Honeybee in 3D - Neuroimaging with µ-Tomography

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Neuroscience has benefited to a great extent from the use of animal models. The honeybee (Apis mellifera) is such an established model for research due to its distinctive behavioral traits and social instincts [1]. Like other model organisms its genome is already sequenced [2]. In contrast to the human central nervous system the brain of the investigated worker honeybee with a volume of about 1 mm^3 and a weight of about 1 mg is relatively simply structured but shows remarkable cognitive capabilities. The total number of neurons in its brain has been estimated to be 960,000 neurons [3].

Honeybees collect food from flowers, an extremely temporary food basis, and have evolved complex cognitive abilities and communication skills to optimize foraging success [4]. Their capability for associative learning is based on the need to associate a color, shape, scent, or location with a food reward. For the understanding of neurophysiologic mechanisms in the brain it is necessary to study the morphology of the wiring between and inside specific brain regions. The majority of these investigations were solved by combined staining and 2D histological sectioning techniques especially in the mushroom body, an insect brain region associated with learning and memory [5].

The development of superior 3D imaging methods was an advance for histological structural analyses. Tomography, specifically X-ray tomography, is a 3D imaging method with the advantage to be non-destructive. By the use of synchrotron radiation the spatial resolution of X-ray microtomography reaches the micrometer range. This resolution might be sufficient to visualize the projecting axons in nervous tissues. Thus, live brain imaging and 3D-neuron reconstruction within the bee brain in vivo can be obtained. These data can further be incorporated into an existing 3D-atlas of the bee brain [6].

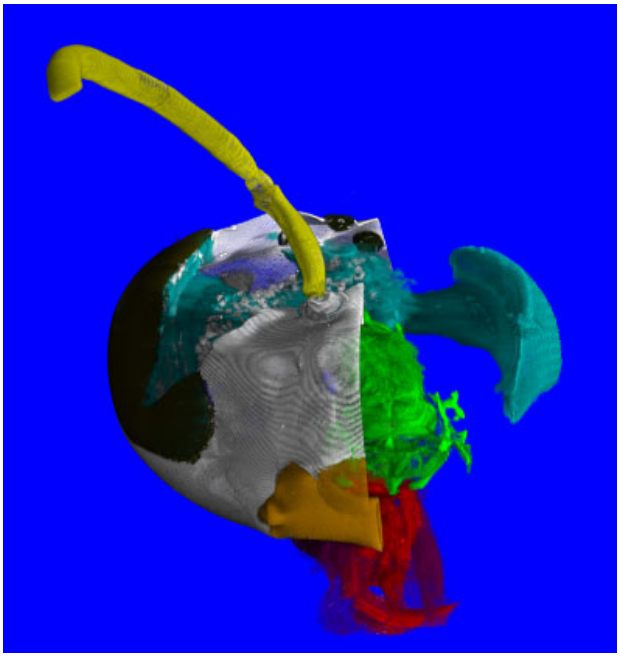

Figure 1: 3D view of a segmented and cropped head of a honeybee with a diameter of 4 mm. The different anatomical parts of the head are colorized by VGStudio Max 1.2 (Volume Graphics, Heidelberg, Germany).

In a pilot study the head as well as isolated brains of worker honeybees were investigated by synchrotron radiation-based computered microtomography (SRμCT) in absorption contrast mode at beamline BW2. The measurements were performed with photon energies of 8 and 9 keV. The voxel size was about ~1.6 μm. Figure 1 shows the segmented and cropped head of a honeybee.

The results of the successful pilot study provide valuable information about the chosen sample preparation techniques and the possibilities of 3D imaging with synchrotron radiation-based computered microtomography (SRμCT).

Acknowledgements

The authors thank the summer students Christian Taubitz and Alexey Voronov for their work of segmentation and colorization of the 3D-dataset.

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