

## HONEY BEE COLONY COLLAPSE DISORDER (*Apis mellifera* L.) - POSSIBLE CAUSES

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### Abstract

*Honey bee (*Apis mellifera* L.) is the most studied insect pollinator in the world, due to its extremely important role in the plant reproduction. More than 80% of agricultural crops in the world are being pollinated by the honey bee. Prior to appearance of CCD syndrome, i.e. syndrome of Colony Collapse Disorder of honey bee colonies, bees have been disappeared en masse. Since the late 60's of the XIX century, there were about twenty recorded cases of large honey bee colony losses, caused by various diseases. However, since 2006, the phenomenon never seen before in the world appeared which was called CCD syndrome. The difference between this „disease” and previous cases of honey bee disappearances lies in the fact that there are no dead bees as evidence of disease. Beekeepers find empty, abandoned hives with only queen bee, brood and very small number of adult workers, where the largest part of worker bees had left the colony. There is a lot of food, honey and pollen, left in the hive. Mentioned syndrome was firstly appeared in the USA, where, for only one week, certain number of large beekeepers reported losses of 50-90% of their bee colonies. Soon, syndrome was noticed in Europe, where in many countries larger disappearance of honey bees were reported. Exact cause of CCD syndrome appearance is not known, but assumptions include individual impact of more factors or, more likely, their synergistic effect. Hypothesis related to causes of mentioned syndrome include the impact of traditional honey bee diseases caused by varroa mites and other parasites, excessive pesticides consumption in agricultural production, genetically modified organisms, electromagnetic radiation, poor honey bee nutrition, crops growing in monoculture and biodiversity loss. Nowadays, a number of researchers think that it is a synergy of many factors, so that the bees as a bio-indicator reflect current state of environment in the world. Economic estimations of damages caused by potential disappearance of this species count billions dollar, where the consequences do not consider just monetary loss, but the impact on agro food safety of the world population.*

**Key words:** causes, CCD syndrome, honey bee, synergistic effect of factors

### INTRODUCTION

The most important role of bees in the nature is plant pollination which provides the reproduction continuity of plant species and by that functioning of ecosystems. Of all bee species (about 20,000 species are known today), honey bee (*Apis mellifera* L.) is the most important pollinator of crops in the world. This species, studied more than any other insect pollinator in the world, provides ecosystem service of enormous significance, for crops and wild plant species in nature. In Europe, about 84% of agricultural crops are being pollinated by insects among which honey bee is dominant. From 127 main agricultural crops about 70% is being pollinated by insects. In USA, bees are responsible for 1/3 of produced food. It is estimated that each year in America, more

than 2 million bee colonies are rented for pollination of agricultural crops [4].

Honey bee is highly specialized insect with morphological - anatomical differences between castes in the colony, as well as differences in their behavior and function. One honey bee colony is consisted of one queen bee, few hundred drones and more thousand workers; so the honey bee colony is multigenerational and multiannual society. From the late 60s of XIX century, there were about twenty cases of large losses of bees due to bee diseases [6]. Winter losses of bees are not news. However, since 2006 until today, in the USA is recorded loss of bee colonies much larger than average losses in previous years (before 2006). Although some American beekeepers reported loss of 50-90% of bee colonies within only a week, average loss of bee colonies is about 30% [2]. In the

period between 2007 and 2011 about 30% of bees died in USA due to CCD (Colony Collapse Disorder), so they did not managed to successfully pollinate agricultural crops.

## MATERIALS AND METHODS

Method used in this research paper was Desktop study. Analysis was based on data available from relevant publications regarding the research topic. Material was collected from scientific journals and electronic data sources.

## RESULTS AND DISCUSSIONS

This section presents the main possible causes of honey bee Colony Collapse Disorder. Main factors of honey bee death in the USA and Europe, till appearance of CCD, were two parasitic species: varroa mites and tracheal mites. Next to them, and very present today, are diseases American foulbrood, nosema and chalkbrood. However, during time, science enabled successful fighting with these diseases and continuum of professional beekeeping, although expenses of beekeeping significantly increased. However, the reasons of present large loss of bee colonies, mainly in the USA, are not known. Only symptoms are known, which numbers of hypothesis are trying to explain.

Generally speaking, main symptoms of CCD are complete absence of adult workers in the hive, where dead bees cannot be found near the hive, there is a capped brood and stocks of food (honey and bee bread) in the hive. Colonies which are affected by this phenomenon have very few adult bees needed for maintenance of the brood; work force is presented with small number of workers, while queen bee is present in the hive. In Europe, significant loss of bee colonies was observed in the fall of 2009 in Switzerland [1] and soon European beekeepers observed the same phenomenon in Belgium, France, Greece, Italy, Portugal, Spain, Germany and Northern Ireland.

Colonies affected by this “disease” may appear healthy for weeks prior to leaving the hive, and in the moment of manifestation of

this phenomenon, adult bees suddenly leave the hive full of honey, pollen, closed brood, queen bee and some worker bees. Beekeepers which experienced this phenomenon, say that nowhere around the hive bees cannot be found and that in the hive there are no dead bees. Main cause of this phenomenon is not known, but there are some hypotheses which try to explain why there is mass disappearance of bees:

- phenomenon caused by traditional bee pests and diseases (American foulbrood, nosema, chalkbrood etc.);
- growing of genetically modified crops;
- narrowing of genetic variability of the queen bee;
- usage of agro-chemistry in agricultural production and poor apiary management;
- poor nutrition of bees;
- impact of undiscovered pests and diseases;
- synergy of all previously stated factors.

According to research of Van Engelsdorp et al. [7], it cannot be stated that there is only one pathogen primarily responsible for CCD syndrome. Still, pathogens and parasites have critical role in creation of this phenomenon (although not the main role), considering that in his research “diseased” colonies had much larger amount of pathogens in bodies, compared to control colonies. One of the possible ways on which bees regulate the number of pathogens and parasites in the hive might be departure of highly infected individuals from the hive. The most researched possible causes of this syndrome are traditional bee diseases and agricultural chemicals, and partially electromagnetic waves, genetically modified organisms and poor nutrition.

### 1. Traditional bee diseases

The most serious candidates, possible causes of this phenomenon, are diseases American foulbrood and varroa. American foulbrood is infectious disease of closed brood caused by bacteria, which is spread by spores through the hive. In time, colony becomes less in number and eventually all bees die. The disease is spread with spores which are very resistant on environmental factors and chemicals. Spores can also be spread by varroa mite as well as wax moth. Beekeeper

can infect the colonies by buying infected swarms, by borrowing infected beekeepers equipment, by independent preparation of foundations from unsterilized wax, etc. Infected brood is irregular (scattered), and by removing the wax caps one can see changes in the larvae (instead of white, larvae are pearly white, yellow-white, dark brown or chocolate). Larva loses clear shape and turns into a soggy formless amorphous mass.

Varroa is a disease that affects brood and adult bees and it is caused by a mite. When colonies become infected, varroa mite is spread very fast and untreated colonies die very quickly, usually in winter. A higher percentage of varroa infestation in Europe, compared to the rest of the world, can be attributed to cold winters and viruses that cause secondary infection of bees, and which are transmitted by mites. Source of varroa mite can be infected colonies, packet swarm of bees, contact with diseased bees, natural swarms, queen bees and brood. Initially, the disease runs smoothly and seamlessly, and does not reflect the productivity of bee colonies. But with time, it reduces the immunity of bees and weakens the strength of colony. The symptoms of the disease manifest if infected more than 20% of the bees. During winter time, bees are agitated, they are buzzing, they have diarrhea and eventually they die. In spring and summer there is a mortality of pupae and the weakening of colony, which is the result of performance of progeny incapable of survival. Drones cannot mate with queens whose fertility, due to varroa, is extremely reduced. Mites are located mainly on the worker brood, which leads to a large number of damaged bees which are unable to fly. The aforementioned claims are related to the so-called secondary viral infections. The most damage, at least in Europe, is caused by virus of acute bee paralysis, which latently infects bees causing visible damage to their bodies. Larvae which have sufficient amount of the virus die before their cells are closed. Survivors continue to evolve in latently infected adult bees. Virus of acute bee paralysis can sometimes be found in pollen collected by bees which appear healthy, as

well as in their thoracic salivary glands. There is a strong correlation between the presence of the viruses transmitted by mites and the appearance of CCD [4].

As one of the possible causes of the Colony Collapse Disorder is nosema disease. It is a widespread disease of adult bees caused by parasitic protozoa. This parasite attacks the cells of the midgut, leading to disturbances in digestion, and then the damage of other organs. Infected bees live shorter compared to the uninfected bees, because the infection reduces the length of life of bees between 25% - 58%. In addition to shortening the life span of bees, one of the consequences is replacement of queen bee, latter orientation flight of young workers, lower or complete absence of nectar and pollen gathering, bee exhaustion and loss of colony.

All of these diseases are taken as a possible cause of honey bee disappearance. However, it should be noted that in each mentioned disease there are clearly visible signs of illness, prior to death of the bees. On apiaries affected by CCD, the bees appeared healthy and there were no clear signs of the presence of traditional bee diseases.

## **2. Genetically modified organisms**

Genetically modified seeds are produced and distributed by major biotechnology companies mainly based in the USA. Corporations are investing a lot of money into research and development of genetically modified seed using genetic engineering, and such seed can be further propagated only under certain conditions. Research papers about the impact of genetically modified seeds (plants) on the occurrence of CCD are very scarce and contradictory. One thing is certain, the bees cannot distinguish between genetically modified crops and crops of conventional or organic production. Pollen, which is collected from genetically modified plants, can be detected in honey which, from an economic point of view, may affect trade of these products. Exploring the impact of GMOs on bees' health and its possible connection with the appearance of the colony collapse should be conducted by independent and competent scientific research institutions, and research results should be known to the general public.

**Narrowing of the queen bee genetic variability**

Narrowing of the queen bee genetic variability is caused by the existence of a smaller number of queen breeders in the USA that produce millions of queen bees for the whole territory of the USA, which may be linked to the collapse of bee colonies. Increased genetic uniformity of the queen bee can be a cause to greater susceptibility to diseases or pests that attack the bee colonies [2].

**Impact of agrochemicals and poor apiary management**

Pesticides are also listed as a possible cause of CCD, such as insecticides from the group of neonicotinoids (they contain the active component imidacloprid) whose residues can be found in the plants nectar. Difficulty in assessment of the chemicals impact on the CCD appearance lies in the fact that there are many different chemicals in use, within the countries where mentioned phenomenon emerged, so it's hard to simultaneously conduct tests for all of them. Besides that, transport of honey bees on long distances, which is common practice in the USA, exposures honey bees to the number of different pesticides within the territories intended for honey bee pasture. Also, bees store pollen and honey for the longer period, which means it can take a long time (days - months) before the contaminated product is used as a food, so that hinders linking of symptoms appearance with the actual time of exposure to pesticides.

Active substances in agrochemicals that are used for the control of crops' pests and diseases affect the mortality of the useful insects in agro-ecosystems, where it should be underlined that they can stay in nature for a long time, through the accumulation into the bodies of living organisms, i.e. their products. It is assumed that the agricultural chemicals, combined with the other stressors, contribute to the worldwide disappearance of honey bees. Pesticides toxic to honey bees include: organophosphate pesticides, chlorinated hydrocarbon pesticides, carbamate pesticides, organic pesticides, pyrethroids and neonicotinoids. Most of the pesticides toxic to

honey bees, affect the bees' nervous system. After the exposure, bees' vital organs paralyze. Behavior of complete colony is changing.

Imidacloprid, insecticide that belongs to the group of neonicotinoids, affects the honey bees foraging success [3]. Its sub-lethal doses adversely affect the longevity of honey bees, brood forming, development of hypopharyngeal glands and queen bee activity. Considering that adult honey bees eat relatively small amount of pollen, if agricultural chemicals are the cause of CCD, they are probably accumulated in nectar (main symptom of CCD is the disappearance of adult honey bees). Imidacloprid can also cause immunodeficiency of honey bees through the chronic intoxication with low doses. In April 2013, EU has proclaimed a two - year ban on the use of neonicotinoids.

Chemicals are also used in the treatment of Varroa mites, such as the coumaphos and fluvalinate, and they may be one of the causes of the Colony Collapse Disorder. Life length of a worker bee can be reduced if it is exposed to sub-lethal doses of coumaphos in the stage of larva or pupa [1]. If worker bees are dying at the rate that exceeds the ability of colony to replace them, reduction of brood size occurs and finally the entire colony collapses. One more chemical, fipronil, was accused in 2010 for the emergence of Colony Collapse Disorder phenomenon, when French researchers found that a very small non-lethal dose of mentioned pesticide affects the ability of honey bees to locate the hive.

**Poor honey bee nutrition**

The cause of Colony Collapse Disorder may also be the poor quality of nutrition. Poor diet is the only common factor in all recorded cases of CCD [8]. This means that there is a possibility that the appearance of mentioned phenomenon is correlated with the stress caused by poor nutrition, so it will manifest itself less in healthy, well-nourished colonies. Problem related to honey bee nutrition can be pasture on monocultures (bees need more diverse diet, i.e. pollen and nectar of larger number of flowering plants). Related to this is the assumption that the local and the global decline of biodiversity may be linked to the

emergence of the colony collapse disorder. Bees that were fed with pollen of various plants have healthier immune systems compared to honey bees which were pastured only on monocultures.

#### **Impact of undiscovered pests and diseases**

Some new bee pests can be the cause of CCD. In fact, during the 2006 scientists have identified, beside the usual type of *Nosema apis*, a new type of nosema - *Nosema ceranae*, in the digestive tract of honey bees, which can be one of the factors that causes CCD [5]. However, collapse of honey bee colonies is probably a consequence of the synergy of all above mentioned factors. Theoretically, combination of all underlined stressors can significantly weaken the immune system of honey bees and lead to its disappearance (extinction).

#### **CONCLUSIONS**

Economic consequences of the bee colonies collapse around the world are incalculable. Due to the decline of bees number in the world main consequence would be a reduction in the yield of main agricultural crops that will dramatically increase the price of all food products. This phenomenon could affect the crop production but also livestock production, by reducing the yield of forage crops. Larger loss of bee colonies would cause the disorder of the world market, i.e. trade between the countries affected by this phenomenon, and those in which still there is no collapse of bee colonies. Also, due to the inability of the natural crops pollination, labor costs would drastically increase. People would have to be hired to simulate the bees by manual pollination of agricultural crops. This case has already been reported in the southern Chinese province of Sichuan, famous for the production of pears, where due to excessive use of pesticides bees are extinct, so people have to manually pollinate fruit trees. One bee colony can pollinate up to 3 million flowers per day, while a man can pollinate about thirty trees per day. This is a difficult and expensive process, and bees do it for free. It is estimated that hand pollination, in the USA would cost more than \$ 90 billion annually. However, it

is believed that this method of pollination is not sustainable, given the trend of emigration from rural areas to the cities, which is present in most developed countries. In this regard, there have been attempts to create a device that would have a role in the pollination of plants, however, it was determined that no device even comes close to be as efficient as bees. The role of honey bees in the provision of ecosystem services of pollination is of enormous importance for the survival of biodiversity as we know it, and hence human survival as a species.

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