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Electronic Bee–Hive (E–Ruche) Project

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Abstract

The purpose of the "Electronic Bee Hive project" is the recording and the scientific study and analysis of bee activity, mainly inside the bee-hive, using very modern methods of telemetry. This can be achieved by installing on the external part of the bee-hive a leading edge technology and also robust Electronic System, which receives electronic signals from various sensors that are located inside and outside the bee-hive. Numerous sensors located at specific points inside the bee hive record various temperatures, humidity level, carbon dioxide concentration and also the weight of the bee–hive. The external temperature and humidity are monitored as well. A web camera can also be used for recording the external conditions around the bee–hive. The various signals are recorded round the clock and sent to the Electronic Bee Hive Server at regular intervals, by wired or wireless telecommunication networks. The information can be accessible from any computer by a bee-keeper or a scientist via the Internet.

Key words: bee, telemetry, sensor networks, bee-hive, electronic bee-hive

1 Introduction

The bee lives on Earth for millions of years. Beekeeping is one of the few commercial and economic activities of man, which is environmentally friendly and contributes to the rational management of natural resources. The bee is considered the most valuable insect on the planet today, but faces many risks and diseases which during the recent years have increased dramatically in number and in intensity. In USA the number of bee-colonies from 5 million in the

1940s decreased to only 2.5 million in 2012. (USA Agriculture Research Service, 2012Anual Report).

Exploitable parts of the bees are pollen, royal jelly, bee-wax, and honey and also bee venom. The bee-honey 'offers' to the man its honey which is considered one of the best foods. But the importance of pollination of the flowers, to which the bees contribute by carrying pollen from flower to flower, is immeasurable. In fact every beehive is a biological sensor for recording and studying of the environment. Unfortunately nowadays the bees are in danger of extinction for various reasons. In recent years the life of bees is threatened by numerous parasites including the one called 'varroa', which tends to weaken the colonies and cause the slow disappearance of the species. Nevertheless some Asian species have managed to develop their defence and can fight this parasite. However, most other species, including those found in Cyprus are helpless against such attacks. (Dominique Micheletto, 2011). That is why the aim of "E-Ruche", Electronic Bee – Hive (EBH), project is to further develop electronic beehive prototypes and install them around the world so as to contribute to realise why there is significant loss of bee colonies through scientific research and analysis. In Europe 30 or 40 years ago the higher percentage of beehives was the property of amateur beekeepers located in almost every village and small town worldwide (Dominique Micheletto, 2012).

Figure 1: A Typical Bee-Hive (left) and an Electronic Bee-Hive (right)
Source: Kourouma Giorgos et al. 2012

Unfortunately this is not the case anymore and one of the major problems that should be rectified is to try to restore a better dispersion of pollinators around us. By doing so would give the hope to provide a local, self-production of the different bees products associated to very high quality standards and the renewing of contacts between consumers and producers and also the respect for each other. That is why another target of EBH project is, by introducing new methods and approaches in beekeeping, to help in attracting people (and especially young ones) to beekeeping which could provide a new opportunity to restore the biodiversity in our rural environment, which is now in serious danger. (Dominique Micheletto, 2012).
The study of bee activity within the framework of the Electronic Bee-Hive (EBH) project, can contribute significantly to the drawing of important and crucial conclusions by expert researchers on the level of environmental quality. Furthermore the specialists will be helped to find ways to improve the quality of the environment and therefore improve the lives of bees and consequently the life of human beings. This project can contribute to the further promotion and development of research by employing leading edge technologies with emphasis on applications in the environmental field and introduce innovative ideas and development processes. The aim is to improve the work process and life of beekeepers, as well as the number of people becoming amateur beekeepers and thus restore a better dispersion of pollinators. In this way it will be achieved the improvement of the quality of life of citizens in general. (Sotos Voskarides, 2012).

The team of researchers involved in the project is focusing for the moment to the comparison of living and behavior of European honey bees (Apis mellifera) mainly in two different geographical areas: Continental Europe (France and Spain) and South East-Mediterranean Europe (Cyprus). Later on comparison with other geographical areas of the planet will follow.

2 The Electronic Bee–Hive Principle

For the last four years the research group of the French University of Orleans (UO) and the Cyprus University of Technology (CUT) have designed together prototype Electronic Bee-Hives which are in operation (two in each university, and also recently one in Spain and one in Argentina) and are connected to the EBH server (www.e-ruche.fr). This is the first time worldwide that through this project the conditions in bee-hives are recorded electronically.

In actual fact, the scientific community for many years uses worldwide normal bee-hives in order to evaluate the state of the environment, but this is done only qualitatively and without the use of technology. What is proposed in the EBH project is the use of quantitative measurements using new technologies with hardware installed mainly within the bee-hive.

The main objective of the "Electronic Bee-Hive" project is the quantitative measurement of the state of bee-hives in order to have also a quantitative measurement of the environmental situation. Each electronic bee-hive can measure more than 20 parameters: the weight, the humidity inside and outside the bee-hive, CO2 concentration, the external temperature and up to 18 internal temperatures. The specific locations of the sensors are identified by the consultant - professional beekeeper. These sensors send analogue or digital signals to the externally mounted circuit. Then the microprocessor, which is connected to the above circuit, processes the signals from the various sensors and then stores them, so as to be sent eventually, in digital form, via the web server at regular intervals so as the recording and analysis of measurements to be followed. The Block diagram of EBH is shown in figure 2. This results in facilitating the beekeeper in following remotely the situation inside the Hive ant thus enabling him to prevent various problems or diseases that occur in bees.

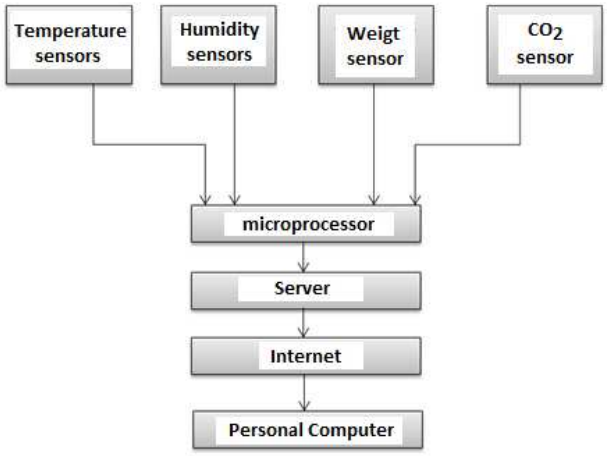

Figure 2: Block diagram of the Electronic Bee-Hive System
Source: Baptiste Lagorce et al. 2011

The beekeeper will be able to carry out much better simple and important processes like collecting the honey. That is the beekeeper can remotely understand, by checking the webpage of the Project, whether the state of the Hive is normal and also weather the Hive is ready for collection of honey. The basic idea of the electronic circuit design is that the information will be collected from the sensors as a small analogue potential difference or automatically in digital

form. These signals will then be processed and stored by the microprocessor which will send the data via the Internet to the server, through which access to the users (beekeepers and scientists) will be possible.

This information is available to the scientific community in real time for biological and environmental studies. So that crucial conclusions can be drawn regarding the quality of various environmental parameters of the area around the beehive.
The multiple recordings inside the Bee-Hive allow the determination of the location and size of the colony of bees inside the hive. These measurements are sent at regular intervals to the central server. All measurements from all electronic bee-hive are recorded in real time in a database server. The next target of the project partners is the installation in the near future of 8 electronic bee-hives in both countries, France and Cyprus, in urban, rural and natural zone areas. With the planned installation of these 8 electronic bee-hives, the total measurements which will be stored on the server (www.e-ruche.fr) in a period of one year are expected to be of the order of 20 millions.
The vision of the designers of the EBH project is to introduce into society the revolutionary technology of Electronic Bee-Hives. In this way, various scientific laboratories around the world will be able to build their own networks and Electronic Bee-Hives to connect to the EBH server. EBH project can thus provide the scientific community with the opportunity to record, analyze and improve the state of the environment in many parts of the world.

2.1 History of the Electrionic Bee – Hive

The idea of Electronics Bee – Hive was developed and implemented by researchers at the University of Orleans (France): Prof. Jean Pierre Marten, Prof. Laurence Josserand, and Prof. Cyril Novales. The first Electronic Bee – Hive was installed for the first time in 2008 at the Technological Institute (IUT) of Bourges – University of Orleans, in central France.

In 2009, Prof. Sotos Voskarides of the Cyprus University of Technology joined the Electronic Bee – Hive Research Group to contribute to the development and implementation of the concept in Cyprus. So in 2009 the construction of the second Electronic Bee – Hive, was concluded in Cyprus, and installed in Nicosia, in collaboration with French professional and expert beekeeper Mr. Dominic Mikelleto, who lives and works in Cyprus for the last 30 years. Mr. Mikelleto was until recently the President of the Beekeepers Association of Cyprus. In 2010, the Frence team of the project built three more Electronic Bee – Hives and installed one in Brittany (France), the other in Cordoba (Spain) and the third one in Buenos Aires (Argentina). In 2011 the construction of the sixth Electronic Bee – Hive in Cyprus was completed by three French students from the University of Orleans (Baptiste Lagorce, Vincent Person and Hamza Ziani) under the remote supervision of their French professors and also of Professor Voskarides in Cyprus. This EBH, has 18 internal temperature sensors (plus one external) and also one internal and one external humidity sensors.

In 2011, two more Electronic Bee – Hives were built in France and installed one in Paris and one in Sain-Eloi, in northern France. In 2012 three Cypriot students of the Cyprus University of Technology (Kourouma Giorgos, Michael Giorgos and Papadakis Theodosis) under the supervision of Professor Voskarides constructed and successfully tested the 9th EBH. The novelty in Hive is that apart from temperature sensors, one carbon dioxide sensor was added to the system, as well as weight and humidity sensors. This addition is considered very important for the study of the life of bees since of the bee-community collecting important information that will help to extend the range life of bees in subsequent research stages.

3 Sensor readings inside and outside the Electronic Bee – Hive

The temperature sensors in the above recent EBH were arranged so that their readings give the ratios within and outside of the 'body' of the colony of bees (melissosfaira). The humidity sensor was placed in the center of the colony so as to measure the amount of water bringing the bees to maintain the temperature within the melissosfaira in satisfactory for these levels (about 35 degrees Celsius).
Also a temperature sensor and a humidity sensor were placed outside the Bee - Hive to be used as external reference sensors. These measurements will help the beekeeper to understand how bees survive in temperatures unsatisfactory for them and the effort they do as to defend against climate changes. Also a study was performed for these sensors so as to choose the most appropriate regarding their installation, operation, cost, etc. One important factor is to choose sensors that will not affect one way or the other, the health of bees.
It is expected that this additional innovation will further help the work of the beekeeper, and will also increase the breeding of bees and thus increase also the production of honey and thus reduce, with the help of researchers, the problem of the gradual reduction in the number of bees, which are an essential part of the ecosystem stability and the environment in general. The development and refinement of Electronic Bee-Hive will gradually help to reduce these negative phenomena and hence contribute to the further development of beekeeping, which in recent years has unfortunately steep recession.

3.1 Temperature

The bees must have body temperatures around 35 ^{o}C in order to be able to fly and perform their work inside and outside the Hive. When flying outside the Hive while the temperature is low, the large muscles of the wings can generate enough heat to maintain the temperature. However, if the ambient temperature falls below 14 ^{o}C the bee cannot produce enough heat to maintain the temperature of 35 ^{o}C. For this reason, the bees do not come out of their hives when the ambient temperature is very low. In this case however, the bees in the hive, gather together, thus creating like forming a sphere 'melissosfaira' to keep warm and to have this body temperature of 35 ^{o}C. As the outside temperature drops, bees gather more closely together, so they can withstand the cold temperatures of winter.

In summer, when temperatures soar, the bees still regulate their own temperature within the Hive by waving their wings to recycle the air and so the temperature of the Hive drops. If the temperature becomes too high, the bees come out of the hive and collect water which spreads to various surfaces inside the Hive. The evaporation of this water eventually helps to cool the Hive. When the bees are in flight, if the temperature is high they spew a very small amount of liquid, which evaporates and helps to cool their head up to 10 ^{o}C. At temperatures below 10 ^{o}C bees stay inactive and at temperatures above 38 ^{o}C the activity decreases again. The bees can withstand temperatures up to 50 ^{o}C for short periods.

3.2 Humidity

The bees must keep their body temperature at about 35 ^{o}C. That is why to regulate the temperature of the Hive they are carrying water from the external environment into the Hive. Evaporation of this quantity of water helps to cool the Hive when the temperatures of the outside atmosphere are very high. The relative humidity in the Hives should not have much deviation from the optimum but it differs for each type of bee. For this reason, the humidity sensor must be selected to be sufficiently accurate and be able to cover the necessary range of measurements needed by the beekeeper.

3.3 Weight

Weight is called the force with which the earth attracts a body. Usually weight is measured with load cells or scales. The weight is given by th eformula: W = m. g where w = the weight of the body, m = mass of the body, and g = the acceleration of gravity.

The constant g, i.e. the acceleration of gravity depends on the geographic location of the body,. In the geographical area of Cyprus the acceleration value due to gravity is approximately 9.8 m/s2. So bodies being at the same geographical area and having the same mass have the same weight. The measurement of the mass of a body is measured in mass units i.e grams or kilograms (g or kg).

3.4 Carbon Dioxide concentration

The measurement of carbon dioxide in a Hive, proved to be a very important factor that will greatly help the beekeeper to understand several factors relating to bees. This is because during the winter time the bees gather in the center of the cell, like forming a sphere, (bee - ball) in order to withstand low temperatures. The bees that make up the bee - ball condense their bodies and recycle to alter their position which is 'democratic' since in this way they share the work. The queen is in the center of the bee - ball and the other bees are trying to protect her raising the temperature as much as possible.

The readings of the carbon dioxide sensor shows to beekeepers how the bee - ball is recycling and how the bees breathe in this period. This sensor is used more for research purposes during this project while measurements are needed mostly during the winter season where the population of bees in the hive is reduced significantly.

4 Readings - Results

The readings of the sensors in the Electronic Bee Hive in Cyprus University of Technology, shown in Table 1, were recorded without the presence of bees. The corresponding graphs of the readings of Temperatur, Humididy, CO2 and Weight are shown in graphs 3, 4, 5 and 6 respectively.

Table 1: Typical Measurements of 8 internal and one external Temperatures, one internal and one external humidity level, CO2 concentration as well as weight, taken every 4 seconds
Source: Kourouma Giorgos et al. 2012

Time	T1	T2	T3	T4	T5	T6	T7	T8	T9	H	H	Co	Kg
22:18:20	22,	23	22,9	22,8	23	22,8	22,8	23	23,3	6	6	41	0
22:18:24	22,	23	22,9	22,8	23,0	22,8	22,8	23	23,3	6	6	41	0
22:18:27	22,	23	22,9	22,9	23,0	22,8	22,8	23	23,3	6	6	40	0
22:18:30	22,	22,9	22,8	23,0	23,0	22,8	22,8	23	23,3	6	6	40	0
22:18:34	24,	23,0	23	27,2	23,0	22,8	22,8	22,9	23,3	6	6	41	0
22:18:37	27,	23,2	23	28,5	23,1	22,9	22,8	23	23,3	6	6	41	0
22:18:41	28,	23,3	23,0	29	23,1	22,9	22,8	23	23,3	6	6	40	0
22:18:44	29,	23,2	23,1	29,3	23,1	22,9	22,8	23	23,3	6	6	40	0
22:18:48	30,	23,2	23,2	29,8	23,1	22,9	22,8	23	23,3	6	6	40	0
22:18:51	29,	23,3	23,1	29	23,1	23	22,8	23	23,3	6	6	42	0
22:18:54	28,	23,3	23,2	27,7	23,1	23	22,9	23,0	23,3	6	6	40	0
22:18:58	27,	23,3	23,3	26,8	23,3	23,0	23	23,0	23,3	6	6	40	0
22:19:01	26,	23,3	23,4	26,2	23,3	23,1	23,0	23,0	23,3	7	6	41	0
22:19:05	26,	23,3	23,4	25,7	23,3	23,1	23,0	23,0	23,3	8	6	41	0
22:19:08	25,	23,3	23,4	25,3	23,4	23,1	23,8	23,0	23,3	9	6	40	0
22:19:12	25,	23,3	23,4	25	23,4	23,1	27,0	23,1	23,3	9	6	41	0
22:19:15	25,	23,3	23,4	24,8	23,5	23,2	28,5	23,1	23,3	9	6	40	30
22:19:19	25	23,4	23,4	24,5	23,5	23,2	27,5	23,1	23,3	9	6	40	0
22:19:22	24,	23,3	23,3	24,3	23,5	23,2	26,5	23,1	23,4	9	6	41	100
22:19:25	24,	23,3	23,3	24,2	23,5	23,1	25,7	23,1	23,5	9	6	40	0
22:19:29	24,	23,3	23,3	24,1	23,3	23,1	25,1	23,1	23,5	9	6	40	0

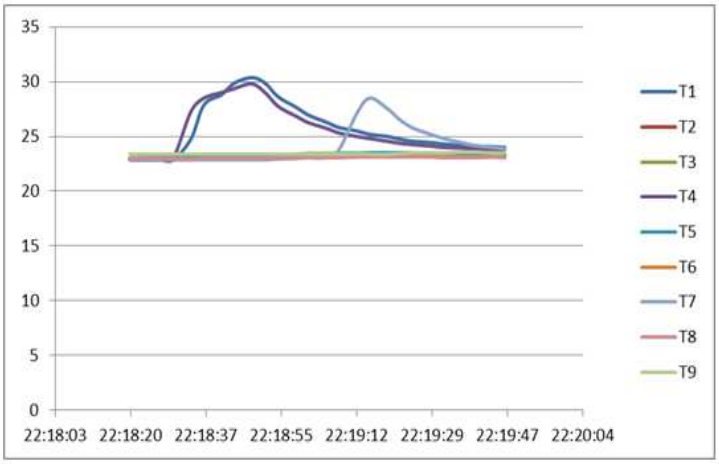

Figure 3: Graph of the Temperature measurements tabulated in Table 1
Source: Kourouma Giorgos et al. 2012

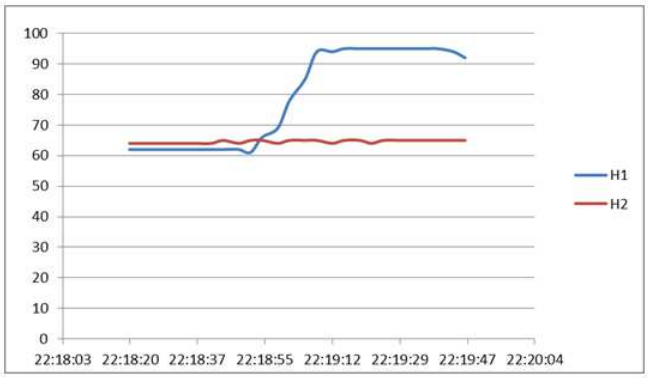

Figure 4: Graph of the Humididy measurements tabulated in Table 1
Source: Kourouma Giorgos et al. 2012

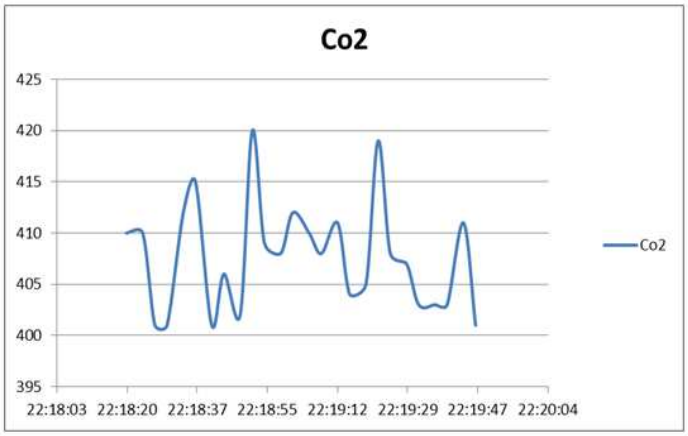

Figure 5: Graph of CO2 concentration measurements tabulated in Table 1
Source: Kourouma Giorgos et al. 2012

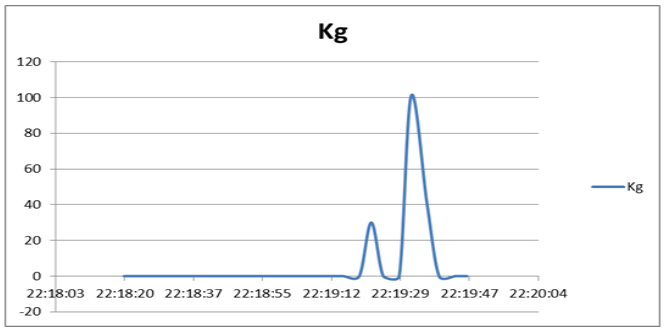

Figure 6: Graph of Weight measurements tabulated in Table 1
Source: Kourouma Giorgos et al. 2012

5 Conclusions - Future work

The recording and the scientific study and analysis of bee activity, mainly inside the bee-hive, is now practically possible by using an Electronic Bee Hive which is a unique System designed and built by researchers in the University of Orleans in France and in the Cyprus University of Technology, under the successful Project under the name "E-Ruche" (EBH). This is achieved using very modern methods of telemetry and leading edge technologies. The aim of this Project is the quantitative measurement of the state of bee-hives in order to have also a quantitative study of the level of environmental quality and therefore improve the quality of life of bees and

consequently the life of human beings. Another parallel aim is to improve the work process and life of beekeepers, increase the number of amateur beekeepers and thus improve the quality of life of citizens in general. Future improvements of the EBH systems may include the following: Introduction of wireless data transfer, using wireless ad hoc networks. Installation of motion sensors: These may be placed in the entrance of the Hive, which will help to monitor the incoming and outgoing bee-traffic. Renewable energy Power supply system: For example a photovoltaic panel could be easily used to charge batteries since the power requirements of the system are low. Installation of thermal camera: At a later stage, when the cost will not be prohibitive, thermal cameras could be installed to control the thermal zones and the concentration of bees inside the hive.

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