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IMPACT OF WEATHER CHANGES ON BEE FAMILIES DEVELOPMENT AND PRODUCTION WITH SPECIAL REFERENCE TO TRANSYLVANIA AREA

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Abstract

Lately, there have been increasing efforts to stimulate the strategic role of the bees in biodiversity protection, in agriculture & horticulture. European Union (EU) has invested in the beekeeping sector in the last years by funding Farm to Fork strategy. The aim of this strategy is to protect them and preserve their contribution in sustainable environmental models. Biodiversity is decreasing by using intensive agriculture, chimization and automatization and consequently a decline in ecosystem services in many parts of the world, most representatives being pollination. Over the past three decades, there was an increasing in atmospheric temperature. Because of changes in plant flowering times patterns, the interaction between pollinators and their food sources is also affected. The challenges facing bee health have multiple sources, including poor nutrition due to less nectar source, heat stress resulting from global warming, agrochemicals used in agriculture, and pathogens becoming increasingly resistant to conventional treatments. However, thermal stress can negatively affect hive activity, which can affect foraging activity, immunocompetence, reproductive capacity, and the growth and development of bees. This, in turn, will affect pollination services and hive production overall.

Key words*: apicultural production, bees, bee development, climate change, Transylvania.*

INTRODUCTION

In the last years, there was an intensive effort made to stimulate the crucial role of bees in agriculture and horticulture by pollination and protecting biodiversity. These small and wonderful creatures pollinate more than two-thirds of the crops and wild plants found in the European landscape. It is estimated that bees contribute at least €22 billion to European agriculture every year. European Union (EU) is investing in bees by the known strategy From Farm to Fork. The aim is to protect the bees and preserve their contribution to sustainable environmental models. To do this, European Union spends 80 million euros annually to finance specific programs designated to beekeeping half of them from EU funds, half of them paid by EU members themselves in their countries.

One of the primary culprits behind the decline of biodiversity is the intensive use of agricultural land, which results in the reduction of natural habitats (Newbold et al., 2015). This form of agriculture is responsible for a significant loss of biodiversity (de Heer et al., 2005), leading to a decline in ecosystem services, including pollination, in many regions across the globe (Kremen et al., 2002; Kremen et al., 2007; Potts et al., 2016). According to Rivera-Gomis et al. (2019), modern beekeeping in Europe is confronted with a multitude of opportunities and threats, primarily linked to the environment, but also to economic and social aspects. Today, good beekeeping practices (BPA) encompass activities that promote animal, environmental, and human health. Ecological beekeeping, one of the modern beekeeping practices, is a testament to these elements, with its numerous beneficial effects.

MATERIALS AND METHODS

Different approaches were studied in the present work, taking into consideration the global climate change and how this problem affect the bees in general and beekeeping as important sector of animal science.

Using specific key words such as climate change, beekeeping, heat stress, bee monitoring,

bee health and development and heat stress, scientific literature was studied. Relevant literature was gathered and processed from the most used databases (Web of Science, Science Direct or Google Scholar) where the keywords were found. In addition, studies of our research group were found and compared with other available literature findings. Our research gathered several articles focusing mainly on the research progress in our geographical region, where the impact of climate changes applies to the health and development of bee families. In the end, some data of weather monitoring in the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca was used, to highlight the periods of the beekeeping season where different measures to protect the bee families must be taken into consideration in order to have strong and healthy bee colonies.

RESULTS AND DISCUSSIONS

Climate change and beekeeping

As per a European Commission (EC) report (Causes of Climate Change, 2018), the current global average temperature on Earth has surged by a staggering 0.85°C since the end of the 19th century. This means that each of the past three decades has been warmer than the previous one, a trend that should raise serious concerns. Another European source (Consequences of Climate Change, 2018) points out that climate change is already impacting human health, with the most affected economic sectors being agriculture, forestry, energy, and tourism.

A Technical Report by Greenpeace Laboratories (2013) states that: "climate change, such as rising temperatures, changes in precipitation patterns and many other irregular or extreme weather events, will impact pollinator populations. Some of these climate changes could affect pollinators at individual level but consequently also their communities, reflected in higher rates of extinction of these pollinator species". For example, in Poland, bees have been observed to react to climate change by performing their first cleaning flight (in spring) earlier than expected, a behaviour that coincides with the phenomenon known as "seasonal change", which refers to the shift in seasons due to climate change. This early cleanup flight occurred one month earlier compared to the average of the last 25 years of the observation period, a phenomenon attributed to the increase in global temperature (Sparks et al., 2010).

Climate change is leading to changes in all flowering patterns, changing implicitly the flowering period of melliferous plants, indispensable source of food for bees, or seasonal changes, in which case the flowering period no longer corresponds to the moment when bees "wake up" in the spring (Kremen et al., 2007). Because of changes in plant flowering times and patterns, climate change also affects the interaction between pollinators and their food sources. Thus, some studies (Memmott et al., 2007) demonstrate the reduction of the number of floral resources available, up to 50% of all pollinator species, depending on the climate change model that causes the modification of plant flowering patterns. The authors anticipate that the predicted outcome of these perturbations is the extermination of pollinators, plants, and interactions between them. In the bibliographic sources mentioned above, in addition to the general conclusions formulated by the authors, concrete information about the influence of climate changes on the evolution of the morpho-productive characters of bee families is not found. Of course, similar studies must be made in order to draw a clear conclusion in this respect.

Bees and heat stress

Bees are affected by heat stress in many aspects: their growth may be affected, the development of the family, bee physiology, and foraging activity, directly related to pollination services and not lately their reproduction (Alqarni, 2020; Bordier et al., 2017; Greenop et al., 2020; Medina et al., 2018). Also, thermal stress may trigger different malformations of bee anatomy (legs, wings, stinger, the proboscis) (Groh et al., 2004).

Because we are talking of global heating, abnormally high temperatures will definitively change the bees normal physiological activities by affecting their immune system. There are not enough studies to state that the changes that occur in time in the immune system of the bees exposed to heat stress are due solely to heat stress, so the conclusions remain unclear. However, lately, some scientific studies have demonstrated the impact of thermal stress on the

immune system of social insects (*A. cerana* and *A. mellifera*), such as the study of Li et al. (2022). Three genes responsible for antimicrobial peptide production (Abaecin, Defensin and Hymenoptaecin) were analyzed at different temperatures and treatment times, and their expression patterns were registered. The expression of these genes was affected by high temperature and treatment time. Under stressful conditions (heat stress), immunity is activated, and as a result, the infection may be prevented. A basis for determining the mechanisms by which the bees' immune system adapts to high temperatures was initiated by these results.

One recent scientific study demonstrates climate change's impact on bee families' vital activities (Cebotari et al., 2019). This work aimed to determine the correlation between the values of the average monthly atmospheric air temperature in different periods of the year and the evolution of the morpho-productive value characters of bee families, thus elucidating the impact of climate change on the vital activity of *A. mellifera* bee colonies. In order to study the impact of climate change on bee families' activity, the data recorded during eight years (2010-2017) from the closest hydro-meteorological station to the apiary were used. During this period, different coefficients were calculated between the monthly average of the atmospheric air temperature and the average values on the hive for each of the six main morpho-productive characters of bee families: queen prolificacy, family strength, colony resistance to wintering, disease resistance, brood viability and honey production of bee colonies. The research results showed that the phenomenon of global warming was also manifested in the area where the experiment was conducted.

Moreover, in this sector, the effects of global warming were more evident than in the EC Report (2018) data. It was found that the annual average temperature is increasing from 10.4°C in 2010 to 10.9°C in 2017, i.e. by 0.5°C. The average air temperature in the first three years (2010-2012) was 9.6°C, compared to the last three years (2015-2017), it can be observed an increasing with 1.5°C (to 11.1°C), a significant increase which is very much and also worrying. The high temperatures and drought periods recorded harmed the flora and fauna of the ecosystem, and, of course, the effects were present on the agriculture in this area. We can assume that if the air warming continues at this rate, we will witness various transformations in a few decades, leading to the change to an arid and desolate area. Research has shown one of the most important climatic factors' influencing the vital activity of *A. mellifera* bee families is temperature.

Between this factor and the morpho-productive evolution of bee colonies, there are different sizes of correlative links. The impact of air temperature on the vital activity of bee families was found to be determined by the average monthly temperatures in some periods of the year and by the average annual temperatures (Cebotari et al., 2019). Another study was conducted to determine the influence of temperature on nectar collection and its storage in the hive in some of the main collections (acacia, linden and sunflower) (Eremia et al., 2017). Nectar production in honey plants is closely related to air temperature, sunlight level, air and soil humidity, plant age and density. If, for example, cold or dry winds blow or there are torrential rains during the flowering of the linden, in these cases, the nectar collection and honey production are interrupted, and the heavy rains destroy the flowers or unopened flowers of the linden. Nectar secretion is influenced by several factors, which include soil factors (soil moisture and fertility, use of fertilizers, agrotechnical factors), sunlight, temperature (below 10°C and above 35-38°C plants do not secrete nectar, the optimum temperature being 16-26°C), meteorological conditions, winds and prolonged droughts (Eremia, 2009). The different harvests are influenced, as mentioned, mainly by the climatic conditions in specific periods of the year.

Both climatic and geographical factors play an essential role in the biogeographical distribution of bee species (Coroian et al., 2014). The study was conducted at the University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca (USAMV Cluj). The Carpathian Mountains are considered a natural geographical division between two subspecies of bees in our country, *Apis mellifera carnica (A. m. carnica)* and *Apis mellifera macedonica (A. m. macedonica)*. To evaluate the role of the Carpathian Mountains on the biogeography of

European *A. mellifera* bees, the bee samples collected from the Transylvanian plateau offer an excellent sampling model because they are almost entirely isolated from the Carpathian Mountains. This population was not only geographically isolated, but it also knew extensive historical isolation (Foti et al., 1965; Ruttner, 1988; Mărghitaș et al., 2009) and the comparison with the adjacent *A. m. carnica* and *A. m. macedonica* would be highly informative about the separating role of the Carpathians. The Transylvanian Plateau with it's over 25,000 km² spreading, would have supported a sufficiently large endemic bee population during the last glaciations (surrounded by an ice belt), is still detectable today. Few years back reports on the Transylvanian ecotypes seem to support such a view (Căuia et al., 2008; Mărghitaș et al., 2009). The experiment was carried out by collecting samples of bees from the entire territory of the country. Thus, samples were taken from 138 traditional beehives inside the Carpathian arc and outside, up to the Danube Delta. The mitochondrial COX2 tRNA intergenic region was sequenced for all samples and genotyped at 12 microsatellite loci. The Carpathian Mountains had a limited impact on biogeography because both subspecies were frequently found on both sides of the mountains. Instead, the differentiation of subspecies was strongly correlated with the different temperature zones in Romania. The conclusion of the study was that *A. m. carnica* is more common in regions with average temperatures below 9°C, while *A. m. macedonica* is more common in regions with average temperatures above 9°C. This selection may impact future biogeography in light of anticipated global climate change.

Weather monitoring and possible impact on bee colony development

Taking the data from weather station of USAMV Cluj from the last two years (up to and including September), registering different parameters that could influence the development of bee families, the following were found: in 2022 (Figure 1), during the period June - September, much higher values of the global solar radiation (the chart is presenting the average values recorded in every month because very high values were registered as maximum in some specific days) were recorded, compared to 2023 (Figure 2), the other recorded parameters remaining relatively constant. This parameter can significantly influence the development of bee families and can influence the quantity of nectar and pollen in melliferous plants and crops. Among the other important parameters for the development of bee families and also for nectar production are precipitations and relative humidity of the air.

More linear average relative humidity in 2023 was recorded compared to 2022. These parameters may be correlated with the development of the bee families and honey production.

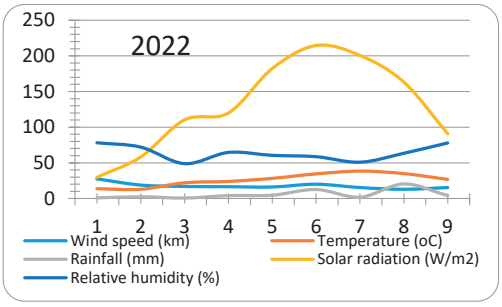

Figure 1. Meteorological records in 2022 at the Meteo Station of USAMV Cluj

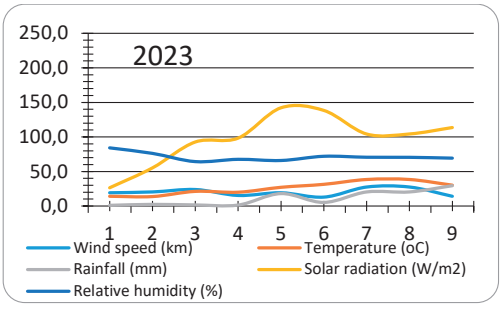

Figure 2. Meteorological records in 2023 at the Meteo Station of USAMV Cluj

If we strictly consider the summer period (USAMV Cluj weather station records), we can observe a decrease in global solar radiation values over the last three years (Figure 3), which can be an encouraging factor for honey production in the central area of Transylvania and the development of bee families, including correlation with all other parameters that determine the development or decline of bee families.

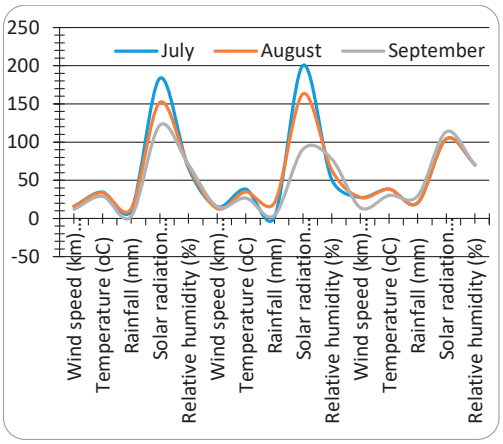

Figure 3. Highlighting the parameters recorded at the weather station of the USAMV Cluj in the summer (July-September) between 2021 and 2023

CONCLUSIONS

Different parameters such as their growth, family development and foraging activity are affected by heat, and conclusively, this may threaten their entire survival.

For this reason, it is very important to follow the weather conditions during a beekeeping year. In addition to the data collected by meteorological stations, different electronic devices are available to measure the honeybee colony development in relation to the weather conditions.

In order to provide quality information on climate changes and bee family development, electronic devices must be placed in the apiary to register the evolution of the harvest, predict the production, and monitor the health of the bees, all in relation to weather changes.

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