X-ray micro-CT is a potentially useful method of studying the fat and protein content of a variety of candidate food and feed insect species at different stages of their development.

[1,2]Bell G D, [3]Corps N and [4]Gretton S.

[1,2]Digital Futures Institute, University of Suffolk, Ipswich IP4 1QJ , [2]School of Computing Sciences, University of East Anglia, Norwich, NR4 7TJ, [3]Wonderful Scientific Ltd, Station Approach, Godalming, Surrey, GU7 IEU [4]School of Allied Health Sciences, University of Suffolk, Ipswich IP4 1QJ.

Introduction

Modern hospital X-ray CT scanners combined with AI technology can now be used could be used to assess both the distribution and mass of fat and muscle in an individual patient.

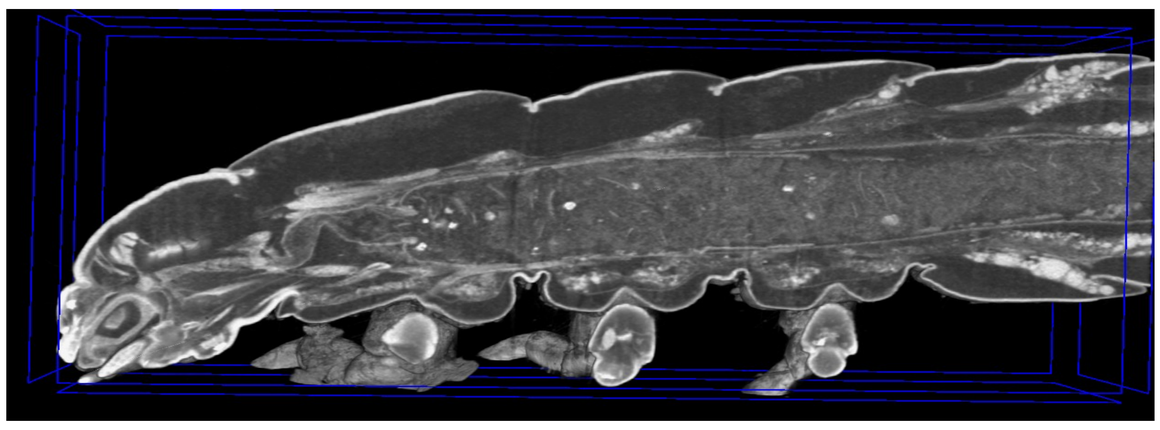
X-ray Micro-CT scanning is an established method for studying insects. To our knowledge, despite the increasing interest in insects as possible sources of food and animal feed, the possible use of micro-CT to quantify insect fat and muscle mass has been little explored.

In the present study we have used Mealworms, both unstained and stained by a sublimated Iodine Technique to assess the feasibility of using micro-CT to assess fat and muscle distribution and mass.

Methodology

The mealworms used in this study were stage 3 larvae obtained from the local Pet shop in Beccles, Suffolk.

The X-ray micro-CT scanners used on the vast majority of the mealworms was a SkyScan 1072 at an isotropic setting of 11.26 microns. A small number of higher resolution scans were performed at other centres at interpixellar distances varying from 4 to 7.5 microns. All scans were viewed and analysed using Disect and Tomomask software as previously described.

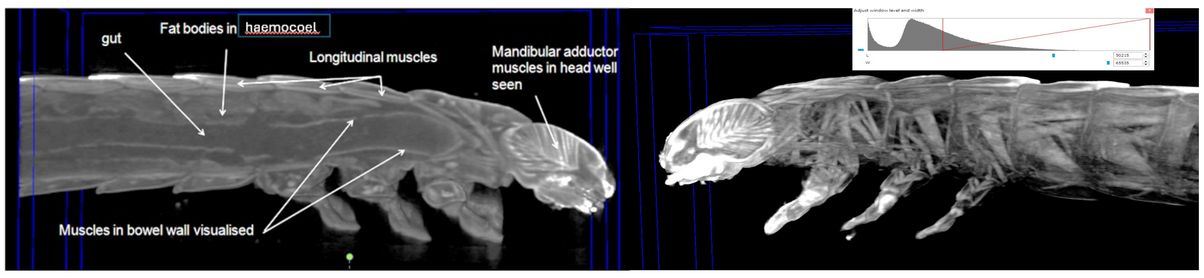


12 mealworms were scanned without any contrast enhancement while 30 were scanned after being exposed to sublimated iodine for period of between 5 and 30 days in small air-tight containers as previously described.

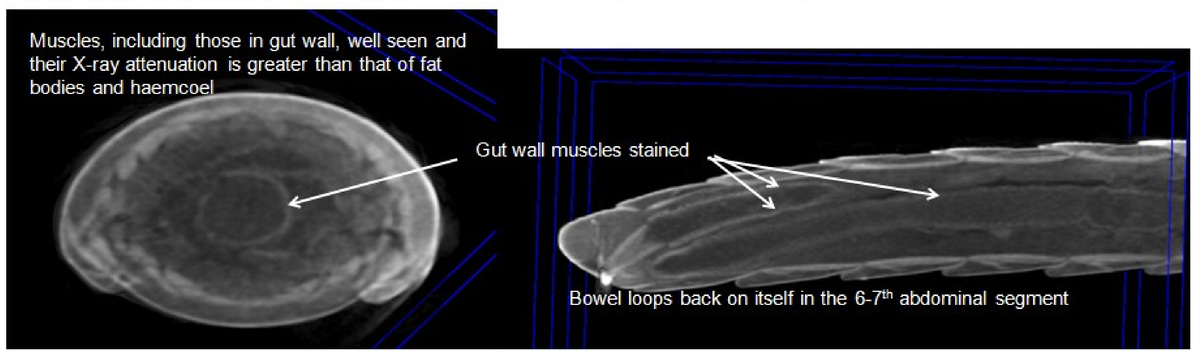
Results

Although the mealworms' external exoskeleton was well seen in all 42 scans. Internal structures such as the muscle layers and fat bodies were better defined by using sublimated iodine while preserving tracheal definition. It often required 2-3 weeks exposure to the iodine vapour to get optimal staining. The distribution of fat along the length of the mealworms varied and the staining of the large mandibular muscles was quite variable. Predictably better and more detailed results were obtained using more modern higher resolution scanners.

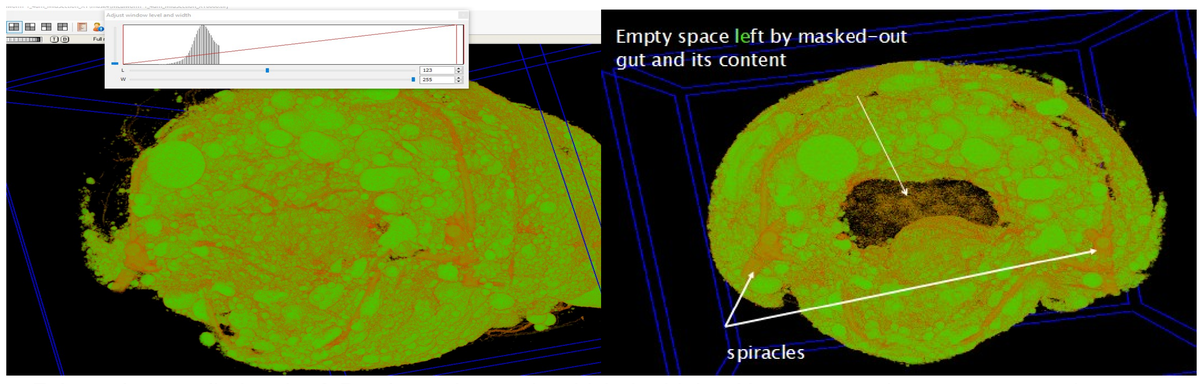
Results 1– Scans using a Skyscan 1072 in Ipswich to scan mealworms exposed to Iodine Sublimation at 11.26 microns for varying periods of time from 5-28 days (figs 6-13)



Transverse 3-D transverse section **Sagittal 3-D cut-plane view**

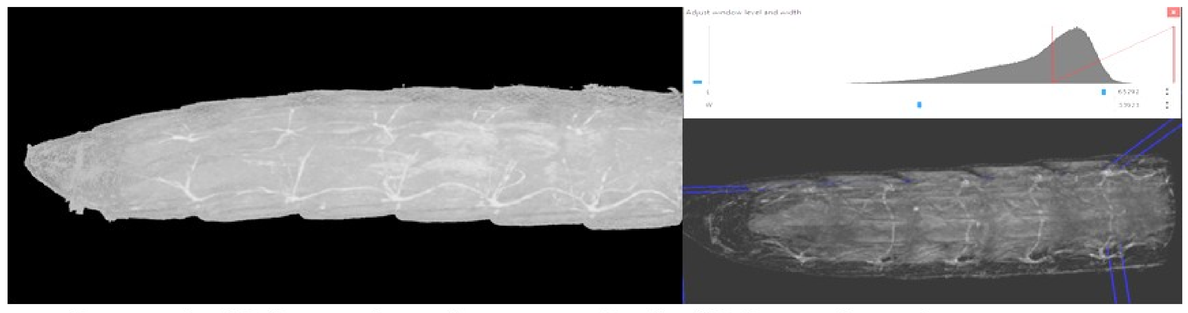


Results 2 Scans using other higher resolution micro-CT scanners to scan mealworms exposed to Iodine sublimation at 4-7.5 microns for 14 -28 days (figs 14-19)

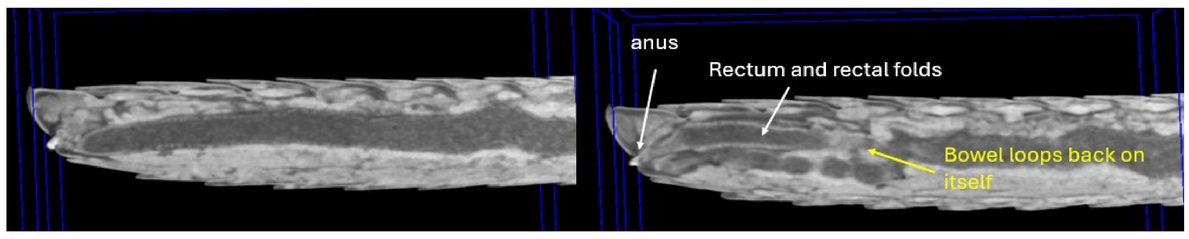


False colour applied to the 3-D volume dataset in which the higher X-ray attenuation structures such as exoskeleton, muscles and GI tract have been masked out leaving lower attenuation fat-rich tissues and air-filled tracheal system (showed in yellow and red respectively).

Results Continued



Parasagittal 3-D cut-plane view **Sagittal 3-D cut-plane view**



Cutting in from a para to a sagittal midline plane the bend in the hind gut is demonstrated as is anus, rectum and rectal folds. As before fat bodies well stained by the iodine after 19 days.

Conclusion

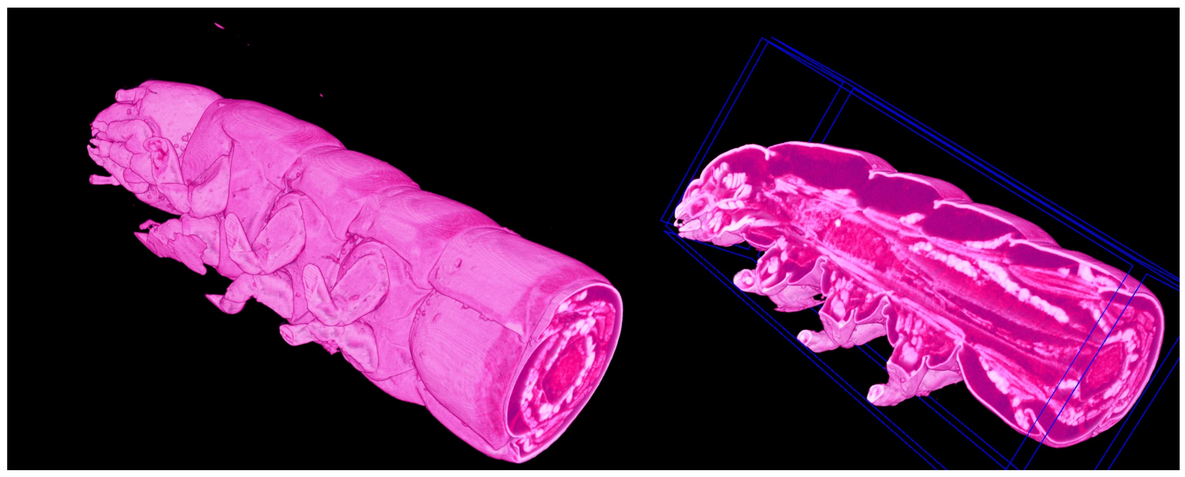
Using whole body human X-ray CT scans and AI technology it is now possible to define and quantify both a patient's muscle and adipose tissues[4]. We have shown that using sublimated iodine staining it is possible to visually define both a mealworm's muscle and fat-rich areas while preserving tracheal structure[8,9].

Micro-CT scans however generate less reproducible X-ray attenuation values than hospital scanners partly because calibrating the equipment daily using radiological phantoms is not routine. Furthermore, since the uptake of iodine into fat and muscle is variable and somewhat time dependent, it seems sensible not to rely on absolute differences in X-ray attenuation values between tissues of interest to do the actual segmentation and quantification process.

Instead ,and in collaboration with UEA and Nottingham University, we are currently exploring the possibility of using an AI visual technique to 'read' the individual transverse slices of mealworm CT scans. If successful, this would in turn permit the rapid screening of multiple possible different insect species at a) different stages of their life cycle b) fed on different substrates or c) after receiving some form of hormonal or genetic manipulation.

Acknowledgements

We are grateful to Professors John Brameld, Tim Parr and Drs Vicky Hill and Craig Sturrock from Nottingham University for permitting us to show images from some of their scanned mealworms.



References

1 Qingxin, H. and Wenfang, X. 2025. Arch Med Sci 21(2) 374-382.

2 Alba-Tercedor,J.and Alba-Alejandre,I. 2019. Wiley Analytical Science Magazine https://analyticalscience.wiley.com/do/10.1002

3 Bell,G.D. et al,2025. Poster at RES Meeting Glasgow Sept 2025.

4 Bell,G.D. et al, 2023.Journal of Insect Physiology **149.https://doi.org/10.1016/jinsphys.2023.104547**