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RURAL SUSTAINABILITY RESEARCH 45 (340), 2021
ISSN – 2256-0939

http://www.llu.lv/en/

Received: 12 April 2021 Revised: 21 May 2021 Accepted: 29 June 2021

Status of the Precision Beekeeping Development in Latvia

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Abstract. Information and communication technologies are part of almost any branch of human lives. During the last decade also beekeeping joined the direction of application of IT tools and solutions and precision beekeeping was defined. Still in the beekeeping many operations and observations are completed manually, and there is a potential to switch to the digital realisation. Information technologies can be used in the beekeeping to partly support the beekeepers by implementation of automatic or semi-automatic solutions for bee colony remote monitoring, apiary record making and other actions. The aim of this paper is to make a summary of the usage of information technology tools by the beekeepers in Latvia, summarizing precision beekeeping development status and conclude about its future development potential. To achieve this aim, in cooperation with Latvian Beekeepers Association, a beekeepers survey was conducted. More than 200 beekeepers shared thoughts and opinions about their application of information and communication technologies for monitoring the bee colonies and apiary management. The summary of the survey conducted is described in this study.
Keywords: Precision Beekeeping, Precision Apiculture, Apiary management, Colony monitoring, Beekeeping in Latvia.

Introduction

Beekeeping is a very old and classical branch of agriculture in Latvia with long lasting traditions. The only honey bee specie used in Latvian beekeeping is *Apis mellifera*. In Latvia, there is no traditional beekeeping region, the branch is well developed throughout the country (Mihailova & Melecis, 2019). Latgale region (eastern part) of Latvia also has professional apiaries with modern, well-maintained apiary premises and a relatively large volume of production (Mihailova & Melecis, 2019). Majority of the beehives in Latvia are made of wood and their popularity is still high, at the same time hives from foam and other modern materials are becoming more common for young beekeepers. Modern beehives have less weight, but are less resistant to attacks of wild animals and birds, which keeps wooden hives still on a high demand in beekeeping, especially if the apiary is stationary. Mainly in Latvia a Dadan-Blat frames for a brood box and half a Dadant-Blat frames for honey supers are common. Langstroth frame system is not so common. Some beekeepers practiced their beekeeping in Norway and in late 90's Norwegian hives and frame systems evolved also in Latvia, but haven't got a big popularity. The most popular is still the wooden beehive, quite a solid one with 13-14 Dadant-Blat frames in the brood box and those hives are more adapted to the Latvian climate conditions and enable less food consumption during the winter and a lot of space for resource harvesting with strong bee colonies in the summer during the active foraging period.

Active resource foraging period is usually from early April to late August, but a significant period of time is dedicated to the passive period, when bee colonies are not foraging. During the passive period (winter period) some significant colony losses can occur. Mortality rate reported for Latvia during winter

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DOI:10.2478/plua-2021-0010

season 2018/19 was 14.1% (Gray *et al.*, 2020). To minimise winter losses and establish optimal wintering conditions for the bee colonies, it is possible to use specific wintering buildings (Zacepins, Meitalovs, & Stalidzans, 2010) with controlled microclimate.

Honey bees in general are the main insect pollinators and their role is irreplaceable in providing the agricultural crop pollination service (Breeze *et al.*, 2011), as around 85% of flowers are pollinated by bees (Warnke, 2009). Honey bees (*Apis mellifera*) are the most economically important managed insects, as well (Moritz & Southwick, 2012; Aizen & Harder, 2009). In many countries, development of agricultural branches is dependent on the success of pollination (Pettis & Delaplane, 2010). Beekeeping not only positively contributes to families income gain, but also plays a role in increased food security (Gratzer *et al.*, 2019).

Nowadays it is hard to imagine our lives without application of information and communication technologies (ICT). ICT is a part of mo-dern agriculture hence technologies are also coming to the beekeeping sector. Precision beekeeping (PB) or precision apiculture is defined as an apiary management strategy based on the remote monitoring of individual bee colonies to minimize resource consumption and maximize the productivity of bees (Zacepins *et al.*, 2015; Zacepins, Meitalovs, & Stalidzans, 2012). The aim of the precision beekeeping is to implement ICT tools and solutions for bee colony remote monitoring and for effective management of the apiary. In relation to the remote monitoring of the colonies there are plenty of solutions available. Mainly weight and temperature are monitored by commercial or hand-made solutions (Zacepins & Karasha, 2013; Meikle & Holst, 2015; Meikle *et al.*, 2017). Technologies can help beekeepers to improve the understanding of the colony behavior without looking inside the hive. Remote monitoring of bee colonies minimizes the number of needed visual inspections; therefore, it helps to reduce the stress of the bee colonies (Stalidzans *et al.*, 2017). The use of precision apiculture allows beekeepers to monitor the beehives for many possible reasons, such as research, information about the daily management of bees by beekeepers, and learning how to reduce the resources and time assigned to tasks without reducing production (Gil-Lebrero *et al.*, 2017).

In this study we aim to provide an overview of beekeeping and its practices in Latvia and to investigate and summarize the status of application of ICT within beekeeping in Latvia and conclude about the needs and future development of the precision beekeeping techniques and methods.

Material and Methods

An online survey was used as a means of gathering information from Latvian beekeepers about the precision beekeeping solutions in their daily beekeeping activities. Such a survey was conducted by the Latvian Beekeepers Association (LBA).

In total, 234 beekeepers participated in the survey and spread their opinion about available precision beekeeping technologies and their experience and needs for the technological solution to improve their bee colony management. The survey was conducted digitally using Google Forms during one month period from mid of February till mid of March 2021. Beekeepers were informed by email about the possi-bility to participate in the survey. Respondents were from different geographical locations, with different beekeeping experience. The survey was divided into several groups of questions. The first group was dedicated to the overall data about the respondent (the number of colonies in the apiary, experience in beekeeping, realisation of honey products). The

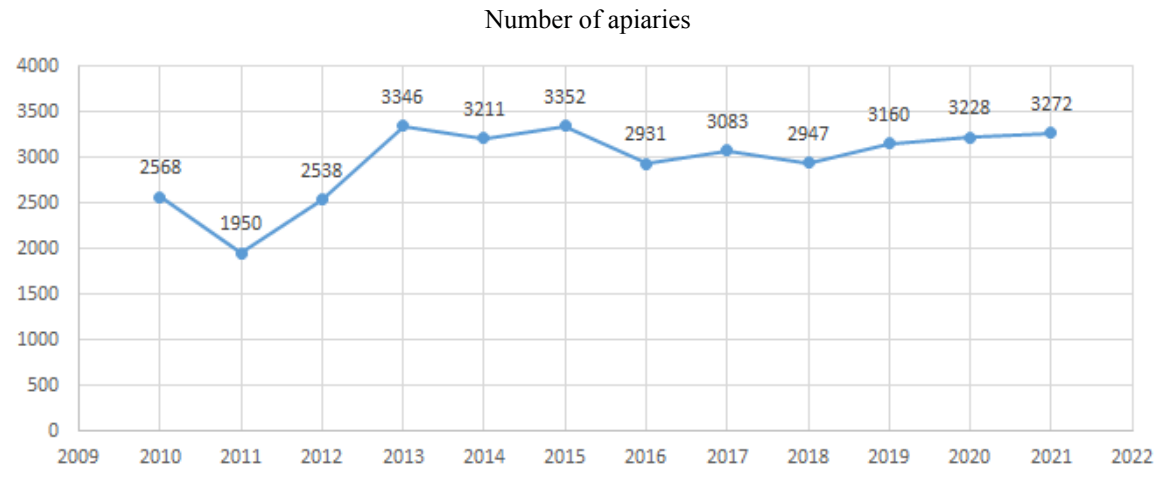

Figure 1. Number of registered apiaries in Latvia.

second group was dedicated to the importance of digital technologies used in practical beekeeping. The third group was about using ICT tools for colony monitoring and management.

General Characteristics and Structure of the Beekeeping in Latvia

Based on the information provided by the Latvian Agricultural data centre (http://pub.ldc.gov.lv/pub_stat.php) in Latvia, there are 3272 apiaries registered to the first of January of 2021, and the total number of registered bee colonies is 104 279.

Figure 1 shows the number of beekeepers (apiaries) that are registered in the Agricultural data centre public database and Figure 2 demonstrates the number of registered bee colonies in the period from the year 2010 to the year 2021. An observed tendency is that the number of colonies is growing every year. But this growing number can also be explained by the fact that more and more beekeepers are registering in the database as only registered users can have some support from the EU and Latvia funding programs. Previously some beekeepers just were not registered in the system.

The main organisation which supports beekeepers is Latvian Beekeepers Association (LBA). In total, 3 200 beekeepers are members of this organisation.

Figure 3 shows the distribution of the number of apiaries in Latvia. Data shows that the highest number of beekeepers (85%) have only from 1 to 50 bee colonies. This means that beekeeping in Latvia is organised very extensively and honeybee colonies are kept mainly as a hobby and to generate additional family income.

Figure 4 shows age distribution of Latvian beekeepers. As it can be seen from the chart, there are beekeepers in all age categories starting from 19 years. According to the available data, most of the beekeepers (52%) were in the 40-59 years age group.

Results and Discussion

Status of precision beekeeping in Latvia (analysis of the beekeepers survey)

A survey was conducted to get the information about the precision beekeeping status in Latvia. Within the survey, beekeepers were asked to rank (by the importance factor) provided potential areas where

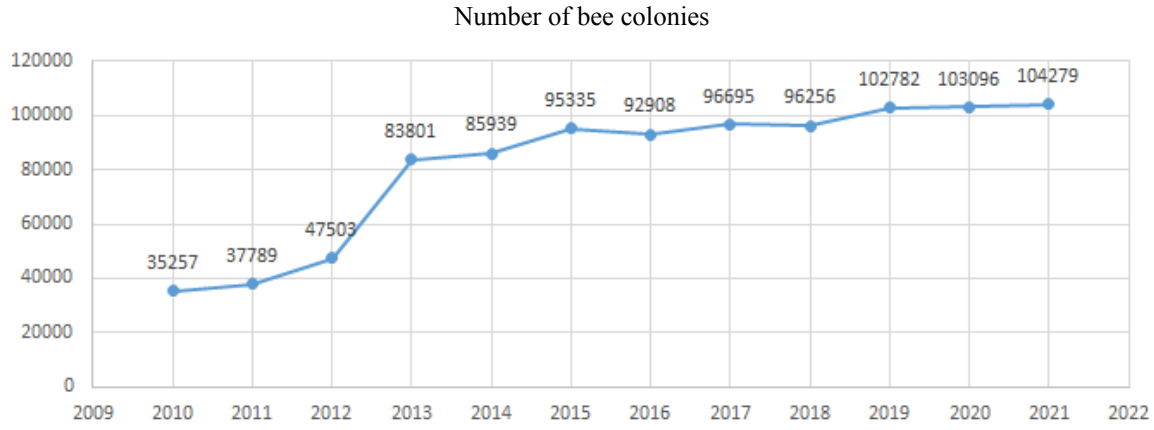

Figure 2. Number of registered bee colonies in Latvia.

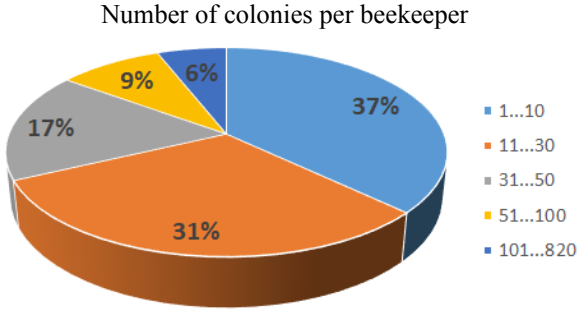

Figure 3. Number of bee colonies per one beekeeper (year 2020).

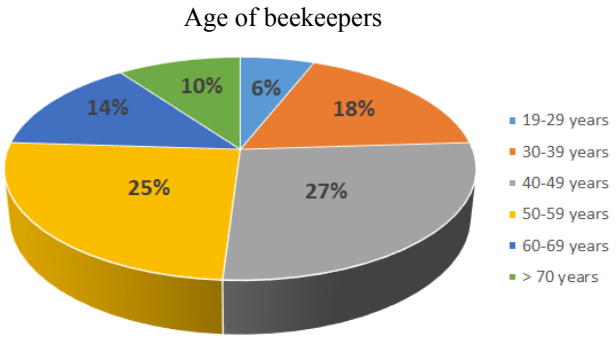

Figure 4. Age distribution of Latvian beekeepers (year 2020).

application of ICT can give additional value for them. Five main areas were discussed:

1. Preserving the strength and number of bee colonies (swarms, illnesses, lack of food supplies, effect of plant protection products).
   a. The simplest way to achieve this is to make constant apiary notes. In addition, digital bee colony measurements can help to identify colony events on time and prevent unwanted activities.
2. Maximisation of the bee colony foraging potential.
   a. For bee colony foraging activity, the best solution is to use scales for constant weight monitoring. Bee weight monitoring can help to identify the start of the intensive nectar flow and signal the beekeeper when additional supers should be placed to the hive.
3. Optimisation of apiary visits.
   a. This can be achieved by the constant bee colony digital monitoring on one hand, as beekeepers remotely will be able to see which colony needs inspection on-site. On the other hand, to equip all colonies with sensors can be complicated and costly. Digital notes can help to plan and manage required actions at the apiary and adapt them to the climate conditions, apiary location and bee colony state.
4. Minimisation of beehive thefts and attacks by wild animals.
   a. There are at least three options that can be mentioned under this section. The most popular solution is usage of video cameras to protect the apiary from theft. Another solution is to apply GPS sensors to track the hive in case of theft. One more solution is to use other sensors (e.g., vibration) to identify abnormal situations in the hive.
5. Honey product accounting and its traceability.
   a. Traceability is more important for the end customer to be sure about honey quality and place of the origin. Digital solutions for the product encoding (e.g., using the QR codes) can be applied here.

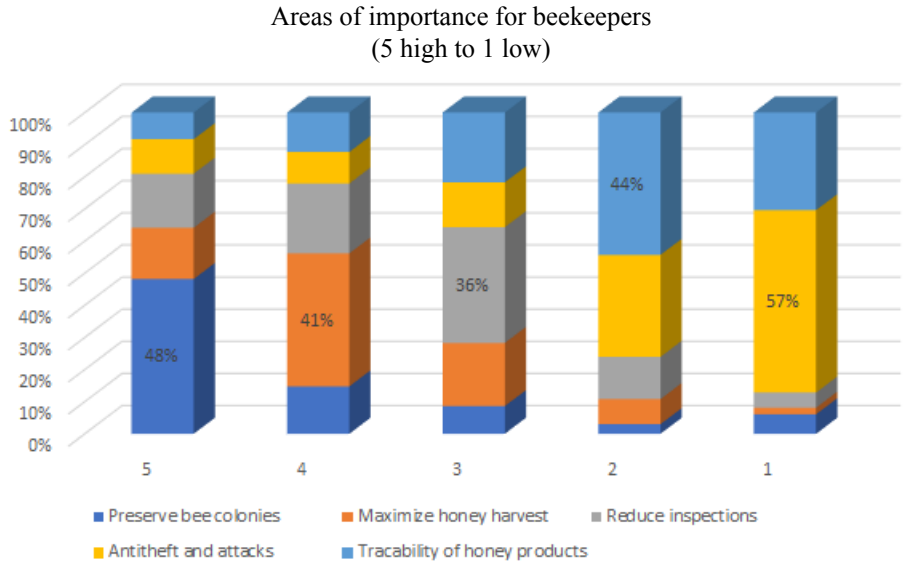

Figure 5. Areas of importance in use of digital tools for beekeepers.

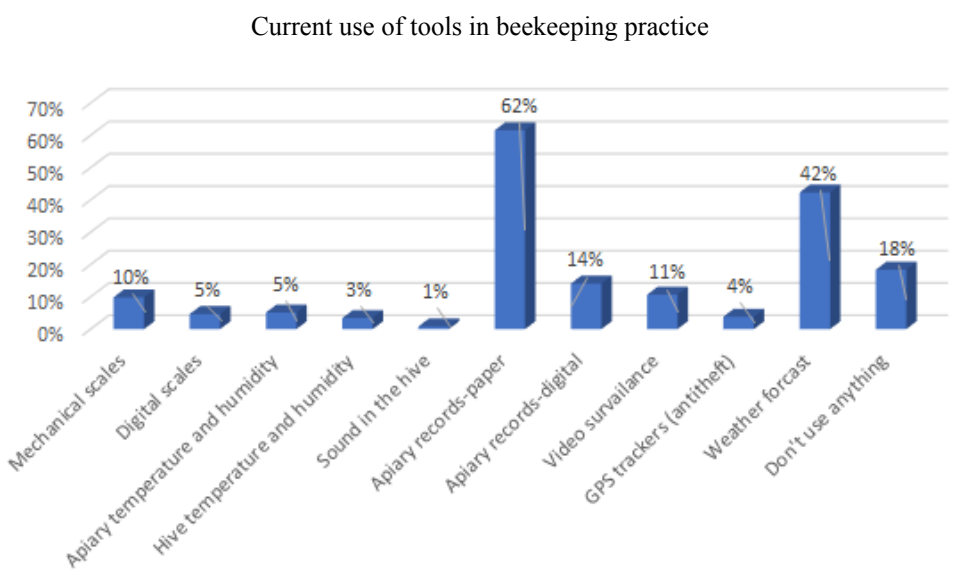

Figure 6. Current use of tools in beekeeping practice.

The distribution of importance for beekeepers in all five areas with ranking 1 (low) - 5 (high) is shown in Figure 5 below:

Based on the survey, the most important (5) area for the beekeepers (represented by 48%) is the first factor "Preserving bee colonies and ensuring the well being of bees". This area is most important in all groups of beekeepers. The second most important (4) area is "Honey harvest" (represented by 41%) and medium importance (3) has a "Reduction of inspections" (represented by 36%), which also dominates in all groups of beekeepers. "Reduction of inspections" has a significant share also in priority 5 and priority 4. Two less important areas for beekeepers in terms of use of digital tools are "Traceability of honey products" (represented by 44%) and last in priorities is "Antitheft and avoiding animal attacks" (represented by 57%). Those last two factors are not so equally distributed among all beekeepers groups and are preferred a bit more by professional beekeepers, which shows presence of those factors on a bigger scale compared to other areas also in medium and high priority areas.

Analysis about used tools in the beekeeping practice are summarised in Figure 6.

Only 18% of all beekeepers within a survey answered that they don't use any kind of tools and ¾ of them are representing beekeepers in a group with up to 30 beehives.

Results show that the use of apiary records in digital or in paper form is the highest and is used by 76% of beekeepers. From the digital support tools a weather forecast is most popular (42%), as based on it, different actions at the apiary can be planned and scheduled (like varroa treatment, bee colony extension, honey harvesting, etc.). Hive scales is the most common device placed in the apiary, combining mechanical and digital scales, it makes up 15% in total. From devices in the apiary a video surveillance is the second most popular (11%). The rest of the sensors are less common, but also present in the apiaries of beekeepers in Latvia.

In 2015, status of the precision beekeeping was already evaluated in Latvia (Zacepins & Brusbardis, 2015). At that time it was not very common in Latvia and only 14% of the respondents (59 beekeepers) used some ICT tools in their beekeeping practice.

After this survey it can be concluded that today beekeepers are more educated and technologically advanced and are starting to more actively use and apply the ICT solutions and tools. There is still a huge potential for this to grow in Latvia and, for example, shift the traditional method of apiary record making to the digital environment.

Solutions for precision beekeeping developed in Latvia

To help the beekeepers and ease the implementation process of the precision beekeeping solutions, local startups and entrepreneurs started to develop products and tools for the remote bee colony monitoring and apiary record management. In addition, several scientific projects were implemented to further investigate the applicability of the remote monitoring systems for the bee colony management. Some of the available solutions in the Latvian market are addressed below.

During 2020, Beesage (https://beesage.co/) developed smart beehive scales for hive monitoring

during peak blooming periods. In addition to weight, temperature and humidity in the apiary is measured, too. Data is captured once per hour and displayed in a web application.

Scientists from Latvia University of Life Sciences and Technologies developed a bee colony monitoring system for weight and temperature dynamic observation. It is possible to define measurement intervals and receive data in the cloud platform using the Wi-Fi or mobile network. Cloud platform provides the interface for data observation and visualisation (Kviesis *et al.*, 2020; Zacepins *et al.*, 2020).

For the apiary management in 2018 a BeeKing (https://beeking.eu/en/) mobile app and portal was developed by the SIA BeeTech Services. From commercial launch in spring of 2019 up to the end of March of 2021 this app is used by more than 400 beekeepers in Latvia and almost 500 beekeepers abroad. BeeKing can be considered as a digital beekeeping assistant which enables planning and tracking of bee colonies based on their life-cycle and status of queen bee. It helps to set-up tasks and track them on a colony or apiary level taking full record of apiaries and hives as it is required for Organic BeeKeeping in the EU and enables to collect data in a format necessary for COLOSS (Colony losses survey). One more important feature of this application is that the beekeeper can make records also using his voice and hive tags (NFC tags). BeeKing is made for small (up to 10 hives) and medium size beekeepers (up to 100 hives) and for professional beekeepers harvesting with up to 500 hives, which represents in the volume of beekeepers a majority of segments in Baltics, Nordic region and Europe.

In relation to the scientific research of precision beekeeping in Latvia, several international scientific projects were implemented, like ITAPIC (Zacepins *et al.*, 2016), SAMS (Wakjira *et al.*, 2021). In addition to this, local projects were completed with the objective to further adapt the technologies for the local beekeepers, for example, project Autonomous Beekeeping (Zabasta *et al.*, 2019).

Practical advice for the beekeepers choosing the digital solution

When choosing the bee colony remote monitoring system, it is worth knowing about the data transmission method and potential additional costs for the data transmission (e.g., payment for mobile network and SIM card). Also, the size of the system is important in order to conclude about the possible system placement (inside or outside the hive). System battery life is crucial for the beekeeper, since frequent battery replacement can lead to additional workload and frustration. In the best scenario, the battery life should be equal to the beekeeping season. Beekeepers should pay attention to the user interface of the data visualisation. It should be simple and easy to use. Notifications about important bee colony states and its changes would be a useful feature as well.

Future development perspectives of precision beekeeping in Latvia

Important direction for the further development of the precision beekeeping solutions in Latvia is to combine both remote monitoring of the colonies with the apiary journal (apiary records) as the description of the beekeepers actions at the apiary and manipulation with colonies are required for the correct monitoring data explanation and analysis.

It is also important for the Latvian beekeepers to prevent remotely located hives from theft and attacks by wild animals, that is why video monitoring of the apiary and hive GPS systems are important.

One more direction of PB development can be sharing information about apiaries between various beekeepers and developing a beekeeping map with the main aim to prevent the spread of possible illnesses.

Conclusions

Information and communication technologies are already part of our lives, and they are introduced to almost any branch including the beekeeping sector. Application of ICT in beekeeping facilitates the development of precision beekeeping. Precision beekeeping in Latvia also started to be part of the beekeeping practice and more beekeepers are starting to test and use different technologies and tools.

Based on the survey conducted within this research only 18% of the respondents are not using any ICT solution in their beekeeping practice. It should be mentioned that the beekeepers that do not use any ICT solutions and tools did not participate in the survey as it was completely electronical. Thus, the real number of beekeepers in Latvia, that are using only manual solutions, can be higher than observed during the survey.

In Latvia, there are not many enterprises which provide ICT tools for the beekeepers, so there is a potential field for new start-ups and entrepreneurs.

To speed-up the adoption of precision beekeeping more education activities and informative seminars for the beekeepers are needed to explain the potential benefits the technologies can provide.

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Acknowledgement

Scientific research and publication is done within the project S396 (Evaluation and identification of the most effective control methods for pests of legumes and identification of main factors influencing the viability of agriculture important pollinators).

Extended thanks to the Latvian Beekeepers Association for conducting the beekeepers survey and dissemination of information within Latvian beekeepers. Also, thanks to Latvian beekeepers for participating in the survey and sharing their thoughts and ideas about the precision beekeeping solutions and its possible applicability.