Bundesamt
für Strahlenschutz

Spotlight on EMF Research

Spotlight on “Oxidative Stress Response of Honey Bee Colonies (*Apis mellifera* L.) during Long-Term Exposure at a Frequency of 900 MHz under Field Conditions” by Vilić et al. in Insects (2024)

Category [radiofrequency, animal study]

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Competence Centre for Electromagnetic Fields (KEMF)

1 Putting the paper into context by the BfS

There is public concern that radiofrequency electromagnetic fields (RF-EMF) from mobile phone base stations could have detrimental effects on pollinators, especially bees. Although individual experimental studies indicate effects, there is no robust scientific evidence of such an association. Recent reviews show that studies predominantly indicate negative effects of RF-EMF on insects or invertebrates, especially concerning reproduction and behaviour, but also that studies of low quality predominate the available data [2, 3]. Field studies examining effects at the population or ecosystem level are extremely rare. In the study at hand [1], Vilić et al. investigate the effects of RF-EMF from base stations on oxidative stress in honey bee colonies under field conditions.

2 Results and conclusions from the perspective of Vilić et al.

The observational field study [1] focuses on the parameters of oxidative stress and lipid peroxidation in Carniolan honey bee larvae, pupae and adults during a one-year exposure to RF-EMF from mobile phone base stations at a frequency of 900 MHz.

The experiment was carried out at three locations with measured average electric field levels of 30 mV m^{-1}, 70 mV m^{-1} and 1000 mV m^{-1}. The distance between the three locations varied between 829 m and 1.64 km.

The study followed the recommendations of EFSA [4]. All colonies were of similar size and had one-year-old queens of the same genetic origin. To reduce variability and to increase statistical power, five bee hives were randomly allocated to each location. Samples from the worker brood and worker adults were taken at 2 weeks, 5 months and 1 year after the beginning of the observation. Six larvae, four pupae and ten adult midguts were collected at each timepoint from each honey bee colony. For each sample, the activity of the antioxidant enzymes glutathione-S-transferase (GST), catalase (CAT) and superoxide dismutase (SOD) was measured and thiobarbituric acid reactive substances (TBARS) was used as an indicator of lipid peroxidation. All samples were measured spectrophotometrically.

The results were statistically analysed using analysis of variance (ANOVA), the normality of data distribution and multiple testing were considered.

The GST activity was not significantly affected by RF-EMF exposure level or duration in any of honey bee life stages.

The CAT activity in larvae was statistically significantly increased at the location with the highest RF-EMF exposure level after five months of exposure and at the location with the lowest RF-EMF exposure level after one year of exposure. In the pupae, the CAT activity was not statistically significantly affected by RF-EMF exposure level or duration. In adult honey bees, the CAT activity was statistically significantly increased at the location with the highest RF-EMF exposure level after two weeks and after one year, but not after five months of exposure.

A single significant increase in the SOD activity was observed in adult honey bees after one year at the location with the highest RF-EMF exposure level.

The TBARS concentration in larvae was statistically significantly increased after two weeks and after one year, but not after five months at the highest RF-EMF exposure level. In pupae, there were no statistically significant effects of exposure level or duration on TBARS concentration. In adults, the TBARS concentration was statistically significantly increased at the location with the highest RF-EMF exposure level after two weeks of exposure.

The authors conclude, that exposure to RF-EMF may cause oxidative stress in certain developmental stages of honey bees, with the larval stage being more sensitive than the pupal stage. Most of the significant changes occurred in the second week of the exposure at the location with the highest RF-EMF exposure level, but there was no consistent relationship between RF-EMF exposure level or duration and effect in any of the developmental stages.

3 Comments by the BfS

The present study is one of the few field studies that investigated the biological effects of RF-EMF exposure from mobile phone base stations on bees, thus addressing an open question. The standardized methodical approach of the study, largely based on EFSA recommendation [4] leads to an improved reproducibility and comparability of study results. However, based on the honey bee foraging range, EFSA recommends a distance of 4 km between experimental locations [4]. In the present study the distances between the locations were smaller, and it cannot be ruled out that the bees visited the other locations.

For relating potential effects to the exposure status, reliable information on the exposure level is necessary. However, it remains unclear how the exposure was measured and if variability in time was considered. The RF-EMF from a base station may vary considerably during days, weeks and the year. As the difference in measured exposure levels was low (only factor two or three between the measured electric field strengths of the locations), an overlap in exposure conditions cannot be ruled out. Together with the flying behaviour of the bees, this may have caused too small an exposure contrast between honeybee populations at different locations and may have prevented the identification of possible effects.

Measurement of antioxidant enzyme activity is regularly used as a marker of oxidative stress, but the markers used in this study are not valid in an in vivo setting and should only be used for in vitro experiments, together with other, more reliable markers [5]. TBARS, on the other hand, are not suited to investigate oxidative stress in any setting because they are produced by many biochemical and metabolic reactions that are not directly related to oxidative stress [5].

The markers of oxidative stress did not show any clear relationship to exposure level or to exposure duration. The differences in oxidative stress markers between developmental stages may well be due to their different metabolic activity and other environmental factors. Overall, the results of this study provide no convincing evidence that of RF-EMF exposure may cause oxidative stress in honey bees.

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