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**Physiological effects of gamma irradiation combined to *Nosema ceranae* infection in the honeybee, *Apis mellifera* – BEERAD**

Margot CREVET\*(1), Béatrice GAGNAIRE (1), Jean-Marc BONZOM (1), Nicolas DUBOURG (1), Fabrice DAIAN (2), Gabriel BON (2), Loïc QUEVAREC (3), Luc BELZUNCES (4), Jean-Luc BRUNET (4)

1 IRSN/PSE-ENV/SERPEN/LECO, Saint Paul lez Durance, France

2 AMU/IBDM, Marseille, France

3 CNRS, Marseille, France

4 INRAE/LTE, Avignon, France

\*Corresponding author: [margot.crevert@irsn.fr](mailto:margot.crevert@irsn.fr)

Radioactive contamination of the environment is a major ecological challenge. In order to predict accurately the repercussions of nuclear disasters such as Chernobyl or Fukushima, it is essential to deepen our understanding of the effects and dangers that irradiation and contamination by radioactive substances represent for our environment. In this context, the honeybee, *Apis mellifera*, has been chosen as a model organism for studying the effects of ionizing radiation. Occupying an essential place within ecosystems, bees play a crucial role not only for the environment, but also for society, due to their preponderant role in the economy, the agro-environment and scientific research. The aim of this study is to develop our knowledge of the consequences and processes of action of ionizing radiation on these insects, a domain of study still insufficiently explored. This work is being carried out as part of the ANR BEERAD project, under the direction of IRSN's Laboratory of radionuclide Ecology and eCOtoxicology (LECO) in Cadarache, in collaboration with INRAE's Laboratory of Environmental Toxicology (LTE) bees and environment in Avignon.

The first study carried out as part of the BEERAD project in the laboratory aims to assess the combined effect of ionizing radiation and the *Nosema ceranae* pathogen on honeybees. Bee colony failure, a complex multifactorial phenomenon, results from the interaction of many factors [1]. Among these factors, biological causes such as the *N. ceranae* pathogen, a microsporidian parasite naturally affecting bees, target the midgut and cause a disease known as nosemosis. This parasite, by invading and growing in the epithelial cells of the gut, weakens the bee and, by extension, the colony [2]. The present study therefore aims to examine the joint effects of an abiotic stress, here represented by ionizing radiation, and a biotic stress, embodied by the *N. ceranae* pathogen, on individual bees. The objective is to simulate as closely as possible a nuclear accident situation affecting a hive parasitized by *N. ceranae*, in order to study the multi-stress effect. To do this, newborn bees were infected and then irradiated in small cages of 50 individuals for 15 days, which, given a bee's lifespan (between 13 and 38 days during the summer season), is equivalent to chronic exposure. The bees were irradiated at a dose rate considered high (14 mGy/h), simulating a typical dose just after a nuclear accident. Several samples were taken throughout the irradiation period (0, 2, 4, 8 and 14 days of irradiation) for kinetics, to determine whether the effects observed were early or late.

The first results of this study suggest a synergistic effect of the combination of stressors (irradiation and infection) on food consumption, with a significant decrease observed in the consumption of both infected and irradiated bees. An antagonistic effect was observed for survival,

with a significant decrease in survival in bees only irradiated and bees only infected, but not in bees both infected and irradiated. This indicates that the combination of the two stressors does have an impact on the bees. These first results, as well as the effects of the combination of stressors on *N.ceranae* spore counts and on tissue activity of enzymes of interest targeting metabolic integrity, oxidative stress control, immunity and neural activity will be presented in this poster.

Keywords: ionizing radiation, honeybee *Apis mellifera*, *Nosema ceranae*, physiology, biomarkers

[1] ANSES. 2021. « Santé des abeilles ». Anses - Agence nationale de sécurité sanitaire de l'alimentation, de l'environnement et du travail. 10 mai 2021. <https://www.anses.fr/fr/content/sant%C3%A9-des-abeilles>

[2] Paris, Laurianne, Michaël Roussel, Bruno Pereira, Frédéric Delbac, et Marie Diogon. 2017. « Disruption of oxidative balance in the gut of the western honeybee *Apis mellifera* exposed to the intracellular parasite *Nosema ceranae* and to the insecticide fipronil ». *Microbial Biotechnology* 10 (6): 1702-17. <https://doi.org/10.1111/1751-7915.12772>.