ROTHAMSTED RESEARCH

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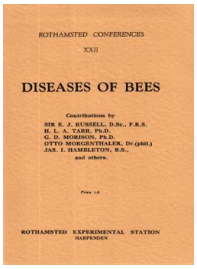

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CONTROL OF AMERICAN FOUL BROOD IN THE UNITED STATES

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DURING the time that Dr. G. F. White, of the Bureau of Entomology, U.S. Department of Agriculture, was investigating the brood diseases of bees, about 1906, a survey was being conducted to determine the distribution of American foul brood in the beekeeping localities of the United States. It soon became evident that the disease was by no means localized but widespread throughout the country. Before this time some of the States had begun to realize the serious inroads that American foul brood was making.

As early as 1877 San Bernardino County, California, passed a bee-disease law, and 6 years later a State law was enacted in California. It is interesting to note that the State law specified that infected colonies be burned. The State of Michigan passed a bee-disease law of State-wide application in 1881 which also prescribed the burning of infected colonies. In 1897 Wisconsin appointed the first State apiary inspector, N. E. France, with headquarters in the State Capitol. Other States followed suit by enacting special laws and appointing apiary inspectors, and to-day practically every State has a bee-disease law or some administrative organization under which bee inspection is carried on.

These early inspectors did their best. Upon receipt of a call from a beekeeper, a gross diagnosis would be made in the apiary and instructions left as to how to treat. Burning had already been frowned upon as unnecessary and wasteful. In some cases, where the inspector felt so inclined, he would lend a hand in the unpleasant task of treating colonies by the so-called shaking method. The next day he would be responding to a call in some other part of the State. Although the inspector would cover a great many miles of territory during a season, the beekeepers who benefited by his visits were insignificantly few. His activities nevertheless filled an educational need, and soon every beekeeper was on the look-out for disease.

In the light of present knowledge it can be seen that from the very beginning the shaking treatment was unsatisfactory. Reduced

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to its greatest simplicity, the method consisted merely in shaking the bees from an infected colony into a clean hive that contained frames having one-inch foundation starters. If there was little brood in the infected colony, combs and small amounts of honey were melted. Hives that contained much honey were usually salvaged. If many colonies in an apiary were infected, the brood combs were stacked on a queen-right but diseased colony and the brood was allowed to emerge, when this colony in turn would be treated, thus saving bees, wax, and honey. So-called improvements in this method came into use. Beekeepers established what were known as hospital yards, which were usually removed some distance from the regular apiaries. All diseased brood was allowed to emerge in the hospital yard. Other variations in the shaking treatment and in the methods of disposing of diseased material were advocated. One unique method was to place an infected colony in a tank, replace the cover with a clean hive, and drive the bees into it by slowly filling the tank with water. The theory was that the bees could be transferred with practically no disturbance and thus carry little contaminated honey into the clean hive. Various other contraptions and methods were used for transferring the bees from contaminated to clean hives. The shaking treatment, however, in some form or other continued to be used and the practice finally became well standardized.

In 1916 the State of Wisconsin again took the lead in the control of American foul brood. In full recognition of the contagious nature of the disease, and also of the inefficiency of a system whereby one inspector examined only the apiaries from which requests had been received, the area clean-up method was invoked, in which the State inspector with several assistants examined all the bees in a given locality, whether or not they were suspected of being diseased. Under this plan the same area would be re-inspected the second year, and while, owing to limited funds, some portions had to be neglected, the inspectors made a conscientious effort to do a thorough job wherever they went. The State of Texas also early adopted this system and organized a highly efficient State inspection service.

Most of the leading beekeeping States now follow some modification of the area clean-up plan, usually organized on a county basis. In several States the counties make definite appropriations for American foul brood control, and such funds are matched by grants from the State. The responsibility for control is thus placed to a certain extent upon the beekeepers of a county. A number of the large States expend as much as $25,000 to $30,000 annually for the control of American foul brood.

The next phase in the control of this disease consisted in the strengthening of statutes relating to inspection work, and several States wrote into their laws the prohibition of entry of bees on combs. In other words, only package bees could enter a State. Other States permitted the entry of bees on combs provided they were accom-

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panied by a certificate issued by a responsible State official stating that the apiary from which they came was free of disease. Some States regulate the movement of bees within their own boundaries, making it necessary, for example, for a beekeeper wishing to move colonies to an out-apiary to receive a permit from the State inspector. In some places the sale of used beekeeping equipment is only allowed upon its being accompanied by a certificate showing freedom from disease. With respect to these provisions there is no uniformity in the laws of the various States. Some are very strict and some lenient. Some States have strict apiary laws, but appropriate no funds for enforcement; consequently, the beekeepers receive little or no State aid. They fight their own battles as best they can and blame their neighbours for maintaining nuisances in the way of sources of infection.

In the application of area clean-up methods where the shaking treatment or some variation of it was the sole method of control or eradication, State apiary officials found they were making little headway and, in spite of vigorous efforts, the disease would reappear even in areas in which control measures had been applied for several consecutive years. It was evident that better methods of control were necessary, and thus was reborn the application of fire to diseased colonies.

The tenaciousness with which beekeepers treasure old combs is well known. Even combs composed mostly of drone cells are discarded with great reluctance, and to melt well-drawn-out combs of worker cells, only a few of which are diseased, or which have been used only in the supers of a diseased colony, requires almost superhuman will power. In 1922 Dr. J. C. Hutzelman, of Glendale, Ohio, came to the rescue of such beekeepers. Dr. Hutzelman, who was a practising physician, had had some training in bacteriology; consequently, when he advocated the use of a solution containing 20 per cent. formalin and 80 per cent. alcohol for disinfecting foul brood combs, the beekeeping fraternity immediately took notice. This happened during the days of national prohibition, when the average citizen could not buy grain alcohol to be used in making his own solution. Also the Hutzelman solution was patented. Stories of the success of formalin-alcohol for saving combs appeared in the bee press, and soon many experimenters were trying other concoctions, the principal one being 1 part formalin to 4 parts water. The University of California and the Department of Agriculture tested both the formalin-alcohol and the formalin-water solutions and found that it was possible to sterilize combs with either, provided the utmost care was taken in the preparation of the combs for treatment and in the subsequent handling of the combs.

The use of disinfectant solutions caught the fancy of beekeepers, and many practical experimenters also entered the field of research. Some concluded that, if formalin-water and formalin-alcohol

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mixtures were satisfactory, pure formaldehyde in vapour form would be better. Large metal-lined fumigating rooms holding thousands of combs were constructed. To do a thorough job some beekeepers shook not only diseased but healthy colonies and subjected all combs to the gas ; they thus started again the following year with all their equipment thoroughly sterilized. Package bees from the South were placed on this clean equipment. However, these beekeepers failed to take into account the poisonous nature of formaldehyde, and the fact that, when combs containing films of honey are exposed to formaldehyde gas the honey absorbs it in lethal amounts. Even though well-aired combs may give no odour of formaldehyde, the honey continues to hold the bitter chemical. Naturally, bees placed on such combs died, and many losses were incurred through the use of formaldehyde vapour. In using the water-formalin solution this trouble was not encountered, since the water in the solution usually dissolved any remaining honey.

The next solution to be advocated was chlorine. This chemical was allowed to bubble through tanks of water in which combs were immersed. Although chlorine can be had only in metal cylinders and is an extremely dangerous gas to handle, nevertheless beekeepers tried it and successes were reported with this, as with all other solutions and methods that have been mentioned.

The use of disinfectants, however, met with indifferent success in the hands of beekeepers, for it failed to check the disease to the satisfaction of State officials from the standpoint of using public funds in the most efficient manner. It merely gave them an added reason for resorting to the burning of infected colonies.

When burning was first advocated, the bee journals were full of articles pro and con, mostly con. It was pictured as a wanton, unethical method of dealing with the disease ; the shaking treatment had been used for years and was as good as when first advocated. Nevertheless, some of the braver State apiary officials felt that nothing less than burning should be employed. To enter a person's premises and destroy his property by fire, however, was another matter, and in many cases, instead of the kindly welcome of a beekeeper, the inspectors found themselves face to face with an armed antagonist.

The State of California finally won support of enough beekeepers to amend its statute in such a manner as to specify that all diseased colonies should be burned. The matter was carried to the courts, and after a bitter struggle the practice was upheld as being constitutional.

The burning treatment usually consists in killing the bees with cyanide and burning all bees, combs, frames and honey in a pit at least 18 inches deep. This pit is afterwards filled in, and the hive, including the bottom board, brood chambers, supers and inner and outer covers, is sterilized by thoroughly scraping and washing with lye or strong soap or by scorching with a gasoline torch.

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Most progressive beekeepers in the United States are now in favour of burning. Many would not resort to the old shaking treatment or the use of disinfectants. As a matter of fact, a beekeeper can use any method he sees fit. It is only the colonies found infected at the time of the inspector's visit that must be burned. It is not uncommon to find apiaries that have had an intermittent history of disease for as long as 50 years, their first complete freedom not coming until 3 or 4 years after application of the safe and economical method of burning and burying.

At this point it is well to go back and draw a parallel with respect to developments that have taken place in scientific research on American foul brood. The participation of the Federal Government with respect to this disease has been confined to research. After Dr. White had worked out the life history of the causative organism and had given it the name *Bacillus larvae*, progress was slow and little was added to our knowledge of the disease until Dr. A. P. Sturtevant reported the results of his work dealing with the development of the disease in relation to the metabolism of *B. larvae*. This research explained why the gross symptoms of the disease were so uniform ; the organism simply would not grow in a medium of high sugar concentration. This in turn explained why larvae of feeding age seldom fell victims to the disease ; it was not until after the feeding period and the beginning of quiescence that the sugar content of the gut fell low enough to enable the spores of *B. larvae* to germinate. The organism then did its work quickly. As a result, in American foul brood the diagnostic features are extremely regular, in great contrast to the symptoms encountered in European foul brood.

Just previous to the publication of these results, Dr. Hutzelman announced to the beekeeping world the success of the formalin-alcohol method for disinfecting combs. Out of the tests that the Department of Agriculture and some of the State universities made of the Hutzelman and various other solutions came the recommendation for the use of formalin-water solution for disinfecting combs, and this mixture was found to be fully as efficacious as formalin-alcohol, if not more so. A great many beekeepers used both solutions, and many samples of treated combs were submitted to the Department of Agriculture for sterility tests. Judging from these, the results were fairly satisfactory ; yet in apiaries in which disease seemed to be carefully handled, American foul brood continued to recur. In fact, the general failure of these disinfectants in the hands of beekeepers helped to encourage the adoption of the more drastic method, namely, that of burning.

One of the State experiment stations, after some preliminary research, recommended the use of chlorine. Again many treated combs were sent to the Department of Agriculture for sterility tests, and at first practically all samples appeared to be sterile. The odour of chlorine, however, clung tenaciously to the treated combs. It

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was then suggested that enough chlorine might be retained in the treated scales of American foul brood to inhibit growth while in culture. When the treated scales were washed in distilled water the spores germinated surprisingly well, whereas there was no growth in cultures from unwashed scales. Consequently all samples that were received for testing were washed, and it was found that the same thing occurred with scales that had been treated with formaldehyde, though to a less extent ; that is, formaldehyde, even in small doses, appeared to delay the germination period of the spores. Cases varied considerably, but, in some, germination would not take place for 30 days. Therefore, before a definite diagnosis could be made on any treated sample, it was deemed advisable to keep cultures in incubation for 30 days before pronouncing the sample sterile.

The placing, by some of the States, of embargoes on the shipment of bees on combs suggested to other States the imposition of embargoes on honey, specifying that only honey accompanied by a certificate showing that it had been produced in disease-free apiaries would be allowed to enter. Whether there was a modicum of retaliation in advocating such action or whether it was just misguided faith, in view of the amount of American foul brood in the United States, the time was not ripe to insist upon the certification of honey. The Department of Agriculture looked upon honey certification as inimical to the welfare of the industry, maintaining that the marketing problems did not warrant this additional burden unless the certification of honey did serve its avowed purpose, namely, constitute a worthwhile disease control measure. Dr. A. P. Sturtevant was therefore assigned the task of ascertaining the part played by commercial shipments of honey in the dissemination of American foul brood. At the outset it was conceivable that the spore content of honey from infected colonies would vary considerably. The spore content of honey from the brood chamber would most likely be different from that produced in the supers. Moreover, the honey from a lightly infected colony would have a smaller spore content than that from a heavily infected one. These conceptions in turn presented for answer the question : What constitutes the minimum infectious dose or inoculum for American foul brood ?

Dr. Sturtevant, working at Laramie, Wyoming, where colonies can be completely isolated and where there are no so-called wild bees, fed healthy colonies different numbers of spores suspended in sugar syrup. Briefly, he found that the dividing line was in the neighbourhood of 50 million spores fed in a liter of sugar syrup, for when a smaller number was used most of the experimental colonies did not develop the disease and above that point most colonies did develop typical American foul brood. Various subsequent tests indicated that the minimum infectious dose must be close to this point.

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The next step was to ascertain the spore content of commercial honeys. Samples of bottled honey were procured from shops and groceries in the principal cities of the United States. Filtration and microscopical examination of 212 samples showed the presence of spores in 8 per cent., or 17 samples. These 17 samples were fed to healthy colonies and positive American foul brood developed in only one. Other series of samples have been examined since, with similar results. It was found that the rôle of commercial honey in the spread of American foul brood had been grossly exaggerated.

During the course of this work Dr. Sturtevant also found that the number of spores in culture affected the time of germination. With a large inoculum the germination period was normal, but with progressively smaller doses it would be delayed as much as 30 days.

Laws requiring the certification of honey still remain on the statute books of certain States, but they are for the most part not enforced. The day may come when the United States will be ready to require honey certification as a clean-up measure, but we are yet too far from the goal to use such a measure.

The possibility that there may be strains of honey bees that show some degree of resistance or immunity to American foul brood has attracted many beekeepers. No doubt this is born of a great desire to have a better weapon than chlorine, formaldehyde, or fire. American foul brood is one of the most costly items with which beekeepers in the United States have to contend. A beekeeper operating an apiary in a locality where American foul brood exists, scarcely dares to perform any colony manipulation without keeping in mind the possiblity of finding the disease. Authentic cases have been found in which colonies have cleaned up the disease, and in the course of experimental work it is not uncommon to find colonies that can be inoculated only with difficulty. There is also the example of Italian bees being superior to black bees in ridding themselves of European foul brood. Consequently, there is some basis for thinking, or hoping, that a disease-resistant strain may be found and perpetuated. The United States Department of Agriculture, in co-operation with several of the State agricultural experiment stations, is outlining a series of experiments to delve into the matter, and a number of outstanding specialists have been enlisted to help with the work. Not the least of these will be geneticists, since breeding will be one of the important features of the investigation. Whether or not a resistant strain is found, or a strain possessing physiological immunity or such characteristics as will enable it to maintain itself free or partially free of the disease, makes little difference. Even if such ends are not attained, much good is bound to come from these experiments, as the complete story of American foul brood is yet to be told.

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