ROTHAMSTED RESEARCH

Diseases of Bees

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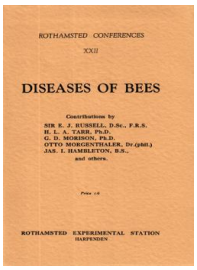

XXII. Diseases of Bees

Sir E. J. Russell

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ROTHAMSTED CONFERENCES

XXII

DISEASES OF BEES

Contributions by

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XXII

DISEASES OF BEES

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DISEASES OF BEES

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON SEPTEMBER 26TH, 1936, UNDER THE CHAIRMANSHIP OF

SIR E. J. RUSSELL, D.Sc., F.R.S.
(Director of Rothamsted Experimental Station)

With contributions by

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INTRODUCTION

By Sir E. J. Russell, D.Sc., F.R.S.

The Conference at which the following papers were read was the third of its kind held at Rothamsted. The Reports of the two previous ones proved so acceptable to beekeepers that the editions were soon exhausted ; a larger edition is being printed this time so as to avoid this possibility. This Conference is in several ways far more important than its predecessors : it gives the results of Dr. Morgenthaler's wide experience on the subject, which he himself came over to present ; it gives also the results of Scottish experience, presented by Dr. Morison, and of American experience, kindly contributed by Dr. Hambleton, who, although he could not be here in person, sent his paper on to be read and printed. Finally it sets out the results of an investigation made here on Brood Diseases of bees by Dr. Tarr, in general consultation with Mr. Morland and Dr. Williams, during the past three years. The work was made possible by the co-operation of the Ministry of Agriculture and the Agricultural Research Council on the one hand, with the Beekeepers' Associations working through the British Bee Keepers' Association on the other : the first time such collaboration has been possible, and a great tribute to the organising ability of the officers of the various associations concerned.

As a result of this work Dr. Tarr has been able to establish a clear distinction between American Foul Brood and European Foul Brood ; he has isolated and studied the organism (a bacterium) responsible for the former and is well on the way to clearing up the complexities of the latter ; he has shown that a third disease, the so-called Addled Brood, is very prevalent, and has worked out its cause and indicated a remedy.

The work has been supervised on the beekeeping side by the expert Bee Advisory Committee at Rothamsted and on the scientific side by Dr. Williams and by Dr. Schütze of the Bacteriological Department of the Lister Institute. All the experts who have examined the work agree that it is unusually good and that the results can be accepted as trustworthy.

It is hoped therefore that the investigations can be continued and extended to other diseases of bees, particularly of adult bees.

There is every reason why the work should go on. Interest in beekeeping is undoubtedly increasing. There are no definite figures, no census having been found practicable, but the increase is undeniable. The reason is clear : beekeeping is a very interesting activity for the amateur and a promising line for the professional.

It adds greatly to the pleasure of gardening ; it gives a new interest to the man who has retired from a busy life in the town to a quieter life in the country ; it is an indispensable adjunct to the growing of fruit—which is considerably increasing in this country. Further, it caters for a healthy and growing public demand ; for honey is a healthy food, supplying in a very agreeable form something not easily obtainable elsewhere, and which more and more people are learning to appreciate and desire.

Further evidence of the interest now being taken in beekeeping and in honey production is that a National Mark has been established for honey. Owing to certain difficulties of definition it was found necessary to carry on investigations into the properties of honey ; these have been started at Rothamsted under a grant provided by the Ministry of Agriculture and the Research Council. It is not unreasonable to suppose that these official bodies were influenced in their decision to bear the whole cost of this work by the fact that the beekeepers were already showing the reality of their own interest in the matter by providing funds for the study of bee diseases.

The Conference, having heard the papers, unanimously carried the resolution moved by Dr. Gregg and Dr. Thompson urging that the work should be continued. It was very gratifying to the Rothamsted Staff that two such well-known authorities should have thus supported their work. We at Rothamsted are prepared to carry on the work : it remains only for the Beekeeping Associations to do their share. With co-operation and good will, success is bound to come.

BROOD DISEASES IN ENGLAND: THE RESULTS OF A THREE-YEAR INVESTIGATION

By H. L. A. Tarr, Ph. D.

(Rothamsted Experimental Station, Harpenden, Herts.)

In the time available it will only be possible to summarize briefly the results which have been obtained since the inception of the brood disease research scheme at Rothamsted. In doing this it will be necessary to assume some knowledge of the common characteristics of the various brood diseases: so much has been said and written about them recently that this demand would not appear unfair. The fact that there is indeed a multiplicity of brood diseases in England must be emphasised. Statements to the contrary have been and are being made by individuals who occupy prominent positions in beekeeping in this country: such statements are definitely erroneous. The fact that there is a multiplicity of brood diseases is of considerable importance when one has to consider their treatment.

Since May, 1934, two hundred and five samples of diseased brood have been sent to the laboratory and the following diagnoses have been made: American foul brood, 104; Addled brood, 58; European foul brood, 13; Chalk brood, 11; American foul brood and Addled brood, 1; American foul brood and Chalk brood, 1; chilled or neglected brood, 4; spray poisoning, 1; Sac brood, 4; drone laying queen and decomposing brood, 5; and drone laying queen and Chalk brood, 3. Though it cannot be stated that these figures denote the actual proportion of brood diseases in England, they certainly are of value in that they give some indication of their distribution, the proportion being relatively constant from year to year. It is practically certain that the distribution of the different diseases could not have been foretold prior to the commencement of the investigation. So far most of the time has been devoted to experiments designed to determine the causes of the three most prevalent brood diseases, for without this knowledge it would be difficult to devise treatment. The results of experiments relating to the different diseases will be discussed separately.

American foul brood

The examination of numerous samples has led to a verification of the fact that the spores of *Bacillus larvae* are almost invariably present in apparently pure culture in the ropy remains and scales of larvae dead of this disease, and further that this organism causes the disease. A number of experiments have been carried out in order to determine the relationship of *B. larvae* to the cause of American foul brood. It has been found that disease is caused by feeding decaying larvae, dead of American foul brood, to bees of healthy nuclei even when the material is suspended in water and heated for twenty minutes at 85°C (185° F), the spores of the causal organism resisting this temperature readily. Heating under steam pressure at a high temperature killed the spores of *B. larvae*, and material so treated was no longer capable of initiating disease. After considerable trouble a culture medium upon which *B. larvae* grew and sporulated readily was evolved : most media upon which this organism grows readily will not support spore formation. Suspensions of the vegetative cells and of the spores of *B. larvae* were prepared upon this medium and were employed in a series of infection experiments.

Vegetative cells of *B. larvae* when introduced into healthy nuclei by feeding the bees, feeding the larvae directly, or spraying the bacteria over developing brood, have in no experiment so far produced disease. Thus in two different experiments, approximately 170,000 million and 80,000 million vegetative cells prepared on the same medium as that employed for obtaining spores, were sprayed over eggs and developing larvae of healthy nuclei and no disease developed. Toumanoff, working in France, obtained similar results. With spores of *B. larvae*, obtained from pure cultures of the organism, American foul brood was readily initiated, providing a fairly large dose (mass inoculum) was employed. It was also found that a very much smaller inoculum of spores was effective in producing the disease, when the developing brood of the nucleus was sprayed directly with them than when they were fed to the bees in syrup. In one series of experiments, in which the same spore suspension was employed throughout, nuclei in which the brood was sprayed with approximately 620 million or 62 million spores soon developed American foul brood, while the disease did not develop in a nucleus receiving only approximately 6.2 million spores. When the spores were fed to the bees in syrup instead of being sprayed over developing brood, disease resulted in nuclei receiving approximately 62,000 million or 6,200 million spores, but not in those receiving approximately 620 million or 62 million spores. Sturtevant, working in the United States, found that a colony of bees would not develop American foul brood unless it received at least 50 million spores of *B. larvae* fed to the bees in 1 litre of syrup, the spores used in his experiments being derived from scales of larvae dead of the disease. The above work confirms, in general, his results. The fact that the

limiting infective dose in Sturtevant's experiments was considerably smaller than that used in the above described experiments may be because *B. larvae* rapidly loses virulence following cultivation on laboratory media. It seems highly probable that a few resistant endospores become established in the guts of very young larvae, and that once established they resist the digestive processes until conditions which favour their development arise, while the less resistant vegetative cells of the organism are rapidly killed under identical conditions.

It is of interest that, in these experiments, relatively large doses of vegetative cells of *B. larvae* would not cause American foul brood to develop. If a method of keeping this organism in the vegetative stage could be devised, then the control of the disease in infected colonies might be simplified. Unfortunately the possibility of doing this seems rather remote.

The results obtained have shown that American foul brood is the most prevalent brood disease in England, that it is a distinct disease caused by a resistant spore forming bacillus, and that a mass inoculum of spores of the organism is required to initiate the disease. So far no attempts have been made to study methods of controlling this disease. The very nature of the disease makes the possibility of obtaining a simple chemical remedy an extremely doubtful one, and it is not proposed to encourage any false hopes in this direction. Practical measures of control are known and the value of these under the conditions which pertain to this country must be determined.

Addled brood

The fact that this complaint should occupy such a prominent position with reference to the total number of brood diseases was not foreseen when the investigation commenced. Should the treatment of this very prevalent disease be as simple as is indicated by preliminary experiments we may well be pleased that so much of the disease is of this type and not so-called " foul brood." Before discussing the results obtained in practical experiments it is essential that brief reference be made to the somewhat scanty pertinent literature.

Throughout the past few decades numerous references have been made in the German literature to " Eitaubheit," a disease of bees in which apparently normal, fertile queens lay eggs which never develop. There is no adequate equivalent in the English language for this name and it is best expressed as Addled egg disease, the eggs being known as "Addled eggs" (Taube Eier). References to the condition in which brood dies at some stage prior to reaching maturity have been far less numerous in comparison. As far as I have been able to ascertain the late Dr. Leuenberger was the first to describe Addled brood though he did not actually employ this term. In one case of Eitaubheit he observed that a small

number of eggs succeeded in hatching, but that the larvae which developed from them, a few of which were sealed over by the bees, died before reaching maturity. This seems to have been a mixed case of Addled eggs and Addled brood, the queen being responsible for the condition. In 1925 Anderson described cases of Addled brood in Scotland. These cases were marked by the fact that practically all the sealed brood died just prior to the time of emergence, but occasionally addled eggs (eggs which did not hatch) were noticed, and, of the bees which did succeed in developing, many could not fly. The disease could be produced in healthy colonies by introducing queens from affected stocks to them, while requeening affected stocks with normal queens always cleared up the disease. Moreaux, working in France, has also recently described a case of Addled brood. His paper appeared at about the same time as the 1935 report on brood diseases was issued from this Station. In the last named article the appearance of larvae in cases of Addled brood (" Uncertain ") was described in some detail. It appears that the numerous cases of diseased brood received at this Station in which at first no accurate diagnosis could be made, and which were temporarily designated " Uncertain," were, in reality, cases of Addled brood. Unfortunately there is not time to describe in detail the appearance of larvae dead of this disease. Normally the pupae or prepupae are attacked, the appearance of the dead brood being similar to that noticed in larvae which have died and undergone autolysis. Usually these larvae are almost, or quite, sterile bacteriologically. The results of a series of experiments which have been carried out in order to ascertain the cause of the complaint leave no doubt that it is, in effect, Addled brood. There is every indication that the complaint can vary greatly in severity. Thus in some colonies relatively few Addled pupae are seen, and such a colony may show few or no external symptoms of weakness. On the other hand some stocks may be badly affected, and become so weak that they store no surplus honey and may even fail to resist the winter. It seems fairly certain that the cases investigated by Anderson merely represented very severe Addled brood in which very advanced pupae were those chiefly affected.

In three years, fifty-eight samples of Addled brood have been sent in, representing about 28 per cent. of all the samples received. Preliminary experiments showed that the disease, unlike American and European foul brood, is not contagious : combs containing an abundance of affected pupae when placed in healthy nuclei never caused disease. During the past season queens taken from affected stocks have been obtained from certain beekeepers, and several of these have been successfully introduced to queenless nuclei. In every case in which such a queen was accepted, the nucleus concerned soon showed signs of Addled brood ; a certain proportion of the sealed brood produced by the queen, dying before reaching maturity. When the affected queen was removed from

such a nucleus normal sealed brood soon appeared, following the introduction of a healthy queen. It seems that the disease is not necessarily one of old queens, for queens mated in 1936 have been found to produce Addled brood. One experiment has shown that drone as well as worker pupae are affected; this might be taken to indicate that the queen is directly responsible for the trouble and that the drone plays no part. The fact that eggs and very young larvae, when inserted in an affected colony, have been observed to develop normally, supports the idea that the queen causes the malady and that it is not due to lack of attention of the larvae by the nurse bees.

Though the superficial cause of the disease is a defective queen, the fundamental cause remains to be determined. The defect may be hereditary, the queen possessing some "lethal factor," or the queen may suffer from some infectious disease or from some abstruse pathological abnormality. This remains to be determined. Since further experiments on the control of this disease are needed, it is hoped that beekeepers who experience the complaint will try requeening affected stocks and will notify this Station of the result. The importance of continued investigation can readily be foreseen, especially in view of the fact that the queen breeder must at all costs eradicate the disease from his apiaries.

European foul brood

At present it appears that this disease is not widespread in England, but the fact that it does occur, that it is highly contagious, that it causes more trouble than American foul brood in Switzerland, and that its cause has been in doubt has made it advisable to investigate it thoroughly. If more is known about it, then it will be easier to employ measures to prevent its spread should it again show signs of increasing.

Larvae affected with European foul brood, unlike those dead of American foul brood, exhibit a very varied bacterial flora, and this fact has greatly complicated the determination of the cause of the disease. The remarkable confusion which has existed with reference to its etiology, has been referred to in a number of publications. The results of preliminary experiments carried out here, led to the suggestion that European foul brood might not be a single disease, but that it was, perhaps, a mixed bacterial infection of the brood of weak stocks of bees. Further experiments carried out during the past season have shown that this hypothesis was erroneous, and that the disease is, in fact, a single one in which various modifications may occur.

White (1912-1920) working at the United States Department of Agriculture, concluded, on the basis of a large number of experiments, that European foul brood was a single disease caused by a lanceolate-shaped coccus organism which he termed *Bacillus pluton*. He was unable to cultivate this organism on any laboratory

DISEASES OF BEES

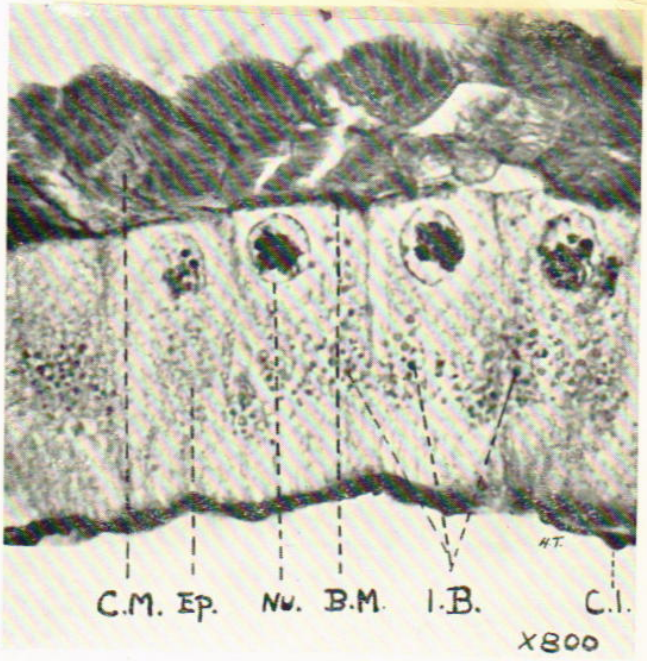


Fig. 1. Photomicrograph (×800) of a portion of a transverse section of the anterior end of the small intestine of a worker bee suffering from Bee Paralysis. The section was stained with safranin and methyl violet. B.M., basement membrane; C.I., chitinous intima lining the cavity of the small intestine; C.M., circular or transverse muscle fibre; Ep., epithelial cell with its nucleus Nu.; I.B., inclusion bodies which seem to be found only in bees suffering from Bee Paralysis.

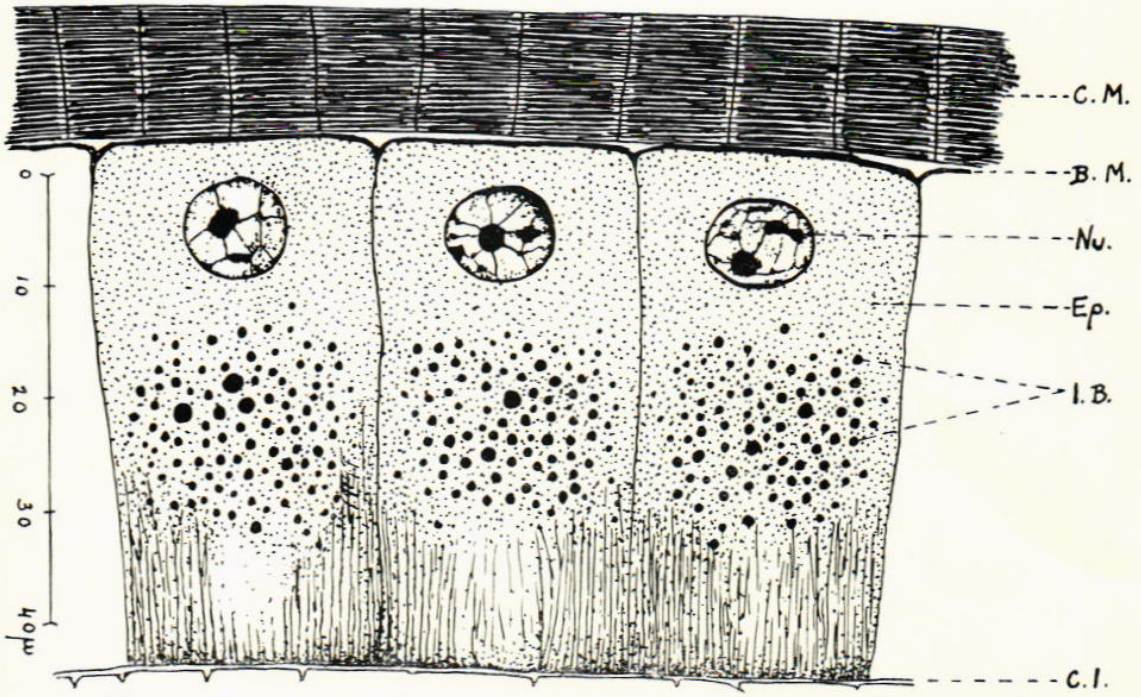


Fig. 2. Drawing made from a similar section. The legend is the same.

bees taken from brood combs containing large numbers of larvae sick or dead of European foul brood have quantities of bacteria in their rectal ampullae. Among these the secondary invaders found in European foul brood are usually most prominent, especially *B. alvei* and small rod-shaped bacteria, but *B. pluton* organisms are frequently present. European foul brood has been produced in a healthy nucleus by spraying an aqueous suspension of the gut contents of six such bees recently taken from an infected colony over the developing brood, but it is not known how long the parasite will remain alive in the gut of the bee. It is extremely doubtful if *B. pluton* multiplies in the digestive tract of the bee. All attempts to demonstrate *B. pluton* in the pharyngeal, mandibular or salivary glands of nurse or house-cleaning bees taken from infected stocks, either microscopically or by means of infection experiments, have failed. So far no evidence has been obtained which indicates that this organism multiplies elsewhere than in the gut of the young larva.

Queens from infected stocks have in no instance caused disease when introduced into healthy queenless nuclei. In these experiments the queen and 12 young worker bees were removed from the affected stock and were caged from 1-2 days with candy as the sole source of food prior to introduction. These results verify those obtained by Morgenthaler and his associates working in Switzerland.

European foul brood has been induced in healthy nuclei early in the brood rearing season by suspending in them combs containing large numbers of decomposing larvae artificially infected by feeding them pure cultures of *S. apis* or *B. alvei* and subsequently starving them for four days at hive temperature. These results have been obtained in each of two consecutive seasons. It has been found that when the disease is initiated in this manner it never appears as soon as in nuclei infected directly with *B. pluton* cells taken from the gut of a young infected larva, especially when this organism is sprayed directly on the eggs and young larvae. There seems to be a definite lag period, usually of about three weeks, during which no infected larvae are seen. It might be inferred from these experiments that *B. pluton* normally exists in colonies of bees waiting for suitable conditions to multiply, and that these conditions can be induced by putting into the colony very large numbers of decomposing larvae which have been artificially infected with secondary invaders found in European foul brood. This is only a suggestion which must be verified by further experiments. So far all attempts to induce European foul brood in healthy nuclei by " artificial weakening " (removing bees or sealed brood and giving a surplus of eggs and young larvae) have failed, but these experiments were not carried out early in the brood-rearing season. Normally European foul brood can only be induced readily in the early part of the brood-rearing season, and, unlike American foul brood, disappears, or tends to disappear, toward the close of the brood rearing.

A thorough study of the control methods employed in the case of European foul brood must be made. In two cases in which swarms from colonies affected with European foul brood were hived on fresh foundation in clean hives the disease did not reappear. In another case in which a swarm was hived on drawn comb the disease soon broke out again. It is not improbable that the shaking method will prove of value in eradicating European foul brood in very obstinate cases of the disease which have failed to respond to the usual requeening treatment.

BEE PARALYSIS

By G. D. Morison, Ph.D.

(North of Scotland College of Agriculture, Marischal College, Aberdeen, Scotland)

I have to apologise for the incompleteness of these notes, which is due to my not having had sufficient time to study the data at my disposal.

Definition: Bee Paralysis is a disease of adult workers, queens and probably drones, and it seems to attack all the common races of honey-bees kept in Great Britain. The affected stock dwindles slowly or more or less rapidly, owing to loss of adult bees. When the stock dwindles slowly, usually a percentage of only older (foraging) bees are affected. In a stock dying rapidly, foragers and younger bees are affected. Bees usually die away from the hive, but they may die scattered in front of the hives or even clustered in small numbers, resembling certain cases of acarine disease. The climatic conditions probably greatly influence the behaviour of bees outside the hive.

When a small percentage of bees is affected, some or all the diseased are hustled away from the hive by their seemingly healthy sisters. These diseased bees are lively with the abdomen not abnormally distended. They try again and again to enter the hive, but each time their healthy sisters forbid their entry, usually without attempting to sting them and often licking them as if to remove a substance from their bodies. The diseased bees lose their hairs in the struggles and they appear polished, darker and smaller than their sisters. In the end they may become almost hairless. They are often mistaken for robbers. Apparently they die from starvation and exposure outside the hive.

A small percentage of bees may be affected without the above mentioned behaviour occurring.

When a large percentage of bees is affected the stock is lethargic, the frames are not, or only slightly marked with faeces. The diseased bee moves its antennae normally ; it flutters its wings considerably, but it cannot fly and it may not be able to right itself if turned on its back. The leg movements for walking are weak and the legs may tremble frequently, finally the bee dies lying more or less on its side with its legs tucked in or spread out in various ways. The mouth-parts are held rather extruded soliciting drink and the bee

continually tries to suck up fluids, but apparently without success. The bee attempts to clean itself or its neighbours with its mouth-parts. *It dies with the mouth-parts widely extended.*

"Respiratory" movements of the post-abdomen are variable, ceasing with loss of movement of wings and legs. The sting will often function on the stimulus of pressure shortly after other movements have apparently ceased. The post-abdomen is usually abnormally distended by the contents of the alimentary canal. The abnormal distention is usually due to :

1. Pale watery contents of the rectum,
2. Normal-looking but abnormal quantity of rectal contents,
3. Rectal contents normal in volume but proventriculus greatly distended with sugary solution.

The thorax and post-abdomen are usually rather polished through loss of hair which has probably been rubbed off by the diseased bees licking one another. The surface of the body may be coated with a very delicate film of sticky substance which, I think, is largely faecal in origin. This faecal matter seems to be passed out in very small droplets. It forms a good stratum for bacteria, which may easily contaminate smears of the blood of the bee. An obnoxious smell, often described as "fishy" may be associated with diseased bees. It may be due to secondary and tertiary amines in the faeces and it may be the chief reason for the eviction of the diseased bees by their healthy sisters.

To sum up, the chief characters of the disease are :—

1. Distended post-abdomen,
2. Trembling of wings and legs,
3. Distended mouth-parts and the bees die with them distended,
4. Exceptional thirst,
5. Loss of hair,
6. Fishy smell,
7. Inclusion bodies in cells of small intestine.

Periods of Disease.—The disease may exterminate a stock within a few weeks or months, but its course is affected by many factors and the stock may recover by itself, or with the conscious aid of the beekeeper. The individual bee seems to succumb to the disease, which may be found during any month of the year, though it is commonest during May-July. It may reappear after disappearing for some months.

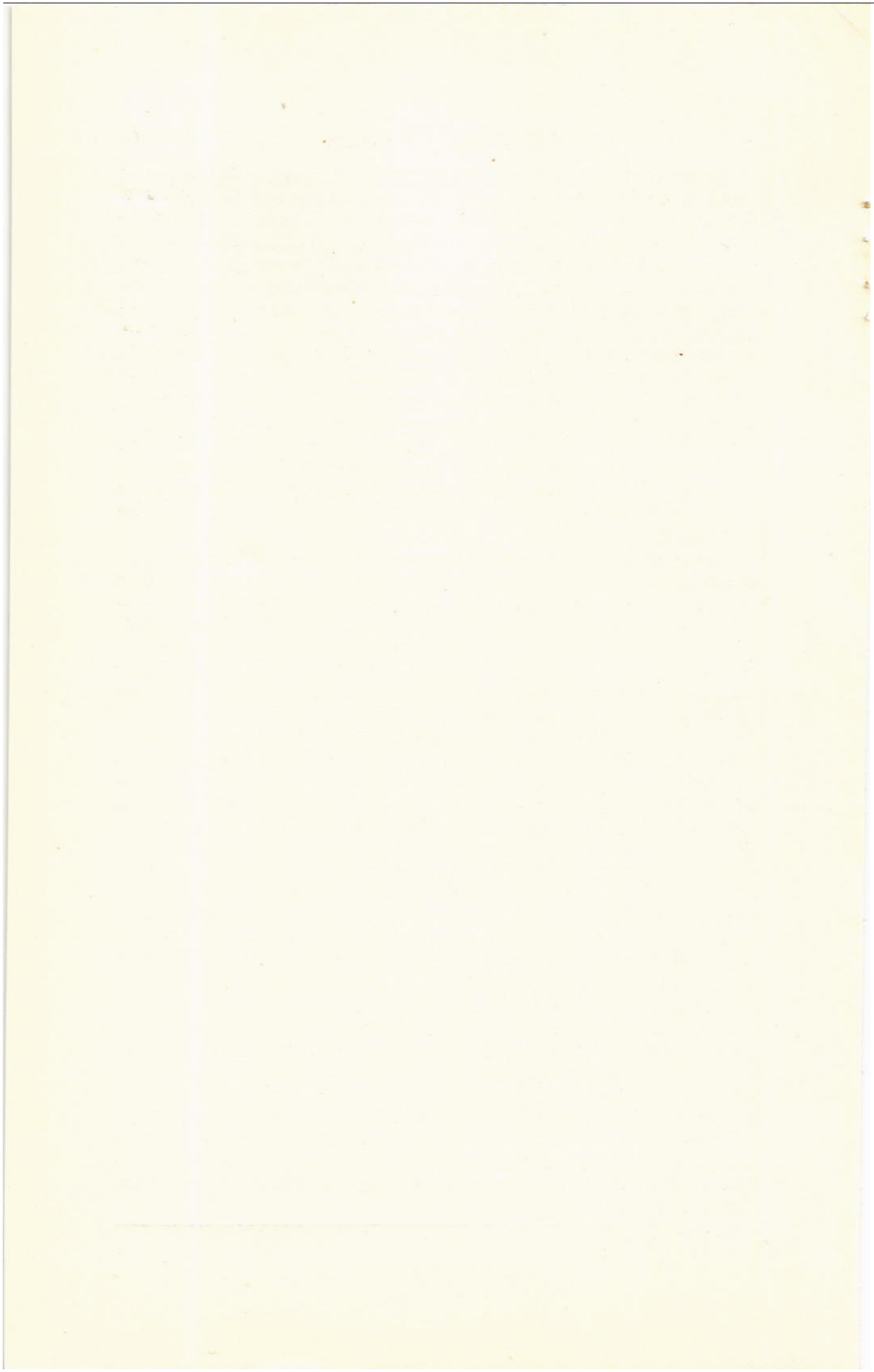
Distribution in Great Britain.—Based on my records for the last ten years and including about 140 cases, the disease occurs throughout England and Wales and in Scotland at least as far north as Aberdeen, but it is much scarcer in Scotland than in England.

COMPARISON WITH OTHER DISEASES.—The disease is also called "Black Robber Disease," from the appearance and behaviour of the bees in certain cases. It may be the disease noted by Cheshire, who ascribed the cause to an organism he called *Bacillus gaytoni*. Unfortunately he did not publish a detailed investigation of the disease or the Bacillus. Certainly, abnormal numbers of bacteria are often present in the alimentary canals of diseased bees and they deserve study. Bee Paralysis resembles the diseases known as May-Sickness, Paratyphoid, Septicaemia, Schwindsucht, Schwarzsucht, Bee Paralysis in America and intoxication and some other diseases associated with fungus or yeasts in the alimentary canal. It may be the Schwindsucht or Schwarzsucht of writers in German, and it may be the Bee Paralysis of America, though Prof. Phillips, on seeing a stock affected with the disease, said that it was not American Bee Paralysis. The symptoms suggest that the disease is located in the alimentary canal and that later paralysis of the nervous system sets in.

INCLUSION BODIES.—The diagnostic characters of Bee Paralysis are not very satisfactory since they are shared by many other diseases. What one wants is a character peculiar to the disease—as for instance the presence of *Nosema* in the alimentary canal indicating *Nosema* infestation. As far as I am aware, no microscopic character diagnostic of the disease has hitherto been found. I now think that I have found such a character. It exists in the form of minute spherical or ellipsoidal bodies which I call "inclusion bodies," inside the cells of the anterior end of the small intestine.* The bodies measure 1-5 microns in diameter, the largest bodies occurring in the cells of the small intestine just behind the openings of the Malpighian tubes and they become smaller the further back they lie till they disappear at about the end of the first quarter of the small intestine. Large numbers are grouped together in each cell. They lie most abundantly between the nucleus and the inner wall of the cell. I have found these bodies in all bees that I considered afflicted with Bee Paralysis and not in bees suffering from other diseases, nor in healthy bees of different ages or at different stages of activity. They are not described by writers on the histlolgy and cytology of the alimentary canal of healthy bees.

What are these bodies? I suggest that they may be "inclusion bodies" like those found in animals and plants suffering from certain virus diseases. If the suggestion is correct, Bee Paralysis is a virus disease, which may be diagnosed by these bodies in the cells of the fore end of the small intestine. Since the bodies do not occur in healthy bees they are not likely to be metabolic products of a normal bee. They do not appear in the cavity of the small intestine or in the rectum amongst the faeces or in the blood. On the whole, I think that the evidence is against their being bacteria, fungi or yeasts.

*Figs 1 and 2.



TECHNIQUE.—I have not yet succeeded in seeing these bodies in fresh tissue or in tissue which is preserved but not sectioned and stained, but this is due chiefly to the difficulty of freeing the cells from the thick layer of muscles and the cuticle between which they lie. The method I adopt is to fix the alimentary canal from the living bees in Bouin's fixative, then pass it through the usual reagents to embedding in paraffin wax. The sections are stained with safranin and methyl violet, resulting in the inclusion bodies being stained bright red by the safranin and clearly differentiated from the surrounding tissue which is stained various combinations of violet and red. Other fixatives and stains will demonstrate the bodies, but the staining is not so differential.

TREATMENT.—The most satisfactory treatment for Bee Paralysis is feeding with syrup (1-2 lbs. per B. S. frame of bees), unless a honey-flow happens to coincide with the outbreak of disease and the stock is strong enough to take advantage of the flow. A change of queen is desirable since there is some evidence that a diseased queen is able to transmit the disease to workers. The disease does not spread easily in an apiary. There seems no need to burn the equipment of a stock which succumbed from this disease alone, yet it seems wise to keep the equipment of an affected stock confined to the single hive.

In conclusion, Bee Paralysis is a field of research where many workers would find problems of scientific interest and practical importance.

BROOD AND ADULT BEE DISEASES IN SWITZERLAND

By Otto Morgenthaler, Dr.(phil.)
(Eidg. milchwirtschaftliche und bakteriologische Anstalt, Liebefeld bei Bern. Director: Professor Dr. R. Burri)

First of all I should like to thank Sir John Russell and the Bee Research Advisory Committee, who invited me to to-day's meeting, for the great honour of being able to speak to you. I know that this honour does not apply to me personally but to my country, and especially to my friend, Dr. Leuenberger, who died in March of this year, and who 28 years ago gave us a foul brood law and, for German-speaking Switzerland, a foul brood insurance, which up to the present has fully stood the test, technically and administratively, and has given beekeepers complete satisfaction. Since the English Bee-keepers are also working toward a foul brood law and a foul brood insurance, I shall speak to-day principally about our experience with foul brood and only at the close shall I briefly touch upon our anxieties and our successes with diseases of adult bees.

Time does not permit me to go into detail, and this is not necessary, as Mr. Illingworth, two years ago, has given you an excellent account of bee disease legislation in Switzerland. So I shall emphasize only three points which to me seem important for the success of the Swiss method. I shall be very glad to give information about special points in the discussion.

The first important step was that we were able to convince our government of the economic importance of beekeeping. By so doing, bees were accorded the same legal protection as other domestic animals. Bee diseases were included in the federal animal disease law and now there are government funds for their control as for combating other animal diseases. The federal veterinary office gives yearly about 10,000 fr. for the control of bee diseases; that is to say, mostly for salaries to the bee inspectors for their work among sick colonies. The cantonal governments together give an equal amount for this purpose. The beekeepers do not give any contribution either to the federal government or to the canton. We find that this sacrifice on the part of the government is not too high if we consider the total expenditure for the control of all animal

diseases. The federal government contributes about 1,000,000 fr. annually for the control of all animal diseases. The contribution for bee diseases (10,000 fr.) is therefore only about 1 per cent.

The second important point is that the beekeepers, in spite of this government aid, have retained full autonomy in the control of bee diseases. Apiculture has its own peculiarities and needs which must be followed if one wants success. It is of little use to be a good veterinarian. To know all the diseases of the other domestic animals does not make one a good bee doctor. The first qualification for our bee inspectors is not that they be good veterinarians or good microscopists, but they they should be good beekeepers. They are trained in special courses for their position as bee inspectors. We can say that in Switzerland the matter is regulated thus : the government gives the money and the beekeepers do the rest. There is a mutual confidence whereby both parties are satisfied.

The government should not be drawn in more than absolutely necessary. For this reason our foul brood insurance is private, that is to say, it is the affair of the beekeepers' society. This requires first of all that beekeepers have a strong central organisation. This condition is fulfilled in Switzerland. Thus it was possible that, with the very small insurance premium of 5 centimes per colony, 100 per cent. of the value of the diseased hive could be paid out as an indemnity. Besides a reserve fund could be created which at present amounts to about 50,000 fr. This sum even enables us to meet unexpected situations.

Each local beekeeper's association has also a special fund for the control of bee diseases ; that is to say, chiefly for the sanitary inspection within its territory.

The third important point is absolute certainty of diagnosis. The whole control of a disease is impossible as long as there is confusion in the diagnosis. Our inspectors are not scientists, they might make a mistake in this matter. Anyone who has much to do with bee diseases knows how closely certain diseases and anomalies resemble each other externally. For this reason it is required that all diagnosis be made in the laboratory. The bee division of the Liebefeld Experimental Station performs this task as well as research work on still unknown bee diseases. It was founded by Professor Burri who, in 1904, was the first to give a clear bacteriological differentiation between the two kinds of foul brood. The bee division at Liebefeld (including a department for pollen analysis of honey) gives work at present to six people Its annual budget is about 50,000 fr. The division is not under the authority of the veterinary office but under that of the agricultural department. Still we do not find these 50,000 fr. disproportionate, since the expenditure of the agricultural department for agricultural experimental stations is about 1½ million francs annually. The expenditure for bees amounts to only the thirtieth part of this total.

With the aid of two Figures I should like to make you better acquainted with our experience with foul brood. The first shows

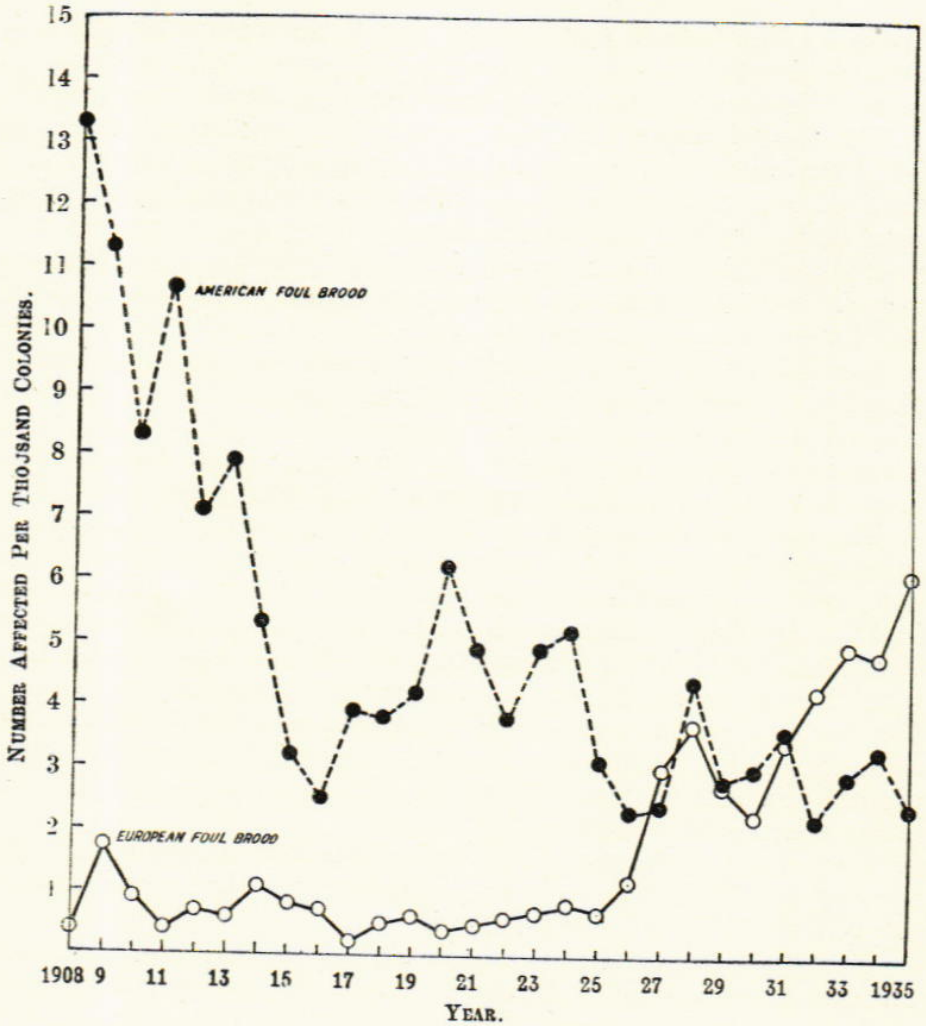


FIGURE 1.

the total number of cases of American and European foul brood from 1908 to 1935, taken from the reports of Dr Leuenberger. I am afraid you will be disappointed on examining this table to see that the success of which I have spoken has reference only to one form of foul brood, namely, American foul brood. We see a pronounced reduction of this disease from about 13 per thousand colonies in the year 1908 to about 3 per thousand in the year 1935. This is the splendid result of Leuenberger's organisation. The control method consists in burning the combs of a sick colony and shaking off the bees as an artificial swarm. The hive is disinfected with a flame and, what is most important, the apiaries of the entire neighbourhood are inspected repeatedly. In this way it has been possible to free large areas from American foul brood. If we have not yet succeeded in entirely banishing this disease from our country it is not the method which is to blame. I emphasize this because recently in America and in Germany certain workers

have criticized the artificial swarm method and have wanted to burn the bees also. In answer to them we can point out that with us the artificial swarm method has proved a complete success in 28 years of practice. It is not this method which is to blame for the fact that we still have 3 cases of American foul brood per thousand colonies, but human imperfection, which again and again prevents the clear regulations for complete inspection, and eradication being correctly carried out.*

The curve which shows the occurrence of European foul brood since 1908 runs in quite another way. This disease was formerly scarcely known in German-speaking Switzerland. But during the last few years it has begun to increase seriously, and is now already more than twice as prevalent as American foul brood. This increase of European foul brood during the period in which we have successfully treated American foul brood was very painful for us, and we had to conclude that our methods of fighting European foul brood were inadequate. What were our control methods and our ideas with respect to European foul brood?

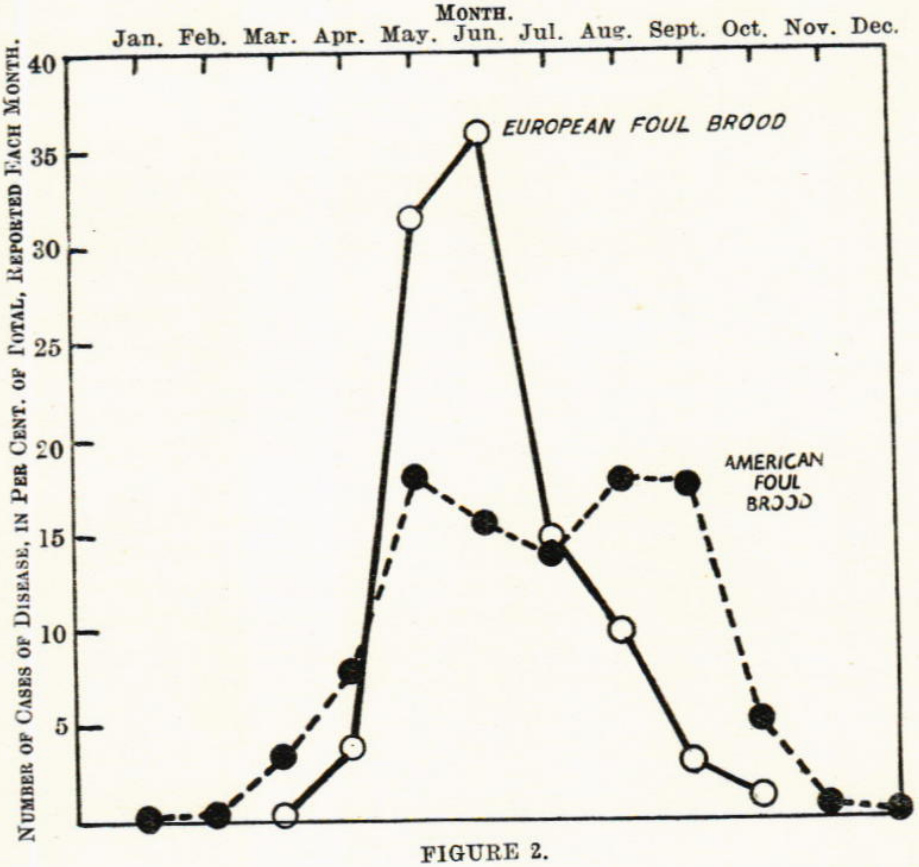


FIGURE 2.

* It is easy to prove that the shaking method, when carefully carried out, is really effective, but whether it is too complicated for official use in every country is a matter of controversy. We are of the opinion that this is really a question of the education of the beekeepers.

As we see, this disease played almost no rôle formerly and furthermore it was observed that it sometimes disappeared again spontaneously. We therefore did not bother ourselves much about it. We also became acquainted at this time with the opinion held in the United States, where on the basis of a very wide experience, European foul brood was represented as a deficiency disease, as a disease which only appeared where there were bad beekeeping methods and where the colonies, especially in spring, suffered from hunger, or for some other reason could not develop well. This hypothesis of a deficiency disease was also strongly supported by the very remarkable seasonal occurrence of European foul brood. I find this seasonal occurrence so interesting and so important for an understanding of European foul brood that I should like to discuss it briefly with the aid of Figure 2. You find here again American and European foul brood represented by two lines. The months are indicated above and directly under each month the number of cases of foul brood, in per cent. of the total for the year, observed in this month.† Let us first examine American foul brood. Naturally we have few cases in winter because few inspections are made then. But from spring until autumn one can always demonstrate the presence of this disease. We say that we can easily find American foul brood in a diseased colony at any time.

It is quite different with European foul brood. It begins slowly in spring, is often scarcely to be demonstrated in the first brood period in April, but increases rapidly, reaching a peak in May and June, then falls back again just as quickly. In autumn, when American foul brood is still very easily demonstrable, European foul brood has practically disappeared without any treatment, but will return again next May and June. We are surprised at the similarity between the seasonal course of European foul brood and that of Nosema infection. Nosema is also most pronounced in May, and apparently disappears in autumn, only to reappear the following spring.

We have no certain explanation for this remarkable seasonal occurrence of European foul brood, but it is understandable that one is inclined to find an explanation in the deficiency theory. May and June are also highly important months for normal bees. The time of greatest growth, of greatest breeding activity, of the mighty impulse for expansion of the bee colony is found at this time. It is a critical period. In the case of other living creatures and also in the case of man, one speaks of a growth crisis. This growth crisis of the bee colony coincides, unfortunately, all to often with a weather crisis, a setback in the weather in May. Instead of spring warmth and a rich flow of honey, hunger and cold invade

†This figure shows all the cases of foul brood received at Liebefeld during the past 30 years. (About 1,500 cases of American and 1,200 cases of European foul brood.)

the hive, and then, even without the influence of bacteria, through undernourishment and lack of warmth alone, the colony can get into a wretched condition.

This temporal coincidence of the European foul brood peak with the growth and weather crisis in colonies has led to the obvious interpretation that European foul brood is merely due to insufficient nourishment and insufficient warmth ; that is to say, a deficiency disease. We do not deny that one can often observe cases where the disease after a good honey yield or after packing and artificial feeding has disappeared again. But recent years have shown us with all clearness that the nature of the European foul brood is not sufficiently characterized by the designation " deficiency disease." We have had several excellent years since 1930 and, in spite of this, the disease has spread. We have also often found a very marked European foul brood infection in vigorous colonies that had plenty of honey and pollen. We have not noticed that the race of bee has great influence on the appearance of the disease, for it is just as common with the black bee of German-speaking Switzerland as with the Italian bee of the canton Tessin and the hybrid bee of French-speaking Switzerland. All cur experts and inspectors are now agreed that, although environmental conditions play an important rôle in the occurrence of European foul brood, we must not, however, disregard the significant part played by disease bacteria. And because we now attribute a more important rôle to infection than we have hitherto, we must also pay more attention to disinfection in its control. We are convinced, that failure in the control of European foul brood comes from the fact that we have tried to fight it only by indirect methods instead of by the direct removal of the infectious substance, as in the case of American foul brood. According to our observations it is not possible for the bees, even after dequeening, to remove the infectious material from the hive sufficiently. For the bacilli of European foul brood are not only present in the sick and dead larvae, but we also find them in great numbers under the cell cappings in cells which contained living and dead nymphs. It seems that the bacilli get into the cell with the excrements of the larvae before cocoon spinning. So we also burn the combs in the case of European foul brood and the experience of recent years leads us to hope that in this way we shall succeed in curbing the increase of European foul brood.

As we attribute a more important rôle to infection the great importance ot bacteriological research becomes evident. We all know how involved the bacteriology of European foul brood is and what conflicting opinions the specialists hold to-day. However, I shall not enter further into such details here and only give expression to the great pleasure which it has afforded me to take a glimpse at the excellent and very important research of my colleague, Dr. Tarr.

As we see, of the two most important brood diseases one is conquered for the Swiss beekeeper, but the other still gives us much concern and requires further careful research. Conditions are exactly the same in the case of the two most important diseases of the adult bee, which I shall discuss in a few words :—When in 1922 acarine disease was discovered in our country, we were very fortunate to possess in the foul brood organization a weapon with which we could also control other bee diseases. Our foul brood inspectors became bee disease inspectors and to the animal disease law was simply added a new paragraph, " acarine disease." This immediate defence has allowed us, up to the present, to save the greater part of Switzerland from an acarine infection. But, in spite of the good organization, our campaign would probably have been hopeless if Mr. Frow had not come to our help at the right moment with his treatment. In extensive scientific and practical experiments we have tested this remedy and found that it actually exceeded the boldest expectations and, when used correctly, killed all mites. Swiss beekeeping owes Mr. Frow great gratitude for his discovery which he, in absolute unselfishness, offered the public for use. Acarine disease will soon be no longer a matter for public concern in Switzerland, since every beekeeper is able to protect his apiary from infection by correct application of this remedy. What remains for us to do in this matter is to get rid of certain disadvantages of the Frow treatment, principally the danger of robbing.

As far as the success of control is concerned, we can therefore compare acarine disease with American foul brood. On the other hand European foul brood has points of great similarity with Nosema disease, as I have already noted in my remarks relating to seasonal occurrence. Also, as yet an effective control method has not been found for Nosema disease. As with European foul brood, one knows much too little of its nature. We are glad that we have not included Nosema in the animal disease law. Before we can introduce a Nosema law or a Nosema insurance, we must study the disease itself further. With us the Swiss Nosema commission has taken up this task. In it the federal veterinary office, the entomological institute in Zürich, the bee division at Liebefeld, and the beekeepers' societies are represented. I think that our Nosema commission corresponds exactly to your Bee Research Advisory Committee.

In the Nosema question we have sufficient material for at least a days' discussion. You all know the remarkable phenomenon in which a bee colony which is 100 per cent. infected with Nosema can appear absolutely healthy externally. I shall not try your patience by naming all Nosema theories and should like here only to offer for discussion the theory which we hold at the present time. We believe that Nosema infection alone, in a well-managed colony and under good conditions, cannot cause great damage. The dreaded devastation which has hitherto been ascribed to

Nosema and which consists in a conspicuous weakening of the colony in spring, " spring dwindling," we believe to be the result of a mixed infection of Nosema (in the middle intestine) and of amoeba (in the malpighian tubes). It interested us very much to learn that Amoeba has also been found in Great Britain by Dr. Morison.

Before I close my survey of Swiss experience with reference to bee diseases, I should like to mention a special field of research with which we have been busy for some years. It concerns the the diseases of the queen. My colleague in Liebefeld, Mr. Fyg, who devotes himself especially to this problem, tells me that up to now, after an examination of about 500 queens, he has found 42 different abnormalities and diseases of the bee queen. We believe that queen diseases play a far greater rôle in practice than has hitherto been recognised.

According to our views bee diseases are not only a question of bad beekeeping methods and of bad environmental conditions. We have seen many cases in which bee colonies, with the best of care and under the best environmental conditions, suffered heavily from a brood disease or a disease of adult bees. Moreover, in the history of apiculture we have seen that the alarm over bee diseases did not originate with careless people and with bunglers, but on the contrary with the pioneers of practical beekeeping. They had realized that all their efforts to improve beekeeping were futile, as long as the diseases were not scientifically studied and as long as they were not conquered by special control methods.

Ladies and Gentlemen, Switzerland is a small country and our experience with bee diseases is based, therefore, only on relatively little material. But I should like to point out that with regard to climate, flora, beekeeping methods and races of bees we have very varied conditions which perhaps invests our conclusions with somewhat greater value. We are always very eager to learn the experience of other countries. Therefore I should like to take the liberty here, as I have done at former international congresses of apiculture, of pointing out the desirability of statistics on the occurrence of bee diseases in all lands. We were highly interested in the work which Mr. Morland has undertaken in determining the geographical distribution of foul brood in England.* I can show you here with the aid of maps the distribution of the four most important diseases in Switzerland.† We should be much better informed on many questions of bee pathology if we possessed such maps of all countries.

If, in conclusion, I should give the reason why Switzerland shows some successes in controlling bee diseases I believe I can say that

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* " Brood Diseases of Bees." Rothamsted Experimental Station Conference Report 18, 1934. (Out of print in separate copies).

† Maps showing the distribution of American foul brood, European foul brood, Acarine disease and Amoeba disease in Switzerland were exhibited.

the reason lies in the good relationship between practice and science. The beekeepers know that they cannot get further in the control of bee diseases without scientific help, and the scientists know that they cannot understand bee diseases if they do not also to some extent understand the life and treatment of healthy bees, viz. apiary practice. I should like to close my address by saying how gratified I am by the fact that this good relationship between science and practice, and with it the most important prerequisite for a successful control of bee diseases, also exists in the British Isles.

CONTROL OF AMERICAN FOUL BROOD IN THE UNITED STATES

By JAS. I. HAMBLETON, B.S.

(Principal Apiculturist, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture).

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

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-

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

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.

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

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.

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.

DISCUSSION

MR. L. ILLINGWORTH (Cambridge) gave the following brief account of the proposed Foul Brood Insurance scheme.

On July 8th, 1936, a Society named BEE DISEASES INSURANCE, LTD., was registered Under the Industrial and Provident Societies Act, with Dr. A. L. Gregg as chairman, Dr. F. Thompson and Messrs. B. C. Berkeley, C. W. Bowell, W. E. Hamlin, J. E. Swaffield, and C. Wilkinson as Directors, and myself as Secretary.

A circular letter describing the aims and objects of the Society has been sent to every Beekeepers' Association in Great Britain.

It is too early to predict what response the Associations will make to this invitation to join the scheme, as most of them will not hold meetings to consider the question before the autumn or winter. The Barnet B.K.A. has definitely decided to come in, Cambridge and District will almost certainly do so, but Cornwall, Norfolk, Warwickshire, and Worcestershire cannot see their way to join, or propose to take no action at present.

The scheme is quite frankly an imitation of the Foul Brood Insurance system initiated by the late Dr. Leuenberger, which has proved such a success in German Switzerland, having now been in operation for nearly 30 years. The small committee appointed to draw up the scheme has carefully considered what modifications are necessary for Great Britain, and has prepared bye-laws and regulations covering every department of the Society's activities, as well as providing for the representation of the subscribing Associations, so that each may have a voice in the working of the scheme. These will be laid before a meeting of delegates from the Associations for approval or modification, to be held during the coming winter as soon as it is known which Associations will join.

This is all the information about the progress of BEE DISEASES INSURANCE, LTD., that can be given at present.

In the moment or two that I have left it may be well to outline the main features of the scheme and to answer one or two objections. For fuller information I must refer you to the registered rules of the Society and to the circular letter already mentioned.

BEE DISEASES INSURANCE, LTD., is not founded for private profit. After providing a reserve fund sufficient for all eventualities all further profit, as well as interest on that fund, will be used to promote bee disease research, or returned to the Beekeepers'

Associations in the form of grants, as the Directors, with the approval of the representatives of the Associations, may decide.

Subscribing Associations will be required to take up five shares of £1 each for every 100 members only 4/- per share being payable the first year. It is hoped that it will be unnecessary to call up any more money on the shares, so there will be no annual payment. Thus Associations will only be asked to pay £1 for every 100 members.

In addition there will be an Annual Premium of 1d. per colony of bees (spring count), minimum 6d.

Some Associations seem to think this is more than they can afford. It is difficult to see how the annual premium can be less than 1d. The chairman of one B.K.A. has offered to pay the 6d. minimum for all the members the first year. Where an Association has a number of very poor members cannot this excellent example be followed ?

As to the initial payment on the shares, even this has been criticized in some quarters. £1 per 100 members the first year only, does not seem very much to ask for, as the Society must have some working capital to start with. If beekeepers really want foul brood control will they not be willing to make some slight sacrifice to obtain it ? Surely, if an Association has no funds to pay for the shares, there is one beekeeper in a hundred who would give £1, or eight who would be prepared to give 2/6 to get control of foul brood.

Let no Association say that there is little disease in its territory and therefore it has no need of foul brood insurance. This is a national scheme. Only by receiving a large number of premiums from areas where there is little disease can we hope to weather the first few difficult years, and set the scheme on a firm financial basis. You can help to make it a success now. If it fails it will be many years before another plan is tried. Your county may not always be as free from disease as it is to-day. You may one day be glad of the help BEE DISEASES INSURANCE, LTD., can give you.

DR. A. L. GREGG stated that the research on brood diseases which was being conducted at Rothamsted had reached a critical stage, and that there was every hope that, if it could be continued, some tangible result might be reached. The beekeepers would, he said, be very foolish were they to let slip the opportunity of continuing this research. He proposed the following resolution : " That this Conference considers that the Beekeepers' Associations should continue to provide the financial support required to ensure the continuance of the foul brood research at Rothamsted."

The motion was carried.

MR. LINDLEY (Gloucester) said that he felt that the work on brood diseases was extremely useful and on behalf of the newly formed Honey Producers' Association offered the sum of five pounds a year for three years in support of the work. (This contribution has since been increased.)

MR. W. HERROD-HEMPSALL (Ministry of Agriculture), said that he had listened with great interest to the papers, especially to the excellent one by Jas. I. Hambleton, chief of the United States Bee Culture Laboratory. He believed that we might eventually be compelled to adopt the plan now being followed in that country. When visiting the United States he had an opportunity to see the terrible ravages caused by foul brood. This occasion gave an opportunity to address a solemn word of warning to beekeepers in the British Isles. During the last three years foul brood had spread to an alarming extent, indeed, in some districts, it is endemic and a serious menace to the industry. He stated that he had inspected apiaries in which all the colonies were affected with brood disease. In England, Scotland and Wales to-day there are thousands of bee colonies affected with brood disease.

He went on to say that in the annual reports of beekeepers' associations it is not unusual for the statement to be made that : " no brood disease is present in the county." Such statements, made in good faith, are misleading because one of the troubles we are faced with is that many beekeepers are obsessed with the idea that the presence of disease in their apiaries is a disgrace and a reflection on their management. Consequently, when an outbreak occurs, they conceal the fact from the association officials. One must also take into account the large proportion of beekeepers who are not members of an association, and from whom no information is available as to the condition of their colonies. He, personally, begged beekeepers, when in doubt about the health of their colonies, not to be reticent, but to obtain the advice of a competent person immediately. Rothamsted provided such advice.

The following note from COLONEL HOWORTH, C.M.G., of Devon, was read as he was unable to attend : " My original communication on the use of the Frow treatment for acarine disease was published in the *British Bee Journal*, June 7th and 28th, 1928 ; since then I have distributed some 30,000 leaflets describing my method. I know of only one instance in which complete extermination of the mites was not effected (I am satisfied with nothing less than 100 per cent. mortality among adult mites and their eggs, although this entails some risk to the bees.) Mr. Frow's method differs from mine in that he applies the treatment from above the bees, whilst I, holding that the temperature is always lower and more equable on the floor board, apply the remedy there. He also uses a smaller dose and permits treatment during the brood-rearing season, whilst I use a larger dose and place a section rack or shallow below the brood-chamber, and have found that the brood of the bee suffers during the treatment."

The following notes with reference to " Bee Paralysis " have been added since the Conference.

BROTHER ADAM, O.S.B. (St. Mary's Abbey, Buckfast.)

Bee Paralysis can cause serious loss to the beekeeper. In cases where this disease has been allowed to develop unchecked I have seen colonies perish outright, the dead bees accumulating within the hive between the combs to a depth of six inches.

The most conspicuous symptoms of paralysis are that the affected bees become denuded of hair, possess a distended abdomen, present a glossy black appearance and are bereft of all power of locomotion. They seem listless and can but feebly flutter their wings. When in this condition the diseased bees are evicted, to perish outside their home, by the still healthy members of the colony. The decomposing bodies, as they accumulate in front of the hive, give off a most obnoxious odour.

Paralysis attacks bees principally during the early part of the autumn. However, minor infestations may occur at any season of the year.

Disinfectants, even if used in strong solutions, impart not the slightest relief to colonies affected by this disease, whereas dusting the bees with flowers of sulphur has never yet to my knowledge failed to effect a complete cure. A handful of sulphur, sprinkled over the bees and the tops of the brood-combs, and the same dose repeated a fortnight later, will cure the worst case of this disease.

Apparently certain strains of bees are practically immune to this form of paralysis. On the other hand some strains seem most susceptible to it.

Very little is known of the causative agent of bee paralysis. According to the findings of a Swedish investigator, G. Turesson, paralysis is caused by poisons produced by certain moulds or fungi. By feeding a colony a solution of honey containing such toxins he found that the bees developed paralysis within three to four days and finally succumbed to its effects.

The disease, supposedly caused by *Bacillus gaytoni*, to which Cheshire referred, whilst similar in some respects to paralysis differs substantially from this malady. In both diseases the affected bees present a shiny black appearance. In paralysis, however, the bees have distended abdomens and are deprived of practically all power of movement, whereas in the other disease, according to Cheshire, the bees are " undersized " and found " running " upon the ground.

The disease mentioned by Cheshire appears to be identical to the Schwarzsucht or Waldtrachtkrankheit so common on the Continent. E. Zander distinctly states that bees afflicted with this complaint possess a contracted abdomen. On the Continent this disease occurs chiefly when bees work on the pines, buckwheat, or heather. Instances of this trouble have come under my observation on Dartmoor. The affected bees were undersized, hairless and

jet-black in appearance. After about ten to twenty days all the diseased bees present in a colony seem to die suddenly, or, perhaps, are killed off by the healthy members. They invariably perish suddenly and their dead bodies are found lying outside the hive. But bees that die of this malady do not give off any perceptible odour.

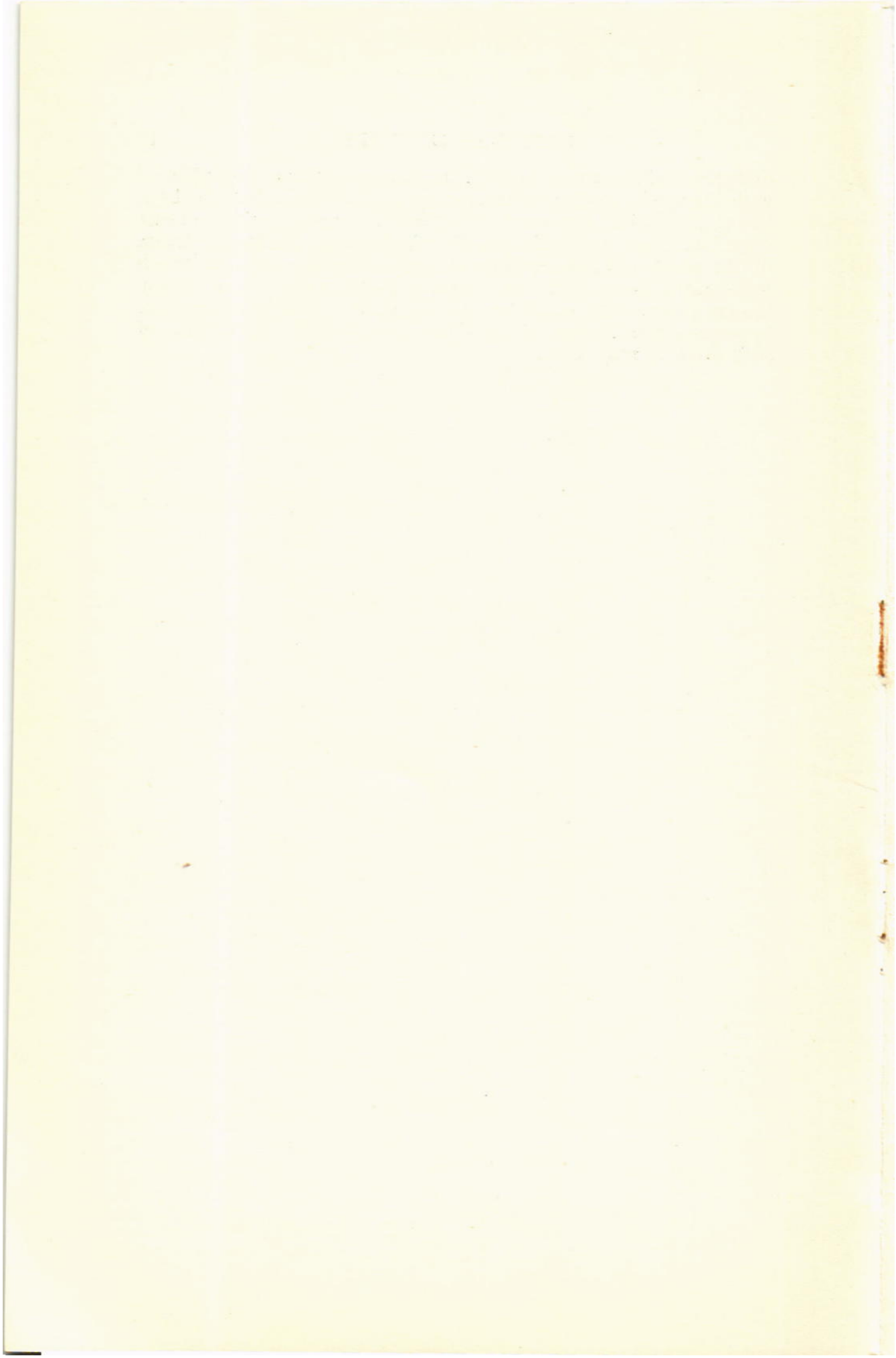
There is a form of paralysis, that is quite distinct from the one first mentioned, which at times causes serious depletion in the strength of colonies. The symptoms of this malady resemble acarine disease in that the affected bees are deprived of the use of their wings. Bees suffering from this kind of paralysis appear to be normal in every respect except that their wings are paralysed and often also dislocated. The disabled bees, mostly young ones, leave and run away from their home and eventually die of exhaustion. They do not form clusters on the ground as in the case of Acarine. The malady comes on suddenly, generally early in July, and again vanishes after a week or ten days. This form of paralysis is no doubt identical to the " Disappearing Disease " that at one time caused such serious losses to many apiarists in the U.S.A.

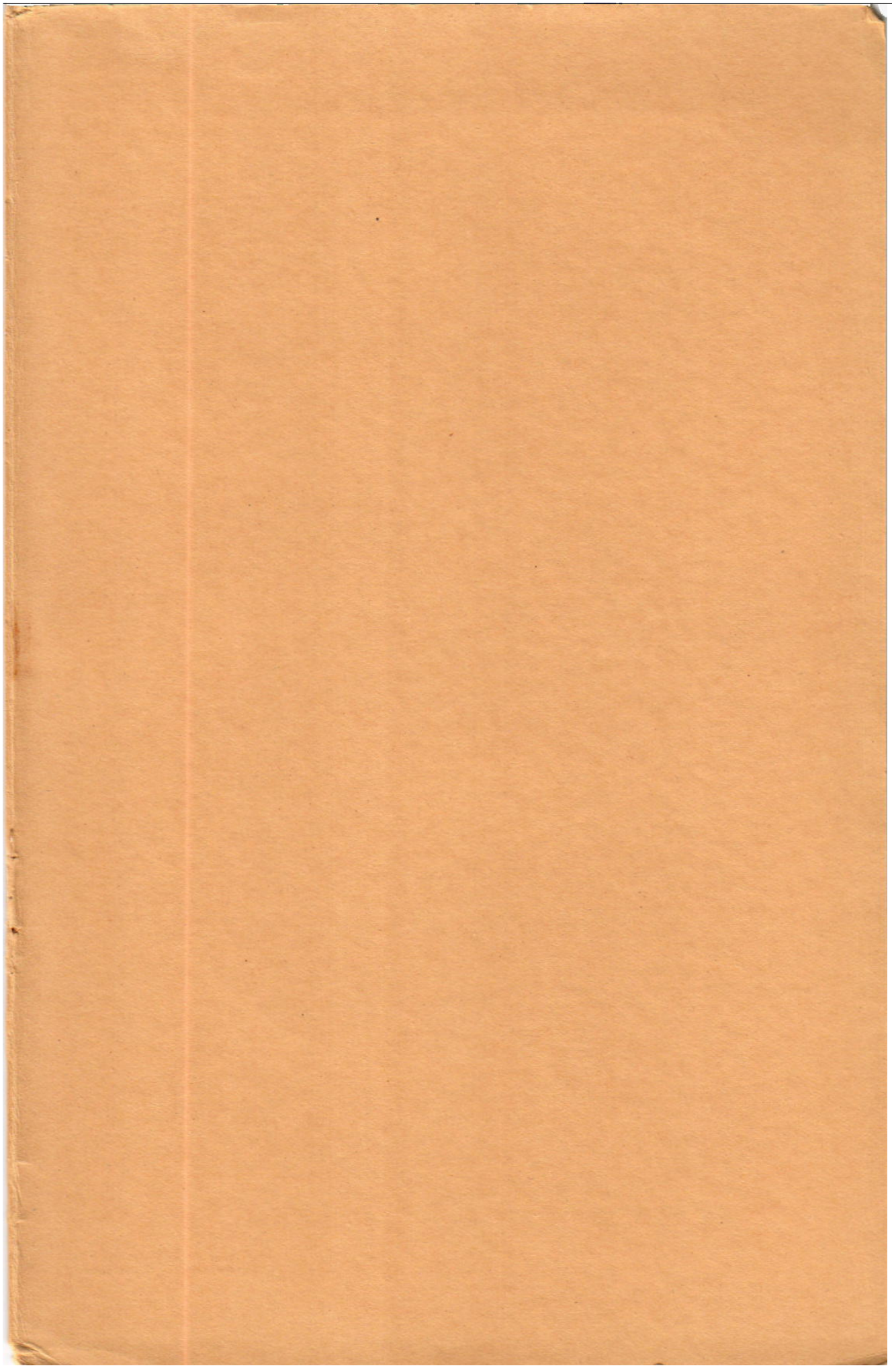
With the exception of the malignant paralysis all the other diseases mentioned are of transitory duration and affected colonies recover without the application of any remedial measures.

Dr. Tarr (Rothamsted). It is by no means certain that Bee Paralysis is a single disease, and, as can be seen from Brother Adam's remarks, there is some confusion as to exactly what is implied by this term. Whether such diseases as Waldtrachtkrankheit, Bee Paralysis and Black Robber Disease (Black shiny bees) are distinct complaints cannot be stated with certainty until their causes have been definitely determined. At present there is no accurate diagnostic feature by which these diseases can be distinguished, though the work accomplished by Dr. Morison may provide a useful clue. It may transpire that there are several virus diseases of the adult bee which differ slightly from one another, or that there is a single disease modified by the presence of various bacteria. Until practical experiments have been made, any statements regarding the etiology of these diseases can only be speculative. In this connection it is of interest that Dr. Morison states that Dr. Phillips, of Ithaca, believes that American Bee Paralysis is not identical with the disease occurring in this country. Many beekeepers state that Black Robber Disease or Bee Paralysis can be cured by requeening the affected colony. However, the success of this method cannot be considered as proven, and the reason for it is not known because there is, as yet, no definite indication that the queen carries the disease.

In 1933, Burnside, working in the United States, published a paper entitled " Preliminary Observations on Paralysis of Honeybees." He concluded that the disease is mildly infectious, and often

disappears of its own accord. Extracts prepared from bees affected with Paralysis in certain cases caused infection in healthy bees, but porcelain filtrates were not, in his experiments, able to cause infection. Burnside (1928) also described an apparently new disease of the adult bee: a septicaemia caused by an organism which invaded the blood of the bee, namely, *Bacillus apisepticus*. These findings show that much remains to be discovered with respect to some of the diseases of adult bees, and that a large number of such diseases may exist.





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