PIANOFORTE travel grant activity report : Study effects of ionizing radiation on honeybee colonies near the Fukushima nuclear power plant, Japan (April 22 - May 8, 2024)

This project is part of the PhD entitled "Evaluation of the Effects of Ionizing Radiation on the Honeybee, *Apis mellifera*, from the Molecule to the Population" (Margot Crevet, IRSN/LECO). The critical role of bees in ecosystems and their undeniable value to society, spanning economic, ecological, and scientific dimensions, forms the foundation of this study. The primary aim is to deepen our understanding of the impacts of ionizing radiation on these vital insects, a subject that has received limited attention in scientific literature. The core problem lies in the lack of comprehensive knowledge regarding the long-term effects of low-dose radiation on non-human organisms and ecosystems. Radioactive contamination poses a significant ecological challenge. It can cause long-term disruptions to ecosystems by affecting the health of living organisms and altering their interactions with the environment. These disruptions can have lasting consequences for the stability and resilience of ecosystems. Despite significant radioactive emissions, particularly after disasters like Chernobyl or Fukushima, limited data exist on the long-term, low-dose effects on non-human organisms. These uncertainties complicate risk assessments and the development of protective strategies. Gaining a deeper understanding of these mechanisms is essential to anticipating ecological consequences and safeguarding biodiversity as well as the ecosystem services we rely on.

A large part of this subject involves comparing two approaches: laboratory and field, both of which are essential for a comprehensive understanding of the effects of ionizing radiation on bees. In the field, the study is being carried out in collaboration with Institute of Environmental Radioactivity (IER) at Fukushima University. Several implemented bee hives located on sites around the Fukushima nuclear power plant are monitored. These sites differ regarding their level of radioactive contamination. Field studies are important because they reflect real-world conditions, where bees face not only radiation but also other environmental stressors such as predation, pollutants, and changing ecological dynamics.

In contrast, laboratory studies allow for controlled experiments where bees are exposed only to radiation, eliminating external variables and making it easier to establish clear causal links between radiation and physiological effects in the present project, controlled experiments involve the external irradiation of bees, enabling precise analysis of the effects of ionizing radiation. One of the aim of this project is to compare results obtained in the field

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and in the laboratory, in order to assess the extent to which laboratory experiments can predict observations made in natural conditions. The common element of these studies is the analysis of the physiological effects induced by ionizing radiation on bees from both laboratory and field environments. Specific markers were chosen, including enzymes involved in oxidative stress response (catalase, glutathione-6-phosphate dehydrogenase, carboxylesterases), metabolic integrity (ATP, glyceraldehyde-3-phosphate dehydrogenase), immune function (glucose oxidase, phosphatases, phenoloxidase), and neuronal activity (acetylcholinesterase). These markers were chosen because they represent key responses to radiation: oxidative stress is one of the first consequences of radiation, which also disrupts cellular metabolism. Impaired metabolism directly affects immunity, making bees more vulnerable to infections. Additionally, radiation can alter neuronal activity by disrupting the transmission of nerve signals, which affects essential functions such as navigation and coordination in bees. By studying these pathways together, we can gain a better understanding of the overall effects of radiation, as they are interconnected and all play a vital role in bee survival.

The hives were set up in April 2024 and have been monitored until July 2024 to study the effects of ionizing radiation not only on worker bees but also on queens, which is crucial for understanding reproductive success and colony survival. During the April mission, several samples were collected to determine the initial health status of the hives at the start of the experiment (physiological analyses) and to assess certain factors that could influence the bees aside from ionizing radiation, such as *Varroa destructor* infection, viruses, and pesticides. A Coleval evaluation was also conducted, consisting of a visual analysis of the percentage of bees, brood, and reserves in each hive. For dosimetry analysis, worker bees were sampled to measure internal cesium activity (gamma spectrometry). These samples and analyses will be repeated in July to allow for comparison. Microdosimeters were placed on the hives to assess external cesium activity, then removed and analyzed in July. This allows for the correlation of ionizing radiation exposure with the biological effects observed in the bees.

I would like to thank the PianoForte grant, which contributed to funding my trip to Japan (from April 22 to May 8), allowing me to participate in the installation of hives in the field and to collect bee samples for the initial phase of the study. This support also gave me access to the IER laboratories and the expertise of the institute's researchers, particularly in the evaluation of radioactive contamination. This mission provided me with a unique experience, exposing me to field conditions.

Margot Crevet

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