High-throughput digitization of insect morphological biodiversity

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Presentation type: Oral **Presentation time:** 10:45-11:00

Insects are the most diverse group of animals on Earth. They are essential to ecosystems, agriculture, and human livelihoods, yet they are declining at alarming rates. More than one billion insect specimens are preserved in scientific collections worldwide, representing an immense but largely untapped research resource.

X-ray microtomography provides entirely new insights into internal and external morphology, with far-reaching implications for biodiversity research, biomimetics, and paleontology. Such fields will greatly benefit from the “Serial CT” for automatic routine scanning of large number of samples that is being developed at KIT. High-throughput capabilities at the KIT Light Source (1) and PETRA III have already demonstrated the potential for digitizing and performing 3D analysis of both important specimens and extensive scientific collections, including extant and fossil insects.

We present recent results, including the discovery of fossil parasites (2), the identification and evolutionary analysis of a unique flexible biting mechanism in chalcid wasps (3), and our most ambitious large-scale project to date: the ANTSCAN initiative (4, 5), a collaboration between KIT and the Okinawa Institute of Science and Technology (OIST), together with partners from museums worldwide. The resulting dataset contains more than 2200 digitized ants which are available to the broad public via Biomedisa (6). Each ant has its own digital object identifier with associated metadata accessible via RADAR4KIT (7). By enabling rapid acquisition of phenotypic data across the ant tree of life, ANTSCAN has paved the way for unprecedented large-scale comparative studies on ant morphology, diversity and evolution (8).

Furthermore, we will highlight recent advances in large-scale data analysis, including semi-automated segmentation of anatomical structures, body regions, and internal organs from volumetric datasets. We will also discuss the growing potential of computer vision and artificial intelligence approaches for fully automated extraction, classification, and quantitative analysis of morphological traits.

References

[1] Cecilia, A., et al. (2025): Journal of Synchrotron Radiation 32: 1036-1051.
[2] van de Kamp, T., et al. (2018): Nature Communications 9: 3325.
[3] van de Kamp, T., et al. (2022): Proceedings of the Royal Society B 289: 20212086.
[4] Katzke, J., et al. (2026): Nature Methods 23: 663-672.
[5] van de Kamp, T. & Economo, E.P. (2026): Nature Methods 23: 505-506.
[6] Lösel, P.D., et al. (2020: Nature Communications 11: 5577.
[7] RADAR4KIT
[8] Matte, A., et al. (2025): Science Advances 11: eadx8068.