MONITORING OF HONEY BEE (*APIS MELLIFERA*) COLONY BEHAVIOR USING ACOUSTIC EMISSION METHOD

MONITOROVÁNÍ CHOVÁNÍ VČELSTEV (APIS MELLIFERA) METODOU AKUSTICKÉ EMISE

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ABSTRACT

Presented paper deals with a continuous monitoring of honey bee colony depending on the activity, hive space and application of medicaments in the hive. Overall colony activity was monitored using acoustic emission (AE) method. Data was recorded to describe development of the bee colony. The information gained will be used to represent a more comprehensive view on the life-cycle and behavior of honey bees (*Apis mellifera*).

Key words: honey bee, acoustic emission

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INTRODUCTION

Presented research project describes life activity of honey bee colonies in the course of the year. Colony members are able to carry vital information using pheromones and vibrations. The project focuses on vibrations/ultra-sound signals measured using of acoustic emission method, which helps to detect individual biological processes of bee colonies.

Honey Bee Colonies

Honey bees live in communities called colonies. The colony is considered a family made up of fertilization-capable mother and her off springs including worker bees and drones. The colony as a social entity did not evolve by chance. It results from long adaptation of honey bees to acceptable living conditions (probably as long as 80 million years). There have been as much 16 328 species, as indicated by prof. Michener. Each species, genus or family seems to be at different stage of development. Honey bee that lives in colonies represent top of the development tree. By living together, honey bees gain a lot of interesting features and characteristics. This is why a colony acts as an organized system unit. [1]

Breeding efforts should be directed towards achieving fit-and-productive condition of all colonies. Since bees are dependent on natural resources for food and thus the vegetation and weather conditions, colony treatment depends on life cycle of bees and nature during the year.

Individual interventions into colony life should be scheduled according to phenological calendar, current nature status and biological patterns. Such a complex background calendar and biological patterns produces breeding calendar, often referred to as beekeeper's year (BY). As a result, the BY features specific beginning and end terms. [2]

It is desirable to treat bees with respect to their natural habitus including species characteristics, and inter-ecosystem relationships. That is why the beekeeper should always judge his interventions using a critical approach. [3]

Acoustic Emission Method

Acoustic emissions are the stress waves produced by the sudden internal stress redistribution of the materials caused by the changes in the internal structure. Possible causes of the internal-structure changes are crack initiation and growth, crack opening and closure, dislocation movement, twinning, and phase transformation in monolithic materials and fiber breakage and fiber-matrix de-bonding in composites. Most of the sources of AEs are damage-related; thus, the detection and monitoring of these emissions are commonly used to predict material failure. In technical diagnostics, AE method has been used to monitor rotational part status (friction and cavitation of bearings/gears), detection of micro-cracks, pressure vessel defects, tubing system defects, aircraft structure evaluation/testing, and bridge status diagnostics. Major advantages of AE include continuous monitoring of the object, time savings, and forecast abilities of the concept. On the other hand, AE wave source is not always obvious, as the emitted energy may result from several phenomena inside of the part. Further variable factors include shape of the object, surface area, material structure, and homogeneity level. [4] .

Recently, the AE method was used to monitor activity of termites and other pests in various materials as well as biotechnological processes (e.g. beer fermentation).

METHODS AND MATERIALS

For the pilot measurement, a small-size bee-hive was chosen (designation Q04/11). The hive contained five frames with dimensions of 37 x 15 cm. Two identical sensors (designated Slot01 and Slot02, manufactured by Dakel Company) were placed in the hive: Slot01 and Slot02. This naming scheme corresponds to individual channels (slots) of the Dakel XEDO analyzer.

Figure 1: Row of small hives used in the experiment. Photo by authors

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The Slot01 sensor was placed on a sheet metal plate with dimensions of 3 x 10 cm. The sensor was coupled with a 35 dB preamplifier. Contact area was treated with acoustic paste for improved acoustic coupling. The actual sensor was fixed in place using a rubber band and the entire plate was hung into the hive between the frames. To have enough space, one frame was necessary to be removed from the hive.

Figure 2: Slot01 sensor on the sheet metal plate in the hive interior. Photo by authors.

The Slot02 sensor was placed on a glass plate inserted in the inlet port of the hive. The sensor was connected to a 35 dB preamplifier. The glass plate covered the entire area of the inlet port and captured both the flight activity and cleansing/ventilation movements. The sensor was attached to the glass plate using a clamp.

Figure 3: Slot02 sensor on the glass plate in the inlet port. Photo by authors.

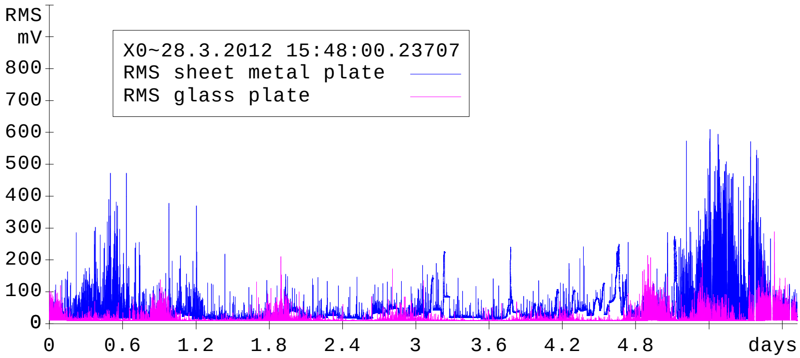
The signals from both sensors were pre-amplified and later processed by the Dakel XEDO AE analyzer. An Ethernet-connected laptop PC with Dakel DaeMon software was used for continuous viewing and storage of the AE data. The data from AE monitoring has been evaluated using Dakel DaeShow software to provide visual representation and statistics. The AE was monitored continuously for a week.

Figure 4: Dakel XEDO AE analyzer used in the experiment. Photo by authors.

RESULTS AND DISCUSSION

Start of the AE monitoring run was scheduled on the 28th of March 2012 at 3:47:59 p.m. (see Figure 5). This way, we monitor the actual activity of the bee colony at different stages of the day. The chart shows RMS of AE signal for both sensors.

Figure 5: RMS for both channels (sheet metal plate, glass plate).



It is clear that the colony activity corresponds to variable temperature. When the temperature was relatively high, there was an increased flight activity of the bees. Later, there was a rapid decrease of the temperature during the day and at night. On the 1st of April, when there was a snowfall, the bees were not leaving the hive at all with an exception of water supply-related flights. To confirm this behavior, bee activity rose stronger as the air got warmer on the following day. Thus, experiment showed a close relationship between temperature and the activity of bees.

Sheet Metal Plate Sensor

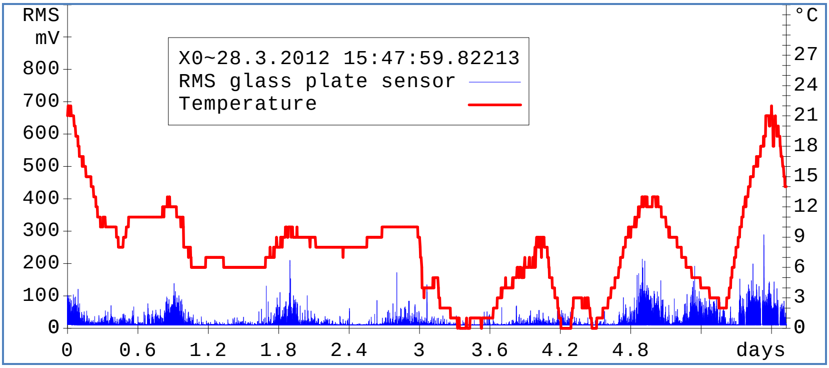
Acoustic emission sensor on the sheet plate was not affected by outside temperature (see Figure 3), because the bees in the hive were able to generate sufficient heat for their thermal comfort.

However, the sensor was influenced by its location, as it was placed on the penultimate frame where a large accumulation of bees does not usually happen. When it got cold outside, the bees stuck together and left the area where the sensor was located. In the first phase, the sensor was accepted by the bees although it was a stranger object. In later phases of the measurement, the colony concentrated into a tight formation to reduce heat losses. Thus, the overall activity decreased. As the outside temperature rose, the cluster was loosened and extended in multiple inter-frame gaps including the one with the sensor plate. The last phase of the measurement shows high activity of the colony. This was when the bee individuals filled the entire inner space of the hive space.

Glass Plate Sensor

The glass plate sensor showed live activity when there was a temperature rise. This can be explained by simple fact that bees performing tasks outside the hive were flying and landing heavily. The time frame of this activity a few hours, when there was a suitable temperature in the course of the day. Bees flew at lower temperatures as well, but many of them did not survive such hostile environment changes. Night activity probably corresponded to cleaning procedures, when the space was cleaned and dead bee corpses were pushed out of the hive space.

Figure 6: RMS and temperature curves for glass plate sensor.



CONCLUSIONS

The acoustic emission (AE) method was used to remotely monitor bee colony responsiveness to various stimuli. This method describes the measurement of online flight activity and intensity of flying bees that provide water and pollen. The method can be used with colonies located at remote sites or for the beekeepers which are too busy to perform separate inspections. The results indicate rather surprising fact: the bee activity never seized completely, not even during the night. This might be due to ongoing cleaning and/or hive ventilation effort of the bees. At the end of the measurement it can be seen that the RMS curves nearly overlap due to high temperature values (se Figure 5). The colony is actively involved in its predetermined development. Temperature seems to be the limiting factor controlling the hive organism life cycle. High temperatures allow the colony for active cleaning, picking water and flying off the hive.

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