Micro-CT visualisation of the parasite-host interface in sandflies and blackflies

Find out more:

Dr Martin Hall and Brett Clark, Natural History Museum
Dr Matthew Rogers, London School of Hygiene & Tropical Medicine
With Dr Daniel Martín-Vega, Debashis Ghosh, Professor Robert Cheke, Francis Veriegh, Tony Tetteh-Kumah, Dr Mike Yaw Osei-Atweneboana

What is the research?

Leishmaniasis and onchocerciasis are neglected tropical diseases (NTDs) vectored by sandflies and blackflies, respectively. Both NTDs are associated with poverty and impose a significant health, welfare and economic burden on many tropical countries. Current methods to visualise infections within the vectors rely on invasive methods. However, using micro-computed tomography (micro-CT) techniques, without interference from tissue manipulation, this study visualised in 3-D for the first time:

- ***Leishmania mexicana* infections and their impact on laboratory reared *Lutzomia longipalpis* sandflies;**
- **an L1 larva of an Onchocerca species within the thoracic musculature of a blackfly, *Simulium damnosum*, naturally infected in Ghana.**

Why is this research necessary?

In research of the infection of vectors with disease agents that cause NTDs, there is tremendous scope for visualisation techniques to improve the fundamental understanding of parasite-vector interactions, the basis of vectorial competence and transmission. Precise spatio-temporal information on the progress of an infection can tell us much about the interactions required for successful colonisation and transmission. However, visualisation of these interactions within the vectors has hitherto proven difficult.

Micro-CT provides a powerful tool to follow the infection within vectors non-invasively, yielding both qualitative and quantitative data. For example, studies of sandfly infection with *Leishmania* confirmed hypotheses regarding gross distension of the fly midgut following secretion of a promastigote secretory gel (PSG) which facilitates transmission of *Leishmania*. In addition, the studies:

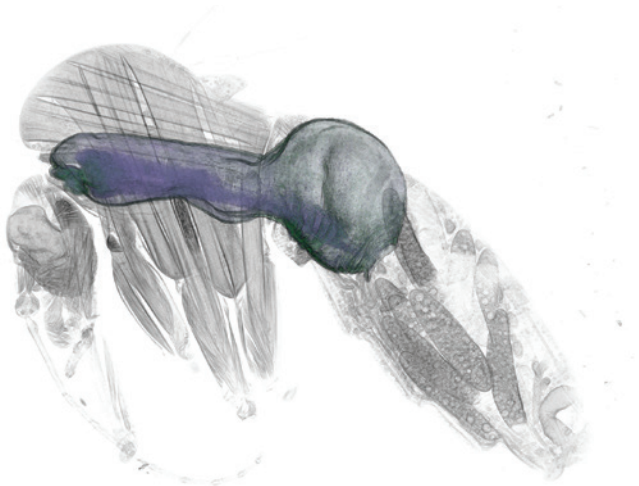
- **provided volumetric data on the midguts of infected sandflies and of the PSG within the midguts;**
- **demonstrated PSG in the pharynx of infected sandflies;**
- **confirmed the amplifying impact of a non-infectious second blood-meal on PSG in an infected sandfly.**

Similarly, in addition to visualisation of *Onchocerca* infection, questions about vector competence in blackflies can be addressed. For example, micro-CT scans of the peritrophic matrix in both 'forest' and 'savanna' blackflies preserved soon after feeding did not support the hypothesis that 'forest' blackflies have a thinner peritrophic matrix, which would allow them to develop more *Onchocerca* L3 larvae than 'savanna' blackflies.

What is the research impact?

Micro-CT studies can complement other fundamental studies of the development of NTD disease agents within their vectors, thereby helping to highlight new avenues for tackling the disease in the vector. For leishmaniasis, micro-CT has the prospect of filling in many of the missing gaps in our knowledge of the spatial arrangement of blood and PSG before, during and after transmission – and, uniquely, their precise volumes – which can all be used to begin to model the biophysics of transmission. For onchocerciasis, it will be possible to follow progress of *Onchocerca* development within a series of infected flies, shedding light on its differential development within different vector species. For arthropod disease vectors in general, fine detail of changes in internal structures may provide a more accurate way of age-grading vectors for epidemiological studies.

In addition, health education has been identified as crucial in efforts to control or eliminate NTDs. Images produced by this study and future studies could have significant value in health education by helping to illustrate and raise awareness of the role of vectors in disease transmission, at public meetings and in outreach publications.
In conclusion, although these initial studies focused on sandflies and blackflies, they demonstrate the great potential for wider use of micro-CT in the research and management of NTDs, providing novel information on many other parasite/vector systems and impactful images for public engagement.



False-coloured 3-D image of an adult female of *Lutzomia longipalpis*, nine days after ingesting a first blood-meal infected with amastigotes of *Leishmania mexicana* and five days after a second, non-infected blood meal. The cuticle is rendered transparent to enable visualisation of the distended midgut (green) part filled with promastigote secretory gel (PSG, purple) secreted by the *Leishmania parasites.*