# Link between hyperacidity and fungal infections in bee hives


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## Key words

Varroa mites, Aspergillosis, Ascopherosis, oxalic acid



## Annotation

Ascopherosis, Aspergillus and other fungal diseases of bees and brood are not only difficult to cure diseases, but also have a high degree of danger to humans. The causes of the disease are usually simple, but not immediately visible. It turns out that this is largely the result of beekeeper mistakes. A combination of factors, such as improper operation of the hive, high humidity, lack of sufficient insolation and increased acidity in the hives due to the regular use of acid-based preparations, lead to the creation of conditions favorable for the growth of pathogenic fungi, which are always present in the hives as part of its natural microbiota. Thus, for an environmentally friendly fight against them, it is necessary to use such preventive methods as placing the apiary in a dry and sunny place so that the humidity is not excessive, and to the sun, if possible, which disinfects the hives and the ground around them, to using clean, young honeycombs in which there is no environment for fungal growth, to improve ventilation of hives during the main honey flow, to increase the temperature inside the hive, which will make it uncomfortable for fungal growth, to carry out preventive treatment of hives with alkaline preparations based on baking soda and soap solutions. All this will help to reduce the use of “heavy” chemicals to combat fungal bee diseases, and will help to prevent illness of people working with bees and of people using honey for food.


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Ascopherosis and aspergillosis are the two most common fungal diseases of brood and adult bees in beekeeping, which cause maximum problems for modern apiaries.

Ascopherosis, or calcareous brood, is a disease of bee brood that manifests itself in the spring-summer period and reaches its maximum development in June-July. The source of spores is considered to be nectar and pollen infected by them [1]. This is what determines the peak of infection development at the height of honey collection.

Aspergillus, or stone brood, is a fungal disease of brood, but also of adult bees. Pollen and nectar are also sources of infection. The fungus easily develops on honeycombs, bee bread, bee larvae, pupae and the bees themselves [1]. The fungus easily infects humans, and the disease is very severe and can lead to death.

It is proposed to fight an infection that has already appeared with rather heavy drugs, since in addition to the bees themselves, all the equipment and the apiary territory itself are infected. For radical treatment, it is recommended to use nystatin, actidione, choline salt of glucosylpolyfungin, thiabendazole, fungizone, unisan, griseofulvin and undecylic acid, a number of organic acids, in particular benzoic sorbic, sorbic monopotassium, acetic anhydride monosodium and others. It was also noted the possibility of using formic acid in high concentrations [1].

It is proposed to combat these diseases in the initial stage, as a rule, by destroying honeycombs with affected brood, by transplanting bee families into clean hives, by insulating and feeding, as well as moving apiaries to a drier place. In addition, it is proposed to use disinfectants such as Vetsan, formaldehyde solution, Percarb, hydrogen peroxide [1], there are also a number of pharmacological drugs.

It is known that spores of fungi, for example, the causative agent of ascopherosis, enter the hive with plant pollen. It is pollen that is the first place for the growth of these fungi in the hive [5]. In addition, the causative agent of aspergillus can also enter the hive from the ground if the hives are standing on it or on old rotting wooden stands, since rotting organic matter is the natural habitat of this fungus. But in order for fungi to grow in a hive, they require a number of conditions - certain humidity, temperature and acidity.

Humidity is an important condition for the growth of pathogenic fungi. For the causative agent of ascopherosis, this is 92.5% [1]. It is wet pollen collected by bees in rainy weather, or beebread damp in the hive, that become an ideal environment for the growth of fungi. Another reason for high humidity in the hive is the powerful honey flow and the great strength of the colony. With this combination, there is a lot of nectar in the hive, which the bees begin to evaporate, sometimes heating the air in the hive to +40C and sharply raising the air humidity due to the moisture removed from nectar. At such moments, humidity can reach exactly those values that are optimal for fungal growth [4]. The only way to reduce humidity in this case is increased ventilation, both forced - by bees, and natural - by opening all possible

ventilation holes in the nest and in honey supers. But not everything is clear with the ventilation of hives. Active ventilation allows you to avoid moisture condensation and its penetration into the depths of the fungal habitat, but if ventilation does not remove excess heat and moisture from the substrate and does not cool the substrate on which fungi grow, then such ventilation can only activate the growth of pathogenic fungi [3].

Fungi that cause diseases in brood and bees belong to the group of thermotolerant fungi, for which optimal temperatures range is from +30C to +40C. For the causative agent of ascopherosis, the ideal temperature for growth and sporulation is +30-35C [1], and for the causative agent of aspergillosis - +30C [2]. This immediately calls into question the treatment of bees by insulating the hives. In the absence of other elements of influence, insulation can only worsen the situation. In addition, it is known that fungi prefer the warm season for growth - June-August [1]. Fungi can be affected by temperatures that are higher than optimal for their growth. Elevated temperatures will also affect the rate of decrease in humidity in the hive.

The acidity of the environment in which they grow is of utmost importance for the life of fungi (Fig. 1). For the causative agent of ascopherosis, the optimal acidity (pH) is close to neutral and is in the range between 7 and 7.5 [2].

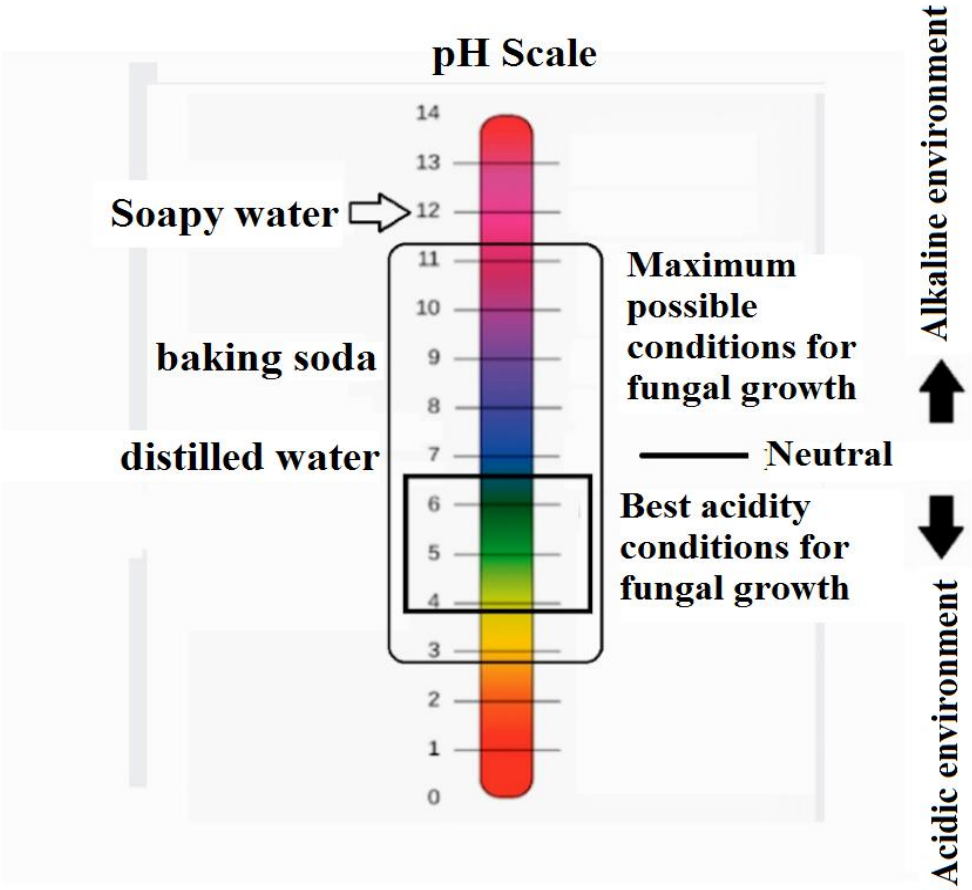


Figure 1 - acidity scale

But practice shows that this is a laboratory result and in real conditions in apiaries everything happens somewhat differently. This is evidenced by information coming from various sources about mass diseases of bees with fungal diseases after treating them with organic acids that are now so popular.

Oxalic and formic acids do have a suppressive effect on Varroa and Tropilaelaps mites, and they are organic in the sense that they are found in small doses in plants, insects and honey. However, a lot depends on concentration. Frequent and regular use of these acids leads to an increase in the acidic background in the hives and ultimately leads to the creation of optimal conditions for the growth of pathogenic fungi.

Observations of an eco-apiary in Sardinia of about 500 bee colonies showed the presence of fungal diseases. According to the eco-apiary status, Varroa mites can be controlled only with drugs approved for use in eco-apiaries, primarily oxalic acid. The search for the best ways to prevent and treat mycoses (Fig. 2) continues.

Figure 2. Examination of families affected by mycosis. Sardinia.

Fungal infections are also widespread in Georgia. One of the reasons is the spread of methods of treating bees with organic acids against Varroa mites instead of drugs amitraz and fluvalinate, which were used previously, but their effectiveness in the fight against mites has significantly decreased, and in addition, they were not recognized as environmentally acceptable.


Figure 3. Samples of affected bees and brood sent by a beekeeper from western Georgia with a request to determine the reason for the weakening of bees after the use of formic acid. The intestines of affected bees were removed without loss of integrity. Samples of bees from frames, as well as those collected in front of the hive from the same apiary with signs of ascopherosis.

Observations in 2021 showed that in April of this year, in samples of bees in apiaries where oxalic acid was used, pathological changes were detected in the digestive system of bees - black color of the intestines, similar to intoxication with honeydew honey, and there were also cases of violation of the integrity of the intestines of bees (Fig. 4).

Figure 4. Intestines of sick bees. A sample of the digestive system removed from a living bee, the integrity of which was damaged during the removal process. The thinned walls of the intestines could not withstand the removal process and were damaged. This sample shows the digestive system of a bee after repeated applications of acid.

And in May, in the same hives, ascospherosis in its classic form was diagnosed, with a characteristic lesion of brood (Fig. 5).

Figure 5. Honeycombs and brood of a colony affected by ascopherosis. State of the intestines of the bees of the affected colony.

It should be noted that in both cases, apiaries are located in subtropical regions and in regions close to subtropical, with high summer temperatures, sometimes reaching +50C, and close to the sea the sea, which creates very high air humidity. In mountain valleys with rivers and streams, humidity is also high in summer. In total, all this is an additional factor that, in addition to increased acidity, contributes to the growth of pathogenic fungi in these two zones.

It is almost impossible to influence the microclimate conditions in a bees' nest. Bees need high temperature and humidity for normal brood rearing. However, other factors can be dealt with. General recommendations are to comply with the following conditions:

- To place the apiary in a dry and sunny place so that the humidity is not excessive, and the sun, if possible, disinfects the hives and the ground around them;
- To change honeycombs frequently;
- To improve ventilation during honey collection. (it is practiced to insert wedges between honey supers during the main honey flow in order to speed up the removal of moisture from honey);
- To increase the temperature inside the hive as a whole, making it uncomfortable for fungal growth;
- To maintain optimal acidity in the hive!

The last point is of great importance right now, when bee colonies are mainly treated with organic acids.

The issue of reducing acidity in hives goes very well with one of the most important methods of combating Varroa mites - the propagation of bees by broodless layering or swarms. When creating layers or after catching a swarm, the bees are placed in a box with mesh walls, through which they can be treated with oxalic acid by spraying or by trickling. In this case, the bees receive the normal treatment, but the acid will evaporate not in the hive, but in the open air, and the bees, after one or two days in a cool room, will be placed in a hive that will not be exposed to acid. A similar treatment can be carried out with bees hatched from the last autumn brood, collected into one or two powerful families. After all the bees have hatched, they are collected in mesh boxes, treated with oxalic acid by spraying or trickling, kept for a day in a cool room, and then combined with the main families which are going into the wintering.

In addition, for prevention, it is recommended to treat equipment, hives, frames (without honeycombs) with environmentally friendly alkaline preparations, such as soap and soda solution. This will neutralize acid residues in the hive and on the frames if they have been treated with acids. In any case, this will worsen conditions for the development of pathogenic fungi.

An important direction in the fight against mycoses may be the study of non-toxic and safe for humans substances that stabilize fungi and prevent them from growing. These are derivatives of propionic or methylacetic acid, known as the preservative E280. The food industry uses mainly derivatives of this substance - propionates E281, E282, E283. These additives are approved for use in some foods and cosmetics. They are used in medicine to treat mycoses, in eye drops, and in cough mixtures. Additives are allowed in the USA, Canada, Australia and European Union.

It is important to note that propionic acid has not only antimicrobial and fungicidal, but also insecticidal effects. It is believed that at a concentration of 0.5% by weight of the substrate it suppresses the vital activity of insects and mites, and at a concentration of 1% it destroys them [3]. It is possible that over time, the development of drugs based on food preservatives will be able to solve the problem of combating fungal infections in hives without loss of bees and the quality of bee products.

In conclusion, it can be saied, that eliminating the problem of acidification of bee hives in ecological apiaries, which arises due to frequent treatments of bees with natural acids, is an issue comparable in importance to the fight against Varroa mites. The solution to this problem must be sought in the same plane as the solution to the problem of varroatosis - in suppressing the development of diseases in a natural way - by creating conditions that are unacceptable for the life of both - Varroa mites and the pathogens of Aspergillosis and Ascopherosis.

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