BSGLg, 82, 2024, 19-46 *Accepté le 10 février 2024*

PERCEPTION OF THREATS TO BEE COLONIES AND THE FUTURE OF LOCAL BEEKEEPING BY BEEKEEPERS IN VARIOUS EUROPEAN COUNTRIES

PERCEPTION DES MENACES POUR LES COLONIES D'ABEILLES ET FUTUR DE L'APICULTURE LOCALE ENVISAGÉ PAR DES APICULTEURS DANS DIFFÉRENTS PAYS D'EUROPE

Samuel PERICHON, Leonora ADAMCHUK, Lejla BIBER, Janko BOZIC, Robert CHLEBO, Janja FILIPI, Sonja LEIDENBERGER, Georgios MAVROFRIDIS, Erkay OZGOR, Cristina POCOL, Marco PORPORATO, Maria Shantal RODRIGUEZ-FLORES, Miguel VILAS-BOAS, Aleksejs ZACEPINS

Abstract
In Europe, the honey bee (*Apis mellifera*) has been confronted by multiple threats often linked to human activities. An online survey was spread between September 2021 and May 2022 among 2,111 beekeepers. The results showed that beekeepers are powerless to deal with threats. They believe that man-made problems can be mitigated or eliminated through authorities. Bee colonies suffer under parasites, predators or declining natural resources. In Southern Europe, it becomes increasingly difficult to keep bees. The situation is in contrast to that described for Northern Europe, especially Iceland, where threats are almost non-existent. This North/South duality is also evident when describe future perspectives in their region. The uncertainty of production can lead to a negative outlook for certain people, especially because selling honey is a motivation, but others have a positive outlook for the future.

Keywords
Apis mellifera, beekeeping, perception, questionnaire survey, Europe

Résumé
*En Europe, l'abeille mellifère (*Apis mellifera*) est confrontée à de multiples menaces souvent liées aux activités humaines. Une enquête en ligne a été réalisée entre septembre 2021 et mai 2022, elle a permis de recueillir l'avis de 2 111 apiculteurs. Les résultats ont montré que les apiculteurs sont souvent impuissants face aux menaces. Certains pensent que les problèmes causés par l'homme pourraient être atténués ou éliminés par les pouvoirs publics. D'autres sont préoccupés par les menaces naturelles telles que les parasites, les prédateurs ou le déclin des ressources naturelles. Dans le sud de l'Europe, il devient de plus en plus difficile d'élever des abeilles. Cette situation contraste avec celle décrite pour l'Europe du Nord, en particulier l'Islande, où les menaces sont perçues comme quasi inexistantes. Cette dualité Nord/Sud est également évidente lorsqu'il s'agit pour les apiculteurs de décrire les perspectives d'avenir dans leur région. Les incertitudes de la production conduisent les uns à une perspective négative aussi parce que vendre du miel est une motivation, tandis que les autres voient l'avenir de manière positive.*

Mots-clés
Apis mellifera*, apiculture, perception, questionnaire, Europe*

INTRODUCTION

Globally, the fate of *Apis mellifera* Linnaeus, 1758 (*Hymenoptera: Apoidea*) is cause for concern due to increasing stress factors (Parveen *et al.*, 2022; Moritz *et al.*, 2016; Vanbergen *et al.*, 2013). In some regions, winter mortality rates of about 35% in apiaries are no longer rare (Gray *et al.*, 2022; Agrebi *et al.*, 2021; Jacques *et al.*, 2017), during the summer, mortality rates can also be significant (Aurel *et al.*, 2022; Bartlett, 2022). Habitat loss and crop homogenisation, pesticides, parasites and pathogens, invasive species, and climate change have all been identified as past and current threats to honey bees and pollinators in general (Brown *et al.*, 2016; Sutherland *et al.*, 2017; Vercelli *et al.*, 2021). The population of managed colonies fluctuates over time, and recent monitoring reports show different levels of colony losses in many regions and countries (Gray *et al.*, 2020; Gray *et al.*, 2019). The causes are multifactorial and cumulative effects are difficult to understand (Scheper *et al.*, 2013;

Vanengelsdorp and Meixner, 2010). One such cause is pesticides exposure. Since the end of the 1990s, in the countries of Western Europe, thousands of beekeepers have mobilized to alert the public to the extreme harm caused by certain chemicals (Neov *et al.*, 2021). As a result, in 2018, three neonicotinoids were banned in the European Union. This decision was definitely motivated by the judgement of the European Court of 6 May 2021 following appeals filed by the agro-chemical industry. It should be noted that in ten of the 27 Member States, there are derogations from the ban. Specific rules are applied outside the EU. Despite the large losses of *A. mellifera* regularly making headlines, the lack of pollinators became a reality in agricultural areas where the use of other pesticides remains excessive (Breeze *et al.*, 2014; Perrot *et al.*, 2018). Indeed, the negative impact of pesticides was not limited to honey bees: in Europe, one in ten species of bees and butterflies is estimated to be at risk of extinction (European court of auditors, 2020). Reduced pollinator populations are an additional threat to our food security (Halvorson *et al.*, 2021; Narjes and Lippert, 2019; Croft *et al.*, 2018; Deguines *et al.*, 2014). These findings on pesticides effects and the reduction of pollinator's populations led the Members of the European Parliament, in June 2021, to an initiative to reduce the use of the most harmful pesticides by 50%.

Beekeeping provides multisystemic benefits to society, contributes to the sustainable development of rural areas and helps the development of global sustainability. This is carried out through the generation of goods and services that often lead to an increase in the *per capita* income of families, as well as important opportunities, since it contributes to the creation of jobs, both directly and indirectly, that are traditionally linked to industry (Patel *et al.*, 2021; Sperandio *et al.*, 2019). Beekeeping is an economic activity, mostly private, which together with traditional goods and services, generates public goods and, consequently, mainly positive externalities (Etxegarai-Legarreta and Sanchez-Famoso, 2022). These public goods are beneficial for the environment (less erosion and biological diversity, among other things), and affect other economic activities (e.g., agriculture) and society (landscape, health, and leisure, among others), but since there are no markets in which to buy and sell them, the externalities generated are not always converted into income and do not impact the producer (Fedoriak *et al.*, 2021; Ashley *et al.*, 2022). Beekeeping is complex, and requires multiple skills in spheres of not only ecological, but also economic, cultural and social sustainability. Beekeeping can be viewed as a social glue that strengthens the opportunity for landscape stewardship for the provision of multiple ecosystem services in particular, and rural development in general (Fedoriak *et al.*, 2021). Apicultural industry within the European Union shows high heterogeneity – the high proportion of non-professional beekeepers and the small mean number of colonies per beekeeper are the only common characteristics at European level (Chauzat *et al.*, 2013). This high heterogeneity encouraged us to try to make an inventory of the beekeeping sector based not on agricultural data, but on the opinion of the beekeepers, especially on feelings and declaratives.

The results of an online questionnaire survey conducted at European level will be presented in this article. To begin with a presentation on the survey approach, the questions that will be covered in the article, and how the data collected will be processed. Our sample will be described in the "Results and Discussion" section, and then we will discuss four successive themes. These are the threats to bees, what can be done about them, the obstacles to the development of beekeeping, and the future of beekeeping. The objective is to present beekeepers' perception of the situation, which may have biases. Additional information will be provided based on bibliographical research in the third part, titled "Perspectives".

I. MATERIAL AND METHODS

This article is based on the results of an online questionnaire. The consultation period took place between September 2021 and May 2022 after a trial phase with 117 European beekeepers. The questionnaire in its original form was widely disseminated throughout Europe. Beekeepers responded from the homepages of beekeeping organisations or specialized journals. The URL was also posted on social networks (Facebook, groups and forums) and distributed on professional mailing lists. Not all national, regional or local organisations that were asked to disseminate the questionnaire react actively, which may be due to the large number of surveys that beekeepers and

their organisations are increasingly requested to fill, including administrative procedures for the activity. Local beekeepers are more likely to participate in surveys conducted in their local language, not just in English, thus this survey was made available in 18 languages. The questions focused on open-ended responses, multiple choice answers, and evaluations in the form of a matrix (scale of 0 to 5) or emoticons. Eight of the 24 questions[1] we asked in our online survey will be the subject of this article, and four of them will be used to classify our sample of respondents (Table 1).

The data processing method was influenced by the type of question asked. The answers given by respondents to the open-ended questions were carefully reviewed and a list of key words that appeared in the written responses was created. The data was analysed using a list of keywords that was expanded during the processing. Once the data was entered, the often large number of keywords required them to be classified by theme. This stage, which required a lot of work, was completed using LibreOffice 7.0 (calc). The sum of responses for each keyword and theme was computed, and the percentage was determined by the number of validated responses. An identical list of keywords was applied to each country for this purpose. To calculate percentages for the multiple-choice question in each country, the number of respondents who verified their answers was considered. Only results to open-ended or multiple-choice questions from countries that submitted at least 40 responses at the regional level or at least 100 responses at the national level will be included in this article.

Our task in the matrix question, which involves an ordinal choice, was to select a category of variables and calculate the percentage of responses compared to all the expressed responses. The calculations were made for the countries that will be presented in this article. Tables, a flowchart for one of the questions, and maps were used to format the collected data. A free and open source geographic information system (Qgis 3.32 Lima) was utilized

Multiple choice question
• Question #1: "Which of the following motivations best fits your personal situation? I like to watch the bees come and go in front of my hives, it is soothing / I think of my bees as pets / I keep bees because it is a tradition in my family / I like to open my hives and watch my colonies grow / I like the smell of a crowded hive / I like to collect honey / I like to give honey to my relatives / I treat my family and myself with honey / I keep bees to improve the pollination of plants in my garden / I keep bees to sell honey and increase my family's income / I'm a professional beekeeper"
Matrix
• Question #11: "Which of these threats do you consider to be the most relevant to honey bees in your region? Note 0 corresponds to entirely irrelevant; note 5 to highly relevant: diseases (e.g. foulbrood, petrified brood…) / predators (e.g. Asian hornet, European bee-eater...), parasites/pests (e.g. varroa mites, wax moths...) / certain beekeeping practices / the use of pesticides in agriculture / modification of landscapes (e.g. destruction of hedges, uniformity/simplification…) / the lengthening of dearth period (dry or very wet season) / the decline in honey resources (pollen, nectar)"
Open-ended questions
• Question #12: "What measures do you think could be taken quickly to reduce the threats to honey bees in your region?" • Question #13: "In your opinion, what are the obstacles to the development of beekeeping in your region?" • Question #14: "How do you see beekeeping (professional and leisure) evolving in your region in the next 20 years (number of beekeepers, stocks, bee breeds, beekeeping practices, production…)?"
Profile survey questions
• Question #17: "How many years have you praticed beekeeping? Less than a year / 2 to 5 years / 6 to 10 years / 11 to 20 years / for over 21 years" • Question #22: "How many hive(s) do you own? And what is approximately your honey production per hive and per year?" • Question #23: "Please indicate: your municipality and region of residence, your age and your profession"

Table 1. Questions on the subject of study (online questionnaire)

for the production of all the maps. There were two types of maps created, one with histograms and another with a layer of points that corresponded to the respondents' places of residence. After being located on Google Earth, these points were created on the OpenStreetMap layer. Each point that was associated with a respondent's place of residence was given an identifier. The answer to the respondent's questions in the spreadsheet was identified by the same identifier. A table join, which is to associate data from our survey with a point on a map, was possible in this manner. The matrix question type was thus formalised with maps by categorised value. In contrast to open-ended or multiple-choice questions, the cartographic formalization will incorporate all the answers given by respondents who have provided their place of residence. However, the map descriptions will mostly focus on the 14 countries mentioned in the next section.

II. RESULTS AND DISCUSSION

A. Characterization of sample and beekeeping activity

1. Sample characterization

A total of 2,111 beekeepers representing 30 European countries participated in the survey (Figure 1). France had the most responses collected (n = 338), followed by Greece (n = 266) and Ukraine (n = 258). The absence of opinions in a region or a

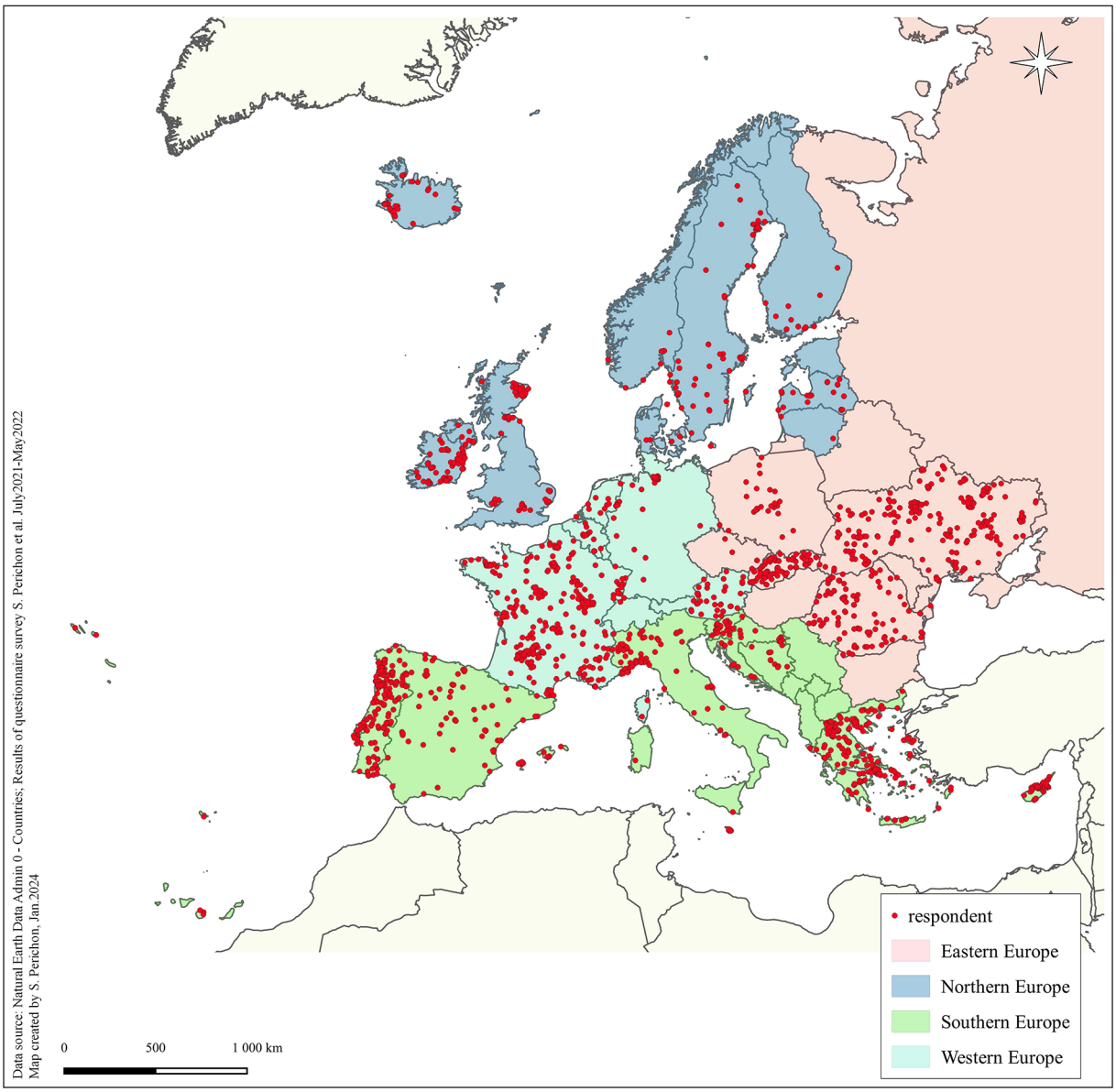

Figure 1. Location of respondents in the Subregions of Europe

country should not be interpreted as a consequence of our refusal to involve beekeepers; simply, no local relay on the spot could be established to support or join our project. At least one of the two thresholds established, either 40 responses at regional or 100 responses at national level, was reached by 13 countries representing the 4 European sub-regions determined on the basis of the United Nations breakdown. In Iceland, we collected 43 responses, which is less than the 100 required, but it represented roughly (or near) 50% of beekeepers on the island who gave their opinion. The reason we included this country in the analysis of results presented in this article is because of this explanation. For Eastern Europe, three countries are involved (Ukraine, Romania, Slovakia); for Northern Europe, four countries (Sweden, Scotland, Ireland, Iceland); for Southern Europe, five countries (Greece, Italy, Spain, Portugal and Northern Cyprus); and for Western Europe, two countries (France, Germany). The results will be displayed on a national scale, even if some are representative of a specific region and not necessarily the entire country. This is the case for Germany with the city-state of Hamburg, Italy with the regions of Liguria and Piedmont, and Spain with Galicia. 90% of our sample (n = 1,876) was made up of responses from these 14 countries.

The average age of beekeepers varies from 42 in Romania (with 23% aged under 30) to 65 in Sweden (Table 2). In the other countries of Northern Europe, the average age is also higher than elsewhere. Pen-

Countries	***n***	**Main regions**	**Average age in years (standard deviation)**	**Main occupations (%)**
Ukraine	258	Kyiv, Poltava, Dniepropetrovs'k	43.5 (± 11.1)	Engineers (20), teachers (14), technicians (12)
Romania	133	North western	42 (± 13.9)	Pensioners (15), beekeepers (15), teacher (11)
Slovakia	102	Strené, Západné	49 (± 14)	Pensioners (27), technicians (17), workers (14)
Ireland	72	Southern, Eastern and Middle	57 (± 11)	Pensioners (33), teachers (21), beekeepers (16)
Sweden	71	Norrbotten, Västsverige	65 (± 10.7)	Pensioners (62), beekeepers (16)
Scotland	69	North eastern	57 (± 11.3)	Pensioners (38), engineers (30), researchers (16)
Iceland	42	Reykjavik, Southern	56 (± 13.5)	Farmers (20), engineers (10), pensioners (10)
Greece	266	Western Macedonia	45 (± 10.8)	Beekeepers (26), employees (17), farmers (11)
Portugal	160	Northern, Middle	48 (± 12.9)	Pensioners (12), beekeepers (12), technicians (12)
Spain	166	Galicia	48.5 (± 12.7)	Beekeepers (31), employees (14), pensioners (9)
Italy	94	Liguria, Piedmont	54 (± 13.4)	Pensioners (30), beekeepers (30), workers (16)
Northern Cyprus	46	Nicosia, Famagusta	43 (± 9.2)	Teachers (30), farmers (13), pensioners (12)
France	338	Occitania, Nouvelle-Aquitaine, Burgundy	56.5 (± 12.8)	Pensioners (32), teachers (24), beekeepers (10)
Germany	63	City-State of Hamburg	53.2 (± 13.1)	Engineers (15), pensioners (14), technicians (11)

Table 2. Profile of respondents from main countries of our sample

sioners are the largest socio-professional group in 9 out of 14 countries, with over 30% of the sample in France, Italy, Scotland, Ireland, and up to 62% in Sweden. The other socio-professional groups of significant importance correspond to jobs accessible after higher education: jobs as technicians, engineers, teachers and researchers, often in the fields of agriculture, the environment, IT or mechanics. Professional beekeepers are mainly represented in Southern European countries: 31% in Spain, 30% in Italy, and 26% in Greece.

2. Characterization of beekeeping activity

The majority of beekeepers who responded to the questionnaires had at least six years of experience in beekeeping. Table 3 shows that in several countries (Italy, Greece, Ireland), the average number of years of practice is over 14 years. In Italy, there are 37% beekeepers who have had more than 21 years' experience, 31% in Spain, and 30% in Portugal and Sweden. Beekeeping in Iceland has only been existed for twenty years. *A. mellifera* does not occur naturally on this island. The honey bees actually originate from another island, the Finnish island of Åland. This is why beekeepers in other European countries have more practical experience: 7.6 years on average, compared to a minimum of 11.7 years in France.

The average number of honey bee colonies per respondent varies significantly between countries: from 3 colonies in Iceland to 180 colonies in Spain. As in Greece and Romania, the average value in our sample has an increase due to the significant number of professional beekeepers. Those who declare beekeeping as their only professional activity, regardless of how many hives they manage, are considered 'professional beekeepers' by us. Other Eastern and Southern European countries, where the average number of honey bee colonies is between 70 and 131, suggest that beekeeping is a second professional activity. In Portugal, 50% of the respondents have over 50 honey bee colonies, it's 56% in Northern Cyprus and 45% in Ukraine. The majority of apiaries in Northern Europe are those with fewer than 10 honey bee colonies. This is true for nearly all Icelandic respondents, over three-quarters of Scots, and two-thirds of Irish and Swedish respondents. For information purposes, as it is very difficult to answer this question precisely, we asked beekeepers to estimate their average annual honey production per hive. The results, which are only based on declarations, reveal obvious differences between Eastern Europe and most other countries. In Ukraine and Romania, the declared honey yield is 37.8 kg per hive and 33.2 kg per hive respectively, compared with 8.4 kg per hive in Iceland, 12.1 kg per hive in Portugal and 14.4 kg per hive in Greece. The average value within this study is slightly lower than the average of 21 kg/hive based on data from 2017 and 2018, as estimated and reported in the National Apiculture Pro-grammes 2020–2022 by the European Commission (2019).

The respondents' main motivation is not selling honey (Supplementary Table S1). However, for a significant proportion of them, it is an additional source of income, and for most professionals it is their main source of income. In Ukraine, Portugal, Greece, Romania and Northern Cyprus, between 40% and 50% of respondents cited financial considerations as one of the reasons for their beekeeping activity. This was also the case for one-third of the respondents in Sweden. The idea of harvesting honey and sharing it with loved ones can serve as a source of motivation. Those with less than 5 years of beekeeping experience are specifically affected by this. The honey harvest is a motivation for 74% of Icelandic respondents to engage in beekeeping, as an example. In this country, as well as elsewhere in Europe, there are two primary motives: "watching their bees" and "opening their hives".

B. The most relevant threats to honey bees in regions

Local threats to bees, as evaluated by beekeepers, suggest that they may affect the entire European continent or be restricted to specific geographical areas. The majority of respondents in six of the fourteen countries surveyed said the parasite threat was "highly relevant" (Table 4). The percentage in Spain has increased to 72%. Although the majority of respondents did not categorize it as such, it was nevertheless ranked number 1 in Scotland (49%), France (48%), and Sweden (40%). Figure 2 shows that there is a consistency in the responses, with areas of concentration corresponding to categories that are close in rank: predominantly "highly relevant" and "relevant". Two countries stand out in particular. According to respondents in Iceland, there is no parasitic threat to bees. In Iceland, there is no threat to bees from parasitic threats, according

Countries	Experience (years old)	Honey bee colonies	Yield (kg/hive/year)	Sell honey (% of respondents)
Ukraine	12.6	70	37.8	50
Romania	11.2	98	33.2	43
Slovakia	11.6	22	22.9	28
Ireland	14.3	18	16.3	22
Sweden	13.6	22	28.1	34
Scotland	13.3	8	15.7	12
Iceland	7.6	3	8.4	19
Greece	14.1	135	14.4	45
Portugal	13.1	131	12.1	48
Spain	13.4	180	15.6	28
Italy	15.1	88	16.0	16
Northern Cyprus	11.6	116	18.6	41
France	11.1	30	15.8	16
Germany	11.7	19	21.4	15

Table 3. Beekeeping activity of respondents from main countries of our sample

Countries	Diseases	Predators	Parasites	Beekeeping	Pesticides	Landscape	Dearth	Resources
Ukraine	9	4	39	8	74	40	28	45
Romania	25	27	50	22	65	25	35	39
Slovakia	44	5	40	12	47	47	39	48
Ireland	25	11	36	13	49	53	13	32
Sweden	18	4	40	11	26	23	14	20
Scotland	20	7	49	4	34	37	10	19
Iceland	9	0	6	3	21	3	3	6
Greece	9	13	53	11	38	19	46	39
Italy	14	16	48	11	53	41	42	53
Spain	16	41	72	13	43	35	23	31
Portugal	13	48	58	15	37	24	31	34
N. Cyprus	28	47	59	21	48	11	53	51
France	5	27	48	13	46	42	28	37
Germany	6	5	54	13	33	59	24	14

Table 4. The percentage of respondents who view different threats to bees as "highly relevant"

to respondents. The threat in Western and Central Macedonia in Greece is perceived by professional beekeepers to be less significant than amateur beekeepers. The health of bees can be threatened by diseases as well. According to our survey, beekeepers think that this threat is less important than the one posed by parasites, except in Slovakia. The respondents in the Nitra and Zilina regions (Figure 3) have indicated a significant problem with bee diseases, but we were unable to explain why.

According to the number of countries where pesticides are in the "highly relevant" category, the use of pesticides in agriculture is the second major threat. Ukraine (74%), Romania (65%), and Italy (53%) are the three countries being discussed. Slo-

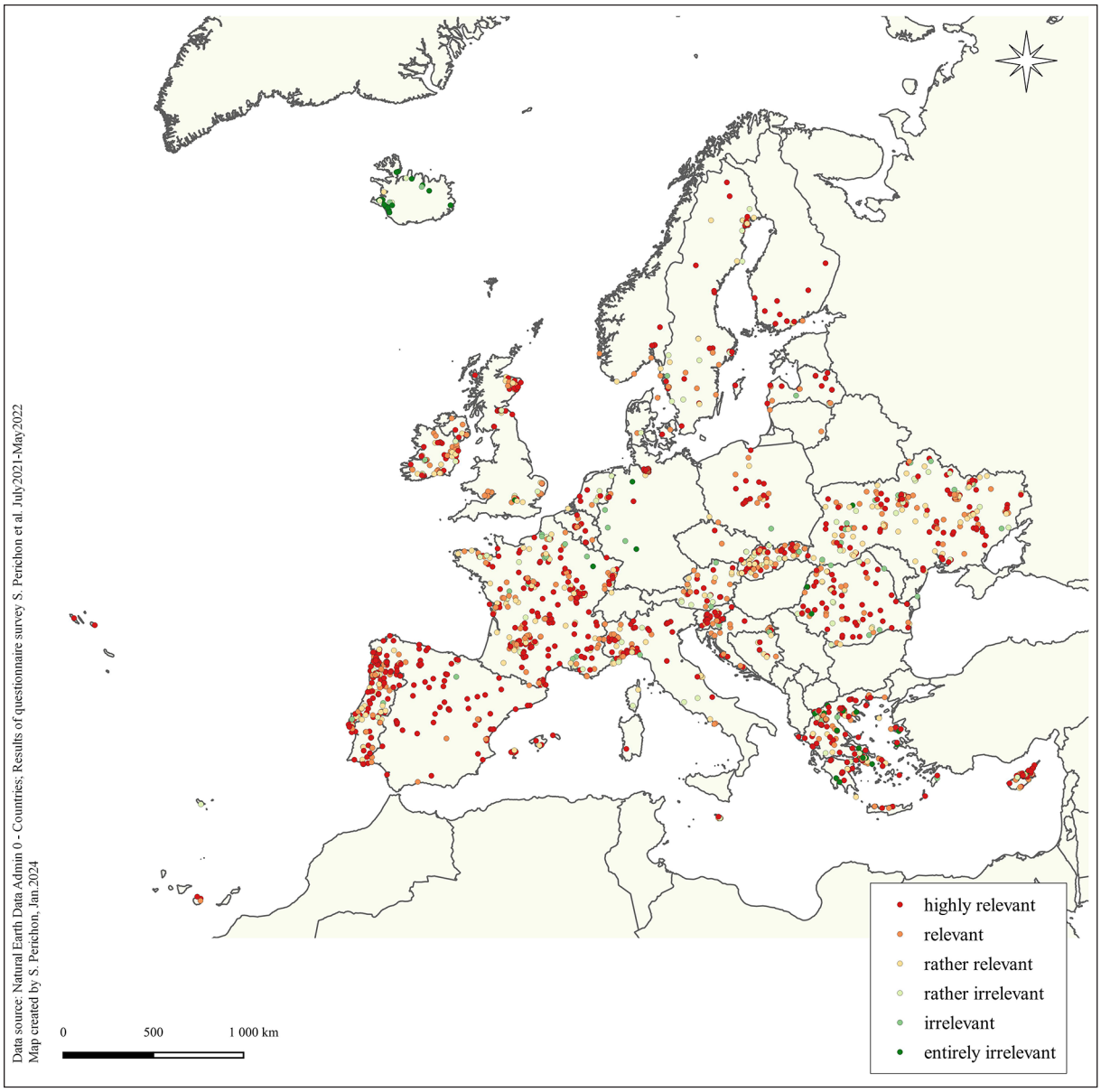

Figure 2. Assessment of the relevance of the parasite threat to honey bees in Europe

vakia (47%) and Iceland (21%) have also ranked this threat as the most relevant. Respondents in regions that specialize in arboriculture, market gardening, vineyards, or oilseed crops grown for their seeds (rapeseed and sunflower) view pesticides as a greater threat than those in other regions. Concerns are usually raised in river valleys and the outskirts of urban areas near the sea, particularly in southern Europe. Thus, river valleys (the main tributaries of the *Danube* in Slovakia and Romania, and the *Po* in Italy) and the outskirts of urban areas by the sea, particularly in southern Europe, are the preferred areas where concerns are expressed (Figure 4). Contrasting situations can result from the terrain, such as in Liguria's mountainous and wooded hinterland, where the threat is not present, while it is "highly relevant" on the coast (Genoa). In both Athens and Thessalonica, the same applies. There are also disparities between certain islands in the Mediterranean. In Cyprus, the Balearic Islands, and Malta, pesticides are seen as a threat, but respondents don't see them as such in Crete and on the north-eastern Aegean islands (Lesbos, Chios). Sweden, where pesticides are the second largest threat (26%) in Northern Europe, may experience differences of opinion in Norrbotten towns like Lule (48,000 inh.) or Pite (22,500 inh.). The modification of landscapes towards uniformity or simplification is another significant threat related to agriculture. The main threat to bees in Germany (59%) and Ireland (53%) is this. The Leinster (Dublin) and

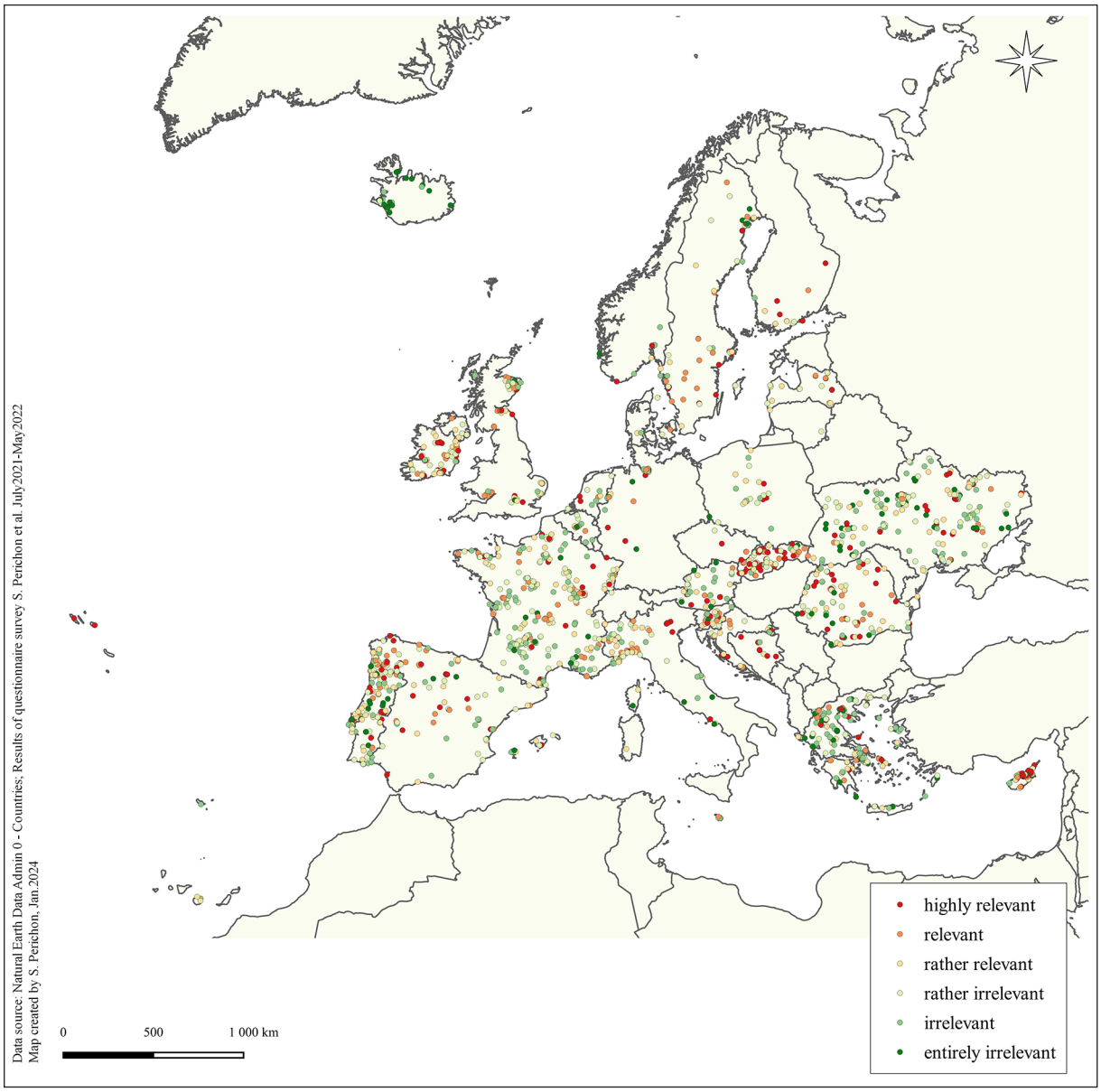

Figure 3. Assessment of the relevance of the threat posed by diseases to honey bees in Europe

Munster (Cork) coasts, as well as the Hamburg region, are shown in greater detail in Figure 5. In addition, it highlights Piedmont, Burgundy, Poitou-Charentes, and Sologne (France), as well as the coastal areas between Lisbon and Pontevedra in Galicia, as well as the Balearic Islands, Malta, and the Salzkammergut (Austria), Nitra and Zilina (Slovakia), and Kyiv and Termopil (Ukraine) regions. Networks of hedges, copses, and orchards structure the agricultural landscape in many of these regions. Trees are an important aspect of the landscape. Beekeepers' responses may include consideration of the standardization of crops, which may not always be beneficial to bees, and the urbanization of farmland. Agriculture in Ireland, Italy, and France is seen as a double threat to bees because it uses harmful substances and produces landscapes that are not (or no longer) favorable to beekeeping.

Two threats to melliferous resources, one cyclical (dearth) and the other structural (depletion), show that beekeepers favor a long-term trend towards a decline in resources. Ireland and Ukraine have the highest percentage of respondents who choose depletion over dearth, with a difference of +19 and +17 points, respectively. Irish respondents seem to be concerned by the threat unlike their counterparts in other northern European countries. Honey resources are considered a more significant issue in southern Europe. In Italy and Northern Cyprus, the majority of respondents believe the threat is

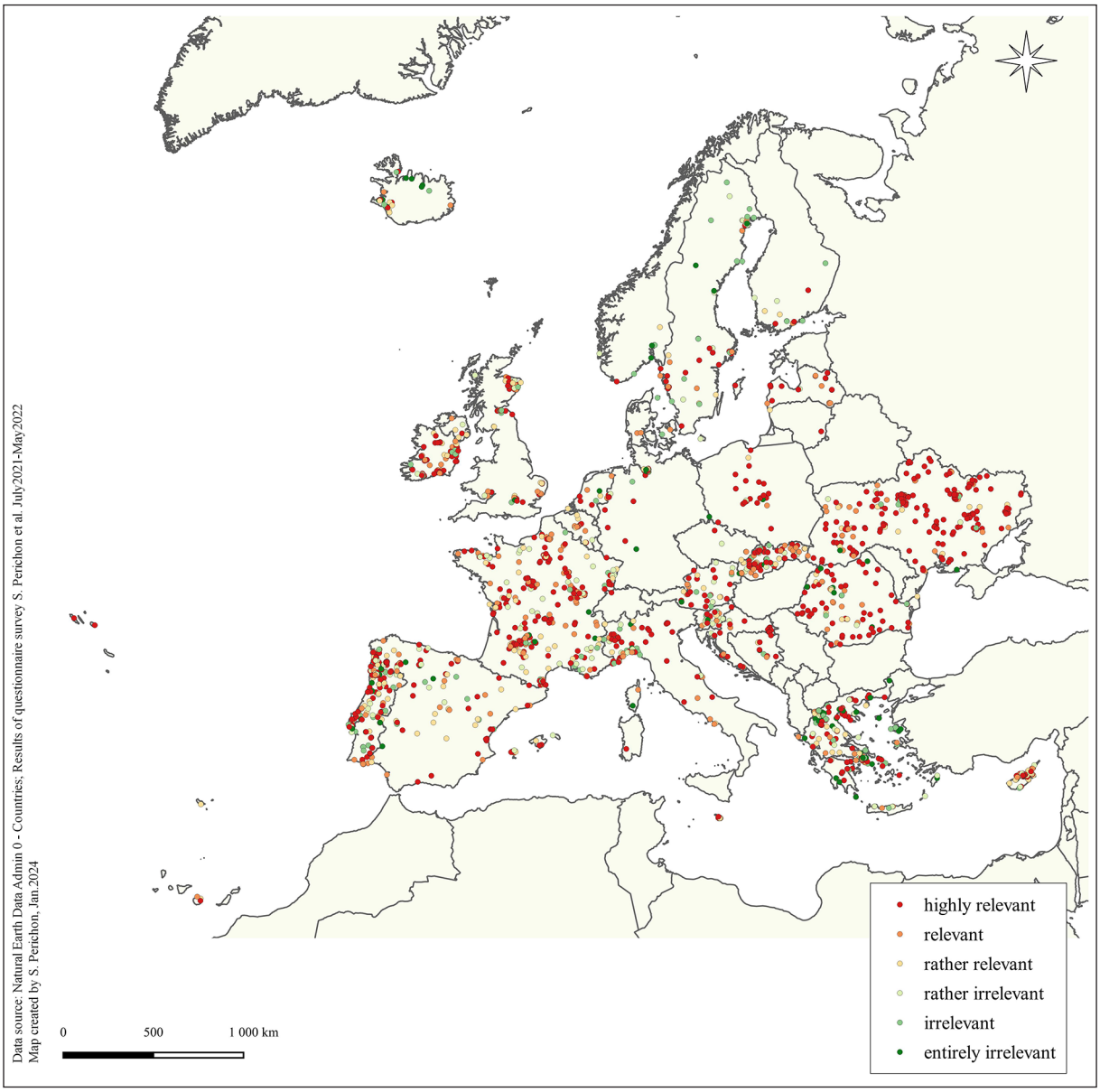

Figure 4. Assessment of the relevance of the threat posed by pesticides to honey bees in Europe

"highly relevant". Like Greece, this island's resource decline would be both temporary (53%) and structural (51%). Slovakia shares this concern, but with a bit less force in the Bratislava region. In a different perspective, it looks like the Austrian Alps, the Transylvanian Alps (Romania), Western Macedonia, and the natural areas of Northern Europe have less exposure to this problem (Figure 6).

The presence of predators is a significant threat to bees in Portugal and Northern Cyprus. Nearly 50% of respondents view this threat as "highly relevant", whereas the percentage is generally lower than 15% elsewhere in Europe. A relationship can be established between the assessment of the relevance of this threat and the current distribution of two hornet species. *Vespa velutina* (Lepeletier, 1836) also called Asian hornet is a natural predator of *A. cerana* (Fabricius, 1793) as is *V. crabro* (Linnaeus, 1758) on the European continent. Since its accidental introduction in 2004 in the Aquitaine Basin (southwestern France), this species has colonized a vast area. It is present in Belgium, France, Portugal's Atlantic coast, Piedmont, Liguria, Catalonia, Nordrhein-Westfalen, Baden-Württenberg, Hamburg. New nests are regularly recorded in the Netherlands, England, and Wales, as it continues to expand (Requier *et al.*, 2019). In Figure 7, it appears that beekeepers are highly impacted in Northern Portugal, Galicia, and Southern France. Some English, Welsh, and German beekeepers are becoming worried, and even beekeepers living in areas where

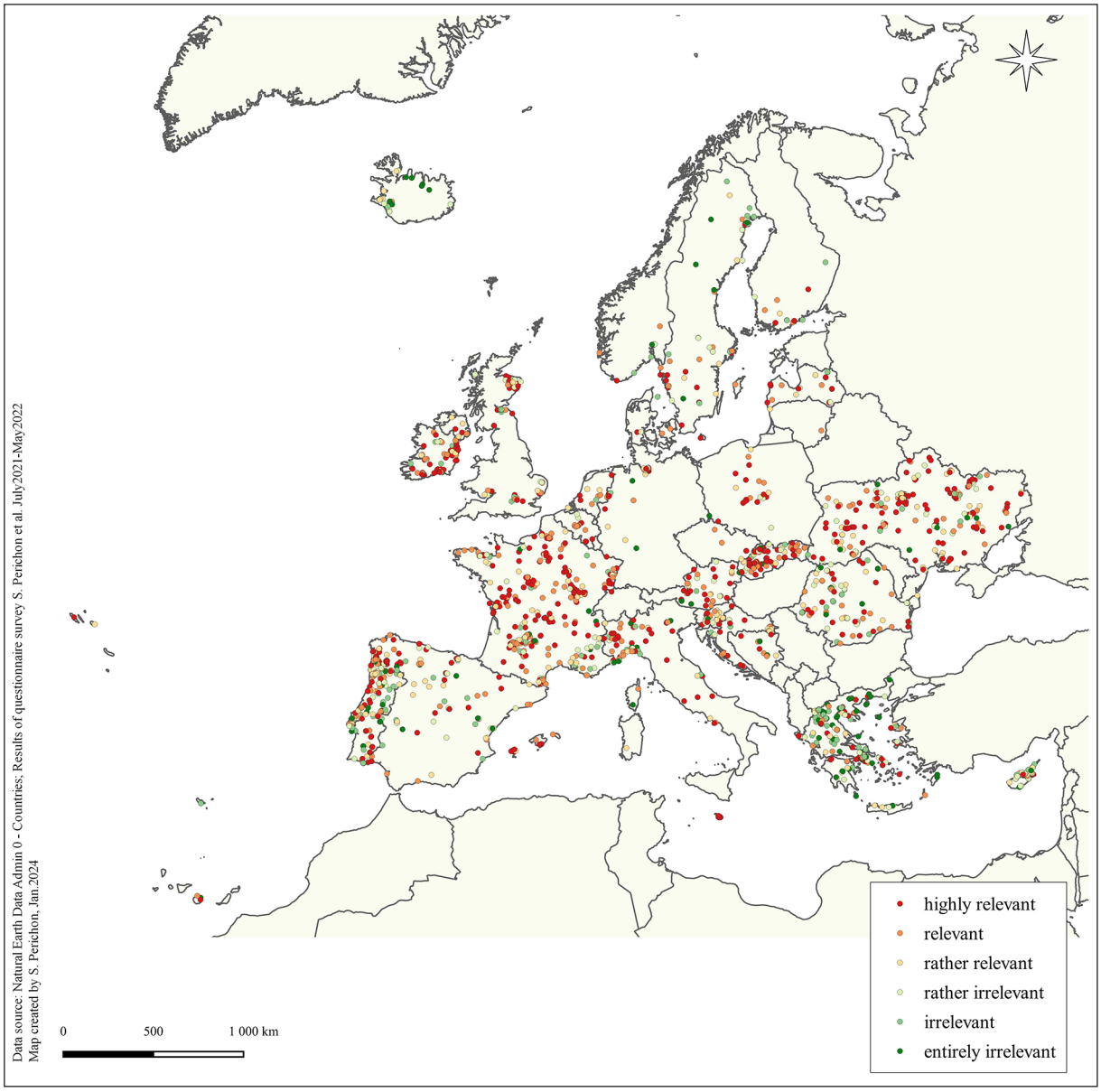

Figure 5. Assessment of the relevance of the threat posed by modification of landscapes to honey bees in Europe

the insect hasn't been recorded (Ireland) are affected. In Northern Cyprus, it is the Oriental hornet (*V. orientalis* Linnaeus, 1771), which has a range that extends to the south of the Mediterranean basin, the Near East, and Asia, that is feared.

C. Proposed from beekeepers for measures to reduce threats to honey bees

European beekeepers have proposed more than 50 measures that they believe would quickly improve the situation of bees. Most of the measures are for public authorities, but others could be taken up by beekeeping organisations or organisations involved in agriculture, forestry, natural resource management or tourism. From the responses, we identified ten fields of intervention. We ranked them in descending order of importance and illustrated them with examples (Supplementary Table S2). Not surprisingly, the measures most often address threats that beekeepers consider to be "highly relevant" or "relevant". On a continental scale, two priority areas for action would be "pesticides" and "Asian hornets". In some countries, additional measures would be indispensable. It should be noted that the parasitic threat is not perceived as likely to be eliminated in a short time. Beekeepers are reportedly resigned to the presence of *Varroa destructor* (Anderson & Trueman, 2000) in their hives and the damage it causes each year. In our opinion, this is due to the fact that beekeepers have learned to control the mite population in the hives and have

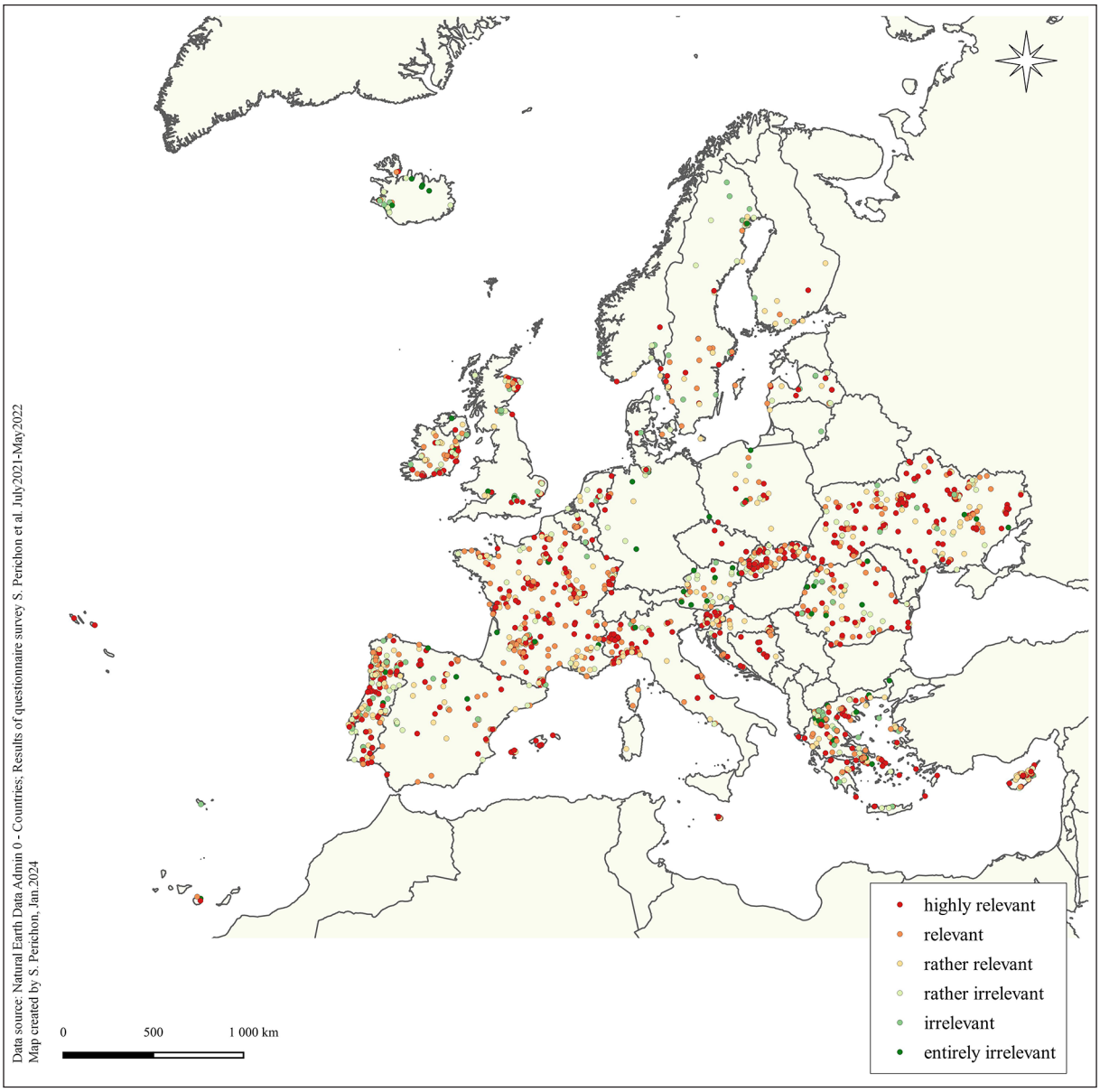

Figure 6. Assessment of the relevance of the threat posed by a decline in melliferous resources for honey bees in Europe

learned to coexist with it. Instead, the application of pesticides does not depend on beekeepers and causes concern, as does the spread of the Asian hornet. We will see later that the situation is perhaps to be put into perspective, especially in Southern Europe. The question of climate and, to a lesser degree, natural resources seems rather remote.

The problem of pesticides is omnipresent in the writings of beekeepers, but opinions about how to deal with it varies from country to country (Figure 8). Exasperation about the damage caused by phytosanitary treatments is especially high in Romania, where 46% of surveyed beekeepers believe that the use of pesticides in agriculture should be prohibited, and 30% believe that their use should be restricted. This opinion is shared in France and Ireland. In both countries, it also seems essential to increase the honey flora by planting rural trees such as hedgerows, trees along rural roads, orchards, groves, etc. In other countries, perhaps because compliance with the regulations on prohibited pesticides is acquired. For example, in Ukraine, this hypothesis cannot be ruled out. Many beekeepers condemn the failure to prosecute of those who continue to use strictly banned pesticides in their fields. Furthermore, because they believe that agriculture cannot go without phytosanitary products to compete, the tolerance is greater. Thus, in Italy (28% vs. 21%), and Scotland (33% vs. 0%),

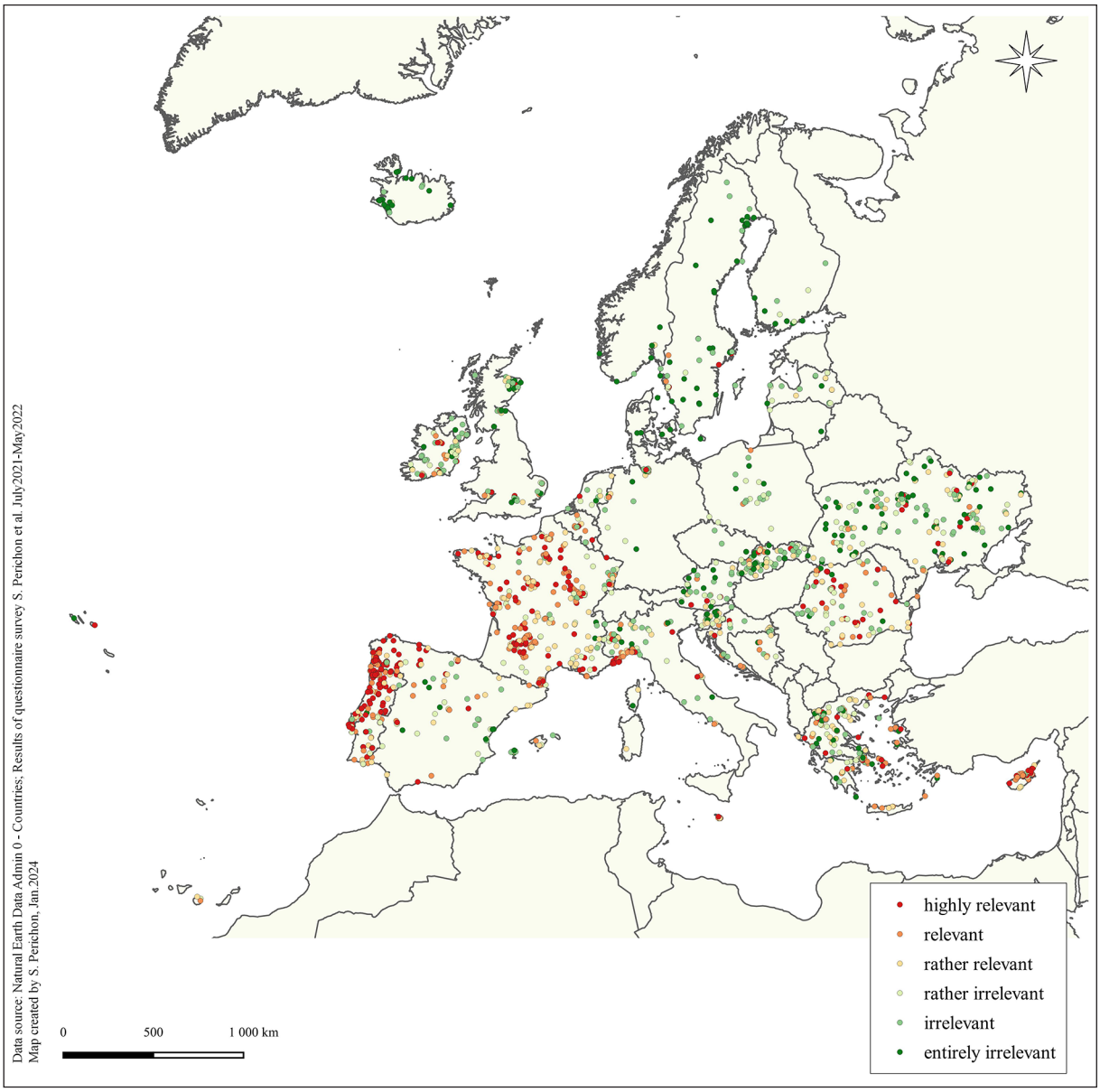

Figure 7. Assessment of the relevance of the threat posed by predators to honey bees in Europe

respondents advocate a reduction of pesticides. For Greek, Cypriot and Ukrainian beekeepers, this is not enough, and at the same time beekeeping should be promoted (development of the beekeeping sector for professional or multi-active purposes). The causal link between the health of the bee and the development of beekeeping is obvious. In Slovakia, it is less important to promote beekeeping than to increase melliferous resources: forage crops (26%, 24%) and tree plantations (20%).

In Portugal, 50% of beekeepers propose measures to regulate or eradicate Asian hornets, but only one out of five do so against pesticides. The ratio is the same in Galicia, but it is reversed elsewhere in Spain. Despite the measures taken in France to control *V. velutina*, beekeepers in the Aquitaine Basin are questioning their efficiency, and in the eastern half of the country, they do not propose any measures. The strong concern of Portuguese beekeepers led the national authorities to implement and keep a specific action plan for surveillance and control of Asian hornets including economic support within the National Programme for Support of Apiculture 2023-2027 (Government of Portugal, 2023). In Spain and France, several situations deserve our attention. Piedmont and Roussillon (Southern France) respondents believe that seasonal hive movements could spread disease and put more pressure on resources, leading them to suggest surveillance measures. In the mountains in Slovakia (Fatra), beekeepers recommend drastically reducing the amount of livestock

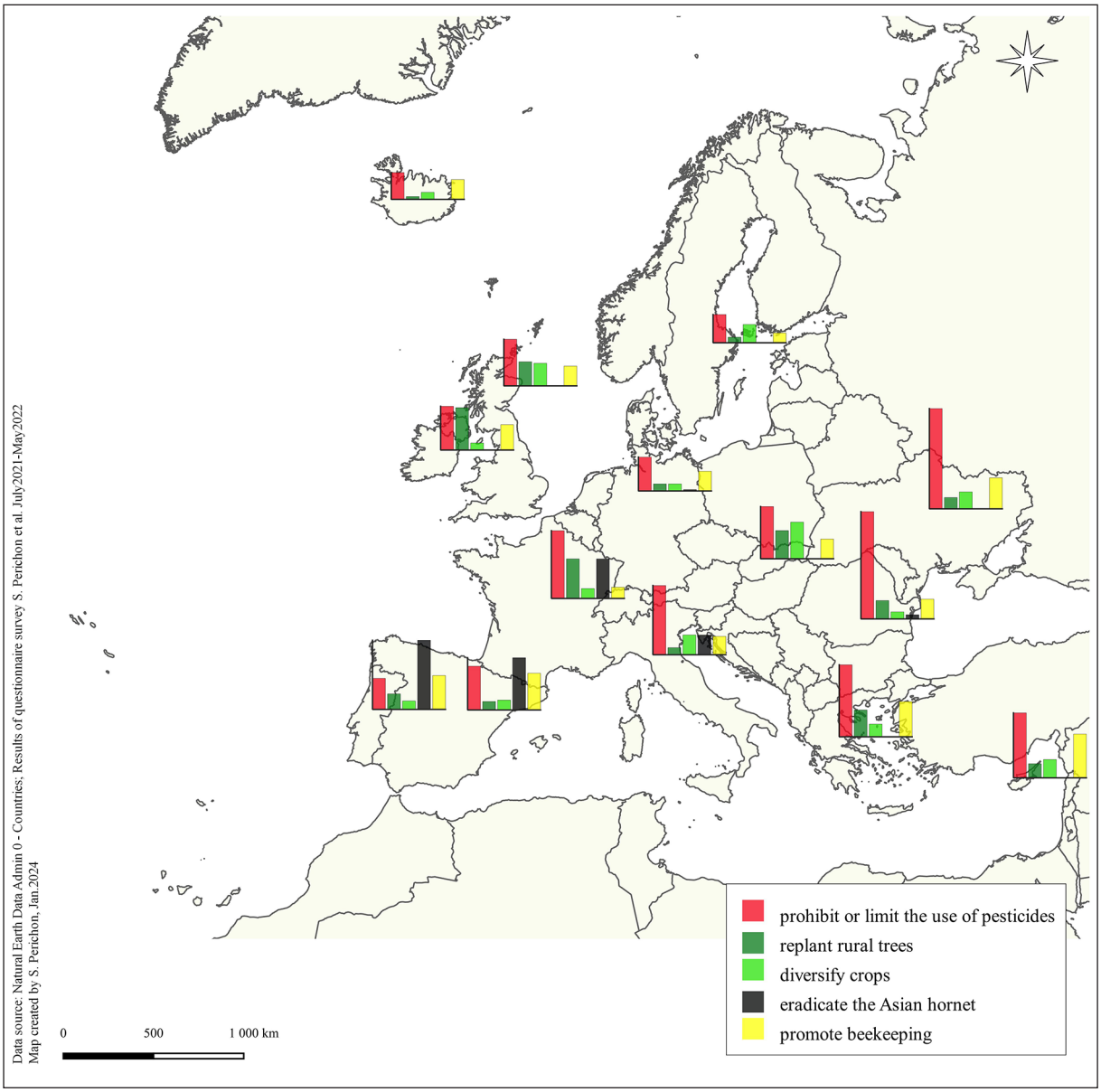

Figure 8. Five measures proposed by beekeepers in various European countries to help honey bees

effluents on the meadows. In western Macedonia, they propose tree planting and propose a more sustainable management of forests. In Norrbotten (Sweden), preventive or curative measures against varroasis are indicated. Their minor importance elsewhere in Europe prompted us to profile the beekeepers who mentioned *Varroa* mites in countries where it was more frequent. In these countries, the measures proposed concerned: compulsory treatment in Northern Cyprus (28%) and Greece (15%), funding of scientific research in Spain (23%) and Italy (13%), or reimbursement of treatments in Portugal (13%). In some of these countries, we also note an over-representation of professional beekeepers and agricultural engineers among the respondents who mention measures against *Varroa* mites.

D. The obstacles to the development of local beekeeping

Almost 90% of sample respondents cite at least one obstacle to developing beekeeping in their region. They denounce public policies that penalize or oppose beekeeping, they are worried about rising operating costs, the visible consequences of climate change, the decline of forage, the intensive agriculture, the growing pressure of predators the indifference of society, the lack of interest of young people, etc. In total, about forty obstacles have been identified. From the outset, a distinction is made between socio-economic barriers which seem easier to deal with and to which the majority of their criticism is directed and natural barriers over which beekeepers

often feel powerless.

Southern European countries are most likely to deplore the lack of realism of public policies on beekeeping (Figure 9; Supplementary Table S3). The inadequacy of financial and technical support, the disorganisation of the beekeeping sector, and the bureaucracy are evoked in Portugal or in Northern Cyprus. Elsewhere in Europe, beekeepers do not regard rising operating costs (fuel, equipment, etc.) as a real impediment to the local development of beekeeping either, even though in the Aquitaine Basin (France), northern Italy, continental Greece and Slovakia. Other respondents explain the poor profitability of the beekeeping activity by structural problems: low purchasing power on the internal market (Ukraine), impossible access to foreign markets (Northern Cyprus). In Germany and Scotland (17%), the difficulty of the tasks (weight to be lifted, to be handled, frequent stings, etc.) would deter potential candidates and this is especially true when beekeepers believe that young people avoid physical work. In Sweden (28%) and Ireland (26%), beekeepers think that geographical or social isolation is detrimental to the local development of beekeeping, as it is sometimes difficult to be initiated in an associative structure close to one's home or to find a mentor. In Ukraine (32%), France (28%), Romania and Italy (21%), beekeepers denounce intensive agriculture. In countries where the threat to bees is perceived

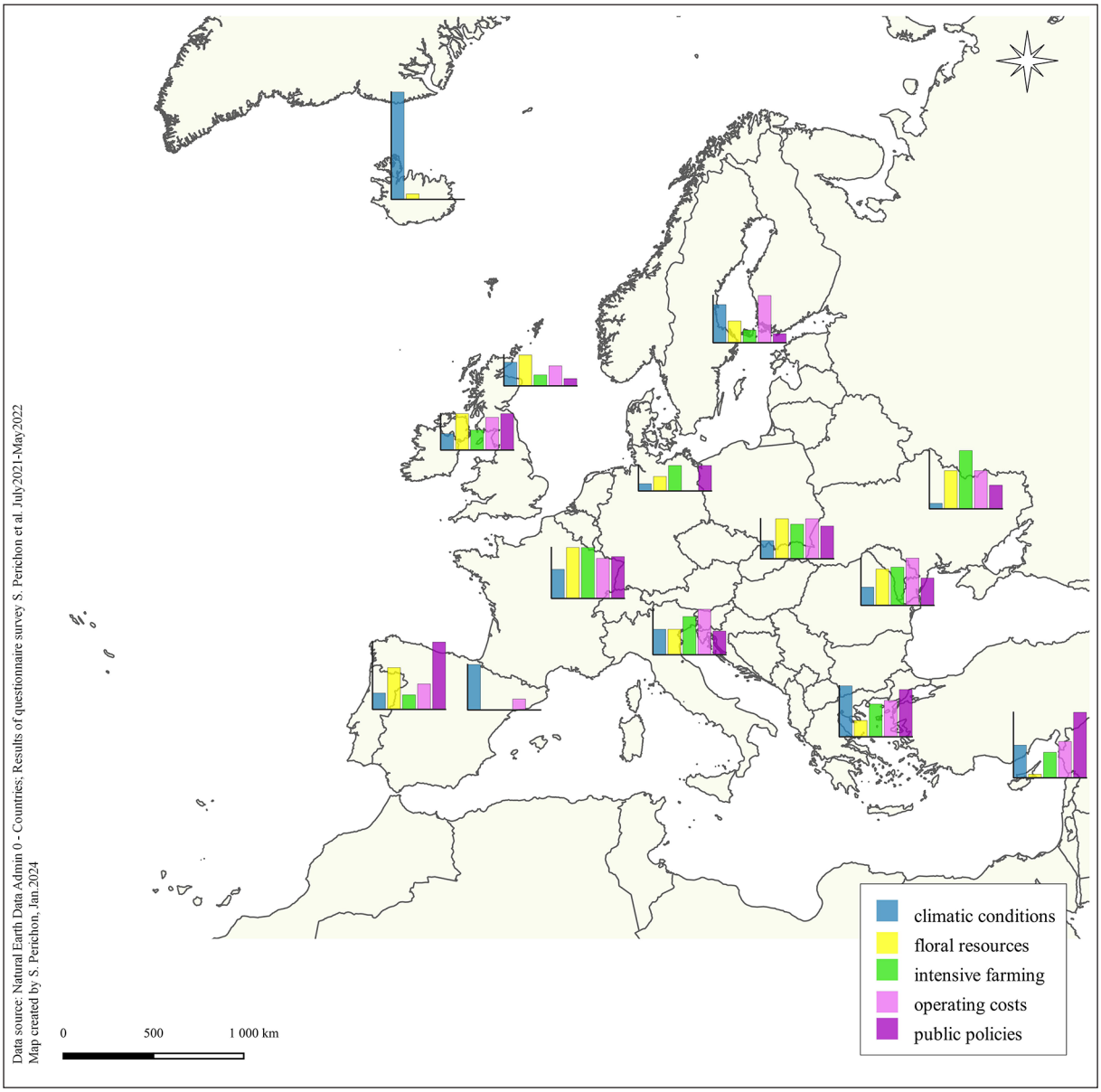

Figure 9. The main obstacles to the local development of beekeeping according to beekeepers from various European countries

as relatively low, beekeepers do not really see any obstacles to the development of the local beekeeping (Supplementary Table S3). The Icelandic case is somewhat special. Although this northern European island is less vulnerable to threats from the continent (diseases, parasites, and predators), beekeepers are confronted with many obstacles. About 60% of them mention climatic conditions that are not conducive to bees, such as long winters, many rainy days, changing weather conditions, and cool summers (Figure 9). Some also speak of landslides that exclude areas where melliferous resources may be attractive. Finally, the requirement to import Finnish bees to populate the island remains another constraint (17%). Climate is also perceived as an obstacle by beekeepers in Southern Europe, especially in Greece (28%) and Spain (25%). Early drought and increased wildfires are already impacting local floral composition. In the South of France, perhaps there is a causal link between the decline in honey resources and the recent evolution of the Mediterranean climate. In Northern Spain, the average number of obstacles mentioned is the highest (2.2), with hornets taking the top spot (39%), followed by climate. By comparison, less than 15% of Portuguese respondents consider the insect an obstacle. However, the perceived threat level was higher than in Spain. This suggests that, the severity of the threat is not so much related to the insect as to the lack of political will to implement the necessary means to fight against its proliferation or to eradicate it.

E. What future for local beekeeping?

Asking beekeepers about what beekeeping could be like in their region in 2040 allows us not only to assess their confidence in the future, but also to better understand the factors involved. Their responses incorporate local trends that are valid on a national or even continental scale, but can also be region-specific. Three scenarios for the development of local beekeeping have been created by us based on around twenty of the most frequently described trends by respondents (Figure 10; Supplementary Table S4).

- In "scenario 1", involving nine out of the 14 countries studied, the respondents are sure that the number of beekeepers in their region will increase in the near future. The trend is commonly viewed as a result of society's growing awareness of the ecological role of honey bees or the advancement of leisure activities. Interest in bees can have an impact on local beekeeping, particularly where native bee species are concerned. Whether by enhancing their value (Sweden, Ireland, Ukraine) or hybridizing them, on the contrary (Germany). The increase in beekeepers is causing Icelandic respondents to look forward to an increase in honey production in their country, which they feel is very positive. In France, there is a perception that the gap between professionals and amateur beekeepers will become wider. There would be a competition to increase practices, often to the detriment of bees' welfare, and on the other hand, the upkeep of amateurism likely to harm local professionals (unfair competition on honey prices) and colony health (lack of treatment for bee diseases). In Northern Cyprus, the respondents believe that beekeeping practices will become more professionalized in the future. In their opinion, a sustained public policy that favors local beekeeping would make this possible. This change in beekeeping practices could lead to an increase in honey production, even if honey resources may deteriorate;
- In "scenario 2", the primary concern is the production of honey. The respondents, typically Italians, support the idea of a trend decline in production. Local beekeepers will have to give up their activities in the future, and also because operating costs will continue to rise. It's possible that local beekeeping will decline until there's no beekeepers left, which could occur in twenty years' time;
- The decrease in the number of beekeepers is the basis for "scenario 3", which can be found in several countries, especially in southern Europe. Some respondents in Portugal, Greece and Romania are considering the possibility that beekeeping has disappeared in certain areas. The Portuguese respondents are a little closer to "scenario 2" in that they are convinced of a future decline in honey production.

The future of local beekeeping is a divisive issue, with beekeepers having different expectations depending on the economic importance of the activity. Confidence in the future is heightened when beekeeping is seen as a leisure activity and an expression of ecological awareness. On the other hand, when beekeeping is an economic activity, confidence can be eroded; the impact of climate

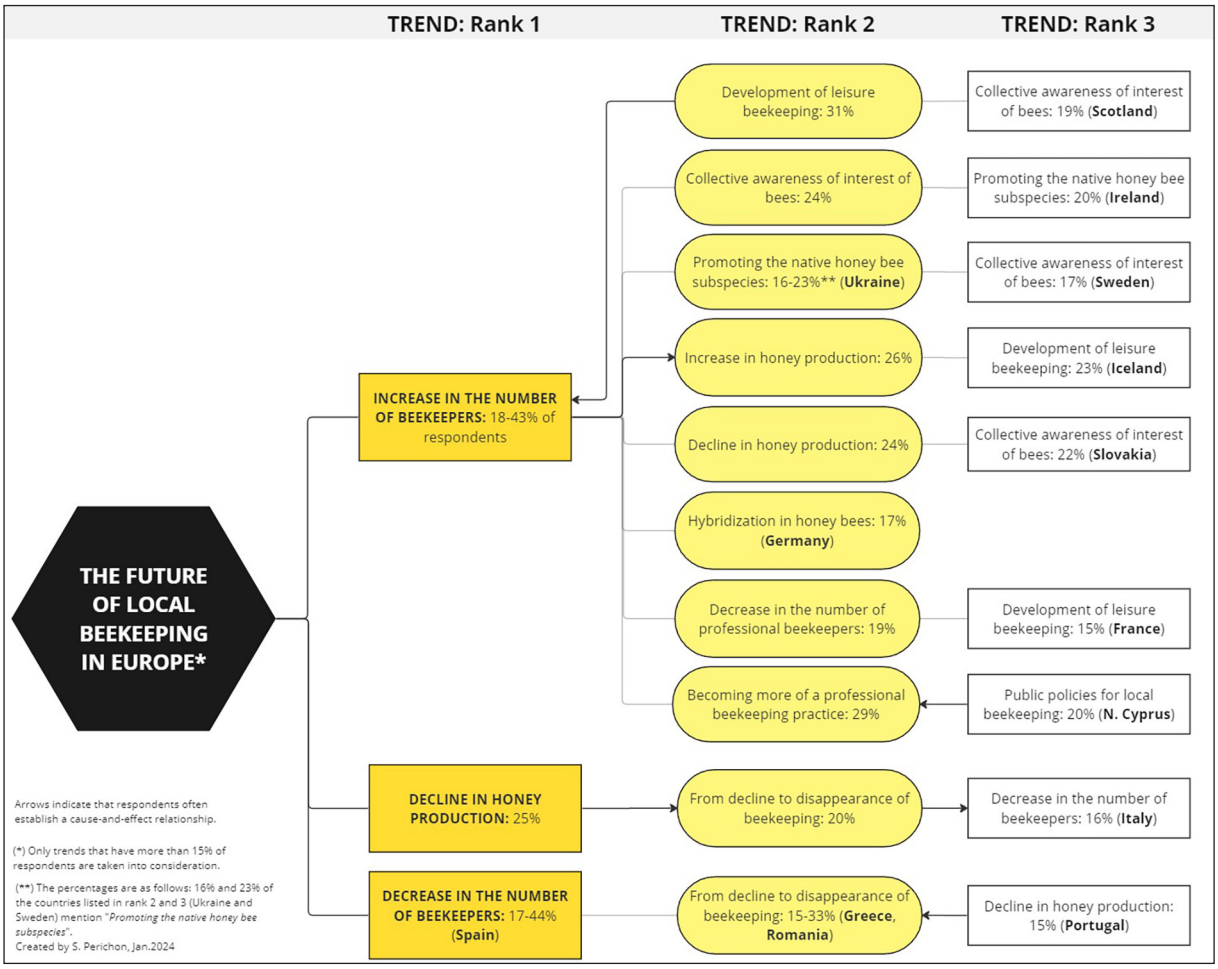

Figure 10. The future of local beekeeping in different countries illustrated by three scenarios

change on wild plants and the presence of monocultures appear in the background.

III. PERSPECTIVES

European beekeeping is characterised by different economic and social situations: operations, technologies, average apiary sizes (Figure 11). It is the consequence of a specific local history, a specific environment which, in recent decades, has evolved differently from one region to another, and whether or not there are local or regional organisations to promote beekeeping. Our results confirmed that the types and levels of threats faced by honey bees vary from one beekeeper to another (Donkersley *et al*. 2020). Here, we found it essential to make a distinction between assessing "threats" and identifying "obstacles to the development of beekeeping" as the connection between the two senses is indeed strong and both determine the level of confidence in the future of beekeepers. According to Marzano (2010), confidence is defined as a mechanism for reducing risk. Our results showed that the level of confidence in beekeeping is based, in part, on the health of bees and honey production. For Balme *et al.* (2003), confidence in the future is based more on a dynamic relationship between the effectiveness of public policies and the political, social and economic demands of citizens. Beekeepers may also be more demanding of politicians than in the past. This is what we have seen in relation to the problems of Asian hornets in some countries like France, Portugal and Galicia (Spain). A Eurofound (2021) report based on several surveys of the European Commission's Eurobarometer (2019) allows us to compare the level of confidence in the future of the citizens of the 27 Member States with that of the beekeepers we interviewed. It is striking to note many correspondences between our ranking of the most optimistic countries with those mentioned in the report (North/South duality). The organisation then proposes some explanations that may help to understand our results, and which confirm a certain number of points of view. For example, distrust of public policies appears to be the most direct indicator of social dissatisfaction, and therefore of pessimism

Figure 11. Photographs to illustrate local beekeeping**.** a) a beekeeper putting supers on his hives in Portugal (author: Miguel Vilas Boas); b) a traditional apiary in Spain (author: Maria Shantal Rodriguez); c) an apiary in Italian Alps (author: Consuelo Ferrier); d) a beekeeper inspecting in his hives in Italie (author: Consuelo Ferrier); e) a beekeeper inspecting in his hives in Greece (author: Konstantinos Exarchos); f) Queen rearing and bee breeding in Greece (author: Konstantinos Exarchos); g) a long row of beehives near a village in Northern Cyprus (author Erkay Ozgor); h) an apiary enclosed by a wooden fences in Ireland (author: Garrett Dempsey); i) an apiary under the snow in Sweden (author: Sonja Leidenberger); j) spring inspection of a hive with children in Iceland (author: Brynhildur Stefánsdóttir); k) inspection of two hives in Iceland (author: Anna Guðmundsdóttir); l) an apiary in a meadow in Latvia, author (Aleksejs Zacepins); m) an apiary in a forest meadow in Slovakia (author: Jan Repka); n) a beekeeper putting supers on his hives in Slovakia (author: Marek Stevko); o) a beekeeper harvesting honey in Ukraine (author: Viktoriia Voloshyna); p) Queen surrounded by bees, *Apis mellifera carnica* var. carpathica in Ukraine (author: Victor Papp)

(ahead of the economic situation). But in every case, confidence reflects a part of individuality where motivations, expectations, choices and experiences are expressed (Thoms *et al.*, 2019; Andrews, 2019).

Beekeeping is complex and depends on ecological, economic, cultural and social sustainability (Fedoriak *et al.*, 2021). From a comparative study on honey bee colony losses in Ukraine, the researchers describe three strata: First, the "traditional landscape", where beekeepers integrate their bees into an exceptional natural environment which makes it possible to produce high-quality honey and ensures a stable income. Second, the "intermediate landscape', where beekeepers believe that rural beekeeping is deteriorating because government control over pesticides is inefficient, hence the development of urban beekeeping. And third, the "intensively managed agricultural landscape", where beekeepers denounce the frequent poisoning of their bees by pesticides, which causes severe conflicts between beekeepers and farmers. However, according to Fedoriak *et al.* (2021) on the basis of three beekeeping seasons, the hypothesis of higher honey bee colony losses in the intensively managed agricultural landscape is not supported, why a sustainable development of beekeeping must necessarily be based on the consideration of the complexity of interactions between landscapes as socio-ecological systems. Beekeepers also need to have social capital to foster exchange and to collaborate with other stakeholders: researchers, policy makers, farmers, etc. (Maderson and Wynne-Jones, 2016). Although beekeeping offers opportunities for social connection, many studies also show that it gives those who practice it with moments of happiness, unforgettable memories, alleviation of anxiety and other mental health problems, and lifelong learning (Whitaker, 2022; Andrews, 2019; Perichon, 2024; Velardi *et al.* 2021). In the United Kingdom, Alton and Ratnieks (2021) assessed the social benefits of beekeeping during lockdown periods (Covid-19). They found that beekeepers not only spent more time with their bees in order to break down feelings of isolation or anxiety, but have also increased their virtual exchanges with their counterparts (e.g., participating in virtual events, reading blogs and feedback on forums).

In Northern Europe, the survey described an optimistic beekeeper situation in contrast to a Southern Europe where the beekeeper's express pessimism bordering on hopelessness. As we explained, a decrease in honey production contributes to this feeling. The southern beekeepers become even more pessimistic when they consider their low honey yields to be the consequence of a global change in the environment. A recent study within the frame of the EU-funded H2020-project B-GOOD described that Southern European beekeepers experienced a 10-fold likelihood of being classified as heavily im-pacted by climate change compared to Northern European beekeepers (Van Espen *et al.*, 2023). The reflections of beekeepers in the survey displayed differences between countries, likely due to the socio-economic, political, geographical and cultural differences. In Northern European countries, beekeeping is carried out for more emotional reasons and the beekeepers have a more positive view of the future of beekeeping. In Southern and Eastern Europe, beekeeping is financially important, but existing threats endanger the future of beekeeping. In the United States of America, using an example from another continent, where beekeeping has a high commercial importance, intense bee losses in recent decades due to colony collapse disorder have negatively affected beekeepers' views of the future, and intensive studies are being carried out to find and eliminate the causes of death (Seitz *et al.*, 2015; López-Uribe and Simone-Finstrom, 2019). Unlike the pest threat, the pesticide threat could be removed quickly in an optimistic scenario. The prohibition or limitation of their use is one of the priority measures proposed by beekeepers, which echoes the recent European guidelines in favour of pollinators. However, the long list of proposed measures demonstrates that the problem goes beyond this framework, and covers a dozen fields of intervention, including agriculture, where pesticides are included. It also demonstrates the complexity of the situation and the need to understand the problems and solve them on spatial scales that do not necessarily correspond to administrative divisions.

CONCLUSION

To summarize, European beekeepers are exposed to very extremely situations depending on the region where they practicing bee keeping. While beekeepers in the south already suffer hardly under economical deficits as a consequence of threats like climate change and pests (e.g., the Asian hornet), the same threats have not reached the northern countries in the same extend yet. This might be the reason, why southern beekeepers are looking more pessimistic in the future of beekeeping, while Northern European beekeepers are fairly optimistic. Southern beekeepers also see a great responsibility for public politicians to act. Interestingly, all European beekeepers would prefer a limit or prohibit use of pesticides in the agricultural industry.

The results presented here are essentially based on local individual experiences, which sometimes makes it difficult to generalise across a country or even within a region. The importance of mapping was evident in this context, as it allowed us to pinpoint more precise areas where, for instance, a specific threat to bees was considered essential. We asked beekeepers more questions in our online survey than what was covered here, including their favorite honey, their best memory with bees, and what it takes to become a good beekeeper. The results confirm some of the points in the article, but they also provide a fresh perspective on the relationship between European beekeepers, their bees, and their environment.

NOTE

[1]URL: https://www.evalandgo.com/form/231600/s/?id=-JTk4ciU5OXElOTklQUE%3D&a=JTk2bCU5Mm4lOTYlQTk%3D

ACKNOWLEDGEMENTS

We would like to thank the following organisation for supporting our study by distributing our questionnaire to their members: Irish Beekeepers Association; for the United Kingdom: Edinburgh & Midlothian Beekeepers' Association, Aberdeen & District Beekeepers Association, High Wycombe & District Beekeepers' Association, Shropshire Beekeepers Association, Welsh Beekeepers Association; Icelandic Beekeeping organisation; for Sweden: Nordbi Association Sweden, Biodlarna Sweden; for Spain: Gran Canaria Beekeepers' Association, Eivissa Beekeepers' Association (Balearic Islands); for France: National Federation of Apicultural Technical Groups (FNGTA), National Beekeeping Union (SNA), National Society of Veterinary Technical Groups (SNGTV), National Federation of Beekeeping Development Network (ADA-France), Departmental Beekeeping Unions and Associations

of Côte d'Or, Pyrénées-Orientales, Lot, Lot-et-Garonne, Charente, Loir-et-Cher, Aisne, Somme and Côtes-d'Armor; for Belgium: Royal Beekeeping Society of Wavre; for Greece: Bee Club Pellas-Macedonia, Beekeeping Centres of Western Macedonia (Kozani), Piraeus - Cyclades (Piraeus) and North Aegean (Mytilene, Lesbos), Beekeeping Cooperatives of Rethymnon and Andros, and Beekeeping Associations of Kavala, Karditsa and Chania; for Portugal: Foundation for Science and Technology (FCT) and the National Federation of Portuguese Beekeepers (FNAP); for Ukraine: Foundation of Women Beekeepers (NGO), BeesAgro Managed Pollination Association, Ukrainian Professional Beekeepers Association, Union of Beekeepers of Ukraine; for Cyprus: North Cyprus Beekeepers Association; and for Slovakia: Slovak Beekeepers Association.

We thank Egill Rafn Sigurgeirsson for agreeing to translate our questionnaire into Icelandic and for distributing the questions to the Icelandic beekeepers; Jean-Xavier Saint-Guily (Bergerie Nationale de Rambouillet), Robert Svensson (Nordbi Association Sweden) and Hanna Udding (Biodlarna Sweden) for distributing the questionnaire in their networks; Kevin Lucey, Yves Cornet, Paul Hurley and Garrett Dempsey for proofreading this article; and Anna Guðmundsdóttir, Brynhildur Stefánsdóttir, Viktoriia Voloshyna, Konstantinos Exarchos, Garrett Dempsey, Consuelo Ferrier, Victor Papp, Jan Repka and Marek Stevko for providing us with pictures illustrating beekeeping in their region or for agreeing to be photographed. We would also like to thank all the beekeepers who agreed to answer our questions.

REFERENCES

Anderson, D.L. & Trueman, J.W., (2000). Varroa jacobsoni (Acari: Varroidae) is more than one species. Exp Appl Acarol., 24(3), 165-89. doi: 10.1023/a:1006456720416. PMID: 11108385.

Andrews, E., (2019). To save the bees or not to save the bees: Honey bee health in the Anthropocene. Agriculture and Human Values, 36, 891-902. Crossref, Google Scholar.

Alton, K. & Ratnieks, F., (2021). Can beekeeping improve mental wellbeing during times of crisis? Bee World, 99, 40-43. https://doi.org/10.1080/0005772X.2021.1988233

Aurel, D., Bruckner, S., Wilson, M., Steinhauer, N. & Williams, G., (2022). United States Honey Bee Colony Losses 2021-2022: Preliminary Results from the Bee Informed Partnership.

Agrebi, N., Steinhaeur, N., Tosi, S., Leinartz, L., De Graaf, D.C. & Saegerman, C., (2021). Risk and protective indicators of beekeeping management pratices. Global Environment Sciences, 799, https://doi.org/10.1016/j.scitotenv.2021.149381

Ashley, L., Zhang, G., Dolezal, A. G., O'Neal, M.E. & Toth, A.L., (2022). Agroecosystem landscape diversity shapes wild bee communities, Agric Ecosyst Environ. 327(1-2). DOI: 10.1016/j.agee.2021.107826

Balme, R., Marie, J.L. & Rozenberg, O., (2003). Motives for political trust (and distrust): interest, knowledge, and conviction in forms of political reasoning. Revue internationale de politique comparée, 10(3), 433-461.

Bartlett, D., (2022). Frontiers in effective control of problem parasites in beekeeping. International Journal for Parasitology: Parasites and Wildlife. https://doi.org/10.1016/j.ijppaw.2022.03.003

Breeze, T.D., Vaissière, B.E., Bommarco, R., Petanidou, T., Seraphides, N., Kozák, L., Scheper, J., Biesmeijer, J.C., Kleijn, D., Gyldenkærne, S., Moretti, M., Holzschuh, A., Steffan-Dewenter, I., Stout, J.C., Pärtel, M., Zobel, M. & Potts, S.G., (2014). Agricultural policies exacerbate honeybee pollination service supply-demand mismatches across Europe. PLoS ONE, 9, e82996 DOI: 10.1371/journal.pone.0082996

Brown, M.J., Dicks, L.V., Paxton, R.J., Baldock, K.C., Barron, A.B., Chauzat, M.P., Freitas B.M., Goulson, D., Jepsen, S., Kremen, C., Li, J., Neumann, P., Pattemore, D.E., Potts, S.G., Schweiger, O., Seymour, C.L. & Stout, J.C., (2016). A horizon scan of future threats and opportunities for pollinators and pollination. PeerJ. https://doi.org/10.7717/peerj.2249

Chauzat, M.-P., Cauquil, L., Roy, L., Franco, S., Hendrikx, P. & Ribière-Chabert, M., (2013). Demographics of the European Apicultural Industry. PLoS ONE. https://doi.org/10.1371/journal.pone.0079018

Croft, S., Brown, M., Wilkins, S., Hart A. & Smith, G.C., (2018). Evaluating european food safety authority protection goals for honeybees (Apis mellifera): what do they mean for pollination? Integr. Environ. Évaluer. Manag. Doi 2018: 10.1002/ieam.4078

Deguines, N., Jono, C., Baude, M., Henry, M., Julliard, R. & Fontaine, C., (2014). Large-scale trade-off between agricultural intensification and crop pollination services. Front. Ecol. Environ., 12, 212-217. https://api.semanticscholar.org/CorpusID:86568895

Donkersley, P., Elsner-Adams, E. & Maderson, S., (2020). A one-health model for reversing honeybee (Apis mellifera L.) decline. Veterinary sciences, 7, 119.

Etxegarai-Legarreta, O. & Sanchez-Famoso, V., (2022). The role of beekeeping in the generation of goods and services: the interrelation between environmental, socioeconomic, and sociocultural utilities. Agriculture, 12-551. https://doi.org/10.3390/ agriculture12040551

Eurofound, (2021). Towards the future of Europe: Social factors shaping optimism and pessimism among

citizens. Publications Office of the European Union, Luxembourg, 61p.

European Commission, (2019). EU Beekeeping Sector: National Apiculture Programmes 2020-2022 [PowerPoint Slides]. https://agriculture.ec.europa.eu/system/files/2020-06/honey-apiculture-programmes-overview-2020-2022_0.pdf

European Court of Auditors, (2020). Protection of wild pollinators in the EU – Commission initiatives have not borne fruit. Publications Office of the European Union, Luxembourg. https://www.eca.europa.eu/Lists/ECADocuments/SR20_15/SR_Pollinators_EN.pdf

Fedoriak, M., Kulmanov, O., Zhuk, A., Shkrobanets, O., Tymchuk, K., Moskalyk, G., Olendr, T., Yamelynets, T. & Angelstam, P., (2021). Stakeholders' views on sustaining honey bee health and beekeeping: the roles of ecological and social system drivers. Landscape Ecology, 36, 763-783.

Government of Portugal, (2023). National Programme for Support of Apiculture 2023-2027. Portaria n.º 54-G/2023 from 27 of february 2023, Diário da República nº 41/23-1.ª série, Ministério da Agricultura e Pescas, pag. 332.

Gray, A., Adjlane, N., Arab, A., Ballis, A., Brusbardis, V., Bugeja Douglas, A., Cadahía, L., Charrière, J.D., Chlebo, R., Coffey, M., Cornelissen, B., Amaro da Costa, C., Danneels, E., Danihlík, J., Dobrescu, C., Evans, G., Fedoriak, M., Forsythe, I., Gregorc, A., Ilieva Arakelyan, I., Johannesen, J., Kauko, L., Kristiansen, P., Martikkala, M., Martín-Hernández, R., Mazur, E., Medina-Flores, C.A., Mutinelli, F., Omar, E.M., Patalano, S., Raudmets, A., San Martin, G., Soroker, V., Stahlmann-Brown, P., Stevanovic, J., Uzunov, A., Vejsnaes, F., Williams, A. & Brodschneider, R., (2022). Honey bee colony loss in 37 countries using the COLOSS survey for winter 2019-2020: the combined effects of operation size, migration and queen replacement. J.Api.Res. https://doi.org/10.1080/00218839.2022.2113329

Gray, A., Adjlane, N., Arab, A., Ballis, A., Brusbardis, V., Charrière, J.D., Chlebo, R., Coffey, M., Cornelissen, B., Amaro da Costa, C., Dahle, B., Drazic, M.M., Evans, G., Fedoriak, M., Forsythe, I., Gajda, A., de Graaf., D., Gregorc, A., Ilieva, I., Johannesen, J., Kauko, L., Kristiansen, P., Martikkala, M., Martín-Hernández, R., Medina-Flores, C.A., Mutinelli, F., Patalano, S., Raudmets, A., San Martin, G., Soroker, V., Stevanovic, J., Uzunov, A., Vejsnaes, F., Williams, A., Zammit-Mangion, M. & Brodschneider, R., (2020). Honey bee colony winter loss rates for 35 countries participating in the COLOSS survey for winter 2018-2019, and the effects of a new queen on the risk of colony winter loss. J.Api.Res. https://www.tandfonline.com/doi/full/10.1080/00218839.2020.1797272

Gray, A., Brodschneider, R, Adjlane, N., Ballis, A., Brusbardis, V., Charrière, J.D., Chlebo, R., Coffey, M., Cornelissen, B., Amaro da Costa, C., Csaki, T., Dahle, B., Danihlik, J., Drazic, M.M., Evans, G., Fedoriak, M., Forsythe, I., Gajda, A., de Graaf., D., Gregorc, A., Ilieva, I., Johannesen, J., Kauko, L., Kristiansen, P., Martikkala, M., Martín-Hernández, R., Medina-Flores, C.A., Mutinelli, F., Patalano, Petrov, P., Simon-Delso, N., Stevanovic, J., Topolska, G., Uzunov, A., Vejsnaes, F., Williams, A., Zammit-Mangion, M.. & Soroker, V., (2019). Loss rates of honey bee colonies during winter 2017/18 in 36 countries participating in the COLOSS survey, including effects of forage sources. J. Apic. Res., 58, 479-485.

Halvorson, K., Baumung, R., Leroy, G., Chen, C. & Paul Boettcher, (2021). Protection of honeybees and other pollinators: one global study. Apidologie, 52, 535-547. https://doi.org/10.1007/s13592-021-00841-1

Jacques, A., Laurent, M., Ribière-Chabert, M., Saussac, M., Bougeard, S., Budge, G.E., Hendrikx, P. & Chauzat, M.P., (2017). A pan-European epidemiological study reveals honey bee colony survival depends on beekeeper education and desease control. PloS ONE. https://doi.org/10.1371/journal.pone.0172591

López-uribe, M.M. & Simone-Finstrom, M., (2019). Honey bee research in the US: current state and solutions to beekeeping problems. Insects, 10, 22.

Maderson, S. & Wynne-Jones, S., (2016). Beekeepers' knowledges and participation in pollinator conservation policy. J. Rural Stud. doi: 10.1016/j.jrurstud.2016.02.015

Marzano, M., (2010). Qu'est-ce que la confiance ? Études – Revue de culture contemporaine, 412, 53-63.

Moritz, R.F.A. & Erler, S., (2016). Lost colonies found in a data mine: Global honey trade but not pests or pesticides as a major cause of regional honeybee colony declines, Agric Ecosyst Environ. 216(7).

Narjes, M.E. & Lippert C., (2019). The Optimal Supply of Crop Pollination and Honey from Wild and Managed Bees: An Analytical Framework for Diverse Socio-Economic and Ecological Settings. Ecol. Econ. doi: 10.1016/j.ecolecon.2018.11.018

Neov, B., Shumkova, R. Palova, N. & Hristov, P., (2021). The health crisis in managed honey bees (Apis mellifera). Which factors are involved in this phenomenon? Biologia, 76, 2173-2180. https://doi.org/10.1007/s11756-021-00684-2

Parveen, N., Miglani, R., Kumar, A., Dewali, S., Kumar, K., Sharma, N. & Singh Bisht, S., (2022). Honey bee pathogenesis posing threat to its global population: a short review. India nat. Sc. Acad. 88, 11-32. https://link.springer.com/article/10.1007/s43538-022-00062-9

Patel, V., Pauli, N., Biggs, E., Barbour, L. & Boruff B., (2021). Why bees are critical for achieving sustainable development. Ambio 50, 49-59. https://doi.org/10.1007/s13280-020-01333-9

Perichon, S., (2024). Feedback from beekeepers that use the Warré (People's) Hive Questionnaire online

survey both in Europe and other parts of the world. J.Api.Res., 63(1), 41-56. doi: https://doi.org/10.1080/00218839.2021.1946939

Perrot, T., Gaba, S., Roncoroni, M., Gautier, J.L. & Bretagnolle, V., (2018). Bees increase oilseed rape yield under real field conditions. Agriculture Ecosystems & Environment, 266, 39-48. https://doi.org/10.1016/j.agee.2018.07.020

Requier, F., Garnery, L., Kohl, P.L., Njovu, H.K., Pirk, C.W.W., Crewe, R.M. & Steffan-Dewenter, I., (2019). The conservation of native honey bees is crucial. Trends Ecol Evol., 34(9), 789-798. doi: 10.1016/j.tree.2019.04.008

Scheper, J., Holzschuh, A., Kuussaari, M., Potts, S.G., Rundlöf, M., Smith, H.G. & Kleijn, D., (2013). Environmental factors driving the effectiveness of European agri-environmental measures in mitigating pollinator loss—A meta-analysis. Ecol. Lett., 16, 912-920.

Seitz, N., Traynor, K.S., Steinhauer, N., Rennich, K., Wilson, M.E., Ellis, J.D., Rose, R., Tarpy, D.R., Sagili, R.R., Caron, D.M., Delaplane, K.S., Rangel, J., Lee, K., Baylis, K., Wilkes, J.T., Skinner, J.A., Pettis, J.S. & Van Engelsdorp, D., (2015). A national survey of managed honey bee 2014–2015 annual colony losses in the USA. J.Api.Res. 54(4), 292-304.

Sperandio, G., Simonetto, A., Carnesecchi, E., Costa, C., Hatjina, F., Tosi, S. & Gilioli, G., (2019). Beekeeping and honey bee colony health: a review and conceptualization of beekeeping management practices implemented in Europe. Sc. Tot. Env., 696. https://doi.org/10.1016/j.scitotenv.2019.133795

Sutherland, W.J., Barnard, P., Broad, S., Clout, M., Connor, B., Côté, I.M., Dicks, L.V., Doran, H., Entwistle, A.C., Fleishman, E., Fox, M., Gaston, K.J., Gibbons, D.W., Jiang, Z., Keim, B., Lickorish, F.A., Markillie, P., Monk, K.A., Pearce-Higgins, J.W., Peck, L.S., Pretty, J., Spalding, M.D., Tonneijck, F.H., Wintle, B.C., Ockendon, N. A., (2017). Horizon scan of emerging issues for global conservation and biological diversity. Trends in Ecol. & Evol., 32, 31-40. https://doi.org/10.1016/j.tree.2016.11.005

Thoms, C. A., Nelson, K. C., Kubas, A., Steinhauer, N. & Wilson, M. E., (2019). Beekeeper stewardship, colony loss and Varroa destructor. Ambio, 48, 1209-1218.

Vanbergen, A.J., (2013). Threats to an ecosystem service: Pressures on pollinators. Frontiers in Ecology and the Environment,11(5), 251-259. doi: 10.1890/120126

Vanengelsdorp, D. & Meixner, M.D., (2010). A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them. J. Invertebr. Pathol., 1, 580-595. doi: 10.1016/j.jip.2009.06.011

Van Espen, M., Williams, J.H., Alves, F., Hung, Y., de Graaf, D.C. & Verbeke, W., (2023. Beekeeping in Europe facing climate change: a mixed methods study on perceived impacts and the need to adapt according to stakeholders and beekeepers. Sc. Total Env., 888, 1-12. https://doi.org/10.1016/j.scitotenv.2023.164255

Velardi, S., Leahy, J., Collum, K., Mcguire, J. & Ladenheim, M., (2021). You treat them right, they'll treat you right: understanding beekeepers' scale management decisions within the context of bee values. Journal of Rural Studies, 81, 27-36.

Vercelli, M., Novelli, S., Ferrazzi, P., Lentini, G. & Ferracini, C., (2021). A qualitative analysis of beekeepers' perceptions and farm management adaptations to the impact of climate change on honey bees. Insects. https://doi.org/10.3390/insects12030228

Whitaker, S., (2022). Tranquil and serene: Beekeeping and Well-Being in the Italian Alps. Ecopsychologie. https://doi.org/10.1089/eco.2021.0068

Authors coordinates:

Samuel PERICHON
Research Associated
Department of Geography and Spatial Planning
Rennes 2 University
France
Corresponding author: sa.perichon@gmail.com

Leonora ADAMCHUK
Faculty of Food Technology and Quality Control of Agricultural Products
National University of Live and Environment Sciences of Ukraine
Laboratory of Methods for Assessing the Quality and Safety of Beekeeping Products
National Science Center «PI Prokopovich Institute of Beekeeping»
Ukraine

Lejla BIBER
Faculty of Agriculture and Food Science
University of Sarajevo
Bosnia-Herzegovina

Janko BOZIC
Biotechnical Faculty
University of Ljubljana
Slovenia

Robert CHLEBO
Institute of Animal Husbandry
Slovak University of Agriculture
Slovakia

Janja FILIPI
Department of Ecology; Agronomy and Aquaculture
University of Zadar
Croatia

Sonja LEIDENBERGER
Department of Biology and Bioinformatics
University of Skövde
Sweden

Georgios MAVROFRIDIS
Department of Geography
University of the Aegean
Greece

Erkay OZGOR
Cyprus Bee and Bee Products Research Centre
Cyprus International University
Northern Cyprus

Cristina POCOL
University of Agricultural Sciences and Veterinary Medicine
Cluj-Napoca
Romania

Marco PORPORATO
Department of Agricultural, Forest and Food Sciences
University of Torino
Italy

Maria Shantal RODRIGUEZ
Department of Plant Biology and Soil Sciences
University of Vigo
Spain

Miguel VILAS-BOAS
Mountain Research Center (CIMO)
Polytechnic Institute of Bragança
Portugal

Aleksejs ZACEPINS
Department of Computer Systems
Latvia University of Life Sciences and Technologies
Latvia

SUPPLEMENTARY TABLES

	Watch	Pets	Tradition	Open	Smell	Harvest	Give	Heal	Pollination	Sell	Profession
Ukraine	132	74	60	134	119	94	105	111	94	125	75
	52%	29%	24%	53%	47%	37%	41%	44%	37%	49%	30%
Romania	90	25	28	60	57	47	47	55	37	56	37
	69%	19%	21%	46%	44%	36%	36%	42%	28%	43%	28%
Slovakia	65	17	29	26	58	27	42	49	43	28	6
	64%	17%	28%	25%	57%	26%	41%	48%	42%	27%	6%
Ireland	48	8	8	29	17	24	24	33	33	16	10
	67%	11%	11%	40%	24%	33%	33%	46%	46%	22%	14%
Sweden	52	44	8	38	32	37	39	41	43	23	10
	76%	65%	12%	56%	47%	54%	57%	60%	63%	34%	15%
Scotland	40	7	11	22	11	22	26	19	31	7	5
	68%	12%	19%	37%	19%	37%	44%	32%	53%	12%	8%
Iceland	39	18	1	33	33	31	29	19	20	8	1
	93%	43%	2%	79%	79%	74%	69%	45%	48%	19%	2%
Greece	153	44	39	172	121	116	101	73	51	116	85
	58%	17%	15%	65%	46%	44%	38%	28%	19%	44%	32%
Portugal	96	45	27	101	85	72	71	44	38	77	33
	60%	28%	17%	63%	53%	45%	44%	28%	24%	48%	21%
Spain	65	16	37	74	49	54	46	35	34	47	44
	41%	10%	23%	47%	31%	34%	29%	22%	22%	30%	28%
Italy	50	21	12	51	35	28	22	28	30	15	28
	53%	22%	13%	54%	37%	30%	23%	30%	32%	16%	30%
North Cyprus	30	11	8	32	19	26	17	27	15	18	15
	65%	24%	17%	70%	41%	57%	37%	59%	33%	39%	33%
France	238	98	32	200	165	177	203	96	156	50	28
	72%	30%	10%	60%	50%	53%	61%	29%	47%	15%	8%
Germany	47	15	11	37	46	37	30	37	31	11	3
	80%	25%	19%	63%	78%	63%	51%	63%	53%	19%	5%

Supplementary Table S1. Motivations that are most appropriate for your situation

Pesticides	Prohibit their use in agriculture, prohibit their use in cities (green spaces), limit their use in agriculture, limit their use in forestry, enforce the regulation on the prohibition of certain products by exemplary penalties/fines, prohibit the use of pesticides during the day on honey crops (night treatment), etc.
Predators	Supply of free traps for Asian hornet, surveillance of Asian hornet nests, reimburse/management of the destruction of nests, allowing the shooting of the European bee-eater, etc.
Agriculture	Prohibit the felling of trees, hedges, afforestation, replanting of melliferous trees, encourage/maintain crops known to be melliferous, encourage/mandate flowering fallows, diversify crops, delay the mowing meadows, limit the use of fertilizers on meadows, facilitate dialogue with beekeepers, etc.
Beekeeping	Support the installation of young beekeepers, regulate seasonal migrations, create/maintain a register of beekeepers, encourage bee-friendly practices, promote beekeeping, etc.
Pests	Reimburse anti-Varroa treatments, make anti-Varroa treatment compulsory, monitor the infestation of colonies, authorize alternative anti-Varroa treatments, finance research on varroa, etc.
Climate	To fight against global warming, etc.
Natural resources	Sustainable management of water resources, facilitating access to public forests, allowing seasonal migrations to natural areas, etc.
Honey bees	Prohibit the introduction of queens/bees from the continent or other countries, etc.
Urban planning	Encourage urban beekeeping, encourage the greening of roofs, encourage melliferous seedlings, etc.

Supplementary Table S2. Examples of measures proposed by beekeepers to help honey bees

	No obstacles	Climate	Honey resources	Asian hornet	Intensive agriculture	Public policies	Operating costs	Bee equipment	Difficulty of the tasks	Social isolation
Ukraine	**34**	7	54	0	82	34	55	0	11	21
	13%	3%	21%	0%	32%	13%	21%	0%	4%	8%
Romania	**9**	13	27	7	28	20	34	0	12	11
	7%	10%	20%	5%	21%	15%	26%	0%	9%	8%
Slovakia	**27**	10	22	1	19	18	22	0	8	21
	26%	10%	22%	1%	19%	18%	22%	0%	8%	21%
Ireland	**7**	6	14	0	8	14	13	14	4	19
	10%	9%	20%	0%	11%	20%	18%	20%	5%	26%
Sweden	**19**	15	9	0	5	4	18	4	11	20
	27%	21%	13%	0%	7%	6%	25%	6%	15%	28%
Scotland	**15**	9	12	0	4	3	8	0	12	6
	22%	13%	17%	0%	6%	4%	12%	0%	17%	9%
Iceland	**5**	25	1	0	0	0	0	7	5	0
	12%	60%	2%	0%	0%	0%	0%	17%	12%	0%
Greece	**8**	75	23	7	48	68	39	3	13	36
	3%	28%	9%	3%	18%	26%	15%	1%	5%	14%
Portugal	**5**	15	36	24	13	59	32	0	16	14
	3%	9%	23%	15%	8%	37%	20%	0%	10%	9%
Spain	**7**	41	13	65	14	39	10	0	5	13
	4%	25%	8%	39%	8%	23%	6%	0%	3%	8%
Italy	**6**	13	13	0	20	12	23	0	11	8
	6%	14%	14%	0%	21%	13%	25%	0%	12%	9%
North Cyprus	**0**	8	1	0	6	17	9	3	4	11
	0%	17%	2%	0%	13%	37%	20%	7%	9%	24%
France	**45**	53	93	0	96	77	76	0	43	37
	13%	16%	28%	0%	28%	23%	22%	0%	13%	11%
Germany	**10**	3	5	0	9	9	0	1	11	12
	16%	5%	8%	0%	14%	14%	0%	2%	17%	19%

Supplementary Table S3. The main obstacles to the development of local beekeeping

	Iceland (n = 39)	Sweden (n = 50)	Scotland (n = 59)	Ireland (n = 50)	Germany (n = 47)	France (n = 219)	Slovakia (n = 51)
Increase in the number of beekeepers	13	20	20	17	10	44	22
	33%	40%	34%	34%	21%	20%	43%
Development of leisure beekeeping	9	5	17	9	4	33	7
	23%	10%	31%	18%	9%	15%	14%
Becoming more of a professional beekeeping practice	3	1	0	1	3	7	5
	8%	2%	0%	2%	6%	3%	10%
Increase in honey production	10	1	3	2	3	6	8
	26%	2%	5%	4%	6%	3%	16%
Increase in honey resources	7	1	6	1	0	5	1
	18%	2%	10%	2%	0%	2%	2%
Native bee subspecies (promoting)	1	11	3	10	3	9	2
	3%	22%	5%	20%	6%	4%	4%
Collective awareness of interest of bees	7	8	11	12	5	16	11
	18%	16%	19%	24%	11%	7%	22%
Public policies in favor of beekeeping	0	2	3	3	2	15	6
	0%	4%	5%	6%	4%	7%	12%
Climate change	4	4	5	1	3	22	4
	10%	8%	8%	2%	6%	10%	8%
From decline to disappearance of beekeeping	0	2	1	2	3	13	4
	0%	4%	2%	4%	6%	6%	8%
Decrease in the number of beekeepers	3	2	1	1	3	34	5
	8%	4%	2%	2%	6%	16%	10%
Decrease in the number of professional beekeepers	0	0	2	1	5	42	5
	0%	0%	3%	2%	11%	19%	10%
Amateurism of beekeepers	0	1	2	1	2	6	5
	0%	2%	3%	2%	4%	3%	10%
Decline in honey production	0	3	1	1	3	6	12
	0%	6%	2%	2%	6%	6%	24%
Decline in honey resources	0	0	1	2	1	14	7
	0%	0%	2%	4%	2%	13%	14%
Deterioration of bee health	3	3	5	12	1	5	4
	8%	6%	8%	6%	2%	2%	8%
Hybridization in honey bees	0	2	5	2	8	5	4
	0%	4%	8%	4%	17%	2%	8%

	Ukraine (n = 158)	Romania (n = 96)	Portugal (n = 148)	Spain (n = 87)	Italy (n = 75)	Greece (n = 224)	N. Cyprus (n = 35)
Increase in the number of beekeepers	29	13	5	13	6	31	12
	18%	14%	3%	15%	8%	14%	34%
Development of leisure beekeeping	2	3	2	3	1	6	4
	1%	3%	1%	3%	1%	3%	11%
Becoming more of a professional beekeeping practice	15	12	13	8	2	15	7
	9%	13%	9%	9%	3%	7%	20%
Increase in honey production	16	7	4	5	1	6	1
	10%	7%	3%	6%	1%	3%	3%
Increase in honey resources	4	1	1	0	2	0	1
	3%	1%	1%	0%	3%	0%	3%
Native bee subspecies (promoting)	26	3	4	5	2	0	0
	16%	3%	3%	6%	3%	0%	0%
Collective awareness of interest of bees	3	2	4	5	0	10	5
	2%	2%	3%	6%	0%	5%	14%
Public policies in favor of beekeeping	10	9	12	12	5	19	10
	6%	9%	8%	14%	7%	9%	29%
Climate change	1	2	12	6	10	22	4
	1%	2%	8%	7%	13%	10%	11%
From decline to disappearance of beekeeping	17	22	49	11	15	32	5
	11%	23%	33%	13%	20%	15%	14%
Decrease in the number of beekeepers	15	28	55	15	12	52	2
	9%	29%	37%	17%	16%	24%	6%
Decrease in the number of professional beekeepers	3	2	11	12	10	12	1
	2%	2%	7%	14%	13%	6%	3%
Amateurism of beekeepers	1	2	4	3	3	13	0
	1%	2%	3%	3%	4%	6%	0%
Decline in honey production	10	9	22	7	19	25	1
	6%	9%	15%	8%	25%	12%	3%
Decline in honey resources	4	4	5	1	3	9	1
	3%	4%	3%	1%	4%	4%	3%
Deterioration of bee health	1	4	7	5	1	2	1
	1%	4%	5%	6%	1%	1%	3%
Hybridization in honey bees	11	13	4	6	3	1	0
	7%	14%	3%	7%	4%	0%	0%

Supplementary Table S4. The future of local beekeeping in Europe («main trends»)