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Honey-bee Colony Losses in Bulgaria: A Case Study during the Period 2017–2019

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Abstract: The study presents the regional differences in the loss rate of honey bee colonies in Bulgaria during the period 2017–2019. The survey was conducted among members of the National Bee Breeding Association, owners of 68 apiaries (more than 7,300 bee colonies). Data on the rate of colony losses and the reported reasons for the mortality of honey bees collected using a standardised in 2017 COLOSS questionnaire by beekeepers from 16 administrative and four geographic regions in Bulgaria were analysed. Additionally, a supplementary questionnaire was used to collect information regarding different forage sources in the studied regions and pesticides used in agriculture that caused acute mortality of honey bee colonies in some of the regions. The loss rate of bee colonies due to unsolvable queen problems, natural disaster or other reasons for mortality has been calculated. Totally, about 2 to 5% of the honey bee colonies included in the survey were lost during the period 2017–2019. Various types of forage sources include the presence of orchards, oilseed rape, maize, sunflower, heather and autumn forage crops, most of which have been treated with different pesticides, including some neonicotinoid agrochemicals.

Key words: *Apis mellifera*, mortality, forage sources, pesticides

Introduction

Honey bees are the main pollinators of plants in nature, as well as of agricultural crops. Due to their valuable biological and economic quality, they are widespread in all continents of the world (except Antarctica); currently, 27 subspecies are described for the species *Apis mellifera*, ten of which are native to Europe (Meixner et al. 2013). At present, the populations of local honey bees are under excessive pressure from genetic contamination as a result of the intense transfer of foreign bees throughout Europe.

The subspecies *A. m. macedonica*, with its local ecotype „*rodopica*", is spread in Bulgaria (Uzunov et al. 2014, Ivanova 2018). The Bulgarian honey bee (*A. m. macedonica*, ecotype *rodopica*) is well adapted to the local conditions and sufficiently productive. It is characterised by high queen fertility, high honey productivity, good winter resistance, high level of gentleness (low aggressiveness) and good hygienic behaviour (Ivanova & Petrov 2010, Ivanova 2018). As part of the gene pool of *Apis mellifera* in Europe and because of its valuable qualities, the local Bulgarian honey bee must be preserved and its conservation and selection should be carried out using a scientifically-based program. Currently, such a breeding program, whose main purpose is to preserve the local Bulgarian honey bee, is being im-

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plemented by the National Bee Breeding Association (Petrov & Ganev 2013).

At present, there are about 783,348 honey bee colonies in Bulgaria and 17,260 registered beekeepers. Nearly 13,500 of the colonies are under the supervision of the National Bee Breeding Association, which supervises the selective work of queen-rearing farms of the local Bulgarian honey bee. The structure of the sector shows that beekeeping in the country is still extensive and scattered. The average number of honey bee colonies per apiary has increased from 57.0 for 2017 to 63.9 for 2018 (Agrostatistics 2019).

In 2002, about 30% of the Central European bee colonies died. In 2007, relatively largest losses of honey bee colonies in the United States were reported. In the period 2008–2016, annual European conferences reported between 8–10% to 35% losses of bee colonies in all European countries.

The phenomenon known now as the Colony Collapse Disorder (CCD) drew the attention of scientists from Europe and the world, uniting them around the idea to oppose the scientific knowledge to the CCD phenomenon affecting bees worldwide, not only as producers of honey and valuable bee products but also as the main pollinators in nature.

Since 2008, the international COLOSS organisation (founded on the basis of the European COST Action FA0803 *Prevention of COlony LOSSes*), has been bringing together researchers of *Apis mellifera* from Europe and the world. Currently, the COLOSS association (http://coloss.org) is an international non-profit association based in Bern, Switzerland, that is focused on improving the well-being of bees at the global level.

The genetic richness that is at the root of biodiversity among honeybee populations in Europe is threatened by: the uncontrolled introduction of genes from other races into the adapted local populations; the stress from the changing environment and its pollution; the occurrence of new pathogens and global climate changes. *Varroa* (38%), problems with the queen (loss, drone layer, etc., 17%) and *Nosema* (8%) have been mentioned as main reasons for losses in Europe. Reasons as starvation, robbing, unspecified winter loss, other diseases and unknown reason were less frequent but together accounted for 37% of the losses (Meixner et al. 2015).

In our previous study (Ivanova & Petrov 2010) based on the data collected from interviewed beekeepers, among the possible causes of losses of bee colonies in Bulgaria during the period 2006–2009 were: *Varroa destructor*; insufficient winter food; untypical spring development of colonies due to continuous dry weather and high temperatures; lack of nectar secretion and expansion of the area grown of oilseed rape, which might be detrimental for the health of colonies owing to the used pesticides. Crop protection and disinfection activities were also reported in some regions as reasons for death or weakness of honey bee colonies due to poisoning (Ivanova & Petrov 2010). It was concluded that even though the overall losses of honey bee colonies in Bulgaria during the period 2006–2009 were low (5–10%), the fundamental reasons for the regional differences in losses need to be studied and considered in more detail.

The negative impact of various pesticides on the viability of honey bees is increasingly being discussed as one of the leading causes of bee loss in Europe and in Bulgaria (Tomizawa & Casida 2003, Elbert et al. 2008, Harper et al. 2009, Gervais et al. 2010, Migdal et al. 2018, Ivanova 2018, Hayasaka et al. 2019). Neonicotinoid insecticides, which are effective in controlling economically important pests, are neurotoxins that after use can be detected in nectar and pollen (Blacquiere et al. 2012). According to Hopwood et al. (2016), neonicotinoid are the most widely used group of insecticides in the world at present and their use in agriculture has increased significantly over the last ten years.

The aim of the present study is to analyse and characterise the regional differences in size of honey bee colony losses and the reasons related to them in Bulgaria during the period 2017–2019 through using of the standardised international 2017 COLOSS questionnaire.

Materials and Methods

A national survey of beekeepers, including standardised questions for comparability of responses (van der Zee et al. 2013), was conducted in Bulgaria between April and June in 2017, 2018 and 2019 as a part of the international COLOSS monitoring survey (Brodschneider et al. 2016, 2018, Gray et al. 2019). Data were collected through paper and email surveys. Beekeepers were asked for the number of colonies that had wintered and how many of these colonies after winter (A) were alive but had unsolvable queen problems (e.g. a missing queen, laying workers or a drone-egg laying queen), (B) were dead or reduced to a few hundred bees and (C) were lost through natural disaster (from various possible causes) following Gray et al. (2019). The study was carried out amongst professional beekeepers, most of them members of the National Bee Breeding Association and owners of apiaries

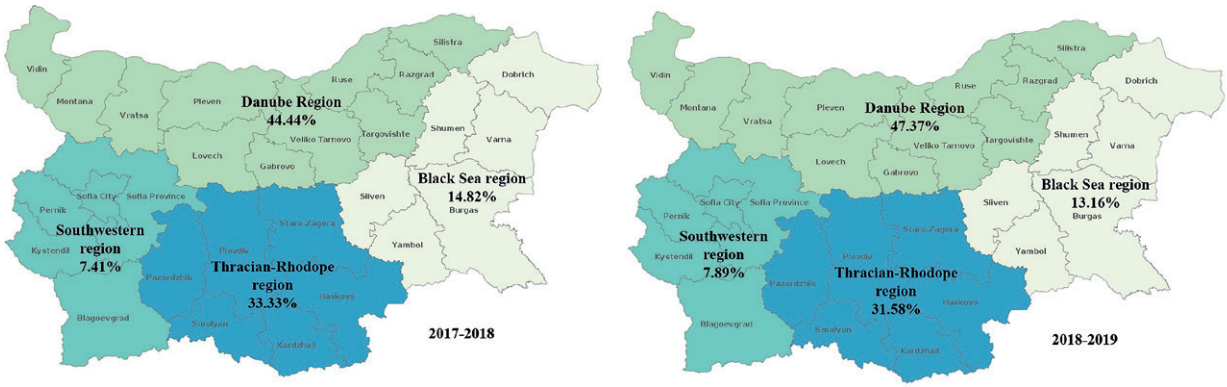

Fig. 1. Percentage of the surveyed beekeepers by region for the periods 2017/2018 and 2018/2019.

with 4,074 and 7,464 bee colonies (for the winters of 2017/2018 and 2018/2019, respectively) located all over the country. The questionnaire analysis represents 0.5–1% of colonies and 0.3–0.6% of beekeepers in Bulgaria, as well as 30% and 55% (for the 2017/2018 and 2018/2019 periods, respectively) of the National Bee Breeding Association colonies located in most geographical areas of the country. A supplementary questionnaire was used to collect information regarding the different forage sources in the regions studied and pesticides used in agriculture that have caused acute mortality of honey bee colonies in some of regions. Non-parametric methods were used for the group comparison. Differences between groups were analysed using the Pearson Chi-Square test. Data on the percentage of the surveyed beekeepers by region for 2017/2018 and 2018/2019 are presented in Fig. 1.

Results

The data on the overall percentage of bee losses for the period 2017–2019 are presented in Fig. 2. We found that up to 2.04% of the bee colonies were lost in 2017/2018, while for 2018/2019 the losses were twice and a half higher (5.22%).

Regarding the three compared criteria, i.e. (A) unsolvable queen problems (e.g. a missing queen, laying workers or a drone-egg laying queen), (B) dead or reduced to a few hundred bees and (C) lost through natural disaster (due to various possible causes), comparative data from the study indicated the following distributions: for the period 2017/2018, the total loss rate was 2.04%, of which 1.13% were related to the criterion A, 0.71% to the criterion B and c. 0.20% to the criterion C. During the period 2018/2019, the total loss rate was 5.22%, of which 1.13% were related to the criterion A, 2.88% to the criterion B and 1.22% to the criterion C. It is noteworthy that the losses associated with unsolvable queen problems for the two study periods remained unchanged (1.13%), while the losses due to death or reduction to a few hundred bees and natural disaster in the second comparison period (2018/2019) increased by four and six times, respectively, as compared to the first period. For the distribution of the three types of losses by region, see Table 1.

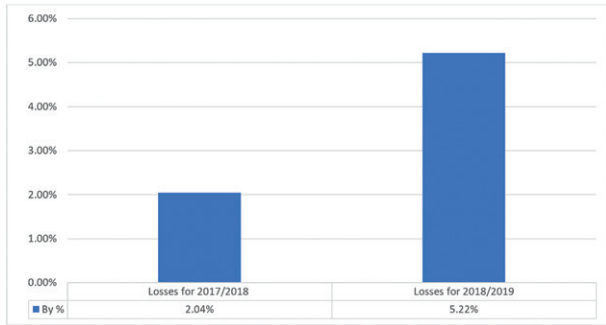

Fig. 2. Overall share of bee colony losses for the periods 2017/2018 and 2018/2019.

The analysis of the results showed that for the first compared period the highest percentage of losses due to unsolvable queen problems (2.98%) and natural disaster (0.8%) was reported for the Thracian-Rhodope Region. On the other hand, the highest percentage of losses due to honey bee colony death or drastically reducing the number of bees in the hive to a few hundred was observed for South-western Region (2.38%). In the second compared period, the most significant losses due to unsolvable queen problems was reported in the Thracian-Rhodope (2.82%) and in Black Sea (2.59%) regions, due to natural disaster – in the Thracian-Rhodope Region (3.07%) and due to death or reducing in the number of bees – in the South-western Region (13.34%) and in the Black Sea Region (6.30%; Ta-

Table 1. Distribution of bee colony losses in Bulgaria by regions according to the studied criteria: A. Unsolvable queen problems. B. Death or reduction to a few hundred bees. C. Natural disaster. Legend: * $0.1 > P \geq 0$; ** $0.5 > P > 0.1$; *** $1 \geq P > 0.5$).

Regions	Criteria		
	A	B	C
2017/2018			
2.04% total losses	1.13%	0.71%	0.20%
Black Sea Region	1.62%***	0.16%***	0%***
Danube River Region	0.25%**	0.65%***	0.10%***
Thracian-Rhodope Region	2.98%*	0.40%**	0.8%***
South-western Region	0.22%**	2.38%*	0%***
2018/2019			
5.22% total losses	1.13%	2.88%	1.22%
Black Sea Region	2.59%*	6.30%*	0.34%**
Danube River Region	0.40%***	0.35%*	0.94%**
Thracian-Rhodope Region	2.82%*	2.62%***	3.07%*
South-western Region	0%**	13.34%*	0%**

Table 2. Different types of forage sources and bee colony losses due to death or reduction to a few hundred bees in the hive by region.

Losses by region	Forage sources					
	Orchards	Oil Seed Rape	Maize	Sunflower	Heather	Autumn Forage Crops
2017/2018						
Black Sea Region – 0.16%	+	–	–	+	–	–
Danube River Region – 0.65%	+	+	+	+	–	+
Thracian-Rhodope Region – 0.4%	+	+	+	+	–	–
South-western Region – 2.38%	+	–	–	–	–	–
2018/2019						
Black Sea region – 6.3%	+	+	+	+	–	+
Danube River Region – 0.35%	+	+	+	+	–	–
Thracian-Rhodope Region – 2.62%	+	+	+	+	+	+
South-western Region – 13.34%	+	–	–	–	–	–

ble 1). Concerning bee colonies' death or the drastically reducing of their number in the hive, it is important to note that the percentage of losses in the Black Sea and South-western regions was, respectively, about two to four times higher than the previous compared period for the same regions, and the highest for the country as general.

Overall, from the analysed in the study reasons for losses of honey bee colonies in Bulgaria for the period 2017–2019, the most significant were losses due to bee and bee colony deaths, especially in 2018/2019, when beekeepers reported almost twice as large growth of losses according to the criterion B. This alarming fact was linked to the many reports of mass poisoning of bees in our country due to the widespread use of various pesticides for agricultural practices. In this regard, the present study also characterised different forage sources by region and the reported mortality of bee colonies depending on the predominant vegetation for the apiaries located in these regions (Table 2). Our results and their analysis showed that in the two compared periods the highest mortality was reported for the apiaries located close to orchards as well as for the regions with predominant sunflower arrays. The bee losses are also significant for areas with oil seed rape and maize fields. The share of bee mortality in the regions with autumn forage crops was lower and areas with heather were associated with a low percentage of bee colony losses only in the Thracian-Rhodope Region for the period 2018/2019 (Table 2). The survey data also indicated that these types of vegetation were associated with serious loss of bee colonies mainly in the South-western and Black Sea regions, where the high mortality was associated with the presence of orchards or with rape, sunflower, maize and orchards in complex. The autumn forage crops had also negative impact in the Black Sea, Danube and Thracian-Rhodope regions (Table 2).

The surveyed beekeepers indicated that they had data on specific pesticides used in particular areas, such as: the neonicotinoid insecticides *Poncho® 600 FS* (with active substance *Clothianidin*) and *CRUISER® 350FS* (with active substance *Thiamethoxam*) for the town of Ruse (Danube River Region), the organophosphorus insecticide, *BI-58®* (with active substance *Dimethoate*) for the town of Kardzhali (Thracian-Rhodope Region), the neonicotinoid insecticide *MOSTAR 20 SP* (with active substance *Acetamiprid*) for Plovdiv (Thracian-Rhodope Region).

Discussion

The results obtained in our study can be compared to the official data from the last published monitoring study of COLOSS (Gray et al. 2019), which show that, for all the countries in Europe, 4.6% (95% CI 4.5-4.7%) of colonies of the honey bee

have been lost because of queen problems, 11.0% (95% CI 10.8-11.2%) because of death after winter and 1.2% (95% CI 1.2-1.3%) due to natural disasters, giving an overall loss rate of 16.8% (95% CI 16.5-17.0%). It was reported that overall loss rate in winter 2017/2018 for Europe was the highest in Portugal (32.8%) as well as in Slovenia, Northern Ireland, England, Wales, Italy and Spain, i.e. countries mostly in Western Europe, where losses were above 25% (Gray et al. 2019). For winter 2016/2017, the highest winter loss rates were in Germany, Spain, Mexico, Malta and Serbia (Brodschneider et al. 2018). The same study noted that Bulgaria, as a new country included in this monitoring study (only professional beekeepers had provided information by completing the COLOSS questionnaire), had the lowest loss rate of 2.0%. Lower loss rates have been reported for 2017/2018 also for Belarus, Serbia, Israel, Algeria and Slovakia (10% or lower). Winter losses related to queen problems vary between 1.1% in Bulgaria to 20.3% in Slovenia but rates of loss due to these problems usually appear to be about 4 to 5% overall (Gray et al. 2019). The colony losses in Europe due to natural disaster have been very low (1.5%) and the colony mortality rate is variable for different countries, as it has been observed also in the present regional studies in Bulgaria (Table 1). The colony mortality rate is the most inconstant across countries and years. The overall loss rate in Europe varies over the years: 16.4% for 2017/2018, 20.9% for 2016/2017 and 12.0% – for 2015/2016 (Brodschneider et al. 2016, 2018, Gray et al. 2019), which demonstrates a significantly higher percentage of losses due to honey bee colonies death or dramatically reducing the number of bees in the hive to a few hundred as compared to the reported for Bulgaria values: 0.71 and 2.88 for the 2017/2018 and 2018/2019 periods, respectively.

On the other hand, the evaluation of the different forage sources, included in the study as potential risk factors for colony loss in Europe, indicates that intensive foraging with each of these five plant sources (orchards, oil seed rape, maize, heather and autumn forage crops) is associated with significantly higher winter losses (Gray et al. 2019). In this aspect, the situation in Bulgaria is similar, except that the presence of sunflower plantations in the apiary areas included in our study is also associated with high levels of loss of honey bee colonies.

According to many authors (Simon-Delso et al. 2014, Goulson et al. 2015), forage plants are considered as potentially useful sources of nutrition for bees. However, by extending the active season, late forage availability may also extend the length of the reproduction cycle for *Varroa destructor*, weakening the colony and hence making winter losses more likely. Agricultural crops are also expected to contain agricultural chemicals with negative effects on honey bees, which may have affected the results for all considered forage sources (Gray et al. 2019).

Conclusion

The low rate of honey bee colony losses (2–5%) in Bulgaria for the period 2017–2019 is related to the fact that mainly professional beekeepers participated in the conducted survey. As a part of the National Bee Breeding Association, these beekeepers are working according to a national breeding program aimed at the conservation of the local Bulgarian honey bee *Apis mellifera macedonica*, ecotype *rodopica*. Losses due to death or reduction to several hundred bees and natural disasters in the second compared period (2018/2019) increase by four and six times, respectively, compared to the first period. The evaluation of the different forage sources for honey bees, such as orchards, oilseed rape, maize, sunflower, autumn forage crops and heather, shows that they are potential risk factors for the loss of bee colonies in Bulgaria. The inclusion of a larger number of beekeepers from the territory of the country, as well as other criteria for characterising the size of bee colonies losses will contribute to a more objective assessment of the health status of honey bees in Bulgaria.

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