

Bee Infection Cured by Heat

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TO reduce the losses due to bee diseases beekeepers have often employed heat in one form or another. The direct flame has been used in scorching or burning the inside of hives that have housed infected colonies. Before being fed back to bees honey is often heated for the purpose of destroying the germs of bee diseases, should any be present. Heat is used in the rendering of wax and in the making of comb foundation. It is natural and very appropriate, therefore that beekeepers should inquire about the amount of heating that is necessary to destroy the germs that produce diseases among bees.

As no work had been done to determine the facts relative to this question with any degree of accuracy, the writer has performed during the last two years a number of experiments for the purpose of ascertaining them. It may be of interest to beekeepers to know in a general way how these experiments were made. An aqueous suspension of larvae sick or dead of the disease is made and placed in a small glass tube. This tube is immersed in water of the temperature desired in the heating. After the germ-containing material is heated in this way it must be tested to determine whether or not the germs have been destroyed. In the case of American foul brood this can be done by inoculating a suitable artificial medium with the heated material and observing the presence or absence of growth of bacillus larvae, the germ of this disease.

Testing for Disease.

As there is no artificial medium now known suitable for cultivating the infecting agent of either European foul brood, sacbrood, or Nosema disease, healthy colonies of bees must be inoculated in making the test in case of these diseases. This is done by feeding the bees the heated germ-containing material in sirup. If the disease is produced by this feeding, naturally the infecting agent has not been destroyed by it. By repeated experiments of this kind in which the temperature used in the heating is varied, the minimum temperature at which any virus is killed can be determined. Thirteen experiments for European foul brood, twenty-two for sacbrood and twenty for Nosema disease have been made in which healthy colonies were inoculated with heated germ-containing material from these three diseases, respectively. In the last disease the stomachs from diseased bees furnished the germ-containing material for heating and feeding. In these experiments the temperature was maintained for 10 minutes as a rule.

Nearly a century and a half ago the name "foul brood" was used for a destructive brood disorder of bees, and for almost a century later it was apparently the custom to diagnose as foul brood any destructive disease of brood. About half a century ago beekeepers began to note that all of the brood diseases are not the same. They began, therefore, to write of different forms of foul brood. At the present time it is known that there are at least three infectious diseases of the brood of bees. All of these diseases are more or less destructive, and it is quite likely that each of them has now and then been diagnosed as foul brood. In America these brood diseases are now known as European foul brood, American foul brood and sacbrood.

Foul Broods.

In European foul brood death occurs early, the larvae dying usually before the time for cell capping. There is no viscidness (ropiness) to the decaying larvae as a rule, and no pronounced odor present.

Numerous samples of this disease have been examined from the United States, and some from Canada. Its presence also in England, Germany, Switzerland and Denmark is strongly suggested by written reports from these countries. It is very probable that the disease has a much wider geographical distribution than these facts indicate.

Two years ago the fact was demonstrated that the germ causing European foul brood is the microorganism to which the name bacillus plutis is

given. In a paper announcing the fact it was stated that the studies then made indicated that the germ is easily killed by heat. This belief has been confirmed by further experiments.

American foul brood is the disease of the brood of bees that is best known to beekeepers and is the one the presence of which they have been able to recognize most easily. In this disease the larvae usually die after the cells containing them are capped. The disease is characterized especially by the marked viscidness (ropiness) manifested by the decaying larvae that are dead of the disease. The pronounced odor noticeable within hives housing colonies affected by this disease, especially in its later stages, is another well-known characteristic.

Until seven years ago the cause of American foul brood was not known. At that time the fact was demonstrated positively that the germ causing the disease is the one to which the name bacillus larvae is given.

The facts obtained to date are too meager to justify anything more than a general statement regarding the minimum amount of heating that can be employed in rendering material containing the germ of American foul brood non-infectious. Taking rather wide limits, it may safely be said that the minimum temperature at which this can be done, if the temperature is applied for 10 minutes, lies somewhere between 90 degrees C. (194 degrees F.) and 100 degrees C. (212 degrees F.). It seems quite probable, indeed, that a temperature less than 98 degrees C. (208.4 degrees F.) will suffice if applied for 10 minutes. When 100 degrees C. was used the spores of bacillus larvae were killed in less than five minutes.

Sacbrood.

Observant beekeepers have for many years noted the presence of dead brood which seemed to them to be different from that dead of foul brood. Some were inclined to believe that the disease was an infectious one; a larger number apparently were disposed to ascribe the trouble to such causes as an unsatisfactory queen, starvation, and the like. This brood disease has been recently demonstrated to be an infectious one, and the name "sacbrood" has been given to it. Larvae that die of this disease do so almost invariably after the time of cell capping. The most characteristic symptom of the disease is the saclike appearance of the dead larvae when they are removed from the cell. This fact suggested the name "sacbrood" for the disease.

More than a year ago it was again the writer's fortune to determine the cause of another brood disease. Unlike the cause of either European foul brood or American foul brood, the infecting agent causing sacbrood has not yet been seen. It was demonstrated, however, that the infecting agent in this disease passes through the pores of earthenware filters. For this reason the cause of sacbrood is spoken of as a filterable virus.

In a paper announcing the cause of sacbrood the statement is made that the germ causing the disease is destroyed by a comparatively small amount of heat. This belief is confirmed by the results of experiments.

Very little is known about the diseases of adult bees. Many names have been used for the purpose of designating them, but the number of such diseases is probably small. There is only one adult disease that can be diagnosed at present by laboratory methods. This one is the Nosema disease.

Nosema Disease.

Fifty-seven years ago Dr. Dönhoff made a more or less brief study of a disease of adult bees in Germany. He observed that the stomach was the organ that was primarily affected. By feeding to healthy colonies in sirup the crushed stomachs from affected bees Dönhoff demonstrated that the disease could be transmitted to healthy colonies. It was therefore infectious.

The work of Dönhoff had been practically forgotten, apparently, when Zander, of Erlangen, Germany, five years ago observed the presence of a disease among the adult bees. From

the evidence at hand it seems most probable that the disorder encountered by Dönhoff and the one encountered by Zander are one and the same disease.

Aside from rediscovering the disease, Zander has identified the germ causing it as a protozoan (a one-celled animal parasite) and has given to it the name *Nosema apis*. For the disease he has used the name "Nosema Seuche." This is an appropriate one, as it suggests somewhat the nature of the disease. The name "Nosema disease," which the writer suggests as the common name for this disease, is, it will be observed, only a translation of the German name used by Zander.

The germ *Nosema apis* gains entrance to the body of the bee by way of the alimentary canal. In the walls of the stomach the growth and multiplication of the parasite take place to an enormous extent, causing the abnormal appearance manifested by the organ. When the disease reaches an advanced stage the stomach is white and fragile and reveals upon a microscopic examination the presence of the parasite in very large numbers. In the spring of the year, especially, many weak colonies show upon examination a high percentage of *Nosema*-infected bees. Quite often, indeed, in the examinations that have been made of such colonies, 50 to 90 per cent of the bees in samples taken from them were found to be infected with the parasite. It is an interesting and important fact that a very large number of colonies which are strong and apparently doing well are found upon examination to contain at least a small percentage of *Nosema*-infected bees.

Summary.

The results of these experiments show that when they are maintained for 10 minutes the minimum temperatures that can be used for destroying the germs of the four bee diseases now known to be infectious are as follows:

- (1) The minimum temperature for European foul brood lies somewhere between 60° C. (140° F.) and 65° C. (149° F.), being approximately 63° C. (145.4° F.).
- (2) The minimum temperature for American foul brood lies somewhere between 90° C. (194° F.) and 100° C. (212° F.), being probably less than 98° C. (208.4° F.).
- (3) The minimum temperature for sacbrood lies somewhere between 55° C. (111.31° F.) and 60° C. (140° F.), being approximately 58° C. (136.4° F.).

(4) The minimum temperature for *Nosema* disease lies between 55° C. (131° F.) and 60° C. (140° F.), being approximately 57° C. (134.6° F.).

It will be noted, therefore, that 63° C. (145.4° F.) for European foul brood, 98° C. (208.4° F.) for American foul brood, 58° C. (136.4° F.) for sacbrood and 57° C. (134.6° F.) for *Nosema* disease are the approximate minimum temperatures at which the germs of these diseases, respectively, are destroyed. Since there are varying factors in experiments of this nature that tend to produce slight variations in results, these temperatures are referred to as being approximate. It is probable that future experiments may cause slight changes to be made in these conclusions. Nothing more than a comparatively slight variation is to be expected, however. In practice the beekeeper, in destroying these germs by heating, will naturally use a quantity of heat somewhat in excess of the minimum amount that is absolutely necessary.

Some generalizations may now be made which will be of interest to the beekeeper. The melting point of beeswax is between 62° C. (143.6° F.) and 64° C. (147.2° F.), inclusive. It will be observed that this same temperature in 10 minutes will destroy the germ causing European foul brood, and that it is about 10° F. above that which will destroy the germs of sacbrood and *Nosema* disease. A further interesting generalization may be made concerning the heating of honey. Honey when heated to 160° F. reaches a temperature 15° F. above the temperature necessary to destroy the germ of European foul brood and about 25° F. above the temperature that will destroy the infecting agents of sacbrood and *Nosema* disease. The infecting agents of these three diseases of the bee, therefore, will be destroyed when the temperature of 160° F. is used in the commercial handling of honey. Finally, it is believed that the results of this work on the thermal death point of the viruses of the bee diseases will be directly applicable to the control of these diseases.

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