CERAMIC BEEHIVE - CONCEPTUAL PAPER

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Abstract: *The present article is a conceptual paper which aims to be a foundation for future experimental work. The conceptual work discusses different aspects of a new utility model – a ceramic beehive. The evidences are based on theoretical models based on the optimal living conditions of the bee family and the specifics of the changing external environment. Along with these factors are considered the ceramic properties and the relevance of the ceramic material as a construction material for the brood (the beehive body). In order to reach the aim of the paper are used the following empiric and non-empiric methods: literature review, expert evaluation, experiment. The results from the study confirm the conceptual model and reason the hypnotized properties of the experimental model for optimization of the living conditions of the bee family. This is supported by evidences in increasing of the honey production in the ceramic beehive.*

Keywords: *CERAMIC, BEEHIVE, CERAMIC BEEHIVE*

Introduction

The importance of the honey bees for the nature of our planet is indisputable- their presence is vital as pollinators (Aslan, Liang, Galindo, Kimberly, & Topete, 2016) of the agro ecosystems, ensuring the productivity and stability in nature (Rogers, Tarpy, & Burrack, 2014), having great importance for national and world economy (Rucker, Thurman, & Burgett, 2012; Southwick & Southwick, 1992) as whole industries benefit and exist due to the bees and their products- agriculture, beekeepers economic sector, the market of honeybee products, cosmetics, pharmacy, etc.

During the last 10 years an alarming event is observed and reported in many North American and European countries- colony loses and the so called "Colony Disease Disorder" (CDD). CDD is associated with complete absence of the colony with no dead bees in/around the colony; presence of capped brood; presence of food stores that are not robbed by other bees or typical colony pets (Ellis, Evans, & Pettis, 2010). The collapsing (weakening) of the colonies can be due to 1. An insufficient number of bees to maintain the amount of brood in the hive; 2. The workforce is composed largely of younger adult bees; the queen is present; 3. The cluster of bees is reluctant to consume food provided to them by the beekeeper. Although the event is not new in the nature, recently its size is going much beyond the normal. Other disturbing facts are concerning increased loses and lethality which can be caused by different factors most commonly connected to bee pathogens and parasites (Genersch, 2010; McMenamin & Genersch, 2015), chemical usage (Gashout, Goodwin, & Guzman-Novoa, 2018), chronic sublethal stress (Bryden, Gill, Mitton, Raine, & Jansen, 2013), etc.

In order to be ready to face the problem, countries like the USA are allocating huge amounts of money for forming ”consortium of investigators working in a coordinated manner to reduce institutional redundancy and optimize the discovery and delivery of sustainable bee management practices”. (Pettis & Delaplane, 2010). This common world problem should attract the attention not only of the academic society but also to the industries and policy makers to join efforts towards finding solution of this problem which is of global importance.

The present paper aims to offer a possible solution matching the reasons for the managed bees loss and the CCD with some specific properties of the baked clay materials. We find it reasonable to explore the potential for a beehive constructed dominantly from ceramic to be a technical solution for improving the living conditions of the managed honey bees. The motivations behind the present study are multidimensional.

The idea for using clay as construction material for beehive is not a new one and we assume that its applicability is already historically proven. There are existing evidences dated back to 2450 BCE when the Egyptians had developed sophisticated apiculture for beekeeping in clay hives which later had spread throughout the Mediterranean (Kritsky, 2017) The continued usage of the clay beehives is evidenced from remainings from the Iron age at the lands of Jordan Valley (Mazar, Namdar, Panitz-Cohen, Neumann, & Weiner, 2008) to different periods from the human history (Francis, 2009) (Harissis & Mavrofridis, 2012; Taxel, 2006).

Combining the example of our ancestors with the trends and development of the technologies in clay processing, theoretically justifies the idea of producing an advanced model of contemporary ceramic beehive. The main reasons for this are in the specific advantages of the ceramic in comparison with the traditionally used for beehive production wooden material. Here we will highlight some of these advantages which we consider as most important.

RH, %	Wood MC (Weight %)	Face Brick MC (Weight %)
50	~9	0.02
80	16	0.09
90	20	0.19
95	24	0.38
100	29+	4.3
100	n/a	5–7

Table 1 Table 1 Correlation of Relative Humidity, Wood Moisture Content, and Brick Moisture Content

Firstly, from technical point of view, one of the most important properties of clay is that when it is baked at high temperatures (over 950 ° C), it is irreversibly transformed into a solid stone-like body that has high strength, fire resistance and low water absorption. What is more, the backed clay is a pore "breathing" structure with high frost durability(Hansen & Kung, 1988) and is performing better in terms of water retain (table 1) which is important when considering the fact that the increased humidity and moisture content of the material are predispositions for bacteria and other microorganisms occurrence in the beehive. This would make the conceptualized ceramic beehive model especially useful for geographical regions characterized with extreme temperatures, high temperature amplitudes between the seasons as well as places with higher risk of fires or windy areas (the relative higher weight of the ceramic lowers the risk of sweeping) which cause serious material damages to the beekeepers. Because of the properties of the baked clay and its relatively higher endurance in terms of physico-mechanical and operational properties, a ceramic beehive is expected to be able to provide an optimal solution for unfavorable environmental conditions both for the bees and the beekeepers.

Additionally, the endurance of the ceramic materials in their solid baked form does not require any successive treatment as it is in the case of the wood materials. The wooden beehives require regular treatment with wood preservatives which affect the quality of living of the bees as well as the quality of the bee products. Authors who worked on the topic argue that the wood preservatives such as chromated copper arsenate, tributyltin oxide, pentachlorophenol are associated with winter losses of colonies (Johnson, 2015; Kalnins & Detroy, 1984) and increased arsenic content in the products. Wood materials have relatively short life cycle in comparison with the bricks. With the time, the wear resistance of the wooden materials decrease and wood declay process takes place due to the wood-inhabiting bacteria and the actinomycetes (Clausen, 1996; Johnston, Boddy, & Weightman, 2016). The process causes effects on the level of hygiene within the beehives well. In this respect, the ceramic beehive is a more hygienic material which does not favor the development of bacteria, it is rot–proof, impermeable, non–absorbent, insulating and easy to clean and disinfect. Usage of ceramic material has also an environmental advantage as the production of ceramic beehives is not connected with cutting trees.

Considering all the above mentioned we assume that there are enough evidences to hypotize that a ceramic beehive would find a good application in the beekeeping industry providing better conditions for the bees and assuring better quality of the bee products.

Methods

In order to reach the aim of the study, is used a complex of non-empirical and empirical methods such as theoretical analysis, expert evaluation, experiment. The expert evaluation has been conducted in two stages - before and after construction design of a model of the conceptualized beehive. The expert evaluation aimed to gather experts who work in different fields connected to beekeeping (beehive production, beekeepers experts, academicians and researchers, constructors) in order to critically evaluate the idea and generate guidelines for the production of the first experimental model. The first experts' evaluation meeting took place in the spring of 2012. Following the production of the first experimental model, another experts evaluation took place in order to discuss practical aspects of the design, construction and production process. In 2014 starts the consequent process of inhabitation of the experimental model with bee families. The beehives are constantly observed and improvements of the construction of the beehive has been done in timely manner. The last upgraded version of the model has been inhabited in 2017.

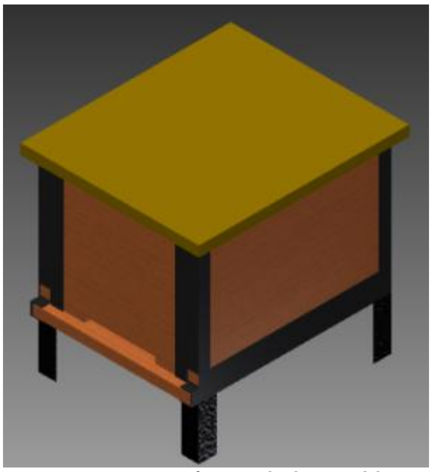

Image 1 *Prototype of ceramic beehive/ model 1*

Results and discussion

The first experts' analysis of the idea gives ground for development of the first utility model. The assumed benefits and advantages of the ceramic beehive have been confirmed by the experts. It was agreed that at this stage of the model development it is most appropriate to be designed and produced only the body (brood) and the top cap as it is the place where the queen lives and where the bees are during the winter season. The construction of the hive consists of ceramic plates and supporting metal structure as it is shown on image 1. The sizes of the design of the prototype is in full compliance with the standard for Langstroth hives enabling the usage of the standard wooden boxes above. The choice of Langstroth standard is not done randomly but because it is the most common used beehive in Bulgaria.

The realization and implementation of the idea has been discussed at the second expert evaluation meeting when advantages and disadvantages of the result has been analyzed. It was concluded that the main disadvantage is the weight of the body so lightening of the construction has been recommended. This led to research and development of new technological solutions ending up with design and production technology of ceramic plates with 66,66 % cavity (image 2). Apart from lightening the construction, the new single plates provide better isolation within the box because of the airbags (the inner part of the plate is filled with air) which ensures better living conditions and optimal temperature, significantly reducing the work of the bees in providing better living conditions.

Image 2 *Ceramic plate with increased cavity*

Along with the utility model has been developed the technology for production of the plates as currently there are model equipment for producing of different types of plates as show in table 2.

Table 2 Specification of the models for production of plates

Size [mm]	**Cavity [%]**	**Water saturation [%]**	**Compressive strength [MPa/ kg/cm^2]**	**Weight [kg]**
310 x 375 x 25	66.66	<10%	28 / 2800	2.900
310 x 500 x 25	66.66	<10%	28 / 2800	3.800
260 x 500 x 25	66.66	<10%	28 / 2800	3.000
260 x 375 x 25	66.66	<10%	28 / 2800	2.600

Image 3 *Ceramic beehives, improved experimental model*

Following the recommended modifications, 14 beehives have been produced and put in natural conditions with bees inhabited in apiaries in different geographical regions. The beekeepers who participated in the experiment were asked to observe the bees' behavior and to report problems and impressions they have from the exploitation of the experimental model. From all the beekeepers feedback has been collected. During the experiment, in summer periods in two of the apiaries occurred fire. In both places the only remaining hive from the burning beehives is the experimental ceramic one. The last report on the results of the usage of the ceramic beehive is from the autumn of 2018 when the beekeepers report 30% increase in the honey production in comparison with the production in the wooden hives. For none of the ceramic hives is reported bee loss or CDD.

Conclusions

The results obtained from the research confirm the conceptual model and reasons the hypnotized properties of the experimental model for optimization of the conditions for life of the bee's family. The idea has been registered as utility model in the Patent Office of Republic of Bulgaria with application number 2412/14.05.2013. Further experimental work is recommended in order to be laboratory tested the qualities of the honey produced in the ceramic beehive as it is assumed that the optimized internal conditions may also have effect not only to the quantity but also to the quality of the bee products.

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