



Morphocytometric analysis of phagocytic cells in the hemolymph of clinically healthy adult honey bees exposed to non-ionizing electromagnetic radiation

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Abstract: The aim of this study was to evaluate the effects of non-ionizing electromagnetic fields on immune status by assessing morphocytometric changes in phagocytic cells from the hemolymph of bees involved in the cellular immune response. The analysis also examined the relationship between these changes, the distribution of electromagnetic power density, and the distance from the emission source. The results showed significant variations in radiation power density as a function of distance, with the highest values recorded at intermediate distances, particularly around 300 m, where both elevated levels and pronounced variability were observed. The exposed group was characterized by higher values for all categories of phagocytic cells analysed, namely granulocytes (9.99% vs. 0.6%), macrocytes (2.3% vs. 1.77%), microcytes (13.1% vs. 6.9%), plasmocytes (29.11% vs. 0.62%), and spindle-shaped cells (1.02% vs. 0.2%), as well as by a lower proportion of non-phagocytic hemocytes (44.21% vs. 89.91%) compared with the unexposed group. Statistical analysis further demonstrated significant differences between the experimental and control groups, reflected in a significant increase in the percentages of granulocytes, microcytes, and plasmocytes in the experimental group compared with the control group.

Keywords: *Apis mellifera*, electromagnetic field exposure (EMF), hemocytes, phagocytic cells

•Introduction

EMFs generated by electrical infrastructure and modern communication technologies are increasingly present in natural and agricultural ecosystems and may affect the honey bee (*Apis mellifera*), a key pollinator species.

•Material and method

Live bee samples were collected in Foti-type boxes, labeled, and transported to the laboratory on the same day. Hemolymph (15–20 µL) was obtained from approximately 50 bees per sample by intersegmental puncture and used for smear preparation.

Sample distribution in the experimental and control groups

Season type	Cytological parameters of hemolymph	No. of colonies/ experimental group	No. of colonies/ control group	No. of live bee samples/ group	No. of smears/ sample	No. of replicates/ group	No. of bees/ sample	Hemolymph volume/ sample (µL)	Total samples (experimental group)	Total samples (control group)
active	cytomorphological analysis	5	5	15	3	3	50	15–20	45	45
	laboratory examinations	5	5	15	-	-	50	-	15	15

• Results and discussions

Field measurements revealed significant variations in power density as a function of distance, with maximum values recorded at intermediate distances, particularly around 300 m.

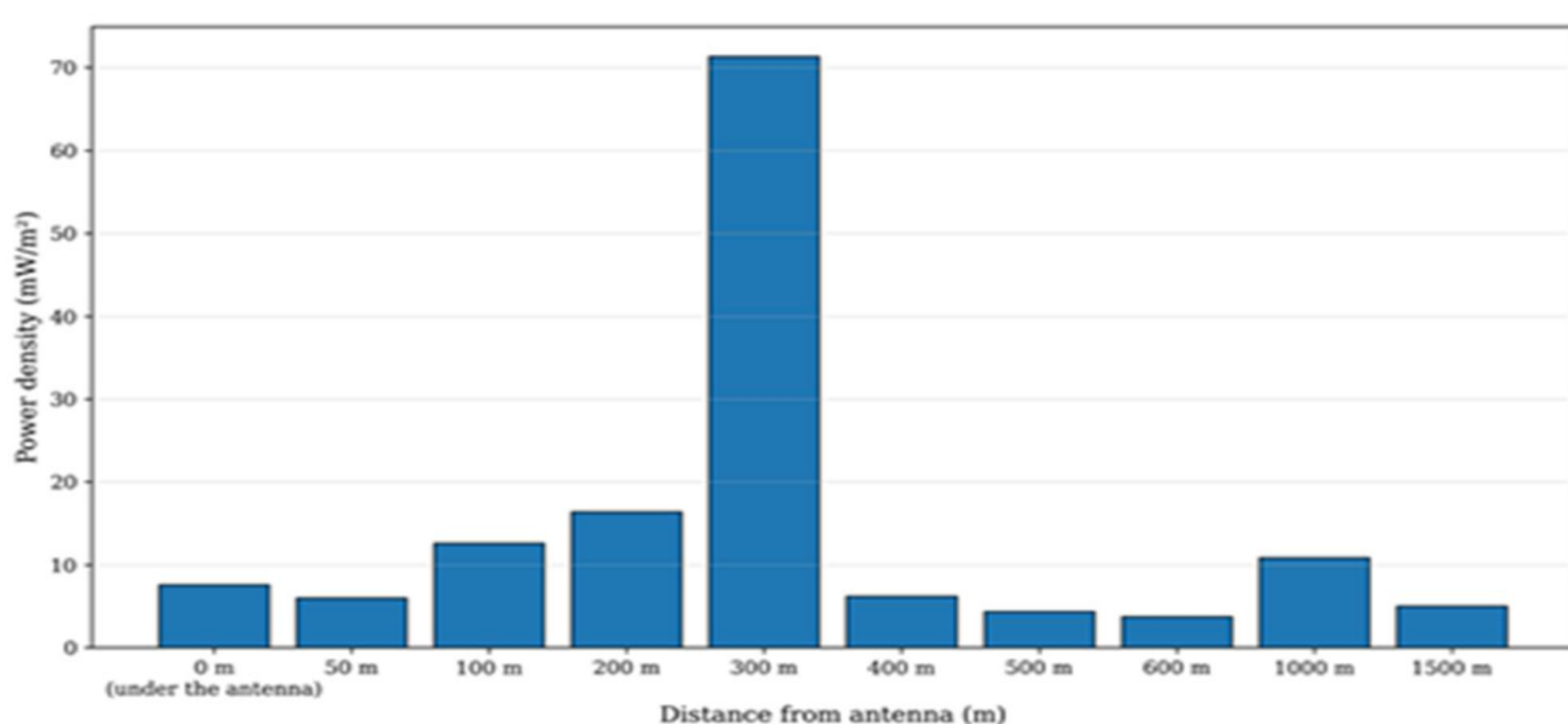


Table 1. Comparative distribution of hemocytes in the hemolymph of nurse bees in the control group and the EMF-exposed group

Biologic material: adult bees	Type of phagocytic cells					other types cell
	granulocyte	macrocyte	microcyte	plasmocyte	fusiform cell	
Exposed nurse bees EMF (%)	9.99	2.3	13.1	29.11	1.02	44.21
Unexposed nurse bees EMF (%)	0.6	1.77	6.9	0.62	0.2	89.91

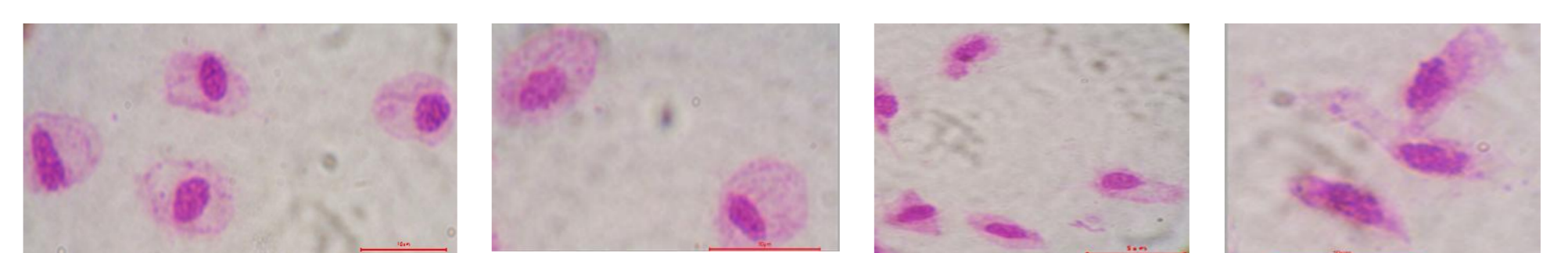
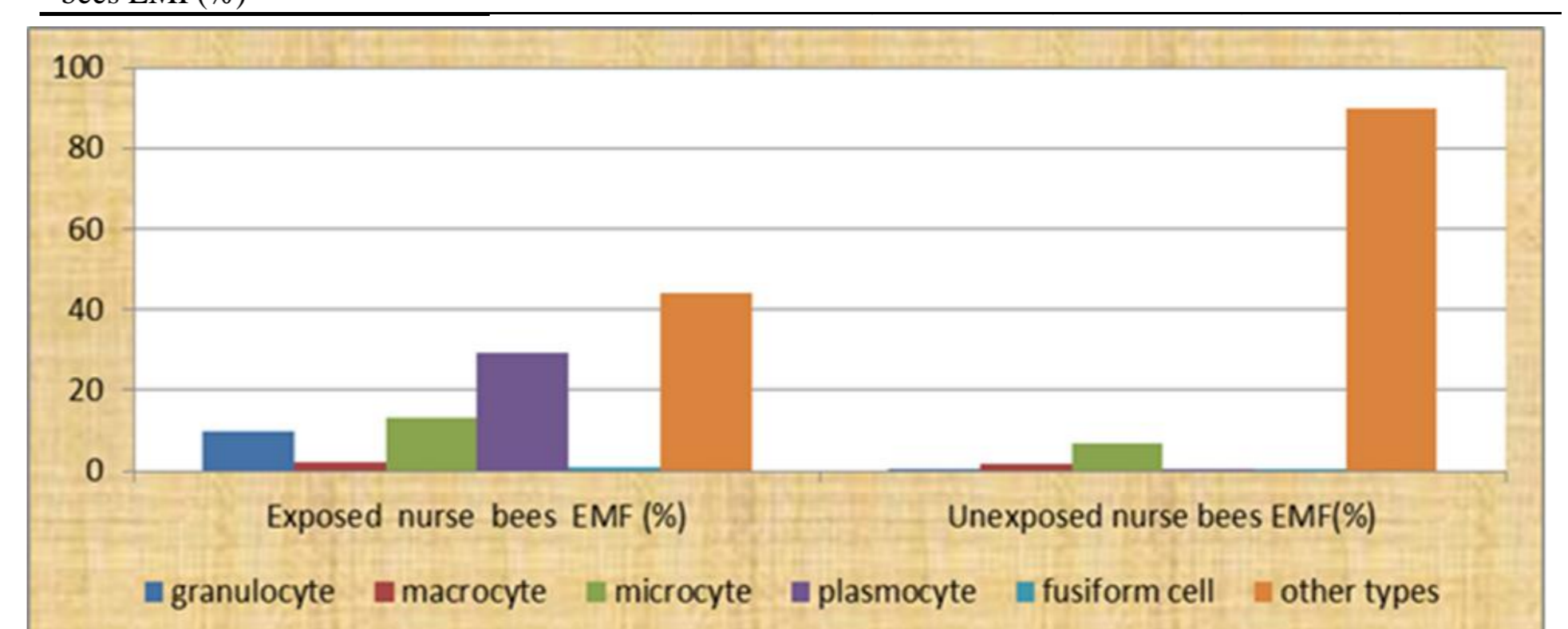


Figure 1. Granulocytes (a) and plasmocytes (b). Giemsa, ×100

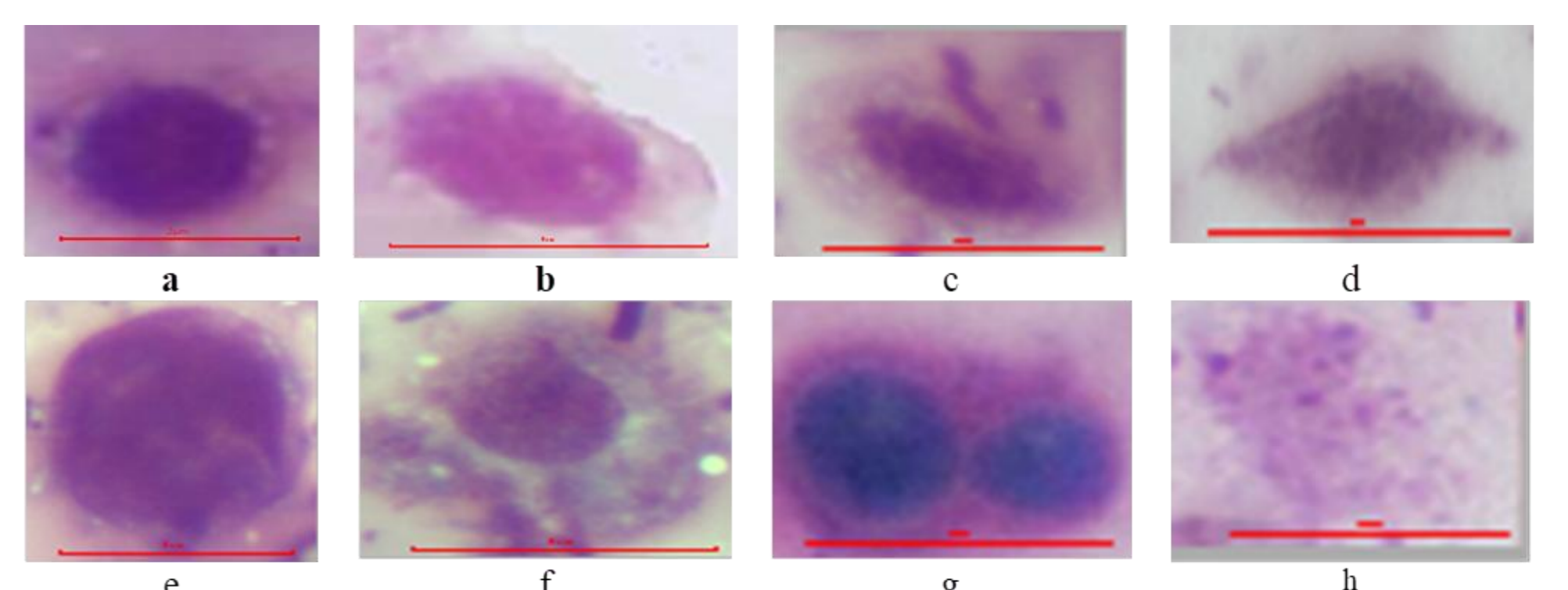


Figure 2. Plasmatocyte PL1 (a), intermediate plasmatocyte PL2 (b), intermediate plasmatocyte PL3 (c), plasmatocyte PL4 (d), granulocyte (e), oenocytoid (f), haemocyte division (h) and coagulocyte (g), Giemsa stain, ×100

•Conclusions

Comparative analysis of hemocyte distribution showed clear differences between nurse bees exposed to EMFs and those not exposed to non-ionizing radiation.

The findings indicate that exposure to non-ionizing electromagnetic radiation may trigger immune system activation in honey bees, as evidenced by the observed alterations in haemocyte profile.