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Precision Apiculture in Mexico, Current Status and Perspectives.

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***Abstract*—Beekeeping in Mexico has great socioeconomic and ecological importance, since it is considered as one of the main cattle-raising activities generating foreign exchange, generally this activity is only associated with production of honey, pollen, royal jelly, propolis, but bees are fundamental for a balance of the environment since the bees when obtaining the food of the flowers foment in the plants the capacity to fertilize itself. During 2015 honey exports reached 45 thousand tons with a value of 150 million dollars, volume that represented the most important sale of the last 25 years . Precision beekeeping or Precision Apiculture consists of implementing technologies that allow us to monitor and control the different variables that are involved in this activity. Within these variables we have moisture, temperature, weight, amount of food and all data that may be considered relevant to collect information. Although one of the major limitations to the access of this type of technology is usually its high cost and low knowledge of the beekeeper in the use of these instruments, this type of innovations could contribute to the achievement of higher yields . Therefore, the training and integration of other disciplines in the development of these new technologies is important. To advance towards a much more technological and professionalized beekeeping, an objective that can be achieved through working together among the agents involved. This is the objective of the present study to know the state of precision apiculture in the country and propose alternatives for its implementation, so that the country continues to advance in this segment and is increasingly positioned worldwide.**

***Keywords*—Apiculture, México, Precision Beekeeping, Mechatronics.**

I. INTRODUCTION

[1] Mexican apiculture is a millenarian activity that contributes to the economic, social and ecological welfare of the production regions.. On the other hand, no suggestion for technological transformation in this sector are known.

Beekeeping in Mexico has great socioeconomic and ecological importance, since it is considered as one of the main cattle-raising activities generating foreign exchange, generally this activity is only associated with production of honey, pollen, royal jelly, propolis, but bees are fundamental for a balance of the environment since the bees when obtaining the food of the flowers foment in the plants the capacity to fertilize itself. During 2015 honey exports reached 45 thousand tons with a value of 150 million dollars, volume that represented the most important sale of the last 25 years. Regarding production, last year there were 61 thousand 881 tonnes, a figure that exceeded In almost 5 thousand tons to the obtained in the last five years, that was of 57 thousand tons annually; Mexico is still sixth in terms of production, and the third largest exporter. According to data from the SIAP, the country's beekeepers set a new record, achieving in 2015 the largest export of bee honey from the last 25 years [12]. For this production requires more 78 million colonies of bees distributed In the 463 municipalities of Yucatan, Jalisco and Campeche, which occupy the top three places in the national production, in addition to Chiapas, Veracruz, Oaxaca, Quintana Roo, Puebla, Michoacán and Guerrero, who are also important producers. 80 percent of the national production goes to the foreign market, the main destinations being Germany, which purchases 43 percent of the exported production; United States, Great Britain, Northern Ireland, Saudi Arabia and Belgium. Yucatan is the main producer of honey in Mexico; in the 2015 season production doubled and the harvest was sold in Europe, mainly in Germany, where they were shipped near Thousand tons. [11]. Precision beekeeping is to implement technologies that allow us to monitor and control the different variables that are involved in this activity. Within these variables we have moisture, temperature, weight, amount of food and all data that may be considered relevant to collect information.

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[2]. Precision beekeeping (AP) is a support system for the production of the sector, which integrates different disciplines and consists of a model focused on optimizing the quality and quantity of bee products, minimizing their costs through implementation Of more efficient technologies, to reduce the use of inputs and reduce the variability of a particular process, in an environmentally friendly way and arises from the changes that the sector has undergone and the need to respond exactly to what happens to the Inside the hive. Although one of the major limitations to the access of this type of technology is usually its high cost and low knowledge of the beekeeper in the use of these instruments, this type of innovations could contribute to the achievement of higher yields. Therefore, the training and integration of other disciplines in the development of these new technologies is important. Moving towards a much more technological and professionalized world Beekeeping, a goal that can be achieved by working together among the agents involved. As the incorporation of the new apicultural technology is in its beginnings in this Region, there is significant potential for the generation of new Models. [3]. This is the objective of the present work to know the state of precision agriculture in the country and propose alternatives for its implementation, so that the country continues to advance in this segment and is increasingly positioned world wide.

II. BACKGROUND *KNOWLEDGE*

2.1 Precision apiculture in the world

Precision Apiculture o Precision beekeeping (PB) is an apiary management strategy based on the monitoring of individual bee colonies to minimize the resource consumption and maximize the productivity. The main task of the PB is to develop real time on -line tools for continuous monitoring and control the bee behavior using the individual access to the objects avoiding exposure of bees to additional stress or unproductive activities. It is not possible and it is not necessary to monitor each and every one of the bees individually, and that is why the object PB is a colony. Similiar to precision agriculture also precision beekeeping can be considered as a three-phase cycle(data adquisition, data analysis and application),where the first phase-data acquisition has an important role. Then, based on the measured data and taking into account the expert knowledge it becomes possible to conclude about the colony behavior and developing process, [14].

Bee colonies can be automatic scaned using diverse techniques And methods. In scheme architectures sensor's data assembly can vary – data transmission (wired or wireless technologies), data packing and usage of middle devices. A particular checking system can also be supplemented with decision care system, which is liable for data analysis, bee colony state determination and correct decision selection. Temperature is the element that can be easily monitored and it is economically achievable. Bee colony temperature checking can be completed using several information tools, systems and methods. This paper describes several methodologies, including on-site and distant temperature nursing, how bee colony temperature data can be transmitted to the beekeeper for real-time data observing. Aim of this paper is to differentiate diverse system architectures for real time bee colony temperature observing. Apiary monitoring can afford useful information for persons associated with beekeeping to help to succeed their honey bee (*Apis mellifera*) colonies. The information acquired from the nursing process can contain data about beehive's temperature, humidity, weight etc. Such a monitoring system is a useful instrument in Precision Beekeeping. Honey bee colonies can be checked using numerous system architectures that are diverse in methods and methods. Meanwhile there are numerous monitoring system architectures, beekeeper himself should choose the one that costumes his needs. [5]. Developed six system architectures for bee colony temperature monitoring showed how different the monitoring systems can be, e. g., since monitoring when using only a sensor with a exhibition (first approach), to tactic when using specific devices for each hive (sixth approach) and accomplishment data analysis. Beekeepers individually should choose the appropriate system architecture for bee colony monitoring, based on their needs and financial calculations and available technologies in the apiary's location. The established selection algorithm can reduce the time that is needed to choose the suitable system architecture because it offers the key conditions that are necessary for specific system architecture. The algorithm does not afford information about the financial calculations while choosing the system architecture, as the calculations depend on different issues (the count of hives, chosen technologies (in the case of interface devices – type and count) etc.). In that way the algorithm can be supplemented by this type of information.

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Honey bee colony improvement. It is important to remotely detect different states of the bee colonies, like developmental states, several events, that may require beekeeper's actions, including swarming, extreme nectar flow, queen less states etc. Although there are sufficient technical means (different sensors, specific measurement systems, monitoring systems) and industrial products for the practical execution of PB, the implementation process is slow due to the differing states of development of three implementation phases: data collection, which is the most developed and advances phase to this moment, data analysis and submission. Presently available PB systems are not widely used because of numerous reasons: technical systems are complicated for beekeepers; benefits of usage of systems are not clear and there are additional operational costs of systems. The advance and practical application of decision support systems (DSS), which is usually a stumbling block in Precision Agriculture, is proposed to be an important mission. In the long term perspective, specific DSS-controlled electronic procedures should be developed to enable new functionalities for PB. Precise classes of actors are proposed to operate within future PB systems for the automatic execution of suggestions made by decision care systems, as well as for diagnostic purposes. PB systems should be optimized by searching for suitable blends of different sensors, and agreeing decision support systems must distribute convenient, reliable and cost efficient solutions. The development and specification of PB systems should consider business interests, distance to the apiary, expected risks and other peculiarities. The future implementation of the PB approach is determined by several factors: convenience of PB technology implementation by a beekeepers and clear economic welfares by which, the controls of return on investment can be consistent. The second point needs scientific energies to increase the consistency of data analysis and suggestions made by DSS. [6].

Several technologies can be applied for monitoring the bee colony and application of data gathering phase. [9]. The data collection process in PB can be categorized into three groups [15] ;1) apiary-level parameters (meteorological parameters and video observation); 2) colony-level factors (temperature, humidity, gas content, sound, video, vibration of hive and weight); 3) individual bee-related considerations (the number of incoming/ outgoing bees, the number of bees in the hive entrance area). Temperature measurements of bee colonies have the stretched history. Currently, bee colony temperature measurements seem to be the humblest and inexpensive way to monitor bee colonies.

The little costs of data collection, processing and data handover of temperature measurement systems facilitate request of temperature measurements in beekeeping. Monitoring of the bee colony temperature can be performed using various approaches and tools: 1) Manual temperature measurements, measurements by different loggers and iButtons; 2) Wired sensor networks; 3) Wireless sensor networks; 4) Infrared imaging. Temperature data can help to identify such colony states as: 1) death; 2) swarming; 3) brood rearing; 4) broodless state.

Weight nursing of the colony can be checked to identify: [8]. 1) occurrence of nectar flow during the foraging season; 2) consumption of food during non-foraging periods; 3) the occurrence of swarming events through a decrease in the hive weight; 4) estimation of the number of foragers. There are two ways of determining the weight of the colony: 1) automatic measurements, which can be made using industrial scales; 2) manual weight measurements.

Many procedures and approaches have been developed for sound analysis but they are not extensively applied in industrial beekeeping. So far, the solutions seem to work only in the hands of researchers. The aim for this may be the great stochastic component in the buzz of a colony and the complexity of sound analysis. As well means of a humble transducer secured to the outside wall of a hive, a set of statistically independent immediate vibration signals of honey bees can be identified and supervised in time using a fully automatic and non-invasive technique. [1]

Nursing physical variables linked with honeybee colonies, counting weight, temperature, humidity, respiratory gases, vibration, sound, and forager traffic, in a continuous way is becoming probable for most researchers as the cost and size of electronic sensors reduction while their precision and capacity growth. Researchers have taken different methods to accumulating and studying the resulting datasets, with a view toward mining information on colony behavior and phenology. The objective of this review is to inspect critically the different categories of data and data analyses, providing researchers with better-informed choices for obtaining information on colony phenology in the field without alarming the hive, and for joining information from different categories of sensors to obtain a more complete image of colony status.[10]

Beekeeping is old and old-style branch of agriculture where still many manual operations are done to attention bee colonies and perceive the apiary state and conditions. Information tools can be used in the beekeeping to partially care the beekeepers by application of automatic or semi-automatic resolutions for bee colony monitoring.

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Like to Precision Agriculture likewise Precision Beekeeping (Precision Apiculture) is recently defined as an apiary administration strategy based on the nursing of individual bee colonies to reduce resource consumption and maximize the efficiency of bees. International scientists and practical beekeepers started to care its expansion by application of several technical systems for programmed and real time bee apiary and colony monitoring.[16].

2.2. *Precision Apiculture in America.*

In America, only Argentina and Chile currently have the precision beekeeping project;

2.2.1 Precision Apiculture In Argentina. in the electronics laboratory of the Institute of Rural Engineering of INTA initiated the project of monitoring the production of hives, with the electronic development for the acquisition of data of weight of beehives. Apiculture products have apiaries dispersed in large geographic areas that Require periodic visits with the corresponding expenses incurentes.Por that was developed a low-cost balance for monitoring the weights of hives in real time, with data transmission by cell and alarms and consultations by SMS, and a historical evolution of weight journal of the hive .[7].

The development of a beehive monitoring system is being carried out at the Experimental Agricultural Station of INTA in Concepción del Uruguay. The project aims to provide solutions to problems that lead to a decrease in the bee population worldwide, such as Collapse syndrome of the hives; The melting of honeycombs due to high temperatures, in particular in the northern provinces of the Argentine Republic, and to obtain information that relates these variables with health aspects of the colony. On the other hand, it is intended to incorporate the collection of data and its registration, in the transport of honey from the origin to its final destination, facilitating the traceability, with the consequent added value to the bee products and thus ensuring their quality. Participating among other institutions are the Faculty of Bioengineering of the National University of Entre Ríos and the beekeeping cooperatives of Villa Elisa, Gualeguaychú and Paraná. The project has articulation with the National Apiculture Program (PROAPI) and those of regional scope of INTA in Entre Ríos.Precision Beekeeping is developed through Temperature and Humidity Monitoring by:

1.-Incorporation of technologies and techniques for monitoring and controlling the different variables involved in the beekeeping activity: 1.-Temperature 2.-Moisture 3.-Weight 4.-Amount of food 5.-Open hive 6.-Population 7 .-Sound

For the above by protection and location of sensors through the use of SOFTWARE through

1.-Applications for mobile devices 2.-Alarms via E-mail or SMS

Adventages and applications

1.-Research; (Early detection of diseases, Environmental effects on the hive, New hive designs)

2.-Economic- Productive (Traceability, Activity Log (software), Beekeeper monitors hives from home (Low / High temperature, Open Hive, Amount of food 3.-In-situ data visualization), Hive .[2].

2.2.2 *Use of precision beekeeping tools in Chile*

Applications have been developed that have improved the management of beehives, an example of this is "Bee Record", developed by the Beekeeping Technological Development Consortium. It consists of a voice recognition application for recording the information collected by the beekeeper at the time of monitoring their hives. It is a free cell phone that, through the recognition of the voice, serves to keep a record and generate reports that help to safeguard the traceability. An experience related to the use of GIS is the "Geographic System of National Apicultural Consultation" of the Agricultural and Livestock Service, created mainly to inform the beekeepers registered in the Ramex register on the distance to which they are located of the seedlings of biotechnological crops .[13].

2.2.3 Precision Apiculture in México

In Mexico there is only one work related to precision beekeeping. [4]. He proposed a system by means of digital signal processing for the improvement of the production of honey. First, the acquisition of data of the hive (signal in time, temperature and weight), then the augmention and refine of the signal . In time to switch to analogue digital conversion of the input signals and we end with the processing of all the data obtained from the hive to be able to store, analyze, transmit or only show the states of the hive. A block diagram is shown in Figure 1 below with the development of the proposed solution.

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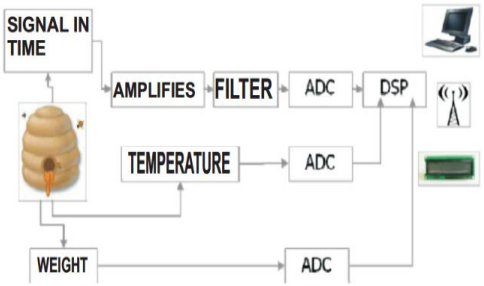

Fig. 1 Improvement of honey production through digital signal processing. Source [4].

III. Discussion

In Mexico the technology used in apiculture, is diverse and it is also a copy from that others countries, which has led to technical failures preventing to achieve a higher productivity .It is evident that research on precision apiculture in Mexico is reduced to one thesis work mainly and some graduate, but institutions with the capacity to do this kind of research to create technology have no interest in the apiculture sector, due to the fact that they have not realized the importance of the matter and minimizing the situation that before the large-scale growth that is taking this sector would need to import technology, and to act on it institutions would advance as double profit generated in the agricultural sector and the technology sector, but these institutions give little importance to the agricultural sector and focusing their efforts in the industrial sector, as does the government, due to the fact the application of the precision apiculture that generates Employment and foreign currency to the country in an important way, and the lack of vision that prevents them from facing the bee production sector could generate an equal or greater economic importance of the sector to which they focus.

The government should fomenter partnerships between educational institutions and companies to generate the required apiculture production technology, as human capital has high-level training in those schools of computation, electronic engineering, control and mechatronics, which can build applications to precision apiculture in the country, which became an important source of jobs for graduates of the afore mentioned professions.

IV. Conclusions

Mexico a major producer of apiculture product. Mexico has the human capital to generate own precision apiculture technology .The country can also become an exporter of precision beekeeping technology.

REFERENCES

[1] Bencsik, M.; Le Conte, Y.; Reyes, M.; Pioz, M.; Whittaker, D.; Crauser, D.; Simon D., N.; Newton, M. I. 2015. "Honeybee Colony Vibrational Measurements to Highlight the Brood Cycle". PLoS ONE 10 (11): e0141926. doi:10.1371/journal.

[2] Caluva E.2014. APICULTURA DE PRECISIÓN Monitoreo de Temperatura y Humedad . http://inta.gob.ar/sites/default/files/script-tmp-inta_-_apicultura_de_precision_ _hase_2014_caluva_ema.pdf

[3] Contreras E. F.; Pérez A.B.; Echazarreta, C. M.; Cavazos A.J.; Macías M., J. O.; Tapia G.J. M. 2013 Características y situación actual de la apicultura en las regiones Sur y Sureste de Jalisco, México Revista Mexicana de Ciencias Pecuarias, vol. 4, núm. 3, pp. 387-398 Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias Morelos, México

[4] Gonzalez C. O. 2010.Mejoramiento de la Produccion de Miel Mediante Procesamiento Digital de Señales .Tesis Instituto Politécnico Nacional.México.

[5] Kviesis A., Zacepins A. 2015.a. System Architectures for Real-time Bee Colony Temperature Monitoring. Procedia Computer Science 43 (2015) 86 – 94

[6] Kviesis A., Zacepins A., Stalidzans E. 2015b. Future Development Perspectives of the Precision Apiculture (Precision Beekeeping). 25th Congress Nordic View to Sustainable Rural Development. June 16-18, 2015

[7] Moltoni.A.F.2014.1ª Jornada Nacional de AGROELECTRONICA Monitoreo de Produccion de Colmenas. http://inta.gob.ar/sites/default/files/script-tmp-inta-telemetria_de_colmenas_-_hase_2014_moltoni_andre.pdf http://www.sagarpa.gob.mx/Delegaciones/distritofederal/boletines/Paginas/JAC0040-21.aspx

[8] Meikle ,W. G.; Rector, B. G.; Mercadier, Guy; Holst, N. 2008. "Within-day variation in continuous hive weight data as a measure of honey bee colony activity". Apidologie 39 (6): 694–707. doi:10.1051/apido:2008055. ISSN 0044-8435.

[9] Meikle 2014 , W. G.; Holst, N. "Application of continuous monitoring of honeybee colonies". Apidologie 46 (1): 10–22. doi:10.1007/s13592-014-0298-x. ISSN 0044-8435.

[10] Meikle W. G., Holst N. 2015. Application of continuous monitoring of honey bee colonies. Apidologie 46:10–22. DOI: 10.1007/s13592-014-0298-x

[11] Pineda C .2016.México es el sexto productor de miel de abeja y el tercer exportador mundial http://agromarketing.mx/agricultura/cultivos/me

[12] Sagarpa 2016. Alcanza México Récord de Exportación de Miel en 2015: Ventas de 45 MIL Toneladas con valor de 150 MDD

[13] Valdés P. 2014.Apicultura de Precisión Agrimundo .Inteligencia competitiva para el sector Agroalimentario.Reporte No.2 http://www.agrimundo.cl/wp-content/uploads/140604_reporte_apicultura_n2.pdf

[14] Zacepins A.,Karasha T.2013.Aplication of Temperature measurements for Bee colony monitoring :a review.Enginering for Rural Development .Jelgava.

[15] Zacepins, A.; Brusbardis, V.; Meitalovs, J.; Stalidzans, E. 2014. "Challenges in the development of Precision Beekeeping". Biosystems Engineering 130: 60–71. doi:10.1016/j.biosystemseng.2014.12.001.

[16] Zacepins A, Brusbardis V.2015. Precision Beekeeping (Precision Apiculture): Research Needs and Status in Latvia. Agriculture & Forestry, Vol. 61 Issue 1: 135-141, 2015, Podgorica. DOI: 10.17707/AgricultForest.61.1.17