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Brood Diseases of Bees

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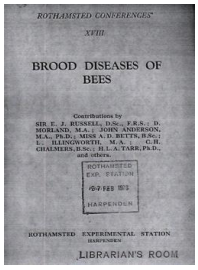

XVIII. Brood Diseases of Bees

Sir E. J. Russell

Sir E. J. Russell (1935) *XVIII. Brood Diseases of Bees ;* Brood Diseases Of Bees, pp 1 - 46 **- DOI: https://doi.org/10.23637/ERADOC-1-211**

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ROTHAMSTED CONFERENCES

XVIII

BROOD DISEASES OF BEES

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BROOD DISEASES OF BEES

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON MAY 19TH, 1934, UNDER THE CHAIRMANSHIP OF

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

With Contributions by

SIR E. J. RUSSELL, D.Sc., F.R.S.; D. MORLAND M.A.; JOHN ANDERSON, M.A., Ph.D.; MISS A. D. BETTS, B.Sc.; L. ILLINGWORTH, M.A.; C. H. CHALMERS, B.Sc.; H. L. A. TARR, Ph.D., and others.

ROTHAMSTED EXPERIMENTAL STATION
HARPENDEN

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INTRODUCTION

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

The exodus from town to country that has been so marked a feature of the post-war period has led to a considerable increase of interest in beekeeping. Recognition of this fact led the Rothamsted Experimental Station about eleven years ago to include bee investigations in its programme. Prior to that date the Development Commission had given a grant to the Cambridge School of Agriculture to investigate bees, but the work did not fit in well with their other activities, and by agreement between the two Institutes it was transferred to Rothamsted in April, 1923. Rothamsted already possessed a strong entomological department under Dr. Imms, who was personally interested in bees and anxious for an opportunity of studying them. Mr. D. Morland was thereupon appointed Apiarist, and an Advisory Committee of practical bee experts was set up to keep Rothamsted informed about the problems of the industry and to indicate which of the possible lines of work would be of chief interest to practical men. We could not, however, hope to cover the whole field of bee investigations with only one worker, nor was this necessary, as Dr. Rennie was already at Aberdeen studying bee diseases, his work having been inaugurated through the generosity of the late Mr. A. H. E. Wood, who had supplied funds for its equipment and furtherance. All bee keepers are under a debt of gratitude to him for his public-spirited action. In addition, the Ministry of Agriculture provided a maintenance grant. The Rothamsted authorities settled with Dr. Rennie and the Ministry the lines we would each take up: he studied Bee Diseases while we studied the Bee as a Honey Producer.

We always recognised that the arrangement was artificial: that for the beekeeper the problems of honey production and of disease cannot be separated. However, artificial arrangements often work out well when all concerned act loyally together, and had Dr. Rennie lived the arrangement would have continued. But unfortunately for science he died in August, 1928.

We at Rothamsted pay tribute to his memory for his noble self-sacrificing devotion to the task he had undertaken. He was never robust, and many a man in his place would have given up and rested. Yet he never lost courage, but continued to the end a faithful friend and helper of the beekeepers. They lost a good friend in him.

After his death the grant for bee disease investigations ceased. The Bee Advisory Committee urged upon the Rothamsted authorities the desirability of securing funds for the study of Bee Diseases.

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Enquiry showed that no Government grants were available for the purpose, and the matter was held in abeyance. The Advisory Committee insisted, however, that steps should be taken to make an attack on the foul brood diseases, and the Rothamsted Committee agreed to do so if funds could be obtained. The decisive move was made by the British Bee Keepers' Association, who secured from their constituent bodies subscriptions enabling them to guarantee a sum of £250 a year for three years, with every probability of continuance, if the Ministry of Agriculture would put up a like sum. The Agricultural Research Council was so impressed with this practical proof of the urgency of the problem and of the deep interest of beekeepers that it made an equal grant, £250 per annum, to bring the income up to £500 per annum, on which sum it was possible to carry out a proper investigation. The Rothamsted Committee placed a very good laboratory in the Entomology Department at the disposal of the bee workers, and provided all ordinary appliances ; Dr. Williams, the Head of the Department, entered enthusiastically into the scheme. Dr. Ledingham and the managers of the Lister Institute kindly offered the use of their wonderful laboratories for such bacteriological work as required special technique and costly equipment, and finally several gentlemen came forward, among them Mr. P. C. Thornton, Editor of *Bee Craft*, Mr. L. Garvin, of The Bear Honey Co., and others, to provide funds for the special appliances, which will cost £250 in all, and which are needed over and above those already contained in the well-fitted Rothamsted laboratories. It may safely be said that no investigation on bees has ever been started with such enthusiastic support as this, and the Rothamsted Committee and Staff feel a deep sense of gratitude and responsibility to all those who have made the work possible.

Dr. H. L. A. Tarr, of the British Columbia and McGill Universities, who has for some time been carrying out biochemical investigations under Sir F. G. Hopkins at Cambridge, was appointed in charge of the work, and took up his duties early in 1934. The laboratory thus inaugurated is the first in this country to be devoted exclusively to bee investigations, and the Staff are fully determined that, so long as they are furnished with means of doing research, its work shall come fully up to the high standards of the other Rothamsted Departments.

This Conference was called at the outset of the investigations so as to give the Rothamsted Staff an opportunity of taking council with practical beekeepers and learning whatever is known about the foul brood diseases. The papers here published represent the best existing knowledge on the subject and they form the starting point of Dr. Tarr's work. Like Mr. Morland, he will do his best to keep in touch with practical beekeepers, and, as his work will preclude visiting on any important scale, it is hoped to call two conferences annually, one in summer at the apiary, and one in winter, so as to ensure that beekeepers may know what we are doing, and we may know what their problems are.

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The papers presented at the Conference and the discussions on them bring out clearly a number of important points. There is much uncertainty as to the prevalence of foul brood diseases: some County Secretaries reported that their counties are free, while experts with a wide knowledge of the subject declare they are not, suggesting that the diseases are not always recognised. There is much confusion between the various foul brood diseases: the so-called American foul brood (although it has apparently nothing to do with America except that an American bacteriologist, Dr. G. F. White, first worked at it), the European foul brood (again having no special connection with Europe) and another which Dr. Morison tells us is different from either. There is also much uncertainty about the causal agents. Mr. Chalmers kindly placed before the conference the whole of the results which he and Mr. W. Hamilton obtained in their interesting investigations at Leeds: these will be carefully reviewed by Dr. Tarr. Something is known about the way in which the diseases are spread about the country. Derelict hives apparently constitute a considerable source of danger of infection; and some of the dealers in bee stocks do not appear to take adequate precautions to ensure that their stocks are free from disease. In these various ways the disease is spread; and matters are often made worse by the fact that the amateur, coming new to the work, does not always recognise the initial stages, and with the best will in the world, and the fullest recognition of his responsibility to his bee-keeping neighbours, he may quite unwittingly cause them much loss. As to cures: a common piece of advice is to burn every infected hive, including all its contents. However, nothing can be done with certainty until clear and accurate knowledge is obtained about the causes of the diseases and the life history and properties of the agents concerned. With definite information before them the scientific workers in consultation with some of the ingenious-minded people among the practical beekeepers will find a way of dealing with these diseases and so removing one of the obstacles to a greater spread of the interesting occupation of beekeeping.

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DISTRIBUTION OF FOUL BROOD IN ENGLAND

By D. MORLAND, M.A.
(Rothamsted Experimental Station)

As Sir John Russell has said in his introduction, this conference was called together as the starting point for the investigation into the brood diseases of bees now to be undertaken at Rothamsted.

In a later paper Dr. Tarr gives a summary of the present state of the scientific investigation of the subject, but it has been thought well to give a brief description of the diseases in question as a guide to those who are unfamiliar with the symptoms, and the treatment usually recommended. This has been printed in the form of an appendix (p. 41). Obviously both the description and the treatment may be subject to revision as a direct result of the present research.

As soon as it was decided to hold this conference, copies of the following Questionnaire were sent out to the secretaries of all Beekeeping associations.

Questionnaire on Brood Diseases of Bees

(1) Area covered by this report.
(2) Localities where brood diseases have occurred within this district.
(3) Years and time of year of outbreaks.
(4) How long has disease been prevalent in your district ?
(5) Symptoms.
(6) Has any attempt been made to differentiate between the different brood diseases ?
(7) Has the disease spread rapidly, (a) in apiary, (b) in district ?
(8) Race of bees (a) Usual in district. (b) Affected.
(9) Steps taken and results.
(10) General remarks.

The Questionnaire method is admittedly an imperfect means of getting information, but, assured of the goodwill of the beekeeping associations, to the extent of their support of the foul brood fund, we had reasonable ground for expecting the willing co-operation of association secretaries. The value of the replies received varied considerably for a number of reasons. The country is very unevenly covered by the beekeepers' organizations: some areas are well served by active associations with a well-organized system of branches; other counties have several societies, apparently at loggerheads. Secretaries also vary in their knowledge of their areas, and while some most valuable replies have been received, others indicate a

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certain amount of apathy, rival associations occupying the same area, and the non-member beekeeper, are a problem : the implication being that members of the reporting association have no disease, while the apiaries of neighbouring non-members are invariably suspect.

In assessing the value of reports it is necessary to bear in mind that some beekeepers consider that the admission of the existence of foul brood carries a stigma. It should be made clear that unless foul brood is neglected (or in the case of European foul brood when it may indicate a weak colony), there is no slur on the beekeeper. It is when bee disease goes undetected or untreated, or when material is exposed in such a manner as to cause re-infection or danger to neighbours, that a beekeeper is worthy of blame.

The fear of legislation and inspection may perhaps have influenced certain replies. A question asked in the House on May 15th might suggest that another bee disease bill is to be introduced into Parliament, but I feel that the very fact that the matter is now undergoing investigation here, is likely to postpone any rash proposal until some sort of answer can be given to the problems which we have set ourselves ; and it is to be hoped that our work may not be hampered by any attempt to force premature deductions.

In considering the replies which have been received, it seems that the confusion which has existed between various brood diseases in this country is even more complete than was supposed. The lack of proper facilities for diagnosis, except in a few areas, has evidently caused many county experts to make no attempt to differentiate between European and American foul brood. While such was the case, there was much to be said for the school which advocates the " Burn the lot " policy ; but it is difficult to believe that the existence of these incendiaries may not be one of the reasons why cases of brood disease are not always reported.

Four Welsh counties do not appear to have any association.

Ten counties did not reply to the questionnaire.

Four counties claim to be free from brood disease.

One county admits only one recent case.

The opinion that foul brood was more prevalent before the outbreak of Isle of Wight disease, and was largely cleaned up by the measures taken to combat that disease, has been expressed in several reports.

A map showing the reported cases and infected areas, based on the replies received has been prepared and is printed with this report : but as appears in the discussion Mr. W. Herrod Hempsall, who, as the Ministry of Agriculture Expert, has unique opportunities of observation all over the country, considers that it is very incomplete.

The detailed replies briefly summarized hereunder confirm the impression that brood diseases are more serious in the South-Western Counties.

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In most counties no attempt was made to distinguish between various brood diseases, but in Devon and Berkshire a microscopic examination is a matter of routine.

It will be seen that in most counties the policy is to destroy infected stocks. Certain areas report that the shaking method is effective for American foul brood when carried out by a competent expert. Disinfection of hives is usually done by means of a painter's blow lamp. In two cases it is stated that disinfection of combs has been tried but is not considered worth while. Treatment of the disease by means of drugs has few adherents, though "Izal," beta-naphthol and "Apicure" are all mentioned.

It will be noticed that some counties have a fund for compensation when stocks have to be burnt. This is interesting in connection with a scheme outlined in Mr. Illingworth's paper.

In some areas reinfection is thought to be due to bees in trees, hollow walls and the existence of old beekeeping appliances on the premises of those who take no further interest in bees.

Particularly helpful replies were received from Kent, Devon, Cornwall and Gloucester, and I would like to tender my especial thanks to those responsible for these reports.

County Reports in Detail

Northumberland.—No foul brood has occurred in Northumberland and N.W. Durham.

Cumberland and Westmorland.—Occurrence of foul brood stated to be rare ; both types occur. Foul brood was prevalent in the days before the Isle of Wight disease outbreak. It is thought that some occurrences of brood diseases have been due to appliances which have been stored away since between 1910-1916 when Isle of Wight disease was at its worst.

Yorkshire.—An outbreak of American foul brood occurred in 1931 and 1932.

Derby.—Two cases have been reported in nine years. Probably brood diseases are more prevalent than is generally believed.

Leicester.—Cases occurred in 1933, the first for some years. The shaking treatment proved effective.

Nottingham and *Lincoln.*—No report was received.

Norfolk.—Spasmodic cases have occurred over a long period. The symptoms are punctured cappings and bad odour. There has been only one case of brood dying before the sealing stage. There is no doubt that the diseases are carried by a manipulator. In the Kings Lynn area, Italian bees appear to be resistant. The stocks affected have been those which were in a dirty and uncared-for condition.

Cambridge.—Several cases occurred in one locality five or six years ago. Three or four cases of single hives slightly infected occurred in the county in 1933. A bad attack of American foul brood occurred at Willingham forty years ago ; forty stocks were burnt in one apiary. The treatment was effective.

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Peterboro' and District.—An isolated case occurred in the spring of 1922 and the stock was promptly burnt. No case has occurred since.

Oundle and District.—No case has occurred within the past five years.

Huntingdon.—The last cases were in 1908 and 1909. The bees were English and were destroyed.

Suffolk.—No report received.

Bedford.—Both diseases occur. The shaking treatment has been found effective. Other stocks have been burnt. European foul brood appears in a mild form and disappears without treatment.

Barnet.—There has been one case in 1934 probably contracted in the autumn of 1933. This was the first case for five or six years and has been destroyed.

Kent.—Sent in a very full report with a map. Foul brood was very prevalent from 1900-1910. The skep system had tended to keep the disease in check, but as bar frames came to be used so foul brood made headway.

From 1910-1920 foul brood was nearly eliminated owing to the destruction of the bee population by Isle of Wight disease. Later with improved education beekeepers have learned to recognize foul brood and to take adequate steps to deal with it. Since 1920 sporadic cases have occurred. Destruction of diseased bees and infected equipment and the scorching of hives has been the rule and has been successful. There was an increase of American foul brood in 1933 and there is still an area in the Faversham-Sittingbourne fruit district where it is known to exist. Kent now maintains a bee-disease service.

Surrey.—In the Riegate district cases occurred five or six years ago and were cleaned up by burning. Two slight cases occurred in the autumn of 1933.

In *Mid-Surrey* foul brood has given very little trouble, but three outbreaks have occurred at Leatherhead and Epsom. In one case, the infection was traced to the apiary of a non-member. The cases were treated by the destruction of brood and the use of Lysol and Creosote to disinfect the hives.

Sussex.—Foul brood is believed to be general in this county. A bad outbreak occurred at Rotherfield five or six years ago. A case in 1918 was attributed to the robbing of a keg of imported honey which was smashed close to the apiary. In an article published in "Bee Craft," March, 1933, the experiences of a beekeeper in the Crowbrough district are described, and the difficulty of diagnosis are

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emphasized. There is an impression that a mild form of American foul brood exists, which may disappear without treatment.

The *Eastbourne* district is stated to be free. However, the reviewer has seen cases of an unrecognised brood disease in this neighbourhood.

Northants and *Oxford* sent no reply.

Buckinghamshire.—No report from the county association, but one isolated case was reported from Chesham.

Berkshire.—American foul brood has occurred sporadically since 1930. Microscopic diagnosis is always made before treatment. The shaking method is effective in the hands of an expert, but the casual beekeeper is always advised to destroy. It is noticeable that in some cases the disease is very infectious, and in others not at all. European foul brood is rare.

Middlesex.—Eleven stocks were destroyed in one apiary at Isleworth in 1933 for European foul brood. There were two cases of suspected American Foul Brood in 1931 and 1933. The stocks were destroyed and the hives disinfected. The treatment was effective.

Hants.—Foul brood, with symptoms corresponding to both American and European occurred all over the county. It is very prevalent in the New Forest. Bees in trees are considered to be responsible. Destruction of colonies, scorching of hives and burning of frames and quilts has been recommended in all cases. Artificial swarming and the use of disinfectants have not been successful. No attempt has been made to differentiate between the two diseases. The Isle of Wight has a considerable quantity of American foul brood.

Dorset.—Outbreaks occur all over the county. One report says, "The average beekeeper takes little interest in bee diseases and is too apathetic to worry whether the disease is present or not. The fear of having to destroy and burn bees and hives leads to the concealment of disease. It would almost seem that a return to skeps and box hives would be not an unmixed blessing."

Devon.—Foul brood has been present in Devon during the last three years. All samples are sent to Mr. John Falkner, Hon. Microscopist to the county Association, who has furnished very useful information of a technical nature. In addition to American and European foul brood, he distinguishes a form which for the present he calls "X brood," which he believes to be that described by Toumanoff in his book, "Les Maladies des Abeilles."

He gives the following table of the characteristics of the three diseases.

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American.	*European.*	*"X"*
80 per cent. capped.	Rarely 10 per cent. capped.	100 per cent. capped.
Odour sometimes strong, usually present.	Odour if present fairly strong.	Odour leatherish.
Adhesive scale.	Loose scale.	No scale, the mass sinks to base of cell.
Strongly ropy.	Non ropy.	Only ropy in the very last stage.
Pure *B. larvae* and its spores throughout.	*B. pluton* followed by *B. alvei* and its spores, alone or with other organisms.	A micro-picture of spores in predominance which are characteristic of neither *B. larvae* or *B. alvei*, associated with a micrococcus and a *bacillus*.

All Foul Brood colonies were destroyed except one, which was satisfactorily and safely treated by an expert with the artificial swarm and re-queening method. This was European. One other case of European was treated with "Apicure." Result—an outbreak the next year and destruction of the colony. He attributes the Chalk and Sac brood to wintering colonies in a damp locality. When aired and moved into full sun the trouble soon disappears of itself.

Somerset.—American foul brood has been endemic along the south side of the Quantocks since 1919. At Street a bad outbreak occurred in 1912 which disappeared in the autumn. Shortly after this, all bees in the district died out through Isle of Wight disease. Since then there have only been isolated cases. One reporter states, "We now think that American foul brood and European foul brood are the same disease."

Gloucestershire.—The disease has only just started. (Seven outbreaks.)

Wilts.—One case in Marlborough, the first for five years, is all that is reported. A case occurred two years ago on the Hampshire border.

Worcester.—foul brood has occurred in several districts, during the past four or five years. It appears to be spreading. All traces of bees seem to be affected. The shaking treatment has been tried but destruction is the usual course. The Association has taken steps to provide nucli to replace stocks which had to be destroyed.

Shropshire.—No reply has been received.

Warwickshire.—Isolated cases crop up in all districts and are dealt with by beginning as soon as the Association authorities can hear of them. In one case the owner has refused access. A bad outbreak occurred in 1900 in South West Warwick.

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Cornwall.—The county is divided into three divisions and travelling experts appointed. Records are kept of all visits paid, the following table was furnished by Mr. Charles Harrison, the County Secretary.

Table showing incidence of Foul Brood in the County for those years for which records are available.

Year.	Apiaries visited.	Frame Hives.	Skeps.	Total Stocks.	Unclassified Disease.	Foul Brood.	Apiaries p.c. affected.
1899* ..	187	732	361	1093	—	44	23.6
1909 ..	258	—	—	1257	359	?	—
1910 ..	146	—	—	755	85	?	—
1911 ..	174	—	—	841	—	63	36.20
1912 ..	129	—	—	648	—	34	26.35
1913 ..	189	—	—	1090	—	71	37.55
1914 ..	199	—	—	844	—	82	41.20
1923 ..	—	—	—	—	—	2	—
1924 ..	152	528	119	647	—	3	1.9
1925 ..	244	683	215	898	—	3	1.2
1926 ..	325	1271	348	1619	—	1	0.3
1927 ..	452	1905	610	2515	—	4	0.88
1928 ..	597	2209	833	3042	—	7	1.17
1929 ..	667	3098	1032	4230	—	5	0.75
1930 ..	548	2528	772	3300	—	5	0.91
1931 ..	566	1961	257	2218	—	6	1.06
1932 ..	512	1650	184	1834	—	1	0.19
1933 ..	464	2306	265	2571	—	5	1.08

*The figures for 1899 are for the area west of St. Austell only. No survey for the eastern area appears to have been made.

The remarkable decline in foul brood from an average of 32.98 per cent in the pre-war period to an average of 0.84 per cent. for the years 1924-1933 is attributed equally to Acarine Disease and to the drastic treatment advised for its eradication. A case occurring in 1933 was imported from Essex by a new resident bringing ten stocks with their hives, one of which was found to be badly infected, but the owner disputed the experts' diagnosis and refused to destroy.

Staffs.—Two outbreaks have occurred since 1918. The affected colonies were destroyed. All beekeepers in the area were advised to fumigate super combs with formaldehyde and to medicate all food supplied, with beta-naphthol. The County Education Committee warned beekeepers against purchase of stocks from outside the county without previously consulting the county instructor.

Lancashire.—Isolated cases occur almost annually and are dealt with in the usual way.

Cheshire.—Outbreaks from time to time during the past twenty-five years. The disease is not prevalent but the county is apparently never quite clear. The disease is generally discovered by visiting

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experts, and rarely by the owner. In most cases it is attributed to American foul brood. Some cases have been due to bees brought in from other counties and in several cases re-infection has been due to neglected hives of non-members. In one case persistent re-infection of a village is ascribed to bees in a roof. It is thought that the disease will never be eradicated until all colonies of bees can be examined annually. The County Association is voting £10 a year to provide compensation for those who have allowed drastic measures to be taken. This probably resulted in more cases of foul brood being notified.

Conway Valley.—Only Sac brood known to occur.

Denbigh.—No Association.

Flint.—Endemic on the borders of Flint and Denbigh. It is also prevalent on N and W sides of Clwydian Range and coastal ranges about Flint Town.

Merioneth
Montgomery
Radnor
Brecon
} No Association.

Cardigan.—No answer.

Pembroke.—No answer.

Carmarthen.—The disease has been prevalent for some years in the Ammanford district and has been introduced from another district with a diseased stock. It was spread by robbing. In nearly all cases the disease was American foul brood. In one case European foul brood was seen. No case of the disease affecting Dutch bees has been noticed. The shaking method is usually successful. The hypochlorite and the formalin method of comb disinfection have been tried and found successful but were not considered worth the trouble. The Association has set aside a disease eradication fund. It is hoped that this will encourage beekeepers to report cases which they would otherwise be inclined to conceal.

Monmouth.—Is believed to be free from foul brood.

Glamorgan.—One case of American foul brood has occurred in the last four years. In the past distinction has been made between European and American foul brood. In mild cases a period of queenlessness together with spraying of combs with Izal and feeding of Izal syrup is reported to have been successful.

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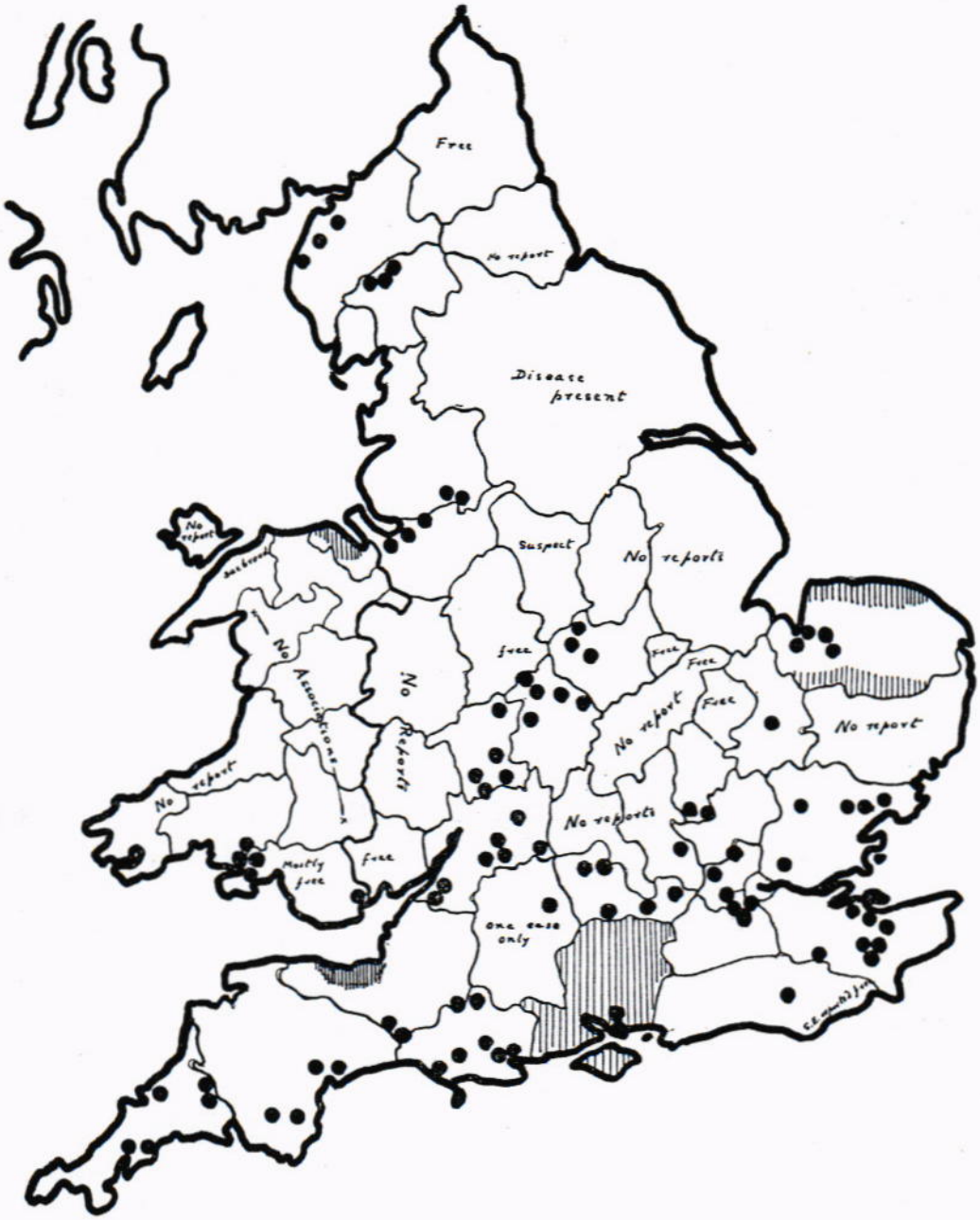

Fig. 1.

Map showing distribution of Brood Diseases in England and Wales in 1933 and recent years, according to reports received in reply to questionnaire.

Dots indicate individual cases, shaded areas show where the disease is considered endemic.

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BROOD DISEASES IN SCOTLAND

By JOHN ANDERSON, M.A., Ph.D.

In recent times brood diseases do not appear to have been prevalent in Scotland, and there is no evidence that the incidence is increasing with the recent considerable extension of beekeeping. When the late Mr. D. M. Macdonald, examiner for Certificates in Beekeeping for the S.B.A., used to insist that candidates must have seen foul brood, there was usually difficulty in finding samples.

Nine years ago when a stock with foul brood was brought to the "Highland" Show at Glasgow it was found that very few of the experienced beekeepers in the South-West of Scotland had ever seen F.B. Mr. Tinsley, in charge of Beekeeping Instruction in that area, reports very little F.B. in the region. I have heard Mr. Avery, until lately in charge of the South-Eastern Area, say that there was very little F.B. in his district.

The 11 counties attached to the Northern District contain more than half the stocks of bees in Scotland, and I have been touring the area for 18 years. My impression is that brood diseases are not serious.

The North Eastern Area, centred round Aberdeen, comprising the counties of Kincardine and Aberdeenshire, with large parts of Forfar, Banff and Moray, is organised by the Aberdeen District B.K.A., and there are 10 Touring Experts who visit each of the 1,300 members once per annum. The reports of these experts are printed in the Annual Report of the Association and refer to diseases if present. The general impression is that Acarine Disease is less formidable than it used to be and that brood disease is almost negligible. Sometimes the report states that no case was encountered, sometimes a single case, and usually the treatment is by extermination.

By American foul brood we mean that the brood has died after "sealing," the cappings becoming darkened, sunken, and later pierced with ragged holes. In some of the affected brood "ropiness" will be present.

In European foul brood the larvae die usually before sealing. They turn yellowish, and become extended in the cells, losing the characteristic position (like the letter C) on the base of the cell. I have not seen a case of European foul brood for several years. It is believed to be due to general weakness in the stock, and is therefore probably due to a microbe which is frequently present but unable to produce symptoms in well-nursed larvae. Italian bees are said to be less liable than brown bees to contract this disease.

https://doi.org/10.23637/ERADOC-1-211

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Some stocks have been observed to have some A.F.B. for years without having efficiency sensibly affected. Cases have even occurred in which an affected stock was able to throw off the disease. On various grounds we are beginning to think that some stocks are more liable to be affected than others.

We frequently requeen brown stocks with Italian Queens obtained from a very famous Italian breeder, and quite often the Italian brood in such cases develops A.F.B. We think that this may be due to the Italians, carefully protected from contact with disease, becoming more susceptible, and developing the disease from germs that were unable to produce symptoms in the brood of the brown bees.

In some seasons and districts Chalk Brood may be quite prevalent. It begins in drone brood and sometimes never gets further, but I have known quite half of the worker brood to be affected, and Dr. Morgenthaler reports the same for Switzerland. The larvae become white friable masses, which the bees ultimately throw out. Some may die before sealing but others are capped. The sealing over affected larvae assumes a characteristic membranous appearance, probably due to the removal of some of the pollen and wax in the caps. Extensive infection may almost disappear in quite a short time, but the loss of so many larvae must reduce efficiency.

"Addled Brood," first observed at Inch, Aberdeenshire, was described in the "Scottish Beekeeper" for October, 1925. In advanced cases the whole of the brood dies just before the bees are due to emerge from the cells. The cappings become markedly sunken, and at first one might suspect advanced A.F.B. But when the cappings are removed, by beekeeper or bees, it will be seen that the young bee is fully formed and pigmented. It lies on its back, indicating that it never moved since pupation.

At an earlier stage there may be three categories of brood: (1) normal bees that can fly and work; (2) bees that cannot fly; and (3) bees fully formed and pigmented that do not emerge from the cell.

If the queens of a normal stock and a stock with addled brood be exchanged it will be found that addled brood is due to the queen, and the substitution of a normal queen for the defective queen will remove the trouble.

Parent stock and swarm may display the same symptoms. We are inclined to think this is because the queens are related, for clearly the disease is not infectious.

I have encountered one case in 1934.

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HISTORY OF OUR KNOWLEDGE OF BROOD DISEASES

By Miss ANNIE D. BETTS, B.Sc.
(Editor, *The Bee World*)

ALTHOUGH man has kept bees for thousands of years, and probably robbed the nests of wild bees for hundreds of thousands of years before that, and although bees most likely suffered then from all the diseases that trouble them now, yet it is only quite recently that beekeepers have learned to distinguish clearly between the various diseases, particularly those of the brood.

This may seem surprising, but there is good reason for it. Before the days of moveable frames there were two main systems of bee management. In by far the greater part of the ancient world the beekeeper did not kill his bees to take their honey. He drove them away from it with smoke, and cut out combs at certain times of the year, not disturbing the brood nest more than he could help, so that he did not often inspect the brood. This was the method of beekeeping in use in Greece and Rome. In those warm climates the wax moth multiplies very quickly.

It would at once attack any diseased and weak stock, and would soon eat up all the signs of disease ; so that when the beekeeper came to clean out the remains he would think that the stock had died of wax moth attack.

In consequence we find that all the classical writers on beekeeping mention the wax moth as one of the worst plagues of the apiary, and are very vague indeed about brood diseases. Aristotle writes of a disease which causes a bad smell in the hive, but it is not clear whether this affected the bees or the brood. Columella, a Spaniard who settled in Italy and was one of the most practical of the Latin writers on bees, mentions a disease which brings about decay of the combs, but it seems to have been an attack by mould, consequent on serious loss of adult bees in bad weather—so that the remainder could not keep the combs dry and the brood warm—rather than an infectious disease. Pliny passes over the brood diseases in a single sentence. Of the two he mentions, one is of course wax moth ! The other he does not describe. It may or may not have been a brood disease.

It is interesting to notice how this tendency to mix up brood diseases with the ravages of the wax moth has persisted into recent

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times. About a hundred years ago, French beekeepers, seeing the webs of the wax moth hanging from the combs in stocks dead from brood disease, called such cases *loque* (rags). This word is still the name for the foul brood disease in France.

The other ancient system of beekeeping is the swarming system. In it the bees are encouraged to swarm early and often ; then after the flow, the very heavy and very light stocks are killed and their contents taken as surplus ; while the medium-heavy ones are wintered. This, of course, is the method our own forefathers used, at any rate since the Saxon invasion, which also brought in the straw skep. In this system the beekeeper inspects a large number of brood nests every autumn, and he might be expected to notice the remains of disease when such was present. Yet early English writers on bees either do not mention diseases, or merely quote the classics. There is good reason for this too.

This system of beekeeping was beautifully calculated to keep brood diseases in check. The light stocks would include all that were badly diseased. The heavy stocks would include all those that had robbed out diseased colonies and so acquired much more than their natural store of honey. All these were sulphured and their contents removed from the apiary ; so that only the slightly diseased stocks and those that had acquired some, but not much, infected honey by robbing, would remain to carry the disease over to next season. The mediaeval British beekeeper, in consequence, was not interested in brood diseases. His method of management dealt with them automatically—especially with the ropy variety of foul brood. The only references to diseases therefore deal with diseases of adult bees, or attribute losses of stocks to the badness of the season.

We know, however, that brood diseases occurred. That great bee-man, the Rev. Charles Butler, writing in the early seventeenth century, is—quite unconsciously—rather amusing on this subject. He says : " In the pleasures of their life the Bees are so moderate, that perfect temperance seemeth to rest only in them : whereby they enjoy such a sound constitution of body, that their whole life is subject to no sickness at all." Two pages further on he remarks that they might live indefinitely long, " if the rottenness of their combs, the hardness of their honey, and *the abundance of noisome stopping* " would allow them to remain in their hives. In other words, if they did not constantly get foul brood, as is plain from another passage, in which he explains what he means by " noisome stopping." He thought that it was pollen which had gone bad from being kept too long. " After a while it corrupteth : and of sweet becometh the sourest, and the most unsavoury of all things, both to taste and smell." He describes how such a stock is robbed out, either in August or (if the beekeeper's care saves it then), next February, as soon as bees can fly. He also describes how infected stocks swarm persistently. There seems very little doubt that foul brood, probably the ropy type, was rampant in Hampshire 300 years ago ;

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but the system of beekeeping kept it in check, so that it caused only slight loss, and a honey crop was secured in spite of it.

As in England, the Continental writers before the middle of the sixteenth century mostly quoted the classics when mentioning diseases. In 1568, however, Nickol Jacob, a Silesian beekeeper, published a book in which he advises treating brood diseases by starving the bees and cutting out the affected combs. He has thus a good claim to be considered the inventor of the " shaking " treatment for foul brood.

In 1604 Johannes Colerus, a German author, published a " Perpetual Calendar," in which he mentions beekeeping. He knew that the brood was attacked by a disease which caused it to putrefy ; and calls this *faule Bruth* (decayed brood). This is, of course, the origin of the modern German name *Faulbrut* and our *Foul Brood* (which is really a mistranslation).

Schirach, the famous Saxon beekeeper, about 1770, also writes of *faule Brut*, and recommends the same cure as Jacob—starvation and cutting out of combs.

Della Rocca, in 1790, describes a bad outbreak, apparently of ropy foul brood, in the island of Syra in the Aegean Sea. The disease was spread all over the island by the unwise practice of the beekeepers, who put out their diseased combs in the open for the bees to clean up.

It was not until well into the nineteenth century that a few beekeepers began to suspect that there was more than one disease of the foul brood type. Dzierzon, the discoverer of parthenogenesis, knew that there were two varieties. He lost nearly all his bees from the ropy disease on one occasion, no doubt because, pleased with his new invention of movable bars, he did what unwise beginners do still—moved combs from one stock to another without thinking about diseases. Doolittle and D. A. Jones, in U.S.A. in the early 'eighties, and our own countryman, S. Simmins, in 1887, also realised that there were two varieties of foul brood.

The causes of the brood diseases were, however, not yet known. Few beekeepers had microscopes ; and even the best microscopes of that date were not very satisfactory for examining such objects as bacteria. In Germany, moreover, brood diseases were much confused with Nosema, which was as prevalent there then as it is now, and was believed to be due to a fungus. It was not until 1874 that Cohn and Eidan found a bacillus in diseased brood and suggested that it was the cause of the disease. Bacteriology was then a very young science indeed, and was still in its infancy when Cheshire and Cheyne published their paper on *Bacillus alvei* in 1885.

Cheyne's description of *Bacillus alvei* is excellent ; he had, it seems, no time to test its pathogenicity for brood, and left that work to Cheshire, who was unfortunately too easily satisfied that he had proved it to be the cause of the disease. All subsequent experiments, with few and very doubtful exceptions, have tended to show that

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Bacillus alvei is not the cause of any brood disease—though, as you will hear from Dr. Tarr, it may possibly be a stage of the life-history of a disease organism.

It was not until the early years of the present century, around 1905, that real proof of the bacterial nature of the foul brood diseases and of the existence of more than one variety of them, was given. This was the work, not of one man, but of three, working independently of one another. Burri in Switzerland, Maassen in Germany, and White in the United States, almost simultaneously found a new bacillus in ropy cases of foul brood. Burri failed to cultivate it, but Maassen and White succeeded. White gave the first technical description of it, and the name by which it has since been known—*Bacillus larvae*. Gradually, since then, the other brood diseases have been disentangled and studied—a process by no means yet complete, as we know.

There have thus been four stages in the history of our knowledge of the brood diseases. In the first, from classical times to the sixteenth century, these diseases were little understood, and their effects were confused with that of wax moth attack. In the second period, from the sixteenth to late nineteenth centuries, the existence of brood disease was realised, and the starvation treatment discovered; but nothing was known as to the cause of disease. Then came a period of some thirty years (1874-1904), when the bacterial origin of brood disease was suspected, but not completely proved. Finally, the fourth stage, in which we now are, of increasingly accurate knowledge of the various diseases and of their causes.

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BEE DISEASE LEGISLATION IN OTHER COUNTRIES

By L. ILLINGWORTH, M.A.

In the short time at my disposal I can only deal with one foreign country, Switzerland, and it will hardly be possible to do more than give you a brief description of the system in force there with little or no comment.

About the beginning of the present century Swiss beekeepers became alarmed at the increase of brood diseases in their country. They first of all tried to get the government to deal with it, but without success. One prominent politician, indeed, remarked that they would become the laughing-stock of Europe if they attempted to legislate about bee disease. The beekeepers, however, said that if the state would not help they must do something themselves, and an insurance scheme was suggested. This met with considerable opposition, mainly on financial grounds, but was finally carried by a small majority at a general meeting of the Verein Deutsch-Schweizerische Bienenfreunde (V.D.S.B.), or German-Swiss B.K.A., and put into operation in the year 1908.

Before describing the scheme let me invite your attention to the chart showing the results achieved.

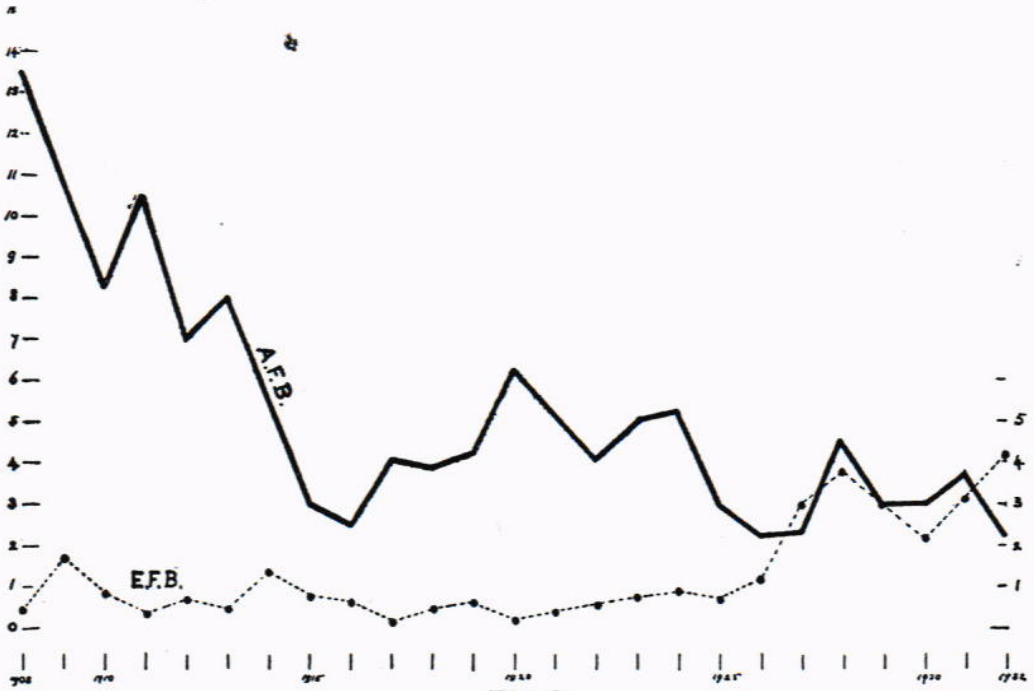

Fig. 2.
Prevalence of foul brood in Switzerland since the insurance scheme came into effect.

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Thus it will be seen that when the scheme was started in 1908, out of every 1,000 insured beekeepers 13.5 had American foul brood (*B. larvae*). A year later this figure had been reduced to 11, and the following year to slightly over 8. The Swiss Government now recognized the good work, and in 1910 passed legislation dealing with bee diseases. The existing Association Insurance Scheme in German Switzerland was allowed to go on as before, the control of it being left in the hands of the beekeepers, but in French Switzerland, where no scheme existed, the government set up one, so there is a dual system at work, a government insurance scheme in one part of the country, and an association scheme in another, though the association system has proved more economical to run and gives further advantages to the beekeeper. In later years American foul brood was reduced to a little over 2 per 1,000. The same success has not attended the efforts to control European foul brood. Though there has never been a great deal of it in Switzerland, a glance at the chart shows that it has been slowly but steadily increasing since 1920, and the more rapid rise in recent years is causing concern. The explanation is probably to be found in the different nature of the disease, and the fact that it is not so well understood, nor has any particular method of treatment been found to prove effective in all cases.

I will now proceed to describe the scheme. By the resolution carried at the meeting of the V.D.S.B., foul brood insurance was made obligatory since 1908 for all members of the association. Any kind of legal compulsion was, of course, out of the question, but from that time no one could enjoy any of the privileges of membership until he had paid his insurance premium in addition to his annual subscription. The premium was fixed at one halfpenny per colony per annum. The Association pledged its funds, and no doubt received donations and guarantees from sympathisers, to form a compensation fund, but did not call in the aid of any insurance company or receive any assistance from the government. It kept the whole thing in its own hands. Compensation is made on a liberal scale. It may be as much as £4 per colony, but averages £1 5s. (All figures are calculated at the par rate of exchange before Britain went off the gold standard.) Combs destroyed are paid for according to their age and value. Compensation for bees is reckoned according to the strength of the diseased colony, not the stage which the disease has reached, at a rate which varies according to the time of year and corresponds to the value at which the same quantity of healthy bees could be bought. This encourages early notification of disease.

The organization consists of a head, who is a member of the central executive committee of the association, and is responsible to the whole association for the working of the insurance scheme. This position has been held since its inception by Dr. Leuenberger. Under him are the bee-disease inspectors. They are all experienced practical beekeepers and correspond more or less to our association experts. They are required to meet from time to time to receive

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special instruction and to discuss their work with each other, so as to keep in touch with the latest scientific and practical developments in all things concerning bee disease. Finally the association has about 130 local, but not independent branches, distributed all over German Switzerland, the smallest (Davos) with 20 members, the largest with over 300. In each of these branches there is a local (voluntary) foul brood Officer, usually the local secretary. It is the duty of the local officer to collect the insurance premiums and to send the money to headquarters.

Now let us see how the system works. Suppose a beekeeper discovers what he imagines is a case of foul brood in his apiary. If he is a member of the association, and therefore insured, he must inform his local officer at once. The latter makes an appointment to visit the apiary when the owner is at home. Together they examine the suspected stock, and the local officer, in the presence of the owner, cuts out a piece of comb containing the suspected brood, puts it in a tin and sends it to the Bacteriological Institute at Liebefeld. Nothing can be done until the report of the Institute is received—a most valuable provision, as it protects the beekeeper from undue or incompetent interference. If the presence of disease is confirmed the bee-disease inspector is notified; he visits the apiary by appointment, so that the owner can be present, and takes with him the local officer who called before. All three proceed to the apiary and the inspector examines all the colonies, decides which require treatment and how, and proceeds, with the assistance of the local officer, to assess the compensation due in accordance with the printed scale drawn up by the association. A report is made and sent to Dr. Leuenberger, who, when he is satisfied that the inspector's instructions have been carried out, pays the sum due to the beekeeper Practical assistance would be available for novices or any beekeeper unable to carry out the work. At first the association offered compensation at half rates to uninsured non-members found to have diseased bees, on condition that they were allowed to clean up the apiary. This was discontinued in 1910, when the government included bees in the Diseases of Animals Act, and made regulations regarding bee diseases.

The insured beekeeper receives payment at the full rate for the time of year if a colony is destroyed. If the bees are saved by the artificial swarm method for American foul brood, then he receives 50 per cent. of their value, and if they are treated for European foul brood by the dequeening method, without destroying the bees or combs, 25 per cent. of their value and 6 francs for every queen destroyed.

When the Swiss Government passed legislation for the control of bee diseases it simply made the association inspectors government officials with power to enter any apiary suspected of harbouring disease. They are now appointed by the government on the nomination of the Bee Keepers' Association, and have a dual capacity. The

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association still pays for their training and the work they do in connection with the insurance scheme, the government only paying for the actual time spent in inspection.

The insurance system, as worked in Switzerland, secures the two main objects which every successful method of controlling disease must aim at. It encourages early notification and provides an effective organization for dealing with cases of disease. It always seems to me that a policy of " burn the lot," which does not provide some form of compensation, might tend to encourage some types of beekeepers to conceal disease and tinker with unscientific nostrums in the hope of curing their bees and saving them from destruction.

The German-Swiss Association had only 7,000 members in 1908. It now has nearly 18,000. Or to put it another way, when the scheme was started its membership represented 42 per cent. of all the beekeepers in the association territory ; now it is 90 per cent. At the present time the profit on the insurance scheme amounts to £2,000 in the hands of the association, all beekeepers' money, which can be used in any way the association likes for the benefit of beekeeping. A splendid and successful scheme, as I think everyone must admit.

https://doi.org/10.23637/ERADOC-1-211

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RECENT WORK ON FOUL BROOD OF THE HONEY BEE

By C. H. CHALMERS, B.Sc., The University, Leeds

THE experimental work on foul brood, carried out at Leeds and extending over a period of two seasons, was essentially of a preliminary character.

It was the increase in the number of cases of foul brood in Yorkshire which stimulated the experimental work at Leeds. The gradual eradication of acarine disease amongst bees has given way to a gradual increase in foul brood. This is probably due to the fact that the earlier treatment of acarine disease was the complete destruction of the hive. The use of fumigation and the consequent preservation of the stock has enabled the causal organism, once again, to obtain a foothold and become a serious problem and a menace to bee husbandry.

Enquiry showed that there is much confusion in the minds of authorities as to the predominant type of foul brood, the causal organism, the source of infection, the progress of the disease and the treatment. The work of Cheshire and Cheyne, carried out in 1885, is the only scientific investigation which has been made in this country. It is unfortunate that this meeting today could not have been held a year or so earlier, when we might have had the pleasure and honour of the company of Sir Watson Cheyne, who carried out the bacteriological work for Mr. Cheshire with such skill and meticulous care. He might have been able to enlighten us on some points which are not explained in his paper. Cheshire and Cheyne were of the opinion that an organism, which they named *B. alvei*, was responsible for the disease.

In 1912, G. F. White, working in America, took up the problem, and after some years of careful work, suggested that the type of foul brood predominant in his country was caused by a rod-shaped organism, slightly more slender than that of Cheshire's, but producing a spore similar in size and shape. This organism he named *B. larvae*. Although he isolated *B. alvei* from a number of diseased stocks, he was unable to reproduce a foul brood with this organism, thus casting some doubt on the work of Cheshire and Cheyne.

The first season at Leeds was confined to the isolation of *B. alvei* and the repetition of Cheshire and Cheyne's work. The isolation of *B. alvei* and its cultivation on the ordinary media of the laboratory is simple and straightforward. It is never found in pure culture is diseased material, being invariably associated with *B. subtilis* species and *Streptococcus apis*. It should be noted, however, that *B. alvei* in seldom, if ever, present in those cases of foul brood, which show the typical characters of the so-called American type, i.e. marked ropiness and the characteristic "glue-pot" odour. Throughout this work, much difficulty was experienced in obtaining frames showing typical

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European foul brood, and consequently it was not possible to study the symptoms manifested by such a diseased brood. During the summer, attempts were made to produce disease by the use of *B. alvei*. Three methods of inoculation were employed, namely feeding the spores of the organism in a syrup solution, spraying the larvae with warm sterile milk containing the spores, and painting the larvae with the vegetative form of the organism. The season closed, however, and none of the infection experiments were successful ; the stocks being as healthy at the end of the season as they were at the beginning.

In the spring of 1933, it was decided to repeat White's work. Several frames, showing typical American foul brood, were obtained. All the diseased frames came from beekeepers in Yorkshire, with the exception of two, which were obtained from the Quantock Hills. A stock of healthy bees were infected with foul brood by inserting one of the diseased frames in the centre of the hive. This stock was kept at a considerable distance from the healthy experimental stocks, and was used as a source of material. The progress of the disease in this hive was interesting. The bees cleaned up the diseased frame and, after some little time, the queen commenced to lay in it. After a period of about 18 days, disease appeared in one of the healthy frames and gradually spread to one side of the hive. Disease did not appear in the introduced frame to any very marked extent until the second brood of larvae were present. The disease then spread steadily to the other part of the hive. This suggests that the responsible organism was being carried by the nurse bees. The first symptom of the disease was an attack on the unsealed larvae just prior to capping. As the disease progressed in severity, this symptom disappeared and only sealed larvae were affected. Later, however, when the disease was at its height this symptom reappeared. This sequence of events was also observed in hives infected experimentally and is considered important. It may be the reason for some of the confusion, which has arisen when diagnosing European and American foul brood by microscopic characters only. At one time most of the diseased larvae were uncapped, suggesting European, whilst at another time all were capped, which suggested the American type.

When the disease had thoroughly established itself in this hive the queen was transferred to a healthy stock, but the stock did not, as a result, show at any time diseased larvae. This observation has, to some extent, been confirmed, for on three further separate occasions the queen of a diseased stock did not produce disease when transferred to a healthy stock. It is not concluded, however, from this observation that the queen does not carry the responsible organisms of disease. Our experience is that in an active healthy hive, where only a few larvae are attacked, a slight infection is rapidly and completely cleared out. It is to be expected that the queen, in her wanderings. over diseased frames, will carry organisms on her body and legs. From this infection a few larvae in the healthy hive may have been

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attacked and rapidly cleaned out before they were observed. Moreover, Sturtevant has shown that a very considerable number of organisms had to be introduced to a stock before disease is produced. This experiment does, however, suggest that the organism is not pathogenic to the queen, that her eggs are healthy and that provided the stock is vigorous, there is little risk in introducing a queen from a diseased stock to a healthy one.

Another interesting observation in connection with this diseased hive was that later the drone brood became attacked and finally the queen cells. By September, practically all the bees were dead, the queen being amongst the last to die.

The changes through which the larvae pass from the time of infection are interesting and throw some light on the methods of attack by the organism and the spread of the disease. Generally, the majority of the larvae die in capped cells, although, as has been explained, some may die before capping. Some of the caps may be removed from cells containing diseased larvae and portions of the larvae removed. It is only when the disease has been present in the hive for some time that sunken and punctured caps appear. The first symptom is that the bluish-white of the healthy larva changes to a very light brown, the surface markings being very similar to those of a healthy larva. The larva at this stage may, with care, be removed from the cells, but an examination shows that the internal tissue is disorganised. Soon, however, the diseased larva is easily ruptured and the decaying mass becomes viscid and adheres to the cell wall. The colour deepens and later becomes so viscid that the mass can be drawn out into thread-like strings. Eventually it dries out, leaving a dark tough scale. Microscopically diseased larvae, at first, show the presence of numerous slender streptobacilli, but by the time the cells are capped, these rods are replaced by spores. These observations suggest that the organism attacks the larva by piercing the gut and extending through the tissue. It will be seen later that it is improbable the organism attacks the larva externally through the body wall. Moreover, a slight attack of the disease probably does not gain a foothold readily, because the few diseased larvae can in the early stages be removed intact and thrown out of the hive, thus eliminating the infection. These conclusions are supported to some extent by later experiments.

The media used to isolate the organism were (1) White's Brood Agar, (2) Egg Yolk Nutrient Agar, (3) Chocolate Agar, (4) Red Blood Agar, (5) Inspissated Serum, and (6) Sturtevant's Egg Agar. *B. larvae* grew well on all of these media, but to a varying extent. Red Blood Agar and Sturtevant's gave the best results. The organism is easily recognised by its slender shape, variable size and motility, its smooth, greyish-white slightly viscid growth on the media mentioned and its inability to grow on any of the ordinary media of the laboratory. The spore is central, but not difficult to stain by ordinary spore staining methods. The organism does not spore readily on Sturte-

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vant's, unless the egg is omitted. Pasteurisation or desiccation does not induce spore production. The organism is present in diseased larvae in practically pure culture. By heating the spore containing material in aqueous suspension at 80°C. for ten minutes, the occasional contaminating organisms are eliminated and a pure culture usually obtained without plating. Several methods of inoculation with *B. larvae* were tried, vigorous healthy stocks of Italian and X-bred bees being used. The methods of inoculation were: (1) Feeding spores in syrup, (2) Inoculating frames, not containing larvae, by means of a capillary pipette, with both the spores and vegetative forms of the organism, (3) "Painting" uncapped full-grown larvae with spores and with active growth from an agar slope, (4) Spraying frames containing eggs and larvae with both the spores and vegetative form of the organism in warm sterile separated milk. The last method was by far the most successful—typical foul brood being produced in from fourteen to twenty-one days. "painting" the larvae and inoculating empty frames gave negative results, whilst the feeding of spores was disappointing. The results, however, are interesting and the following explanation is offered:

(*a*) *Painting full-grown larvae.*—The organism apparently does not gain entrance to the larva through the body wall, and since feeding at this stage is practically at an end, there is little opportunity for the organism to infect the larvae.

(*b*) *Inoculating empty frames.*—The cells of the frame are, as far as possible, thoroughly cleaned and polished by the nurse bees before the eggs are laid, and consequently any infection is cleaned out. It was interesting to note, however, that a few larvae took the disease, but these were soon removed, and the frame remained healthy.

(*c*) *Feeding infected syrup.*—This experiment was commenced in June, and negative results were obtained until about the end of August, when foul brood appeared. It is suggested, therefore, that the syrup was stored and not used as part of the food of the young larvae, until outside food was becoming scarce.

(*d*) *Spraying warm milk, containing spores and vegetative rods.*—This was successful, because the active form of the organism became mixed with the actual food of the young larva, and being absorbed into the gut almost immediately, set up an infection rapidly. The disease produced was typical American foul brood, and the organism was re-isolated from the diseased larvae with ease.

From these preliminary experiments, the following conclusions are suggested. It should be remembered, however, that much more work requires to be carried out before final conclusions can be drawn. The most frequently occurring type of foul brood is the American type. It was only with difficulty that specimens of the European type were obtained and these were not typical. *B. alvei* was isolated from cases of so-called foul brood, but infection of healthy stocks could not be produced, either by inoculation of the larvae, or by feeding. *B. larvae* was isolated in pure culture, from typical cases of

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American foul brood, and the disease reproduced by feeding infected syrup and by spraying healthy larvae with the organism. It is probable that infection of the larva is through the wall of the intestine and is carried by the nurse bees. The difficulty encountered by the bees in cleaning out badly-diseased grubs and dried scales is responsible for the persistence of the disease in a stock. The trailing of pieces of badly-diseased larvae across the frame containing healthy brood no doubt produces some infection. Frames containing much diseased brood will cause the disease when placed in a hive containing healthy larvae. It is probable that in nature, a considerable period elapses from the time the hive is first infected until the disease obtains a foothold. Strong healthy stocks of vigorous bees will, in the early stages of the disease, eradicate it by the complete removal of diseased larvae. Slight infections of the disease may, therefore, disappear without treatment. All types of larvae are subject to disease but adult bees, including the queen, do not appear to suffer. Finally, there appears to be little risk of transmitting the disease by transferring the queen of a diseased stock to a healthy stock.

I should like to take this opportunity of thanking Mr. W. Hamilton, Instructor in Beekeeping at Leeds University, for much help during the course of this work.

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REMARKS ON BEE DISEASE INVESTIGATIONS AT LEEDS

By W. Hamilton

(*County Bee Instructor for Yorkshire*)

The investigation into the problem of foul brood at Rothamsted has my full support. Before I came to Yorkshire in 1926 I had seen little or nothing of foul brood, and depended on my knowledge from books. These books were confusing, and when cases were found in the county from 1928 onwards the need for a fuller knowledge of the problem became apparent.

With the co-operation of Mr. Chalmers I saw the opportunity for a piece of useful research work, and in 1931 an investigation was commenced.

You have heard some of the details from Mr. Chalmers, and I might add that first no case of so-called European foul brood was encountered, although samples were received which had been diagnosed by experts as of that type.

It was soon seen where the confusion lay, as in the early and last stages of American foul brood the symptoms were similar to those describing European foul brood.

The taking of the queens from the diseased colonies and exchanging to healthy ones was interesting.

Another point of interest was the apparent difficulty in getting the disease to take hold of the colony unless a large infection was given. Further, there was the immunity of the control stocks which had stood, and still stand, among the diseased ones with not the slightest sign of the disease appearing. Also the fact that no precautions were taken in the handling of the healthy stocks after the diseased ones. The changing of quilts and combs was of course not practised, although it had been planned.

The disease is found in various parts of Yorkshire and almost always in isolated cases. Some of these cases have been traced to people buying bees from dealers in the South. Most of the dealers are careful not to send out disease, but in some cases they do not take proper precautions and buy bees for resale from doubtful sources.

From the samples which I see from time to time I am of the opinion that in many cases it is impossible to make satisfactory diagnosis of foul brood without microscopical examination and I sincerely hope that the research to be conducted at Rothamsted will result in the classifying of all the maladies or other troubles to which the brood of bees is subjected.

https://doi.org/10.23637/ERADOC-1-211

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THE PRESENT POSITION OF THE SCIENTIFIC INVESTIGATION OF FOUL BROOD DISEASES OF BEES

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

At the present time much confusion exists in the literature dealing with brood diseases of the bee, and although much valuable work has been done there is yet a pressing need for advancement in our scientific knowledge of this subject. I recognize that, as one of at present rather limited experience in this field of investigation, I am as yet not fully qualified to criticise the published papers relating to this subject, and I must therefore ask you to accept what is, on the whole, a non-critical survey of this field.

American Foul Brood

White (1906, 1907, 1920a) first succeeded in isolating the causative organism of this disease, and proved by actual inoculation experiments that pure cultures of this organism actually caused American foul brood. He named the infecting agent *Bacillus larvae*. There is practically no doubt that Maassen's *Bacillus brandenburgiensis* (1906) was identical with *B. larvae*. Since White's discovery Toumanoff in France, Borchert (1930) in Germany, Lochhead (1928a) in Canada and Chalmers and Hamilton (1933) in England, and a good many other investigators have accepted, without much reserve, the findings of the American investigator.

Perhaps the most striking characteristic of *B. larvae* is its inability to grow upon the more common bacteriological culture media, and it was undoubtedly this fact which caused such confusion among earlier workers who attempted to isolate organisms responsible for brood diseases. Such workers as White (1920a), Sturtevant (1924), Lochhead (1928a, 1933) and Toumanoff (1930b) have described media upon which this organism will grow with comparative ease. The spores of *B. larvae* are remarkably resistant to heat, a fact which makes its elimination from the apiary a rather difficult matter.

Recently Sturtevant (1932) has shown that a relatively large initial inoculum of the spores of *B. larvae* is required to initiate a definite infection in a colony of bees: he has estimated that at least 50 million spores fed in one litre of syrup are necessary to infect a colony, and that each larvae required some 10 million spores in 0.01 cc of syrup in order to develop the disease. His results tend to show that commercial honey is probably not a fruitful source of infection in American foul brood.

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It is well known that American foul brood does not usually develop until the larva have been sealed, and Sturtevant (1924) attributed this fact to the inability of *B. larvae* to multiply in the presence of much sugar. He found that concentrations of glucose in the neighbourhood of 5 per cent. completely inhibited multiplication of both spores and vegetative cells of this organism. Lower concentrations of glucose also caused partial inhibition of growth.

The comparatively recent experiments conducted by Toumanoff (1929) are of interest in connection with American foul brood, for he is apparently the only investigator who has questioned the pathogenicity of *B. larvae*. In his experiments he employed aqueous suspensions prepared from young cultures of five different strains of this organism, and fed small amounts to healthy larvae. Of 302 inoculated larvae, 170 were removed by the bees, while the 132 remaining underwent metamorphosis in the normal manner and developed into healthy adult bees. He found that the bees removed some of the larvae when ordinary saline was fed as control in place of the bacterial suspension. He used both vegetative cells and spores. He assumed from his results that it is by no means always easy to infect brood with *B. larvae*, and suggests that his results may be explained by an attenuation in virulence of the organism resulting from cultivation on artificial media. In the light of Sturtevant's work it is possible that Toumanoff's results may be explained by the fact that the number of organisms fed was insufficient to cause disease. There is room for further work along these lines.

European Foul Brood

While American foul brood appears at present to be a relatively well-defined disease, European foul brood is a disease the etiology of which is still in doubt. It is now practically certain that the brood disease attributed to *Bacillus alvei* by Cheshire and Cheyne (1885) is identical with that which was christened European foul brood by Phillips (1906), and which was studied in detail by White (1912, 1920b). White believed that the disease was caused by a lanceolate-shaped, non spore-forming organism, which occurred in large numbers in freshly infected brood, and which would not grow on any of the culture media which he tried. He named the organism *Bacillus pluton*. He assumed that this organism was responsible for producing European foul brood because, when fed in sugar syrup or honey to healthy larvae, typical disease resulted, and because none of the readily-isolable so-called " secondary invaders " (*Streptococcus apis*, *B. alvei*, *B. orpheus* and *Bacterium eurydice*) produced disease when inoculated into experimental colonies. Although many investigators accept White's work, the fact that he was unable to isolate *B. pluton* leaves his conclusion rather open to criticism, and in certain quarters his thesis has not gone unchallenged.

In 1927 Wharton published what appears to have been a premature statement on the etiology of European Foul Brood. He claimed to

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have developed "a medium admirably suitable for the growth of *B. pluton*," and at the same time suggested that this organism is merely a stage in the life cycle of *B. alvei*. Shortly afterward Lochhead (1928b) published a note in which he condemned Wharton for his unauthorized and premature statement. Lochhead himself (1928b) apparently doubted the existence of *Streptococcus apis* as a species distinct from *B. pluton*. He also pointed out (1928c) that it is possible that *B. alvei* dissociates into *B. pluton*, but he has never asserted that this change actually occurs. Thus he stated that, "As yet the identity of the coccoid form of *B. alvei* with the coccoids seen in European foul brood is suggested only on the strength of microscopic comparison." . . . "Our attempts to produce the disease in a colony of black bees through feeding cultures have so far been inconclusive, and consequently no statement can be made at this time regarding the pathogenicity of this form of *B. alvei*."

In connection with the controversy on European foul brood it seems proper to include the recently-discovered disease termed "Para foul brood." Burnside and Foster (Burnside, 1932) (Foster and Burnside, 1933) have recently described this apparently new brood disease, the symptoms and course of which appear to differ from those commonly experienced in American and European foul brood infections. Because of its apparently close relationship to *B. alvei* the authors have chosen the name *Bacillus para-alvei* for the organism which they claim is responsible for the disease. These authors make the mistake of misquoting Lochhead when they say that he actually demonstrated that *B. pluton* is a stage in the life cycle of *B. alvei*. However, if their claim that this has been verified in the Washington laboratory is true, it may be that the problem of what is the infecting agent in European foul brood has been solved. It is to be hoped that a comprehensive scientific report of their work will appear in the near future, and that it will clarify some of the existing confusion in our knowledge of this disease.

Sacbrood

This disease, which is apparently more benign than malignant, was discovered and studied thoroughly by White (1913, 1917). The infected brood presents what appears to be a very characteristic appearance. The most important distinguishing feature from the bacteriological standpoint is the entire, or almost entire, absence of bacterial cells in the infected larvae. This disease, according to White, is due to the activity of a filtrable virus capable of passing through the pores of Berkefeld and Pasteur-Chamberland filters. The porosity of the filters employed in his work is not stated. Apparently no further publication on this disease has appeared since White's original communications, though certain European investigators refer to Sacbrood as a well-defined disease in their publications.

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Rarer Infections of the Brood

In 1921 Sturtevant found that American and European foul brood occasionally occurred simultaneously, but such outbreaks were extremely exceptional. Borchert (1934) claimed that *Bacillus orpheus*, an organism considered by White (1920b) to be a non-pathogenic secondary invader in European foul brood, can infect the brood of bees. The results obtained by Borchert do not appear to be very striking, since the relative amounts of infected brood obtained in his experiments was very small. At present it appears as if this type of infection is more of academic than of practical importance.

Toumanoff (1927) has described a brood disease which appears to differ from any previously described. From combs containing naturally infected larvae he isolated four different organisms: *Colibacillus paradoxus*, *Bacillus agilis larvae*, *Micrococcus luteus liquefaciens* var *larvae* and an unidentified species of *Torula*. He describes the cultural and morphological characteristics of these organisms in some detail, but makes no attempt to explain which of these organisms is the primary infecting agent.

The most recent work dealing with fungus diseases of bee larvae is that of Burnside (1930), though his work is chiefly concerned with diseases of adult bees. He found that the moulds of the *Aspergillus-oryzae* group are largely responsible for fungus diseases of the brood, *A. flavus* being the most common infecting agent. *Pericystis apis* and *P. alvei* have, according to Burnside, never been reported in North America.

The Immune Reactions of Larvae

Borchert (1924, 1930) claims to have demonstrated complement-fixing antibodies in extracts of the larvae and scales from foul brood combs, but he failed to find agglutinins or precipitins for *B. larvae* or *B. alvei* in such extracts. He was able to demonstrate a complete serological difference between these two organisms.

Metalnikoff and Toumanoff (1930) and Toumanoff (1930a), showed that two types of blood cells are present in larvae, namely proleucocytes and leucocytes, the form of which they describe in detail. In normal larval blood 85 per cent. of the cells are proleucocytes and 15 per cent. are leucocytes. In certain experiments they injected number of 3 to 5-day-old larvae with 1/160th of a cc. of a thick suspension of a human strain of *Staphylococcus* The injection was made at the caudal end of the larvae directly into the blood. They observed a considerable decrease in the number of proleucocytes and a simultaneous rise in the number of leucocytes, accompanied by a pronounced phagocytosis by the last-named cells. At the end of twenty-four hours all the inoculated larvae had died of septicaemia, and blood cells were no longer demonstrable. In a subsequent experiment the larvae were immunized with a heat-killed culture of the same strain of *Staphy*

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lococcus twenty-four hours before the injection of virulent cocci. In this experiment after 24 hours ninety-nine per cent. of the total blood cells were leucocytes, and all free bacteria had vanished from the larval blood. The larvae survived two days after this experiment It appears as if phagocytes are important in determining immunity in these simple forms of life.

It is apparent from the foregoing remarks that our scientific knowledge of foul brood and other brood diseases of the bee is by no means in a satisfactory state, and this is especially true of European foul brood. In the case of this disease the controversy as to what is the infecting bacterium must be settled. There is also the question of bacterial diseases of the brood which are of rarer occurrence and of ascertaining whether they are of much practical importance and what the infecting organisms are. In England the distribution of the different types of foul brood must be determined. Again, more effective measures of scientific control of the spread of foul brood infection are badly needed. It is hoped that some of these problems may be solved at this Station.

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Note added August 20th, 1934. Since this paper was read, Burnside (J. Econ. Entomol., *27*, 656, 1934) has published the results of his investigations on European foul brood. In his paper he states that there is, in all probability, no such organism as *Bacillus pluton*, and that it is merely *Streptococcus apis*. He describes experiments in which he succeeded in producing foul brood with both *Streptococcus apis* and *Bacillus alvei*. He also believes that European foul brood is caused by a pleomorphic organism which may assume the form of *S. apis* or *B. alvei*, but the evidence which he presents in support of this hypothesis is rather inadequate.

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DISCUSSION

DR. GUY MORISON (Aberdeen) spoke of the samples which he had been called upon to examine in Aberdeen, and mentioned cases of a hitherto unknown brood disease which had occurred.

MR. JOSEPH TINSLEY (Ayr).—Emphasized the debt which beekeepers owe to Mr. A. H. E. Wood of Glassel, who made the investigation of the Isle of Wight Disease at Aberdeen possible.

DR. F. THOMPSON (Epsom) called attention to the danger of introducing bee disease by purchase of stocks of bees.

MR. LESLIE HAGUE (Warwick) suggested that the viability of spores of American foul brood in honey was an important point which should be investigated.

A BEEKEEPER referred to the problem of control of derelict hives.

MR. J. HERROD HEMPSALL (Ed. "British Bee Journal") mentioned a case where infection had been traced to the use of old quilts, which had been laid by for a number of years.

MR. JUDGE (Kent) recalled the serious extent of foul brood in pre Isle-of-Wight days. He outlined the organization of the bee disease service in Kent. He advocated the destruction of stocks until more is known on the subject, but expressed himself hopeful of the outcome of the present investigation.

MR. W. HERROD HEMPSALL (Ministry of Agriculture) stated that foul brood is spreading at an alarming rate: and said that reports received in reply to the questionnaire gave no idea of the present extent of the disease. He thanked Sir John Russell and the staff of Rothamsted for the part they were playing in this campaign.

MR. GAUNTLETT THOMAS (Newmarket) suggested that the faeces of the queen were an important source of infection in the hive. He offered to submit his own remedy against foul brood to be tested and reported on by Rothamsted.

MR. B. C. BERKELEY (Berkshire) advocated compulsory notification of brood diseases, and said that the sale of apiaries by the executors and widows of deceased beekeepers was a very frequent cause of the dissemination of brood disease.

MR. MORLAND (Rothamsted) mentioned a case of the dispersal of infected appliances at an auction sale.

MR. J. HERROD HEMPSALL spoke of the ignorance often displayed by beekeepers as to the precautions necessary when dealing with bee diseases.

DR. THOMPSON asked whether a low lying locality were favourable to brood diseases.

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DR. ANDERSON (Aberdeen) was gratified that this investigation was now being undertaken and hoped it would prove the wisdom of taking action in time. He gave instances of the rapid spread of foul brood in New Zealand and in the United States of America. He agreed as to the importance of educating beekeepers.

MR. ACASON (Pinner) gave particulars of the scheme in force in the Pinner Beekeepers Association for the replacement of cottagers' stocks of bees, which have had to be destroyed owing to bee diseases.

A CHESHIRE MEMBER said that a scheme was in force in his county to recompense poorer beekeepers who have suffered from Foul Brood.

DR. THOMPSON and another suggested that the possible vitamin-content of honey, pollen or royal jelly might have some bearing on the preparation of media for the laboratory culture of foul brood organisms.

MR. W. HERROD HEMPSALL spoke on the subject of legislation.

DR. MORISON raised the question of the packing of samples sent for diagnosis.

DR. TARR replied that he was sending out a special box and grease-proof envelope to be used for the purpose. He also said that the greater number of the samples so far received were of the so-called American foul brood.

MR. J. HERROD HEMPSALL said that in 1909, 75 per cent. of both apiaries and colonies in Great Britain were affected with foul brood.

MR. GILBERT BARRATT (Queen breeder, Hampshire) pointed out that disease was frequently spread by dealers in bees and said that every dealer should give a guarantee of freedom from disease.

A MEMBER thought that an investigation should be made into the viability of spores of American foul brood in respect to heat, and expressed the opinion that boiling was not effective for sterilizing wax.

MR. HAMLIN (Surrey) and Mrs. HOOPER (Glamorgan) also contributed to the discussion.

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organisms. It attacks the larvae at an older stage than is usual in the case of European foul brood. The larvae generally die at about the time of pupation so that much of the diseased brood is found to be capped, and a cocoon is often formed.

Symptoms of American Foul Brood. The prevalence of sealed cells, is characteristic of this disease. The sealed brood is seen to be sprinkled with open cells. Cappings may be stained by the decay going on within the cell; they may be sunken, or partially or wholly torn away by the bees. The smell is characteristic and a more reliable indication than it is in the case of European foul brood; it has been likened to that of an ill-kept glue pot. The brood may die as larvae or pupae. The dead grubs lie on their backs on the lower side of the cell in a stretched out position; in the case of the larvae the head is slightly raised, while the tongue of the pupa, pointing upwards and often sticking to the top of the cell, is very typical. At a certain stage of decay of the larvae, the mass, if stirred with the end of a match, can be drawn out like a thread. Brood which has died from other causes does not behave in this manner.

The dead brood changes to a coffee colour. The dried scales adhere strongly to the cell wall and cannot readily be removed, except when the cell is an old one lined with larval skins which tear away with the scale.

Spread and Prevention. All races of bees are equally susceptible to American foul brood. The disease attacks strong as well as weak colonies, and may occur at any time when there is brood in the hive.

Since the causative organism forms resistant spores which remain alive for many years in diseased material and in honey, the greatest care must be taken to disinfect or destroy any hive or appliance which has been in contact with infection. Honey from unknown sources should not be given to bees, nor should vessels which have contained honey be left where bees may have access to them. After handling diseased or suspected stocks, the beekeeper should disinfect his hands and his smoker and other tools. Washable overalls should be worn when working in an apiary in which disease exists. The exchange of combs between hive and hive even in healthy apiaries should only be practised with a full realization of the risk involved, and never where disease is suspected.

Treatment. Before treating stocks for American foul brood it is well to weigh the value of the bees and of the hive and combs, against the time and attention needed to save them, and the risk of the occurrence of further outbreaks of the disease in the event of some detail being overlooked.

Beginners would do well to call in the aid of an experienced beekeeper and to choose one of the more drastic of the measures here indicated.

Any comb, whether of brood or stores, and any part of a hive infected with American foul brood, is liable to carry contagion.

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movements. The larvae usually die before the cells are sealed. In cases where the disease has taken a firm hold, some of the cells may be sealed, but the diseased larvae in them neither spin a cocoon nor pupate. The dead brood turns greyish and finally to a dark brown or black mass lying irregularly in the cell, and dries up, forming a scale which can easily be removed. The odour is unpleasant but very variable both in quality and intensity and is quite unreliable as a character for diagnosis. When *S. apis* predominates among the putrefactive organisms it somewhat resembles that of sour paste, whereas the *alvei* form of the disease has been referred to by Continental beekeepers as "stinking foul brood." On the other hand American writers state that in European foul brood there is usually little odour.

Prevention. European foul brood usually makes its presence known in spring and is essentially a disease of weak stocks. Owing to their more vigorous house cleaning habits, bees of the Italian race are less liable to suffer from it than are other races. A strong colony of Italian bees is but little liable to contract this disease. *Only strong stocks of vigorous bees should be kept.*

The following treatment is recommended for European foul brood, but it is essential first to make quite certain that it is not a case of American foul brood. (1) Unite weak stocks, because strong colonies are far better able to rid themselves of this disease. (2) Cage the queen, and later remove her and introduce a young Italian queen, allowing a clear ten days during which there is no egg laying in the hive. If a young fertile queen is not available the old queen may be removed at once and a virgin or queen cell provided. (3) Feed the colony with a dilute sugar syrup, until the honeyflow commences. (4) The colony may then be strengthened with combs of *sealed* brood from healthy stocks. During the ten days broodless period there will be no fresh diseased larvae, and under the stimulus of feeding, the infective material will be removed by the bees. Later the stock will be repeopled with a race of bees less liable to succumb to this particular disease.

Experiments have shown that medication of the syrup has no direct effect. Beneficial results which have been reported of this treatment are due to the feeding rather than the medicament. Odorous substances such as formalin have been used in the treatment of European foul brood, allowing them to evaporate in the hive. It is thought that the presence of an irritating vapour causes the bees to fan more vigorously and that the scales therefore dry more quickly which makes them more easily removed.

American Foul Brood

A more serious disease, now generally known as "American foul brood" or alternatively "malignant foul brood" or "brood-pest," is caused by *Bacillus larvae* a spore-bearing bacillus, which is itself an agent of decay and does not tolerate the presence of other

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APPENDIX

BROOD DISEASES OF BEES

By D. MORLAND, M.A.

Owing to the greater urgency of the problems of adult bee disease, brood diseases have lately been neglected in the United Kingdom: in consequence of which much of our knowledge of brood diseases is derived from work done in other countries.

Foul Brood

There are at least two distinct diseases referred to by the term "foul brood." Owing to the somewhat variable nature of the symptoms, much uncertainty has existed, which has been increased by lack of agreement as to nomenclature. It should be pointed out that the terms "European" and "American" foul brood are not used with reference to their geographical distribution, and are only here used to avoid the worse confusion which has been caused by attempts to coin better names.

European Foul Brood

The milder disease, called "European" in recognition of the early investigations of the English microscopist, Frank Cheshire, in collaboration with Dr. W. Cheyne, is now generally regarded both in North America and on the continent of Europe as being caused by *Bacillus pluton*—a non-spore organism which attacks the young larvae. In view of the difficulties attending its culture, further investigation of its pathogenic behaviour, and also of its relations with *Bacillus alvei* (see below) is desirable. Various other organisms invade the diseased brood, so that *B. pluton* can only be recognised in those which have recently become infected, while in dead larvae. and those in more advanced stages of disease, it is masked by the presence of auxiliary, putrefactive agents. The two most important of these are *Bacillus alvei*, which Cheshire considered to be the cause of this disease, and *Streptococcus apis*. The symptoms and to some extent the course of the disease are apparently modified according to which of these secondary invaders predominates.

Appearance of healthy brood. In normal healthy brood the larvae are plump and pearly white in colour and lie at the base of the cell in the form of the letter C. The brood is regularly arranged and the cappings of the sealed cells are slightly convex. The smell is not unpleasant.

Symptoms of European Foul Brood: In a comb affected by European foul brood the diseased larvae become limp and watery yellow in colour, the lateral tracheal tubes showing through the skin. Instead of continuing to lie normally at the base of the cell, they assume a spiral or stretched out condition and exhibit uneasy

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Destruction of Stock. (*a*) Where the hive and colony is of small value, the bees should be destroyed after nightfall by suffocation over a sulphur candle, or by pouring a little petrol or carbon disulphide into the hive from above, and closing again until all sounds have ceased. A good bonfire should then be started in a pit and the hive and combs placed on it. * The pit should be filled in again before morning, to cover any wax or honey which may have escaped the flames. (*b*) When the hive is worth saving, it may be disinfected as described later and the combs alone burnt.

The Shaking Treatment consists of shaking the bees on to a newspaper in front of a new hive on the old stand, so that they run in and start life again as a swarm on strips of foundation. The honey in the honey-sacs of the bees is used up in the formation of wax. The old infected hive and combs should be quickly removed to a place of safety, out of reach of the bees, and dealt with as soon as possible. This treatment is better performed in the evening and during a honey flow, in order to avoid the spread of the disease to other colonies through robbing, and in any case syrup may with advantage be given after an interval of a few hours. Care should be taken not to allow unripe honey to fall anywhere but on the newspaper, and this should afterwards be gathered up and burnt. Many experts prefer to brush the bees off the combs instead of shaking them, especially when newly gathered honey is present. For additional security the swarm may subsequently be shaken again on to full sheets of foundation, but this puts a great strain on the bees. The shaking treatment is only advisable with strong stocks and early in the season. (*d*) The hive should be scraped clean, and disinfected, either by scorching all over inside with a painter's blowlamp or by scrubbing with a stiff brush in hot water and soda. 1 lb. soda to 1 gall. water. † The use of goggles and rubber gloves is advised. This is a good opportunity for giving the hive a new coat of paint. (*e*) If the combs have been saved they may be melted down in boiling water. (The Solar extractor should not be used for this purpose, on account of the danger of spreading the disease.) The wax may then be used with safety even for the manufacture of comb foundation. The frames may be steeped in boiling soda if they are worth saving, but it is usually better to burn them. (*f*) Disinfection of combs. It is rarely advisable to save the combs, but in commercial apiaries, where large numbers of good combs would otherwise have to be sacrificed it has been found possible to disinfect them, using a solution of formalin in alcohol in the proportion of one part of formalin to four parts of alcohol, and allowing them to soak

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* Remember that petrol and carbon disulphide are dangerously inflammable, the vapours should be allowed to dissipate first.

† Before painting, the soda must be washed away and the last traces neutralized with a weak solution of vinegar, or the paint will not take well.

https://doi.org/10.23637/ERADOC-1-211

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for 48 hours. For details, reference should be made to recent American literature.

Other maladies of brood

Sac brood. An infectious disease of brood which is apparently due to a filtrable virus. The dead larvae form watery sacs which contain some granules of broken down tissue, but no bacteria. The scales are easily removed from the cells. This disease is not usually serious.

Chalk brood. The larvae die and turn to white mummies of a cork-like consistency. It attacks chiefly the drone brood, and the Dutch race of bees seem to be most susceptible. It is not serious and usually disappears as the season proceeds. It is caused by a fungus *Pericystis apis ;* closely related to the white pollen mould *P. alvei.* This disease is favoured by damp, ill ventilated hives.

Stone brood. A disease similar to chalk brood, in which the dead larvae turn to hard grey masses in the cell. It is caused by the fungus *Aspergillus flavus.* This disease is more serious than chalk brood but is not yet known to occur in this country. In Germany it is said to attack adult bees in addition to brood.

Accidental injury to brood

Chilled brood is purely accidental in origin. It may be due to inadequate protection of hives in spring or to a colony having expanded its brood nest too early. Cold winds or spring frosts will find out such colonies. A more common cause of chilled brood is unseasonable manipulation of colonies by the too enthusiastic beginner, or the unwise " spreading " of brood by the insertion of empty combs between combs of brood in the hope of stimulating the queen to lay. Unless it is a very bad case, the dead brood is not allowed to putrefy in the comb, but is quickly removed by the bees. In the case of chilled brood the whole patch of larvae dies and not cells here and there as in foul brood.

Starved brood. Colonies which have indulged in breeding beyond their resources, in the expectation of an early honey flow, which fails to materialise, may find themselves faced with starvation. The usual result is a cessation of egg laying, and the casting out of pupae. The younger larvae also may be removed, and apparently are consumed by the worker bees. The remedy is syrup feeding. Both the above conditions more commonly occur with Italian strains, which are inclined to be speculative in their brood rearing ; the black races being more conservative in this respect.

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Heated Brood. Brood may occasionally die of over heating. This sometimes occurs when moving stocks of bees by rail if there is brood in the hive. If the travelling box is left in the sun during the journey, bees and brood may die. In opening colonies in very hot weather, combs of brood should not be put in the sun or some of it may be killed by the heat, drying, or the intensity of the light, or by a combination of these factors.

Spray Poison. In districts where spraying and dusting of fruit and crops with insecticides is practised, bees may collect the poison. In the former case, heavy mortality among the bees may cause such depletion in the hive that brood may die showing the symptoms of neglect and chilling. Where poison dust is used, it is liable to be collected with the pollen, and lead to direct poisoning of the brood in the hive.

Poisonous Plants. In California, brood is said to suffer from poisoning by the nectar of certain plants. No case of this kind has been known to occur in Great Britain.

Pollen Shortage. This causes severe mortality of bee brood in parts of Australia. Such a thing is never known in this country.

It should be clearly understood that neither form of foul brood can be spontaneously engendered in cases of accidental mortality. Since foul brood is due to definite disease organisms, infection must be brought from another case of the disease. Micro-organisms are frequently found in the decaying remains of dead brood, but this is only to be expected and they are not necessarily those which cause disease.