

IMPACT OF SOME ENVIRONMENTAL FACTORS OVER APIS MELLIFERA L. (REVIEW)

Zheko Radev

Tobacco and tobacco products institute - Markovo, Agricultural Academy - Sofia, Bulgaria

Abstract: A number of factors and reasons from different directions, accumulated over the last two-three decades, led to a negative impact on the environment and threaten the existence of number of living organisms from the plant and animal world. Ones of the main problems are the increased urbanization and agriculture. Honey bee *Apis mellifera* L. are one of the most affected and concerned living organisms. They are under the direct influence and impact of the pesticides used in agriculture during plant protection measures. Heavy metals in the environment and acaricides used to control the mite *Varroa destructor* Anderson & Trueman also have a negative effect over honey bees. A number of scientific reports prove honey bees as a bioindicator of the environment. This study examines the status of *A. mellifera* and the impact of the environment over honey bees in modern conditions, as well as the understanding of the ecological role of *A. mellifera*.

Keywords: honey bees, *Apis mellifera*, environment, pollution, ecology.

INTRODUCTION

Nowadays, the change of the natural environment and the urbanized ecological systems is easy to see. Ecological balance is of exceptional importance to all living organisms and their relationships, as well as for the air, soil, waters, forests and everything else. Changes to the environment can be assessed through different indicators, methods and instruments. Bioindicators may be one of the most important methods for monitoring ecological change. They must be applied extensively and purposefully, because only they can yield up-to-date and accurate information about the condition of the environment, and therefore, allow for adequate measures to be taken. Honey bees of the *Apis mellifera* L. species are an intrinsic part of biological diversity on the Earth, and are dependent on all factors of the environment. Regardless of whether these factors are created by the natural processes on the planet or by humans, they affect bees positively or negatively.

Bees and their products can be used as bioindicators (Cunningham et al., 2022), while *A. mellifera* are the foundation for sustainable agriculture and food production (Zavrtnik and Cvitkovic, 2023). In recent years, the number of alarming signals regarding the state of honey bees has been increasing. High and permanent loss of bee colonies associated with leaving the beehive or mortality within it has been reported. Also, observation shows that bee colonies are weakening dramatically starting as soon as the middle of their active season and stretching through the fall period, followed by total loss. Pollutants in the environment become attached to the bees' bodies and are thus transferred to the hives (Papa et al., 2021). The specific morphological characteristics and features of the honey bee body predispose it to higher vulnerability in comparison to other insects. Contamination is of another origin, but urbanized and industrialized regions play an important role (Panseri et al., 2020). Therefore, attention has to be paid particularly to limiting the risk of contamination and preserving not only honey bees, but also pollinators overall.

Due to the biology and specifics of the *A. mellifera* species, it can be used as one such bioindicator which provides up-to-date and accurate information regarding the pollution of the environment, and research has confirmed this fact (Crane, 1984). High and typical mortality under the influence of pesticides is found; traces of pesticides, heavy metals and radionuclides in their bodies and in their products can be detected (Celli and Maccagnani, 2003), and bee products are also consumed by humans.

Honey bees are invaluable bioindicators of environmental pollution (Sereviciene et al., 2022). Flying bees are entirely influenced by the environment - the pollution of water, soil, and air (Zaric et al., 2017). Environmental pollution generated by anthropogenic factors directly and adversely affects honey bees and the quality of their products - honey, pollen, and wax (Ryalls et al., 2022). Over the past two or three decades, *A. mellifera* is exposed to the direct effect of anthropogenic factors, and significant losses of bee colonies have been estimated in Europe and the United States (Jovetic et al., 2018).

Heavy metals and pesticides used in agriculture are among the potential contaminants which have to be seriously accounted for due to their negative impact on the condition of bee colonies.

HEAVY METALS

Research indicates that there is a correlation between environmental pollution and the presence of the same pollutants in bee products (Crane, 1984). As bees are the major pollinator on the Earth (Brown and Paxton, 2009), they visit a tremendous number of plant species and can be used as bioindicators of the environment (Celli & Maccagnani, 2003), due to their sensitivity to specific types of pollutants (Scarfone et al., 2024).

A number of research authors have used honey bees as bioindicators in monitoring heavy metal environmental pollution (Fry et al., 2023). Various substances and volatile organic compounds are capable of polluting not only plants, but pollen and nectar that bees need (Bogdanov, 2006) for their development, reproduction and productivity (Radev et al., 2014). Notably, the propolis that bees bring to the beehive is of plant origin and can also act as a contaminant as well as the water. Deposited metals have been established in the bodies of drones and worker bees (Filipiak et al., 2017). The harmful effect of heavy metals on bees depends on their concentration - low concentration does not lead directly to mortality, but high concentration can affect the nerve pathways of bees (Abd Wahid et al., 2021). In the coming years, people should pay increasing attention to urbanization, intensive agriculture, heavy industry, and other activities, in order to reduce environmental pollution.

Over the last few years, a number of studies indicate that heavy metals are known contaminants of the environment. The presence of chemical elements in the bee hemolymph is an object of studies (Ilijevic et al., 2021). Honey bees have the capability of differentiating some toxins through their antennae and proboscis receptors, but given a high concentration, the toxic element selenium cannot be traced (Hladun et al., 2012), despite the sensitivity of the representatives of *A. mellifera*.

Heavy metals are found everywhere in the surrounding environment and are characterized by high density (Briffa et al., 2020). The distribution of metals in the environment can be natural or in most instances under the influence of anthropogenic factors (Yu et al., 2023). Heavy metals are among the most studied contaminants together with pesticides, volatile organic compounds and dust particles (Satta et al., 2012), perhaps as major pollutants.

Some chemical elements, such as Al, Ba, Cd, Ni, Pb and Sr are not frequently encountered, but may come into reaction with the molecules of basic metals and become toxic (Schmarsow et al., 2023), thus inflicting more significant harm. Specific to the element Pb is that it is mainly found in the middle intestine and is not passed with food to the hemolymph (Raes et al., 1992). At this stage, only Pb has a set maximum value in honey equal to 0.1 mg/kg established in Regulation (EU) 2023/915 (European Commission, 2023). There must be further effort with this respect to including the other chemical elements as well.

For insects the elements S, P, Na, Zn and Cu are considered the major ones (Nation, 2015). Heavy metals are with density above 5 g/cm³ and atomic weights above 20 (Porrini, 2003); they are non-biodegradable, and they only change their chemical nature (Perugini, 2011). They are released

constantly by various sources, build up in the environment, and are characterized by hidden toxicity and continuous action of their physical cycles (Yu et al., 2023). In contrast to other contaminants, heavy metals are characterized by specific diffusion and stability in the environment (Mitra et al., 2022). Due to their specific morphology and etiology *A. mellifera* are effective carriers of pollutants, including heavy metals, products of human activity or ones naturally found in nature. These pollutants are then transferred to the hives and contaminate bee products such as honey and pollen, hence decreasing their quality (Scarfone et al., 2024).

According to studies, the elements are accumulated inside and not on the surface of the bodies of honey bees (Taylor et al., 2023). These bee products are also used for human consumption, and can be accumulated in the human body as well. The accumulation of heavy metals in the body can cause chronic diseases (Dudka and Miller, 1999), but in tiny quantities they can positively affect the organism. As is well known, the deficiency of some of them in our bodies can lead to anemias.

Food is a major source of the elements that are accumulated in the bodies of bees (Gekiere et al., 2023). Ground traffic affects environmental pollution with heavy metals, volatile organic compounds and dust particles (Kumari et al., 2021). According to conducted research, the presence of ground transportation in the vicinity of an apiary impacts the level of heavy metals in bee products. Near a railway station wax was found to be more contaminated with elements such as Al, Zn and Ni, while near a highway honey and pollen were significantly more contaminated with elements such as Al, Fe, Cu and Zn (Scarfone et al., 2024).

Some metals can function as enzyme cofactors, like Cu, Mo, Co and Cr (Gordon, 1959). It is proven that small doses are beneficial, but larger ones are toxic for honey bees, and there is a narrow margin between the two for some elements, for example Se (Alburaki et al., 2019).

It is widely known that metals are a part of nature (planet Earth), of its essence, and are necessary and essential, being an integral part of the composition and development of living organisms - humans, plants and animals. They are needed for the normal course of the biological and biochemical processes of living organisms.

For insects Mn and Zn play an important role for the proper development of the mandibles (Behmer, 2008). Research shows that the metals K, N, Na, Zn, P, Cu, and S affect the growth and development of bees from larva to imago, and any deficiency impacts their biological characteristics (Ciric et al., 2021). Higher values of the elements Na, P, S, Zn, Cu were found in bodies of drones, and in particular 2.2 times higher values of Se, which is of great significance for bees. In drones these are important for the sperm quality. Until now, higher levels of Se have not been found in other male insects. The reported differences may be attributed to different exposure to the environment, the reproductive ability of the drones and especially the quality of the food they consume (Zaric et al., 2024).

PESTICIDES

In recent years, globally, on all continents, a drastic reduction of pollinators has been reported (Kulhanek et al., 2017), and bees are the most important ones (Potts et al., 2016). The causes of this damage are complex and include a number of aspects - diseases, intensification of agriculture, increase in monocropping, the excessive use of agrochemicals (Goulson et al., 2015) and various other reasons.

It is assumed that one of the major causes is the effect of pesticides (Siviter et al., 2021). The impact of pesticides and the shortage of food are serious factors which contribute to the loss of honey bee colonies. A combination of these factors is very often encountered (Vodovnik et al., 2021). Food plays a significant role for pesticide sensitivity (Archer et al., 2013). Bees' access to food and the consumption of a wide variety of pollen increases their tolerance to pesticides

(Schmehl et al., 2014), while insufficient feeding with pollen reduces their resistance (Huang, 2012).

Pesticides include a range of products and depending on their type, they are degraded in the environment by different factors over a varying span of time (Alister et al., 2017). The impact of pesticides depends on: their type (Straw et al., 2021), application (Graham et al., 2022) and the characteristics of the entomological species (Knapp et al., 2023) they affect. It is established that the insecticide Thiacloprid affects food choice, shifting bees' preferences towards polyfloral honey in comparison to the control group, while the choice of pollen remains similar. The mortality of bees contaminated with spores of *Nosema ceranae* in combination with Thiacloprid was higher than of those only contaminated with *N. ceranae* (Vidau et al., 2011).

Pesticides affect food preferences of bees (Vodovnik et al., 2021) and have negative effects on the survival of both *A. mellifera* and bumble bees (Tosi et al., 2017). The time of pesticide application - the crop phenophase in which the plant protection activity is carried out, arguably affects the entomofauna the most. In principle, treatments during flowering are undesirable, because the pesticide accesses the nectar and pollen, and contaminates them. More pesticides have been found in pollen than in nectar or bee bodies (Laurent et al., 2024). Thus, the food of pollinators becomes toxic and leads to intoxication of the insects. Radev and Raycheva (2022) under laboratory study have found higher toxic tolerance when *A. mellifera* consumed pollen with higher protein content.

Contamination may also take place through a direct contact of the bees with pesticides (Arena and Sgolastra, 2014). Data on the synergic or additional effects of lowquality feeding of bees and their exposure to pesticides is scarce at this time (Goulson et al., 2015). When crop protection activities are to be carried out, beekeepers have to be informed and the bee colonies have to be isolated with all precautions taken. Areas where plant protection application occurs permanently are not suitable for beekeeping.

Besides through nectar and pollen, bees can be contaminated also under the influence of various chemicals and through the water (McCune et al., 2021) they carry to the beehives for consumption and cooling on hot days. Other sources include the use of veterinary medical products for prophylaxis and treatment of diseases and against pests (Kiljanek et al., 2021), and under the influence of air (Negri et al., 2015).

Depending on the type, concentration and dose of the pesticide, toxicity can be ultra-acute, acute and chronic. In ultraacute toxicity, bees die immediately; in acute within a few hours or a day, and in chronic within a larger time period, mostly during fall and winter. Low concentration of pesticides in bee food may not lead to immediate death, but can have a chronic effect on the orientation and memory of bees (Yang et al., 2008). One study found a larger number of pesticides in apple orchards (7.6) in comparison to fields with oilseed rape (3.5), where fungicides held the highest share in the apple orchards.

Systemic pesticides are widely used and known for contaminating all plant parts. Nowadays, neonicotinoids are the most used insecticides globally (Craddock et al., 2019), attacking the central nervous system of insects (Goulson, 2013), thus affecting their survival and existence of the whole beehive (Henry et al., 2012). One of the preventive measures which limits the treatment applications is encapsulating the crop seeds with pesticides (Wisk et al., 2014).

CONCLUSIONS

With today's anthropogenic influence including intensive agriculture, urbanization and other activities which directly affect the environment, the consequences should be accounted for. Further preliminary risk assessment of the impacts on humans and the environment needs to be carried out.

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