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Threats and drivers of change in populations of managed honey bees (*Apis mellifera*) in the Balkan countries of Albania and Kosovo

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Abstract

Pollinators and their pollination services provide economic, environmental and socio-cultural value worldwide. In the last decades, managed honey bees have declined due to the synergistic effects of habitat loss, pathogens and anthropogenic threats such as chemical use and climate change. Annual colony losses have been considerable in many regions where beekeeping is established. This study was conducted to assess the perceptions of beekeepers in Albania and Kosovo with respect to factors that threaten honey bees and other pollinators and negatively affect their beekeeping operations. The investigative methodological approach consists of a questionnaire administered to beekeepers online. This investigative tool aimed to identify the principal drivers of beekeeping and colony loss as perceived by beekeepers in Albania and Kosovo. The main categories included in the investigative tool were: a) parasites and pathogens, b) beekeeping practices, and c) agricultural practices and climate change. The study participants were established beekeepers distributed over a wide geographic area, that spans different Albanian and Kosovo districts. Apiaries included in this study showed an average of 56.2% colony loss, ranging from 10-60%. The analysis indicates that beekeepers perceived that the three main factors to have negatively affected productivity and bee health in 2020-2021, listed in order of their importance, are: a) parasites and pathogens; b) environmental factors (climate change), and c) beekeeping practices. Although significant seasonal losses occurred in some areas, the overall trend of beekeeping in Balkan Countries, specifically Albania and Kosovo, is one of growth due to recent significant interest and development of beekeeping in these regions. Follow up studies are needed to investigate the impact that each identified factor has on honey production and income loss for rural households.

Key words: pollinators, honey bees, colony losses, threatening factors.

Introduction

Globally, approximately 90% of flowering wild plants depend, at least in part, on pollinators (IPBES, 2016). Pollinators and their pollination services are classified into two categories: a) wild pollinators, including most pollinating species (bees, flies, ants, beetles, moths, butterflies and vertebrates); and b) managed pollinators, including several managed bees and bumblebees species, and among these the most managed pollinator in the world is the western honey bee *Apis mellifera* L. Pollinators are a primary indicator of an ecosystem's health and are critical for biodiversity conservation. Abundant research has shown the critical value of most wild and managed pollinators, and the ecosystem services they provide (Ellis *et al*., 2010; Williams *et al*., 2010; IPBES, 2016; Potts *et al*., 2016; Tokarev *et al*., 2018; Dicks *et al*., 2021). Honey bees, but also other wild insect pollinators, play a significant role in the productivity of crops (Douglas *et al*., 2020), and are vital to the productivity of orchards, horticulture and fodder. Pollinators play a central role in securing food reserves and their decline or disappearance directly threatens ecosystems and food security (Breeze *et al*., 2016; Reilly *et al*. 2020). Plant species that depend on pollinators include many crops of fruits, vegetables, seeds, nuts and hanging plants, which provide micronutrients, vitamins and minerals in the human diet (Obermeister, 2019). Pollinators also play an essential role in combating soil degradation by increasing the recycling cycle, i.e. more pollination, more seeds, more plants, and more biomass returns to the soil (Ansari *et al*., 2014). This in turn leads to decreased land erosion, and flooding, while increasing favourable environments for sustainable living that provide habitat and food for a wide range of invertebrate and vertebrate species (Kremen, 2005; Thakur, 2012).

Economic value is another asset of pollinators (Bauer and Sue Wing, 2016). Animal-driven plant pollination has a significant global economic impact (Pan *et al*., 2018). Between USD 235-577 billion worth of annual global food production relies on the direct contributions of pollinators (Pan *et al*., 2018). Pollinators also generate other products of great commercial value, i.e. honey, pollen, propolis, royal jelly, venom and wax.

Beekeeping activities contribute to rural development, supporting agricultural production, providing honey and facilitate the sustainability of rural areas (Garibaldi *et al*., 2011; Lautenbach *et al*., 2012). Threats to pollinators in general (Obermeister, 2019), and honey bees in particular (Tokarev *et al*., 2018), include changes in land use, climate change, pesticides, genetically modified crops, poor pollinator management, pests and pathogens, and invasive alien species (IPBES, 2016; Marrero *et al*., 2016; Kovács-Hostyánszki *et al*., 2017; Senapathi *et al*., 2017; Obermeister, 2019). The negative impact of the decline of pollinators in developing countries can be seen in the reduction in yield of honey and other bee associated products (Delaplane, 2011; Aslan *et al*., 2016), which translates in nutritional and economic losses (Kevan and Phillips, 2010), and an increase in the vulnerability of honey bee pollination services (Aizen and Harder, 2009; Jordan *et al*., 2021).

The agricultural sector in Albania and Kosovo, plays a significant role in food production, biodiversity management, rural economy, and the local conservation of species (Kerolli-Mustafa and Gjokaj, 2016; Oda *et al*., 2018; Sharku *et al*., 2018). Both countries have favourable ecological and climatic conditions for the growth of a rich flora (Nuri, 1965; Bajraktari *et al*., 2020), which supports pollinators and translates into food security locally, and comprises a significant part of exported goods in the open-market economy. However, there is a lack of knowledge about pollination services in the agricultural sector of both countries. The main pollinator species in Albania are the commercial honey bee *A. mellifera*, as well as *Bombus terrestris* L., *Bombus pendulus* (Latreille), and *Anthidium manicatum* L. (Kuliçi, 2017). The native subspecies of *A. mellifera* in Albania is *Apis mellifera carnica* Pollmann (Nuri, 1965; Thomo *et al*., 2002; Kuliçi *et al*., 2014). According to Mladenović and Simeonova (2014), the autochthonous subspecies which is bred in the north Kosovo area, is *A. mellifera carnica*. There is a lack of published data regarding the presence of other subspecies of *A. mellifera* and other pollinating species in Kosovo.

The seasonal and/or year-round decline of *A. mellifera* colonies has been reported from most regions of the globe (Bauer and Sue Wing, 2010; Potts *et al*., 2010; Moritz and Erler, 2016; Althaus *et al*., 2021; Wagner *et al*., 2021). This decline has also been observed in Albania and Kosovo. Although limited published data is available on mortality in both countries, losses are regularly reported by beekeepers. This is the first study conducted in both countries that aims to assess the major factors threatening honey bees as perceived by beekeepers.

According to the Albanian Beekeepers Federation, during the winter of 2020-2021, approximately 26% of the total bee colonies in Albania were lost (unpublished data), while as per the 2022 report, Kosovo lost 16.6% of its colonies (Republic of Kosovo, 2022). The decline of honey bees constitutes a threat to food security for most countries and it is often linked to intensive human action in the environment, or management strategies of both crops and domesticated animals, including honey bees. Examples of these detrimental activities range from sublethal impacts of chemicals used in agriculture, pest and pathogen resistance to antibiotics and heavy-metal pollution (Biesmeijer *et al*., 2006; Klein *et al*., 2007; Potts *et al*., 2010; Dicks *et al*., 2021; Traynor *et al*., 2021). This study aims to assess what beekeepers in Albania and Kosovo perceive to be the current threats and drivers of change for managed colonies in their respective countries and the degree of importance they associate to each factor.

The investigative questionnaire tool used aims to investigate the perceptions of beekeepers with respect to: 1) current health status of managed honey bee populations of *A. mellifera*; and 2) factors that may have led to the loss of managed pollinators. This study aims to gather information that may inform policymakers, beekeepers, farmers, and other stakeholders of the threats to managed honey bees. These in turn can assist in the drafting of informed and judicious decisions to stem the decline of honey bees and stimulate the development of the beekeeping sector in Albania and Kosovo.

Materials and methods

Research instrument and data analysis

Data on honey bee colony health were collected through online questionnaires given to beekeepers with the assistance of the beekeeping associations of Albania and Kosovo. Similar questionnaires have been used in other studies to gather data regarding the perception of beekeepers on particular beekeeping topics, such as honey bee mortality rates and causes (Mazur *et al*., 2022). The research was conducted from January 2021 to February 2022. A total of two hundred beekeepers responded and completed the questionnaires. The geographic location of respondents is shown in figure 1 and the percentage listed represents the portion of the total number of beekeepers known to be present in a given region.

The aim of the research and the questionnaire was to determine the perception of beekeepers regarding the reasons for their operational losses and was composed of three sections that assessed the following: 1) demographic characteristics of the beekeepers, such as age, gender, education, beekeeping experience in years and location of operation (table 1); 2) data on the number of hives, honey production, current losses and their economic impact (table 1); 3) perceived colony health status; factors that may have led to winter losses; and the rank of each factor *vis-a-vis* the observed losses (table 2). Specifically, key factors previously identified by Kuliçi (2017) were assessed: a) parasites and pathogens; b) beekeeping practices, and c) agriculture practices.

We assessed the perception of beekeepers with regards to possible negative factors that could impact the productivity of their operation. The impact of parasites and pathogens was explored using an adaptation of the Likert Scale (Albaum, 1997) in the framework of the Q-methodology (Kahane *et al*., 2022). Q-methodology is a research method used in social sciences to study people's viewpoints. The latter is used to investigate the perception of participants on issues by having participants rank and sort a series of statements (Brewer-Deluce *et al*., 2020) (i.e. *How much did the following parasites and pathogens have affected the number of bees and honey production, Likert scale: 1 no impact* to *5 very high impact*). Six key parasites and pathogens that affect the beekeeping industry in most parts of the globe (table 2), as well as the predators *Merops apiaster* L. and *Vespula germanica* F., were included in the questionnaires, in addition to information as to their influence on bee losses.

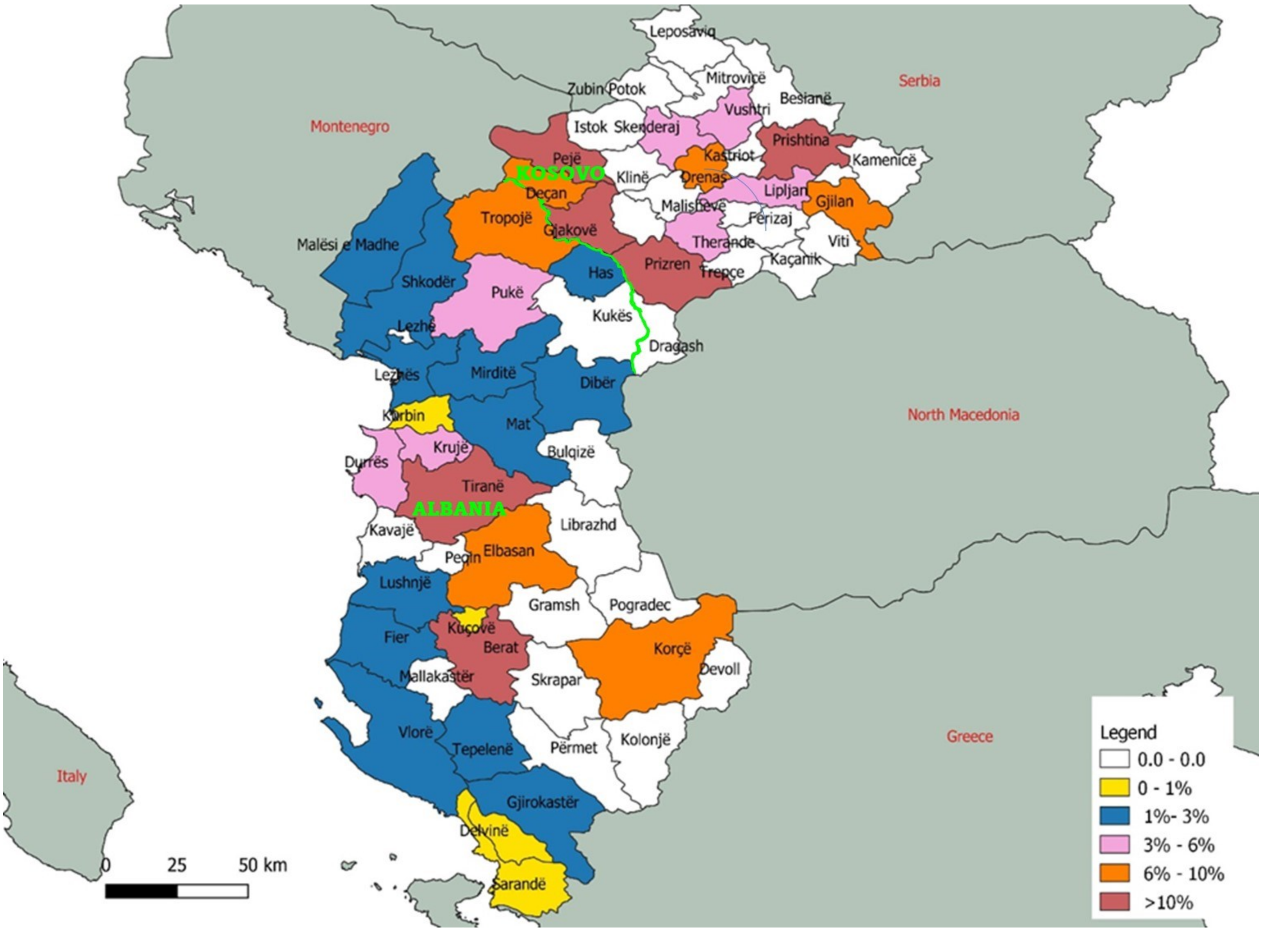

Figure 1. Map of Albania and Kosovo showing the regions where beekeepers that responded to the questionnaire used in this study were located. Percentages indicate the number of respondents, as a portion of the total number of beekeepers known to be present in a given region. Green colour line indicates the border between Kosovo and Albania.

Table 1. Socio-demographic parameters of questionnaire responders.

	Category	Albania %	Kosovo %
Age (average = 38.5)	18-24 years old	6.2	5.8
	25-34 years old	26.7	17.3
	35-44 years old	17.1	28.8
	45-54 years old	30.1	34.6
	More than 55 years old	19.9	13.5
Gender	Male	89	88.5
	Female	11	11.5
Education	Basic to middle school	2.1	1.9
	High school	37.9	34.6
	Higher education, university	60	63.5
Beekeeping Experience	0-5 years	36.3	51.9
	6-10 years	16.4	19.2
	11-20year	17.1	11.5
	Over 20 years	30.1	17.3
Number of hives	1-10	16.4	21.2
	11-20	17.1	15.4
	21-50	30.1	30.8
	Over 50	36.3	32.7
Bee losses in winter 2022	5-20%	58.2	78.8
	21-40%	19.2	9.6
	41-60%	18.5	5.8
	Over 60%	4.1	5.8
Honey produced/hive (kg)		15	15

Table 2. Threatening factors and their evaluation by beekeepers. Perceived impact level (PI): 1 = no impact, 5 = high impact.

	Albania (N = 150)		Kosovo (N = 50)	
	Mean PI value	Standard deviation	Mean PI value	Standard deviation
a) How much do you think the following pathogens and predators have influenced this winter losses?				
1. *Varroa destructor*	3.4	1.4	2.3	1.2
2. *Nosema ceranae*	2.9	1.5	1.9	1.5
3. *Nosema apis*	2.5	1.4	1.8	1.4
4. *Ascosphaera apis*	2	1.2	1.7	1.2
5. *Paenibacillus larvae*	1.8	1.2	1.6	1.2
6. Viruses	2	1.3	1.8	1.3
7. Predators	2.1	1	2	1
Total mean	2.3		1.8	
b) How much do you think beekeeping practices have influenced this winter losses?				
1. Migratory beekeeping	2.2	1.4	1.7	1.3
2. Gene exchanges with neighbouring border countries	3	1.5	2.1	1.5
3. Import of foreign queens (breeds)	3.2	1.3	2.2	1.3
4. Failure to perform timely maintenance of the hives	3.2	1.3	2.4	1.1
5. Failure to perform correct management practices	3.2	1.3	2.5	1.3
Total mean	2.9		2.1	
c) How much do you think these agricultural practices and climate change have influenced this winter losses?				
1. Chemicals applied to beekeeping intended to control parasites or pests of the colony (antibiotics)	3	1.5	2.1	1.5
2. Agricultural chemicals (pesticides)	3.2	1.5	2.3	1.5
3. The rapid expansion of urban areas	2.6	1.5	2.2	1.5
4. Habitat fragmentation	2.6	1.4	1.9	1.4
5. Intensification of agriculture land-use	2.6	1.5	2	1.5
6. Climate change	3.5	1.4	2.6	1.5
Total mean	2.9		2.1	

An evaluation of beekeepers' perceptions of the influence of beekeeping practices on honey bee losses was also included in the questionnaire. The practices listed were: 1) migratory beekeeping, 2) gene exchange with neighbouring countries, 3) import of foreign queens (hybrid queens and queens that do not belong to the subspecies *A. mellifera carnica*), 4) failure to perform technical maintenance of hives and 5) failure to perform correct management practices (table 2). Agricultural practices and their influence on bee losses were also part of the questionnaires. These practices include: 1) use of chemicals applied as part of beekeeping and agricultural practices (i.e. the use of antibiotics and pesticides especially acaricides), 2) landscape and urbanization, 3) habitat fragmentation, and 4) land-use intensification. The questionnaire also assessed the degree to which beekeepers consider climate change as an important threat to honey bee health and the profitability of their operations (table 2).

Data analysis

The descriptive analysis in this study analyses the central tendency and measure of the dispersion of the data. It aims to quantify the spread or variability of the data linked to beekeepers' perceptions and was conducted on data from Albania and Kosovo.

We also conducted a T-test to compare perceptions of beekeepers regarding the three test categories affecting possible losses in bee colonies: 1) parasites and pathogens, 2) agricultural practices and climate change, and 3) beekeeping practices. In addition, a one-way ANOVA was run using the demographic and beekeepers' perception data to test for an association between demographic status and perception type. However, given the low number of beekeeper respondents from Kosovo (N = 50), only the descriptive analysis was conducted on this data set. The remaining analysis (T-test and ANOVA) was only conducted on the data collected from the 150 Albanian respondents.

Results and discussion

An overview of the beekeeper demographics and their operations profile from Albania and Kosovo can be found in table 1. Beekeepers who participated in the survey were between 18 to 75 years old. Circa 90% of respondents in both countries were male, and approximately 60% had completed a university degree. Circa half of the sampled beekeepers in Kosovo had only up to five years of experience, while 30% of Albanian beekeepers had over 20 years of beekeeping experience. This result is a consequence and reflection of the longstanding tradition of beekeeping in Albania and of the traditional use of honey in the diet. The majority of beekeeping operations in both countries have between 20 to 50 hives; this similarity is reflected in the similar production levels between the two countries of 15 kg of honey per hive. Beekeepers in both countries faced significant bee colony losses during the winter of 2021-2022, when this study was conducted (table 1). However, in Albania losses ranged from 21-40% and 41-60%, and were three times higher than those in Kosovo where the beekeepers reported 5 to 20% losses (table 1). This pattern of loss was seen for medium and small beekeepers as well as beekeepers with more than 100 colonies. Understanding the underlying reasons for these losses was one of the motivations for conducting this study. However, losses may not always be reported accurately because some districts' Beekeeping Associations reported higher losses than those reported by small independent beekeepers. This discrepancy may result from some beekeepers' beliefs that releasing this information may damage their reputation (i.e. prejudice about their work as unprofessional).

Our data indicates that the average annual honey production per hive in both countries was 15 kg (table 1) except for 2020, when Kosovo reported a value of only 3 kg (788 tons from 262,541 beehives compared to 2,198 tons in 2019) (DEAAS, 2021; MAFRD, 2021). This decrease has been attributed to unfavourable atmospheric conditions that occurred in 2020, which negatively affected production. The value listed above are the average production values for both countries. However, the potential for production, based on the favourable geographical and climatic conditions and the presence of various naturally occurring melliferous plants, i.e. preferential plants for *A. mellifera* (Paparisto and Balza, 2003; Kuliçi and Kola, 2013), for both countries is much higher.

Hive losses were reported by beekeepers from both Albania and Kosovo (table 1). Beekeepers indicated that, to various degrees, all the threatening factors listed in the questionnaire, chemicals applied during beekeeping management practices and agricultural practices, gene exchanges with border countries, improper beekeeping, as well as indirect impacts that arise from changes in land-use, inadequate management of ecosystem services, and climate change (table 2), may have affected the losses of colonies, especially current winter losses.

Assessment and comparison of threatening factors

Assessment and comparison of the three factors perceived by beekeepers to cause honey bee decline in Albania and Kosovo: parasites and pathogens; beekeeping practices; agricultural practices and climate change.

Parasites and pathogens

Mortality due to parasites and pathogens was not given a high ranking by Albanian beekeepers. The reported perceived impact (PI) of this factor was PI 2.3 (from an increasing range of 1 to 5 PI points (table 2). Similarly, beekeepers from Kosovo did not perceive parasites and pathogens as a high-impact factor (mean PI 1.8). The parasite with the highest PI (3.4 Albania, 2.3 Kosovo) was considered to be the mite *Varroa destructor* Anderson et Trueman, which is also the most notable threat to beekeeping worldwide. During 2016-2017 the presence of *Varroa* was reported by 91.8% of apiaries (Kuliçi, 2017). Not all beekeepers took this problem seriously when it was first noted, hence colonies were not treated promptly and efficiently, which may have led to significant losses for some apiaries.

Nosema ceranae (Fries *et al.*), recently reassigned to *Vairimorpha* (*Nosema*) *ceranae* (Microsporidia Nosematidae) (Tokarev *et al*., 2020) is an emergent and ubiquitous invasive fungal parasite that threatens bee populations worldwide. This disease is difficult to detect as it requires molecular tools for confirmation, as it is often present in both healthy and diseases colonies and thus often undetectable by visual observation (Martín-Hernández *et al*., 2018). Results from our study show that the mean perceived impact for this factor was PI 2.9 for Albania and PI 1.9 for Kosovo. This result may be influenced by the inability to readily detect this pathogen and a lack of general knowledge regarding its presence. *Nosema* species occur continuously throughout the year, as it is not affected by seasons, thus facilitating reinfection. *N. ceranae* ranks among the possible causes of the depopulation of colonies as the death of individual honey bees takes place away from the hives resulting in the beekeeper not noticing their loss until the hive is extinct. In both countries, beekeepers did not consider other fungal, bacterial and viral pathogens as a factor with high impact (table 2).

Beekeeping practices

Beekeeping practices were considered to have more of an impact than parasites and pathogens by beekeepers of both countries (PI 2.9 Albania, PI 2.1 Kosovo). In the last 20 years, the Albanian honey bee has been threatened by many activities and one of them is the importation of foreign queens from neighbouring countries. In the Caucasus and European region 15 subspecies of *A. mellifera* have been reported with established populations (Fontana *et al*., 2018). However, given the routine replacement of queens of different origin, and no restriction to the movement of queen honey bees in Europe (EU, 2020), it is likely that more subspecies can be present in these regions and are being moved via queen breeding or drone dispersal. The current number of accepted subspecies of *A. mellifera* worldwide is thirty-one (Ruttner, 1988; Meixner *et al*., 2013). There exists breeding data for many subspecies of honey bees in Albania, such as *A. mellifera carnica*, *Apis mellifera ligustica* Spinola, *Apis mellifera siciliana* Dalla Torre, *Apis mellifera cecropia* Kiesenwetter, *Apis mellifera caucasica* Pollmann, *Apis mellifera macedonica* Ruttner, *Apis mellifera mellifera* L., *Apis mellifera scutellata* Lepeletier, *Apis mellifera monticola* Smith and *Apis mellifera armeniaca* Skorikov, as well as hybrid races of several breeds known as Buckfast bees (unpublished data from authors and from the Albanian Beekeepers Federation and Beekeeping associations). These imports may have introduced new pathogens as well as impacted the native populations of honey bees in Albania.

According to Mladenović and Simeonova (2014) honey bee breeding in Kosovo is based on rearing *A. mellifera carnica* and there are no published data for the breeding of other subspecies.

Albanian beekeepers ranked the impact of gene exchange resulting from the importation of honey bees from neighbouring countries higher than their counterparts in Kosovo (PI 3.0 Albania, PI 2.1 Kosovo). Detailed data on honey bee breeding strategies in Kosovo are not available thus it is difficult to make direct comparisons between the two countries.

Failure to perform maintenance practices in an effective and timely manner was ranked at PI 3.2 by beekeepers in Albania and PI 2.4 and PI 2.5 for each parameter by beekeepers in Kosovo. Beekeepers in these regions do not receive assistance for efficient treatments and this in turn may have affected losses during the winter of 2022.

The impact of migratory beekeeping on colony losses was ranked by beekeepers in Albania and Kosovo as PI 2.2 and PI 1.7, respectively. The evaluation of this factor as a low-impact parameter related to colony losses may result from incomplete information about this beekeeping practice. Migratory honey bee colonies that are intentionally moved by beekeepers toward monofloral pastures, to improve the health of colonies or to avoid adverse climatic conditions, can affect colonies depending on method of transport. In addition, the movements and exchange of local honey bees between beekeepers can facilitate exchange and contact with other pathogens or new pests.

Agricultural practices and climate change

Multiple chemicals, aimed at controlling pathogens (i.e. antibiotics), are applied in beekeeping management practices. Large disparities in legislation occur, ranging from substances that are prohibited in the European Union (EEC, 1990) to those that are indicated for veterinary use in the USA and most of South America (Maggi *et al*., 2016; Cilia, 2019). The use of such products commonly results in adverse negative effects for the health of honey bees (Tosi *et al*., 2022). In Albania and Kosovo, the use of a limited number of antibiotics at low levels has been permitted for many years mainly for the purpose of pests control. However, this has been only allowed under veterinary control and supervision. During 2022-2023 the use of all antibiotics in Albania was prohibited in accordance with EEC (1990) and the recently approved "Law on Beekeeping in Albania", while in Kosovo their use is not regulated. According to the beekeepers' evaluation in Albania, the risk to honey bee health from chemical use has PI 3 while Kosovo beekeepers rate it as PI 2.1. Kuliçi (2017) showed that bees in the areas tested can collect chemicals from various sources in the surrounding environment (nectar, water, stolen honey from treated colonies, etc.). The use of chemical products may result in the presence of undesirable chemical residues in their bee products (Al-Waili *et al*., 2012), which can adversely alter the behaviour, productivity and longevity of honey bees (Bargańska *et al.*, 2011) in addition to leading to pesticide resistance of the targeted pests.

The intensification of agriculture has led to the extensive use of agricultural chemicals to which honey bees are directly or indirectly exposed, e.g. herbicides, fungicides, and insecticides (Mullin *et al.*, 2010; Van der Steen *et al*., 2011; Doublet *et al.,* 2015; Traynor *et al.*, 2021). Honey bees are threatened and harmed by uncontrolled and inaccurate use of these chemicals (e.g. loads and cycles of application). Agricultural chemical use (pesticides) is of medium level concern to beekeepers in Albania (PI 3.2). However, this value is higher than the level of impact perceived by Kosovo beekeepers (PI 2.3). Neonicotinoids are widely used in Albania. Some of them may have caused sublethal harmful effects on pollinators as they can accumulate in nectar and plant pollen. Using pesticides damages human health because crops and honey bee products become contaminated with agrochemicals that humans eventually ingest. Beekeepers of Albania and Kosovo would benefit from training and information regarding the potential negative impact of pesticides coupled with guidelines delineating their safe application to mitigate health risks to honey bees and humans.

The rank given to the rapid expansion of urban areas (PI 2.6 Albania, PI 2.2 Kosovo), habitat fragmentation (PI 2.6 Albania, PI 1.9 Kosovo), and increasing intensification of agriculture (PI 2.6 Albania, PI 2 Kosovo), indicate that they are not perceived as significant threats by beekeepers in both countries but to have only a moderate impact on the reduction of honey bee colonies.

Beekeepers ranked climate change as the highest impact parameter affecting colony losses (PI 3.5 Albania, PI 2.6 Kosovo). While climate change may have accelerated pest life-cycles, the emergence of new invasive species and changes in temperature and rainfall, it is difficult for beekeepers to establish a direct causal effect between the consequences of climate change and colony losses. Moreover, it cannot be excluded that beekeepers ranked this factor as high impact due to the recent frequent mention of climate change as a problem affecting various aspects of human life by various news outlets and information from beekeepers' associations.

Results from our data show that beekeepers in Albania and Kosovo considered beekeeping practices, agricultural practices and climate change to have a greater impact (PI 2.9 Albania, PI 2.1 Kosovo) on honey bee losses than parasites and pathogens (PI 2.3 Albania, PI 1.8 Kosovo).

The analysis of the influence of beekeeper demographics indicates that beekeepers aged 44-55 and 55+ years show a higher inclination than other age groups to regard the effect of *N. ceranae*, *Nosema apis*, *Ascosphaera apis*, *Paenibacillus larvae* and viruses as having a higher impact on losses.

Members of this age group also ranked the other factors, especially antibiotics, habitat fragmentation, and intensification of agriculture land use and climate change, higher than members of the other four groups (table 3, post hoc analysis not shown).

Beekeepers experience influenced their perception of the impact of parasites in five out of seven factors (table 3). Those with 11 to 20 years of experience show the highest rank scores. Higher losses are associated with higher rank scores in all the factors influencing winter bee losses (table 3, post hoc analysis not shown). Reported losses are statistically different among age groups of the beekeepers ($F = 4.665$; $P = 0.004$), education level, ($F = 4.273$; $P = 0.006$) and years of experience ($F = 4.670$; $P = 0.004$; post hoc analysis not shown). Contradictory results are shown; older beekeepers with higher experience and a high school education reported the highest losses. If the rankings are a true reflection of actual losses, these results might indicate that there is a need for older beekeepers to embrace new innovative beekeeping practices that may assist in limiting losses.

Table 3. ANOVA to test the influence of beekeepers demographics on the three major factors linked to winter losses.

Group of factors influencing winter losses	Age		Education		Experience		Losses %	
	F	P	F	P	F	P	F	P
Parasites, pathogens and predators influencing winter losses								
1. *Varroa destructor*	1.915	0.111	2.14	0.121	2.207	0.09	16.373	0.001
2. *Nosema ceranae*	2.236	0.068	2.378	0.096	4.588	0.004	14.751	0.001
3. *Nosema apis*	2.062	0.089	1.359	0.26	5.921	0.001	16.007	0.001
4. *Ascosphaera apis*	4.327	0.002	3.885	0.023	5.093	0.002	12.318	0.001
5. *Paenibacillus larvae*	3.216	0.015	2.323	0.102	1.809	0.148	14.757	0.001
6. Viruses	3.115	0.017	1.726	0.182	3.928	0.01	8.159	0.001
7. Predators	0.529	0.715	4.014	0.02	0.903	0.442	6.323	0.001
Beekeeping practices								
1. Migratory beekeeping	0.768	0.548	0.442	0.644	0.636	0.593	6.427	0.001
2. Gene exchanges with border countries	2.577	0.04	0.815	0.445	3.035	0.031	18.624	0.001
3. Import of foreign queens (breeds)	1.53	0.197	3.412	0.036	2.406	0.07	15.877	0.001
4. Lack of timely hive maintenance	1.236	0.298	0.414	0.662	1.182	0.319	9.036	0.001
5. Lack of correct management practices	0.989	0.416	0.279	0.757	1.265	0.289	9.036	0.001
Agricultural practices and climate change								
1. Antibiotics	2.674	0.034	2.392	0.095	2.459	0.065	15.809	0.001
2. Pesticides	1.647	0.166	2.825	0.063	0.726	0.538	21.618	0.001
3. Rapid expansion of urban areas	1.754	0.141	0.275	0.76	1.13	0.339	13.425	0.001
4. Habitat fragmentation	2.018	0.095	0.565	0.57	1.329	0.268	16.502	0.001
5. Intensification of agriculture land-use	2.273	0.064	1.244	0.291	0.759	0.519	15.14	0.001
6. Climate change	3.618	0.008	2.267	0.107	1.847	0.141	12.097	0.001

Pair comparisons were made for each category within each group of factors influencing winter losses (table 4). For group A (parasites, pathogens and predators, table 4) *V. destructor* had the highest score. For group B (agricultural practice and climate change, table 4) pesticides used in agriculture shows a higher score than antibiotics. While antibiotics show the highest score compared to the remaining factors in this category. For group C (beekeeping practices, table 4) the highest score was failure to perform maintenance with the lowest being migratory beekeeping. A pair wise comparison between the three major categories listed in table 4 shows that the pest *V. destructor* was a higher concern with respect to all categories with the exception of climate change (table 5).

This study has outlined the demographic and preference profiles of beekeepers in Albania and Kosovo. This information can be of utility to policy-makers and bee associations to design training programs and other educational initiatives to improve production and safety for beekeepers and their products and increase the income of beekeepers.

Table 4. Comparison between: A) Parasites, pathogens and predators influencing winter losses; B) Agricultural practices and climate change; C) Beekeeping practices, using a t-test.

	Mean differences	Standard deviation	t	P
A) Parasites, pathogens and predators influencing winter losses				
*Varroa destructo*r - *Nosema ceranae*	0.473	1.097	5.207	0.001
Varroa destructor - Nosema apis	0.884	1.251	8.532	0.001
Varroa destructor - Ascosphaera apis	1.363	1.225	13.439	0.001
Varroa destructor - Paenibacillus larvae	1.562	1.248	15.116	0.001
Varroa destructor - Viruses	1.26	1.35	11.283	0.001
Varroa destructor - Predators	1.315	1.247	12.742	0.001
B) Agricultural practices and climate change				
Antibiotics - Pesticides	−0.205	1.191	−2.084	0.039
Antibiotics - Rapid expansion of urban areas	0.253	1.317	2.325	0.021
Antibiotics - Rapid expansion of urban areas	0.432	1.423	3.663	0.001
Antibiotics - Habitat fragmentation	0.486	1.335	4.401	0.001
Antibiotics - Intensification of agricultural land-use	0.397	1.294	3.708	0.001
C) Beekeeping practices				
Gene exchanges with border countries	−0.705	1.649	−5.169	0.001
Import of foreign queens (breeds)	−1.021	1.72	−7.17	0.001
Lack of timely maintenance of the hives	−1.034	1.464	−8.535	0.001
Lack of correct management practices	−1	1.424	−8.486	0.001

Table 5. Pair comparison between beekeeping practices using a t-test.

	Mean difference	Standard deviation	t	P
Varroa destructor - antibiotics	0.329	1.193	3.331	0.001
Varroa destructor - climate change	−0.164	1.175	−1.691	0.093
Varroa destructor - migratory beekeeping	1.212	1.598	9.165	0
Varroa destructor - import of foreign queens	0.192	1.366	1.696	0.092
Varroa destructor - lack of correct management practices	0.212	1.293	1.984	0.049

Conclusions and recommendation

Although significant seasonal losses have occurred in some regions, the long-term trend of beekeeping in Balkan Countries, specifically Albania and Kosovo, is that of growth, indicating a significant development of beekeeping in these regions. Albanian beekeeping accounts for over 6,500 apiaries with about 288,000 bee colonies (INSTAT, 2020). While in Kosovo, beekeeping in 2020 accounted for 262,541 bee colonies, an increase of 19.4% (DEAAS, 2021; MAFRD, 2021) from the previous year.

Our study, based on the self-assessment of beekeepers, indicates that the main factors that may have caused losses in the year 2021-2022 are: a) climate change, b) parasites and pathogens, and c) beekeeping and agricultural practices. The top causes linked to colony losses as perceived and reported by beekeepers in Albania and Kosovo were: climate change (PI 3.5 Albania, PI 2.6 Kosovo), *V. destructor* (PI 3.4 Albania, PI 2.3 Kosovo), failure to perform correct management practices (PI 3.2 Albania, PI 2.5 Kosovo) and agricultural chemicals (PI 3.2 Albania, PI 2.3 Kosovo). The mean derived from beekeepers perceptions for all considered potential threats to beekeeping and honey bees (1 = no impact, 5 = very high impact) is below three for Albania and around two for Kosovo. An interesting result is that climate change has the highest mean among all the considered threatening factors. Studies that explore the impact of climate change on beekeeping operations in Albania and Kosovo could provide information that could assist beekeepers in confronting and mitigating potential future losses. Climate change awareness is essential in addressing bee losses and mitigating the impacts of climate change on bee populations. Participation in the association of the Beekeepers of Albania is an essential key factor in raising the awareness of beekeepers. Awareness of climate change is gaining momentum in Albania even if environmental protection is not yet a top priority (Kokthi *et al.*, 2021a; 2021b). Participation in the association can play a role in increasing the awareness of beekeepers to climate change and its effects on bee losses in the short and long term.

The results from this study indicate that, in the beekeeper community of Albania and Kosovo, there is a need for the dissemination of information and training related to colony diseases and proper maintenance. Beekeeping is a popular and growing occupation in urban and rural areas of both countries, such an educational intervention would be of benefit to the beekeeping industry of both countries and the environment.

Control of pesticide use, adoption of technologies that reduce the spread of pesticides, and access to educational opportunities that inform farmers about pesticide risk assessment and other practices that reduce pollinators' exposure to pesticides are some of the directions that can be pursued to reduce the negative impact of agricultural practices. Similarly, landscape interventions that create refuge fields for a variety of nectar and/or pollen plants with different blooming periods, and encouraging farmers to plant melliferous plantations, managing crops with different flowering periods would further support pollinators. Additionally, encouraging municipalities to plant melliferous plants in cities and along roads to create biodiversity corridors would further support pollinators. The implementation of controls regarding the exchange of managed pollinator subspecies (mainly queens) also would limit the spread of pathogens and pests.

Educational and training activities would serve to create a more robust beekeeping industry by increasing the profitability of beekeeping in Albania and Kosovo and the awareness of beekeepers and the general population regarding the importance of honey bees to food security and ecosystem stability. This increased awareness and success would likely encourage the entry of new and young beekeepers into the profession and contribute towards the long-term sustainability of agricultural systems in Albania and Kosovo in specific and the Balkans in general. Moreover, it would be helpful if a formal communication network was instituted to facilitate interactions and the dissemination of information between beekeepers and agricultural institutes. Such information would allow beekeepers to acquire the necessary information to make informed decisions that could lead to safer and more sustainable and productive beekeeping operations.

To design a well-targeted education program, it is important to understand the demographics typology. In the present study, we show minimal participation of women even though they actively participate in beekeeping practices. Beekeeping is not inherently tied to gender, and both men and women engage in beekeeping (Mburu *et al.*, 2017). Recognising and supporting the role of women in beekeeping is crucial for sustainable beekeeping practices, environmental conservation, and inclusive economic development.

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