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doi:10.15199/48.2018.12.60

Thermal and acoustic changes in bee colony due to exposure to microwave electromagnetic field – preliminary research

***Abstract**. The paper presents the results of preliminary research on the influence of the electromagnetic field from microwave range on the population of honeybees, analysing changes in the sounds coming from the hive and temperature trends in the hive. Research was made using two mini-hives, where one was exposed to electromagnetic field and other was a control hive. During the experiment the temperature and acoustic pressure inside the hive was monitored to check if EMF exposure affects any of these factors.*

***Streszczenie.** W pracy przedstawiono wyniki badań wstępnych wpływu pola elektromagnetycznego z pasma mikrofal na populacje pszczół poddając analizie zmiany temperaturowe w ulu oraz dźwięki wydobywające się z ulów. Badania przeprowadzono na dwóch mini-ulach, z których jeden poddawano ekspozycji na pole elektromagnetyczne, a drugi był ulem kontrolnym. (**Zmiany akustyczne i termiczne w kolonii pszczół pod wpływem ekspozycji na pole elektromagnetyczne – badania wstępne**).*

Keywords: electromagnetic field, microwaves, bees, exposure, GSM
Słowa kluczowe: pole elektromagnetyczne, mikrofale, pszczoły, ekspozycja, GSM

Introduction

At the turn of the last decades, we are experiencing a significant reduction in the honeybee population all over the world. The number of bee colonies has decreased in recent years in Europe by 10 to 30 percent, in United States by 30 percent and in the Middle East up to 85 percent. There is no unambiguous answer what is causing this state of affairs. It is assumed, that responsible factors are pesticides, viruses, climate change, GMOs or parasites. The coincidence of this phenomenon with the development of telecommunications and the expansion of mobile phone base stations has led to the thesis, that such factor may also be the electromagnetic field (EMF) from cellular telephony base stations.

Electromagnetic field can have both positive and negative influence for insects life. There is a species identity through analysis of flight buzzing of social insects [1]. Bees cannot hear the pressure fluctuations of sounds but they are sensitive to airflows related with sound waves. Most of these airflows are caused by vibrating wings and bodies [2]. Positive communication is the noise generated by honeybee colonies in the course of swarming [3], while EMF from mobile phones can affect negatively the honeybees life system [4].

Since honeybees are shown to be sensitive to the earth's magnetic field and are likely to use it for navigation, many studies on bees have been carried out [5] in which various reactions were tested exposing them to EMF from different frequency bands, starting from a constant magnetic field, through the power transmission lines frequencies (50 / 60 Hz) [6], GSM base stations (typically 900 and 1800 MHz) [7,8] and also from higher frequency ranges (eg 2.4 GHz or 10 GHz) [9]. Reviewing the results of mentioned studies it can be concluded that there are no unambiguous results. The authors indicate links between honeybee behaviour and EMF presence, but at the same time similar experiments show their lack. In many cases, the research methodology is debatable, and the most controversial is the way in which bees are exposed to electromagnetic fields. The exposure system are set as close surroundings of mobile phone base stations, cell phones or DECT telephone bases put inside the bee hives or duck taped to its wall, or field generators with unverified parameters. In this work special attention was paid to develop reliable EMF exposure system with large homogenous area and proper parameters of generated EMF field in relation to what can be encountered in real conditions.

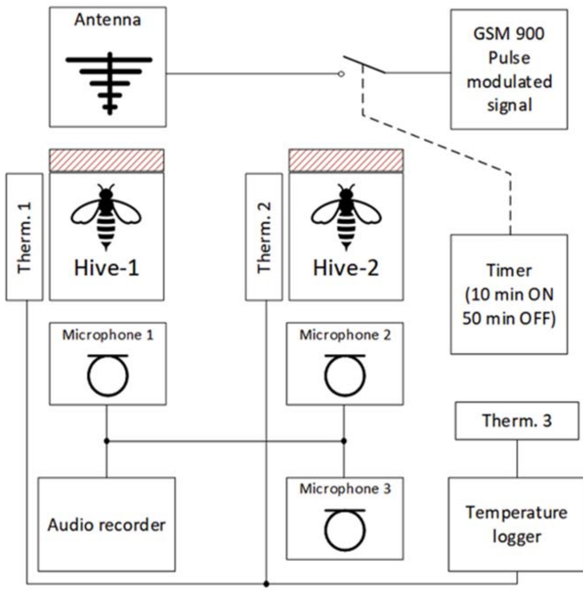

Fig.1. Measurement setup block diagram

Methods

The experiment was conducted on popular honeybee species (Apis mellifera carnica), in one of the Wroclaw University of Science and Technology laboratory during 4 days. Because the laboratory conditions slightly differed from the natural environment of bees, first two days were the "adaptation stage", where bees weren't subjected to EMF and get used to the prevailing new conditions and next two days were the "exposure stage", in which the actual experiment took place. The room temperature was 24°C and humidity 30-40%. The research was performed at the turn of spring and summer, so the day was relatively long. It allowed to provide environmental lighting conditions close to natural. The schematics of the research system setup was presented in Fig 1. Honeybees were placed in wooden micro-hives with two glass walls (Fig. 2). Insects were obtained from same family and same hive frame in number of approx. 200 per micro-hive. Each micro-hive was equipped in two scaled feeders, contained water and the food (aqueous sugar solution in 1:1 proportion). Food and water consumption was monitored at specific intervals, as well as insect mortality. Micro-hives were placed at such a distance from each other to minimize mutual influence and also to provide similar environmental conditions. First micro-hive (exposed hive) has been subjected to the electromagnetic field from the 900 MHz frequency, pulse-modulated with parameters similar to the electromagnetic field parameters from the mobile phone base station operating GSM900 system. The antenna used in the experiment is presented in Fig. 3 and have been designed to ensure uniform exposure of the micro-hive and at the same time reducing the unwanted emission towards other directions (presented in [10]). Applied field strength values reflected the levels that could be encountered in the environment: 7 V/m (maximum permitted value according to environmental protection law in force in Poland [11]). Exposure time was controlled by computer system with settings: 10 minutes with exposure, 50 minutes without exposure (relaxation time). Second hive contained the honey bee control group staying under the same conditions, but not exposed to EMF.

During the experiment hives temperature were monitored and the acoustic signals from the hives were recorded. The temperature and the acoustic signals from system surroundings were also recorded exclude from the results any potential measurement errors caused by external factors.

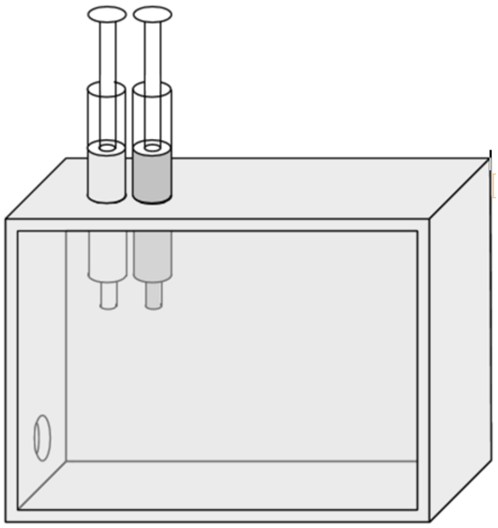

Fig.2. Micro-hive for bee colony for the purpose of the research

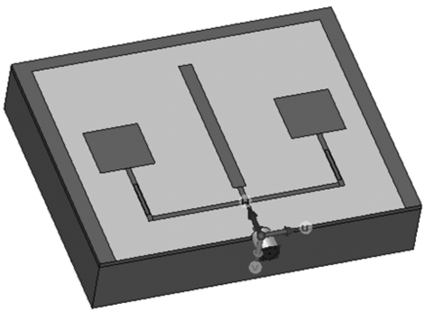

Fig.3. Antenna used in EMF exposure system

Results

During the experiment a large amount of data was obtained, especially the audio recordings. Some of the data was excluded from the results, as it was corrupted by unwanted and accidental sounds from the experiment environment.

Thermal analysis

Fig. 4 present the temperature graph during 48 hours of experiment (exposure stage), where a repetitive cycle of can be observed. The graph doesn't show any significant changes in the temperature during exposure or after the exposure time. It need to be emphasised, that used temperature sensors have significant response time, but the 10 minute period should be sufficient to observe any effects. Additionally, thermal change analysis was also done using statistical tests of significance of differences between the temperature samples measured before turning the EM field and during the EM field emissions. The tests were performed for pairs of samples from the 10-minute periods preceding the exposure and from the immediately following 10-minute periods during exposure. The paired-sample t-test [12] on significance level 5% did not reject null hypothesis that difference of the two samples comes from a normal distribution with mean equal to zero. The obtained p-values are as follows: 0.1390 for null hypothesis that there is no difference between temperature in exposed hive with applied EMF and the temperature without applied EMF, and correspondently 0.0797 for control hive with EMF and without EMF.

Acoustics analysis

Audio recording analysis methodology was aimed to estimate the honeybee acoustic activity (for example: bee worker piping or excitation of the colony) related to electromagnetic field exposure. The main problem was, that the buzzing sounds from bee hives were always present during the experiment and only its intensity changed depending on the time of day or the hive temperature. What was noticed during the time domain analysis, is that the buzzing sometimes can be described as a form of pulse emerging from the background noise. Therefore, it was assumed that the number of such pulses occurring in 1 hour period will serve as an indicator of acoustic activity of bees. When calculating the number of pulses, the following criteria were used:

- audio waveforms have been converted to RMS value with averaging in time (125 ms), which allowed to observe the smoothed signal envelope while eliminating short-term signals.
- weak buzzing was omitted
- pulses below the threshold value and resulting from overdriving the microphone have been omitted
- pulses shorter than 10s have been omitted
- gaps between successive pulses shorter than 5s have been also omitted (two pulses are counted as one).

In Fig. 5 exemplary waveform (RMS value with time constant of 125ms) is showed with indication of 4 properly recognized pulses. Fig. 6 is showing 48-hour changes of pulse per hour count during the exposure stage of experiment. The curve representing the control hive has similar shape as the one in the temperature graph from Fig. 4, but in case of exposed hive the same tendency is not quite visible. It may be assumed, that exposed hive is "more quiet" in term of buzzing pulses presence, so during 1 hour periods less pulses were detected, than in case of control hive. In Fig. 7 showed 24-hour changes of recorded pulses comparing adaptation and exposure stage of the experiment for both hives (exposed and control group). Totally different conclusion may be drawn, because it showed, that during adaptation stage in each of the hives less pulses could be counted, that during a 24-hour observation in exposure stage.

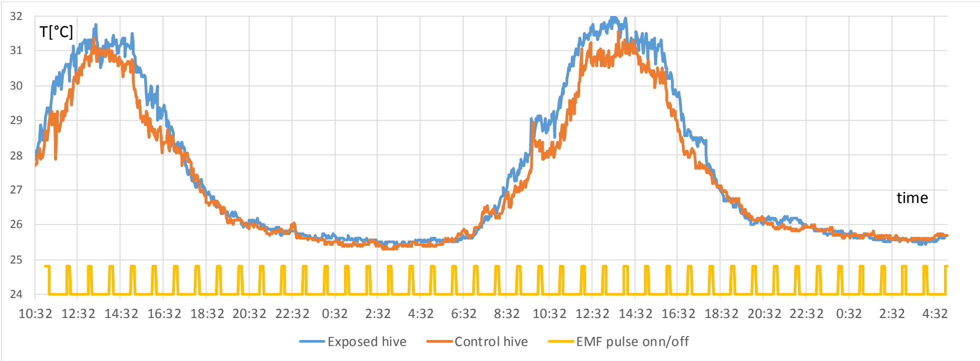

Fig.4. Temperature change in time during 24-hour exposure stage of the experiment with indicated EMF exposure

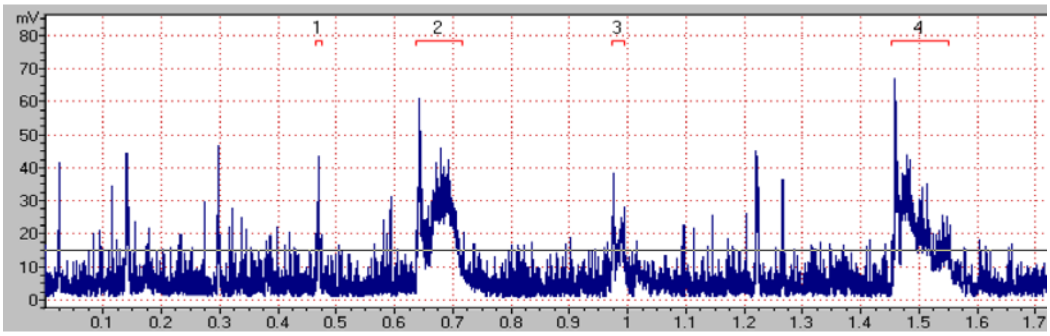

Fig.4. Temperature change in time during 24-hour exposure stage of the experiment with indicated EMF exposure

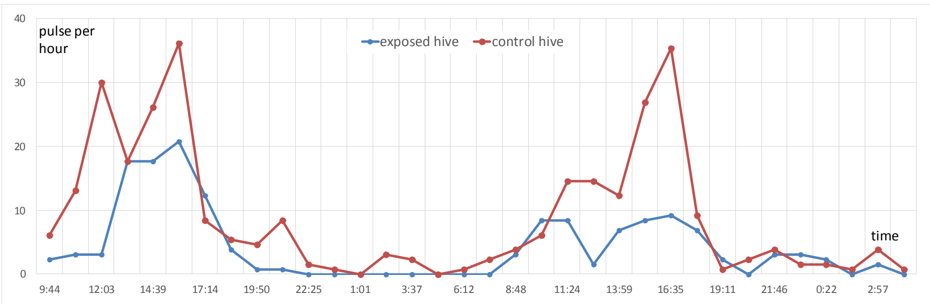

Fig.5. Exemplary RMS waveform value of acoustic signal obtained from one of the hives with 4 pulses detected

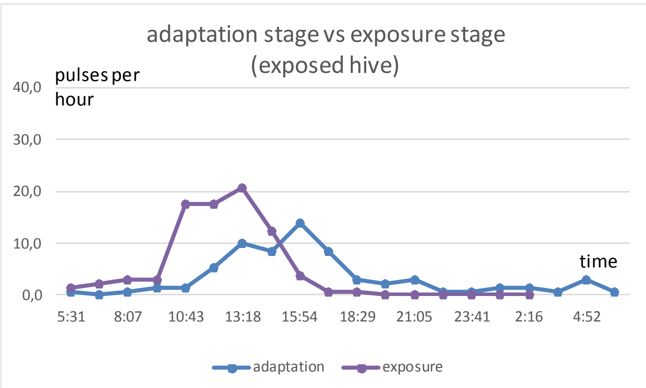

Fig.6. Pulse per hour change in time during the 24-hour exposure stage of the experiment

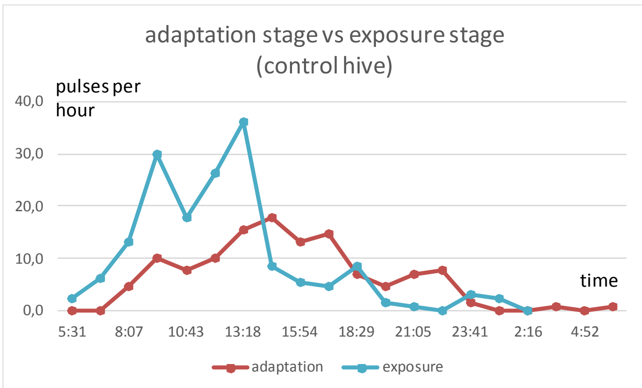

Fig.7. Comparison of 24-hour changes of recorded pulses of adaptation and exposure stage for exposed and control hive

Conclusions

Preliminary research presented in this work showed, that there is no clear evidence of the influence of electromagnetic field from microwave range with parameters similar to the GSM900 mobile telephony base station on honeybees colony, that can be noticed based on a basic audio analysis of sounds recorded in micro-hives and temperature changes in the micro-hives during 4-day research.

Although the authors were surprised by the dependence observed in Fig. 7, which showed that in the same hive during the adaptation stage, bees “buzzed” significantly less impulses per hour than in the exposure stage (during EMF exposure).

It should be emphasized that the tests were carried out for the electromagnetic field from the frequency band corresponding to GSM900 cellular telephony and with modulation reflecting the parameters of such a signal. Nowadays, we deal with multi-system base stations working in GSM1800, UMTS and LTE technologies, so further research should also include those systems.

As the recorded sound presents source of data with greater potential, more sophisticated methods need to be applied in further research. Taking into account the modern possibilities in the field of acoustic signal analysis, where there is a plethora of methods and tests, it would be necessary to plan research based on more precise working hypotheses. In this case it would be possible to optimize the selection of research methods.

The result cannot be generalized in any way, it may be caused by too low sensitivity and resolution of the recording method and should be a contribution to further research and analysis. Also there could be a factor, that was missed, such as mutual acoustic connection of hives (as there was no acoustic isolation between the hives).

The research was conducted thanks to internal resources of Wroclaw University of Technology for the scientific research. The support is appreciated very much.

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