Noise loading in beehives made out of different materials

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Abstract: *Bees are highly sensitive to noise pollution and in some cases, noise can impact their behaviour. Towards the goal to create optimal living conditions for the bees, we aim to understand how the material of the beehive impacts the microclimate of the beehive. The present paper aims to examine and compare the noise levels inside beehives of the same construction but made out of different materials. Three 10-frame Dadan-Blatt beehives were used in the experiment – a ceramic beehive made out of high-cavity ceramic tiles of marl clay; a ceramic beehive made out of high-cavity ceramic tiles with increased kaolin content and a wooden beehive (pine). The noise was measured in an urbanized area and inside the beehives. The results show that the best performance in terms of noise insulation is the ceramic beehive with increased kaolin content.*

Keywords: *CERAMIC BEEHIVE, NOISE POLLUTION, BEES, BEEHIVE MICROCLIMATE*

1. Introduction

Noise pollution or unwanted noise is the excessive sound that has bad effects on human health, wildlife and environmental quality. Noise pollution is mostly caused by the sound from highways, railways, airplanes, and any transportation traffic, from construction activities and industrial sites [1]. Noise pollution affects the health and wellbeing of many animals including bees.

It is known that bees are using for communication vibroacoustic signals produced by stridulation, gross body movements, wing movements, high-frequency muscle contractions without wing movements, and scraping mandibles or tapping body parts on resonant substrates [2]. For them, airborne sound and vibration signals have a great biological significance [3]. But when honey bees are subject to pure tones at frequencies from 100 to 1500 Hz audible at distance 250 m, the normal activities inside the beehive stop and the insects stop[4, 5]. Another study of the reaction of the honeybees inside the beehive confirms this statement showing that in the presence of sound with a frequency of 100 cy/sec (120 db) to 2000 cy/sec (128 db), it is observed a considerable effect expressed in total cessation on the movements of the workers and drones which even allowed the experimenters to open the beehive and take out a frame without using any smoke [6].

Some specialists argue that noise pollution is considerably affecting the wellbeing of bees creating a great amount of stress which is leading to increased mortality. Another effect on their behavior is the inclination to leave the beehive when exposed to increased stress factors like noise.

The data from the noise level measurements over the last 10 years show that the regulated permissible noise levels have been exceeded in 72% of the examined checkpoints in Bulgaria [7]. The relative share of points with exceeded levels has not changed since 2013, and the indicated results in the last measurements of 2019 and 2020 show a relative increase in noise levels above 61dB. A threshold value of 50 dB is taken as the norm. In most of the control points, the measured equivalent noise levels exceed the limit values with no tendency for improvement.

Increasing noise pollution is threatening the wellbeing of one of the most important pollinators in nature and it is necessary to start studying opportunities to improve their living conditions. Of course, it is hard to influence the environment outside the hive but it might be possible to influence the conditions inside it. One possible way to do so is through technical improvements or even through change in the construction material of the hive. Traditional beekeeping is connected with wooden hives and sometimes plastic or Styrofoam. Recently, a new type of beehive has been introduced to the beekeepers – a ceramic beehive made out of ceramic tiles with increased cavity. One of the advantages of such hives is the better insulation properties [8].

2. Aim

The aim of the present study is to examine and compare the noise levels inside beehives of the same construction but made out of different materials in order to make conclusions about the comfort of the bees which each of them can provide in terms of noise insulation.

3. Methods

The examination has been conducted in the urbanized area of the industrial region of the city of Debeletz, Veliko Tarnovo District, Bulgaria. The evaluation has been performed during daytime (between 10:00 a.m. and 6:00 p.m.) for the period of 31 days, from 01.05.2022 to 31.05.2022. Noise levels have been evaluated by high-sensitivity super-cardioid condenser microphone brand BOYA type BY-MM1+ with the following characteristics:

Table 1. *Technical characteristics of the used microphone*

Converter	Electric capacitor
Polar diagram	Supercardioid
Frequency response	20 Hz-18kHz
Sensitivity	-36 dB +/- 3dB (0 dB = 1V/Pa, 1kHz)
Ratio Signal/ Noise	78 dB
Input plug	3,5mm TRRS line-out/ line output 3,5 мм TRS headphone output
Size	Φ26x100mm (Φ1x3.9")
Weight	60 gr. (2.1oz)

The beehives which were used for the experiment have the same construction, type 10-frames Dadan-Blatt, but the material of the walls is different, respectively from a ceramic beehive made out of high-cavity ceramic tiles of marl clay; a ceramic beehive made out of high-cavity ceramic tiles with increased kaolin content and a wooden beehive (pine). The beehives were not inhabited.

Fig.1. *From left to right: A ceramic beehive made out of high-cavity ceramic tiles of marl clay; a wooden beehive (pine); a ceramic beehive made out of high-cavity ceramic tiles with increased kaolin content*

Table 2. *Coding*

Beehive	**Description**
Beehive 1	A ceramic beehive made out of high-cavity ceramic tiles of marl clay
Beehive 2	a wooden beehive (pine)
Beehive 3	a ceramic beehive made out of high-cavity ceramic tiles with increased kaolin content

All beehives have a removable drawer-type bottom, which is tightly closed.

The microphone was installed in the beehives and there were measured average values for noise inside the hive. Levels of the environment were also measured.

Fig. 2. *Installation of the microphone inside the beehive*

The output is visualised in figure 3.

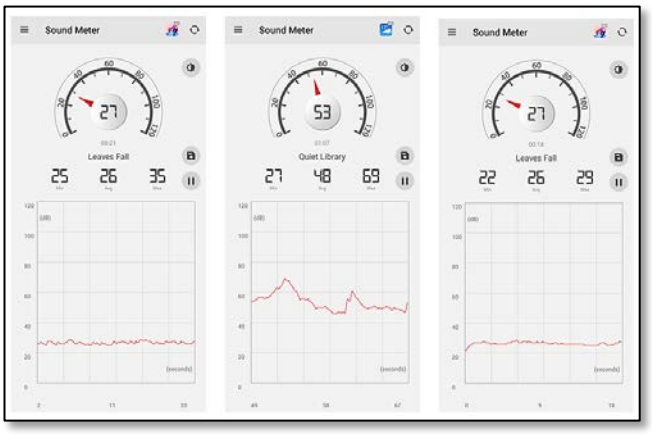

Fig. 3. *Display of the results from the noise measurement, respectively for a ceramic beehive made out of high-cavity ceramic tiles of marl clay; a wooden beehive (pine); a ceramic beehive made out of high-cavity ceramic tiles with increased kaolin content*

The obtained results for the 31-days period were statistically analysed using software IBM SPSS Statistics Software 2019.

4. RESULTS

According to Annex No. 2 of Ordinance No. 6 of June 26, 2006 [9], the maximum value of noise allowed in the urbanized area is 55 db(A) during daytime while in industrial regions, it is 70 db(A). During the time of the experiment, the noise in the area was evaluated to be between min = 32 to max = 61 db(A) with average value of 46 db(A) which is within the permitted levels for the area. Although the area is industrial, in the perimeter of 1 kilometer, there are 3 bee farms and the region is typical for beekeeping which makes the results from the present study relevant and applicable for the apiculture sector.

The following graph presents the evaluated levels of noise for the period. What we observe is that for the whole period of thirty-one days, the ceramic beehive with increased kaolin content (Beehive 3) is showing the best performance in terms of noise insulation.

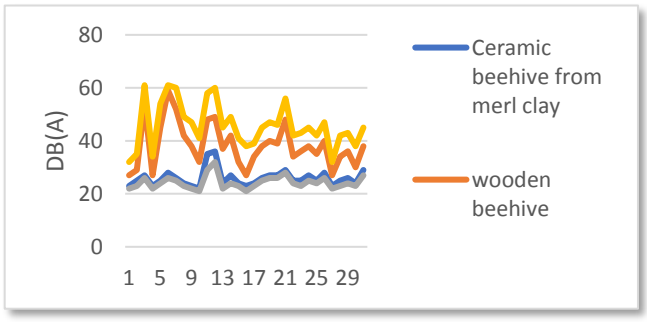

Fig. 4. *Evaluated level of noise*

The graph shows that the values of the ceramic beehive from merl clay (Beehive 1) and the ceramic beehive with increased kaolin content (Beehive 3) are close. In order to understand if the identified difference is significant or not we perform non-parametric statistical test - Related-Samples Friedman's Two-Way Analysis of Variance by Ranks. The results for the pairwise comparisons are presented on table 3.

Table 3. Pairwise comparison

Sample 1 – Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Beehive 3 – Beehive 1	1,000	,254	3,937	,000	,000
Beehive 3 – Beehive 2	2,000	,254	7,874	,000	,000
Beehive 1 – Beehive 2	-1,000	,254	-3,937	,000	,000
Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same. *Asymptotic significances (2-sided tests) are displayed.* *The significance level is ,05.*					
Significance values have been adjusted by the Bonferroni correction for multiple tests.					

What we see is that the difference of the levels of noise between the three beehives is statistically significant ($\alpha = 0.00 < 0.05$).

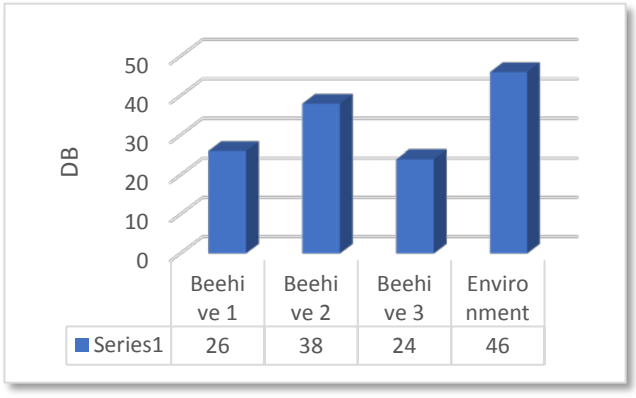

Fig.5. *Levels of noise, average values for the period*

The results displayed of figure 5 are average values for the indicated days in dB, and the graph clearly shows the relative ability to reflect and absorb noise of the different materials. The coefficient ratio $\alpha_n = Rw_n/Rw_o$, where Rw_n is the index of sound insulation from airborne noise inside hive in the range of 100-3150 Hz, where n = 1, 2, 3 is the number of the studied models, and Rw_o is the evaluated average noise in an urbanized environment.

$\alpha_1 = 26/46 = 0.5652$

$\alpha_2 = 38/46 = 0.82$

$\alpha_3 = 24/46 = 0.5217$

What we see is that in terms of noise insulation, the ceramic beehive with increased kaolin content has the best performance followed by the ceramic beehive made out of merl clay - $\alpha 3 < \alpha 1 < \alpha 2$.

5. Conclusio

With the high pace of industrial development, increased connectivity and transportation opportunities, and constantly growing number of people, we manage to create a lot of noise. Although in most parts of the world the noise level is regulated by law, we still manage to disturb the life and the regular habitat of many living creatures. The present study, discusses the importance of the level of noise for one of the most valuable insects - the honey bees. High levels of noise cause total cessation of the moves and there is no data about the influence of a constant exposure of lower noise. It is already a problem for the humanity the ability to provide them optimal living conditions and prevent loss and mortality and while it is hard to influence the environment, improving the living conditions inside the beehive is a much easier task. New approaches with construction and materials seem to give a solution. We can conclude that in terms of noise insulation, the ceramic beehives perform considerably better than the classical wooden one. This gives us the reason to think that such beehives will allow much less disturbance and respectively less stress of the bees in the hive.

6. References

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