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Article

# The Economic Value of the Ecosystem Services of Beekeeping in the Czech Republic

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**Abstract:** Beekeeping is an important part of the bioeconomy. Throughout its existence, it has been one of the fields of human endeavour that contributes to sustainability. It has significant benefits for society, both economically and environmentally. Most (90%) of honeybees' benefit to humankind lies in their pollination capacity, and only 10% lies in bee products (honey, propolis, wax, etc.). The research presented was carried out in the conditions of the Czech Republic in the first half of 2020 through a questionnaire survey within a Google Form, which was aimed at beekeepers. The aim of this paper is, based on a questionnaire survey, to evaluate ecosystem services of beekeeping from the perspective of beekeepers, including the valuation of selected types of ecosystem services. The results show that in the Czech Republic, the most common reason for beekeeping is as a hobby (34.18%). As expected, the demand for pollination is very low compared to other countries (11.6%). From the point of view of the benefits of ecosystem services, the questionnaire survey showed that the most important benefit is the pollination of cultivated and other plants (54.7%) and honeybee products (24.8%). The value of all selected ecosystem services totals 3,646,368 CZK. The results show that state support is needed, which should address the negative demographic development of beekeepers and thus ensure the production of ecosystem services.

**Keywords:** apiculture; apiary products; bioeconomy strategy; ecosystem services; honeybees; pollination

## 1. Introduction

Beekeeping is an important human activity [1] and an integral part of the bioeconomy. A number of ecosystem services, often vital to humans, can be identified in beekeeping, as evidenced by a number of studies [2–6]. According to the [7] classification, these are mainly honey and other beekeeping products, pollination, recreation, which is known as api-tourism [8,9], cultural and educational services, and aesthetic value. It is clear that ecosystem services significantly affect well-being and have an irreplaceable benefit for human life [4]. At the same time, they are important for ensuring sustainability. Primarily, pollination affects the quality and quantity of agricultural production [10,11]. Beekeeping products are used in food and pharmacy and have economic benefits for beekeepers [12]. An increased density and diversity of pollinators has a direct impact on crop productivity and can help smallholder farmers increase their productivity by a global average of 24%. It has positive social impacts [13] and a significant impact on biodiversity [14–16].

The rate of the positive externalities of honeybees and other pollinators are often discussed regarding beekeeping. Despite some worldwide decline in the number of pollinators, the number of hives managed is increasing, which has a positive effect on crop production and food safety. [2,17,18]. However, there are potential downsides of managed pollination that ecologists are aware of, such as increased transmission of disease to wild pollinators [19]. Beekeeping is associated with higher willingness to support native pollinators [20]. Presently, research is being carried out on the resistance of bees to disease, fertilizers, and other adverse influences reducing bee populations, including economic impacts [16,21,22]. In 2016, the International Platform for Biodiversity and Ecosystem Services (IPBES) and the International Union for Conservation of Nature (IUCN) warned, in a global integrated assessment of systemic insecticides, about the decline of pollinators. At the same time, some governments are supporting beekeeping financially to increase agricultural production. In some countries, honeybee pollination is provided in a market environment and studies focus on efficiency related to the number of hives [23].

The relationship between the demand and supply of ecosystem services in beekeeping is therefore problematic, as some pass through the market and some do not. In the event that honeybee colonies are endangered by disease, chemicals, etc. [22], the supply of ecosystem services will decline. This paper deals only with pollinator honeybees, not with other pollinators.

The aim of the paper is to evaluate ecosystem services of beekeeping from the perspective of beekeepers, including the valuation of selected types of ecosystem services. The article consists of six parts: the Introduction is followed by Theoretical Background, Material and Methods, Results, Discussion, and Conclusion.

## 2. Theoretical Background

Beekeeping in the Czech Republic is facing a very serious demographic and ageing problem; with only a small percentage of beekeepers under the age of 50, the future of the sector is threatened. After the decline in the number of Czech beekeepers in the 1990s, caused by post-revolutionary economic changes, the popularity of beekeeping in the Czech Republic continues to grow [24] and beekeeping is becoming increasingly popular (cf. e.g., [25]). As the number of beginners grows, so do the risks associated with lack of experience. The EU has set up support programs for beekeepers, taking into account the challenges facing European beekeepers. Stress factors [26,27] include increased bee mortality, Varroa destructor [28,29], the small hive beetle (Aethina tumida) [30], the Asian hornet (Vespa velutina) [31], and fetal bee plague [32]; as well as animal diseases such as nosemosis [33], the impact of some active substances used in plant protection and other biocidal substances [34], climate change, environmental degradation, degeneration of natural habitats, and the gradual disappearance of flowering plants or insufficient nutritional resources [35].

Beekeepers are often helpless in the fight against bee diseases and parasites because they lack information and training or an effective means of control, such as access to medicines for bees. The obligation for beekeepers to report diseases and parasites leads to the systematic destruction of hives and may lead beekeepers to not report these problems. Medicinal products available on the market for the treatment of bee diseases have only limited efficacy and do not meet the increased need for effective veterinary medicine. The increase in bee mortality has led beekeepers to buy new hives more regularly, which leads to increased production costs, and bee replacement often leads to a short- or medium-term reduction in production because new hives are less productive than established ones. Research therefore focuses on reducing morbidity and increasing efficiency in beekeeping.

Honeybee products are popular in the Czech Republic, especially honey, the average consumption of which is 1.0 kg per person per year [36]. With a production of around 280,000 tonnes/year, the EU is the world's second largest producer of honey, and it is still unable to satisfy its own honey consumption [37]. There is a permanent shortage of honey in the EU; production has barely reached 60% of the demand for a long time [38], and there is no indication that this will change significantly in the coming years. The EU is a major global importer of honey [39].

Not all countries have a system in place for registering beekeepers and hives to monitor development in the sector, including bee health. Since 1990, the Czech Association of Beekeepers (CAB) has been coordinating the activities of basic organizations at the level of individual municipalities or groups of municipalities through district committees [40]. The CAB is the sole administrator of European beekeeping subsidies for technical assistance. It forwards the requirements of beekeepers to

SAIF (Silesian Agricultural Advisory Centre). European subsidies for technical assistance are now divided into two classes, those for beekeepers with up to 150 hives and those for beekeepers with over 150 hives, their purpose being to improve production conditions and ensure the sale of honeybee products [41]. National beekeeping programs co-financed by the EU give participants the opportunity to carry out research and development projects.

In the Czech Republic, the honeybee is classified as a farm animal, and consequently, generally binding legal regulations apply to beekeeping. Beekeeping as a field falls within the competence of the Ministry of Agriculture of the Czech Republic. That there is no demand for pollination in the Czech Republic is unusual. "Nomadic" beekeeping [6,29,42] has many positive but also problematic aspects, especially in terms of compliance with rules to prevent the spread of problems.

## 3. Materials and Methods

The Czech Association of Beekeepers has more than 54,000 members, which represents 98% of all beekeepers in the Czech Republic. The Czech Republic is therefore one of the countries with the highest degree of organization of beekeepers in the world. Registered Czech beekeepers keep 573,676 beehives [43].

The primary data was gathered by conducting quantitative research, using an online questionnaire technique for gathering data. The research was carried out in the conditions of the Czech Republic in the first half of 2020 through a questionnaire survey within a Google Form, which was aimed at honeybee beekeepers. A link to the questionnaire was also given in the journal Včelařství.

To ensure the high quality of the questionnaire survey, a preliminary survey was conducted with a sample of 5 respondents. Careful pre-research reduced the risk of failure of the questionnaire survey. Based on the results, the proposed questionnaire was corrected (item formulation adjusted).

Nine closed questions and 1 open question were asked, which addressed the following areas:

- the number of hives per beekeeper;
- why honeybees are bred; from this derives a personal relationship to beekeeping, with the fact that it is known that in the Czech Republic it is very often a hobby;
- the demand for pollination and the beekeeper's idea of how to be recompensed for pollination, even though this is not a normal service; and
- scoring of four ecosystem services—production, pollination of cultivated plants, pollination of other plants, and cultural (aesthetic and educational); a scale from 1 (least important) to 10 (most important) points was set for evaluation.

The requirement of representativeness was fulfilled by means of probabilistic selection (simple random selection) of the research set; the basic set was representative of all members of the Czech Association of Beekeepers. The minimum required sample size was determined, and the number of respondents was in accordance with Krejcie and Morgan's formula [44]:

$$S = \frac{z^2 \cdot N \cdot r \cdot (1-r)}{(d^2 \cdot (N-1)) + (z^2 \cdot r \cdot (1-r))}, \tag{1}$$

where:

$s$ = required sample size;
$N$ = size of the basic group (= 54,000 members of the Czech Association of Beekeepers);
$z$ = required degree of certainty, reliability (= coefficient 1.96, degree of certainty 95%);
$d$ = permissible error rate, error rate (= 3%, i.e., 0.03); and
$r$ = expected rate of deviation/expected level of the sample (= 4%, i.e., 0.04).

According to this formula, the minimum number of respondents was 163, which was met in this case with the total number of respondents being 169. The questionnaire respected ethical aspects and the anonymity of the respondents.

The questionnaire survey was promoted through the Czech Association of Beekeepers and advertisements in Včelař magazine.

Selected categorical variables were incorporated into the table of absolute ($n_i$) and relative ($p_i$) frequencies, and appropriate pie charts were compiled to ensure visual clarity of the data.

For a more detailed assessment of the data obtained, the Kruskal–Wallis test was used to verify the dependence of the number of hives on the reason for beekeeping. This is a test of the concordance of the medians of the individual selections. The hypotheses were as follows:

**Hypothesis 0 ($H_0$):** *The number of hives and reason for breeding are independent variables.*

**Hypothesis 1 ($H_1$):** *Not $H_0$.*

In the case of the relationship to the demand for pollination, it is the relationship between the numerical quantity "Number of hives" and the nominal variable "Demand of pollination" (values Yes/No). One-way analysis of variance (ANOVA) was used to verify independence. Firstly, it was necessary to verify the assumption of this method, namely, the agreement of the variance of the number of hives in the examined samples using the Bartlett test. The resulting p-value was 0.38, so we did not reject the variance match. We continued with our own analysis of variance with the following hypotheses:

**Hypothesis 0 ($H_0$):** *The number of hives and demand for pollination are independent variables.*

**Hypothesis 1 ($H_1$):** *Not $H_0$.*

To examine the relationship between the number of hives reported by beekeepers and the importance of individual breeding benefits, we used methods of correlation analysis. For each pair, the number of hives given the benefit of breeding, we calculated the selection correlation coefficient and tested whether it was equal to zero. Therefore, the hypotheses were:

**Hypothesis 0 ($H_0$):** *The number of hives and the given breeding benefit are independent quantities.*

**Hypothesis 1 ($H_1$):** *Not $H_0$.*

For all tests, the significance level was 5%. If we rejected the null hypothesis, it means that these were not independent quantities.

It was further assessed whether the significance of the chosen benefit of beekeeping (selected ecosystem services) for beekeepers does not depend on whether the reason for breeding is relevant to him. Significance was a numerical variable (values 1–10) and the reason for breeding was a factor (1 means that a specific reason occurred for a given beekeeper, 0 means that it did not occur). To verify the hypothesis of the independence of evaluation and the presence of a given reason for breeding, we again used analysis of variance. Given that there were six reasons for breeding and four benefits, a total of 24 combinations of the values of these variables were tested.

The choice of ecosystem services was based on the relevant publications [45–48] and conditions in the Czech Republic. The following four ecosystem services were valued: production, pollination of cultivated plants, pollination of other plants and cultural. Nonmonetary valuation was chosen [49–51]. The aim was to achieve comparable valuations between different ecosystem services. It was therefore based on the method of expert scoring.

An important step was also that the evaluation not be addressed to the public, but to beekeepers who are sensitive to the environment and can relatively objectively assess the importance of selected ecosystem services. In this sense, it was an expert assessment [52] defined by a group of respondents—beekeepers.

Following the point estimate of ecosystem services, an evaluation of selected ecosystem services was performed. In the next step, the value of one point was determined because the valuation of production ecosystem services was based on the market price of honeybee products, which corresponds to production for the entire Czech Republic. According to the results of the scoring, other ecosystem services were valued based on the price of honeybee products. The valuation of ecosystem services was based on Equation (2):

$$V_{ES} = V_{PS} + \frac{V_{PS}.PE_{CP}}{PE_{PS}} + \frac{V_{PS}.PE_{OCP}}{PE_{PS}} + \frac{V_{PS}.PE_{CS}}{PE_{PS}}, \tag{2}$$

where:

$V_{ES}$ = total value of ecosystem services,
$V_{PS}$ = value of provisioning services,
$PE_{PS}$ = point estimate of provisioning services,
$PE_{CP}$ = point estimate of crop pollination,
$PE_{OCP}$ = point estimate of other plant pollination, and
$PE_{CS}$ = point estimate of cultural services.

The production of the bioeconomy can then be valued as the sum of the values of all ecosystem services. This was based on the average export price of honey, which reached 89.24 CZK/kg and the total production of honey in the Czech Republic in 2018, which was 9000 tonnes [24].

## 4. Results

The initial information is the number of hives per beekeeper. The questionnaire survey shows that the average number of hives per beekeeper is 25 (median is 13). Regarding the reason for beekeeping, the six most common reasons are shown in Figure 1.

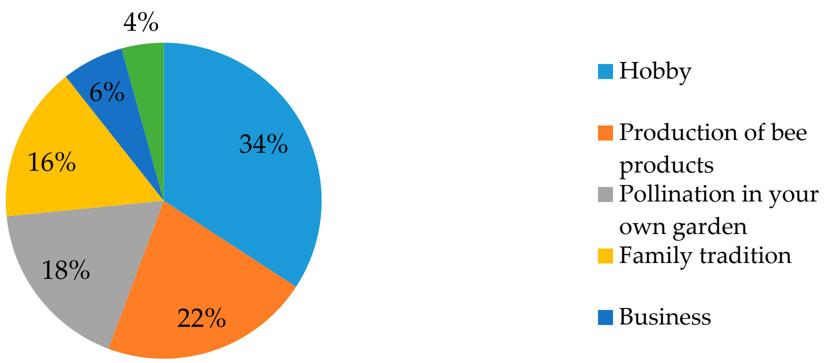


**Figure 1.** Reason for beekeeping in % in the Czech Republic.

With the descriptive data presented in this way, we have an approximate idea of the data distribution that this study envisages (see Table 1).

The descriptive statistics above show that the average number of hives is almost 25 and the median is 13, but the data are relatively variable (the standard deviation after rounding is 31). Regarding the assessment of the benefits of beekeeping in the Czech Republic (corresponding to selected ecosystem services) according to importance, the respondents answered on a scale of 1–10. According to the respondents, pollination of other plants had the highest average benefit (8.65), followed by pollination of cultivated plants and then honeybee products. Cultural significance scored the least (6.51).

According to the results of the questionnaire survey, the demand for pollination is very low, at 11.6%.

**Table 1.** Characteristics of the level and variability of the questionnaire survey (number of hives and benefits of breeding).

| | Number of Hives | Products | Pollination of Cultivated Plants | Pollination of Other Plants | Cultural Significance |
|---|---|---|---|---|---|
| Range of selection | 169 | 169 | 169 | 169 | 169 |
| Average | 24.71 | 7.77 | 8.62 | 8.65 | 6.51 |
| Median | 13 | 8 | 10 | 10 | 7 |
| Dispersion | 950.22 | 4.25 | 4.27 | 4.69 | 6.19 |
| Standard deviation | 30.83 | 2.06 | 2.07 | 2.17 | 2.48 |
| Minimum | 0 | 1 | 1 | 1 | 1 |
| Maximum | 150 | 10 | 10 | 10 | 10 |

### 4.1. Comparison of the Number of Hives and Reasons for Breeding

We examined whether the number of hives that the beekeeper has and the demand for pollination are independent quantities. If all selections except commercial are included in the comparison, we do not reject the null hypothesis (test statistic is equal to 0.3, $p$-value = 0.99), so the number of hives does not depend on the reason for breeding. However, if we add commercial among the reasons for breeding, we reject the null hypothesis (test statistics are equal to 15.26, $p$-value = 0.009). From the sample statistics, it is evident that the average number of hives for commercial purposes (59.8) is more than double compared to hives for other breeding reasons, where the values range from about 20 to 30 (see Table 2). The difference is statistically significant.

**Table 2.** Sampling statistics—number of hives (NH) and reasons for breeding.

| | Range | Average | Median | Standard Deviation |
|---|---|---|---|---|
| NH—Hobby | 135 | 24.78 | 13 | 31.48 |
| NH—Products | 85 | 22.15 | 13 | 25.74 |
| NH—Trees | 70 | 22.39 | 13 | 26.96 |
| NH—Others | 17 | 30.47 | 23 | 43.59 |
| NH—Tradition | 63 | 19.94 | 13 | 24.96 |
| NH—Commercial | 25 | 59.8 | 66 | 46.83 |
| Total | 395 | 25.48 | 13 | 31.61 |

### 4.2. Number of Hives and Demand for Pollination

Conformance analysis of the number of hives in the examined samples using the Bartlett test: the resulting $p$-value is equal to 0.38, so we do not reject the agreement of the variances. To supplement, statistics on the number of hives for individual selection are given first (see Table 3).

**Table 3.** Sampling statistics—number of hives and demand for pollination.

| Demand for Pollination | Range | Average | Median | Standard Deviation | Min | Max |
|---|---|---|---|---|---|---|
| YES | 20 | 32.05 | 10.5 | 34.88 | 3.0 | 126.0 |
| NO | 151 | 23.46 | 13.0 | 30.12 | 0 | 150.0 |
| Total | 171 | 24.47 | 13.0 | 30.73 | 0 | 150.0 |

We do not reject the assumption of agreement of variance (the $p$-value of the Bartlett test is 0.38). Test statistics of analysis of variance were $F = 1.38$ and $p$-value = 0.24, so we do not reject the hypothesis of independence. Thus, it can be said that the number of hives does not depend on the demand for pollination.

### 4.3. Number of Hives and Individual Benefits of Breeding

Table 4 shows the values of the sample correlations between the number of hives and the individual benefits of breeding. The last row of the table shows the *p*-value. In all cases, it is higher than 5%, so we do not reject the null hypothesis in any case and the benefit of breeding and the number of hives can be described as independent quantities.

**Table 4.** Selective correlations between the number of hives and the benefit of breeding.

| | Products | Pollination of Cultivated Plants | Pollination of Other Plants | Cultural Significance |
|---|---|---|---|---|
| R(x,y) | −0.0151 | −0.0968 | −0.1182 | −0.1015 |
| *p*-value | 0.8458 | 0.2104 | 0.1259 | 0.1892 |

The results show that the reason for beekeeping and the evaluation of the benefits of breeding are independent variables. The null hypothesis was rejected only for the pairs Tree Pollination–Pollination of Cultivated Plants and Tree Pollination–Pollination of Other Plants, but in these cases the assumption of concordance of variances in the samples was not fulfilled. Therefore, the Kruskal–Wallis test was used alternatively, where the null hypothesis was subsequently rejected in both cases.

### 4.4. Valuation of Ecosystem Services

The valuation of the production ecosystem service was based on the total value of honey in 2018, which amounted to 803,160 CZK, bearing in mind that, according to the questionnaire survey, the share of honey in total sales of bee products was 89.58%. The total value of the production ecosystem service is then 896,584 CZK, see Table 5.

**Table 5.** Evaluation of ecosystem services as a result of a questionnaire survey.

| Ecosystem Services | Production | Pollination of Cultivated Plants | Pollination of Other Plants | Cultural |
|---|---|---|---|---|
| Points (average) | 7.77 | 8.62 | 8.65 | 6.51 |
| Valuation in CZK | 896,584 | 996,973 | 1,000,435 | 752,346 |

The value of all selected ecosystem services totalled to the amount of 3,646,368 CZK.

## 5. Discussion

According to the results, the average number of honeybee colonies held is 25. The study by [39] gives an average of 22, most of which are kept by individuals. The reasons for beekeeping are different in different countries [53,54]. In the Czech Republic, it is, in the first place, a hobby (34.18%), followed by for the production of honeybee products (21.52%), pollination in one's own garden (17.72%), and family tradition (15.95%). Beekeeping for commercial reasons is only 6.33%. There is also a higher number of hives in business, which is on average 59.8.

In the Czech Republic, the demand for pollination in beekeeping is low. It is clear from the questionnaire survey that it is only relevant to 11.6% of respondents. This is mainly due to the above-mentioned reasons for beekeeping and at the same time low government support. It would be expected that those who grow crops should be particularly interested in pollination. Currently, the importance of pollination is not properly appreciated across the EU (e.g., [55]), while in the US, $2 billion a year is spent on targeted pollination [39]. It is essential to maintain and further deepen dialogue and cooperation between all stakeholders (especially beekeepers, farmers, scientists, NGOs, local authorities, the plant protection industry, the private sector, veterinarians, and the general public) to coordinate research and to share all relevant data in a timely manner. The honeybee, together with wild bees and other pollinators, provides essential ecosystem services by pollinating cultivated plants, without which European agriculture could not otherwise exist.

The importance of pollination is evident from the questionnaire survey, where the ecosystem service of pollination is the highest in the point estimate (see Table 5). The point estimate is reflected in the valuation of individual ecosystem services of beekeeping. The total valuation of selected ecosystem services of 3,646,368 CZK is a financial expression of the benefit of beekeeping for society, although the aspect of the irreplaceability of pollination for food production is not taken into account.

The Czech government's support for beekeeping amounts to around 64 million CZK annually [24], i.e., 1.8% in comparison with the value of all ecosystem services. Government support is mainly provided for addressing of risks and technical assistance. This is due to the fact that insurance companies in some EU member states refuse to insure hives.

It is clear that in many countries they are aware of the role of honeybees in pollination and the importance of other ecosystem services. The use of insecticides is a widespread obstacle [56,57]. There are a number of government strategies that address environmental protection and where honeybee pollination is one of the basic conditions for environmental protection and biodiversity. Research in this area should lead to the introduction of tools to protect honeybees and promote pollination and other ecosystem services.

## 6. Conclusions

Beekeeping is an indispensable part of the bioeconomy. It is clear that pollination is one of the most important ecosystem services ahead of honeybee production and cultural significance. The research confirmed that the beekeeping situation in the Czech Republic is less commonly found in other countries. Beekeeping is mainly a hobby here (34.18%). This is also related to the low demand for pollination (11.6% of respondents).

The research further confirmed that ecosystem services have a relatively high financial value, which was calculated on the basis of respondents' scores. Within the total amount for the Czech Republic, the value of selected (most important) ecosystem services was 3,646,368 CZK in 2018. From the valuation performed and foreign experience, it is clear that support from the state is necessary, both in the form of subsidies and instruments restricting the use of insecticides. Future research should perhaps focus on the bioeconomy and the optimization of ecosystem services.

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## References

1. Bradbear, N. *Bees and Their Role in Forest Livelihoods: A Guide to the Services Provided by Bees and the Sustainable Harvesting, Processing and Marketing of Their Products*; Non-Wood Forest Products No. 19 Bulletin; Food and Agriculture Organization of the United Nations (FAO): Rome, Italy, 2009.

2. Klein, A.M.; Boreux, V.; Fornoff, F.; Mupepele, A.C.; Pufal, G. Relevance of wild and managed bees for human well-being. *Curr. Opin. Insect Sci.* **2018**, *26*, 82–88. [CrossRef] [PubMed]
3. Vinci, G.; Rapa, M.; Roscioli, F. Sustainable Development in Rural Areas of Mexico through Beekeeping. *Int. J. Sci. Eng. Invent.* **2018**, *4*, 1–7. [CrossRef]
4. Gomes, G.C.; Gomes, J.C.C.; Barbieri, R.L.; Miura, A.K.; de Sousa, L.P. Environmental and ecosystem services, tree diversity and knowledge of family farmers. *Floresta Ambiente* **2019**, *26*, e20160314. [CrossRef]
5. Patel, V.; Pauli, N.; Biggs, E.; Barbour, L.; Boruff, B. Why bees are critical for achieving sustainable development. *Ambio* **2020**, *50*, 49–59. [CrossRef] [PubMed]
6. Patel, V.; Biggs, E.M.; Pauli, N.; Boruff, B. Using a social-ecological system approach to enhance understanding of structural interconnectivities within the beekeeping industry for sustainable decision making. *Ecol. Soc.* **2020**, *25*, 24. [CrossRef]
7. Millenium Ecosystem Assessment. *Ecosystems and Human Wellbeing: Opportunities and Challenges for Business and Industry*; World Resources Institute: Washington, DC, USA, 2005.
8. Woś, B. Api-tourism in Europe. *J. Environ. Tour. Anal.* **2014**, *2*, 66–74.
9. Cecchi, S.; Terenzi, A.; Orcioni, S.; Piazza, F. Analysis of the sound emitted by honey bees in a beehive. In Proceedings of the 147th Audio Engineering Society International Convention 2019, Ancona, Italy, 16–19 October 2019.
10. Breeze, T.D.; Bailey, A.P.; Balcombe, K.G.; Potts, S.G. Pollination services in the UK: How important are honeybees? *Agric. Ecosyst. Environ.* **2011**, *142*, 137–143. [CrossRef]
11. Qaiser, T.; Ali, M.; Taj, S. Impact Assessment of Beekeeping in Sustainable Rural Livelihood. *J. Soc. Sci.* **2013**, *2*, 82–90.
12. Bekić, B.; Jovanović, M. Beekeeping as a factor of Danube Region sustainable development. In Proceedings of the IAE Scientific Meetings, Belgrade, Serbia, 10–11 December 2015; pp. 156–172.
13. Amulen, D.R.; D'Haese, M.; D'Haene, E.; Acai, J.O.; Agea, J.G.; Smagghe, G.; Cross, P. Estimating the potential of beekeeping to alleviate household poverty in rural Uganda. *PLoS ONE* **2019**, *14*, e0214113. [CrossRef]
14. Bogdanov, S. Beeswax: Uses and Trade. In *The Beeswax*; Bee Product Science: Muhlethurnen, Switzerland, 2009.
15. Pocol, C.B.; Mărghitaş, L.A.; Popa, A.A. Evaluation of sustainability of the beekeeping sector in the North West Region of Romania. *J. Food Agric. Environ.* **2012**, *10*, 132–138.
16. Hamauswa, S.; Mulenga, J.; Shula, R.B.; Malunga, M.M. Promoting micro, small and medium enterprises in beekeeping in Zambias Central Province: Making a case for the adoption of business incubation strategy. *Afr. J. Agric. Res.* **2017**, *12*, 3045–3060. [CrossRef]
17. Potts, S.G.; Imperatriz-Fonseca, V.; Ngo, H.T.; Aizen, M.A.; Biesmeijer, J.C.; Breeze, T.D.; Dicks, L.V.; Garibaldi, L.A.; Hill, R.; Settele, J.; et al. Safeguarding pollinators and their values to human well-being. *Nature* **2016**, *540*, 220–229. [CrossRef] [PubMed]
18. Vanbergen, A.J.; Insect Pollinators Initiative. Threats to an ecosystem service: Pressures on pollinators. *Front. Ecol. Environ.* **2013**, *11*, 251–259. [CrossRef]
19. Mallinger, R.E.; Gaines-Day, H.R.; Gratton, C. Do managed bees have negative effects on wild bees?: A systematic review of the literature. *PLoS ONE* **2017**, *12*, e0189268. [CrossRef] [PubMed]
20. Penn, J.; Hu, W.; Penn, H.J. Support for Solitary Bee Conservation among the Public versus Beekeepers. *Am. J. Agric. Econ.* **2019**, *101*, 1386–1400. [CrossRef]
21. Siebert, J.W. Beekeeping, Pollination, and Externalities in California Agriculture. *Am. J. Agric. Econ.* **1980**, *62*, 165–171. [CrossRef]
22. Bauer, D.M.; Wing, I.S. The macroeconomic cost of catastrophic pollinator declines. *Ecol. Econ.* **2016**, *126*, 1–13. [CrossRef]
23. Ritten, C.J.; Peck, D.; Ehmke, M.; Patalee, M.A.B. Firm efficiency and returns-to-scale in the honey bee pollination services industry. *J. Econ. Entomol.* **2018**, *111*, 1014–1022. [CrossRef]
24. *Report on the State of Agriculture in the Czech Republic in 2018*; Institute of Agricultural Economics: Ministry of Agriculture: Prague, Czech Republic, 2019; 269p, Available online: http://eagri.cz/public/web/file/648258/Zelena_zprava_2018.pdf (accessed on 25 August 2020).
25. Lowore, J. Understanding the Livelihood Implications of Reliable Honey Trade in the Miombo Woodlands in Zambia. *Front. For. Glob. Chang.* **2020**, *3*, 28. [CrossRef]

26. Cox-Foster, D.L.; Conlan, S.; Holmes, E.C.; Palacios, G.; Evans, J.D.; Moran, N.A.; Quan, P.L.; Briese, T.; Hornig, M.; Geiser, D.M.; et al. A metagenomic survey of microbes in honey bee colony collapse disorder. *Science* **2007**, *318*, 283–287. [CrossRef]
27. Qi, S.; Zhu, L.; Wang, D.; Wang, C.; Chen, X.; Xue, X.; Wu, L. Flumethrin at honey-relevant levels induces physiological stresses to honey bee larvae (*Apis mellifera* L.) in vitro. *Ecotoxicol. Environ. Saf.* **2020**, *190*, 110101. [CrossRef]
28. Amdam, G.V.; Hartfelder, K.; Norberg, K.; Hagen, A.; Omholt, S.W. Altered physiology in worker honey bees (Hymenoptera: Apidae) infested with the mite *Varroa destructor* (Acari: Varroidae): A factor in colony loss during overwintering? *J. Econ. Entomol.* **2004**, *97*, 741–747. [CrossRef]
29. Smart, M.; Pettis, J.; Rice, N.; Browning, Z.; Spivak, M. Linking measures of colony and individual honey bee health to survival among apiaries exposed to varying agricultural land use. *PLoS ONE* **2016**, *11*, e0152685. [CrossRef] [PubMed]
30. Tarver, M.R.; Huang, Q.; de Guzman, L.; Rinderer, T.; Holloway, B.; Reese, J.; Weaver, D.; Evans, J.D. Transcriptomic and functional resources for the small hive beetle *Aethina tumida*, a worldwide parasite of honey bees. *Genom. Data* **2016**, *9*, 97–99. [CrossRef] [PubMed]
31. Leza, M.; Herrera, C.; Marques, A.; Roca, P.; Sastre-Serra, J.; Pons, D.G. The impact of the invasive species *Vespa velutina* on honeybees: A new approach based on oxidative stress. *Sci. Total Environ.* **2019**, *689*, 709–715. [CrossRef] [PubMed]
32. Pohorecka, K.; Bober, A. Occurrence of *Paenibacillus larvae* spores in honey samples domestic apiaries. *J. Apic. Sci.* **2008**, *52*, 105–111.
33. Faita, M.R.; Cardozo, M.M.; Amandio, D.T.T.; Orth, A.I.; Nodari, R.O. Glyphosate-based herbicides and Nosema sp. microsporidia reduce honey bee (*Apis mellifera* L.) survivability under laboratory conditions. *J. Apic. Res.* **2020**, *159*, 332–342. [CrossRef]
34. Johnson, R.M.; Ellis, M.D.; Mullin, C.A.; Frazier, M. Pesticides and honey bee toxicity—USA. *Apidologie* **2010**, *41*, 312–331. [CrossRef]
35. Di Pasquale, G.; Salignon, M.; Le Conte, Y.; Belzunces, L.P.; Decourtye, A.; Kretzschmar, A.; Suchail, S.; Brunet, J.L.; Alaux, C. Influence of Pollen Nutrition on Honey Bee Health: Do Pollen Quality and Diversity Matter? *PLoS ONE* **2013**, *8*, e72016. [CrossRef]
36. Zavodna, L.S.; Pospisil, J.Z. Honey bee: A consumer's point of view. *Environ. Socio-Econ. Stud.* **2016**, *4*, 26–32. [CrossRef]
37. Honey Market Presentation. Available online: https://ec.europa.eu/info/sites/info/files/food-farming-fisheries/animals_and_animal_products/presentations/market-presentation-honey_en.pdf (accessed on 25 August 2020).
38. Report on Prospects and Challenges for the EU Apiculture Sector. Available online: https://www.europarl.europa.eu/doceo/document/A-8-2018-0014_EN.html (accessed on 25 August 2020).
39. Virgil, N.; Simona, S. The Role of Partnerships in the Development of the Short Chains of Organic Honey Distribution. *Stud. Bus. Econ.* **2020**, *15*, 142–157. [CrossRef]
40. Veselý, V. *Včelařství*; Brázda: Prague, Czech Republic, 2003; ISBN 80-209-0320-8.
41. Ignjatijević, S.; Milojević, I.; Andžić, R. Economic analysis of exporting Serbian honey. *Int. Food Agribus. Manag. Rev.* **2018**, *21*, 929–944. [CrossRef]
42. Malkamäki, A.; Toppinen, A.; Kanninen, M. Impacts of land use and land use changes on the resilience of beekeeping in Uruguay. *For. Policy Econ.* **2016**, *70*, 113–123. [CrossRef]
43. Czech Association of Beekeepers. Available online: https://www.vcelarstvi.cz/dokumenty/ (accessed on 25 August 2020).
44. Krejcie, R.V.; Morgan, D.W. Determining Sample Size for Research Activities. *Educ. Psychol. Meas.* **1970**, *30*, 607–610. [CrossRef]
45. Moreno, G.; Aviron, S.; Berg, S.; Crous-Duran, J.; Franca, A.; de Jalón, S.G.; Hartel, T.; Mirck, J.; Pantera, A.; Palma, J.H.N.; et al. Agroforestry systems of high nature and cultural value in Europe: Provision of commercial goods and other ecosystem services. *Agrofor. Syst.* **2018**, *92*, 877–891. [CrossRef]
46. Haines-Young, R.; Potschin, M. *Common International Classification of Ecosystem Services (CICES), Version 4.3*; Report to the European Environment Agency; Centre for Environmental Management: Nottingham, UK, 2013.
47. Garbach, K.; Morgan, G.P. Grower networks support adoption of innovations in pollination management: The roles of social learning, technical learning, and personal experience. *J. Environ. Manag.* **2017**, *204*, 39–49. [CrossRef]

48. Narjes, M.E.; Lippert, C. The Optimal Supply of Crop Pollination and Honey from Wild and Managed Bees: An Analytical Framework for Diverse Socio-Economic and Ecological Settings. *Ecol. Econ.* **2019**, *157*, 278–290. [CrossRef]
49. Castro, A.J.; Vaughn, C.C.; Julian, J.P.; García-Llorente, M. Social Demand for Ecosystem Services and Implications for Watershed Management. *J. Am. Water Resour. Assoc.* **2016**, *52*, 209–221. [CrossRef]
50. Makovníková, J.; Pálka, B.; Kološta, S.; Flaška, F.; Ordágová, K.; Spišiaková, M. Non-Monetary Assessment and Mapping of the Potential of Agroecosystem Services in Rural Slovakia. *Eur. Countrys.* **2020**, *12*, 257–276. [CrossRef]
51. Wurster, D.; Artmann, M. Development of a concept for non-monetary assessment of urban ecosystem services at the site level. *Ambio* **2014**, *43*, 454–465. [CrossRef]
52. Schernewski, G.; Inácio, M.; Nazemtseva, Y. Expert based ecosystem service assessment in coastal and marine planning and management: A baltic lagoon case study. *Front. Environ. Sci.* **2018**, *6*, 19. [CrossRef]
53. Šedík, P.; Pocol, C.B.; Horská, E. A Comparaison of Beekeeping Sectors between Slovakia and Romania. *Bull. USAMV Hortic.* **2017**, *74*, 183–190. [CrossRef]
54. Cilia, L. The Plight of the Honeybee: A Socioecological Analysis of large-scale Beekeeping in the United States. *Sociol. Rural.* **2019**, *59*, 831–849. [CrossRef]
55. Koprivlenski, V.; Dirimanova, V.; Agapieva, V. Economic analysis of state and development of beekeeping in Bulgaria. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural Dev.* **2015**, *15*, 167–170.
56. Croft, S.; Brown, M.; Wilkins, S.; Hart, A.; Smith, G.C. Evaluating European Food Safety Authority Protection Goals for Honeybees (*Apis mellifera*): What Do They Mean for Pollination? *Integr. Environ. Assess. Manag.* **2018**, *14*, 750–758. [CrossRef]
57. Razik, M.A.R.A.M.A. Toxicity and side effects of some insecticides applied in cotton fields on *Apis mellifera*. *Environ. Sci. Pollut. Res.* **2019**, *26*, 4987–4996. [CrossRef]