



EU beekeepers' views, opinions and attitudes towards healthy and sustainable beekeeping

Deliverable D4.3

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B-GOOD

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making**



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Preface

WP4 aims to map the business environment and identify key socio-economic components of healthy and sustainable beekeeping in the EU. It investigates how stakeholders and beekeepers assess and might overcome their beekeeping business environment's complexity. It also sets out to evaluate the production efficiency, the (health) management decisions by beekeepers, and their personal, environmental and managerial determinants as the key to identify viable, healthy and sustainable business models of EU beekeeping.

This Deliverable (D4.3) is the third of five deliverables from WP4 'Socio-Economic Drivers'. It presents a set of results from 'Task 4.2: Beekeepers' attitudes, management decisions, production efficiency and determinants'. D4.3 describes the materials and methods and presents results from the B-GOOD WP4 European beekeeper survey. It provides a description of the sample characteristics, beekeeper views, opinions and attitudes (beekeeper orientations) related to health and sustainability of beekeeping in relation to beekeepers' personal characteristics, the managerial characteristics of their beekeeping activities and their honey bee colony attributes. It also identifies and profiles European beekeeper segments as potential targets for future communication and extension.

The insights presented on beekeeper views will support and contribute to the data pool of the Health Status Index for honey bees (HSI) and health assessment methodology in other WPs of B-GOOD. The insights will also feed into 'Task 4.3: Business models for sustainability', which aims to identify potential and viable future business models for sustainability for EU beekeeping. The contents of this deliverable report result from a beekeeper survey (n=844) for which the fieldwork data collection was conducted from 8 October 2021 until 10 January 2022. This deliverable is divided into four sections: 1) Background and objectives, 2) Materials and methods, 3) Results and 4) Conclusions.

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Summary

B-GOOD is a multi-disciplinary project committed to providing solutions to the diverse problems in the EU beekeeping sector, particularly also designing innovative technologies that help keeping healthy colonies and implementing healthy and sustainable business strategies. This report presents the latest developments of the B-GOOD Work Package 4, particularly Task 4.2: Beekeepers' attitudes, management decisions, production efficiency and determinants.

The objectives for this deliverable can be split into two overarching goals. The **first** is to provide a description of beekeepers' views, opinions and attitudes (beekeepers' motivations, orientations, beliefs and perceptions) related to health and sustainability of beekeeping in relation to 1) beekeepers' personal characteristics 2) the managerial characteristics of their beekeeping activities and 3) colony attributes; and the **second** is to identify and profile European beekeeper segments as potential targets for future communication and extension.

The results of this deliverable are based on a survey of a total of 844 beekeepers from 18 European countries who completed the survey during a three-month period from 8 October 2021 until 10 January 2022. The sample of beekeepers is very diverse and covers Western, Eastern, Southern and Northern European regions, hobbyist and professional beekeepers, urban and non-urban beekeepers, starters and experienced beekeepers, beekeepers who migrate their bees for honey production and/or engage in the provision of pollination services.

Besides providing a detailed description of the personal and beekeeping characteristics of the study sample, a main focus of this deliverable has been to analyse beekeepers' motivations for beekeeping, ranging from merely passion to an interest in own honey production or economics, as well as beekeepers' utility vs. affect orientations towards honey bees and beekeeping. These orientations have been used as segmentation variables to identify five clusters or types of beekeepers, which have consecutively been profiled/characterised.

Another main focus has been to provide a detailed analysis of beekeeping management practices related to the management of queens and colonies, comb replacement and wax recycling, administration and record keeping, hive monitoring, environment management and monitoring, equipment management, and health and welfare monitoring, which led to the introduction of a Good Beekeeping Management Practice (GBMP) index. Furthermore, honey bee colony outputs (e.g. the production of honey and other apiary products) as well as honey bee colony winter loss rates have been analysed and compared across regions and beekeeper types. Finally, specific efforts have been made to assess the external validity of the study sample through comparing average honey yields per hive per country and reported honey bee colony winter loss rates per country with secondary data accessed from other sources.

1. Background and objectives

1.1 Background

In Europe, beekeepers have been reporting a deterioration of honey bee colony health that has caused high colony losses for the past 10 to 15 years, particularly in Western European countries (EFSA, 2017). These high losses not only concern the beekeeping sector (López-Urbe & Simone-Finstrom, 2019; Potts et al., 2010) but are also of great societal and economic concern, as they are experienced as a sign of the vulnerability of the environment, including the ecosystem service of crop pollination (EFSA, 2017; FAO, 2008; Goulson et al., 2015). Preventing loss and underpinning the causes and mechanisms is essential to avert this crisis.

It is recognised that key factors within a holistic approach towards healthy honey bee colonies in the EU include a better understanding of beekeepers' views and opinions, beekeepers' socio-economic profiles and beekeepers' management styles. Within the EU, beekeepers fall largely into two broad categories: professionals deriving their main income from honey bees, and hobbyists with a small home apiary. The latter have been shown to perform significantly worse with respect to colony survival (Jacques et al., 2017; Owen, 2017), which is associated with their smaller scale, and lack of experience and knowledge, amongst other potential factors that require further study.

Furthermore, objectives, values and drivers of these two groups differ substantially (Chauzat et al., 2013). As a result, their perception of bee health – as an indicator of wellbeing – may differ. Moreover, a single professional business model and policy and advice system may not benefit all beekeepers. Understanding the diversity across Europe and the respective socio-economic goals, value propositions and drivers of all types of beekeepers is essential for deriving tailored advice and recommendations for beekeeping management to improve bee health.

Therefore, a major focal point for this study was the assessment of beekeepers' values, attitudes, orientation and opinions. Beekeepers can be grouped according to their attitudes towards their beekeeping practice. A number of studies have sought to characterise the different typologies of animal-related attitudes by assessing attitude scales (Austin et al., 2005; de Graaf et al., 2016; Serpell, 2004). Austin et al. (2005), who investigated the attitudes of dairy farmers and agriculture students towards animal welfare, labelled two typologies as natural living orientation and business orientation. de Graaf et al. (2016), who investigated consumers' attitudes towards animal welfare, further refined these typologies to business orientation, natural living orientation, and functioning orientation.

Describing the different attitudes of beekeepers in relation to information on beekeeper personal characteristics, managerial characteristics and colony attributes will help to develop recommendations for beekeeping management to improve bee health. Insights provided by Jacques et al. (2017) stressed the role of beekeeper background, knowledge, experience, and management practices in honey bee colony survival. Glăvan (2014) and Vural and Süleyman (2009) dealt with how the socio-economic profile of beekeepers influences honey production. Other studies assessed economic performance, though only in single EU countries or regions (Ceyhan, 2017; Güner & Akyol, 2018; Makri et al., 2015).

Owen (2017) argued that beekeeper activity has been a key driver in the global distribution of honey bees and the associated spread of pathogens impacting bee health, pointing at necessary adaptations in management decisions. Several studies confirmed that environmental conditions together with beekeeping management determine *Varroa destructor* infestations in honey bee colonies (Giacobino et al., 2017; Pohorecka et al., 2014), but also indicated that the interplay between different sets of determinants is complex.

1.2 Objectives

This is the first of two deliverables for Task 4.2: Beekeepers' attitudes, management decisions, production efficiency and determinants. The purpose of this Deliverable 4.3 is to provide a descriptive analysis of 1) beekeepers' views, opinions and attitudes, 2) beekeepers' personal characteristics, 3) beekeepers' managerial characteristics and 4) colony attributes. The second deliverable of Task 4.2 (D4.4) will provide a more detailed picture of the key socio-economic components of healthy and sustainable beekeeping, taking additional factors into account such as production efficiency analysis of beekeepers and an assessment of ecological-environmental characteristics, due in month 36. The results of both this Deliverable 4.3 and Deliverable 4.4 will feed into Task 4.3 which aims to identify context-specific business models and plans for European beekeeping.

This Deliverable 4.3 uses a pan-European quantitative survey (n=844) to explore the relationships between:

- 1) Beekeepers' personal characteristics (country, age, gender, education level)
- 2) Beekeeping characteristics (number of hives, hobby/professional, urban/rural location, association membership, inherited or not, years of experience, migratory beekeeper or not)
- 3) Beekeepers' views, opinions and attitudes (beekeepers' motivations and orientations)
- 4) Beekeepers' managerial characteristics in terms of a Good beekeeping Management Practice score (GBMP score)
- 5) Beekeeping outputs (honey, pollination services, estimated impact of pollination, other apiary products)
- 6) Colony health (winter losses, health management)

With the end goal in Task 4.3 to develop tailored recommendations towards healthy and sustainable beekeeping business models, it will be an essential step to segment beekeepers into typologies based on the above criteria, as a starting point to group beekeepers as potential targets for future communication and extension. Former studies attempting to segment farmers into typologies have used variables such as attitudes, perceived motivations and barriers to change, sources of information and value orientations (Upadhaya et al., 2020), and socio-economic profiles, environmental values and beliefs (Foguesatto et al., 2019).

Studies on the typology and characterization of beekeepers have used variables such as economic performance, age, experience, beekeeper management styles, and honey bee health index (Bragulat et al., 2020; Izquierdo et al., 2016). Bragulat et al. (2020) was able to categorise beekeepers into those practicing subsistence beekeeping, industrial beekeeping

and commercial beekeeping based on a variety of economic production indicators. Izquierdo et al. (2016) used beekeepers' demographic profile and economic production indicators together with indexes (management index, genetic index, nutrition index and honey bee health index), each composed of multiple variables; we use a similar approach. Specific information on the calculation of a good beekeeping management practice (GBMP) index and the health status monitoring index is described in Sections 3.5 and 3.7.2.

2. Materials and methods

2.1 Study questionnaire

The quantitative beekeeper survey (see Appendix 1) aimed to gather information for this Deliverable 4.3, as well as future Deliverable 4.4 (also within Task 4.2) and Deliverable 4.5 (within Task 4.3). Therefore, the objectives of the survey were broader than the objectives addressed in this deliverable alone.

The survey contained a total of 72 questions divided in eight sections:

Section 1: Socio-demographic variables and beekeeper/beekeeping characteristics

Section 2: Economic performance in beekeeping

Section 3: General beekeeping management

Section 4: Honey bee colony health

Section 5: Digital technology in beekeeping

Section 6: Beekeeper orientations towards honey bees

Section 7: Environmental quality

Section 8: Intention to use hive monitoring technology in beekeeping

Findings related to Section 1, Section 3, Section 4, and Section 6 are reported in this deliverable D4.3, whereas findings related to Section 2, Section 5, Section 7 and Section 8 will be reported in future deliverables (D4.4 and D4.5) and additional dissemination activities.

2.2 Testing phase

During the preliminary stages of questionnaire construction, it was extremely useful for members of the research project team to test the questionnaire among themselves. Testing phases handled internally helped to develop and fine-tune the overall survey protocol. To do so, a test version of the survey was created in Qualtrics and the link was distributed to members of the B-GOOD consortium. All B-GOOD researchers who are personally also beekeepers were invited to participate as testers. The test survey provided an opportunity for B-GOOD consortium members to give detailed feedback on each survey section. In the test version, a comment box was provided at the end of each section where B-GOOD consortium members were invited to give feedback on what went well, what was difficult, and any suggestions they may have had for improvement. The testing phase ran from 27 July 2021 until 10 August 2021. A detailed description of the feedback that was received from survey testers is provided in Appendix 2: Beekeeper Survey Test: Feedback Summary Report.

2.3 Translations and web-programming

Survey questions are most effective when they are precise and clearly contextualised, short and formulated in simple language, and when the terms used cannot be misinterpreted. Therefore, it was very important to have experts in beekeeping translate the survey to avoid misinterpretation of technical terms. The informed consent literature and master questionnaire were first developed in English, and then translated into 11 additional languages: Dutch, Danish, Finnish, French, German, Italian, Polish, Portuguese, Romanian, Spanish, and Bulgarian by B-GOOD partners who are native speakers in each country and are familiar with practical beekeeping and related terminology. The multilingual survey allowed respondents to be reached in the language they were most comfortable with, while still allowing results to be analysed together as a single data set after merging data from the individual language versions. Translations of the surveys and further pre-testing of the translated versions ran from 16 August to 30 August 2021. All language versions were web-programmed in the online survey software Qualtrics.

2.4 Sampling and survey distribution

The initial target for this study was to attain a minimum of 600 completed surveys, covering beekeepers located in Northern / Southern / Eastern and Western regions of Europe, reflecting different geographical, climatic and cultural influences within European beekeeping. The twelve language versions of the questionnaire were produced with the aim to distribute the survey among beekeepers in the following 14 countries:

1. Belgium (Dutch, French and German)
2. Denmark (Danish)
3. Finland (Finnish)
4. France (French)
5. Germany (German)
6. Italy (Italian)
7. The Netherlands (Dutch)
8. Poland (Polish)
9. Portugal (Portuguese)
10. Romania (Romanian)
11. Spain (Spanish)
12. United Kingdom (English)
13. Bulgaria (Bulgarian)
14. Switzerland (German, French, Italian)

A website was created with the link: **bgoodwp4.ugent.be**, which provided a selection button to each language version on the same webpage (see Figure 1). After a language button was clicked, the participant was directed to a page with the downloadable information sheet for participants and the informed consent form, and a button to start the survey (see Figure 2). This allowed the same link to be easily distributed to multiple countries regardless of language spoken.



Figure 1. Webpage under the link bgoodwp4.ugent.be used for survey distribution

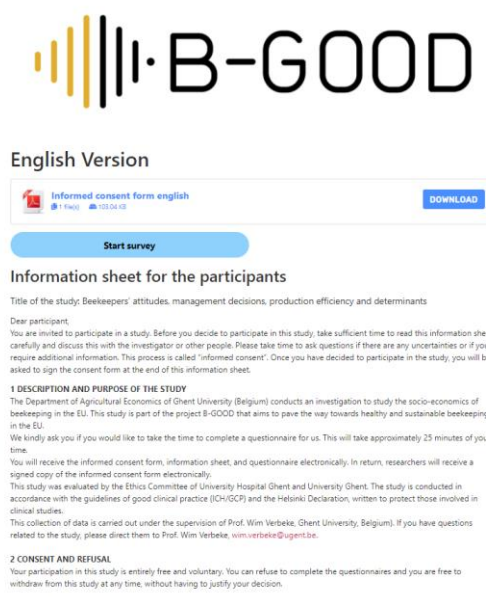


Figure 2. English version of the downloadable information sheet and “start survey” button

The web link was aimed to be distributed to beekeepers in each of the 14 countries in the following four phases:

- 1) First, the link was to be distributed to national beekeeping associations in each of the 14 countries with the help of B-GOOD partners in each country, requesting that they place the link in their monthly newsletters, send the link directly to their members by email, or post the link on their Facebook page.
- 2) Second, beekeeper contacts of involved partner institutions were to be utilised. This included newsletters from research institutions that targeted beekeepers.
- 3) Third, personal contacts of B-GOOD consortium partners were to be utilised.
- 4) Fourth, broader social/mass communication channels of B-GOOD were to be utilised.

Recruitment has been actively done in all countries with the exceptions of Spain and Denmark for the following reasons. Since there are no B-GOOD partners located in Spain, our network there was limited. The coordinator of the B-GOOD project, Prof. Dirk de Graaf, had a prominent contact in Spain who had contacts at the Asociación Veterinarios (ESPA) and the Asociación Española de Apicultores. Our Spanish contact attempted to motivate the associations several times without success. As a result, only a few Spanish beekeepers completed the survey. In Denmark, the Danish Beekeeper Association temporarily declined our request for survey distribution, since they had another major survey for beekeepers running simultaneously and did not want to burden their members. It has however been agreed to pick up the thread again after the completion of their data collection (beginning 2022) and to reconsider the decision and to distribute our survey at a later date, either in March or April 2022.

For the other 12 countries, the above four steps were actively done and have generally worked well except for the UK, France, Switzerland, and Bulgaria, in which the number of participants turned out to be less in these four countries than the other countries. We found the greatest response success when a description of the survey and the survey link was distributed by the heads of national beekeeping associations to members via personal email including a direct link to the survey website. Details on the beekeeper recruitment for each of these 12 countries are provided in Appendix 4.

In the UK, the largest beekeeping organisation, the British Beekeepers Association (BBKA), did not respond to our request after several attempts. However, the Bee Farmers Association confirmed that they sent the survey link to all 539 members via email, and the Central Association of Bee-Keepers (CABK) sent the survey link to all 275 members via electronic newsletter. Reasons for the low response rate in the UK are partly attributed to unsuccessful beekeeper recruitment by the British Beekeepers Association (BBKA); however, other reasons are unclear but perhaps beekeepers in the UK were burdened with other surveys concurrently, a hurdle that has been stressed also in several other countries.

In France, the following associations were contacted several times without success: the Union Nationale de l'Apiculture Française (UNAF), the Syndicat national de l'apiculture (SNA), the Syndicat des Producteurs de Miel Français (SPMF), the Association Nationale des Éleveurs de Reines et des Centres d'Élevage Apicole, the Fédération Nationale des Organisations Sanitaires Apicoles Départementales, the Groupement des producteurs de gelée royale, the Syndicat d'apiculture méridionale, and the Fédération française des apiculteurs professionnels. The Fédération Nationale du Réseau de Développement Apicole (ADA France) utilised their network by sending personal emails with the survey link to the coordinators of each ADA region for further distribution, and they also placed the survey link on their Facebook page. It is estimated that ADA France's network reaches around 1,600 beekeepers; therefore, reasons for the low response rate in France are partly attributed to unsuccessful beekeeper recruitment by national associations such as UNAF and SNA. However, other reasons are unclear.

In Switzerland, the following associations were contacted several times without success: the Service sanitaire apicole (SSA), the Société Romande d'Apiculture (SAR), Apisuisse, the Formation suisse d'apiculteur Sàrl, Api3valli association and BienenSchweiz. A survey announcement with the link was posted on the Facebook group "Apiculture en Suisse Romande" with 834 members. Reasons for the low response rate in Switzerland are attributed

to unsuccessful beekeeper recruitment by national associations such as the Service sanitaire apicole (SSA) and the Société Romande d'Apiculture (SAR).

In Bulgaria, the following associations were contacted several times without success: the Bulgarian Bee Breeding Association, Pollenity, Ghoney, the Dobrich Beekeeping Association, the Burgas Beekeeping Society, the Municipal Beekeeping Society Akaciya, the Bulgarian beekeepers forum, Hoseyni beekeepers, Teddy Honey, the National association of women beekeepers, and the Regional beekeepers union in Pleven. The survey link was distributed through two personal contacts of the B-GOOD partner Pensoft Publishers in Bulgaria. However, since Pensoft Publishers is a communications organisation which handles the dissemination and science communication for B-GOOD, their personal beekeeping contacts are limited, which partly explains the low response rate in Bulgaria.

With the closure of data collection for this deliverable (10 January, 2022), 844 complete responses had been recorded, which is well beyond the initial target sample size of 600. However, the survey will remain open to collect further responses from the countries where responses are lagging behind, and from additional recruitment efforts in Spain and Denmark. In Spain, additional efforts will be done to find contacts beyond the network of B-GOOD who can help distribute the survey through national organisations. In Denmark, the Danish Beekeeping Association might still reconsider their decision and eventually distribute the survey in March or April 2022.

2.5 Data handling and ethics approval

The collected personal data in this research project includes: socio-demographic and socio-economic characteristics such as age (years), gender, education, training, experience with the beekeeping sector, economic performance in beekeeping, as well as attitudes, beliefs, perceptions, opinions and views, which are all exclusively related to beekeeping and its context. All collected data are cross-sectional data collected at one point in time. Sensitive personal information relating e.g. to health, ethnicity, sexual lifestyle, political opinion, religious or philosophical conviction fell beyond the scope of B-GOOD and was not probed for.

The informed consent procedures and information sheets informed all data subjects of the purpose of the data collection, of what was to be done with the data and of the processing of the data. All data collection was fully anonymous; thus, data records are anonymous and are shared for study purposes and in dissemination activities only in aggregated form. Survey records do not include the name(s) or any personal identifier of the participants. Ethics approval for this WP4 beekeeper survey was obtained on 27 August, 2021 by the UZ Gent / UGent Medical Ethics Committee under application number **BC-10610** (see Appendix 3).

2.6 Sample composition

By the closure of this deliverable, a total of 1,460 beekeepers had started the survey, out of which 59% (860) had completed the entire survey and 41% (600) had given incomplete responses. Out of the 600 beekeepers who did not complete the survey:

- 55 (9%) started but stopped because of not consenting with one of the informed consent questions at the beginning of the survey;
- 197 (33%) fully consented to the study but stopped after seeing the first question of Section 1: Socio-economic variables: *A_1: What is your country of residence?* These beekeepers may have stopped because their country of residence was not on the list (since probably residing in a non-EU country) or because they changed their mind at that moment;
- 256 (43%) stopped after seeing question *B_9: What was the total quantity of honey that you produced in 2021 (kg)?* This is the first question where the survey requests that the beekeeper enters his or her own economic figures about their beekeeping practises, and it was where most beekeepers decided to quit;
- A remaining 92 (15%) stopped later in the survey, of which 31 stopped after completing Section 2: Economic performance; for the rest, no clear pattern emerges.

Out of the 860 beekeepers who completed the survey, 16 have been deleted from the dataset as invalid for several reasons, yielding a dataset for analysis counting 844 valid cases. The reasons for deleting 16 invalid cases from the dataset were:

- large numbers of missing values on a series of question items where responses were not forced (n=11);
- zero number of beehives reported, i.e. does not fit the criteria for inclusion since not considered as a beekeeper (n=2);
- non-EU/UK/Switzerland country of residence, i.e. does not fit the criteria for inclusion since not considered as an EU/British/Swiss beekeeper (n=1);
- age below 18 years, i.e. does not meet the criteria for inclusion in line with the adult age limit for participation and the ethics approval obtained for the study (n=1);
- obvious response bias, specifically acquiescence and non-differentiation bias in this concerned case (e.g. ticking series of '1's or '5's as response values) (n=1).

3. Results

3.1 Sample characteristics

Beekeepers resided in 18 countries, with most beekeepers residing in either Belgium or The Netherlands. Table 1 gives an overview of both the frequency and percentage of each country represented, and Figure 3 displays the relative percentages in a pie chart.

Beekeepers were split into four regions of Europe (North, South, East and West) using the United Nations Geoscheme for Europe, in which the majority of beekeepers resided in Western Europe. Table 2 gives an overview of both the frequency and percentage of each region represented, and Figure 4 displays the relative percentages in a pie chart.

Table 1. Frequency and percentage of survey respondents by country

Country	Frequency	Percent
Belgium	170	20.1
The Netherlands	169	20.0
Germany	93	11.0
Portugal	78	9.2
Poland	74	8.8
Italy	73	8.6
Romania	67	7.9
Finland	53	6.3
United Kingdom	23	2.7
France	18	2.1
Bulgaria	13	1.5
Switzerland	4	0.5
Czechia	2	0.2
Slovenia	2	0.2
Spain	2	0.2
Austria	1	0.1
Lithuania	1	0.1
Sweden	1	0.1
Total	844	100.0

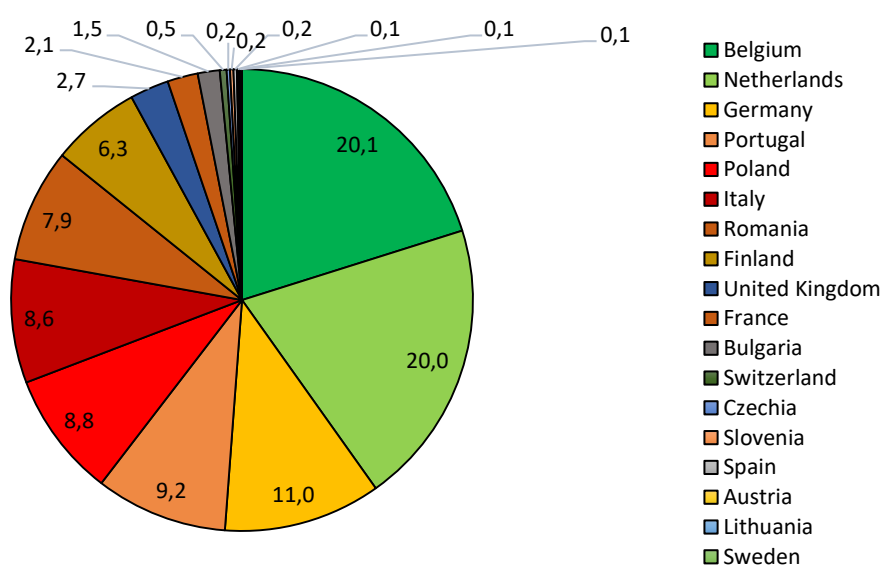
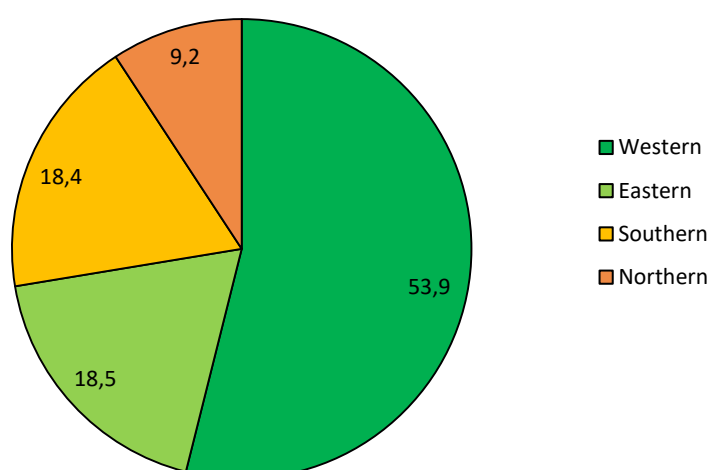
**Figure 3.** Percentage of each country represented by the sample (%; n=844)

Table 2. Frequency and percentage of survey respondents by UN geoscheme region

UN geoscheme region	Frequency	Percent
Western	455	53.9
Eastern	156	18.5
Southern	155	18.4
Northern	78	9.2
Total	844	100.0

**Figure 4.** Percentage of each European region represented by the sample, according to the UN geoscheme for Europe (% , n=844)

Beekeepers' ages ranged from 18 to 91 years old, with the mean age among the sample being 53 years old. Age groups were created based on tertiles, where beekeepers were divided into three age groups; less than 46 years, 46-59 years, 60 years or more, each containing a third of the sample. Table 3 gives an overview of both the frequency and percentage of each age group represented, which shows that two thirds of beekeepers are over the age of 46 years.

Table 3. Frequency and percentage of survey respondents by age

Age	Frequency	Percent
Less than 46 years	279	33.1
46-59 years	293	34.7
More than 60 years	272	32.2
Total	844	100.0

Around four fifths of beekeepers were male and around one fifth were female, with six beekeepers indicating other or preferred not to say. Table 4 gives an overview of both the frequency and percentage of each gender represented in the sample, revealing that beekeepers in our sample are predominantly male.

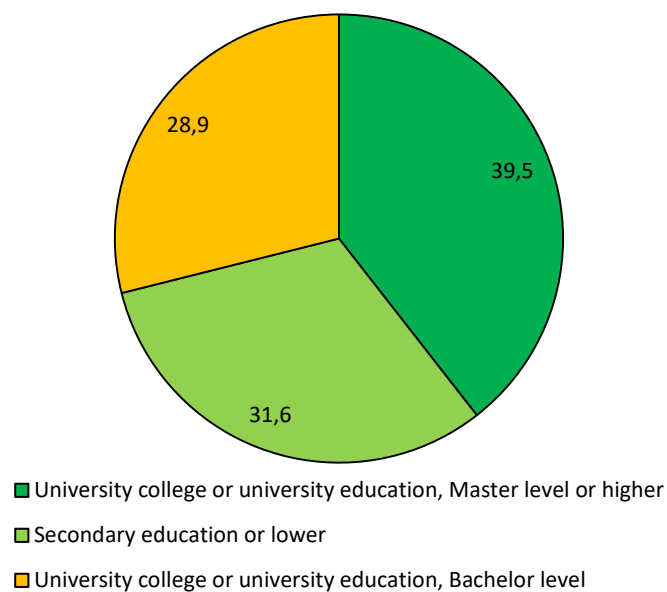
Table 4. Frequency and percentage of survey respondents by gender

Gender	Frequency	Percent
Male	681	80.7
Female	157	18.6
Other / Prefer not to say	6	0.7
Total	844	100.0

Beekeepers reported being highly educated, where 39.5% had a Master degree and 28.9% had a Bachelor degree. Table 5 gives an overview of both the frequency and percentage of the education levels represented, and Figure 5 displays the relative percentages in a pie chart, which shows that almost three quarters of the beekeepers in the sample had a university education.

Table 5. Frequency and percentage of survey respondents by education level

Education level	Frequency	Percent
Secondary education or lower	267	31.6
University college or university education, Bachelor level	244	28.9
University college or university education, Master level or higher	333	39.5
Total	844	100.0

**Figure 5.** Percentage of each education level represented by the sample (%, n=844)

3.2 Beekeeping characteristics

In the survey, beekeepers were asked to classify themselves on a 5-point categorical scale as a hobby or professional beekeeper based on both 1) size and economic value of their beekeeping operation and 2) personal expertise. Based on size and economic value, 46.9% of beekeepers classified themselves as purely hobbyist, 21.9% as rather hobbyist, 12.2% as neither hobbyist nor professional, 10.2% as rather professional and 8.8% as fully professional. Based on personal expertise, 29.5% of beekeepers classified themselves as 'purely hobbyist', 20.1% as 'rather hobbyist', 14.8% as 'neither hobbyist nor professional', 24.5% as 'rather professional' and 11.0% as 'fully professional' (see Table 6).

Both indicators of hobby-ism vs. professionalism were strongly correlated (Pearson $r=0.75$; $p<0.001$). The variable referring to professionalism based on expertise was also correlated with the number of years active as a beekeeper (Pearson $r=0.20$; $p<0.001$), suggesting a relationship between expertise and experience, albeit not very strong. These variables will be used further in the analysis (Section 3.8.1) to identify and profile a group of beekeepers who consider themselves as (rather) hobbyists based on size but professional based on expertise.

Table 6. Frequency and percentage of beekeeper types based on size and expertise

Beekeeper type	Based on size		Based on expertise	
	Frequency	Percent	Frequency	Percent
Purely hobbyist	396	46.9	249	29.5
Rather hobbyist	185	21.9	170	20.1
Neither hobbyist nor professional	103	12.2	125	14.8
Rather professional	86	10.2	207	24.5
Fully Professional	74	8.8	93	11.0
Total	844	100.0	844	100.0

Two dummy variables (i.e. variables coded as '1' if the specific criterion is met and '0' otherwise) were created to classify beekeepers labelled either hobby or professional beekeepers based on size and expertise, where professional beekeepers (dummy coded as '1') were those who indicated "rather professional" or "fully professional" on the original 5-point scale.

- Based on classification by **size**, 684 beekeepers (81%) were classified as hobby beekeepers whereas 160 beekeepers (19%) were classified as professional beekeepers.
- Based on classification by **expertise**, 544 beekeepers (64%) were classified as hobby beekeepers whereas 300 beekeepers (36%) were classified as professional beekeepers.

Given that both indicators of hobby-ism vs. professionalism (on size and expertise) were strongly correlated, further analysis between hobby and professional beekeepers is undertaken only using classification based on **size**.

The number of hives reported by beekeepers in the entire sample ranged from 1 to 6,100, with a mean of 72 hives and a median of 15 hives. Professionals exhibited a higher average number of hives than hobbyists, shown in Table 7. The numbers of hives between hobby and professional beekeepers classified based on size shows a significant difference ($t = -6.1$; $p < 0.001$).

Table 7. Number of hives exhibited by hobby and professional beekeepers (n=844)

Number of hives	Based on size	
	Hobby	Professional
Mean	21	291
Standard deviation	29	556
Minimum	1	5
Maximum	301	6100

When comparing the average numbers of hives between the different regions of Europe based on the UN geoscheme, beekeepers from the Southern region had the highest average number of hives (136), followed by beekeepers in the Eastern (118), Northern (116) and Western (27) regions. One-way ANOVA tests were conducted to test differences between regions for the number of hives, and we found the numbers of hives per beekeeper for the Western region to be statistically lower than other regions ($F=9.9$; $p < 0.001$).

Considering beekeeping experience, the average number of years that beekeepers have been active with beekeeping among the sample was 15 years, with a median of 10 years, a minimum of 1 year and a maximum of 80 years. The number of years active as a beekeeper was correlated with beekeepers' age (Pearson $r=0.475$; $p < 0.001$) as well as with the size of the apiary expressed in total numbers of hives in 2021 (Pearson $r=0.183$; $p < 0.001$), though the latter correlation is only moderate.

Groups based on beekeeping experience were created based on tertiles, where beekeepers were divided into three groups; less than 5 years of experience, 6-15 years of experience and 16 years or more of experience, each containing a third of the sample. Table 8 gives an overview of both the frequency and percentage of each experience group represented, which shows that around one third of the total sample has less than 5 years of beekeeping experience.

Table 8. Frequency and percentage of survey respondents by beekeeping experience

Beekeeping experience	Frequency	Percent
6-15 years	311	36.8
16 years or more	273	32.3
Less than 5 years	260	30.8
Total	844	100.0

Most beekeepers reported being in a fully rural location (49%) or in a rather rural location (31%), whereas 9% reported their location as neither urban nor rural, 6% reported rather urban and 5% reported fully urban. Table 9 splits beekeepers into either urban or non-urban, (where urban beekeepers are classified as indicating being in either a rather urban or fully urban location) and compares these groups between European regions.

Table 9. Percentage of non-urban and urban beekeepers in each UN geoscheme region of Europe

UN geoscheme region	Non-urban	Urban	Percentage of urban beekeepers	Total
Western	389	66	15%	455
Eastern	140	16	10%	156
Southern	147	8	5%	155
Northern	75	3	4%	78
Total	751	93		844

Table 9 shows that 15% of beekeepers located in the Western region of Europe are urban beekeepers, 10% of beekeepers in the Eastern region are urban beekeepers, 5% of beekeepers in the Southern region and 4% in the Northern region.

Table 10 shows that a higher percentage of hobby beekeepers are urban beekeepers than are professionals.

Table 10. Percentage of non-urban and urban beekeepers by beekeeper type based on size

Beekeeper type (classified based on size)	Non-urban	Urban	Percentage of urban beekeepers	Total
Hobby	596	88	13%	684
Professional	155	5	3%	160
Total	751	93		844

Of the sample, 86% belonged to a local or regional beekeeping association, 66% belonged to the national beekeeping association of their own country, 45% belonged to an informal club of friends or colleagues who are beekeepers, 26% were active as chairperson, secretary or board member of a beekeeping association, 26% belonged to more than one local or regional beekeeping association, 9% belonged to a cooperative or honey producer group, 5% belonged to a national beekeeping association of another country, and 5% belonged to an international beekeeping association (see Figure 6).

It should be noted that the large majority of the study participants have been recruited through national or local/regional beekeeping associations, which may have some bias towards high levels of beekeeping association membership in our data. Furthermore, the fact that one quarter of the study sample consists of beekeepers who were active in the management or board of a beekeeping association indicates that especially beekeepers with a strong involvement with beekeeping and its context took part in the study. Strong involvement with the study topic is a typical phenomenon in survey response, with potential implications in terms

of the representativeness of the sample and generalisability of its findings. This issue is addressed further when exploring the external validity of the sample (Box 1 and Box 2).

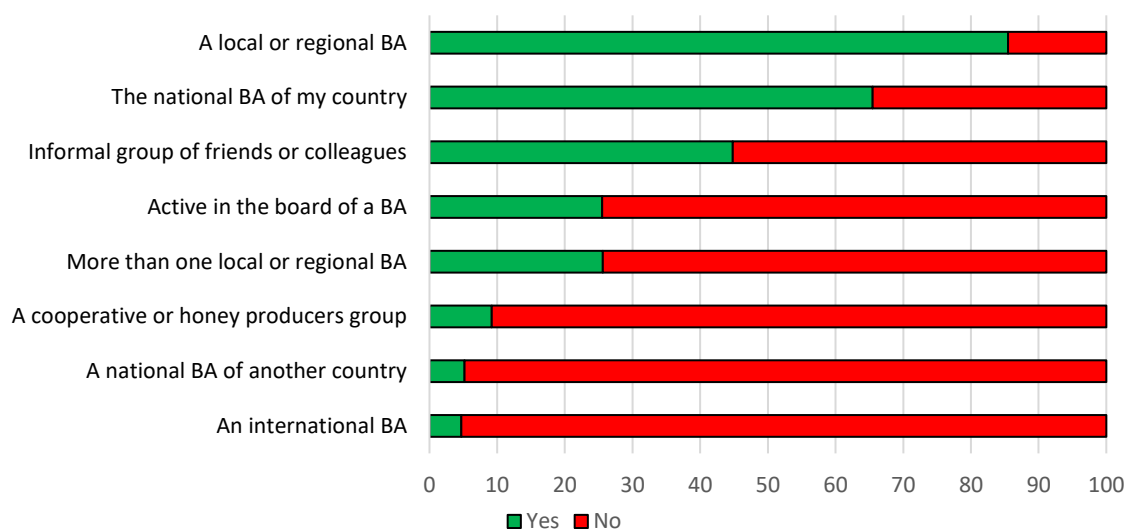


Figure 6. Beekeeping association (BA) membership (%; n=844)

Table 11 shows the percentage of association members and non-association members per European region, where “association member” was classified as at least belonging to either a local or regional beekeeping association, a national beekeeping association of their own country, a national beekeeping association of other countries, or an international beekeeping association.

Table 11. Percentage of association members and non-association members in each UN geoscheme region of Europe

UN geoscheme region	Association Member	Non-association member	Percentage of association members	Total
Northern	77	1	99%	78
Western	431	24	95%	455
Southern	138	17	89%	155
Eastern	128	28	82%	156
Total	774	70		844

Regarding the beekeeper training that respondents in the sample had received, 82% had attended one or more starter courses, 60% had attended one or more advanced courses, and 52% had a beekeeper apprenticeship since they started beekeeping (see Figure 7).

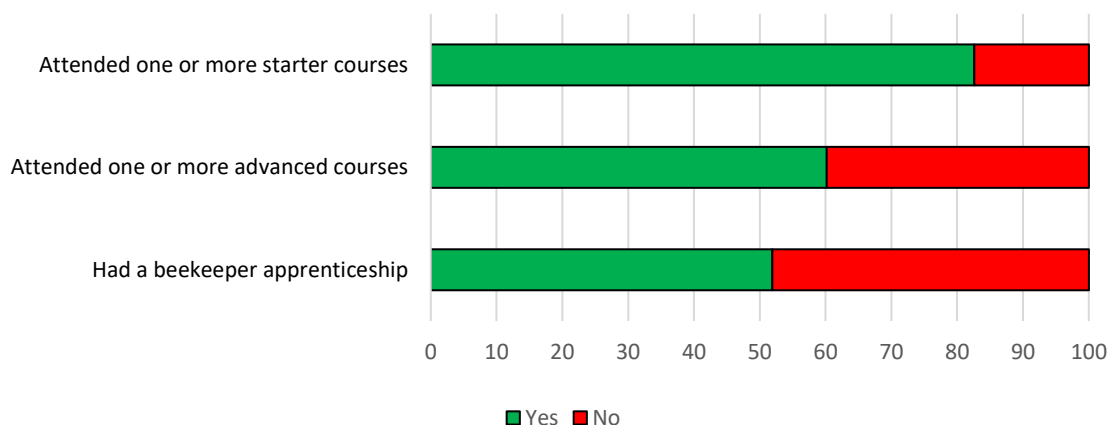


Figure 7. Beekeeping training since start of beekeeping practice (% , n=844)

In addition to a high number of beekeepers in the sample indicating having attended courses on beekeeping, the frequency of attending these trainings was also quite high (see Figure 8); 59% of beekeepers reported attending follow-up lectures, demonstrations, workshops or seminars on beekeeping several times a year. In the survey, we asked that beekeepers think of the pre-COVID period (e.g. 2019 or 'normal times') as reference, given that there were less opportunities to attend training during the last 18 months because of COVID.

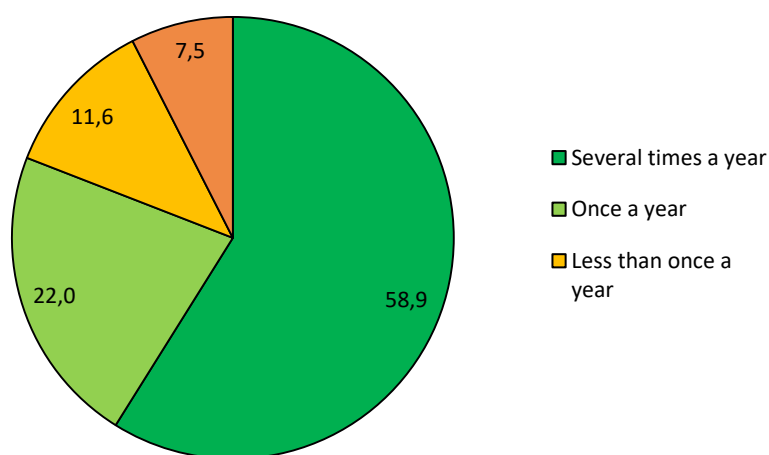


Figure 8. Frequency of attending beekeeping training activities (% , n=844)

When comparing beekeepers who had taken at least one course in beekeeping with their years of experience, the group of beekeepers with 16 years or more of experience reported the lowest percentage of those having taken a course out of the three groups, (see Table 12).

Table 12. Percentage of beekeepers taking beekeeping at least one beekeeping course by years of experience

Years of experience	Beekeeping course	No beekeeping course	Percentage of beekeepers taking course	Total
Less than 5 years	219	41	84%	260
6-15 years	274	37	88%	311
More than 16 years	204	69	75%	273
Total	697	147		844

When comparing beekeepers who had taken at least one course in beekeeping with their beekeeper type (hobby or professional), a higher percentage of hobby beekeepers had taken a beekeeping course compared with professionals (see Table 13).

Table 13. Percentage of beekeepers taking beekeeping at least one beekeeping course by beekeeper type based on size

Beekeeper type (classified based on size)	Beekeeping course	No beekeeping course	Percentage of beekeepers taking course	Total
Hobby	580	104	85%	684
Professional	117	43	73%	160
Total	697	147		844

Almost one fourth of beekeepers within the sample (23%) reported inheriting their beekeeping practice from their parents or grandparents. When comparing beekeepers who had taken at least one course in beekeeping with whether they had inherited their beekeeping practice from their parents or grandparents or not, a higher percentage of beekeepers who had not inherited their beekeeping practice had taken a beekeeping course compared with beekeepers who had inherited their beekeeping practice (see Table 14). This suggests that some knowledge may be passed down to beekeepers who have inherited their practice, decreasing the need to take a beekeeping course.

Table 14. Percentage of beekeepers taking beekeeping at least one beekeeping course by inheritance of beekeeping practice

Inherited or not	Beekeeping course	No beekeeping course	Percentage of beekeepers taking course	Total
Not inherited	555	93	86%	648
Inherited	142	54	72%	196
Total	697	147		844

Finally, 32% (270) of beekeepers within the sample reported were migratory beekeepers, in which they migrate, move or travel with honey bee colonies for honey flow. Table 15 shows that more than half of beekeepers located in the Eastern region of Europe were migratory beekeepers, whereas migratory beekeepers make up about one fourth of beekeepers located in Western and Southern regions, and one fifth of beekeepers in Northern regions.

Table 15. Percentage of migratory beekeepers in each UN geoscheme region of Europe

UN geoscheme region	Migratory beekeeper	Non-migratory beekeeper	Percentage of migratory beekeepers	Total
Eastern	81	75	52%	156
Western	129	326	28%	455
Southern	44	111	28%	155
Northern	16	62	21%	78
Total	270	574		844

When comparing the number of migratory beekeepers between hobby and professional groups, Table 16 shows that more than half of all professional beekeepers were migratory beekeepers. Whereas migratory beekeepers make up about one fourth of all hobby beekeepers.

Table 16. Percentage of migratory beekeepers by beekeeper type based on size

Beekeeper type (classified based on size)	Migratory beekeeper	Non-migratory beekeeper	Percentage of migratory beekeepers	Total
Professional	105	55	67%	160
Hobbyist	165	519	24%	684
Total	270	574		844

Interestingly, almost half of all beekeepers who inherited their beekeeping practice were migratory beekeepers (see Table 17). This suggests that the practice of migratory beekeeping is a practice that may be passed down from generation to generation, or the practice may be more difficult for in-experienced beekeepers to learn.

Table 17. Percentage of migratory beekeepers by beekeeper type by inheritance of beekeeping practice

Inherited or not	Migratory beekeeper	Non-migratory beekeeper	Percentage of migratory beekeepers	Total
Inherited	87	109	44%	196
Not-inherited	183	465	28%	648
Total	270	574		844

In summary, the following information can be drawn about sample and beekeeping characteristics from the total sample of 844 beekeepers:

- The majority of beekeepers in our sample is located in Western Europe (Belgium and The Netherlands), with Northern Europe being the least represented.
- Two thirds of beekeepers in our sample were over the age of 46.
- Beekeepers in our sample were predominantly male (81%), with only 19% being female.

- Almost three quarters of beekeepers in our sample had a university education.
- Hobby beekeepers were represented more than professionals, with hobbyists based on size constituting 81% of the total sample and hobbyists based on expertise constituting 64% of the total sample.
- Professionals possessed a higher number of hives than hobbyists on average, however the number of hives ranged from under 5 hives to 300 hives for hobbyists and from under 5 hives to 6100 hives for professionals. Beekeepers located in Southern regions had a higher number of hives (on average: 136) than the other European regions, especially beekeepers in Western Europe, who possessed a very low number of hives (on average: 27).
- Beekeepers in our sample have been active with beekeeping for an average of 15 years, with around one third being active for less than 5 years.
- Most beekeepers in our sample were located in rural regions. Responding urban beekeepers tended to be hobbyist rather than professional.
- 92% of beekeepers in our sample belonged to at least one formal beekeeping association. This reflects our sampling procedure in which beekeepers were mainly contacted to take the survey via beekeeping associations. Beekeepers located in Northern Europe were the most active in beekeeping associations, and beekeepers located in Eastern Europe were the least active.
- One fourth of our sample was active as chairperson, secretary or board member of a beekeeping association, suggesting that many beekeepers within our sample are quite passionate about beekeeping.
- The majority of beekeepers in our sample (82%) had attended one or more starter courses in beekeeping and 60% had attended one or more advanced courses, and 59% reported attending training activities several times a year.
- Attending training courses is associated with less experience, being a hobby beekeeper, and not inheriting beekeeping practices from parents or grandparents.
- One third of the beekeepers in our sample reported being migratory beekeepers, and these beekeepers tended to be more in the Eastern region of Europe, professional beekeepers and also beekeepers who had inherited their beekeeping practice.

3.3 Beekeepers' motivations

Beekeepers were asked to indicate to what extent the following reasons applied to them as personal motivation for keeping honey bees on a 5-point Likert scale (1=not at all, 5=definitely yes), in which *passion for beekeeping* received the highest mean agreement score among the entire sample (see Figure 9).

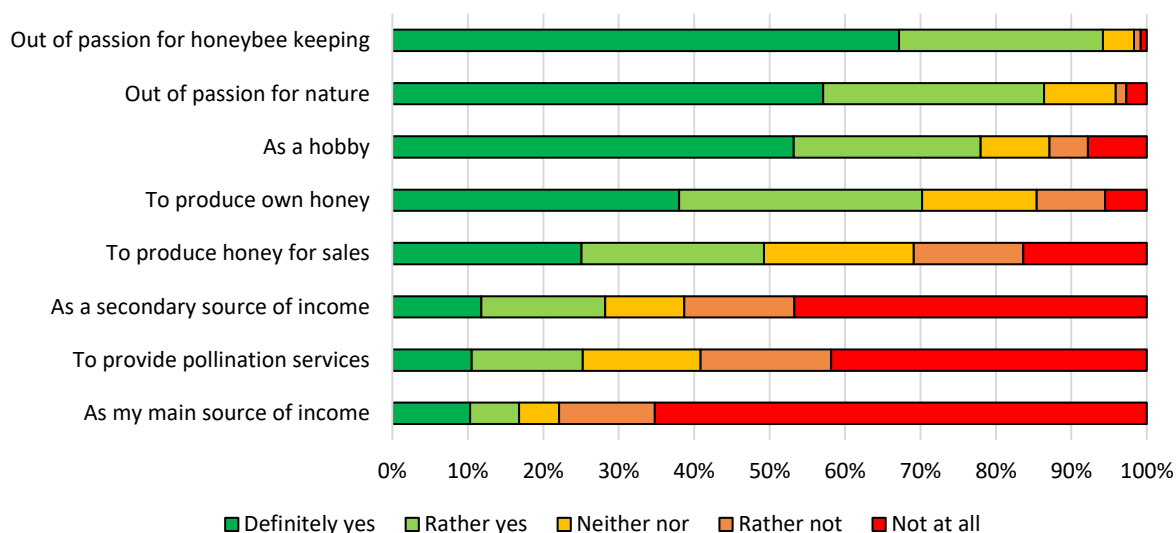


Figure 9. Mean agreements scores for 8 reasons for keeping honey bees (%; n=844)

Motivations to keep honey bees between professional and hobby beekeepers are compared in Table 18, where mean agreement scores between professional and hobby beekeepers are presented.

Table 18. Mean agreement scores for motivation for beekeeping for total sample, hobby and professional beekeepers (n=844)

	Total sample		Based on size	
	Mean	SD	Hobb.	Prof.
Out of passion for beekeeping	4.59	0.695	4.59	4.56
Out of passion for nature	4.37	0.914	4.37	4.35
As a hobby	4.10	1.234	4.41	2.79
To produce own honey	3.88	1.173	3.92	3.71
To produce honey for sales	3.27	1.405	2.94	4.71
To provide pollination services	2.35	1.412	2.21	2.94
As a secondary source of income	2.32	1.481	2.07	3.40
As my main source of income	1.84	1.368	1.36	3.91

Among the total sample, passion for beekeeping, passion for nature, and as a hobby received the highest mean agreement scores, whereas as the main source of income received the lowest mean agreement score. Mean agreement scores for hobby beekeepers reflected the entire sample in which they exhibited highest mean agreement scores for *out of passion for beekeeping* and lowest for *as main source of income*. Professionals exhibited the highest mean agreement scores for producing honey for sales and lowest as a hobby.

Independent samples *t*-tests were performed to explore differences on all 8 motivations between hobby and professional beekeepers based on size, where the two groups differed significantly on all motivations except for *out of passion for beekeeping*, *out of passion for nature and the ecological environment*, and *to produce honey for own consumption* (all otherwise $p < 0.001$). Differences in motivation between different types of beekeeper are further elaborated in Section 3.8, where specific beekeeper groups and segments are identified and profiled.

Discriminant factor analysis was performed on seven of the eight motivation items, excluding “To provide pollination services” since pollination services were only practised by 10% of beekeepers in the sample. A three-factor solution emerged which explained 72% of the variance in the original data (see Table 19). The resulting factors were labelled as **economic**, **passion**, and **own honey**. The factor labelled **economic** (Cronbach’s $\alpha = 0.77$) incorporated items concentrating on keeping honey bees for income or sales. The factor labelled **passion** ($\alpha = 0.63$) contained items about passion for beekeeping or the ecological environment. The factor labelled **own honey** ($\alpha = 0.31$) consisted of statements about producing honey for own consumption as a hobby beekeeper.

Table 19. Rotated factor loadings of the factor analysis of the motivations to keep honey bees, with 3 factors labelled economic, passion and own honey (n=844)

Item	F1: Economic	F2: Passion	F3: Own Honey
To produce honey for sales	0.836²	0.008	0.130
As my main source of income	0.807	0.025	-0.236
As a secondary source of income	0.775	0.000	0.285
Out of passion for nature and the ecological environment	-0.030	0.855	0.040
Out of passion for honey bee keeping	0.009	0.855	0.090
As a hobby	-0.639	0.144	0.470
To produce honey for own consumption	0.072	0.087	0.891

²Boldface type indicates items and their loading that have a major contribution to each factor.

When comparing scores for the three factors between European regions, Table 20 shows that, for the factor **economic**, highest average factor scores are exhibited in the Eastern region and lowest in the Western region. For the factor **passion**, highest average factor scores are exhibited in the Southern region and lowest in the Northern region, and for the factor **own honey**, highest average factor scores are exhibited in the Eastern region and lowest in the Southern region.

Table 20. Mean factor scores for three factors for motivation by European region (n=844)

Mean Factor Scores				
	n	Economic	Passion	Own Honey
Northern	78	0.417 ^a	-0.415 ^c	0.209 ^a
Western	455	-0.492 ^b	0.029 ^{ab}	-0.064 ^b
Eastern	156	0.608 ^a	-0.137 ^b	0.367 ^a
Southern	155	0.624 ^a	0.262 ^a	-0.288 ^b

a,b,c,d indicate significantly different means among regions for a factor score at the P=0.05-level following Tukey post-hoc tests.

One-way ANOVA tests were conducted to test differences between regions for the three factors, and there was a significant difference between regions for all three factors: economic ($F=112.6$; $p<0.001$), passion ($F=9.4$; $p<0.001$) and own honey ($F=13.6$; $p<0.001$). Tukey post-hoc tests reported that for the factor **economic**, Western regions differed significantly and had lower scores than the other regions. For the factor **passion**, Northern regions differed significantly and had lower scores than the other regions, and Southern regions differed significantly and had higher scores than the Eastern and Northern regions. For the factor **own honey**, Southern and Western regions differed significantly and had lower scores than the Northern and Eastern regions.

We found beekeepers' age to be correlated with the factor **economic** ($r = -0.32$, $p<0.001$) but not **passion** or **own honey**, which suggests that younger beekeepers may be more motivated by economic reasons. No significant differences were found between male and female beekeepers for all three factors. Regarding differences in education levels, there was a significant difference between beekeepers with a non-university/university college education and those with a university education (bachelor, master, or higher) on the factor **economic** ($F=4.1$; $p<0.001$), where those with a non-university/university college education scored significantly higher on this factor.

Regarding differences between professional and hobby beekeepers, we found significant differences between professional and hobby beekeepers based on size for the factor **economic** ($t = -31.7$; $p<0.001$), where professional beekeepers were more driven by economic reasons. We found significant differences between professional and hobby beekeepers based on size for the factor **own honey** ($t=5.2$; $p<0.001$), where hobby beekeepers were more driven by producing **own honey** for own consumption. No significant differences were found between professional and hobby beekeepers on the factor **passion**, which suggests that both groups are similarly passionate about their beekeeping practice.

Regarding differences between beekeepers with less than 5 years of experience, 6-15 years of experience and 16 years or more of experience, there was a significant difference between the three experience groups for the factor **economic** ($F=19.02$; $p<0.001$), where beekeepers with less than 5 years of experience scored significantly lower on this factor, suggesting that beekeepers with lower experience levels may be less economically motivated.

In summary, the following information can be drawn about beekeepers' motivations to keep honey bees:

- Beekeepers were the most highly motivated by passion to keep honey bees, either passion for beekeeping itself or out of passion for nature, and were least motivated by gaining a main source of income from their beekeeping practices.
- Beekeepers in the Eastern region of Europe tended to be more motivated by economic reasons and by wanting to produce their own honey, whereas beekeepers in the Southern region tended to be motivated by passion.
- Beekeepers in the Western region tended to be less motivated by economic reasons.
- Having a strong motivation for economic reasons may be correlated with being a younger beekeeper and also having a non-university/university college education..
- Professional beekeepers were more driven by economic reasons, whereas hobby beekeepers were more driven by producing own honey for own consumption.
- No significant differences were found between professional and hobby beekeepers on the factor passion, which suggests that both groups are similarly passionate about their beekeeping practice.
- Finally, beekeepers with very little beekeeping experience (less than 5 years) tended to be less motivated by economic reasons.

3.4 Beekeepers' orientations towards honeybees and beekeeping

As a major focal point for this study is the assessment of beekeepers' values, attitudes, orientation and opinions in relation to beekeeping, we included a 9-item construct based on previous studies by Austin et al. (2005) and de Graaf et al. (2016). These nine items have been selected from the 13 items used by de Graaf et al. (2016) to assess farmers' attitudes towards dairy cows, who in turn selected those items from the original 75-item construct used by Austin et al. (2005) to study attitudes towards farm animal welfare. Only a limited number of those items fitted with the context of beekeeping and their formulation has been adapted accordingly. These studies demonstrated that these items may capture two superordinate dimensions which have been referred to as a '**natural living orientation**' and a '**business orientation**'. These dimensions have also been referred to as **affect vs. utility**, representing people's affective / emotional responses to animals, and people's responses to animals based on their instrumental value, respectively.

Each item was assessed on a 5-point Likert scale (1=strongly disagree, 5=strongly agree). Figure 10 shows the nine items used in the survey with their agreement scores, where item 1: "Honey bee colonies should be ideally kept in a suitable environment that is as natural as possible" received the highest agreement score among the entire sample.

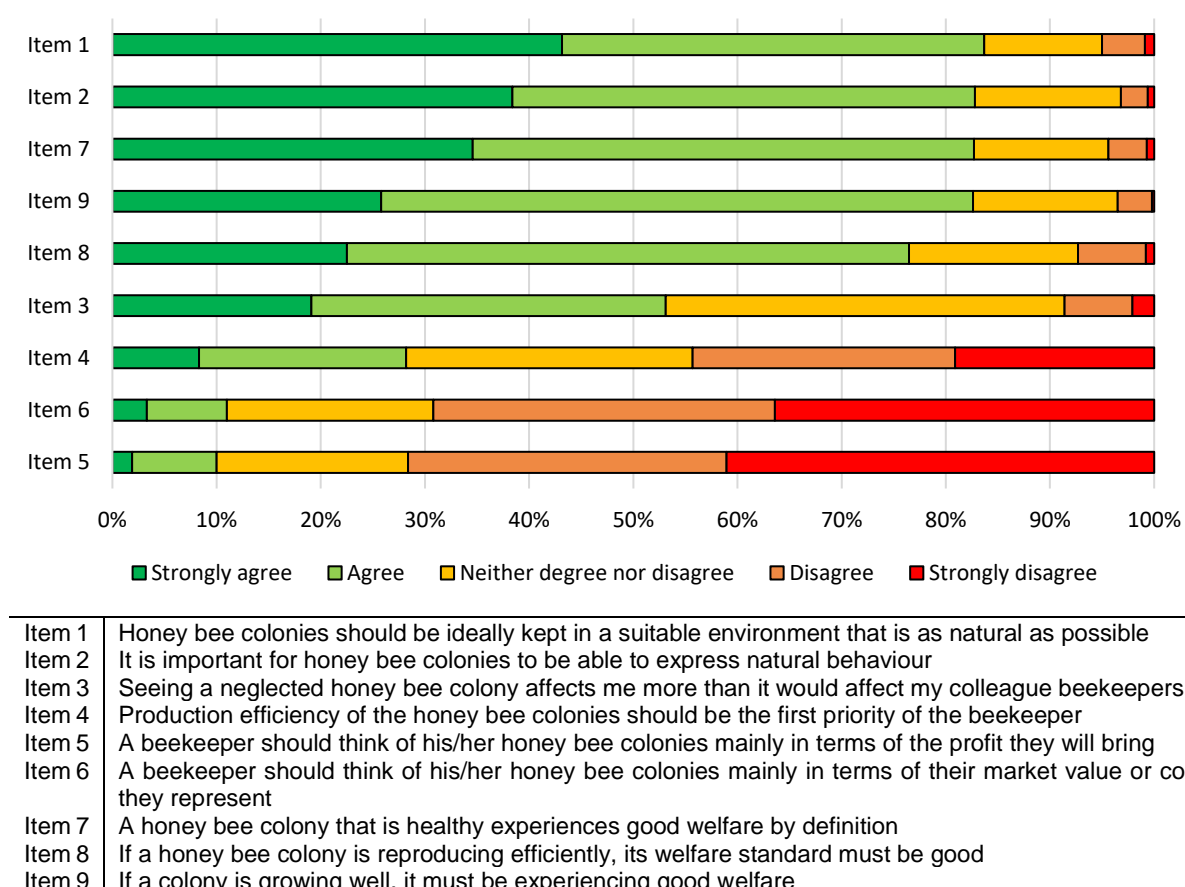


Figure 10. Agreements scores for 9 beekeeper orientation items (% , n=844)

Mean agreement scores for the nine beekeeper orientation items between professional and hobby beekeepers are compared in Table 21.

Table 21. Mean agreement scores for beekeeper orientation items for the total sample, hobby and professional beekeepers (n=844)

	Total sample		Based on size	
	Mean	SD	Hobby	Profes siona
Item 1: Honey bee colonies should be ideally kept in a suitable environment that is as natural as possible	4.21	0.868	4.18	4.34
Item 2: It is important for honey bee colonies to be able to express natural behaviour	4.17	0.807	4.19	4.09
Item 7: A honey bee colony that is healthy experiences good welfare by definition	4.12	0.821	4.07	4.33
Item 9: If a colony is growing well, it must be experiencing good welfare	4.05	0.741	3.99	4.27
Item 8: If a honey bee colony is reproducing efficiently, its welfare standard must be good	3.91	0.846	3.85	4.18
Item 3: Seeing a neglected honey bee colony affects me more than it would affect my colleague beekeepers	3.61	0.937	3.52	4.01
Item 4: Production efficiency of the honey bee colonies should be the first priority of the beekeeper	2.73	1.215	2.50	3.73
Item 6: A beekeeper should think of his/her honey bee colonies mainly in terms of their market value or cost they represent	2.09	1.078	1.90	2.88
Item 5: A beekeeper should think of his/her honey bee colonies mainly in terms of the profit they will bring	1.99	1.043	1.79	2.87

Among the total sample, item 1: “Honey bee colonies should be ideally kept in a suitable environment that is as natural as possible” received the highest mean agreement score, and item 5: “A beekeeper should think of his/her honey bee colonies mainly in terms of the profit they will bring” received the lowest mean agreement score.

Observed in Table 21, mean agreement scores for both hobby and professional beekeepers were all lowest for item 5: “A beekeeper should think of his/her honey bee colonies mainly in terms of the profit they will bring.” Professionals based on size had the highest mean agreement score for item 1: “Honey bee colonies should be ideally kept in a suitable environment that is as natural as possible.” Hobbyists had the highest mean agreement score for item 2: “It is important for honey bee colonies to be able to express natural behaviour.”

Independent samples *t*-tests were performed to explore differences on all nine beekeeper orientation items between hobby and professional beekeepers, where hobby and professionals based on size differed significantly on all beekeeper orientation items (largest $p=0.027$) except for item 2: “It is important for honey bee colonies to be able to express natural behaviour”. Differences in orientations towards honey bees and beekeeping between different types of

beekeepers are further elaborated in Section 3.8 where specific beekeeper groups and segments are identified and profiled.

Similar to the approach adopted by Austin et al. (2005) and de Graaf et al. (2016), factor analysis was implemented to assess the presence of an underlying structure in the data, also in our case relating to beekeeping. Initial factor analyses of the nine items suggested the stepwise exclusion of two items due to low communality values, i.e. the resulting factor solution explained a too low share of the variance in those two original items. These items were: “Seeing a neglected honey bee colony affects me more than it would affect my colleague beekeepers” and “A honey bee colony that is healthy experiences good welfare by definition.”

Factor analysis was repeated on the remaining seven items. A three-factor solution emerged which explained 73% of the variance in the original data. The resulting factors were labelled as **business orientation**, **performance equals welfare orientation** and **natural orientation** (Table 22). The factor labelled **business orientation** (Cronbach’s $\alpha = 0.84$) contained items about considering honey bee colonies as a tool to gaining a profit, representing market value and from whom production efficiency is the first priority. This factor corresponds with the previously mentioned utility-dimension.

The factor labelled **performance equals welfare orientation** ($\alpha = 0.67$) consisted of items in which good welfare is closely associated with a honey bee colony’s health and performance, which corresponds with the ‘functioning orientation’ as reported by de Graaf et al. (2016). The factor labelled **natural orientation** ($\alpha = 0.46$) consisted of items about the importance of a natural environment for honey bees and their ability to express natural behaviour, thus corresponding with the previously mentioned affect-dimension. The factors business orientation and natural orientation are further used in Section 3.8.2, where the two items with highest factor loadings for each factor are used as segmentation variables.

Table 22. Rotated factor loadings of the factor analysis of beekeeper orientations towards honey bees and beekeeping, three-factor solution (n=844)

Item	F1: Business orientation	F2: Performance equals welfare orientation	F3: Natural orientation
A beekeeper should think of his/her honey bee colonies mainly in terms of their market value or cost they represent	0.906 ²	0.031	-0.031
A beekeeper should think of his/her honey bee colonies mainly in terms of the profit they will bring	0.896	0.005	-0.078
Production efficiency of the honey bee colonies should be the first priority of the beekeeper	0.791	0.242	0.029
If a colony is growing well, it must be experiencing good welfare	0.062	0.869	0.060
If a honey bee colony is reproducing efficiently, its welfare standard must be good	0.125	0.833	0.144
Honey bee colonies should be ideally kept in a suitable environment that is as natural as possible	0.059	0.100	0.809
It is important for honey bee colonies to be able to express natural behaviour	-0.121	0.085	0.791

²Boldface type indicates items and their loading that are included in each factor.

When comparing scores for the three factors between beekeepers from different European regions, Table 23 shows that, for the factor **business orientation**, highest mean factor scores are exhibited in the Eastern region and lowest in the Western region. For the factor **performance equals welfare orientation**, highest mean factor scores are exhibited in the Eastern region and lowest in the Western region, and for the factor **natural orientation**, highest mean factor scores are exhibited in the Southern region and lowest in the Northern region.

One-way ANOVA F-tests were conducted to test differences between regions for the three factors, and there was a significant difference between regions for all three factors: **business orientation** ($F=77.7$; $p<0.001$), **performance equals welfare orientation** ($F=3.86$; $p<0.05$), and **natural orientation** ($F=3.67$; $p<0.05$). Tukey post-hoc tests reported that, for the factor **business orientation**, all four regions differed significantly, with beekeepers in the Western region of Europe scoring lowest on this factor, followed by the Northern region, Southern region and finally beekeepers in the Eastern region, who scored highest on this factor. For the factor **performance equals welfare orientation**, the Eastern region differed significantly and had higher scores than the Western and Northern regions. For the factor **natural orientation**, beekeepers in the Northern region differed significantly from and scored lower on this factor than all other regions.

Table 23. Mean factor scores for three factors for beekeeper orientation by European region (n=844)

	n	Mean Factor Scores		
		Business orientation	Performance equals welfare orientation	Natural orientation
Northern	78	0.090 ^c	-0.071 ^b	-0.310 ^b
Western	455	-0.400 ^d	-0.072 ^b	-0.013 ^a
Eastern	156	0.753 ^a	0.236 ^a	0.058 ^a
Southern	155	0.370 ^b	0.011 ^{ab}	0.135 ^a

a,b,c,d indicate significant different means within a column at the P=0.05-level following Tukey post-hoc tests.

We found beekeepers' age to be negatively correlated with the factor **business orientation** ($r = -0.21$, $p < 0.001$) and positively correlated with **performance equals welfare orientation** ($r = 0.1$; $p < 0.05$) but not **natural orientation**. Younger beekeepers may have more of a **business orientation** and older beekeepers may have a more **performance equals welfare orientation**. Note that the bivariate correlation coefficients, though significant, are very small. No significant differences were found between male and female beekeepers for all three factors. No significant differences were found between beekeepers with non-university/university college education, a bachelor's level education, or masters level education or higher for all three factors.

Regarding differences between professional and hobby beekeepers, we found significant differences between professional and hobby beekeepers based on size for the factor **business orientation** ($t = -14.02$; $p < 0.001$), where professional beekeepers were more business oriented. We found significant differences between professional and hobby beekeepers based on size for the factor **performance equals welfare orientation** ($t = -3.77$; $p < 0.001$), where professionals were more *performance equals welfare* oriented. No significant differences were found between professional and hobby beekeepers for the factor **natural orientation**, which suggests that both groups are similarly naturally oriented towards their beekeeping practice.

Regarding differences between beekeepers with less than 5 years of experience, 6-15 years of experience and 16 years or more of experience, there was a significant difference between the three experience groups for the factor **business orientation** ($F = 20.55$; $p < 0.001$), in which beekeepers with less than 5 years of experience scored significantly lower on this factor, and **performance equals welfare orientation** ($F = 5.96$; $p < 0.05$), in which beekeepers with 16 years or more of experience scored significantly higher on this factor.

In summary, the following information can be drawn about beekeepers' orientations towards honey bees and beekeeping:

- Beekeepers were in high agreement that honey bee colonies should be ideally kept in a suitable environment that is as natural as possible, and that it is important for honey bee colonies to be able to express natural behaviour.
- Beekeepers shared the lowest agreement that a beekeeper should think of his/her honey bee colonies mainly in terms of the profit they will bring.

- Beekeepers residing in the Eastern region of Europe may have a more business and/or 'performance equals welfare' orientation towards their beekeeping practice, and beekeepers in the Southern region may have a more natural orientation.
- Beekeepers residing in the Western region of Europe may have less of a business and/or performance equals welfare orientation.
- Beekeepers in the Northern region may have less of a natural orientation to their beekeeping practice.
- Younger beekeepers may have more of a business orientation and older beekeepers may have a more performance equals welfare orientation towards their beekeeping practice, however the associations are very small.
- Professional beekeepers were significantly more business oriented and significantly more performance equals welfare oriented than hobbyists.
- No significant differences were found between professional and hobby beekeepers for natural orientation, which suggests that both groups are similarly naturally oriented towards their beekeeping practice.
- Finally, beekeepers with very little beekeeping experience (less than 5 years) may have less of a business orientation, and beekeepers with 16 years or more of experience may have more of a performance equals welfare orientation.

3.5 Beekeeping management practices

A substantial part of the survey was devoted to assessing beekeepers' implementation of specific beekeeping management practices. Literature review formed the starting point for composing an initial list of beekeeping management practices for eventual inclusion in the survey (FAO, 2015; Rivera-Gomis et al., 2019; FAO, 2020). This initial list was reduced to a manageable number of items (e.g. the proposed list by Rivera-Gomis et al. contains 140 items) based on insights from the stakeholder interviews performed within Task 4.1 and feedback from B-GOOD consortium members who were involved in the drafting and pre-testing of the survey questionnaire.

Following an internal evaluation workshop at the B-GOOD Consortium Meeting 6 (December 2021) involving B-GOOD consortium members who are experts in beekeeping, a consensus set of 11 items was identified as signalling good beekeeping management practices across different European regions and beekeeper types. This set of items are further referred to as 'Good Beekeeping Management Practices' (GBMP) and form the basis for constructing an aggregated GBMP-index.

In the following sections, differences in the implementation of beekeeping management practices between professional and non-professional beekeepers and between beekeepers from different European regions were assessed by means of cross-tabulation and chi-square association tests. Professional beekeepers (n=160) were those who reported to be 'rather professional' or 'fully professional' based on the size and economic value of their beekeeping activities; the other study participants are referred to as 'non-professional beekeepers'.

It should be noted that specific items relating to colony health status checks were covered in another section of the survey. Findings from the section on colony health are reported in Section 3.7 of this deliverable.

Management of queens and colonies

A first question related to the management of queens and honey bee colonies probed for the frequency of **queen replacement**. The majority of beekeepers (44.0%) reported to replace queens 'every two or three years'; one quarter (25.1%) reported to replace queens 'only when they no longer perform well'. Finally, 18.2% reported to never replace queens but 'leave it to the bees to decide' and 12.7% to replace queens 'every year'. The frequency of queen replacement was significantly higher among professional vs. non-professional beekeepers: 17.5% and 59.4% of the professional beekeepers reported to replace queens 'every year' and 'every two or three years', respectively, vs. 11.5% and 40.4% among non-professional beekeepers (chi-square=36.1; $p<0.001$). More than one fifth (21.1%) of the non-professional beekeepers reported to never replace queens but 'leave it to the bees to decide' vs. only 5.8% among professional beekeepers. The frequency of queen replacement also differed significantly across European regions with 'never' replacing queens being most common among Western European beekeepers; replacing queens 'every two or three years' being most common among Northern European and Eastern European beekeepers; and replacing queens 'when they no longer perform well' among Southern European beekeepers (chi-square=88.6; $p<0.001$).

A second set of questions pertained to **purchasing queens and colonies from others**. About one third (36.4%) of the beekeepers reported to never purchase queens from others; almost two thirds (64.9%) reported to never purchase honey bee colonies from others. In case queens or colonies were purchased from others, this mostly concerned less than 20% of the apiary's stock. The frequency of purchasing queens from others was significantly higher among professional beekeepers compared to non-professionals, e.g. 22.5% of the professionals reported to purchase 20-50% of their queens from others vs. only 10.5% of the non-professionals (chi-square=22.6; $p<0.001$). Purchasing queens from others was significantly more common among Northern and Eastern European beekeepers (chi-square=94.7; $p<0.001$). A similar significant association between purchasing honey bee colonies from others across the European region was observed. Purchasing 'at least some but less than 20% of [my] colonies' was most common among Eastern and Northern European beekeepers (chi-square=22.7; $p=0.007$).

Findings related to a third set of items are summarised in Figure 11. **Quarantine measures** for new introductions to the apiary were 'always' observed by 43.2% of the beekeepers vs. 27.3% who reported to 'never' observe such measures. The degree of observing quarantine measures did not differ significantly between professional and non-professional beekeepers while 'always' observing quarantine measures was significantly less common among Southern European beekeepers (chi-square=22.0; $p=0.001$).

Queen marking emerged as a common practice by almost half of the beekeepers (47.0%) whereas one quarter (25.7%) reported to 'never' mark queens (see Figure 11). The marking of queens was significantly more practised by professional beekeepers (58.8% 'always') compared to non-professionals (44.3% 'always') (chi-square=13.76; $p=0.001$). With respect to European regions, queen marking emerged as more common in Eastern and Northern European regions (with 54.5% and 52.6% indicating 'always') and least common in Southern European regions where only one third (34.2%) of the beekeepers reported to 'always' mark queens (chi-square=20.2; $p=0.003$).

Raising own queens was practised by 37.0% of the beekeepers. This management practice was significantly more common among professional beekeepers, of whom 49.4% reported 'always' (chi-square=34.3; $p<0.001$). Significant regional differences were observed, with a relatively high share (31.6%) of Southern European beekeepers indicating 'never', relatively high shares of Northern European (48.7%) and Eastern European (40.4%) beekeepers indicating 'sometimes to mostly', and a high share of Western European (42.9%) beekeepers indicating 'always' (chi-square=20.6; $p=0.002$).

A small proportion of the beekeepers (12.8%) reported to **participate in breeding programmes**. This proportion was significantly higher among professional beekeepers (24.4%) (chi-square=31.1; $p<0.001$); higher among Western European beekeepers (where 15.2% reported 'always') and lower among Northern European beekeepers (where 82.1% reported 'never') (chi-square=19.4; $p=0.003$).

From the beekeeping management items discussed in this section, consensus was reached for one item to be included in the **GBMP-index**, namely '**I observe quarantine measures for all new introductions to my apiary**'. Although several of the other items might also signal good practice, their implementation or adherence to them was believed to depend largely on either beekeeper type, management style, regional habits or local circumstances.

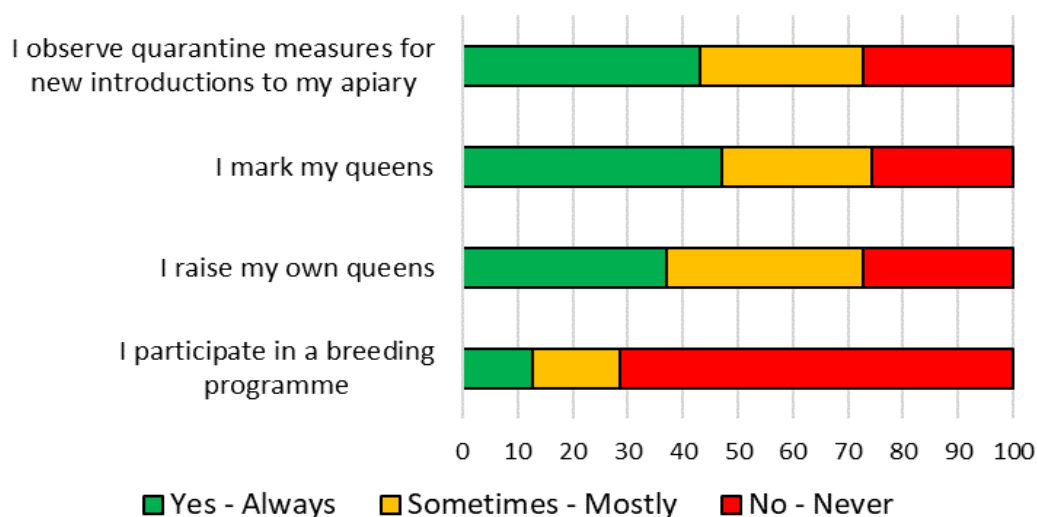


Figure 11. Beekeeping management practices related to the management of queens and honey bee colonies (% , n=844)

Comb replacement and wax recycling

First, beekeepers were asked to report the **percentage of combs replaced on an average annual basis** using a ratio scale from 0-100. The frequency distribution displayed in Figure 12 indicates that participants mostly reasoned in multiples of ten with 30% emerging as the most frequent reported number (22.4% of the beekeepers), followed by 50% (15.2%) and 20% (12.2%). Almost one fifth (19.1%) reported to replace only 10% or less of their combs on an average annual basis. The sample mean was 30.8%. The mean percentage of combs replaced on an average annual basis did not differ significantly between professional and non-professional beekeepers, but it differed significantly between European regions ($F=59.6$; $p<0.001$). Mean percentage of comb replacement was significantly higher among Eastern (36.3%) and Western (35.2%) European beekeepers, compared to Northern European beekeepers (25.4%), who in turn reported a significantly higher percentage combs replaced than Southern European beekeepers (14.9%).

As second set of questions reported in this section probed for practices related to **wax recycling and reuse**, i.e. the eventual implementation of an 'own closed wax cycle', which typically involves the recycling of wax from honey capping and honey chambers while excluding wax from older, dark and possibly polluted old brood frames. Almost one third (30.0%) of the beekeepers reported that all the beeswax they use comes from their own closed wax cycle. Another third (33.5%) reported to not recycle and reuse their own wax. Equal shares of 18.2% reported that 'less than 50%' or 'more than 50% but not all' of the wax they use originates from their own closed wax cycle.

The practice of implementing an own closed wax cycle was significantly more common among professional beekeepers, of whom almost half (48.8%) reported their own cycle as their only source of beeswax ($\chi^2=37.2$; $p<0.001$). In a similar vein, only 19.1% of the professional

beekeepers vs. 36.8% of the non-professional beekeepers reported to not recycle and reuse their own wax. The implementation of an own closed wax cycle was significantly less common among Northern European beekeepers, where only 9.0% reported to implement this practice vs. 57.7% who reported not to recycle and reuse their own wax (chi-square=32.8; $p<0.001$).

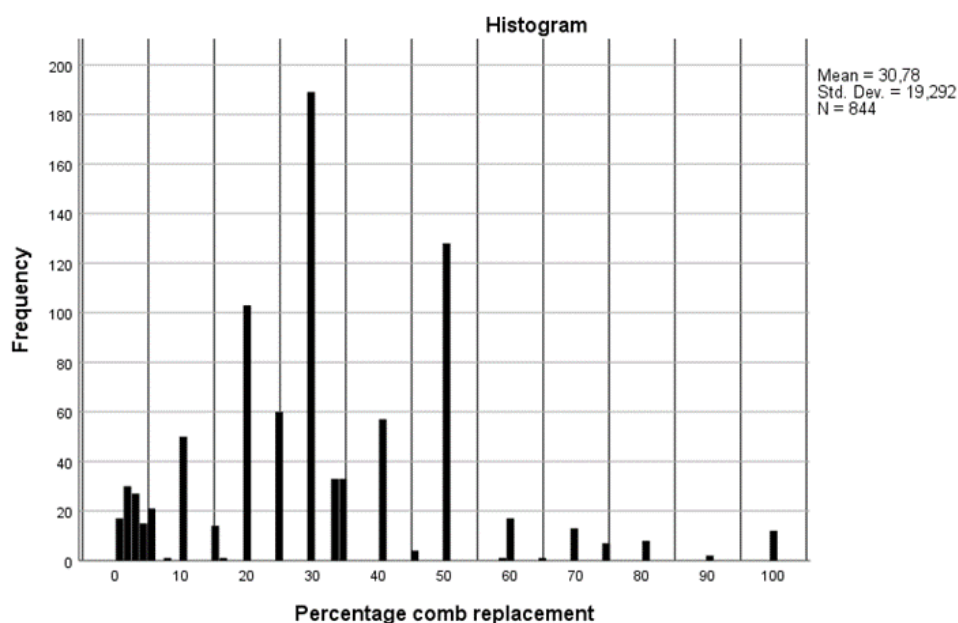


Figure 12. Histogram (frequency distribution) of beekeepers' reported average annual percentage of comb replacement (n=844)

The practice of implementing an own closed wax cycle was significantly more common among professional beekeepers, of whom almost half (48.8%) reported their own cycle as their only source of beeswax (chi-square=37.2; $p<0.001$). In a similar vein, only 19.1% of the professional beekeepers vs. 36.8% of the non-professional beekeepers reported to not recycle and reuse their own wax. The implementation of an own closed wax cycle was significantly less common among Northern European beekeepers, where only 9.0% reported to implement this practice vs. 57.7% who reported not to recycle and reuse their own wax (chi-square=32.8; $p<0.001$).

With respect to **beeswax purchasing**, beekeepers reported to predominantly purchase 'local (not imported) wax' (49.2%), followed by 'wax with a specific certification other than local or organic' (29.4%) and 'organic wax' (21.8%). Professional beekeepers opted significantly more often for organic wax in case of beeswax purchasing (chi-square=13.7; $p<0.001$), as did Southern European beekeepers (chi-square=61.5; $p<0.001$). 'Local (not imported) wax' emerged significantly more as the preferred choice of Southern, Eastern and Northern European beekeepers as compared to Western European beekeepers (chi-square=41.2; $p<0.001$). Western European beekeepers opted in turn more frequently for 'wax with a specific certification other than local or organic' (chi-square=36.2; $p<0.001$).

Items relating to **comb replacement** and **wax recycling** as discussed in this section were **not included** in the **GBMP-index** despite agreement that both practices might in fact signal good beekeeping management practice. Multiple reservations were raised by experts with respect to considering wax recycling as GBMP, e.g. that the possibility to implement this practice largely depends on the size of the apiary, on the eventual provision of the service of making

wax foundation by beekeepers' associations, or that it requires substantial investment from individual beekeepers. However, the most important reservation was that recycling can only be considered as good practice assuming that beekeepers implement rigorous triage of their beeswax and that they are aware of the eventual presence of contaminants or harmful residues in their wax. As the average annual percentage of comb replacement was assessed on a ratio scale (thus providing a continuous scale metric), this variable will be used as a **separate indicator of good management** in further analysis rather than merging or integrating it with the GBMP-index.

Administration and record keeping

Five items referring to administrative beekeeping management practices were included in the survey. Almost three quarters (72.6%) of the beekeepers reported that their beekeeping activities are **officially registered** in line with their national guidelines, systems or registers. **Identifying hives** with a unique code or number for documentation was a common practice among slightly more than half of the beekeepers (54.1%). Among administrative record keeping, **productive records** of honey bee colonies are most commonly kept track of (44.7%) followed by **economic records** (34.0%), whereas **time record** keeping is clearly less common among European beekeepers (14.6%) (see Figure 13).

Each of these administrative management practices was significantly more common among professional beekeepers compared to non-professional beekeepers (all practices, $p < 0.001$). The difference was most obvious as concerns keeping track of economic records, which was never done by 43.1% of the non-professional beekeepers vs. only 7.5% of the professionals (chi-square=101.3; $p < 0.001$). Official registration as well as each of the included record keeping activities were significantly less common among Western European beekeepers (chi-square association tests; all $p < 0.001$). Northern European beekeepers stood out as the most active with respect to productive as well as economic record keeping; Southern European beekeepers with respect to official registration of their beekeeping activities and time record keeping; and Eastern European beekeepers with respect to hive identification using a unique code or number for documentation purposes.

None of the items referring to administrative beekeeping management practices has been included in the **GBMP-index** because their implementation or adherence to them was believed to depend largely on either beekeeper type, management style, regional habits or local circumstances. For example, official registration of beekeeping activities is mandatory in some countries (e.g. Belgium) but not in others (e.g. the Netherlands) and it may eventually also depend on the size of the activity.

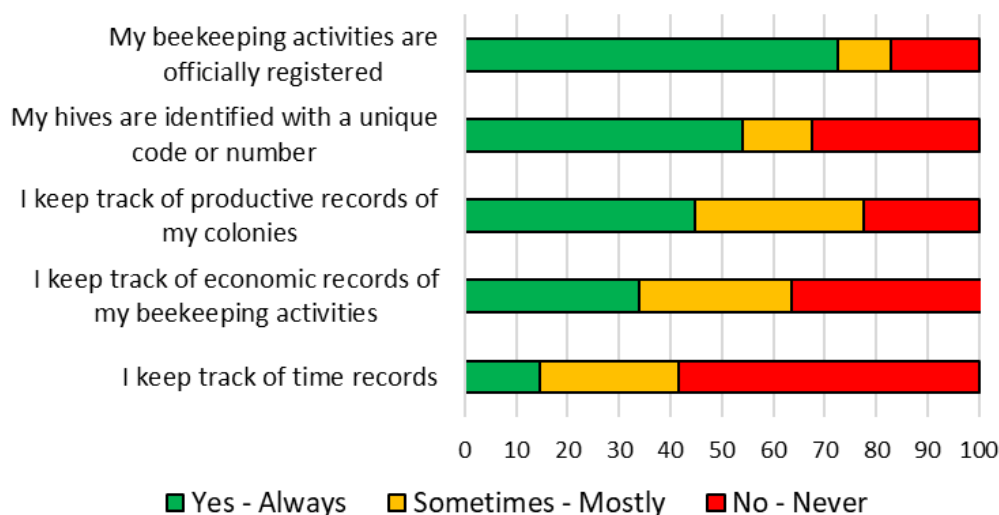


Figure 13. Beekeeping management practices related to administration and record keeping (% , n=844)

Hive monitoring

Three items referring to the monitoring of hives and related actions were included in the survey. Almost three quarters of the beekeepers reported to **monitor and adapt hive capacity** to discourage swarming (73.3%) and to **make efforts to prevent robbing** among colonies (71.3%). Three quarters of the beekeepers (75.1%) also reported to never **make use of a weighing scale** under (at least some of) their hives (see Figure 14).

Each of these beekeeping management activities was implemented significantly more often by professional beekeepers compared to non-professional beekeepers (largest $p=0.004$), with the difference in the use of a weighing scale being the most striking. More than two thirds of the professional beekeepers reported to make use of a weighing scale under at least some of their hives vs. only 9.2% of the non-professional beekeepers (chi-square=88.2; $p<0.001$).

Efforts to prevent robbing among colonies and monitoring and adaptation (enlarging) of the hive volume to discourage swarming were significantly more common among Eastern and Northern European beekeepers (chi-square association tests; both $p<0.001$), whereas beekeepers from these regions differed most strongly among each other with respect to making use of a weighing scale (28.2% by Eastern European vs. 5.1% by Northern European beekeepers) (chi-square=60.3; $p<0.001$).

The two items '**I monitor and adapt hive capacity to discourage swarming**' and '**I make efforts to prevent the act of robbery among colonies**' were included in the **GBMP-index**. There was some discussion whether the first item consistently signals good beekeeping management practice because of the specific purpose ('to discourage swarming') that was explicitly mentioned; the reason is that in some types of beekeeping swarming is deliberately not discouraged, e.g. in order to allow honey bee colonies to express natural behaviour,

multiply colonies or expand the size of the apiary. It was nevertheless decided to integrate this item following considerations about the welfare benefits of discouraging swarming for both the bees, the beekeeper and the neighbourhood.

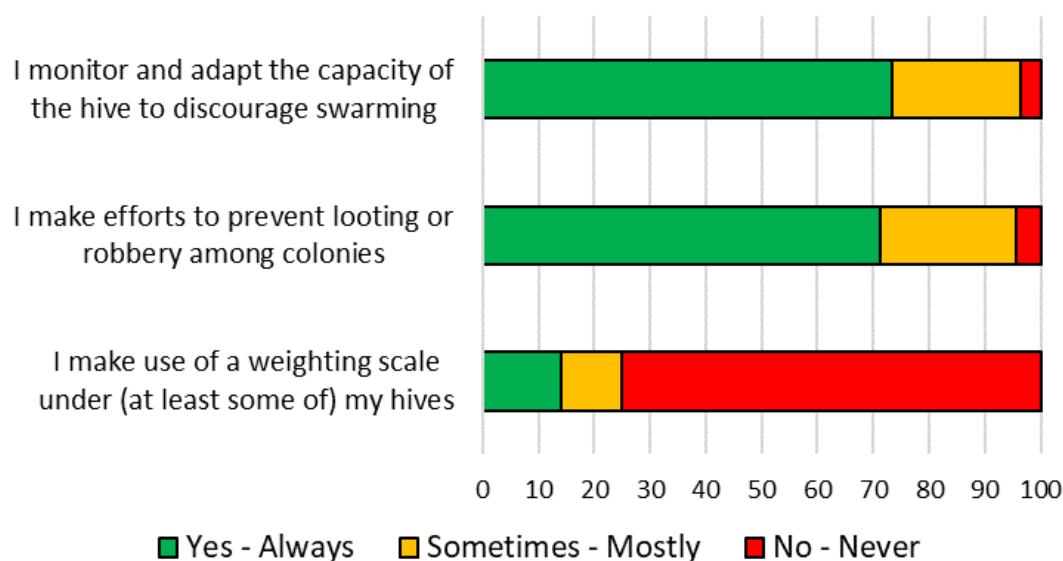


Figure 14. Beekeeping management practices related to hive monitoring and related actions (% , n=844)

Environment management and monitoring

Three items referring to the management and monitoring practices in relation to the natural environment were included in the survey. Almost half of the beekeepers reported to **plant nectar and pollen producing plants** in the neighbourhood of their hives (48.8%) and to periodically **mow the grass or vegetation** in front of their hives (45.7%). A more common practice is **inspecting the suitability of the environment and surroundings** of the hives, which is done by almost two thirds of the beekeepers (64.7%) (See Figure 15).

Mowing the grass or vegetation in front of the hives was more commonly practiced by professional beekeepers (58.1%) than by non-professional beekeepers (42.8%) (chi-square=14.7; $p=0.001$). Professional beekeepers also reported to inspect the suitability of the environment and surroundings of their hives more often (76.3%) compared to non-professional beekeepers (62.0%) (chi-square=12.8; $p=0.002$). By contrast, non-professional beekeepers were more active with respect to planting nectar and pollen producing plants in the neighbourhood of their hives (51.9%) compared to professional beekeepers (35.6%) (chi-square=22.8; $p<0.001$).

Analysis of regional differences revealed that planting nectar and pollen producing plants was most common among Western European beekeepers, mowing grass or vegetation in front of the hives among Eastern European beekeepers, and inspecting the suitability of the environment and surroundings of the hive among Northern European beekeepers (all $p<0.001$).

One of these items, namely '**I inspect the suitability of the environment and surroundings of my hives**' was included in the **GBMP-index**. The two other items were not included in the GBMP-index because their implementation or adherence to them was believed to depend largely on either beekeeper type, management style, regional habits or local circumstances.

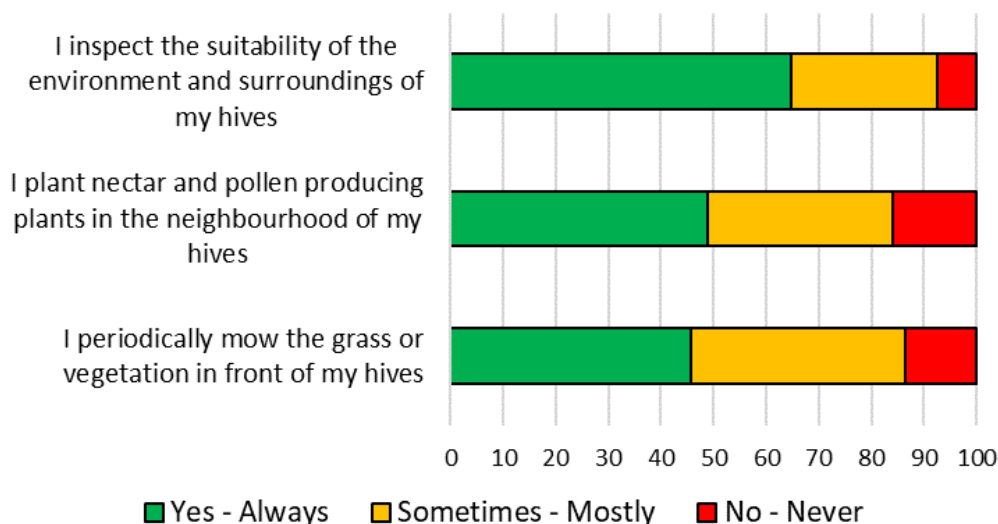


Figure 15. Beekeeping management practices related to environment management and monitoring (%; n=844)

Equipment management

Three items referring to the management of beekeeping equipment were included in the survey. Three quarters (76.4%) of the beekeepers reported to **repair their hives and frames whenever needed**; about half (55.8%) to **regularly clean their beekeeping equipment**; and about one third (37.3%) to **regularly disinfect their beekeeping equipment** (See Figure 16).

Regular cleaning ($p=0.007$) as well as disinfecting ($p<0.001$) beekeeping equipment were significantly more common among professional beekeepers compared to non-professional beekeepers, whereas there was no significant difference among beekeeper groups with respect to repairing hives and frames whenever needed. Regular cleaning and disinfecting of beekeeping equipment was most common among Eastern and Northern European beekeepers, whereas repairing hives and frames was most common among Northern and Western European beekeepers (both $p<0.001$).

The items '**I regularly clean my beekeeping equipment**' and '**I regularly disinfect my beekeeping equipment**' were included in the **GBMP-index**. The item referring to repairing hives and frames was not included in the GBMP-index because its implementation or adherence to it was believed to be standard practice yet influenced by multiple factors (eventually also economic circumstances) rather than good beekeeping management practice *per se*.

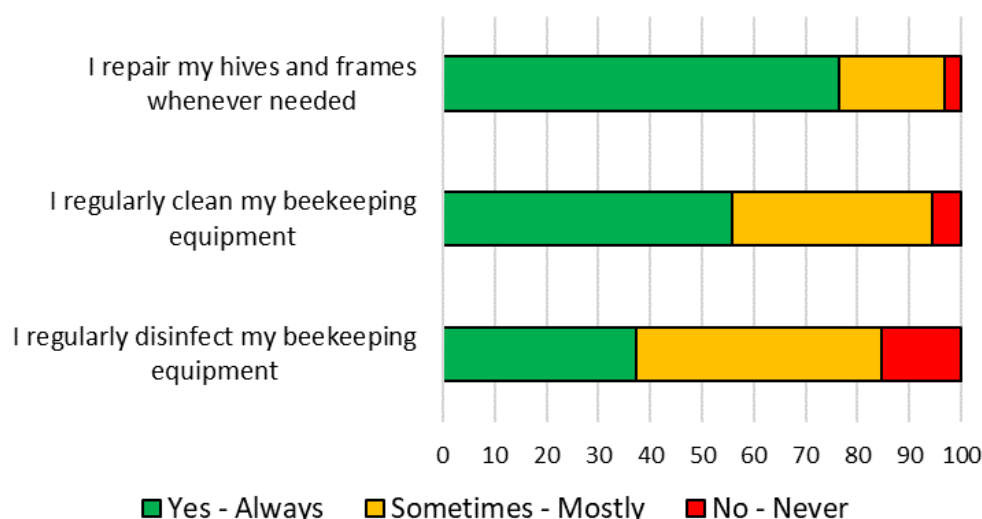


Figure 16. Beekeeping management practices related to equipment management (% , n=844)

Health and welfare monitoring

Six items referring to management practices related to colony health and welfare monitoring were included in the survey. The vast majority of beekeepers reported to **monitor the welfare status** (e.g. food stocks; especially of younger and weaker colonies) (84.4% and 81.5%, respectively) as well as to **monitor the health status** (e.g. absence of diseases) (81.4%) of their colonies, and to **only apply drugs or substances that are officially registered in their country** for use in honey bees (79.0%). About half of the beekeepers reported to **not transfer combs from one colony to another without certainty about the colony's health status** (57.5%) and to **consult experts in case of anomalies** with their bees or hives (52.3%) (see Figure 17).

Professional beekeepers differed significantly from non-professional beekeepers in the sense that they reported to monitor the health status of their colonies (chi-square=18.2; $p<0.001$) and to only apply drugs and substances that are officially registered in their country (chi-square=9.7; $p=0.008$) more often than non-professionals. Professional vs. non-professional beekeepers did not report differences in their monitoring of the welfare status of their colonies ($p=0.083$ for the item referring to 'food stocks' and $p=0.189$ for the item referring to 'especially for younger and weaker colonies'), consulting experts in case of anomalies ($p=0.123$), and transferring combs from one colony to another without certainty about the colony's health status ($p=0.142$).

Significant regional differences were observed in consulting experts in case of anomalies (chi-square=22.8; $p=0.001$) and not transferring combs between colonies without certainty about the colony's health status (chi-square=14.8; $p=0.022$), both of which were least common among Eastern European beekeepers, whereas exclusive application of drugs or substances that are officially registered in the country was least common among Western European beekeepers (chi-square=32.8; $p<0.001$). Specifically, only 44.9% of Eastern European

beekeepers reported to consult experts in case of anomalies vs. 52.3% in the overall beekeeper sample; and more than one quarter (27.7%) of the Western European beekeepers reported not to restrict their application of drugs or substances to those that are officially registered within their country vs. no more than 14% of the beekeepers in other European regions.

Since the response distributions for the two items referring to monitoring of the welfare status of colonies were very similar, only one of the two items has been considered for inclusion in the **GBMP-index**. As a result, **five items** referring to colony health and welfare monitoring practices have been included in the **GBMP-index** because their implementation or adherence to them was believed to be absolutely part of the basic duties and tasks that beekeepers should implement, and thus indispensable for good beekeeping management. There was some discussion about the need for consulting experts in case of anomalies since some beekeepers may be better qualified than others to assess anomalies themselves (e.g. beekeepers who were trained as a veterinarian, or professional beekeepers because of their expertise). Notwithstanding this, there was consensus that this item also deserves to be included in the GBMP-index.

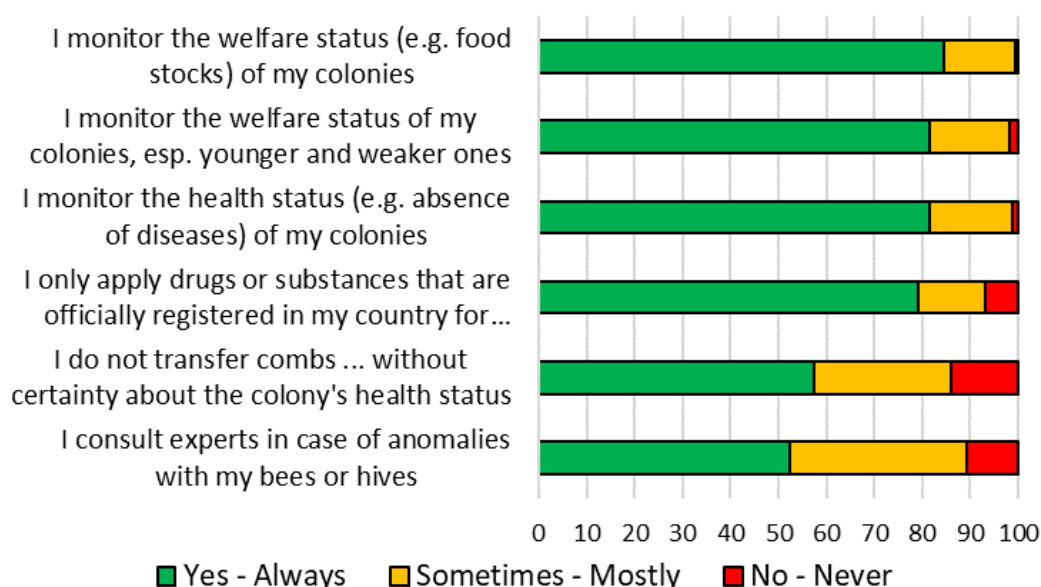


Figure 17. Beekeeping management practices related to honey bee colony health and welfare monitoring (%; n=844)

Other items: use of the bee smoker and honey feeding

For completeness, we also report on two other items that were included in the survey and assessed by beekeepers, but whose formulation has been debated. The statistical distribution of responses reveals possible confusion occurred among participants when completing the survey.

A first item concerns the use of the bee smoker. It is generally considered to be good practice to have a bee smoker at disposal and ready for use during each hive inspection, but also to use it in moderation and only when needed and to avoid its use in specific cases such as during honey harvesting. The survey contained the item '**I use the bee smoker only when**

needed with the same response categories as for the other items, namely 'Yes - Always' (52.6%), 'From sometimes to mostly' (39.9%) and 'No - Never' (7.5%). Across the different language versions, there is a possibility that 'always' and/or 'never' were interpreted as 'I always/never use the bee smoker'. In hindsight, a better response scale would have been 'Yes - Always', 'Only when needed' and 'No - Never', where the middle response category might signal best practice. Because of the possible confusion, this item was not considered for eventual inclusion in the GBMP-index.

A second item concerns the feeding of honey to bees, e.g. as complementary or winter feed. There is consensus that it is good practice not to feed honey to honey bees, unless exceptionally it concerns its own honey that has not been heated (not heating honey prevents the formation of 5-HMF which is toxic for honey bees), whereas it is absolutely bad practice to feed honey from an unknown origin to honey bees. The survey contained the item **'I do not use purchased honey to feed my bees'** with the same response categories as mentioned previously. The response distribution reveals that this wording has raised ambiguity in combination with the response categories 'Yes - Always' (53.3%) and 'No - Never' (44.5%), although its wording had been discussed extensively during the pre-testing and adapted several times prior to launching of the survey. The response frequencies signal that more than 95% of the beekeepers indeed never feed purchased honey to their bees, but because of the possible ambiguity, this item was not considered for eventual inclusion in the GBMP-index.

The 11-item GBMP-index

Following the aforementioned analysis and an internal workshop within B-GOOD, 11 items were selected for inclusion in a Good Beekeeping Management Practice (GBMP-) index. For each of these 11 items, dummy variables were computed taking the value of '1' if a beekeeper responded 'Yes - Always' and '0' otherwise. Next, the 11 dummy coded variables were summated into a 12-point GBMP-index ranging from 0-11 (mean GBMP-index = 7.0; S.D.=2.06) (see Figure 18).

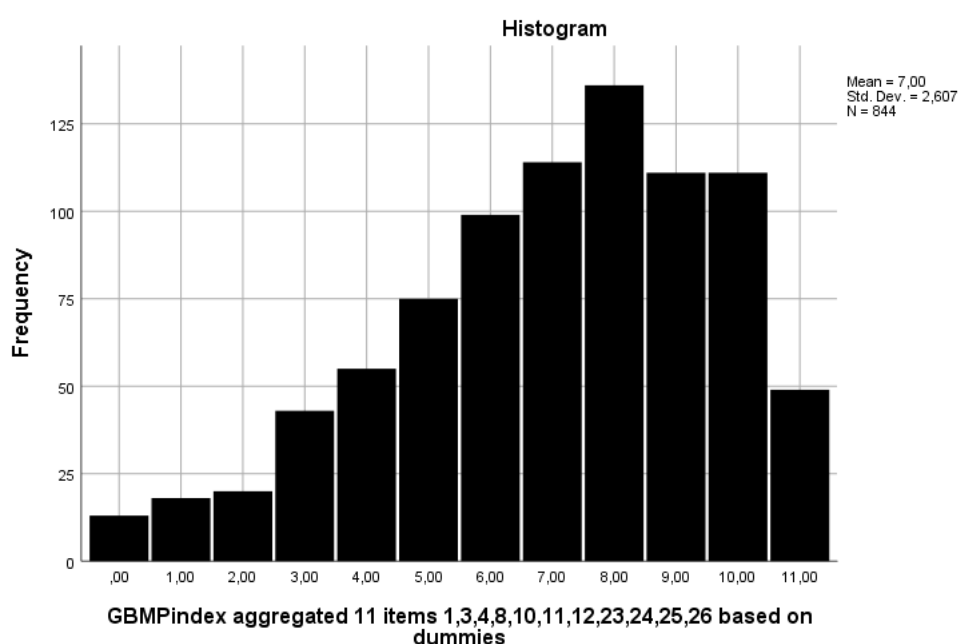


Figure 18. Histogram (frequency distribution) of beekeepers' GBMP-index score (n=844)

Figure 19 provides an overview of the mean GBMP-index scores across selected beekeeper and beekeeping characteristics of beekeepers and reported level of average annual colony winter losses. Mean GBMP-index scores differed significantly between male vs. female beekeepers ($p=0.001$), professional vs. non-professional beekeepers ($p<0.001$), and beekeepers who inherited vs. not inherit beekeeping from their (grand)parents ($p=0.035$) (all p -values based on independent samples t -tests). Mean GBMP-index scores also differed significantly depending on degree of professionalism in beekeeping based on size and economic value of the activities (beekeeper type as reported on a 5-point scale ranging from purely hobby to fully professional) ($p<0.001$), European region ($p<0.001$), and years active as a beekeeper ($p=0.016$) (all p -values based on ANOVA F -tests).

Characteristics of beekeepers with the **highest GBMP-index** scores were obtained using bivariate statistical comparisons, which denotes an analysis involving just two variables (Vetter & Mascha, 2018). Following these analyses, the highest GBMP-index scores were obtained for beekeepers characterised as: **rather or fully professional, Northern European, female, who are 16 or more years active** as a beekeeper, and who **inherited beekeeping** from their (grand)parents.

Most importantly, GBMP-index scores differed between beekeepers depending on their reported percentage average annual colony **winter loss**, with a clear gradient signalling lower winter losses associated with better beekeeping management practice ($F=69.77$; $p<0.001$).

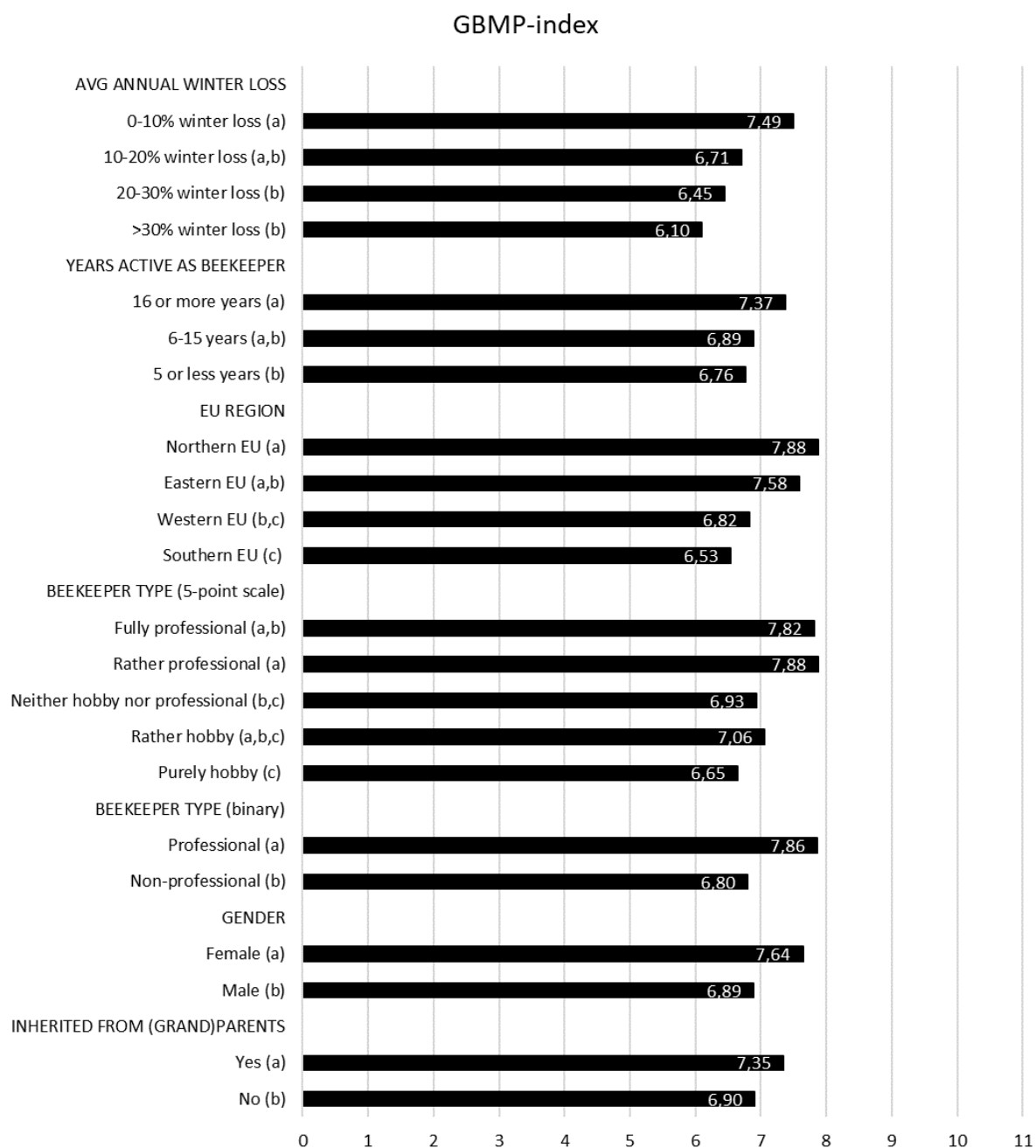


Figure 19. Mean GBMP-index scores across selected beekeeper and beekeeping characteristics of beekeepers and reported level of average annual colony winter losses (n=844); indicators (a,b,c) within a beekeeper or beekeeping characteristic signal significantly different mean scores following independent samples *t*-test or ANOVA F-tests.

Beekeepers who had an **apprenticeship**, attended one or more **advanced courses**, and with a higher **frequency of attending training activities** such as lectures or workshops had a significantly higher GBMP-index score (all $p < 0.001$). By contrast, having attended one or more starter courses did not result in a significantly different GBMP-index score ($p = 0.798$) (see Figure 20). Membership of an **international beekeeper association** ($p = 0.011$) and membership of the **national beekeeper association of their own country** ($p = 0.004$) were also associated with a higher GBMP-index score, whereas membership of a local/regional beekeeper association ($p = 0.382$) did not result in a significantly different GBMP-index score.

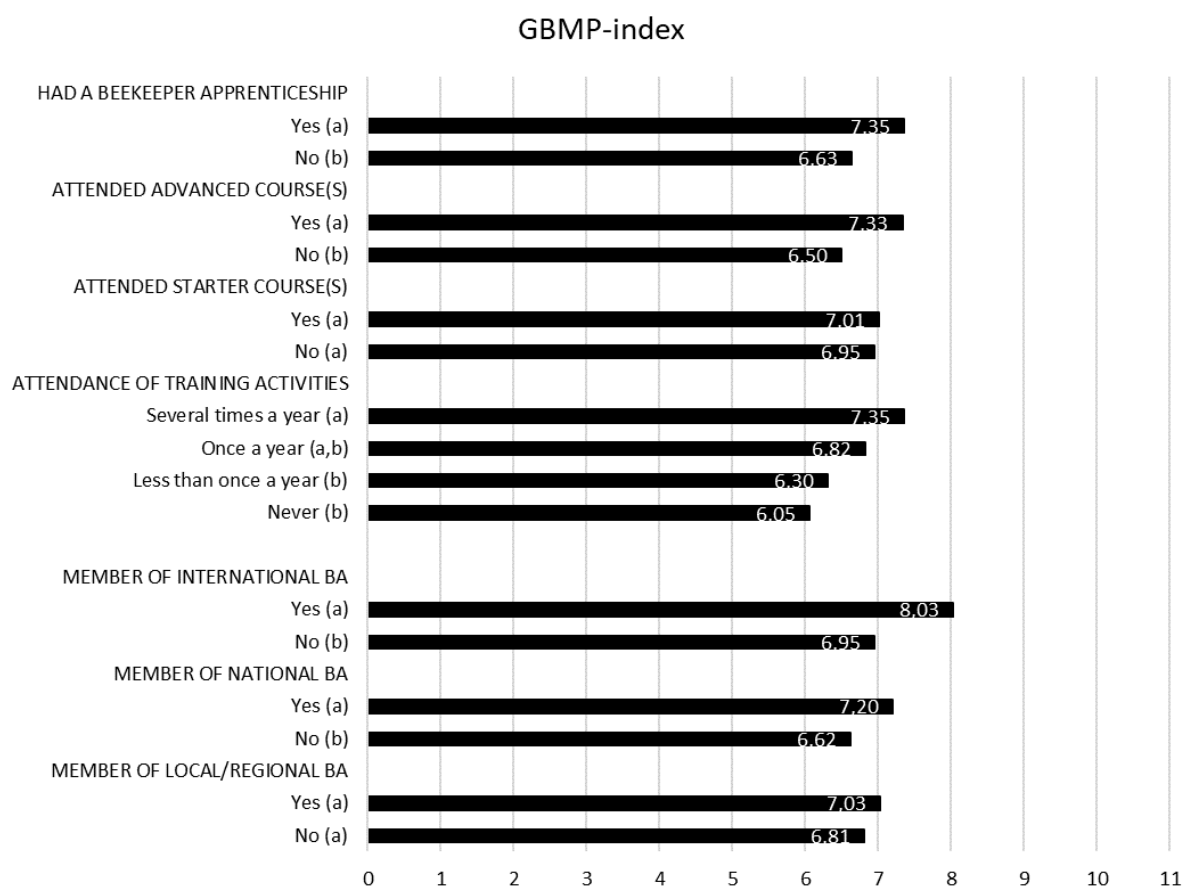


Figure 20. Mean GBMP-index scores across groups depending on reported beekeeper training and beekeeper association (BA) membership ($n = 844$); indicators (a,b,c) within a category (training or membership) signal significantly different mean scores following independent samples t -test or ANOVA F-tests.

Finally, the GBMP-index score was significantly positively correlated with the reported **percentage of combs replaced on an average annual basis** ($r = 0.213$; $p < 0.01$) and **average honey production per hive** ($r = 0.150$; $p < 0.01$) (see Section 3.6), as well as significantly associated with the degree of application of an **own closed wax cycle** ($F = 6.80$; $p < 0.001$) (see Figure 21). Beekeepers who used only wax from their own closed wax cycle, or whose wax originates for at least 50% from their own closed wax cycle, had a significantly higher GBMP-index score than those who did not implement an own closed wax cycle.

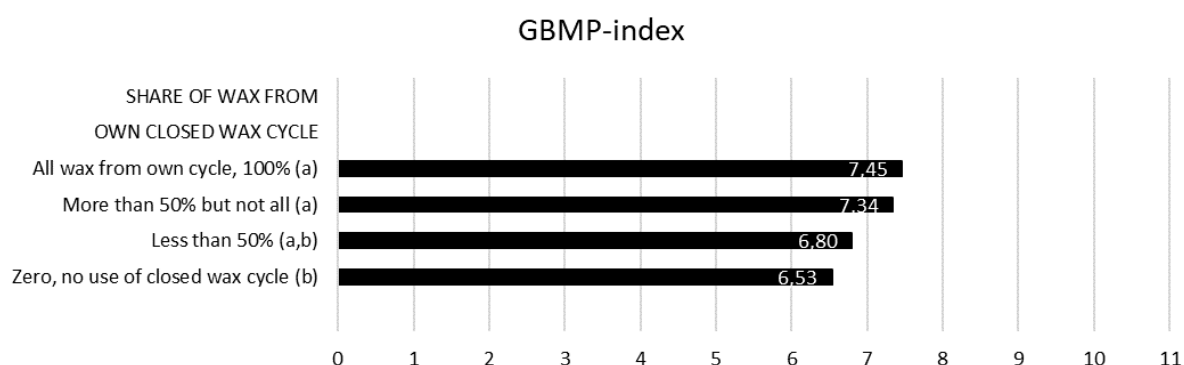


Figure 21. Mean GBMP-index scores across groups depending on reported implementation of an own closed wax cycle (n=844); indicators (a,b,c) signal significantly different mean scores following an ANOVA F-test.

In summary, the following information can be drawn about beekeepers' management practices:

Management of queens and colonies

- Professional beekeepers purchase queens from others and replace their queens more often than non-professional beekeepers, whereas beekeepers in the Western region of Europe tend to replace queens less often, and beekeepers in Northern and Eastern regions tend to purchase queens from others more often.
- Observing quarantine measures for introductions into the apiary did not differ between professional and non-professional beekeepers, but was less common among beekeepers in the Southern region of Europe.
- Almost half of beekeepers in our sample marked their queens, and professionals did this more often. Queen marking was more common in the Eastern and Northern regions and less common in the Southern region.
- The practice of raising own queens was more common among professional beekeepers. Beekeepers in the Western region of Europe tend to raise their own queens more than beekeepers in the Southern region.
- Participating in breeding programmes was more common among professional beekeepers. Beekeepers in the Western region of Europe tend to participate in breeding programmes more than beekeepers in the Northern region.

Comb replacement and wax recycling

- The frequency of comb replacement did not differ between professional and non-professional beekeepers, but was more common in the Eastern and Western regions.
- Almost one third of beekeepers reported that all the wax they used came from their own closed wax cycle.
- The practice of implementing an own closed wax cycle was more common among professional beekeepers, and was less common among beekeepers in the Northern region.
- In the case of beeswax purchase, professional beekeepers and beekeepers in the Southern region tended to purchase more organic wax

Administration and record keeping

- Almost three quarters of the beekeepers reported that their beekeeping activities are officially registered in line with their national guidelines, systems or registers.
- Northern European beekeepers stood out as the most active with respect to productive as well as economic record keeping.
- Southern European beekeepers stood out with respect to official registration of their beekeeping activities and time record keeping.
- Eastern European beekeepers stood out with respect to hive identification using a unique code or number for documentation purposes.

Hive monitoring

- Almost three quarters of beekeepers reported to monitor and adapt hive capacity to discourage swarming, to make efforts to prevent robbing among colonies, and to never make use of a weighing scale under (at least some of) their hives.
- All these hive monitoring practices were implemented more by professional beekeepers compared to non-professional beekeepers.

Environmental management and monitoring

- Almost half of the beekeepers reported to plant nectar and pollen producing plants in the neighbourhood of their hives, and to periodically mow the grass or vegetation in front of their hives.
- Almost two thirds of beekeepers inspect the suitability of the environment and surroundings of their hives.
- Non-professional beekeepers were more active with respect to planting nectar and pollen producing plants in the neighbourhood of their hives, whereas professional beekeepers reported more to mow the grass or vegetation in front of their hives and to inspect the suitability of the environment and surroundings of their hives.

Equipment management

- Three quarters of the beekeepers reported to repair their hives and frames whenever needed.
- About half of the beekeepers reported to regularly clean their beekeeping equipment.
- About one third of the beekeepers reported to regularly disinfect their beekeeping equipment.
- All these equipment management practices were implemented more by professional beekeepers compared to non-professional beekeepers.

Health and welfare monitoring

- About four fifths of beekeepers reported to monitor the welfare status (e.g. food stocks; especially of younger and weaker colonies), to monitor the health status (e.g. absence of diseases), and to only apply drugs or substances that are officially registered in their country for use in honey bee colonies.

- About half of the beekeepers reported to not transfer combs from one colony to another without certainty about the colony's health status and to consult experts in case of anomalies with their bees or hives.
- Exclusive application of drugs or substances that are officially registered in the country was least common among Western European beekeepers.

GBMP-index

- The highest GBMP-index scores were obtained for beekeepers characterised as:
 - Rather or fully professional
 - Northern European
 - Female
 - 16 or more years active as a beekeeper
 - Inherited beekeeping from their (grand)parents.
- Beekeepers with higher GBMP-index scores generally reported lower annual colony winter losses.
- Beekeepers who had an apprenticeship, attended one or more advanced courses, and with a higher frequency of attending training activities such as lectures or workshops had significantly higher GBMP-index scores.
- Having attended one or more starter courses, or being a member of a local/regional beekeeper association, did not result in a higher GBMP-index score.
- Beekeepers with a higher percentage of combs replaced on an annual basis, beekeepers with an own closed wax cycle, and beekeepers with a higher average honey production per hive had higher GBMP-index scores.

3.6 Beekeeping outputs

Beekeepers were asked to report the total quantity of honey that they produced in 2021 in kilograms (kg), which ranged from 0 to 125,000 kg, with a mean of 986 kg and a median of 130 kg. A total of 55 beekeepers (6.5%) reported zero honey production and another 10 beekeepers (1.2%) reported a total honey production of less than 5 kg (which is the equivalent of only 2-3 honey frames).

Beekeepers were also asked for their maximum total number of beehives for honey production in 2021, where the total kg of honey was divided by their number of beehives to get a value for their honey production per hive. This revealed that two beekeepers reported figures that were believed to be unrealistic (namely one with an average honey production per hive of 138 kg and one with 250 kg), probably as a result of reporting errors. These two cases have not been further included in analyses related to beekeeping outputs. Thus, all other beekeepers (n=842) had an average honey production of 100 kg per hive or less.

Average honey production per hive for these 842 beekeepers ranged from 0 to 100 kg, with a mean of 16 kg per hive and a median of 14 kg per hive. The mean of 16 kg per hive is less than the European average yield of 22 kg of honey per hive in 2018 (EU, 2019).

Table 24 shows the mean kg of honey per hive produced by professional and hobby beekeepers, in which professional beekeepers based on size had a significantly higher honey production per hive than hobbyists ($t=-2.79$; $p<0.001$).

Table 24. Kilograms of honey per hive produced by hobby and professional beekeepers (n=842)

Kg of honey per hive	Based on size	
	Hobby	Professional
n	684	158
Mean	15	20
Standard deviation	13	19

Beekeepers in Northern Europe had the highest mean honey production per hive (28 kg) compared with beekeepers in the Eastern region (19 kg), Western region (15 kg) and Southern region (11 kg) (see Figure 22). There was a statistically significant difference between all four regions for honey production per hive, in which beekeepers in the Southern region exhibited statistically significant lower honey production per hive, followed by the Western region, Eastern region, and finally the Northern region, which exhibited statistically higher honey production per hive than all other regions ($F=30.3$; $p<0.001$). This is generally in line with data reported by the European Union, where Sweden had the highest average kg of honey per hive in 2018 and Finland had the highest in 2017, and Greece had the lowest average kg of honey per hive in 2018 and Cyprus had the lowest in 2017 (EU, 2019). Further consideration of these figures is presented in **Box 1** in relation to the external validity of the survey data.

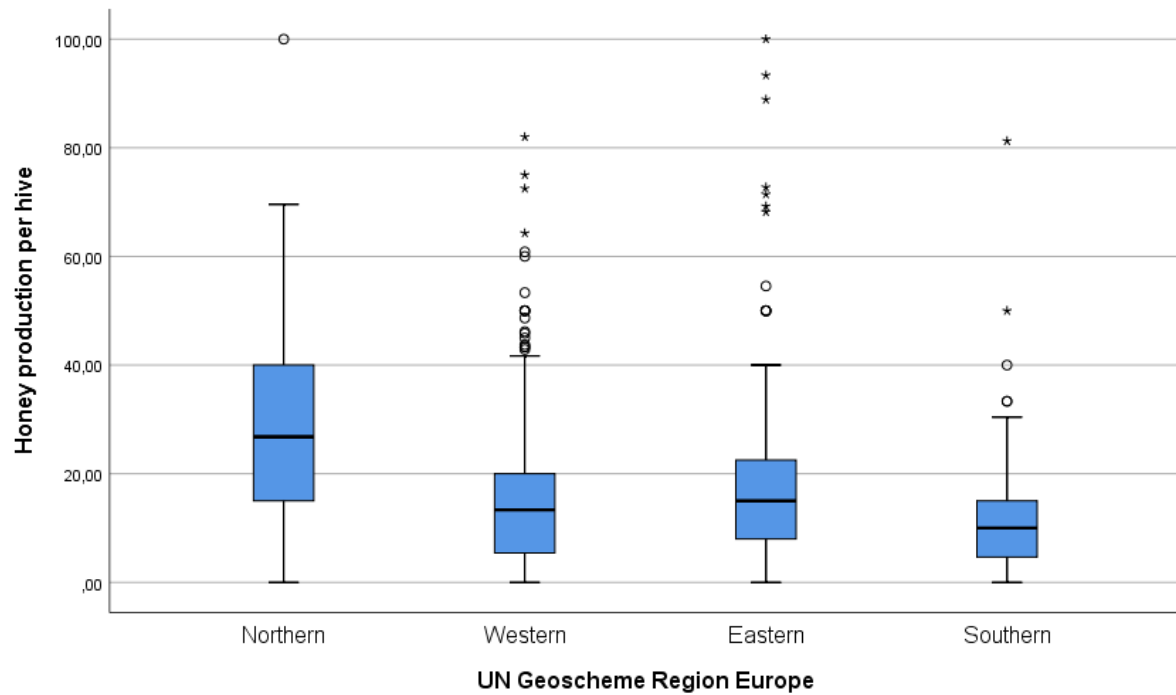


Figure 22. Box plots of honey production per hive (kg) across European regions (n=842). Note: The blue boxes represent the second and third quartiles (i.e. the bottom border of the box marks Q1 and the top border marks Q3); the whiskers represent the minimum and maximum values excluding outliers; the black lines inside the boxes represent the median value, and the circles/stars indicate eventual moderate/extreme outliers.

Beekeepers with 16 years or more of beekeeping experience had a higher average honey production per hive (20 kg) compared with beekeepers with 6-15 years of experience (16 kg) and beekeepers with less than 5 years of experience (13 kg), in which there was a statistically significant difference between all three experience groups. Beekeepers with less than 5 years of experience had significantly lower honey production per hive, followed by beekeepers with 6-15 years of experience, and finally beekeepers with 16 years or more of experience. who had significantly higher honey production per hive ($F=14.95$; $p<0.001$), (see Figure 23).

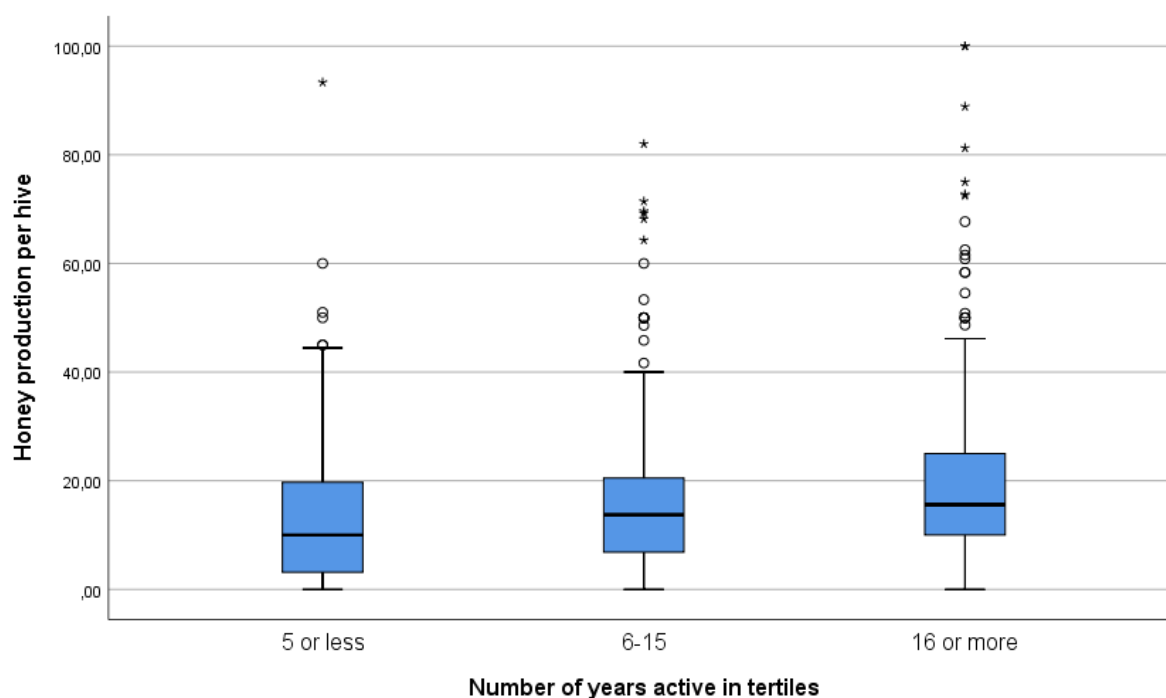


Figure 23. Box plots of honey production per hive (kg) across years of beekeeping experience (n=842). Note: The blue boxes represent the second and third quartiles (i.e. the bottom border of the box marks Q1 and the top border marks Q3); the whiskers represent the minimum and maximum values excluding outliers; the black lines inside the boxes represent the median value, and the circles/stars indicate eventual moderate/extreme outliers.

Regarding the apiary products, bees and services that beekeepers in our sample produced and sold, most beekeepers produced and sold honey (93%), following by 29% who produced and sold beeswax, 23% who produced and sold honey bee colonies, 23% who produced propolis, 14% who produced pollen, 13% who produced queens, 10% who provided pollination services, and finally 3% who produced royal jelly (see Figure 24).

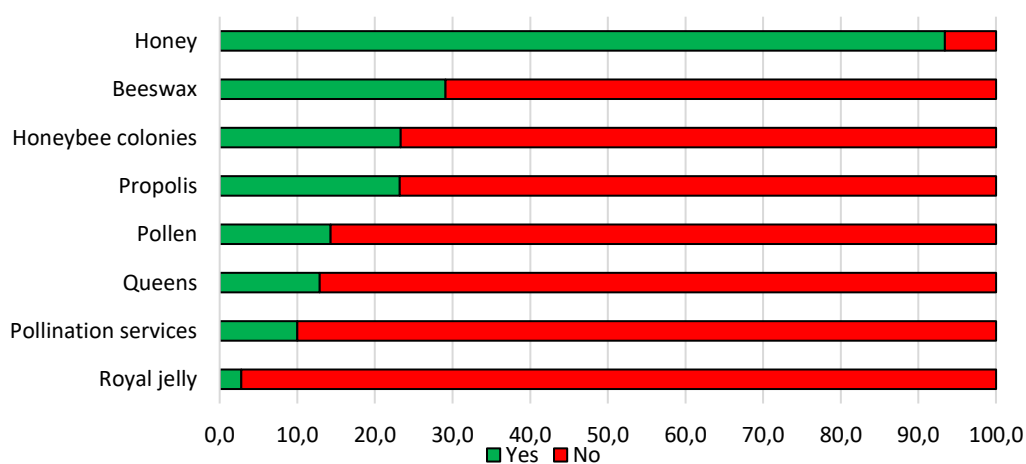


Figure 24. Production and sales of apiary products, bees and services (% , n=844)

Beekeepers were asked to indicate to what extent they believed their honey bees by means of pollination contributed to improve or increase 1) Agricultural crop production, 2) Horticultural crop production, 3) Fruit production and 4) Overall biodiversity in their environment on a 5-point Likert scale (1=not at all, 5=a lot) (see Figure 25).

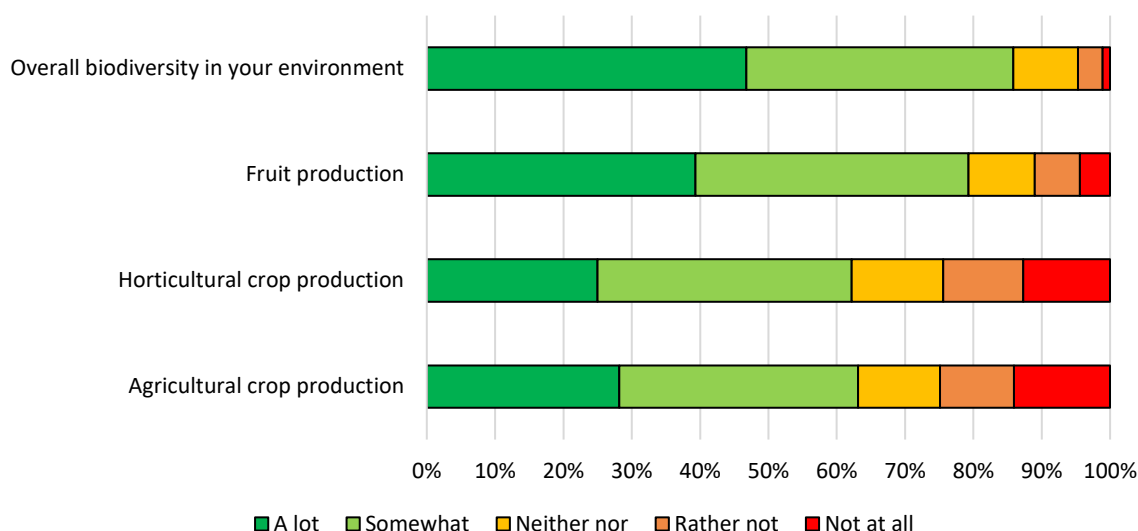


Figure 25. Mean agreements scores for four perceived impacts of pollination (% , n=844)

Mean agreement scores for all four perceived impacts of pollination are provided in Table 25, in which ‘overall biodiversity in your environment’ received the highest mean agreement score among the entire sample.

Table 25. Mean agreement scores for perceived impact of pollination among total sample (n=844)

Perceived impact of pollination	Mean	Std. Deviation
Overall biodiversity in your environment	4.27	0.854
Fruit production	4.03	1.073
Agricultural crop production	3.52	1.370
Horticultural crop production	3.50	1.322

In summary, the following information can be drawn about beekeeping outputs:

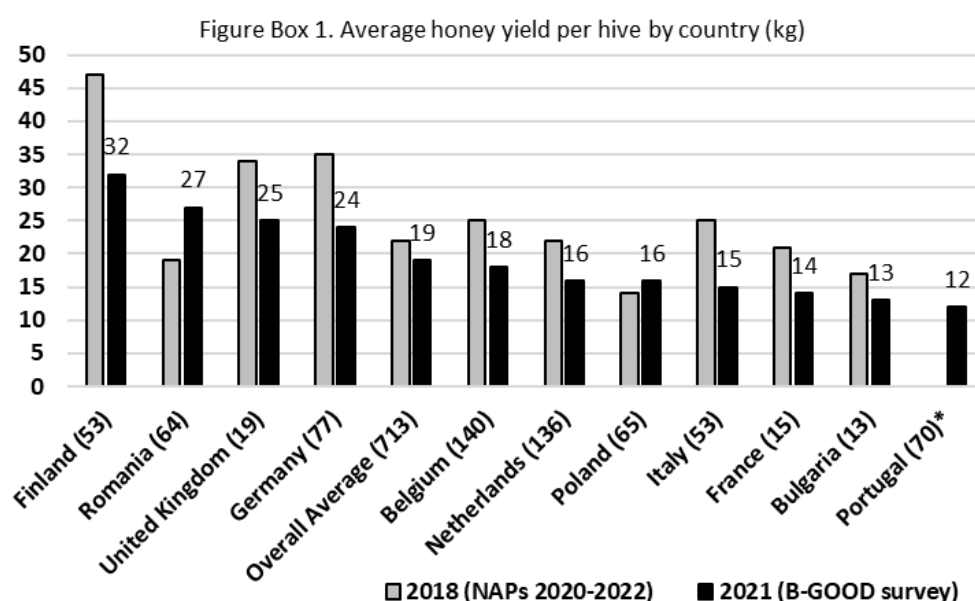
- Beekeepers in our sample produced a mean total of 986 kg of honey in 2021, with a mean of 16 kg per hive, which is slightly less than the European average yield of 22 kg of honey per hive in 2018.
- Professional beekeepers had significantly higher honey production per hive than hobby beekeepers.
- Beekeepers in Northern Europe had the highest mean honey production per hive followed by beekeepers in the Eastern region, Western region and finally the Southern region, which had the lowest mean honey production per hive; this is generally in line with data reported by the European Union.

- Beekeepers with more experience generally had a higher mean honey production per hive.
- Honey was by far the most common apiary product or service that beekeepers in our sample produced, followed by beeswax, honey bee colonies, and propolis.
- The least common apiary product or services that beekeepers in our sample produced was royal jelly and pollination services.
- Beekeepers tended to agree that their honey bees by means of pollination contributed to improve or increase overall biodiversity in their environments.
- Beekeepers tended to agree that their honey bees contributed to improve or increase fruit production more than improve or increase horticultural crop production or agricultural crop production.

Box 1. Exploring the external validity of the B-GOOD beekeeper survey data based on average honey yield per hive by country

External validity generally refers to the extent to which research findings based on a sample of individuals can be generalised to the same population the sample is taken from or to similar populations in terms of contexts, individuals, times and settings (Lavrakas, 2008). A first means to explore the external validity of our B-GOOD beekeeper survey data is by evaluating average honey yield per hive by country. EU-2018 data have been reported in preparation of the National Apiculture Programmes 2020-2022 (EU, 2019) and are suitable for the purpose of exploring the external validity of our B-GOOD survey data.

In order to meaningfully compare average honey yields between the EU-2018 data and our B-GOOD survey data, first, a detailed inspection of the frequency distributions of total honey production and average honey yields was performed. A total of 129 beekeepers reported extremely low values, i.e. total honey production below 5 kg and/or average honey yield per hive below 3 kg, which is the equivalent of only 2-3 honey frames in total or 1-2 honey frames per hive, respectively. Another two beekeepers reported extremely high values, i.e. an average honey yield per hive exceeding 100 kg. For comparison with the EU-2018 data, average honey yields were calculated per country after excluding these cases. Data from the resulting sample (n=713) are displayed for countries with at least 10 participants in the sample. The number of participants per country is reported between brackets. Note that no EU-2018 data were available for Portugal.



Direct comparison is not straightforward as honey yields may differ substantially from year to year and from region to region depending on e.g. climatic conditions. Average honey yields as obtained from the B-GOOD survey data (2021) are consistently lower compared to the EU-2018 data, except in Romania and Poland. On one hand, this may signal systematic underreporting in our B-GOOD survey, which is consistent with the observation that many beekeepers stopped completing the survey when they were asked to report their total honey production in 2021 (see Section 2.6). On the other hand, we also asked the study participants 'how they evaluated their bee season 2021 from a honey production point of view compared to previous years' with response categories from 'very bad', 'bad', 'neither bad nor good', 'good' to 'very good'. Only 14% and 15% of the Romanian and Polish beekeepers reported that their bee season 2021 was 'bad' or 'very bad' from a honey production point of view. By contrast, this share was much higher among beekeepers from France (100%), Italy (76%), Belgium (64%), Germany (62%), the UK (47%), Portugal (46%), the Netherlands (40%) and Finland (30%). Most importantly with respect to external validity, the same gradient between countries is observed in both datasets.

3.7 Colony winter loss rate and health status monitoring

3.7.1 Honey bee colony winter loss rate

In order to gain an estimate of the health status of beekeepers' colonies, we asked beekeepers for their **average honey bee colony winter loss rate over the past five years**, and also how often they **check or monitor for a series of health indicators** of their colonies during the beekeeping season. This section reports on the colony winter loss rate of our beekeeper sample, and the following section reports on colony health status monitoring/checks.

Regarding the reported average colony winter loss rate over the past five years, almost half of the beekeepers in our sample (48.2%) reported an average colony winter loss rate of 0-10%, followed by 30.7% of beekeepers having an average colony winter loss rate of 10-20% (see Figure 26).

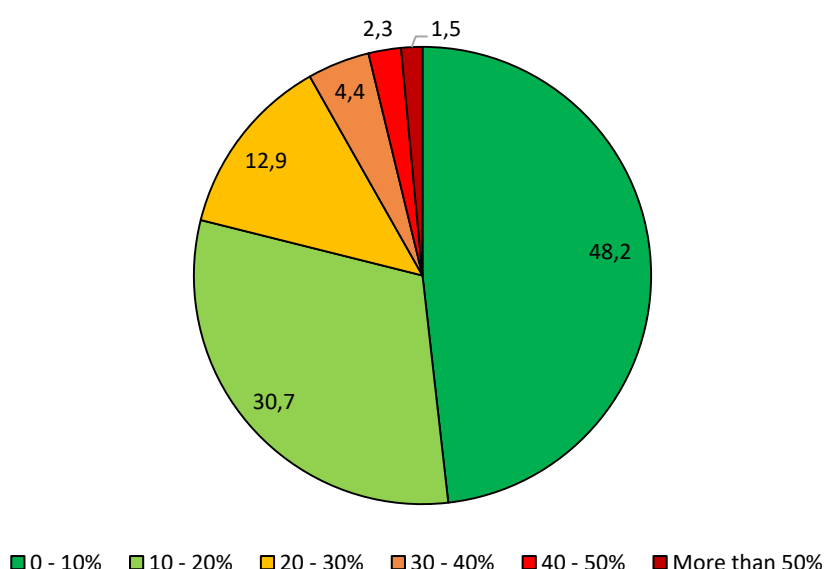


Figure 26. Honey bee colony winter loss rate among the total sample (%; n=844); in response to the question 'What is your average beehive winter loss percentage over the past five years?'

As shown in Figure 27, the sample of beekeepers in Northern Europe had the highest share of beekeepers with a low (0-10%) average colony winter loss rate among all four regions. Figure 27 shows that beekeepers in the Northern region suffered the least colony winter losses, followed by beekeepers in the Eastern region, Western region, and finally beekeepers in the Southern region suffered the most colony winter losses. Further consideration of winter loss data is presented in **Box 2** in relation to the external validity of the survey data.

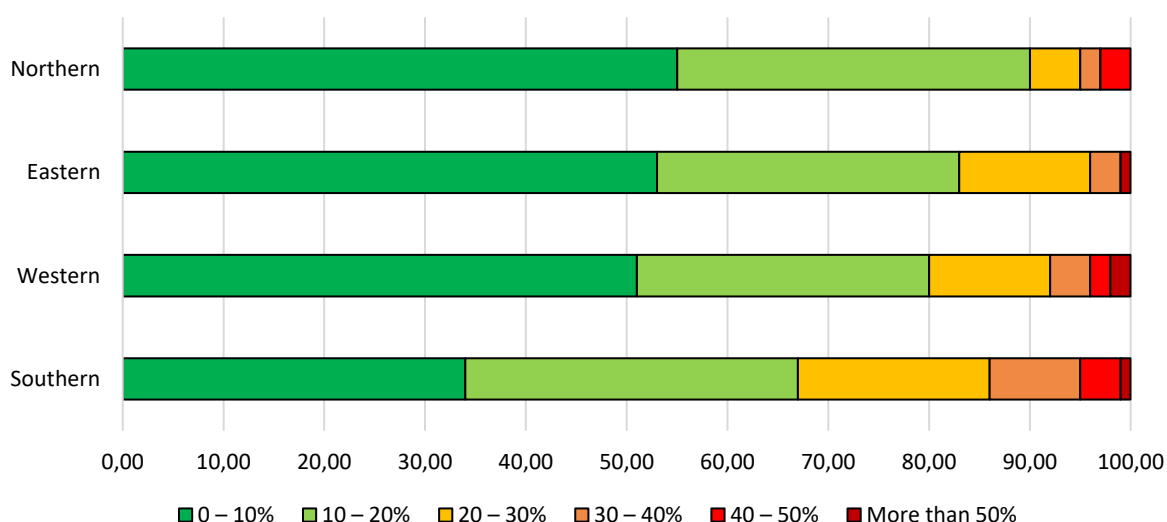


Figure 27. Average colony winter loss rate among four European regions (% , n=844)

To allow reliable cross-tabulation and statistical association testing (chi-square) with the variable 'European region' (and other variables), colony winter loss rate was recoded into four categories through merging the three largest groups into one category '>30%'. More than half of the Northern European (55.1%), Eastern European (52.6%) and Western European (50.5%) beekeepers reported colony winter loss rates in the range 0-10% versus only one third (33.5%) of the Southern European beekeepers (chi-square=28.97; $p=0.001$), thus supporting significantly higher winter loss rates in Southern Europe (see also Box 2).

When comparing beekeepers' average colony winter loss rate with their years of experience, Figure 28 shows that beekeepers with less than 5 years of experience had the highest share of beekeepers with a low (0-10%) average colony winter loss rate, but also the highest share of beekeepers with winter loss rates of 30% or more. Figure 28 suggests that beekeepers with less than 5 years of experience suffered the least colony winter losses, followed by beekeepers with 16 years or more of experience, and finally beekeepers with 6-15 years of experience suffered the most colony winter losses.

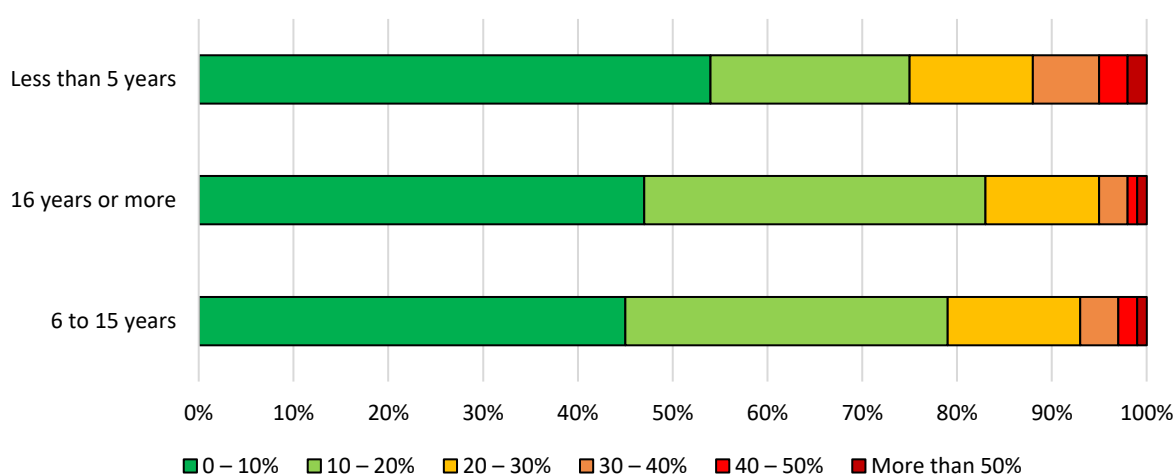


Figure 28. Average colony winter loss rate by years of experience (% , n=844)

Over half of beekeepers with 5 years or less of beekeeping experience (53.8%) reported suffering only a 0-10% colony winter loss rate, compared with beekeepers with 6-15 years of experience (44.0% reporting a colony winter loss rate of 0-10%), and beekeepers with 16 years or more of beekeeping experience (46.5% reporting a colony winter loss rate of 0-10%) (chi-square=22.25; $p=0.001$). It should be noted that starting beekeepers had significantly less colonies (see also Section 3.8.1) and thus losing one colony may result in a higher percentage reported as colony loss rate (e.g. 50% or 100% colony loss rate).

When comparing beekeepers' average colony winter loss rate with their level of beekeeper training, Figure 29 shows that beekeepers who have taken an advanced course were more represented in the category lower (0-10%) average colony winter loss rate than beekeepers with no advanced course. Interestingly, beekeepers who had an apprenticeship seemed to have had slightly higher average winter losses than beekeepers who had not had an apprenticeship. However, chi-square tests revealed that there is no significant association between taking a starter or advanced beekeeping course and colony winter loss rate. Similarly, there is no significant association between having a beekeeper apprenticeship and colony winter loss rate.

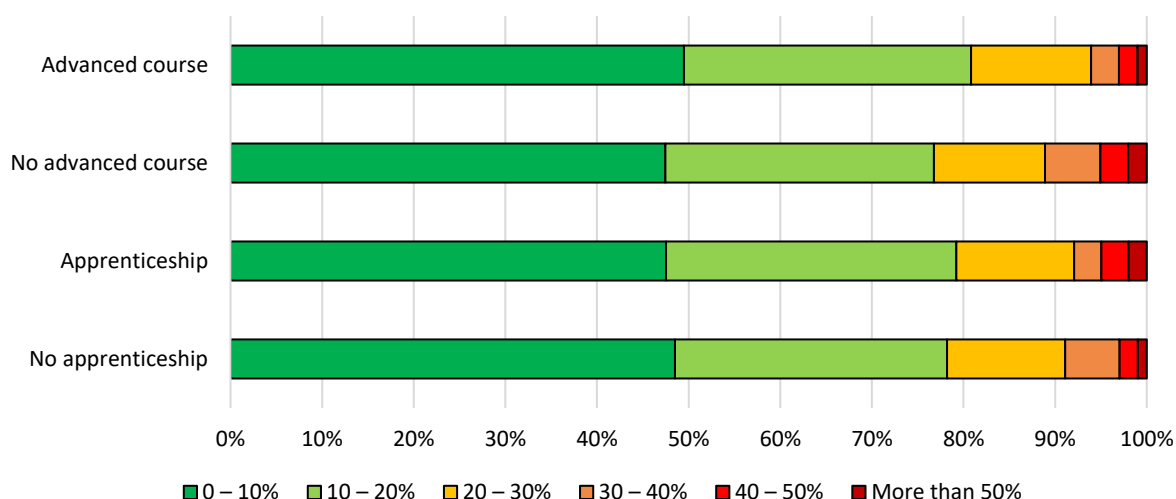


Figure 29. Average colony winter loss rate by beekeeper training (%; n=844)

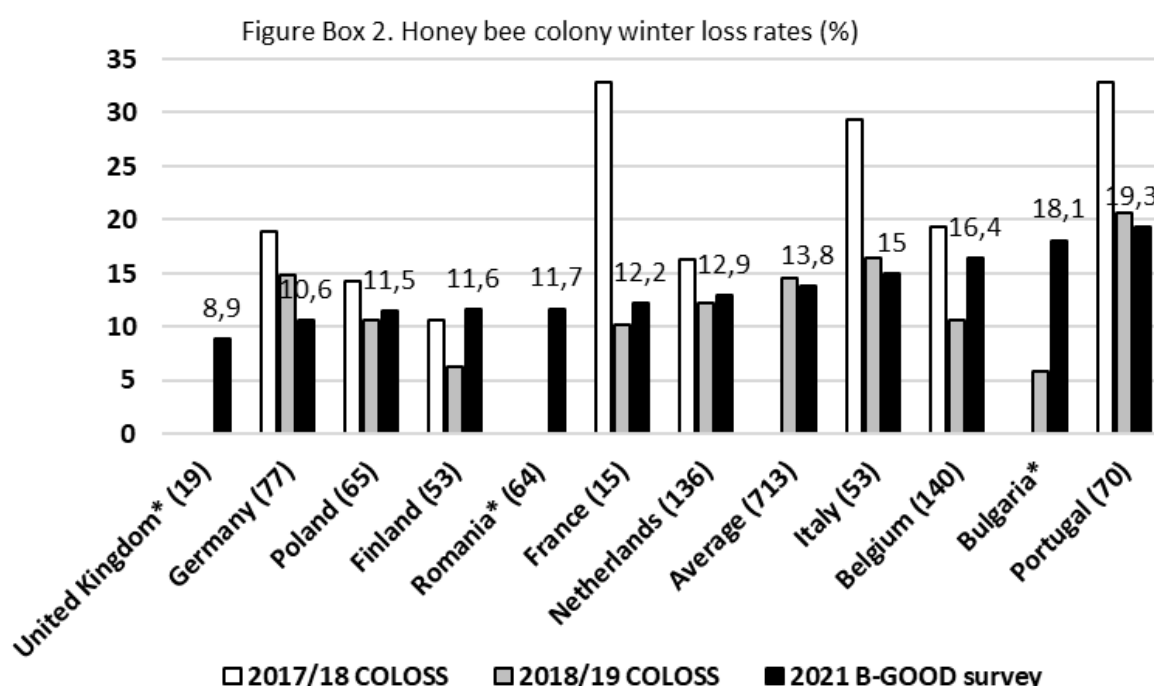
Interestingly, there was an association between being a migratory beekeeper and colony winter loss rate, in which 46.5% of non-migratory beekeepers reported a 0-10% colony winter loss rate as compared to 51.9% of migratory beekeepers reporting 0-10% colony winter loss rate, which suggests that migratory beekeepers suffer less colony loss than non-migratory beekeepers (chi-square=8.78; $p=0.032$) (see also Box 2).

Finally, winter loss rates were higher among (purely or rather) urban beekeepers compared to others (chi-square=7.02, $p=0.030$); almost two thirds (31.2%) of the urban beekeepers reported winter losses exceeding 20% vs. less than a fifth (19.8%) of the other beekeepers reported winter losses exceeding 20%.

Box 2. Exploring the external validity of the B-GOOD beekeeper survey data based on honey bee colony winter loss rates

Besides exploring honey yield per hive (Box 1), a second means to explore the external validity of our B-GOOD beekeeper survey data is by evaluating honey bee colony winter loss rates, in this case in comparison with data reported by the COLOSS monitoring group, such as reported by Gray et al.(2019) for 2017/18 and Gray et al.(2020) for 2018/19.

The honey bee colony winter loss rate was measured in the B-GOOD beekeeper survey using a 6-point categorical scale with ordered numerical response labels ranging from '0-10%', '10-20%', '20-30%', '30-40%', '40-50%' to '>50%' (Figure 26). For comparison with winter loss data from COLOSS surveys, these ordered categorical data were transformed to numeric data by replacing the categories with the average response value of the category. Specifically, responses corresponding with the categorical label '0-10%' were replaced by the numeric value 5%, '10-20%' by 15%, and so on. The categorical label '>50%' was replaced by the numeric value 67% assuming a loss of two-thirds of the colonies when this highest response category was ticked. An alternative approach assuming a loss of 100% of the colonies in case '>50%' was ticked did not yield different insights as the number of beekeepers who ticked this highest winter loss category was very low ($n=13$; 1.5%) in the overall sample (see Figure 26). Furthermore, the assumption of 100% winter loss rate is not plausible since the question probed for average winter losses over the past five years. Within COLOSS, the proportion of colonies lost over winter is calculated by dividing the sum of reported colonies with unsolvable queen problems, dead colonies or colonies reduced to a few hundred bees, and colonies lost through natural disaster after winter by the reported number of colonies that went into winter (Gray et al., 2020). Whereas COLOSS winter loss data are reported on an annual basis, the B-GOOD survey probed for an average over the past five years.



The average honey bee colony winter loss rate within the B-GOOD sample amounted to 13.8% (S.D.=11.8%), which corresponds with the 'over all EU countries' and 'over all European countries' 2018/19 winter loss rates of 14.5% reported by COLOSS (Gray et al., 2020). Apart from some very high winter loss rates observed in the COLOSS 2017/18 data (e.g. in France, Portugal and Italy), the winter loss rates of both data sources correspond rather well and show a similar gradient across countries, with lower rates in e.g. Poland and Finland and higher rates in Portugal, Belgium and Italy. Direct comparison is less straightforward or not possible at all for several countries, e.g. the UK where COLOSS presents figures for England, Scotland, Wales and Northern Ireland separately; and

Romania which is not covered in the COLOSS data. COLOSS data for Bulgaria were first available in 2018/19 and based on a relatively small sample of mostly professional beekeepers; the B-GOOD data for Bulgaria are also based on a very small sample, though containing an equal share of fully professional and other beekeepers.

Further exploration of similarities/differences with the COLOSS winter loss data was feasible through testing associations with beekeeping operation size, whether beekeepers migrate their colonies for honey production, and frequency of queen replacement.

First, the COLOSS studies consistently reported significantly lower winter losses among larger beekeeping operations (defined in COLOSS as more than 150 colonies), but also that the size of this effect is relatively small. The honey bee colony winter loss rate obtained from the B-GOOD beekeeper sample was not significantly correlated with the size of the beekeeping operation, as assessed by the numbers of hives in 2021. Furthermore, mean winter loss rates did not differ significantly ($p=0.886$) between operations in the B-GOOD sample with sizes '0-50 hives' (13.9% winter loss rate), '51-150 hives' (13.5%) and '151 hives or more' (13.4%), i.e. the operation sizes commonly used by COLOSS. However, an operation size effect has been confirmed when comparing beekeeping operations with '0-15 hives' (14.9% winter loss rate) vs. '16 or more hives' (12.8% winter loss rate) (with 15 hives being the median number of hives in the B-GOOD sample) ($t=2.62$; $p=0.009$).

Second, beekeepers within the B-GOOD survey who reported to migrate their colonies had a significantly lower winter loss rate (12.1%) compared to those who did not migrate their colonies (14.6%) ($t=-3.21$; $p=0.001$). A similar finding has been reported based on the COLOSS 2017/18 data (Gray et al., 2019), whereas the opposite has been reported based on the COLOSS 2018/19 data (Gray et al., 2020). Fully professional beekeepers within the B-GOOD sample reported significantly more often to migrate their colonies for honey than other beekeepers; more than three quarters of the fully professionals did migrate their colonies vs. only one quarter of the other beekeepers in the sample (chi-square=75.6; $p<0.001$). Yet, honey bee winter loss colony rates did not differ significantly between fully professional (14.4%) and other beekeepers (13.8%) in the overall B-GOOD sample. This additional insight corroborates the suggestion raised by Gray et al. (2020) that the effect of migration depends on seasonal or local environmental factors rather than on management - assuming better beekeeping management practice among fully professional beekeepers (which has indeed been confirmed by the higher GBMP-index score among fully professional beekeepers, see Section 3.8.1).

Third, Gray et al. (2020) found that the risk of colony winter loss decreases as the percentage of new queens introduced (i.e. queens bred in the year before winter) increases, and that the effect size of this factor on winter loss was larger than for operation size. Within the B-GOOD beekeeper survey, we also asked beekeepers to what extent they replaced queens through using a categorical measurement scale. Significant differences in winter loss rates were observed; beekeepers who reported to replace their queens 'every year' (11.1% winter loss rate) or 'every two to three years' (12.3%) had significantly lower winter colony loss rates than beekeepers who reported to replace their queens 'only when they no longer perform well' (15.1%) or 'leave it to the bees to decide when to replace the queen' (i.e. queen supersedure) (17.5%) (ANOVA $F=10.22$; $p<0.001$).

In a similar vein as with honey yields (Box 1), direct comparison is not straightforward as honey bee colony winter loss rates differ substantially from year to year, from country to country, and within a country even from region to region. Furthermore, there are substantial methodological differences between the COLOSS surveys and the B-GOOD beekeeper survey for obtaining an estimate of winter loss rates, e.g. related to the measurement scales and time frame used as a reference. Notwithstanding these differences and consequent limitations, there are important similarities in the honey bee colony winter loss rate estimates obtained from both sources, including similar gradients across countries, and significant associations with other beekeeping variables such as operation size, migration and queen replacement, which altogether suggest a good degree of external validity of the B-GOOD beekeeper survey data.

3.7.2. Colony health status monitoring/checks

Beekeepers were asked how often they check for a series of health indicators of their colonies during the beekeeping season on a categorical frequency scale (1=never, 5=at every inspection), shown in Figure 30, where more than three fifths of beekeepers reported checking for the presence of all stages of brood, sufficient amount of nutrition, suitable space for colony development and sufficient amount of adult bees at every inspection, suggesting that most beekeepers in our sample take their beekeeping practice seriously.

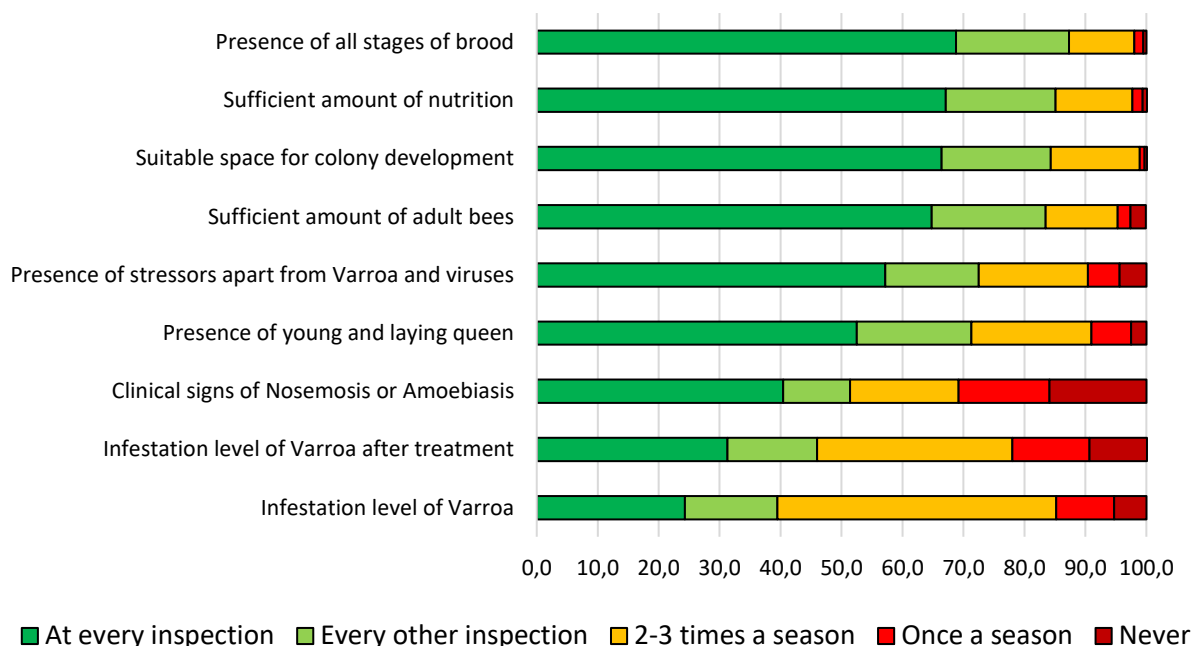


Figure 30. Frequency of colony health status checks during the bee season (%; n=844)

To create a health status monitoring index, we computed a score for each beekeeper by taking the first six colony health status checks into consideration. For the last three health checks: “Clinical signs of Nosemosis or Amoebiasis,” “Infestation level of Varroa after treatment” and “Infestation level of Varroa,” we cannot assume that checking these at a higher frequency is necessarily better, e.g. beekeepers may apply only 2-3 varroa treatments during the bee season, and therefore may check varroa infestation levels only 2-3 times a season. For the rest of the six indicators, where it can be assumed that checking these at every hive inspection is best practice, each beekeeper was given a score of ‘1’ if they indicated ‘at every inspection’ and ‘0’ otherwise, and these scores were summed to create a health status monitoring index, which ranges from 0 to 6.

This scoring method using only ‘at every inspection’ was used since almost all beekeepers in our sample generally implement good practices, indicating that they show responsibility towards their bees. Therefore, to distinguish between groups, we must analyse the extremes thus identifying those who are extremely good or consistent in the practices they implement.

Table 26 shows that beekeepers in the Northern region of Europe had the highest mean health status monitoring index score and beekeepers in the Southern regions had the lowest among

the four European regions. However, the observed differences in the health status monitoring index scores between European regions were not statistically significant.

Table 26. Mean health status monitoring index score across European region (n=844)

European region	Mean	Std. Deviation
Northern	4.14	2.0
Eastern	3.93	2.0
Western	3.76	2.0
Southern	3.50	2.1

When comparing beekeepers' health status monitoring index score with their years of experience, beekeepers with 6-15 years of experience and 16 years or more of beekeeping experience had the same mean health status monitoring index score, followed by beekeepers with 5 years or less of beekeeping experience, who had a lower mean health status monitoring index score (see Table 27). No statistical differences were found in the health status monitoring index between levels of beekeeper experience.

Table 27. Mean health status monitoring index score by years of beekeeping experience (n=844)

Years of beekeeping experience	Mean	Std. Deviation
5 years or less	3.58	2.17
6-15 years	3.87	1.90
16 years or more	3.87	2.06

When comparing beekeepers' health status monitoring index score with their beekeeper training, Table 28 suggests that taking at least one starter course, advanced course, or having an apprenticeship in beekeeping may contribute to an increase in colony health status monitoring, where beekeepers having taken a starter course, an advanced course or an apprenticeship in beekeeping had higher mean health status monitoring index score than those who did not.

Table 28. Mean health status monitoring index by beekeeper training (n=844)

Beekeeper training	Mean	Std. Deviation
Starter course	3.79	2.04
No starter course	3.74	2.06
Advanced course	3.92	1.94
No advanced course	3.57	2.18
Apprenticeship	3.84	1.98
No apprenticeship	3.72	2.11

Independent samples *t*-tests were performed to explore differences on health status monitoring index scores between beekeepers with different levels of training; there were no statistically significant differences found between those who had taken a starter course or not, or between those who had had a beekeeping apprenticeship or not. There was however a statistically significant difference in the health status monitoring index between beekeepers who had taken an advanced course or not, suggesting that taking an advanced course may help to increase the health status monitoring index ($t=2.43$; $p=0.015$).

In summary, the following information can be drawn about colony winter loss rate and health status monitoring:

- Almost half of the beekeepers in our sample reported an average colony winter loss rate of 0-10% on average over the past five years, and almost one third of the beekeepers in our sample reported an average colony winter loss rate of 10-20% on average over the past five years.
- Beekeepers in Northern Europe reported the lowest colony winter loss rates, followed by beekeepers in the Eastern region, Western region, and finally beekeepers in the Southern region, who suffered significantly higher winter loss rates.
- Beekeepers with less than 5 years of experience suffered the least colony winter losses, followed by beekeepers with 16 years or more of experience, and finally beekeepers with 6-15 years of experience suffered the most colony winter losses.
- We found no significant association between taking a beekeeping course or having a beekeeper apprenticeship and colony winter loss rate.
- We found an association between being a migratory beekeeper and colony winter loss rate, where migratory beekeepers suffered less colony losses than non-migratory beekeepers, however the effect of migration depends on seasonal or local environmental factors rather than on management, so this result should be interpreted with caution.
- Urban beekeepers reported higher winter losses than other beekeepers.
- Beekeepers who reported to replace their queens frequently had significantly lower winter colony loss rates than beekeepers who did not replace their queens frequently.
- More than three fifths of beekeepers reported checking for the presence of all stages of brood, sufficient amount of nutrition, suitable space for colony development and sufficient numbers of adult bees at every inspection, suggesting that most beekeepers in our sample take their beekeeping practice seriously.
- Very few differences were exhibited in the health status monitoring index between European regions, level of beekeeping experience, and whether beekeepers had taken a starter course or had had a beekeeping apprenticeship.
- Beekeepers who has taken an advanced course in beekeeping, however, had a statistically higher health status monitoring index than beekeepers who had not, suggesting that taking an advanced course may help to increase the health status monitoring index.

3.8 European beekeeper segments

3.8.1 Identification and profiling of specific beekeeper groups

A first set of analyses aiming at the identification and profiling of European beekeeper segments focused on **specific beekeeper groups** such based on gender (female beekeepers), age (young beekeepers), years active as a beekeeper (starters), location (purely urban beekeepers) and degree of professionalism (fully professionals, and professionals by expertise), which were chosen with the purpose of profiling groups of beekeepers that are fewer in number and constitute less than 20% of the total sample, in order to compare these groups with the sample majority. Each of these groups account for a small share of the total beekeeper sample, yet comprise a sufficient number of individual beekeepers who completed the survey to warrant reliable statistical comparison with the rest of the study sample.

In order to identify and compare the profile of these beekeeper groups with the rest of the sample, first, dummy variables were created to identify the concerned group, and second, comparisons of mean scores using independent samples *t*-tests (in case of ratio-scaled or continuous variables) or cross-tabulation with chi-square tests (in case of categorical variables) were performed. Comparisons were performed systematically for the following set of variables:

- socio-demographics: age, gender, education
- beekeeping characteristics: hobby/professional, urban/rural, number of hives, years of experience, association memberships, training activities, inherited from (grand)parents, migration with bees for honey production
- motivations to keep honey bees and orientations towards honey bees
- beekeeping management characteristics: GBMP-index score, percentage of combs replaced annually, implementation of own closed wax cycle
- output characteristics: average honey production per hive
- colony winter losses

Only variables where significant differences were observed have been reported, i.e. if a variable is not mentioned, it means there were no significant differences between the concerned beekeeper groups and the rest of the sample. In a few cases, marginally significant ($0.05 < p < 0.10$) differences or associations have also been mentioned if these were believed to be meaningful. The means or percentages reported below refer to the concerned group vs. the rest of the sample and are followed by the respective test statistic and p-value.

Female beekeepers (n=156; 18.5%) are characterised by:

- Younger age (49.5 vs. 53.2 years) ($t=3.14$; $p=0.002$)
- Smaller apiaries (38.2 vs. 80.3 hives in 2021) ($t=3.13$; $p=0.002$)
- Less years active as beekeeper (10.1 vs. 16.0 years) ($t=6.10$; $p<0.001$)
- Less migration with bees for honey (21.0% vs. 34.2%)* (chi-square=10.25; $p=0.001$)
- Weaker 'business orientation' ($t=2.61$; $p=0.009$)
- Stronger 'natural orientation' ($t=-4.14$; $p<0.001$)
- Higher GBMP-index score (7.64 vs. 6.87) ($t=-3.36$; $p=0.001$)
- Less implementing an own closed wax cycle (45.2% vs. 30.5% zero reuse of own wax) (chi-square=12.57; $p=0.006$)

*Note: The interpretation of the reported percentages is as follows: 21.0% of the female beekeepers reported to migrate with bees for honey, which is significantly less than the 34.2% of the male beekeepers migrating bees for honey.

Young beekeepers (defined as beekeepers aged 35 years or younger, n=89; 10.5%) are characterised by:

- (Obviously) Younger age (29.9 vs. 55.2 years) ($t=40.07$; $p<0.001$)
- Higher share of professional beekeepers (30.3% vs. 17.6%) (chi-square=8.39; $p=0.004$)
- Less years active as beekeeper (6.9 vs. 16.0 years) ($t=11.74$; $p<0.001$)
- Less likely to be a member of a local/regional beekeeper association (76.4% vs. 86.6%) (chi-square=6.72; $p=0.010$)
- Less likely to be a member of the national beekeeper association of their country (42.7% vs. 68.2%) (chi-square=22.94; $p<0.001$)
- Less active as a board member of a beekeeper association (16.9% vs. 26.5%) (chi-square=3.89; $p=0.048$)
- Less attendance at starter course(s) (73.0% vs. 83.7%) (chi-square=6.31; $p=0.012$)
- Less attendance of advanced course(s) (39.3% vs. 62.6%) (chi-square=18.07; $p<0.001$)
- Less frequent attendance of lectures, workshops, training activities for beekeepers (46.1% vs. 60.4% attendance several times a year) (chi-square=7.84; $p=0.050$)
- More likely to have inherited beekeeping from their (grand)parents (38.2% vs. 21.5%) (chi-square=12.52; $p<0.001$)
- Stronger 'economic motivation' ($t=-3.07$; $p=0.002$)
- Stronger 'business orientation' ($t=-4.08$; $p<0.001$)
- Though only marginally statistically significant, young beekeepers tend to have a weaker 'performance equals welfare' orientation ($p=0.055$)

Starting beekeepers (also called 'novices') (defined as beekeepers who are three or less years active as a beekeeper; n=144; 17.1%) are characterised by:

- Younger age (46.3 years vs. 53.8 years) ($t=6.56$, $p<0.001$)
- Higher share of female beekeepers (29.2% vs. 16.6%) (chi-square=12.43; $p<0.001$)
- Higher share of urban beekeepers (16.0% vs. 10.0%) (chi-square=4.35; $p=0.037$)
- Higher share of non-professional beekeepers (99.3% vs. 0.7%) (chi-square=12.43; $p<0.001$)
- Smaller apiaries (9.6 vs. 85.3 hives in 2021) ($t=6.88$, $p<0.001$)
- (Obviously) Less years active as beekeeper (2.3 vs. 17.7 years) ($t=29.3$; $p<0.001$)
- Less likely to be a member of a local/regional beekeeper association (16% vs. 84%) (chi-square=8.44; $p=0.004$)
- Less likely to be a member of a national beekeeper association of other countries (1.4% vs. 98.6%) (chi-square=5.14; $p=0.02$)
- Less active as a board member of a beekeeper association (7.6% vs. 92.4%) (chi-square=29.1; $p<0.001$)
- Less attendance of advanced course(s) (28.5% vs. 66.7%) (chi-square=72.89; $p<0.001$)
- Lower level of beekeeper apprenticeship or to likely to have worked with another beekeeper (38.2% vs. 54.7%) (chi-square=13.06; $p<0.001$)

- Less likely to have inherited beekeeping from (grand)parents (88.2% vs. 74.4%) (chi-square=12.69; $p<0.001$)
- Less migration with bees for honey (17.4% vs. 35.0%) (chi-square=17.08; $p<0.001$)
- Lower GBMP-index score (6.58 vs. 7.09) ($t=1.99$; $p=0.048$)
- Weaker 'economic motivation' ($t=5.41$; $p<0.001$)
- Weaker 'business orientation' ($t=6.07$; $p<0.001$)
- Lower average annual comb replacement (24% vs. 32%) ($t=4.71$; $p<0.001$)
- Lower share of wax from own closed wax cycle (9% vs. 34.3% all wax from own closed wax cycle) (chi-square=52.5; $p<0.001$)
- Lower average honey production per hive (11.5 kg vs. 17.3 kg) ($t=4.35$; $p<0.001$)
- With respect to colony winter loss rates, a relatively higher share of starters are observed in both the '0-10%' winter loss rate category as in the '>30%' winter loss rate category (chi-square=23.79; $p<0.001$); 58.1% of the starters reported '0-10%' vs. 46.1% of the non-starters; and 14.6% of the starters reported '>30%' vs. only 6.9% of the non-starters. This finding is plausible since on one hand winter loss may be less likely to occur in the first year(s) after starting with beekeeping, whereas on the other hand high winter loss rates may be associated with lower experience.

Urban (purely + rather urban) beekeepers (n=93; 11%) are characterised by:

- Higher share of non-professional beekeepers (97.8% vs. 90.4%) (chi-square=5.72; $p=0.017$)
- Smaller apiaries (15.2 hives vs. 79.4 hives in 2021) ($t=6.07$; $p<0.001$)
- Less years active as beekeeper (12.1 vs. 15.4 years) ($t=2.19$; $p=0.029$)
- Higher probability of membership of a local or regional beekeeping association (92.5% vs. 84.7%) (chi-square=4.06; $p=0.044$)
- Less attendance of advanced course(s) (45.2% vs. 62.1%) (chi-square=9.85; $p=0.002$)
- Less likely to have inherited beekeeping from (grand)parents (14.0% vs. 24.4%) (chi-square=5.01; $p=0.025$)
- Less migration with bees for honey (16.1% vs. 34.0%) (chi-square=12.09; $p=0.001$)
- Weaker 'economic motivation' ($t=5.87$; $p<0.001$)
- Weaker 'business orientation' ($t=4.32$; $p<0.001$)
- Higher share of zero wax from own closed wax cycle (48.4% vs. 31.7% with zero wax from own closed wax cycle) (chi-square=11.7; $p=0.008$)
- Higher colony winter loss rates (31.2% vs. 19.8% with colony winter loss >20%) (chi-square=7.02; $p=0.030$)

Fully professional beekeepers based on the size and economic value of their beekeeping activities (n=74; 8.8%) are characterised by:

- Younger age (47.1 vs. 53.1 years) ($t=4.57$; $p<0.001$)
- Larger apiaries (480 vs 33 hives in 2021) ($t=-5.01$; $p<0.001$)
- More years active as a beekeeper (21.1 vs. 14.4 years) ($t=-4.01$; $p<0.001$)
- Higher GBMP-index score (7.82 vs. 6.92) ($t=-3.42$; $p=0.002$)
- Stronger 'economic motivation' ($t=-25.8$; $p<0.001$)
- Lower 'own honey production motivation' ($t=6.25$; $p<0.001$)
- Stronger 'business orientation' ($t=-9.95$; $p<0.001$)
- Stronger 'performance equals welfare orientation' ($t=-3.27$; $p=0.001$)

- More 'fully rural' location (59.5% vs. 41.2%) (chi-square=12.32; p=0.015)
- Lower likelihood of membership of a local or regional beekeeper association (77.0% vs. 86.4%) (chi-square=4.76; p=0.029)
- More migration with bees for honey (77.0% vs. 27.7%) (chi-square=75.6; p<0.001)
- Lower attendance of starter course(s) (66.2% vs. 84.2%) (chi-square=15.1; p<0.001)
- More attendance of advanced course(s) (71.6% vs. 59.1%) (chi-square=4.42; p=0.035)
- More beekeeper apprenticeship or working experience with another beekeeper (63.5% vs. 50.8%) (chi-square=4.39; p=0.036)
- Higher share of wax from own closed wax cycle (56.8% vs. 27.4% all wax from own closed wax cycle) (chi-square=30.1; p<0.001)
- More likely to have inherited beekeeping from their (grand)parents (45.9% vs. 21.0%) (chi-square=23.5; p<0.001)

Professional beekeepers by expertise (n=145; 17.2%), defined as beekeepers who scored their degree of hobby-ism/professionalism two or more scale points higher for the item 'I consider my beekeeping activities as hobby/professional based on my expertise' compared to the item 'I consider my beekeeping activities as hobby/professional based on their size and economic value', are characterised by:

- Higher education (48.3% vs. 37.6% university/university college master degree or higher) (chi-square=6.67; p=0.036)
- Higher share of non-professional beekeepers (100% vs. 77.1%) (chi-square=40.95; p<0.001)
- Smaller apiaries (24.2 vs. 82.4 hives in 2021) ($t=5.15$; p<0.001)
- More years active as a beekeeper (18.8 vs. 14.3 years) ($t=-3.23$; p<0.001)
- More likely to have membership of an international beekeeper association (9.0% vs. 3.9%) (chi-square=6.93; p=0.008)
- More likely to be a member of the board of a beekeeper association (33.1% vs. 23.9%) (chi-square=5.37; p=0.021)
- Higher attendance of one or more advanced courses (77.9% vs. 56.5%) (chi-square=23.0; p<0.001)
- Higher level of beekeeper apprenticeship or worked with another beekeeper (62.1% vs. 49.8%) (chi-square=7.26; p=0.007)
- Higher frequency of attendance of lectures, workshops, training activities for beekeepers (73.8% vs. 55.8% 'several times a year') (chi-square=16.64; p=0.001)
- Weaker 'economic motivation' ($t=5.89$; p<0.001)
- Weaker 'business orientation' ($t=3.08$; p=0.002)
- Furthermore, professional beekeepers by expertise tended to have a weaker 'performance equals welfare' orientation (p=0.086).
- Higher GBMP-index score (7.90 vs. 6.82) ($t=-5.40$; p<0.001)
- Higher share of annual comb replacement (36.2% vs. 29.7%) ($t=-3.36$; p=0.001)
- This group did not differ from other beekeepers with respect to colony winter loss rate (despite a marginally significant association suggesting a tendency towards lower winter loss rates, p=0.079), implementation of an own closed wax cycle and average honey yield per hive.

3.8.2 Identification and profiling of attitudinal-based beekeeper segments

A second set of analyses aimed at the identification and profiling of European beekeeper segments focused on **beekeepers' attitudinal characteristics** by using orientations towards honey bees and beekeeping as segmentation variables. Specifically, the two items with the highest factor loadings from the 'business orientation' factor (referring to the 'utility' dimension) and from the 'natural orientation' factor (referring to the 'affect' dimension) were selected as segmentation variables. For each segmentation variable, the sum of both item scores (originally scored on 1-5) was used as a continuous variable, though standardised for analysis. Specifically, the item scores for 'A beekeeper should think of his/her honey bee colonies mainly in terms of the profit they will bring' and 'A beekeeper should think of his/her honey bee colonies mainly in terms of the market value or cost they represent' were aggregated as 'utility / business orientation', and the item scores for 'Honey bee colonies should be ideally kept in a suitable environment that is as natural as possible' and 'It is important for honey bees to be able to express natural behaviour' were aggregated as 'affect / natural orientation'.

A two-step cluster analysis was performed using Schwartz's Bayesian Information Criterion (BIC) as clustering criterion (Chen & Gopalakrishnan, 1998), log-likelihood as distance measure, automatic detection of the optimal number of clusters and 15% noise handling, the latter allowing to identify and exclude eventual cases that do not fit any of the clusters. Five clusters have been identified using this procedure; three cases were classified as outliers (noise) and not included in the cluster solution. The five clusters and their scores on the segmentation variables are shown in Figure 31.

One cluster (**CL3**) stands out in terms of its score on 'utility / business orientation'. The other four clusters are positioned in each of the four quadrants formed with the axes intersecting at the median of both dimensions (i.e. 4 for 'utility / business orientation' and 8 for 'affect / natural orientation'). This implies that beekeeper types combining all possible combinations of low/high utility and affect are identified and can be profiled. Hence, there are beekeepers in Europe whose orientation towards honey bees and beekeeping is utilitarian as well as affective (**CL5**), and there are also beekeepers whose orientation is neither utilitarian nor affective (**CL1**). In a similar vein, there is a beekeeper type that is characterised by low affect and high utility (**CL2**), as well as the opposite type characterised by high affect and low utility (**CL4**).

The profile of the five clusters is detailed in Table 29 and Table 30 for variables where statistically significant differences across clusters were observed. A summary of the characteristics of each cluster is provided in Box 3. The five clusters did not differ significantly with respect to:

- education;
- years active with beekeeping;
- honey bee colony winter loss rate (both categorical and continuous, see Box 2);
- colony health monitoring index score.

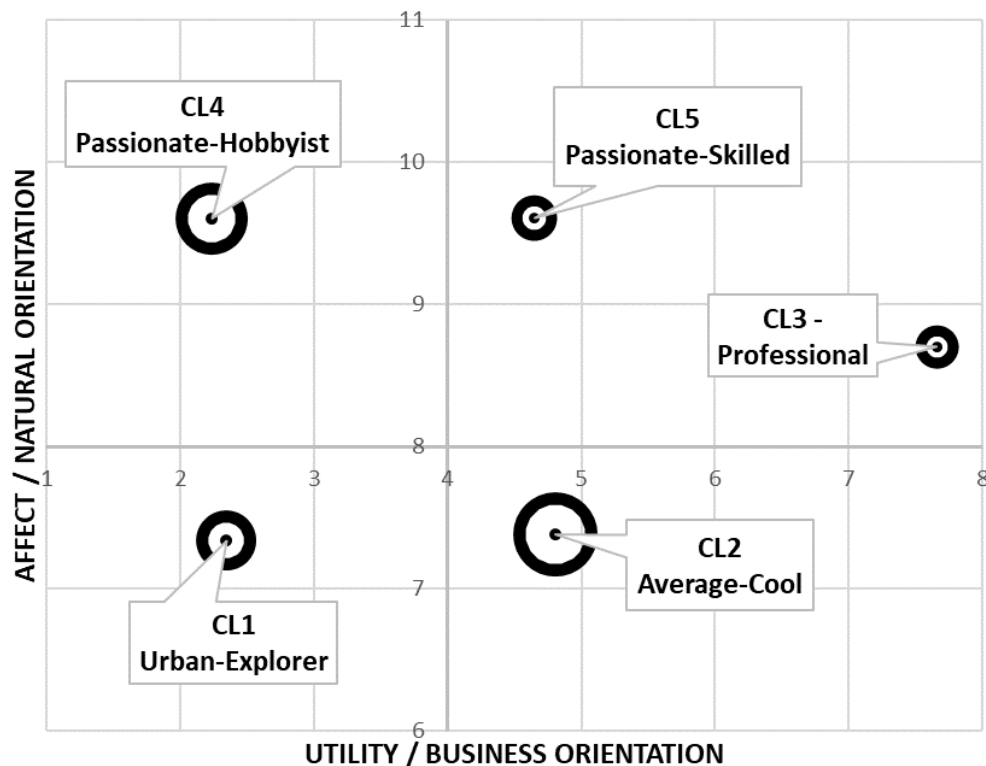


Figure 31. Five-cluster solution following two-step cluster analysis, positioning of the beekeeper clusters on the segmentation variables 'utility / business orientation' and 'affect / natural orientation'; the size of the dots indicates the relative size of the clusters (n=841)

CL3-beekeepers, who are characterised as **Professionals**, manage to combine their very high utility / business orientation towards honey bees and beekeeping with an above-average affective orientation. This means that professional beekeepers share the belief that honey bees are ideally kept in an environment that is as natural as possible and that honey bees should be able to express their natural behaviour. This finding underscores that utility and affect in European beekeeping (might) go hand in hand to the extent that this may also fit with professional beekeeping status and economic motives. These European professional beekeepers are relatively young (47 years); manage the largest apiaries on average (160 hives), and are predominantly based in Eastern European regions. They are involved in the provision of pollination services with about one third of their hives, and half of them migrate their colonies for honey production. They are also among the most active beekeepers with respect to managing an own closed wax cycle. As compared to other clusters, beekeeping is relatively less an activity Professionals inherited from their (grand)parents. They manage to realise the highest average honey yield per hive (21 kg/hive), which is almost double that of the cluster with the lowest honey yield per hive.

CL5-beekeepers resemble CL3-beekeepers in that they also exhibit a combined moderate-to-high utility / business orientation with a high affective orientation. With the CL3-Professionals, they furthermore share an orientation towards honey bee welfare that associates good animal welfare with good performance. However, passion for beekeeping and nature, and an interest in producing their own honey are their main motivations. They stand

out in terms of good beekeeping management practices as they have the highest GBMP-index score as well as the highest share of implementing a 100% own closed wax cycle of all clusters. Interestingly, this does not translate into a significantly lower winter loss rate or a higher average honey yield per hive compared to the other clusters. This profile is relatively more seen in Southern European regions. Given this profile, CL5 is referred to **Passionate-Skilled**.

CL2-beekeepers share the moderate-to-high utility / business orientation with CL5 but exhibit a low affective orientation and an opposite 'welfare equals performance' orientation. This means that honey bee welfare has a different meaning for them than pure performance. They are the most active as compared to other beekeepers with respect to annual comb replacement as well as annual queen replacement, but at the same time they also exhibit the lowest GBMP-index score. This beekeeper type is relatively more seen in Northern European regions. CL2 is the largest beekeeper cluster with a profile that is, compared to beekeepers in other clusters, rather average. Combined with their low affective orientation, this cluster is referred to as **Average-Cool**.

CL4-beekeepers have a high affective orientation towards honey bees and beekeeping and a low utility orientation. Clearly, honey bees are part of nature and not meant for business, according to these beekeepers. This view is underscored by passion being their motivation as opposed to economics. They have the smallest apiaries on average (27 hives) and are hardly involved in the provision of pollination services and migration of bees for honey production. They have the lowest average honey yield per hive (13 kg) and the strongest tendency to leave queen replacement to the bees to decide. This cluster has a relatively high share of female beekeepers and beekeepers who reported beekeeping as a pure hobby. This beekeeper profile is more seen in Western European regions. This cluster is referred to as **Passionate-Hobbyist**.

CL1-beekeepers are characterised by a low affective and a low utility orientation towards honey bees and beekeeping. Yet, they have a clear albeit multifaceted profile. On one hand, this cluster contains a relatively high share of urban beekeepers and starters (less than 3 years active as a beekeeper). On the other hand, this cluster contains a relatively high share of 'professionals by expertise', i.e. beekeepers who reported to be (rather) hobbyists by size and economic value of their beekeeping operations, but (rather) professional by the expertise they have gained. Similar as with CL4, this profile is more seen in Western European regions. This cluster is referred to as **Urban-Explorer**.

Table 29. Comparison of means on continuous variables (ANOVA F-tests) across the five identified beekeeper clusters (means, n=841)

	Overall sample (n=841)	CL1 (n=159)	CL2 (n=246)	CL3 (n=113)	CL4 (n=206)	CL5 (n=117)	test statistic and p-value
Age (years)	52.5	54.1a,b	51.3b	46.7c	56.2a	52.0b	F=10.88; p<0.001
# hives total	72.3	62.1b	71.8b	159.0a	26.9b	83.6a,b	F=4.72; p=0.001
# hives honey	54.2	43.6b	56.4a,b	117.8a	15.7b	70.1a,b	F=4.69; p=0.001
# hives pollination	17.0	8.0b,c	16.3b,c	47.7a	3.2c	25.0b	F=12.46; p<0.001
Annual % comb replacement	30.8	32.4a	32.0a	30.8a,b	31.1a,b	25.8b	F=2.53; p=0.039
GBMP-index score	7.01	6.8a,b	6.6b	7.3a,b	7.2a,b	7.6a	F=4.05; p=0.003
Avg. honey yield per hive (kg)	16.3	15.7b	17.2a,b	20.7a	13.0b	16.7a,b	F=5.63; p<0.001
Economic motivation FS*	0.00	-0.49c	0.23b	0.91a	-0.49c	0.18b	F=64.47; p<0.001
Passion motivation FS*	0.00	-0.19b	-0.09b	-0.25b	0.24a	0.29a	F=9.55; p<0.001
Own honey motivation FS*	0.00	-0.01a,b	0.06a,b	0.05a,b	-0.19b	0.22a	F=3.69; p=0.005
Welfare equals performance orientation FS*	0.00	0.02a,b	-0.23b	0.15a	0.07a,b	0.18a	F=5.16; p<0.001

Notes: a,b,c indicate significantly different means following Tukey post-hoc tests within a variable; * FS = Factor Score; as factor scores are standardised values, factor score sample means are zero.

Table 30. Comparison of the five identified beekeeper clusters on categorical variables (Chi-square association tests) (% , n=841)

	Overall sample (n=841)	CL1 (n=159)	CL2 (n=246)	CL3 (n=113)	CL4 (n=206)	CL5 (n=117)	test statistic and p-value
Females	18.8	15.2	15.6	13.3	27.3	20.5	X ² =15.18; p=0.004
Purely hobby	46.8	67.9	37.0	14.2	65.0	38.5	X ² =171.6; p<0.001
Fully professional	8.7	2.5	9.8	24.8	2.4	10.3	X ² =55.46; p<0.001
Migrates with honey bees	32.0	34.6	36.2	50.4	17.0	28.2	X ² =42.24; p<0.001
Queens replaced every year	12.7	11.3	18.7	15.9	6.8	9.4	X ² =93.83; p<0.001
Queen replacement left to the bees	18.1	17.0	10.6	8.0	36.4	12.8	
100% own closed wax cycle	30.1	19.5	31.7	36.3	28.6	37.6	X ² =23.07; p=0.027
Northern Europe	9.2	6.9	12.6	8.0	8.3	7.7	X ² =200.7; p<0.001
Western Europe	54.0	75.5	48.4	15.9	74.3	37.6	
Eastern Europe	18.5	9.4	17.9	53.1	5.8	21.4	
Southern Europe	18.3	8.2	21.1	23.0	11.7	33.3	
Inherited beekeeping	23.2	15.7	19.1	13.4	24.5	13.9	X ² =43.87; p<0.001
Professional by expertise	17.2	22.0	16.7	7.1	18.4	19.7	X ² =11.46; p=0.022
Urban (purely + rather)	10.9	17.0	11.0	7.1	12.1	4.3	X ² =14.76; p=0.005
Starter (<3 yrs beekeeping)	17.0	23.9	15.9	7.1	20.9	12.8	X ² =17.11; p=0.002

Note: X² denotes the chi-square statistic following cross-tabulation.

Box 3. Summary profile of the five identified European beekeeper clusters

Cluster 1 (Urban-Explorer) (n=159; 18.9%) is characterised by (relatively high shares of):

- Low utility and Low affect
- Lowest economic motivation
- Purely hobby
- Urban beekeepers
- Western European
- Starters
- (Self-declared) professionals by expertise

Cluster 2 (Average-Cool) (n=246; 29.3%) is characterised by (relatively high shares of):

- Moderate-to-high utility and Low affect
- Northern European
- Lowest GBMP-index score
- Lowest 'welfare equals performance' orientation
- Annual queen replacement

Cluster 3 (Professional) (n=113; 13.4%) is characterised by (relatively high shares of):

- Very high utility and Moderate-to-high affect
- Youngest mean age
- Largest beekeeping operation size
- Highest average honey yield per hive
- Strongest economic motivation
- Migration with bees for honey production
- 100% own closed wax cycle
- Eastern European
- Fully professional beekeepers

Cluster 4 (Passionate-Hobbyist) (n=206; 24.5%) is characterised by (relatively high shares of):

- Low utility and Very high affect
- Oldest mean age
- Female beekeepers
- Smallest beekeeping operation size
- Weakest economic motivation
- Strong passion motivation
- Purely hobby
- Queen replacement left to the bees to decide
- Western European

Cluster 5 (Passionate-Skilled) (n=117; 13.9%) is characterised by (relatively high shares of):

- Moderate-to-high utility and Very high affect
- highest GBMP-index score
- 100% own closed wax cycle
- Southern European
- Passion motivation
- Own honey motivation

4. Conclusions

This deliverable provided an overview of the B-GOOD WP4 quantitative beekeeper survey as part of the research activities within Task 4.2. Following study protocol and questionnaire development and pre-testing, and the granting of ethics approval on 27 August 2021, a total of 844 beekeepers from 18 European countries completed the survey during the period from 8 October 2021 until 10 January 2022. The sample composition is diverse and covers Western, Eastern, Southern and Northern European regions, hobbyist and professional beekeepers, urban and non-urban beekeepers, starters and experienced beekeepers, beekeepers who migrate their bees for honey production and/or engage in the provision of pollination services, as well as beekeepers who are stationary.

Although generalisation from the study sample to the overall European beekeepers' population was not a main objective of the survey as such – the main objective being rather to explore and map diversity, identify similarities and differences, as well as homogeneous segments of beekeepers in Europe – specific efforts have been made to assess the external validity of the study sample. This has been done through comparing average honey yields per hive per country (Box 1) and reported honey bee colony winter loss rates per country (Box 2) with available data from other sources, in this case the National Apiculture Programmes 2020-2022 and the COLOSS 2017/18 and 2018/19 winter loss surveys. Although straightforward comparison is not possible owing to major differences in study methods and their framing, both assessments provide a good degree of external validity of the B-GOOD WP4 beekeeper survey sample. Notwithstanding this, findings remain to be interpreted while taking the characteristics of the study sample into account. The accuracy of the data reported in this deliverable depends on the accuracy and representativeness of the data reported by the participants.

Besides providing a detailed description of the personal and beekeeping characteristics of the study sample, our results present insights into beekeepers' motivations for beekeeping, ranging from merely passion to an interest in own honey production or economics, as well as about beekeepers' utility vs. affect orientations towards honey bees and beekeeping. These orientations have been used as segmentation variables to identify five clusters or types of beekeepers, which have consecutively been profiled or characterised and referred to as: Urban-Explorer, Average-Cool, Professional, Passionate-Hobbyist, and Passionate-Skilled.

Furthermore, the data allowed an analysis of beekeeping management practices related to the management of queens and colonies, comb replacement and wax recycling, administration and record keeping, hive monitoring, environment management and monitoring, equipment management, and health and welfare monitoring. Based on the quantitative analyses of these data and backed up by insights from beekeeping experts, a Good Beekeeping Management Practice (GBMP)-index consisting of 11 items has been composed. The highest GBMP-index scores were obtained by beekeepers characterised (based on bivariate statistical comparisons) as rather or fully professional, Northern European, female, who are 16 or more years active as a beekeeper, and who inherited beekeeping from their (grand)parents. This GBMP-index also showed a clear gradient with beekeeping success, signalling lower winter loss rates in case of higher GBMP-index scores, and it was significantly (though only moderately) correlated with average honey yield per hive. In addition, beekeepers' engagement in the production of honey, other apiary products and the provision of pollination

services have been analysed, alongside reported colony winter loss rates and colony health status monitoring activities.

With respect to beekeeper segments, first, specific groups such as female beekeepers, young beekeepers, novices, urban beekeepers, professional beekeepers and professional beekeepers by expertise have been profiled. Second, five beekeeper segments have been identified based on their utility / business orientation vs. affect / natural orientation towards honey bees and beekeeping and summary profiles of them have been presented (Box 3).

The main conclusions from the different sections reported in this deliverable are:

Sample and beekeeping characteristics

- The majority of beekeepers in our sample is located in Western Europe (Belgium and The Netherlands), with Northern Europe being the least represented.
- Hobby beekeepers were represented more than professionals, with hobbyists based on size constituting 81% of the total sample and hobbyists based on expertise constituting 64% of the total sample.
- 92% of beekeepers in our sample belonged to at least one formal association. This reflects our sampling procedure in which beekeepers were mainly contacted to take the survey via beekeeping associations. Beekeepers located in Northern Europe were the most active in beekeeping associations, and beekeepers located in Eastern Europe were the least active.
- One third of the beekeepers in our sample reported being migratory beekeepers, and these beekeepers tended to be more in the Eastern region of Europe, professional beekeepers and also beekeepers who had inherited their beekeeping practice.

Beekeeper motivations

- Beekeepers were most highly motivated by passion to keep honey bees, either passion for beekeeping itself or out of passion for nature, and were least motivated by gaining a main source of income from their beekeeping.
- Having a strong motivation for economic reasons is associated with being a younger beekeeper and also having a non-university/university college education.
- Professional beekeepers were more driven by economic reasons, whereas hobby beekeepers were more driven by producing own honey for own consumption.
- No significant differences were found between professional and hobby beekeepers on the factor passion, which suggests that both groups are similarly passionate about their beekeeping practices.

Beekeeper orientations

- Beekeepers were in good agreement that honey bee colonies should be ideally kept in a suitable environment that is as natural as possible, and that it is important for honey bee colonies to be able to express natural behaviour.
- Professional beekeepers were significantly more business-oriented and significantly more *performance equals welfare* oriented than hobbyists.
- No significant differences were found between professional and hobby beekeepers for natural orientation, which suggests that both groups are similarly naturally oriented towards their beekeeping practice.

Beekeeping management practices

- The highest GBMP-index scores were achieved by beekeepers characterised as:
 - Rather or fully professional
 - Northern European
 - Female
 - 16 or more years active as a beekeeper
 - Inherited beekeeping from their (grand)parents.
- Beekeepers with higher GBMP-index scores generally reported lower annual colony winter loss rate.
- Overall, higher GBMP-index scores go hand in hand with a higher degree of comb replacement and the implementation of an own closed wax cycle, which in turn is associated with lower colony winter loss and higher average honey production per hive.

Beekeeping outputs

- Beekeepers in our sample produced a mean of 986 kg of honey per beekeeper in 2021, with a mean of 16 kg per hive, which is slightly less than the European average yield of 22 kg of honey per hive in 2018.
- Professional beekeepers had significantly higher honey production per hive than hobby beekeepers.
- Beekeepers with more experience generally had a higher mean honey production per hive.
- Honey was by far the most common apiary product or service that beekeepers in our sample produced, followed by beeswax, honey bee colonies, and propolis.

Colony winter loss rate and health status monitoring

- Almost half of the beekeepers in our sample reported an average colony winter loss rate of 0-10% on average over the past five years, and almost one third of the beekeepers in our sample reported an average colony winter loss rate of 10-20% on average over the past five years.
- Beekeepers in Northern Europe reported the lowest colony winter loss rates, followed by beekeepers in the Eastern region, Western region, and finally beekeepers in the Southern region, who suffered significantly higher rates of winter loss.
- Urban beekeepers reported higher winter losses than other beekeepers.
- Very few differences were exhibited in the health status monitoring index between European regions, level of beekeeping experience, and whether beekeepers had taken a starter course or had had a beekeeping apprenticeship.

Following the reporting of this deliverable, further data analyses (e.g. multivariate analyses) will be performed and findings and insights will be disseminated through scientific journal publications, policy briefs and integrated in training activities in collaboration with WP7. Furthermore, national/regional beekeeper magazines articles will be published in countries where a sufficient sample size has been reached (e.g. Belgium, the Netherlands, Germany, Portugal, Poland, Italy, Romania and Finland) to provide insight in the respective country's beekeepers' views, opinions and attitudes.

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Appendices

Appendix 1. Beekeeper questionnaire: master English version

WP4 – Task 4.2 – Questionnaire for Beekeepers

	Introduction
Intro_1	<p>Dear participant,</p> <p>Thank you for being willing to participate in this study. Your participation in the study is very important to us and your input is valued in helping to gather your insights on beekeeping in the EU. This survey should take you approximately 25 minutes to complete.</p> <p>In order to ensure that all information will remain anonymous, your name will not be recorded or used. No personal data or data that can identify you as participant will be shared with any third party. The data provided will be analysed in an anonymous way and the results of the survey will be communicated and disseminated in aggregated anonymous format only.</p> <p>Your participation is entirely voluntary and you may refuse to participate or withdraw at any time.</p> <p>Thank you and stay safe!</p> <p>The B-GOOD research team</p>
Intro_2	   <p>This project receives funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817622.</p>

Confirmation of informed consent and agreement to participate

Intro_3) I have read and understood the “Information sheet for the participants”, page 1 to page 2, and I have received a copy of this document. I have been informed of the nature of the study, its purpose, its duration and what is expected of me.

Yes/No, please consider reading the information sheet for participants at this link before proceeding: bgoodwp4.ugent.be

Intro_4) I understand that participation in the study is voluntary and that I can withdraw from the study at any time without giving a reason for this decision and without this having any implication for myself.

Yes/No

Intro_5) I agree to participate in the study.

Yes/No

Block A: Socio-economic variables

A_1	What is your country of residence ?	<p>(Choose one from list of all European countries)</p> <p> Austria Belgium Bulgaria Croatia Cyprus Czechia Denmark Estonia Finland France Germany Greece Hungary Ireland Italy Lativa Lithuania Luxembourg Malta Netherlands Poland Portugal Romania Slovakia Slovenia </p>
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		Spain Sweden Switzerland United Kingdom None of the above
A_2	What is your age? (years)	

A_3) What is your highest completed education level?

Primary education (until the age of 12) or lower	1
Lower secondary education (until the age of 15)	2
Higher secondary education (until the age of 18)	3
University college or university education, Bachelor level	4
University college or university education, Master level or higher	5

A_4) What is your gender?

Male	Female	Other/prefer not to say
1	2	3

A_5	What is your maximum total number of beehives in 2021?	
A_6	What is your maximum total number of beehives for honey production in 2021?	
A_7	What is your maximum total number of beehives used for pollination services in 2021?	

A_8) Please indicate to what extent you would classify your beekeeping activities based on their **size and economic value** as being rather hobbyist versus rather professional using the following scale.

I consider my beekeeping activities considering their size and economic value as:

Purely hobbyist	Rather hobbyist	Neither hobbyist nor professional	Rather professional	Fully Professional
1	2	3	4	5

A_9) Please indicate to what extent you would classify your beekeeping activities based on your **personal expertise and beekeeping skills** as being rather hobbyist versus rather professional using the following scale.

I consider my beekeeping activities considering my personal expertise and beekeeping skills as:

Purely hobbyist	Rather hobbyist	Neither hobbyist nor professional	Rather professional	Fully Professional
1	2	3	4	5

A_10) Please indicate to what extent you would classify your beekeeping activities based on **the location of your hives during the main bee season** as being rather rural versus rather urban using the following scale.

I consider my beekeeping activities as:

Purely urban	Rather urban	Neither urban nor rural	Rather rural	Fully rural
1	2	3	4	5

A_11) Please indicate whether you are member of, or registered with, the following types of apicultural or beekeepers' associations.

An informal club of friends or colleagues who are beekeepers	Yes/No
A local or regional beekeepers association	Yes/No
More than one local or regional beekeepers associations	Yes/No
A cooperative or honey producer group	Yes/No
The national beekeepers association of my own country	Yes/No
The national beekeepers association of other countries	Yes/No
An international beekeepers association	Yes/No

A_12	Do you assume responsibility as chairman, secretary or board member of any beekeepers association?	Yes/No
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A_13		Yes/No
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	Did you migrate, move or travel with honeybee colonies in 2021 for honey flow?	
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A_14) Please indicate to what extent you have attended training courses in beekeeping (since you started with beekeeping).

I have attended one or more starter courses	Yes/No
I have attended one or more advanced courses	Yes/No
I have had a beekeeper apprenticeship or have worked with another beekeeper	Yes/No

A_15	<p>To what extent do you attend follow-up lectures, demonstrations, workshops or seminars on beekeeping?</p> <p>Note: We are aware that there were less opportunities during the last 18 months because of COVID. Therefore, please think of the pre-COVID period (e.g. 2019 or 'normal times') as reference.</p>	<p>Never</p> <p>Less than once a year</p> <p>Once a year</p> <p>Several times a year</p>
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A_16	How many years have you been active with beekeeping?	
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A_17) Please indicate to what extent the following reasons applied to you as your personal motivation when you started keeping honeybees?	Not at all	Rather not	Neither nor	Rather yes	Definitely yes
I started keeping honeybees...					
As my main source of income	1	2	3	4	5
As a secondary source of income	1	2	3	4	5
Out of passion for honeybee keeping	1	2	3	4	5
Out of passion for nature and the ecological environment	1	2	3	4	5

As a hobby	1	2	3	4	5
To produce honey for own consumption	1	2	3	4	5
To produce honey for sales	1	2	3	4	5
To provide pollination services	1	2	3	4	5
I inherited this from parents or grandparents	1	2	3	4	5

A_18) Please indicate to what extent the following reasons apply to you as your personal motivation for keeping honeybees today?	Not at all	Rather not	Neither nor	Rather yes	Definitely yes
I am keeping honeybees today...					
As my main source of income	1	2	3	4	5
As a secondary source of income	1	2	3	4	5
Out of passion for honeybee keeping	1	2	3	4	5
Out of passion for nature and the ecological environment	1	2	3	4	5
As a hobby	1	2	3	4	5
To produce honey for own consumption	1	2	3	4	5
To produce honey for sales	1	2	3	4	5

To provide pollination services	1	2	3	4	5
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Block B: Economic Performance

B_1) Below, we ask for your economic figures to the best of your knowledge. If you are unsure of an answer, **please provide a reasonable estimate**. If a question does not apply to you, please leave the answer **blank**.

The purpose of asking for economic figures is to identify economically sustainable and profitable business models for beekeeping. The information that you provide is anonymous, it will be treated confidentially and shared only in aggregated format with anyone besides the B-GOOD research team.

Please answer all economic figures in your national currency, and all economic figures should include VAT if applicable.

In the questions regarding figures for the entire year 2021, please add future predictions based on expectations for the rest of 2021 in the figure.

B_2	What is your national currency? (the currency you will also use to enter economic figures)	Euro (EUR) Danish krone (DKK) Polish złoty (PLN) Romanian leu (RON) Pound sterling (GBP)_ Bulgarian lev (BGN) Swiss franc (CHF)
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B_3) Please indicate to what extent you believe your honeybees by means of pollination contributed to improve or increase...	Not at all	Rather not	Neither nor	Somewhat	A lot
Agricultural crop production	1	2	3	4	5
Horticultural crop production	1	2	3	4	5
Fruit production	1	2	3	4	5

Overall biodiversity in your environment	1	2	3	4	5
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B_4	Do you provide pollination services that are paid for?	Yes/No
B_5	If yes , What is your total revenues from paid pollination services that you provided in 2021 ?	
B_6	If yes , Do you esteem this amount paid for pollination services as a sufficient and fair reimbursement?	Yes/No
B_7	If no , Would you like to get paid for the pollination services that you / your honeybees provide?	Yes/No
B_8	If no , What is the reason why you don't get paid for the pollination services that you / your honeybees provide?	

B_9	What was the total quantity of honey that you produced in 2021 (kg) ?	
B_10	Do you perform other economic activities (besides beekeeping)?	Yes, I am employed with a fixed wage Yes, I have my own business besides beekeeping No, beekeeping is my only economic activity
B_11	How much of your beekeeping activities contribute to your income?	Less than 50%

		More than 50% but less than 100% Beekeeping is my only source of income
B_12	What is your total revenue from honey harvested in 2021?	
B_13	What is your total revenue from other beekeeping activities in 2021, besides the provision of pollination services and honey production? This may include for example the production and sales of queens, colonies, or other apiary products such as wax, royal jelly, pollen or propolis.	
B_14	What were your total costs for feed in 2021?	
B_15	What were your total costs for disease prevention and treatment (including against varroa) in 2021?	
B_16	<p>What were your total costs for honey harvesting materials (e.g. rent of honey extractor or depreciation cost* of your own honey extractor) and packaging materials (e.g. jars and lids) in 2021?</p> <p>*depreciation cost = purchase price divided by the expected number of years that the extractor will be used</p> <p>(do not include labour costs for honey harvesting in this figure)</p>	
B_17	What were your total costs for fuel (for your beekeeping activities) in 2021?	
B_18	What were your total costs for electricity (for your beekeeping activities) in 2021?	
B_19	What were your total costs for water (for your beekeeping activities) in 2021?	

B_20	Did you have other beekeeping expenditures for production or marketing in bee season 2021? If so what were they and how much did they cost?	Description of other expenditures Total cost for other expenditures
B_21	When you began beekeeping, what was your total cost for hives and colonies (including frames, bottom boards, queen excluders, feeders)?	
B_22	When you began beekeeping, what was your total cost for other beekeeping equipment (such as honey extractor, smoker, hive tools, protective gear, ...)?	
B_23	What was your total annual labour (in man-days) on beekeeping, your own labour included, in 2021? This should include time spent both on managing bees and other aspects related to beekeeping (e.g. cleaning, sales, bookkeeping, etc.) Assume a total of 8 working hours for one man-day. For example: 4 working days of 8 hours for 2 people = 8 man-days	
B_24	Given your answer for number of man-days above, how accurate (precise) would you say this number is?	It is a very rough estimate It is a rather rough estimate It is a rather good estimate It is a highly accurate estimate
B_25	What was the average hourly rate that you paid for hired beekeeping labour, if applicable?	
B_26	Do you produce and sell other apiculture products (wax, propolis, royal jelly, etc.) ?	Wax Propolis

		Royal Jelly Pollen Colonies Queens Other _____
B_27	What is the average price (per kg) you got in 2021 for honey sold locally in consumer units?	
B_28	What is the average price (per kg) you got in 2021 for honey sold in bulk (e.g. in buckets or barrels to honey packers)?	

B_29) Compared to previous years, how do you evaluate your bee season 2021 from a **honey production** point of view?

Very bad	Bad	Neither bad nor good	Good	Very good
1	2	3	4	5

B_30) Compared to previous years, how do you evaluate your bee season 2021 from an overall **economics** point of view (this means considering production, honey yield, costs, revenues, profits)?

Very bad	Bad	Neither bad nor good	Good	Very good
1	2	3	4	5

Block C: General beekeeping management

C_1) Please indicate to what extent you perform the following activities in your beekeeping practice.

C_2) I replace my queens:

Never, I leave it to the bees to decide when	Only when they no longer perform well	Every two or three years	Every year
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C_3	On an annual basis, what percentage of your combs do you replace on average?	
-----	--	--

C_4) What share of the wax you use in your hives (e.g. new combs) comes from your own closed wax cycle:

Zero, I do not recycle and reuse my own wax	Less than 50%	More than 50%, but not all	All the wax I use comes from my
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			own closed wax cycle
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C_5) If you have to purchase wax, does this concern:	Yes	No	Not applicable
Local (not imported) wax			
Organic wax			
Wax with a specific certification other than local or organic			

C_6) To what extent do you buy honeybee colonies from others?

Never	Less than 20% of my colonies	20-50% of my colonies	More than 50% of my colonies
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C_7) To what extent do you buy queens from others?

Never	Less than 20% of my queens	20-50% of my queens	More than 50% of my queens
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C_8) Please indicate to what extent you implement the following practices in your beekeeping.

		N o / N e v e r	F r o m s o m e t i m e s t o m o s t l y	C o m p l e t e l y / A l w a y s
1	I observe quarantine measures for all new introductions I make to my apiaries			
2	My hives are identified with a unique code for documentation			
3	I do efforts to prevent acts of looting or robbery among the colonies			
4	I monitor and adapt hive capacity to discourage swarming			
5	I monitor the welfare of my colonies, especially the younger and weaker colonies			

6	I do not use purchased honey to feed my bees			
7	I use the bee smoker only when needed			
8	I do not transfer combs from one colony to another without certainty about the colony's health status			
9	I periodically mow the grass or vegetation in front of my hives			
10	I regularly clean my beekeeping equipment			
11	I regularly disinfect my beekeeping equipment			
12	I consult experts in case of anomalies with my bees or hives			
13	My beekeeping activities are officially registered in line with national guidelines, systems or registers			
14	I keep track of productive records of my colonies			
15	I keep track of economic records of my beekeeping activities			
16	I keep track of time records (for time spent on my beekeeping activities)			
17	I raise my own queens for queen replacement			
18	I mark my queens			
19	I participate in a breeding programme			
20	I repair my hives and frames whenever needed			
21	I make use of a weighting scale under (at least some of) my hives			
22	I plant nectar and pollen producing plants in the neighbourhood of my hives			
23	I inspect the suitability of the environment and surroundings for my hives			
24	I monitor the health status (e.g. absence of diseases) of my colonies			
25	I monitor the welfare status (e.g. food stocks) of my colonies			
26	I only apply drugs or substances that are officially registered in my country for use in honeybees			

Block D: Honeybee health

D_1) To what extent do you believe the following items are important in terms of impacting honeybee colony health?

You are asked to distribute 100 points across the following five items, where 0 means this item is not important at all according to you. A score of 100 given to one of the items would mean this is the only item that matters according to you; scores of 20 for each of the items would mean the items are all equally important. The total of 100 points must be used and not exceeded.

The beekeeper and his/her management of the honeybees and hives	
The quality and diversity of natural resources in the environment	
The characteristics of the colony (size, queen, brood, colony genetics ...)	
The presence or absence of contaminants in the environment	
The presence or absence of parasites (such as varroa) and diseases in the hives	
Total	100

D_2) You attributed equal importance to each of the 5 items that may impact honeybee colony health in the previous question. What was your main reason for doing so?

- ☐ I am really convinced those 5 items have an equal weight
- ☐ I have limited knowledge / no idea about all aspects and therefore gave all 5 items equal weight
- ☐ I may have misunderstood the question

D_3) Please indicate how often you check for the following when assessing the health status of your colonies during the beekeeping season?

	Never	Once a season	Two or three times a season	Every other inspection	At every inspection
The presence of all stages of brood	1	2	3	4	5
Sufficient amount of adult bees	1	2	3	4	5
The presence of a young and laying queen	1	2	3	4	5
Sufficient nutrition: water, forage, and food stores available (inside and/or outside the hive)	1	2	3	4	5

The presence of (apparent) stressors (apart from varroa and viruses, thus e.g. wasps, other animals, anything that can produce shocks or disturbance to the hives) that would lead to reduced colony survival and/or growth potential	1	2	3	4	5
Suitable space (not too much or too little) for current & near-term expected colony size that is sanitary, defensible, and spacious enough for egg laying	1	2	3	4	5
Infestation levels of Varroa	1	2	3	4	5
Infestation levels of Varroa after treatments to evaluate if more treatments might be necessary	1	2	3	4	5
Clinical signs of Nosemosis or Amoebiasis	1	2	3	4	5

D_4	What is your average beehive winter loss percentage over the past five years?	0 – 10% 10 – 20% 20 – 30% 30 – 40% 40 – 50% More than 50%
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Block E: Digital technology

E_1) Please indicate which practices you apply in the following checklist. In the following checklist, to “monitor” is not simply to measure but rather to check, observe and interpret over a period of time.

Do you digitally monitor the weight of at least some your hives?	Yes/No
---	--------

Do you digitally monitor the temperature inside at least some your hives?	Yes/No
Do you digitally monitor the humidity inside at least some your hives?	Yes/No
Do you digitally monitor the sound of at least some your hives?	Yes/No
Do you use a digital bee counter for at least some of your hives?	Yes/No

E_2	What percentage of your hives are digitally monitored?	
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Block F: Beekeeper orientation

F_1) To what extent do you agree or disagree with the following statements?	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Honeybee colonies should be ideally kept in a suitable environment that is as natural as possible	1	2	3	4	5
It is important for honeybee colonies to be able to express natural behaviour	1	2	3	4	5
Seeing a neglected honeybee colony affects me more than it would affect my colleague beekeepers	1	2	3	4	5
Production efficiency of the honeybee colonies should be the first priority of the beekeeper	1	2	3	4	5
A beekeeper should think of his/her honeybee colonies mainly in terms of the profit they will bring	1	2	3	4	5

A beekeeper should think of his/her honeybee colonies mainly in terms of their market value or cost they represent	1	2	3	4	5
A honeybee colony that is healthy experiences good welfare by definition	1	2	3	4	5
If a honeybee colony is reproducing efficiently, its welfare standard must be good	1	2	3	4	5
If a colony is growing well, it must be experiencing good welfare	1	2	3	4	5

Block G: Environmental quality

G_1) In case your hives are at multiple locations, the following questions apply to the location of the **major part of your hives**.

G_2) To what extent do you agree or disagree with the following statements?	Str on gly dis agr ee	Dis agr ee	Nei the r agr ee nor dis agr ee	Agr ee	Str on gly agr ee
The landscape surrounding my hives is mainly agricultural crop production	1	2	3	4	5
The landscape surrounding my hives is mainly agricultural livestock production / pasture	1	2	3	4	5
The landscape surrounding my hives is mainly forest	1	2	3	4	5
The landscape surrounding my hives is mainly human constructions/urban area	1	2	3	4	5
There are sufficient floral resources surrounding my hives from early to late in the bee season	1	2	3	4	5
The environment surrounding my hives is biodiverse in terms of floral resources	1	2	3	4	5
The environment surrounding my hives contains chemical contaminants	1	2	3	4	5

G_3) To what extent do you agree or disagree with the following statements?	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I collaborate with farmers in my region to encourage pollinator-friendly landscapes	1	2	3	4	5
Current policy measures in my region adequately address issues of floral resources, biodiversity, and landscape diversity	1	2	3	4	5
Climate change has forced me to change my beekeeping practices (changes in treatment, changes in monitoring frequency and activities, etc.)	1	2	3	4	5

	Very negative	Negative	Neither negative nor positive	Positive	Very positive
G_4) According to my personal experience, climate change has a impact on my beekeeping activities (changes in honey yield, changes in season length, etc.)	1	2	3	4	5

G_5) Please indicate the extent you believe climate change has a positive or negative impact on your beekeeping activities, based on your personal experience.	Very negative	Negative	Neither negative nor positive	Positive	Very positive
Food resource availability	1	2	3	4	5
Water availability	1	2	3	4	5

Honey yield	1	2	3	4	5
Colony survival	1	2	3	4	5
Disease infestation	1	2	3	4	5
Length of the bee season	1	2	3	4	5
Swarming behaviour	1	2	3	4	5
Natural disasters like fires or flooding	1	2	3	4	5
Local weather conditions	1	2	3	4	5

Block H: Intention to use hive monitoring technology

H_1) In the section below, “digital hive monitoring” means checking, observing and interpreting data collected by means of electronic devices for beekeeping that are connected to other devices or networks over time. Examples of digital hive monitoring in beekeeping include hive monitoring, colony surveillance, swarm detection, bee counting and using a digital logbook. In the questions below, the questions pertain to at least some, and not necessarily all of your hives.

	H_2) To what extent do you agree or disagree with the following statements?	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
INT1	I intend to use digital hive monitoring in my beehives within the next two years	1	2	3	4	5
INT2	I plan to use digital hive monitoring in my beehives within the next two years	1	2	3	4	5

INT3	I will try to use digital hive monitoring in in my beehives within the next two years	1	2	3	4	5
INT4	I am determined to use digital hive monitoring in my beehives within the next two years	1	2	3	4	5
ATT1	I feel that using digital hive monitoring would be a good idea for my beehives within the next two years	1	2	3	4	5
ATT2	I would enjoy using digital hive monitoring in my beehives within the next two years	1	2	3	4	5
ATT3	I feel that using digital hive monitoring would be important for me and my beehives within the next two years	1	2	3	4	5
SN1	Most people whose opinions I value think I should use digital hive monitoring in my beehives within the next two years	1	2	3	4	5
SN2	Most people who are important to me think that I should use digital hive monitoring in my beehives within the next two years	1	2	3	4	5
SN3	Many beekeepers who are like me think I should use digital hive monitoring in my beehives within the next two years	1	2	3	4	5

PBC1	I have the financial resources to implement digital hive monitoring in my beehives in the next two years	1	2	3	4	5
PBC2	I have the technical know-how to implement digital hive monitoring in my beehives in the next two years	1	2	3	4	5
PBC3	I can easily obtain digital hive monitoring equipment for my beehives in the next two years	1	2	3	4	5

H_3) To what extent do you agree or disagree with the following statements? In your beekeeping practice...	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I would choose to use digital hive monitoring to save time	1	2	3	4	5
I would choose to use digital hive monitoring to save costs	1	2	3	4	5
I would choose to use digital hive monitoring for easier management	1	2	3	4	5
I would choose to use digital hive monitoring to decrease colony loss	1	2	3	4	5
I would choose to use digital hive monitoring to enhance colony health	1	2	3	4	5

H_4) To what extent do you agree or disagree with the following statement?	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I currently use smart devices in other areas of my life besides beekeeping (i.e. for kitchen appliances, door locks, television, lighting, heating, speakers, etc.)	1	2	3	4	5

Appendix 2: Beekeeper Survey Pre-tests: Feedback Summary Report

Section 1: Socio-demographic variables and beekeeper/beekeeping characteristics

Overall, the questions were clear and logical. There is a suggestion to be more clear in our wording for “total number of beehives in 2021” since the number changes throughout the season. Perhaps by adding the word “average.” The distinction between advanced and expert training courses in beekeeping is not clear. Asking information on beekeeping apprentices and work experience might give more insight than only asking about formal training. In the questions on motivations to start beekeeping, remove the word “Purely” in “Purely as a hobby.” Add the option “not applicable” to the question on beekeeper association membership.

Section 2: Economic performance in beekeeping

The economic section was clear and logical for some and difficult for others. The way in which the questions were answered varied, with some typing the euro symbol or others writing the word “Euro” and some indicating a range, which we don’t want. There may be a way to force beekeepers to respond with only one number. We must also specify the currency asked for in the questionnaire. For the question on labour, we need to specify what this entails; is it only managing bees or running the whole business (bookkeeping, etc.)? Many said that their figure for labour was a very rough estimate. In general, asking for total figures for 2021 is difficult since 2021 will not be over yet. Perhaps either adding “so far” or “please add future predictions for the rest of 2021.”

We may want to specify if we want beekeepers to include VAT in their figures for cost. For question on do you produce and sell other apiculture products, add colonies and queens. The question on to what extent you believe your honey bees by means of pollination contribute to, could be more clear on what we mean by “contribute.” There is a suggestion to separate costs for fuel into a separate question instead of tying it with fuel and electricity, since many beekeepers have their apiaries in remote places. There is also a concern that beekeepers won’t be able to estimate separate costs for colonies and hives at the beginning of their beekeeping practice, since often they are bought together.

Section 3: General beekeeping management

There was some confusion with double negative questions in this section, especially “I do not use not own honey to feed the bees,” perhaps we can consider formulating all statements to positive ones. There is a suggestion to make the statement “I analyse the environment and surroundings of my hives” more specific. There is a suggestion to change the question on comb replacement to a continuous scale instead of categories of less than 20%, 20-50% and 50% or more, for easier analysis of results. Finally, the question on recycling own wax might not be a fair indication of good beekeeping practices since not all beekeepers are able to do so.

Section 4: Honey bee colony health

This section was generally well-understood, with most confusion being on the time scales that we use in asking what beekeepers check for, since they vary throughout the season. The time intervals seem a bit random and there is nothing that beekeepers will check for every day. Perhaps intervals such as never, once a season, two or three times a season, every other inspection, every inspection would be better. There was some confusion about why we specifically ask for the presence of a less than 1 year old queen, there is a suggestion to instead of asking if beekeepers check for the presence of a less than 1 year old queen, to ask if they mark queens. The statement on having “no apparent stressors” is too vague. The question on “To what extent do you believe the following items are important in terms of impacting honey bee colony health” is quite general and depends on the number of hives and management practices; however, this question is currently matched with the stakeholder survey.

Section 5: Digital technology in beekeeping

This section was all clear except for a couple remarks on whether a simple yes/no is sufficient. Perhaps asking beekeepers the number of hives that they monitor for each question would be better. Also, we must consider the word “monitor,” if we mean to monitor or to measure.

Section 6: Beekeeper orientations towards honey bees

This section was all clear to testers except for one suggestion for wording, to add the word “suitable” to “Honey bee colonies are ideally kept in a suitable environment that is as natural as possible.”

Section 7: Environmental quality

This section was all clear to testers except for one suggestion for wording, to replace the word “practices” with “activity,” since the word practices can be interpreted in different ways. There was also a suggestion to have an open question asking beekeepers how climate change has had an impact on their bees.

Section 8: Intention to use hive monitoring technology in beekeeping

The lack of feedback on this section was probably partly due to respondent fatigue. There was only one suggestion to state in the introduction of the section that the questions pertain to only some and not necessarily all of one’s hives. One tester said the questions on intend, plan, and determined to use IT were a bit puzzling.

Appendix 3. Copy of Ethics Approval (BC-10610)

Afz.: Commissie voor Medische Ethiek

Prof. Dr. Wim Verbeke
Vakgroep landbouweconomie - LAD1
ALHIER

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Ons kenmerk	Uw kenmerk	datum	pagina
BC-10610	NVT	26/08/2021	1/3

Betreft : Advies voor monocentrische studie met als titel:
"Beekeepers' attitudes, management decisions, production efficiency and determinants. Follow-up pan-EU B-GOOD survey"

B.U.N.: B6702021000814
EudraCT: N.V.T
Fase (Phase): NVT

- Financiële overeenkomst versie 3 dd. 13/5/2019
- GCP certificaat - versie 2.1 dd. 5/2/2020 Yung Hung
- Vragenlijsten versie 1 dd. 15/7/2021
- Patiënteninformatie- en toestemmingsformulier versie 1 dd. 15/7/2021 voor de deelnemers
- Adviesaanvraagformulier versie 1 dd. 15/7/2021 doc. C (volledig ontvangen op 02/08/2021)
- Begeleidende brief dd. 15/7/2021 (ontvangen op 02/08/2021)
- Protocol versie 1 dd. 15/7/2021

Advies werd gevraagd door: Wim Verbeke

BOVENVERMELDE DOCUMENTEN WERDEN DOOR HET ETHISCH COMITÉ BEOORDEELD. ER WERD EEN POSITIEF ADVIES GEGEVEN OVER DIT PROTOCOL OP 26/08/2021. INDIEN DE STUDIE NIET WORDT OPGESTART VOOR 26/08/2022, VERVALT HET ADVIES EN MOET HET PROJECT TERUG INGEDIEND WORDEN.

Vooraleer het onderzoek te starten dient contact te worden genomen met HIRUZ CTU (09/332 05 00).

THE ABOVE MENTIONED DOCUMENTS HAVE BEEN REVIEWED BY THE ETHICS COMMITTEE. A POSITIVE ADVICE WAS GIVEN FOR THIS PROTOCOL ON 26/08/2021. IN CASE THIS STUDY IS NOT STARTED BY 26/08/2022, THIS ADVICE WILL BE NO LONGER VALID AND THE PROJECT MUST BE RESUBMITTED.

Before initiating the study, please contact HIRUZ CTU (09/332 05 00).

* Het Ethisch Comité werkt volgens TCH Good Clinical Practice* - regels
 * Het Ethisch Comité bevestigd dat een gunstig advies niet betekent dat het Comité de verantwoordelijkheid voor het onderzoek op zich neemt. Bovendien dient U er over te waken dat Uw mening als betrokken onderzoeker wordt weergegeven in publicaties, rapporten voor de overheid enz., die het resultaat zijn van dit onderzoek.
 * In het kader van 'Good Clinical Practice' moet de mogelijkheid bestaan dat het farmaceutisch bedrijf en de autonome instellingen krijgen van de originele data. In dit verband dienen de onderzoekers erover te waken dat dit gebeurt zonder schending van de privacy van de proefpersonen.
 * Het Ethisch Comité benadrukt dat het de promotor is die garant dient te staan voor de conformiteit van de anderstalige informatie- en toestemmingsformulieren met de Nederlandse taal documenten.
 * Geen enkele onderzoeker betrokken bij deze studie is lid van het Ethisch Comité.
 * Alle effectieve leden van het Ethisch Comité, of hun plaatsvervangers, hebben dit project beoordeeld. (De ledenlijst is bijgevoegd)

ALGEMENE DIRECTIE
Commissie voor Medische Ethiek

VOORZITTER:
Prof. dr. P. Deron

SECRETARIS
Prof. dr. R. Peeters

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Pagina
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- * The Ethics Committee is organized and operates according to the 'ICH Good Clinical Practice' rules.
- * The Ethics Committee stresses that approval of a study does not mean that the Committee accepts responsibility for it. Moreover, please keep in mind that your opinion as investigator is presented in the publications, reports to the government, etc., that are a result of this research.
- * In the framework of 'Good Clinical Practice', the pharmaceutical company and the authorities have the right to inspect the original data. The investigators have to assure that the privacy of the subjects is respected.
- * The Ethics Committee stresses that it is the responsibility of the promotor to guarantee the conformity of the non-dutch informed consent forms with the dutch documents.
- * None of the investigators involved in this study is a member of the Ethics Committee.
- * All effective members of the Ethics Committee, or their representatives, have reviewed this project. (The list of the members is enclosed)

Namens het Ethisch Comité / On behalf of the Ethics Committee



Prof. dr. P. Deron
Voorzitter / Chairman

CC: UZ Gent – HIRUZ CTU
FAGG - Research & Development; Victor Hortaplein 40, postbus 40 1050 Brussel

Appendix 4. Details on the beekeeper recruitment procedures per country

1) Belgium

Beekeepers were recruited in Flanders through two main routes. First, a Newsflash was spread electronically on 8 October 2021 by Honeybee Valley, which is an information exchange, collaboration and dissemination platform on honey bee health and related research, established by Ghent University (Belgium). This medium has a reach of around 1,600 beekeeping contacts. The recruitment message was also archived on the Honeybee Valley website

(<https://honeybeervalley.eu/newsflash/neem-deel-aan-de-b-good-enqu%C3%AAte>).

Second, the Royal Flemish Beekeepers Association (KonVIB) and the Flemish Bee Institute (VBI) sent an e-mail announcement to their members that are registered to receive e-mail announcements on 9 October 2021 (number to be included). The announcement was also included in the KonVIB Chairman's Newsletter to members as published on the association's website on 10 October 2021 (https://konvib.be/?page_id=5443).

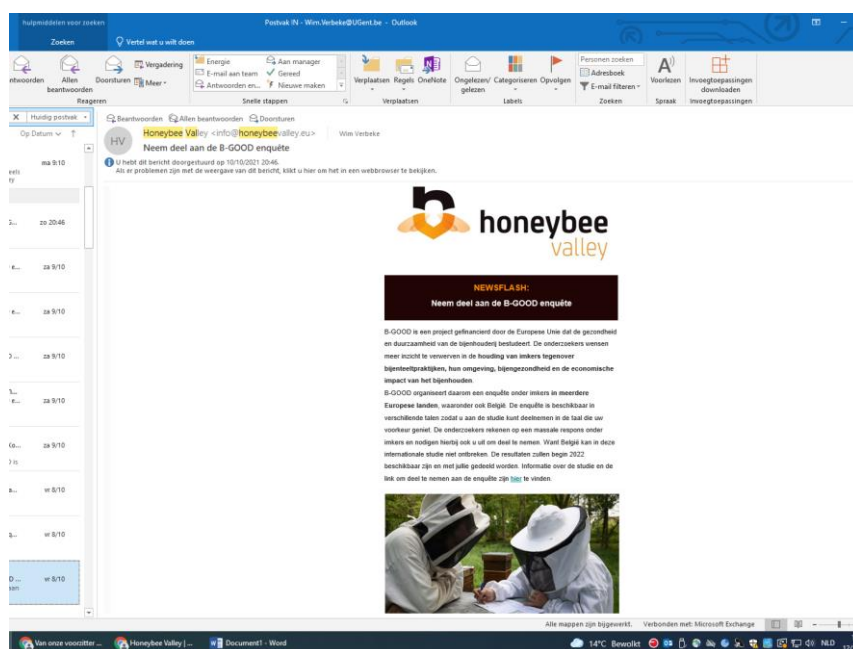


Figure 1. E-mail Newsflash spread by Honeybee Valley

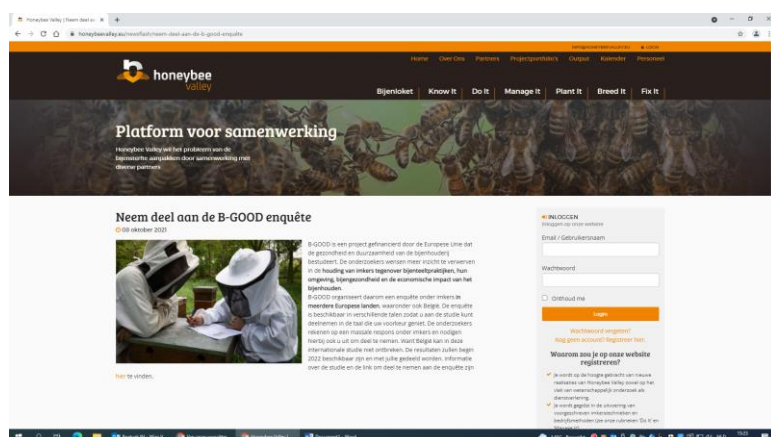


Figure 2. Post on the website of Honeybee Valley as archived Newsflash

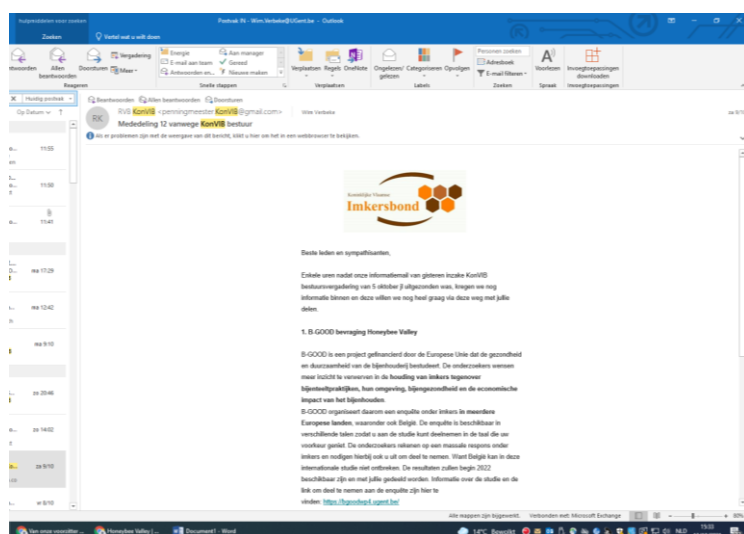


Figure 3. E-mail invitation to participate in the B-GOOD survey spread by KonVIB

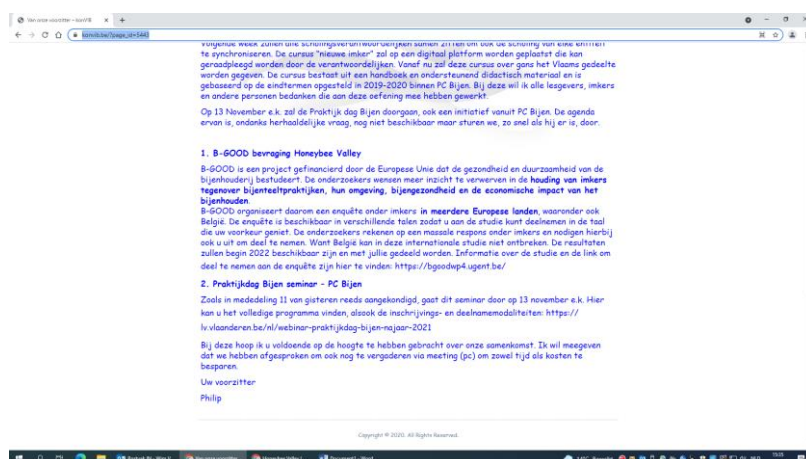


Figure 4. KonVIB Chairman's newsletter of 10 October 2021 with invitation to participate in the B-GOOD survey

Regarding beekeeper recruitment in Wallonia, a contact at the Université de Liège and a contact at CARL were invited to spread the survey link to beekeepers in their networks on 12 October 2021. Additionally, BeeLife re-tweeted a B-GOOD electronic survey invitation on 15 December 2021.



Figure 5. Re-tweet of B-GOOD electronic survey invitation by BeeLife

2) Poland

Beekeepers were recruited through the Polish Beekeepers Association (Polski Związek Pszczelarski) using three methods, all on 8 October 2021. First, the survey was distributed via an email invitation directly from the Polski Związek Pszczelarski to their members. Second, a survey announcement with the survey link was placed on the homepage of the Polski Związek Pszczelarski's website (<https://pzp.biz.pl/>):

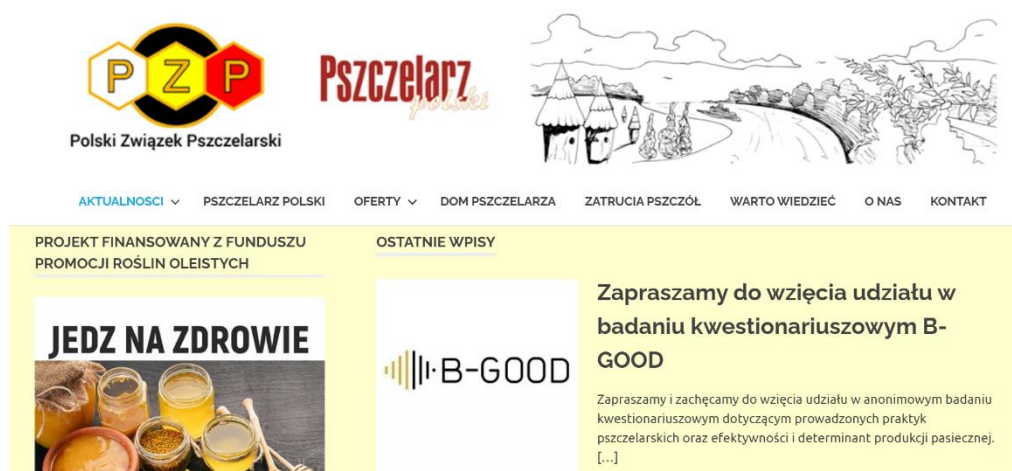


Figure 6. Post on the homepage website of the Polski Związek Pszczelarski

Third, a survey announcement with the survey link was placed on the official Facebook page of the Polski Związek Pszczelarski (<https://www.facebook.com/Polski-Zwi%C4%85zek-Pszczelarski-364082317527079>):

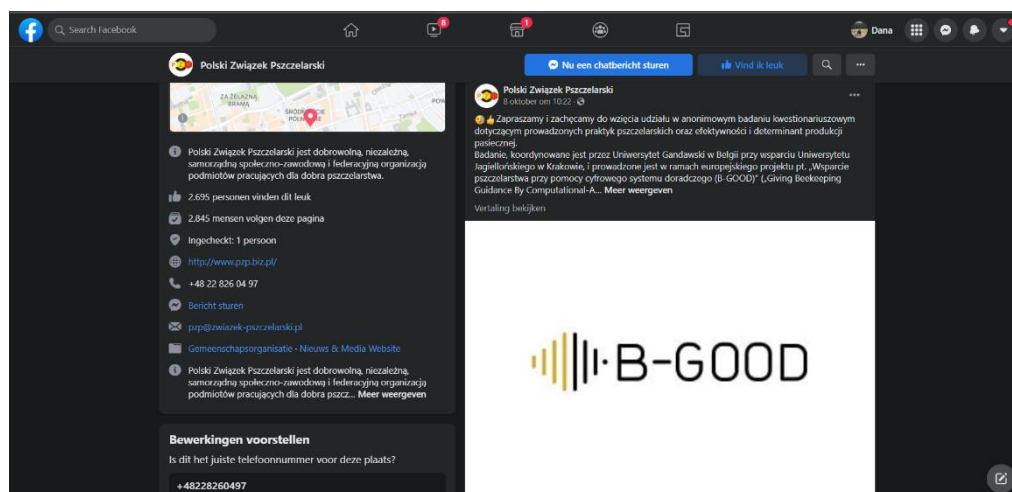


Figure 7. Post on the official Facebook page of the Polski Związek Pszczelarski

Beekeepers were also recruited via a Facebook post on one of the major Facebook's groups for beekeepers in Poland called "Pszczelarstwo moje hobby" on 19 November 2021.

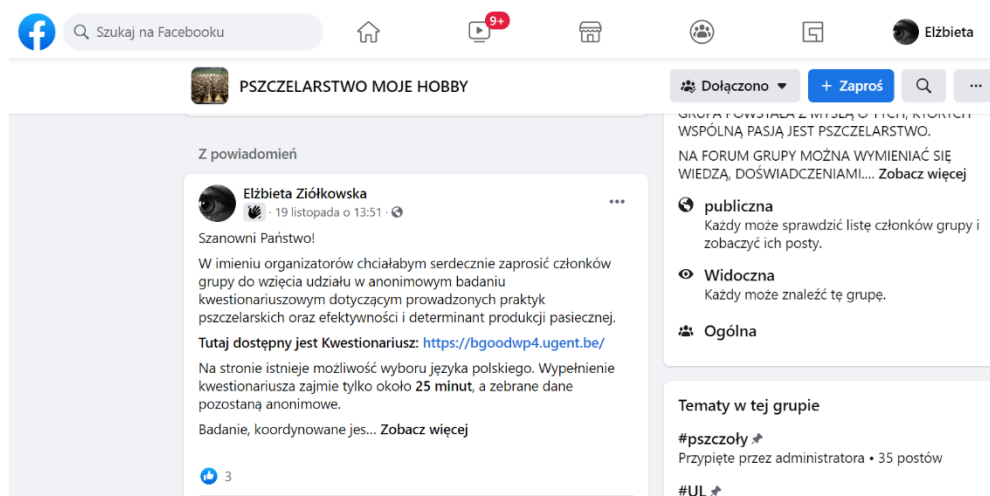


Figure 8. Post on the official Facebook page of the Pszczelarstwo moje hobby

3) Finland

Beekeepers were recruited through the Finnish Beekeepers Association (Suomen Mehiläishoitajain Liitto) through their official newsletter which reaches about 2500 beekeepers. The newsletter was sent on 12 October 2021 and the B-GOOD survey was included as a news item:

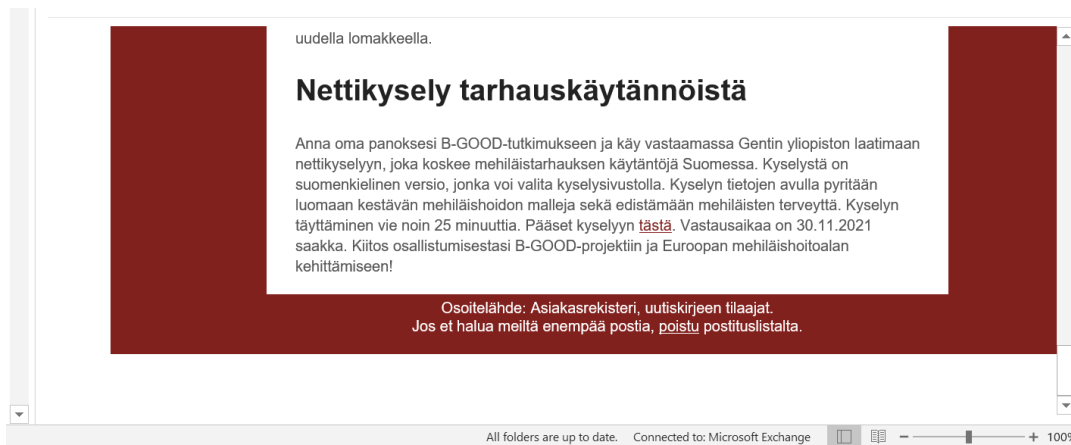


Figure 9. Suomen Mehiläishoitajain Liitto's newsletter of 12 October 2021 with invitation to participate in the B-GOOD survey

Beekeepers were also recruited two monitoring beekeepers seminars where the survey was announced in person; 1) Havaintotarhaajaseminaari, for about 30 people, on 5 November 2021 and 2) during the Harvest Seminar (Sadonkorjuuseminaari) for a few hundred people, on 6 November 2021.

4) Germany

Beekeepers were recruited through the German Beekeepers Association (Deutschen Imkerbundes) by placing a survey announcement with the survey link on the homepage of the Deutschen Imkerbundes's website (<https://deutscherimkerbund.de/>) on 13 October 2021.

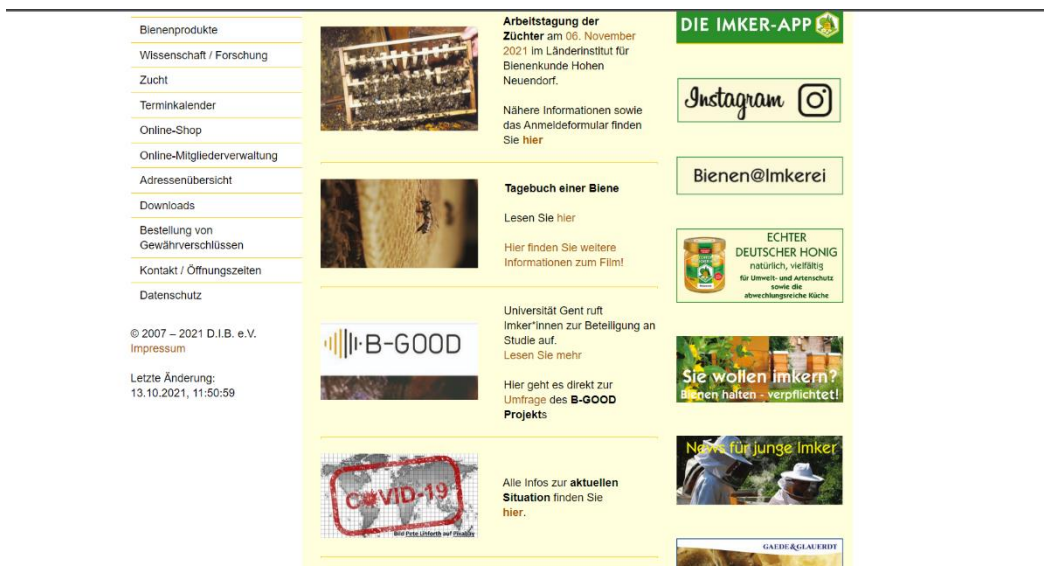


Figure 10. Post on the homepage website of the Deutschen Imkerbundes

Beekeepers were also recruited via the Fachzentrum für Bienen und Imkerei by placing the link in their newsletter, Bienen@Imkerei, on 29 October, 2021. The Bienen@Imkerei reaches around 34000 beekeepers.

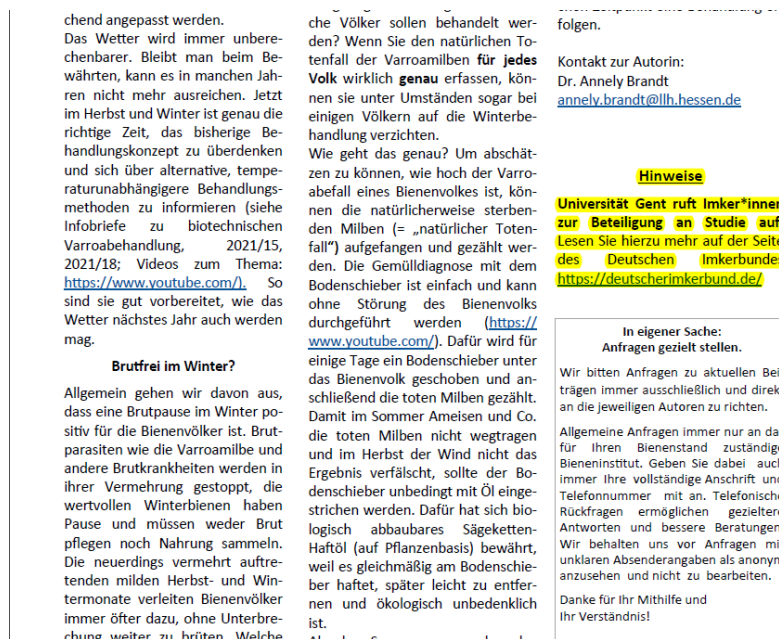


Figure 11. Fachzentrum für Bienen und Imkerei's "Bienen@Imkerei" newsletter of 29 October 2021 with invitation to participate in the B-GOOD survey

5) The Netherlands

Beekeepers were recruited through two main routes. The first is through the Wageningen University & Research (WUR)'s "Bijennieuws" which is an email newsletter that reaches 3808 beekeepers, on 14 October 2021.

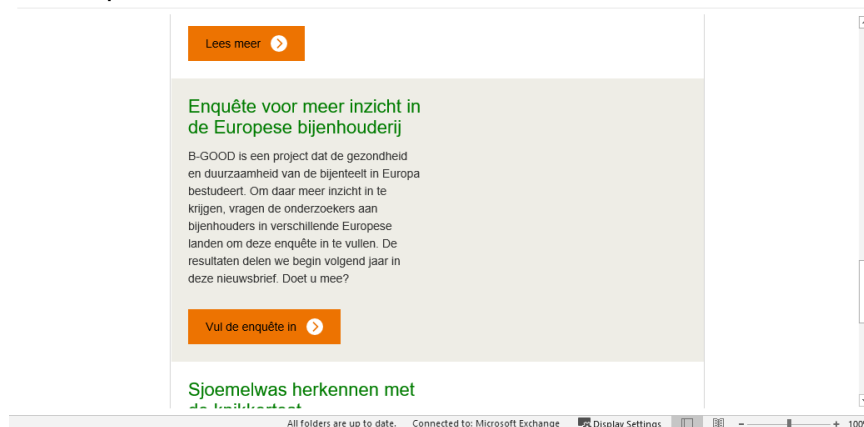


Figure 12. WUR's "Bijennieuws" newsletter of 14 October 2021 with invitation to participate in the B-GOOD survey

Second, the Nederlandse Bijenhoudersvereniging distributed the survey in three ways: 1) they placed a survey announcement on their website on 18 October 2021, 2) they placed the link in their newsletter on 19 October 2021, which reaches around 10000 beekeepers, of which 60% open it and 3) they posted an announcement on Facebook with the survey link on 20 October 2021, which has around 1000 views.



Figure 13. Post on the homepage website of the Nederlandse Bijenhoudersvereniging

Beste imker

De bijen komen tot rust maar de imkerwereld is nog volop in beweging. De NBV heeft twee vacatures voor de redactie en er is nieuws over het online platform Community en het Imkersoverleg. Onderaan deze mail vind je nog nieuws uit het buitenland wat ook de gang van zaken in Nederland zou kunnen beïnvloeden.



B-GOOD enquête

B-GOOD is een door de Europese Unie gefinancierd project dat de gezondheid en duurzaamheid van de bijenteelt bestudeert. B-GOOD organiseert een enquête onder bijenhouders in meerdere Europese landen, waaronder Nederland. De onderzoekers rekenen op een massale respons onder bijenhouders en nodigen jou hierbij uit om mee te doen. De bevindingen van het onderzoek zullen begin 2022 beschikbaar zijn. Uiteraard zullen we de resultaten t.z.t. delen in Imkernieuws.

[Meer informatie & link naar de enquête](#)

Figure 14. The Nederlandse Bijenhoudersvereniging newsletter of 19 October 2021 with invitation to participate in the B-GOOD survey

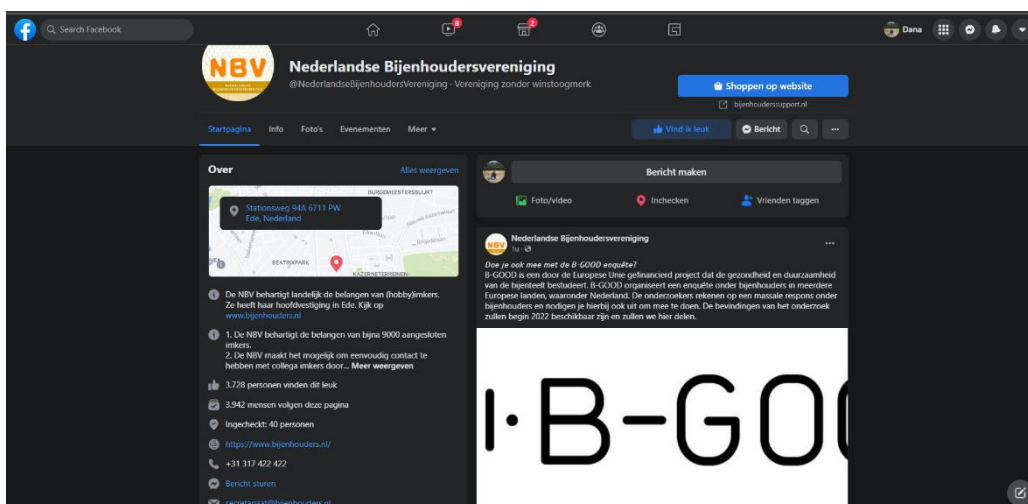


Figure 15. Post on the official Facebook page of Nederlandse Bijenhoudersvereniging

6) Italy

Beekeepers were recruited in Italy in two ways. First, a personal email from the head of the National Association of Italian Beekeepers (UNAPPI) was sent to their associates on 15 October, 2021, with the survey link and a description.

Care Associata,

con la presente vorrei attirare la vostra attenzione su un progetto internazionale relativo al mondo dell'apicoltura dal nome B-Good, che vede coinvolte 13 nazioni europee.

Informazioni sul progetto nel suo insieme sono disponibili al link di seguito riportato (<https://b-good-project.eu/about>) ed i risultati divulgabili sono periodicamente aggiornati sul sito web.

In questa fase attuativa di B-Good viene proposto un corposo questionario in italiano da compilare on line.

Lo scopo del sondaggio è di chiarire il rapporto tra gli aspetti socio-economici dell'apicoltura e lo stato di salute delle colonie al fine di identificare possibili accorgimenti gestionali utili a migliorare la salute degli alveari stessi.

Il risultato finale atteso dalla elaborazione dei dati raccolti con il questionario sarà di elaborare diversi modelli di business che hanno come scopo comune la salute degli alveari e la sostenibilità dell'allevamento apistico.

Nella prima metà del 2022, verrà restituita al mondo associazionistico italiano una panoramica generale sui risultati del sondaggio tra cui:

dati demografici, pratiche apistiche, performances economiche, indicatori di salute degli alveari, qualità degli ambienti circostanti gli apiari.

Nel caso in cui in Italia saranno compilati un minimo di 100 questionari, verrà fornita dai ricercatori una ulteriore elaborazione con un focus mirato sulla nostra situazione nazionale.

Di seguito, il link per la compilazione online del questionario in questione:

<https://bgoodwp4.ugent.be/home/italian-version/>

Sarà possibile rispondere al questionario a partire da subito, fino al 30 novembre.

Vi preghiamo di dare diffusione del progetto B-Good e del questionario associato nei vostri canali di comunicazione e di farlo pervenire ai nostri associati.

Cari saluti,

Figure 16. Email sent from UNAPPI to their associates for further distribution to beekeepers

Second, a personal email from B-GOOD partner, BSOUR, was sent to 8 selected beekeeping contacts on 10 November. All of them forwarded the link to their mailing lists, with an estimation of 600 beekeepers reached.

Gentilissimi,

chiederei la vostra collaborazione nel compilare e diffondere il questionario che trovate a [questo link](#).

Il sondaggio è in italiano e richiede circa 15 minuti per la compilazione.

Lo scopo del sondaggio è di chiarire il rapporto tra gli aspetti socio-economici dell'apicoltura e lo stato di salute delle colonie al fine di identificare possibili accorgimenti gestionali utili a migliorare la salute degli alveari stessi.

I risultati dell'elaborazione dei dati verranno restituiti nella prima metà del 2022.

Sarà possibile rispondere al questionario fino al 30 novembre.

Cari saluti,

Raffaele

PS. per chi volesse saperne di più sul progetto BGOOD <https://b-good-project.eu/about>

Figure 17. Email sent from BSOUR to 8 selected beekeeping contacts

7) France

Beekeepers were recruited via ADA France, by a personal email sent to the coordinators of each ADA in the region on 29 October, 2021, as well as by posting the survey link on the Facebook page of ADA France on 21 October, 2021. It is estimated that ADA's network reaches around 1600 beekeepers. In addition, several ADAs passed on the survey in their regional newsletters.

B-GOOD, enquête sur les aspects socio-économiques de l'apiculture européenne

A diffuser dans vos réseaux ! L'Université de Gand (Belgique) lance une enquête auprès des apiculteurs de l'Union Européenne. Elle souhaite recueillir les opinions des apiculteurs sur la santé des abeilles et des informations sur leurs pratiques. A termes, l'objectif est de **proposer des modèles socio-économiques apicoles** adaptés aux différents types d'apiculteurs. Les données françaises seront analysées et comparées avec les données européennes et un rapport sera disponible.

[Participer à l'enquête](#)

Figure 18. Personal email sent to the coordinators of each ADA



Figure 19. Post on the official Facebook page of ADA France

8) Portugal

Beekeepers were recruited via FNAP – Federação Nacional dos Apicultores de Portugal by personal email invitation from the Director of FNAP to their members on 27 October, 2021.

Exmo(a). Sr.(ª)

A pedido da Universidade de Coimbra, parceira do projeto B-GOOD (<https://b-good-project.eu/>), vimos por este meio divulgar a existência de um inquérito dirigido aos apicultores. O Projecto B-GOOD é um projeto europeu financiado pelo H2020, que tem como principal objetivo contribuir para uma apicultura mais sustentável em toda a UE.

Para tal, o Departamento de Economia Agrícola da Universidade de Ghent (entidade parceira deste projeto) elaborou o presente inquérito, cujo objetivo é estudar os aspetos socioeconómicos da atividade apícola em toda a União Europeia. O público alvo são os apicultores europeus, independentemente da sua dimensão, (profissionais ou hobbystas). Este inquérito será disponibilizado junto dos apicultores de todos os Estados Membros da União, sendo objetivo de que em Portugal se recolham 100 respostas. O inquérito é relativamente longo e demora cerca de 25 minutos a responder.

Para responder ao inquérito, por favor siga o seguinte link: bgoodwp4.ugent.be. Depois basta escolher o inquérito em língua Portuguesa e seguir as indicações dadas.

Face ao acima exposto, solicitamos a V. Exa. que responda ao inquérito ou, se for esse o caso, o divulgue junto dos vossos associados, clientes ou colaboradores.

Em caso de dúvida ou qualquer dificuldade com o preenchimento do inquérito, agradece-se que seja contactado o parceiro nacional do projeto, a Universidade de Coimbra (Nuno Capela) através do seguinte endereço eletrónico: nunocapela.bio@gmail.com (em CC).

Com os melhores cumprimentos,

A Direção da FNAP

FNAP – Federação Nacional dos Apicultores de Portugal

Rua Mestre Lima de Freitas nº 1

1549-012 LISBOA

Tel: + 351 217 100 084

Figure 20. Email sent from FNAP to their members

In addition, survey announcements with the link were posted on the pages of three Facebook groups on 10 November 2021.

- 1) Apicultores de Portugal - 5.2 thousand members
- 2) Os Amigos Das Abelhas - 16.3 thousand members
- 3) Apicultura Natural em Portugal - 9.2 thousand members

9) Romania

The survey was sent to 94 beekeepers in the network of B-GOOD partner USAMV Cluj-Napoca by email and WhatsApp on 19 October, 2021. The survey link was also sent to the following associations on 19 October, 2021:

- Romanian Beekeepers Association
- Association “Apis-Tomitana Dacica” – Beekeeping Consulting and Marketing Center, Constanța
- Federation of Romanian Beekeeping Associations from Romania (ROMAPIS)
- Association APICOLA READIVAS SRL
- International Centre for Young Beekeepers (ICYB)

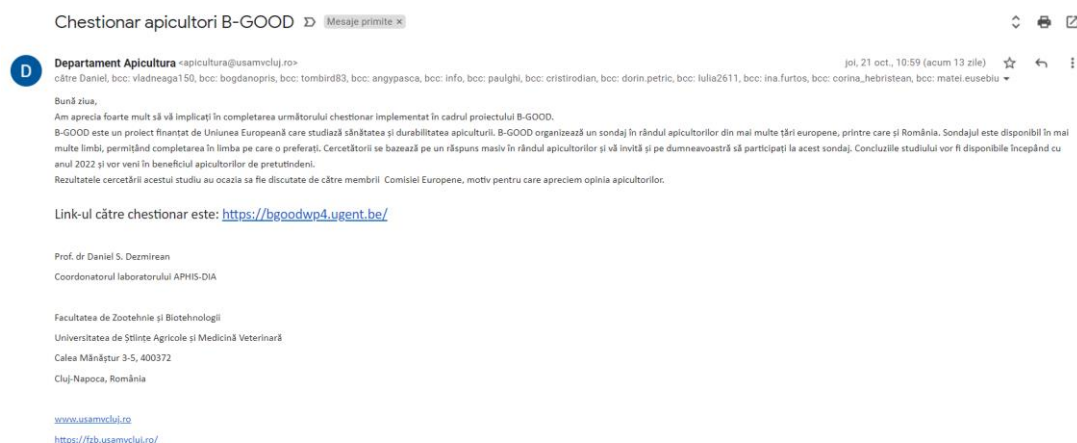


Figure 21. Email sent from USAMV Cluj-Napoca to beekeepers

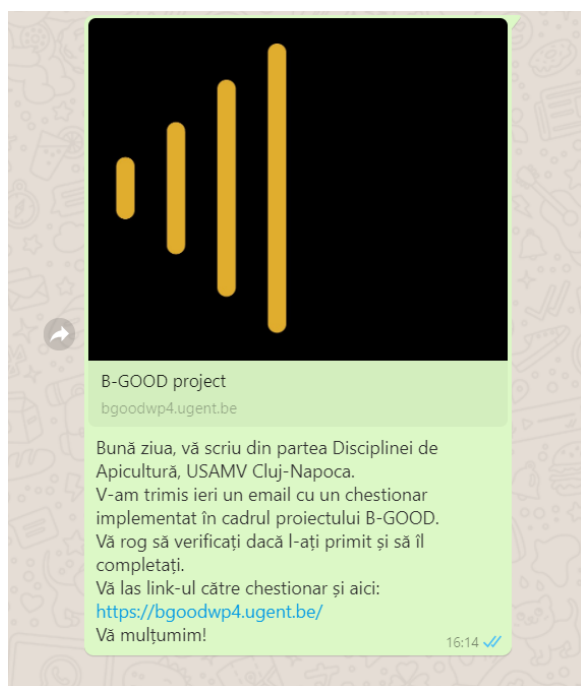


Figure 22. WhatsApp message sent from USAMV Cluj-Napoca to beekeepers

10) United Kingdom

Beekeepers were recruited via the Bee Farmers Association by personal email invitation to their 539 members on 26 October, 2021.

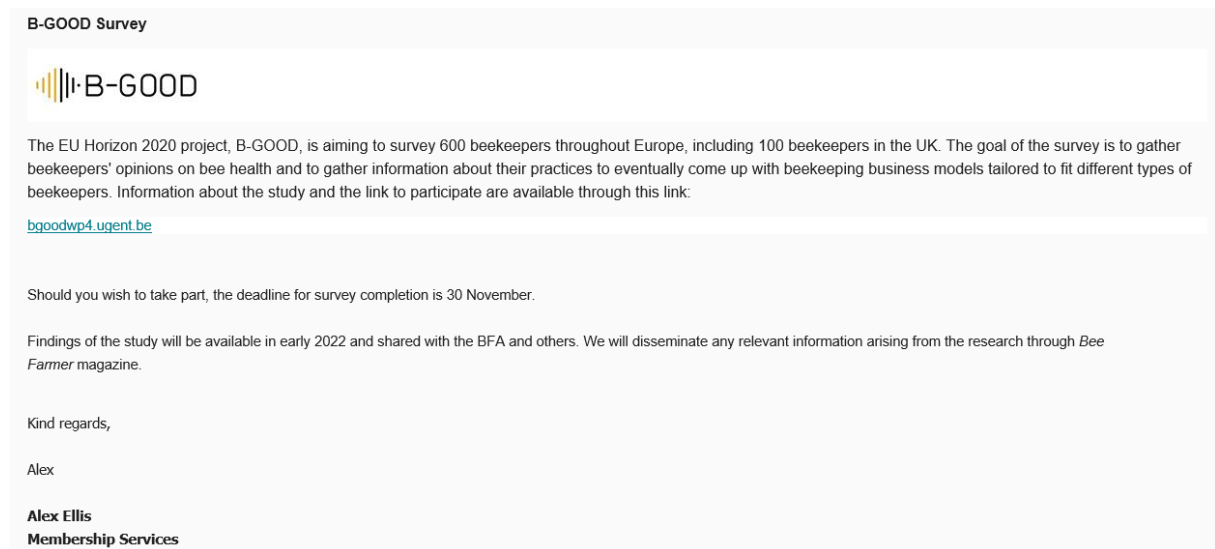


Figure 23. Email sent from the Bee Farmers Association to their members

Beekeepers were been recruited via the Central Association of Beekeepers (CABK) by their internal newsletter on 15 December 2021, sent to all 275 members.

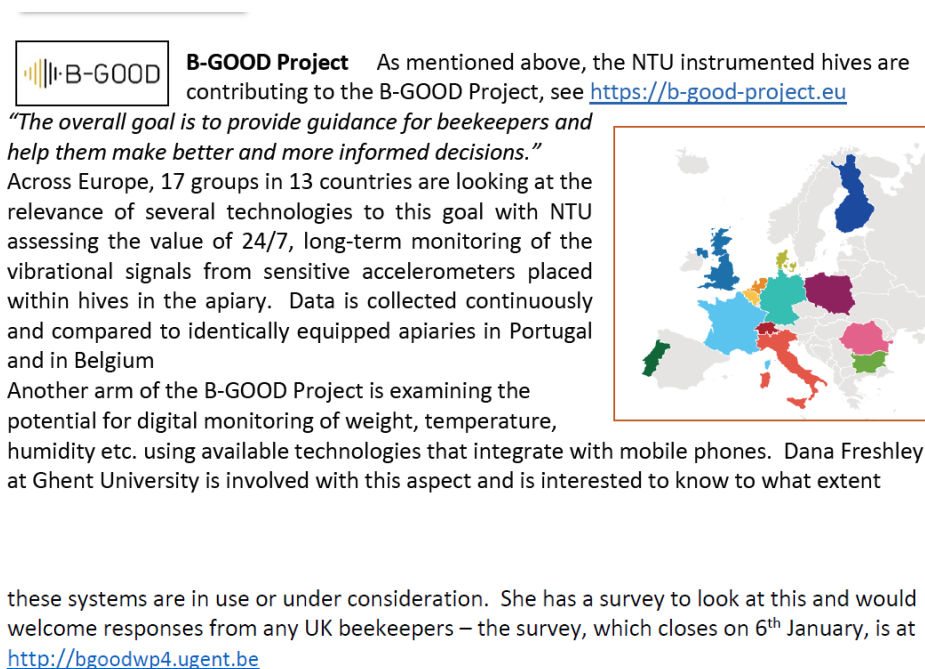


Figure 24. The Central Association of Beekeepers (CABK) newsletter of 15 December 2021 with invitation to participate in the B-GOOD survey

11) Bulgaria

The survey was sent by B-GOOD partner Pensoft to the following associations by email on 19 October, 2021.

- National Bee Breeding Association
- Pollenity
- Ghoney

- Pchela - Dobrich Beekeeping Association
- Beekeeping Society – Burgas
- Municipal Beekeeping Society Akaciya - Plovdiv
- Bulgarian beekeepers forum
- Istinski med beekeeper program
- Hoseyni beekeepers
- TeddyHoney
- National association of women beekeepers
- Regional beekeepers union in Pleven

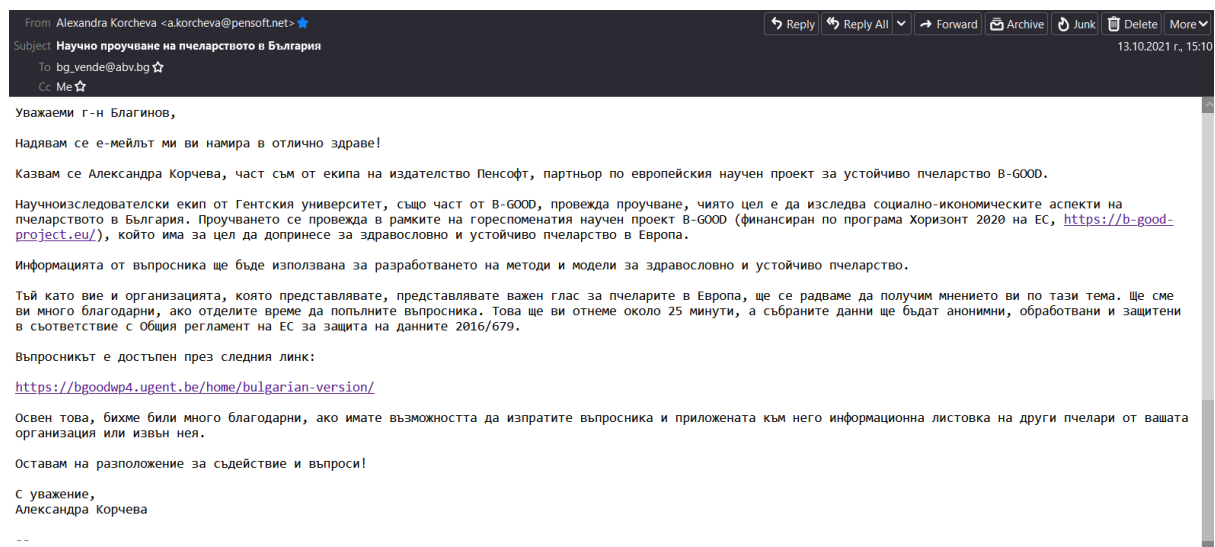


Figure 25. Email sent from Pensoft to the above associates for further distribution to beekeepers

In addition, survey announcements with the link were posted on the pages of three Facebook groups on 12 October 2021.

- 1) Beekeepers in Bulgaria -- 5,800 members
- 2) Bulgarian beekeeper – traditional and contemporary beekeeping, Beekeepers' club -- 2,900 members

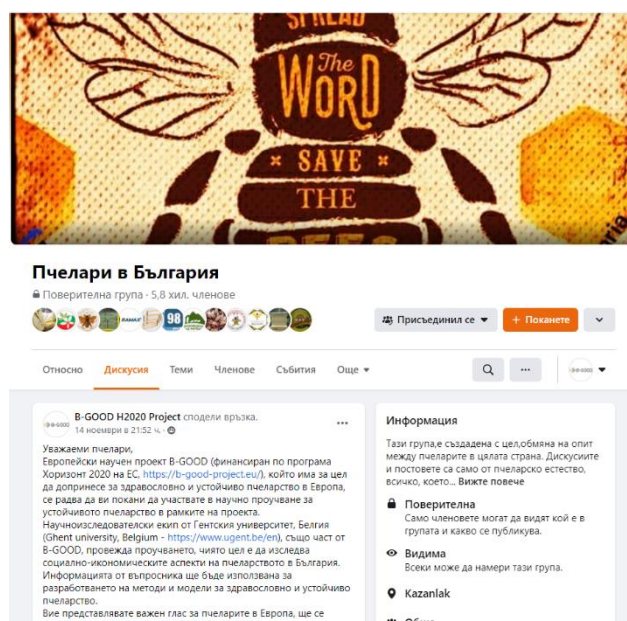


Figure 26. Post on the official Facebook page of “Beekeepers in Bulgaria”

In addition, beekeepers were recruited through two personal beekeeping contacts of the B-GOOD partner Pensoft Publishers.

12) Switzerland

Beekeepers in Switzerland were recruited in two ways. First, a survey announcement with the link was posted on the Facebook group “Apiculture en Suisse Romande” with 834 members on 11 October 2021.

Second, the main coordinators of the following beekeeping associations were contacted in all three language regions to request further distribution to beekeepers.

- 1) Le Service sanitaire apicole (SSA)
- 2) Société Romande d'Apiculture (SAR)
- 3) Apisuisse
- 4) Formation suisse d'apiculteur Sàrl
- 5) Api3valli association
- 6) BienenSchweiz

13) Spain

Two beekeeping associations were contacted in Spain to request further distribution to beekeepers on 19 October 2021; Asociación Veterinarios ESPA and Asociación Española de Apicultores.

14) Denmark

The Danish Beekeepers' Association was contacted to request further distribution to beekeepers on 25 July 2021.