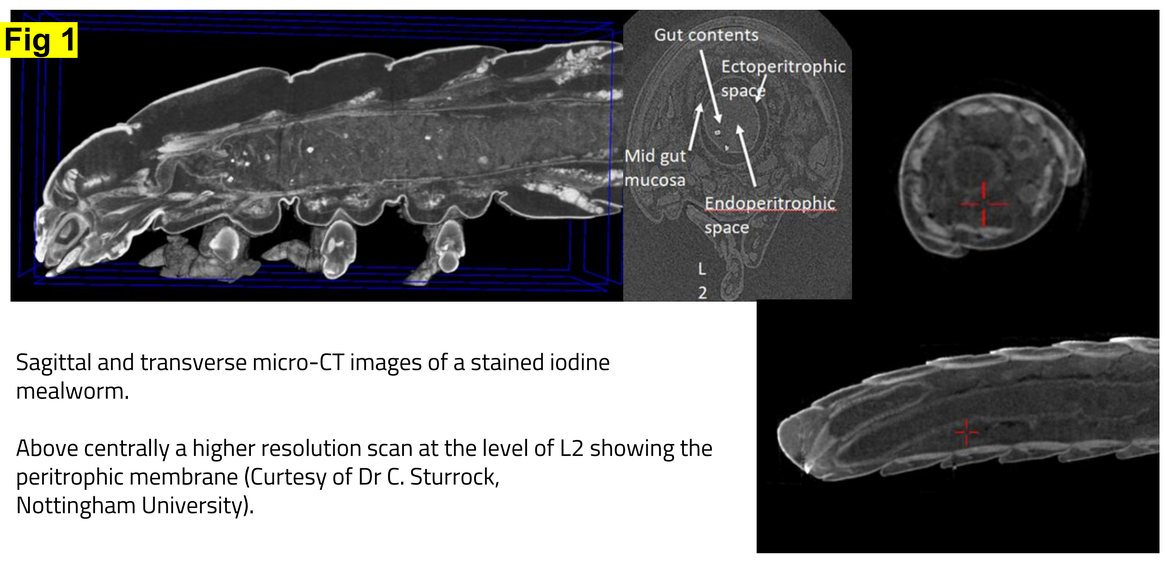
Materials and Methods

Iodine stained and unstained mature mealworms and BSFL were scanned using various different micro-CT scanners. Some of the specimens were first either fed or injected intra abdominally with Omnipaque, an image-contrast improving agent.

Results:

The GI tract of mealworms was relatively simple (Figs 1 and Fig 2a and Fig 2b). BSFL had considerable amounts of calcium-rich concretions in the anterior two Malpighian tubules and its GI tract was considerably longer and more tortuous (see Figs 3 and Fig 4).

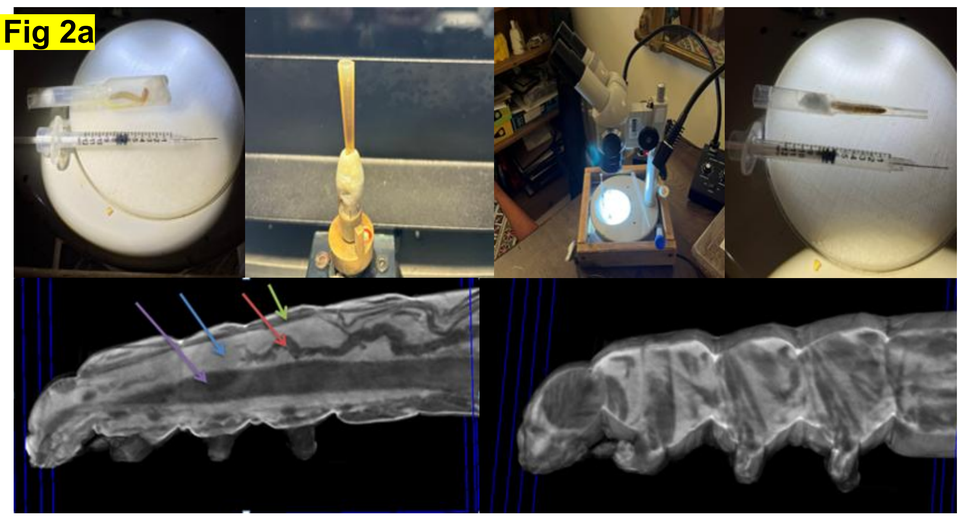
Fig 1

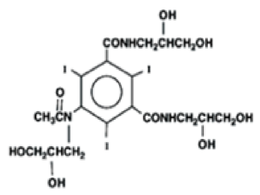


Sagittal and transverse micro-CT images of a stained iodine mealworm.

Above centrally a higher resolution scan at the level of L2 showing the peritrophic membrane (Curtesy of Dr C. Sturrock, Nottingham University).

Fig 2a





- Omnipaque

A small amount of Omnipaque injected into the abdominal haemolymph of an anaesthetised mealworm using a dissecting microscope. A scan 24 hours later scanned showed considerable anatomical details including the salivary glands (red arrow), the straight GI tract (purple arrow) above and body wall muscles below.

BSFLs were considerably more convoluted such that their GI tracts were approximately 4.5 times longer than their body lengths:

Four iodine stained BSFL scans demonstrating the complex nature of the BSFL's GI tract. In the centre below we show our postulated positions of the fore, mid and hind gut in green, blue and purple. based on 10 BSFL.

Fig 3a

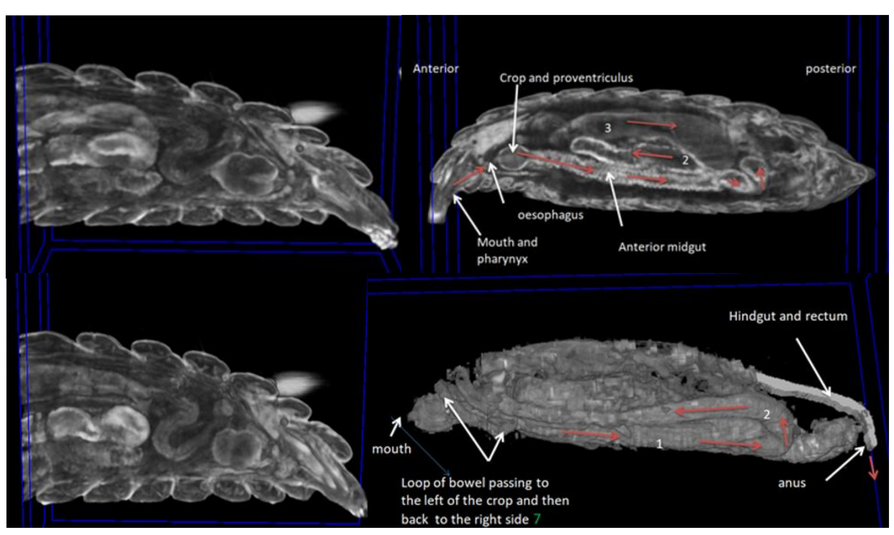
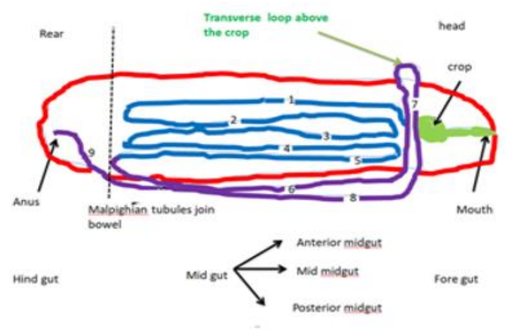
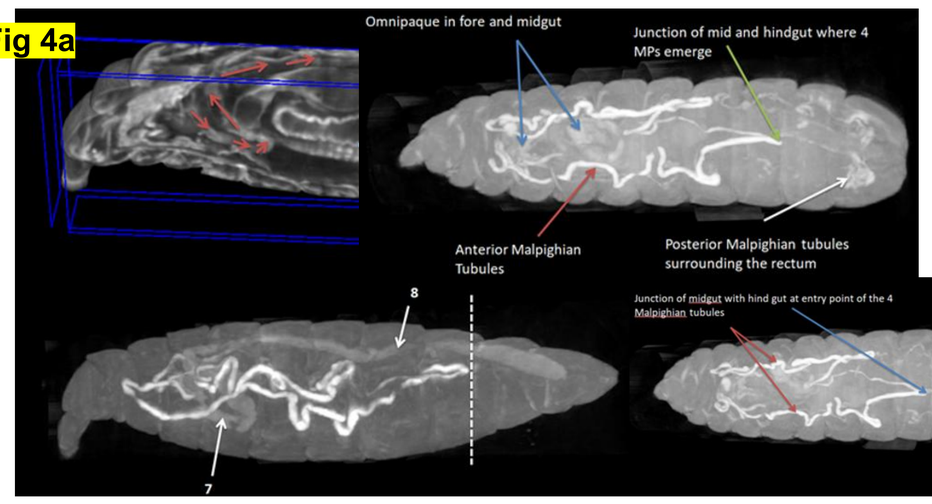


Fig 3b



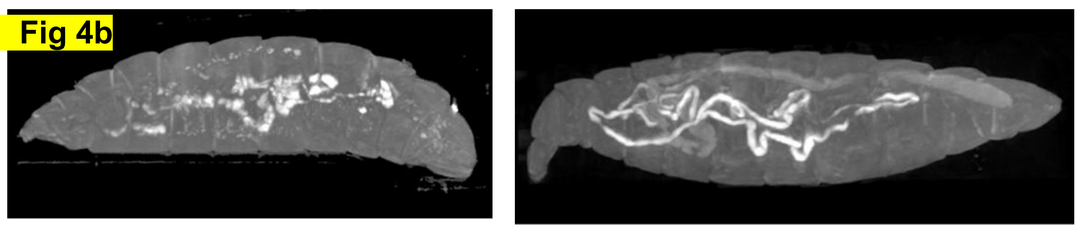
Scans of a BSFL given oral Omnipaque to outline parts of the GI tract. The contrast was rapidly absorbed into the haemolymph and promptly excreted by both the 2 anterior and 2 posterior MTs revealing the cryptonephric nature of the latter. The dotted white line indicates the level of the junction between the mid and hind gut which appears to be between GI loops 5 and 6 on the central cartoon.

Fig 4a



Below two scans (MIP views) of BSFL on a low calcium diet. The two anterior MTs are more clearly delineated after oral omnipaque.

Fig 4b

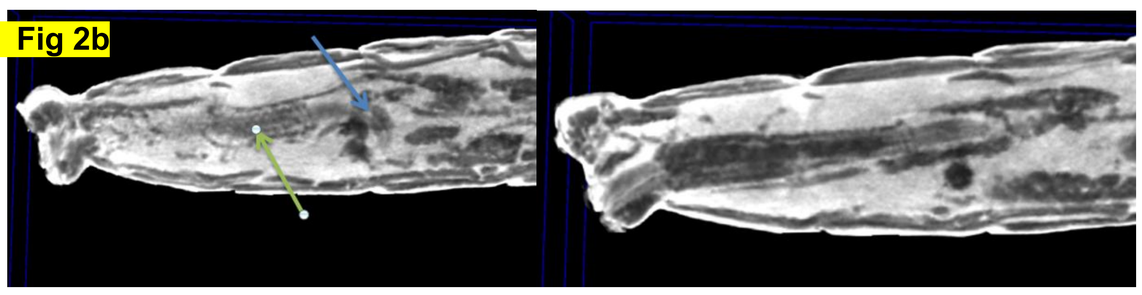


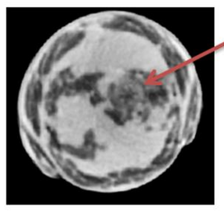
Unstained MIP –low Calcium diet

Low calcium diet + oral Omnipaque

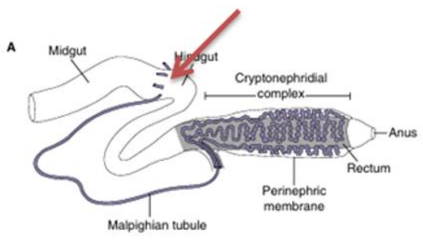
Intra-abdominal Omnipaque injections revealed the size and extent of mealworms' salivary glands, its 6 MTS and the nature of its rectal complex.

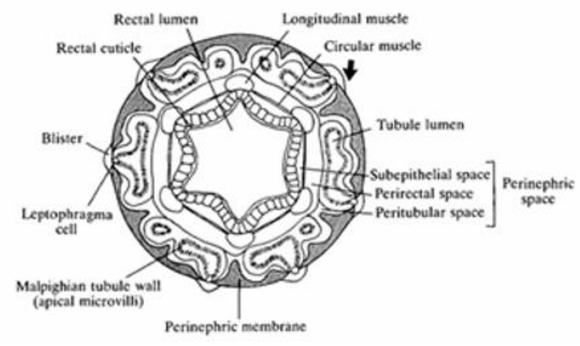
Fig 2b

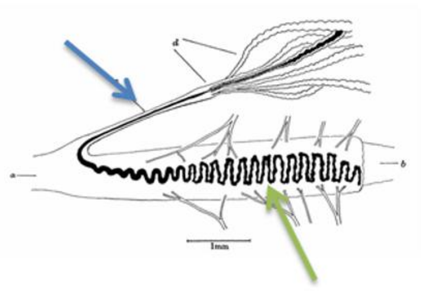




Pylorus and surrounding 6 MTs







Discussion

BSFL are rich in calcium, much being stored in its anterior 2 MTs (ref 1). The GI tract of the BSF, especially it's hindgut, is considerably more complicated than depicted diagrammatically in many

previous publications while the GI tract of mealworms is relatively simple. Intra haemolymph injections of Omnipaque in mealworms is a useful ways of demonstrating its 6 cryptonephridial MTs (refs 2,3 and 4). Both oral and injected Omnipaque similarly better defining BSL's 2 anterior MTs and demonstrate its 2 cryptonephidial posterior MTs. We are currently attempting to develop a 3-D printed model of the BSFL's entire gut using segmenting and AI methodologies and a higher specification micro-CT scanner.

References

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