

MAGNETIC RESONANCE IMAGING (MRI) OF THE HONEYBEE

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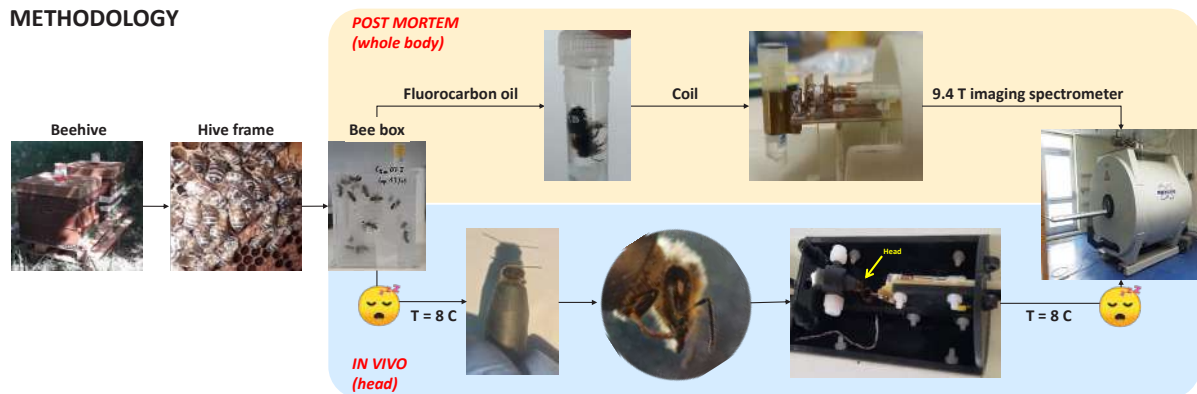
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CONTEXT AND OBJECTIVES

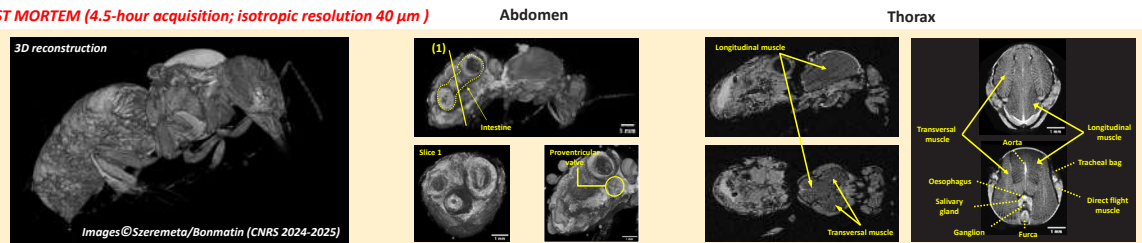
- MRI technology has the advantage of providing contrasted images of soft tissues such as muscles, organs and brain
- We developed methods for obtaining highly-resolved images of the whole honeybee and its organs by using high-field MRI (9.4 Tesla)
- These methods aim to study the soft tissues in the honeybee, both *post mortem* and *in vivo* and with/without pesticide

METHODOLOGY

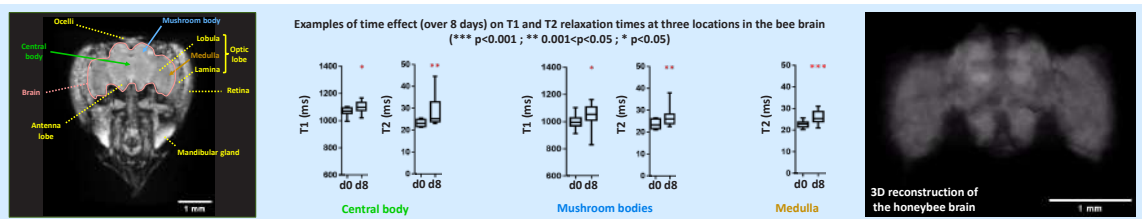


RESULTS

➤ POST MORTEM (4.5-hour acquisition; isotropic resolution 40 μm)



➤ IN VIVO (1.5-hour acquisition; isotropic resolution 50 μm)



CONCLUSION AND FUTURE PROSPECTS

- Our MRI methods allow very fine description of honeybee organs in abdomen, thorax and head. This without prior chemical fixation
- For instance, the brain volume was measured at 1.3 mm³ and the volume of mushroom bodies at 0.027 mm³
- These values are consistent with data from chemically-fixed honeybee brain (Haddad et al., 2004; Fu et al., 2024)
- T1 and T2 relaxation times are sensitive parameters to detect changes, for instance after 8 days in laboratory conditions (bee box)
- We measured the lethal dose 50% of imidacloprid (DL50 48h) at 12 ng/honeybee; DL50 decreased when exposure duration increases
- MRI *in vivo*, depicting changes in honeybees by imidacloprid, is under investigation (comparisons before/after chronic exposure)

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Although the honeybee's morphology is fairly well described, little is known about the dynamic functioning of its various organs. MRI technology has the advantage of providing contrasting images of soft tissues such as muscles, organs and brain. But MRI was not suited to very small animals such as insects. Today, this technique is demonstrating its outstanding capacity to study the soft tissues inside of the bee's exoskeleton, both post-mortem and, above all, in vivo. We have developed experimental protocols for obtaining highly resolved images of the whole honeybee and its organs using high-field MRI (9.4 Tesla) on post-mortem honeybees positioned in fluorocarbon oil for 24 to 48 hours. These images enable detailed identification of organs in the abdomen, thorax and head, and in particular the brain. We have also developed a set-up with a micro-coil and experimental technology for obtaining well-resolved images of the honeybee in vivo, anaesthetised by cold, for 12 to 24 hours. The images obtained of the brain make it possible, for example, to identify the mushroom bodies. MRI adapted to very small animals is a promising technique for better describing the biology of insects and bees in particular. It should be possible to identify changes in contrast following exposure to neurotoxic pesticides (e.g., neonicotinoids insecticides) or mitotoxic pesticides (e.g., SDHI fungicides), either post mortem or in vivo. In the latter case, it should be also possible to detect the sublethal effects of pesticides on a honeybee, larva, drone, queen... following a chronic exposure at low doses. Thus, bee MRI is a new non-invasive, rapid and relatively inexpensive technique for laboratories already equipped with an imager. In addition, this technique does not require the sacrifice of a large number of individuals for toxicological studies. This technique is highly complementary to electron microscopy and micro-computed tomography (micro-CT) techniques, with the great advantage that MRI can be carried out in vivo, on a single individual that can be its own control after sublethal exposure to pesticides. The authors have no links of interest and they thank the CNRS and the Fondation Lune de Miel for their financial support.