



EVALUATING POSSIBLE EFFECTS OF RADIO-FREQUENCY ELECTROMAGNETIC FIELDS (RF-EMF) EXPOSURE ON BIODIVERSITY, DEVELOPMENT & FITNESS OF INSECTS

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Introduction

- Insects play a vital role in maintaining ecosystem health.
- Insects are exposed to **Radio-Frequency Electromagnetic Fields (RF-EMFs)** emitted by telecom antennas.
- RF-EMF exposure of insects is expected to change due to evolutions (from 4G to 5G) in telecom networks [1].
- Pollinators, such as bees, are at risk of peak exposures close to powerful antennas
- RF-EMF exposure can have biological effects in insects [2], but the impacts of RF-EMF exposure on insects are unclear [2].

Goals: The Horizon Europe project 101057216, Exposure To electromagnetic fields and plaNetary health (ETAIN) aims to develop and validate approaches to assess the impact of existing and novel communication technology from a planetary health perspective. To this aim, we will focus on insect biodiversity and fitness w.r.t. RF-EMF exposure. The aims are:

- To define thresholds for wellbeing, health, behavior, and productivity of honeybee colonies under RF-EMF (3G to 5G) exposure
- To measure possible changes in the fitness of a solitary bee species under RF-EMF exposure
- To record possible impacts on insect biodiversity under RF-EMF exposure
- To create digital models for dosimetric analysis of bees and other insects

To this aim 6 tasks are defined, which are outlined below

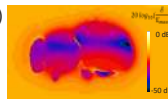
T1: Development of 3D-EM Insect Models

- Goal:** Create digital models of insects that can be used in EM simulations
- Methods:** Micro-CT scanning and postprocessing in Python and Blender. Illustrated below in 5 steps for a bumble bee (*Bombus terrestris*).
- Outcomes:** Models available for use online (<https://skfb.ly/oTnsG>)



T2: Numerical Quantification of RF-EMF exposure on insects

- Goal:** Determine absorption of RF-EMFs in insects (0.1-120 GHz)
- Methods:** Numerical simulations with 3D-EM Insect Models (T1) to obtain whole-body averaged absorbed power and specific absorption rates in insects under:
 - (1) Far-Field exposure (environmental exposure)
 - (2) Near-Field exposure (near telecom antenna)
 - (3) exposure as experienced in T3-6.
- Outcomes:** Quantification of insect exposure to RF-EMFs, necessary for The interpretation of biological effects [5].



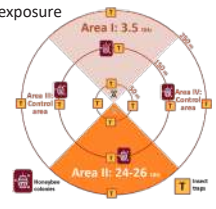
Example of RF-EMFs around a honey bee worker at 12 GHz [5]

T3: Controlled Experiments with Managed and Solitary bees

- Goal:** Determine potential effects of RF-EMF exposure on HB colonies and SB under development
- Methods:** HB colonies will be placed indoors with outlet for workers to freely forage outside. Hives will be continuously exposed at 3.5 and 26 GHz. HBs and brood will be monitored for at least 3 cycles (meaning one cycle before, one during, and one after the exposure). SBs will be exposed at same frequencies in artificial nests. (1) Molecular gene expression related to oxidative stress as function of different exposure times or conditions, (2) Colony health and development, & (3) SB Development time & sex ratio will be measured.
- Outcomes:** Determine thresholds for effects on HB and SB under RF exposure

T4: Effects of Environmental RF-EMF exposure on Insect Biodiversity

- Goals:** Determine effects of 5G RF-EMF exposure on insect biodiversity
- Methods:** Installation of custom 5G-emulating exposure setup with RF-EMF emission in two 90° sectors. Insect traps and HB colonies (T5) are placed in all areas at different distances.
- Outcomes:** Determine insect presence population fluctuations, & biodiversity w.r.t. RF-EMF exposure.



T5: Effects of Environmental RF-EMF exposure on Honey Bees

- Goals:** Determine effects of 5G RF-EMF exposure on HB colony development and SB development
- Methods:** HB Colonies and SB artificial nests will be placed in the same setup as T4. Colony and SB development, aggressiveness, colony growth/population/ brood, and queen survival will be measured during 2 years.
- Outcomes:** same as T3, but for 5G environmental exposure.



T6: Survey monitoring of biodiversity of solitary bees (SB) under commercially installed 5G RF-EMF

- Goal:** Determine influence of commercial 5G network on SB biodiversity
- Method:** Monitoring SB at different locations (using artificial nests and variable transects) and compare species richness and abundance
- Outcomes:** Determine potential impacts of 5G exposure on insect biodiversity



Envisioned Impact and Outlook

From a **policy perspective**, we aim to give recommendations to policy makers in terms of sustainable management of honeybee and wild bee populations.

From a **planetary health perspective**, RF-EMF effects on insects may also have indirect effects on human health and the economy. ETAIN is expected to generate scientific evidence of RF-EMF exposure effects on human, ecosystem and planetary health, feeding into policies and current regulatory frameworks.

References: [1] Thielens, et al. Scientific Reports 8(1), 3924, 2018. [2] Thielens, PE 690.021, 2021, doi: 10.2861/318352. [3] Greco, et al. J. Insect Sci. 12, 1–7, 2012. [4] De Borre, et al. PLOS Comp. Biol. 17 (10), e1009460. [5] De Paepe et al. IJB, doi: 10.1080/09553002

PP-096 [Bee Health]
Evaluating Possible Effects of Radio-Frequency Electromagnetic Fields (RF-EMF) Exposure on Biodiversity, Development & Fitness of Insects

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The Horizon Europe project 101057216 Exposure To electromAgnetic fields and plaNetary health aims to develop and validate approaches to assess the impact of existing and novel communication technology from a planetary health perspective while exploring options for exposure reduction and interacting with the public and stakeholders about exposure levels and possible associated risks. Among the endpoints studied are possible effects on insect biodiversity and fitness, focused on pollinators, like bees. Newly introduced telecommunication technology (3G/ 5G/ 6G) results in changes in exposure patterns and biological interactions of RF-EMFs that can be absorbed in different organisms with unclear biological consequences. We exposed honey bee colonies indoors at 3.6 GHz and followed the development of amateur stages. We installed an RF-EMF antenna in an experimental field, in Greece. The antenna will expose two parts of the field to 5G signals within the 3.6 GHz and 26 GHz bands, respectively, and leave two other parts unexposed. We will systematically record insect biodiversity and simultaneously, we will deploy managed bee hives to study their development over time. In parallel, wild and managed bees were digitized using micro-CT scanning. 3D digital insect models have been created for adult wild and managed bees. Indoors exposure of bees at 3.6 GHz has shown delayed larvae development and eventually emergence. Background RF-EMF exposure was found to be at very low levels, in comparison to the exposure caused by the installed antenna mast. Preliminary pre-exposure sampling has shown that there are no significant differences in insect biodiversity between the different parts of the experimental field. We will monitor the honey bee colonies and solitary bees in the field, sample insect species and perform numerical simulations of the insects' exposure using the digital models.

Digital bee models will be made available for educational purposes. New telecommunication networks create new exposures to RF-EMFs but also create new opportunities for exposure reduction or prevention, which are not possible in legacy networks. Any advice for beekeepers will depend on evidence of the presence or absence of unintended biological effects and will take into account potential technical and non-technical interventions mitigating or avoiding such effects.