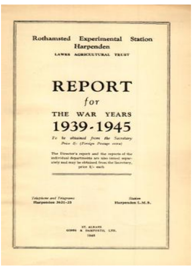
ROTHAMSTED RESEARCH

Report for 1939-45



Bee Department

C. G. Butler

C. G. Butler (1946) *Bee Department ;* Report For 1939-45, pp 194 - 205 **- DOI: https://doi.org/10.23637/ERADOC-1-87**

BEE DEPARTMENT

By C. G. Butler

In January, 1939, on the resignation of Mr. D. M. T. Morland who had been in charge of the Bee Section, a Sub-Department of the Entomological Department, since it first came to Rothamsted from Cambridge in 1921, Dr. C. G. Butler was appointed Entomologist in Charge of the Bee Section. A few months later Mr. P. S. Milne was appointed to the Section to carry on and extend the work commenced by Dr. H. L. A. Tarr on brood diseases of the honeybee, Dr. Tarr having resigned some months before Mr. Morland. At the outbreak of the war, therefore, the staff of the Section as it then was, consisted of Dr. Butler, Mr. Milne and Mr. A. C. Rolt who had been the Section's Apiarist since 1921. During the period under review the following people have also worked for a year or more in the Section, Dr. G. F. Cockbill, Miss P. Schiele, Dr. A. C. Fabergé, and Mr. E. P. Jeffree.

In 1944 the Bee Section received its autonomy from the Entomological Department and became an independent Bee Department. The following persons staff the Department today; Dr. Butler, Mr. Milne, Miss A. D. Synge who replaced Mr. Jeffree when he resigned in 1944 to take up a beekeeping post at the North of Scotland College of Agriculture, Mr. N. Ellement, Chief Apiary Assistant, succeeding Mr. A. C. Rolt who resigned in 1944, to become Beekeeping Instructor to the County of Somerset, Mr. J. Clifford, Junior Apiarist, two girl Laboratory Assistants, and the Department also has the services of a Secretary-Laboratory Assistant, Mr. A. Wafa, of Cairo University, joined the Department as a Ph.D. student of London University in 1945.

The Bee Department differs from other Departments at Rothamsted in that, although research work is the primary objective of its members, it also carries out a great deal of advisory and extension work, thus being brought into closer contact than would otherwise perhaps be the case with the problems both of the growers of fruit and seed crops and of the beekeepers. During the war both the research and the advisory work of the Department have increased very considerably. Members of the Department have also been called upon to serve on various specialist committees such as the Ministry's Bee Disease Advisory Committee and a Sub-committee of the British Standards Institution concerned with the standardisation of beekeeping equipment. In addition, since the retirement of the Ministry's Technical Advisor on Beekeeping, Dr. Butler has been acting as the Ministry's beekeeping expert.

Members of the Department had a good deal to do with the drawing up and application of the Foul Brood Disease of Bees Order, 1942, and have since this Order came into force been responsible for the examination of all sample combs taken, and for organising courses of instruction at Rothamsted for over 300 officers appointed under the Order to examine colonies of bees suspected of being diseased.

As intimated above, the work of the Bee Department during the period under review falls naturally into two main categories, research work and advisory work, each of which may be subdivided as follows :—

1. *Research Work*
   (*a*) Research on the various diseases of the honeybee and her brood.
   (*b*) Pollination studies including examination of the possible dangers to pollinating insects resulting from the use of insecticidal and fungicidal sprays and dusts.
   (*c*) Work on various problems of bee anatomy, physiology and behaviour, on bee husbandry, etc.
2. *Advisory and Extension Work*
   (*a*) Diagnosis of adult bee diseases and of brood diseases in samples of bees and their brood submitted for examination.
   (*b*) Advice to beekeepers and to fruit and seed growers on problems concerned with both the healthy and the diseased bee, pollination, etc.
   (*c*) Lecturing, demonstrating, broadcasting, the preparation of Bulletins and Leaflets, and of illustrated lectures for loan to Beekeepers' Associations, etc., and the elaboration of measures for the control of bee diseases on a national scale.

Various aspects of the work of the Department enumerated above will be discussed briefly in the following pages.

FOUL BROOD DISEASE OF BEES ORDER, 1942

Almost as soon as war broke out steps were taken to obtain an increased measure of control over bee diseases, particularly of the two diseases usually described as Foul Brood. In this connection a scheme for the control of Foul Brood on a national scale was drawn up and served as the basis for the Foul Brood Disease of Bees Order which was introduced in March, 1942. The introduction of this Order soon led to a very considerable increase in the number of brood combs submitted for examination since the Department became the official laboratory to which all samples of comb have to be submitted in the course of application of the Order. Besides the Order directly effecting a big increase in this side of the Department's work it has also, because it tended to make beekeepers more disease conscious, led indirectly to a considerable increase in advisory work.

The following Tables show the numbers of samples of brood combs and of adult bees examined during the years 1939-1945 inclusive :—

Brood combs examined

Year (Jan. 1-Dec. 31)	Total No. of combs examined	No. of combs with American Foul Brood	No. of combs with European Foul Brood	No. of combs in which other diseases were found	No. of combs in which no diseases were found
1939 ..	270	112	18	45	98
1940 ..	182	90	2	26	64
1941 ..	316	140	16	26	134
1942 ..	1,055	613	13	60	374
1943 ..	1,801	1,161	43	124	478
1944 ..	2,519	1,791	43	136	559
1945 ..	2,244	1,559	30	104	567
	8,387	5,466	165	521	2,274

(*Note.*—More than one disease may be present in the same comb, hence the total of columns 2-5 is usually greater than the figure in column 1.) The effect of the introduction of the Foul Brood Disease of Bees Order in March 1942 was, as shown above, to cause a great increase in the number of sample combs sent for examination each year, this increase resulting from a widespread search for these diseases in most districts in England and Wales.

Samples of adult bees examined

Year: (Oct. 1-Sept. 30)	Total No. of samples	No. samples with Acarine disease	No. samples with Nosema disease	No. samples with Amoeba disease	No. samples in which no diseases were found. (Paralysis not counted as a disease)
1939-40 ..	—	—	—	—	—
1940-41 ..	194	48	12	0	134
1941-42 ..	1,310	298	90	0	922
1942-43 ..	2,317	559	56	18	1,693
1943-44 ..	1,545	481	11	18	1,035
1944-45 ..	1,224	344	32	8	837
	6,590	1,730	201	44	4,621

[*Note*.—More than one disease may be present in the same sample of bees, hence the total of columns 2-5 may be greater than the figure in column 1.]

The incidence and distribution of adult-bee diseases

Two entirely objective surveys to determine the incidence and distribution of adult-bee diseases in England and Wales were carried out during the winters 1941-42 and 1943-44. The first of these surveys showed that at least one in five of all colonies of bees in England and Wales was at that time suffering from Acarine disease. Further, the results showed that there were areas of low percentage infection in Cheshire and in the east Midlands, and of high infection in the south and south-west.

Nosema disease was also found to be widely distributed, although not nearly so common as Acarine disease. Amoeba disease is widespread, but relatively rare.

The results of the 1943-44 survey largely confirmed those of the earlier survey and also indicated that the position with regard to Acarine disease, taking the country as a whole, had not deteriorated since the spring of 1942, but, if anything, showed some signs of improvement. A paper on the incidence and distribution of adult bee diseases in England and Wales, based on data collected in these two surveys and also from routine examination of samples of bees submitted for diagnosis, has been published (10).

Acarine disease

Comparative tests of methyl salicylate, safrol, nitrobenzene, and various other substances, particularly pine-oil derivatives, for the treatment of acarine disease have been carried out. One substance in particular, terpineol, was found to be of considerable value as a poison to *Acarapis woodi* and certain other mites. It was further shown that the effect of this heavy fraction of crude pine oil on the bee and on the mite was markedly differential: that is, that the exposure time required to kill the mite is much less than that required to harm the bee in any way. The dosage when applied to a colony for the treatment of acarine disease is, apparently, not very critical (5).

Nosema disease

During 1940 a colony of bees that was heavily infected with *Nosema apis* was kept under observation. Marked bees from a healthy colony were introduced into the infected colony at intervals during June and July. Samples of these marked bees were taken at regular intervals and examined for the spores of *Nosema*. The degree of infection fell from 100 per cent in April, when the first examination was made, to zero in August, when no more infected bees could be found. This result is in agreement with previously made observations.

During the period under review a series of experiments have been conducted to test the effects of various drugs, including sulphonamides, on the development of *Nosema* disease in bees kept in cages and infected with known concentrations of viable *Nosema* spores. None of the substances so far tested has fully satisfied the condition that it should be effective in checking the course of the disease and, at the same time, be harmless to the bees themselves. This is in agreement with conclusions reached in the U.S.A. as the result of trials with sulphonamides for the control of this disease.

Bee paralysis

Work has shown that in many instances bee paralysis should be regarded as a complaint, often due to a dietary upset, rather than as a disease caused by some pathogenic organism. Various forms of paralysis have been described, only one of which can be considered a disease in the strict sense of the term. The nature and cause of many of these forms of paralysis were investigated, and several new types described (7).

Poisoning of honeybees by insecticidal and fungicidal sprays

A considerable amount of work has been done on this subject. Prior to the introduction of D.D.T., work upon which has been commenced and tends to show that this new insecticide is probably less harmful to adult bees than had been anticipated, the only ingredient in the spray mixtures commonly employed in this country that causes serious poisoning of bees is arsenic in the form of lead or calcium arsenate. It was found that bees become poisoned in one of two ways. Either by collecting their drinking water from the foliage and trunks of sprayed trees or surrounding herbage, or by the collection of pollen contaminated with arsenic. Bees collecting the contaminated drinking water usually die in the field, whereas those collecting contaminated pollen often regain the hive and both the adults and their brood become poisoned when they eat the pollen. It has been found that the addition of 1 per cent lime sulphur to arsenical spray mixtures is sufficient to repel honeybees from collecting their drinking water from this source. The other, more serious, form of arsenical poisoning can only be prevented by growers refraining from spraying open blossom with spray mixtures containing arsenic (15).

Spread of Foul Brood via wax foundation

In 1939 an experiment was set up to determine whether Foul Brood could be transmitted by means of wax taken from infected colonies being sent to the manufacturers, processed and redistributed as wax foundation. A quantity of wax was obtained by very gentle heating from combs heavily infected with both American and European Foul Brood. This was turned into foundation by one of the manufacturers who employed their usual technique. This foundation was given to a number of healthy nuclei and their subsequent needs in the shape of further combs were supplied from this source. Although these nuclei were built up to colony strength and have been kept under close observation since the summer of 1939, no trace of Foul Brood has been detected in them. It appears fairly safe to conclude, therefore, that there is little danger of Foul Brood being disseminated via infected wax sent to the manufacturers and, after processing, being distributed to beekeepers as wax foundation.

Bald-headed brood

Wax-moth larvae (*Achroia grisella* Fabr.) have from time to time been found lying alongside pupal honeybees contained in cells from which the normal capping was missing. Masses of faecal pellets of the wax-moth larvae were sticking to the pupae, many of which developed with deformed legs and wings. Perforations in the cell walls made by the larvae in their wanderings from cell to cell were seen. The large number of faecal pellets and the absence of damage to the mid-rib of the comb suggested that the " bald-headed " appearance was due to the cappings having been eaten away from below by the wax-moth larvae (19).

Sulphonamides and Foul Brood

During 1944 a preliminary test of sulphapyridine for the treatment of colonies of bees suffering from American Foul Brood, reported by a beekeeper (Mr. C. A. Ekins, of Surrey) to have given successful results against this disease, was carried out. It appeared from this preliminary small-scale test that the progress of the disease was in fact arrested by the use of sulphapyridine (23). More extensive tests with various sulphonamides were carried out during 1945 for the elimination of both American and European Foul Brood from infected colonies. The tests for the control of American Foul Brood yielded highly promising results. This work is being continued and more exhaustive trials in different parts of the country are planned for 1946.

Brood diseases—general

Papers on the incidence and distribution of brood diseases have been published (20, 21, 22). A number of unpublished observations and experiments have been made on the various brood diseases such as American Foul Brood, European Foul Brood, Sac Brood, Addled Brood and Chalk Brood.

A method of rearing individual bee larvae by hand, first described by von Rhein in 1933, has been developed and improved.

https://doi.org/10.23637/ERADOC-1-87

Losses, particularly those due to the attacks of fungi after the larvae had been reared successfuly to the pupal stage, were heavy at first but these have been substantially reduced as a result of improvements in the technique and familiarity with the requirements of the larvae.

This technique will be of value in the study of the initiation and development of the various brood diseases. It will also be of value for observations on the nutrition of the healthy larvae, on the evaluation of the nutritive value of pollens and pollen substitutes, and in similar problems in which it is desirable to keep larvae under closer observation than is possible in the hive.

Investigations on the nature of the complaint known as "Addled Brood" have been carried out during the period under review, but no definite conclusions have yet been reached. Work on various problems connected with both American and European Foul Brood has similarly been carried on.

Pollination studies

A considerable amount of work has been carried out in attempts to estimate the value of the honeybee and other insects for the pollination of various fruit and seed crops. It has been found that, contrary to statements frequently made, the honeybee does assist in the pollination of Red Clovers to a very considerable extent (6). Evidence has also been collected to show that the honeybee plays a most important part in the pollination of many other crops (8).

The behaviour of populations of various pollinating insects, including the honeybee, when foraging, has been studied in some detail. It has been found that, contrary to expectation, the honeybee (and some other pollinating insects studied, including the bumblebees) does not wander at random over a crop when seeking nectar and pollen, but restricts its activities to a small area of the flowers usually some 4-5 yards in diameter. However, if a sufficiently large population of foraging insects is working the crop concerned, another population of "wandering bees" which have not yet become "established" in any particular area, is superimposed on the general population of "established" bees (16). These and other observations have led to considerable changes in the advice given to fruit and seed growers who employ honeybees as pollinating agents, and have made it possible for any grower to determine how many colonies of honeybees of any given strength he will require in order to obtain a maximum set of fruit or seed in any given area (11).

A good deal of attention has been paid to the effects of the various physical and biological factors of the environment upon the flying activities of honeybees (12, 14, 18) since a knowledge of the probable effects of given weather conditions would help to solve some of the problems connected with insect pollination of fruit and seed crops. In order to obtain accurate measurements of the flight activity of a colony of bees throughout the day special bee counters were designed and built. These counters give continuous records of the number of bees entering and leaving the hive throughout the day (17).

Observations on the relationships between honeybee activity and solar radiation (14) and between activity and nectar concentration and abundance (12) have also been made, as have observations on the effects of temperature, humidity and wind velocity, precipitation, etc. A start has also been made in an endeavour to determine the effects of the various physical factors of the environment upon nectar secretion in various species of plants visited by honeybees, and plans have also been made to attempt to determine the effects of various soil constituents.

Work has been carried out during the past few years, and is being continued, in an endeavour to find a reliable and simple method of causing a large and ever-increasing proportion of the foraging bees from any selected colony to visit the flowers of, and thus pollinate, any given crop. Some success has been achieved in Russia, Germany and this country by feeding the colonies of bees concerned with concentrated sugar solutions containing the "scents" of the flowers of the crops which it was deemed desirable that the bees should visit. The feeding in this way of syrup containing "scent" causes many of the young foraging bees to associate the particular "scent" with the presence of desirable nectar and, on leaving the hive on their foraging expeditions, to seek this "scent" in the field, thus finding the flowers which it is desired that they should work. Even should the flowers contain little nectar, observation has shown that the bees will continue to work them for some days, particularly if the feeding of correctly "scented" syrup within the hive is continued. This technique may well prove to be of considerable value to seed growers.

General work. Bee husbandry

Many suggestions have been put forward from time to time with regard to the most suitable type of drinking water for bees. It has been suggested that bees obtain certain salts essential for their well-being by collecting water from sources containing such salts. The whole matter was investigated during 1939 and 1940, and it was found that honeybees were attracted to particular sources of water primarily by their odour, irrespective of what salts the water at these sources contained (3). An automatic drinking fountain was designed (2).

In collaboration with the Electrical Research Association a series of experiments on the electrical heating of beehives during the winter and early spring has been conducted. Several different intensities of heat were employed, the heat being evenly distributed over a special crown-board, or applied to the colonies by means of a special heater frame upon which the bees could, and did, cluster. Nevertheless it was found, when the considerable body of data collected was examined, that the colonies to which heat was applied in no case wintered so well as the control colonies to which no heat was applied. Further, the "heated" colonies consumed considerably more stores of honey than the control colonies (13).

The drifting of drones from one colony to another (1) and the age groups of bees comprising a swarm (4) have been investigated by making use of large numbers of marked bees.

A series of comparative trials to determine the best methods and times of feeding bees during the winter months, and the best concentrations of sugar syrup, etc. to use at these different times, have been carried out each year. The results appear to demonstrate that honey is better than syrup as a winter food for bees, but that a mixture of more or less equal proportions of honey and syrup is a satisfactory alternative : that the best results are obtained when the bees are left for winter with 35-40 lb. carbohydrate stores and some 4-5 British Standard brood combs full of pollen, and no winter or spring feeding is practised. So-called stimulative feeding in spring was found to be not only useless, but also wasteful of food unless the colonies of bees concerned were definitely short of either carbohydrate or protein stores, although not necessarily starving. If the bees were short of carbohydrate stores in spring, i.e., if each colony had not been left 35-40 lb. honey or honey and syrup, then the feeding of syrup was valuable, similarly if the bees were short of pollen stores, the feeding of soya-bean flour as a pollen supplement proved useful. It was not found that slow bottle feeding was at any time or in any way superior to feeding the same quantity of fluid in a rapid feeder.

Investigations on queen introduction, hive odour, etc. have been carried out during the period under review and have led on to a study of the problem of the " laying worker." The results obtained indicate that the " laying worker " which may be present much more frequently and in much larger numbers than the average beekeeper suspects, is often a most important factor in the successful introduction of queens to apparently normal colonies of bees. It has been found possible to produce " laying workers " in the laboratory and the problems of their origin and behaviour has, and is, being investigated.

Work on " colony balance," swarm control, bee breeding, etc. has also been carried out during the last few years, but these investigations are not yet sufficiently advanced for publication of the results obtained.

PUBLICATIONS

1. BUTLER, C. G. 1939. *The drifting of drones.* Bee World, **20**, 140-42.

Large numbers of drones belonging to several different colonies were marked with coloured paints, each colony being given its own distinguishing mark. Subsequent observation of the distribution of these drones in the apiary, which contained some 20 mating nuclei as well as 40 full-strength colonies of bees, led to the conclusion that drones seldom drift from their own hive into that belonging to another colony or even into a nucleus with a virgin queen. Drones will, however, join any swarms which happen to be about, being readily accepted and, having once joined them, remain attached to them thereafter.

2. BUTLER, C. G. 1939. *An automatic drinking fountain in the apiary.* Bee World, **22**, 119-120.

A well-protected, warm and easily cleaned drinking fountain with automatic control of the water supply by means of the float-chamber of a carburetter is described.

3. BUTLER, C. G. 1940. *The choice of drinking water by the honeybee.* J. Exp. Biol., **17**, 253-261.

The honeybee prefers dilute sodium chloride and ammonium chloride solutions to distilled water. She does not prefer concentrations of these salts higher than N/20 solutions, and solutions of various other salts to distilled water. The honeybee appears unable to distinguish between N/160 sodium chloride or N/160 ammonium chloride and distilled water. Bees are probably largely attracted to such sources of drinking water as rain water gutters choked with decaying organic matter, sewage effluent, etc., by a water perception sense coupled with an olfactory appreciation of various volatile substances contained in these sources of water.

4. BUTLER, C. G. 1940. *The ages of the bees in a swarm.* Bee World, **21**, 9-10.

As the result of marking experiments and the subsequent analysis of bees in eight prime swarms into age groups it is concluded that a swarm is largely composed not of the older bees, as had previously been assumed, but of the younger and middle-aged bees.

5. BUTLER, C. G. 1941. *A possible new cure for acarine disease of honeybees.* Nature, **148**, 86.

The vapour of terpineol, a heavy fraction of crude pine oil, was found to be highly toxic to the nymphs and adults of *Acarapis woodi* but to be harmless to adult bees and their brood.

6. BUTLER, C. G. 1941. *A study of the frequency with which honeybees visit red clover* (Trifolium pratense) *together with an examination of the environmental conditions.* Ann. Appl. Biol., **28**, 125-134.

Honeybees were found to work red clover, both first and second crops, for pollen and nectar. Two peak periods of activity, about 10.30 a.m. and 3 p.m. (G.M.T.) are exhibited by pollen gatherers ; it is probable that these plants reach their peak of pollen dehiscence at these times. The visits of honeybees to collect nectar are chiefly determined by the height reached by the nectar in the corolla tubes of the flowers. When the sugar concentration of the nectar of red clover flowers was lower than that of other " honey " plants in bloom at the same time in the locality, or when the nectar was not sufficiently high in the corolla tubes for easy collection, bumblebees were usually more abundant on red clover than honeybees except at the peak periods of pollen collection. When conditions were suitable for the nectar collection five or six times as many honeybees as bumblebees were usually present. Few insects other than honey bees and bumblebees were found working red clover.

The honeybee carries on an average about 284,000 red clover pollen grains per load and visits a minimum of 284 flowers in collecting this load. In the U.S.A. honeybees have been credited with the cross-pollination of about 82 per cent. of the red clover crop, bumblebees with 15 per cent. and the hymenopterous, lepidopterous and dipterous pollinating insects with 3 per cent. No comparable data collected in this country are available for cross pollination of an important part of the seed crop.

7. BUTLER, C. G. 1943. *Bee paralysis, May sickness, etc.* Bee World, **24**, 3-7.

There are a number of complaints and one true disease of the honeybee which all exhibit very similar signs in the apiary, and which may conveniently be grouped together as Bee Paralysis. Nine types of Paralysis are distinguished, most of these being due to a dietary upset or poisoning. Paralysis due to the consumption of frost-damaged pollen, honeydew from lime trees, concentrated lime nectar, the spores of the fungi *Aspergillus calyptratus* and *A. versicolor*, etc., is described. It is pointed out that these forms of paralysis, although sometimes serious in their effects, soon disappear once the causative agent has been removed, which fact accounts for the sudden outset and equally sudden disappearance of the complaints in the apiary.

8. BUTLER, C. G. 1943. *The position of the honeybee in the national economy.* Ann. Appl. Biol., **30**, 189-191.

The main function of beekeeping in both peace and wartime is the provision of pollinators for fruit and seed crops. There is good evidence that in many places where large orchards or large areas of insect-pollinated seed crops are planted, there are insufficient wild pollinating insects present for full production to be obtained. Man has upset the balance between the numbers of flowers requiring pollination and the number of pollinating insects available to effect their pollination. The honeybee is the only pollinating insect which can readily be used to redress the balance. It has been estimated that the average annual value of each colony of bees to the nation is about £12.

9. BUTLER, C. G. 1943. *Work on bee repellants. Management of colonies for pollination.* Ann. Appl. Biol., **30**, 195-196.

It was found that lime sulphur, nicotine and nicotine sulphate were all capable when added to spray mixtures containing arsenic of repelling honeybees from collecting these mixtures as drinking water. If applied to open flowers, they had some, but not a 100 per cent., deterrent effect upon honeybees attempting to visit these blossoms.

10. BUTLER, C. G. *The incidence and distribution of some diseases of the adult honeybee.* Ann. Appl. Biol., **32**, 344-351.

Since 1918 four complaints of the adult honeybee, acarine disease, nosema disease, amoeba disease, and bee paralysis, have been recognised in this country. Surveys designed to discover the incidence and distribution of these diseases were carried out during the winters 1941-42 and 1943-44. It was found that none of these diseases is clearly confined to any definite areas of England and Wales. Acarine disease, however, is apparently more abundant in the west and south-west ; and nosema disease appears to be most prevalent in the home counties and also has other areas of heavy infection in Leicestershire and Cumberland, Lancashire and Yorkshire. Bee paralysis in its various forms is both widespread and common, and amoeba disease, although relatively rare, has been found to be widely distributed throughout the country.

11. BUTLER, C. G. 1945. *The behaviour of bees when foraging.* J. Roy. Soc. Arts **93**, 501-511.

From the 20th day of adult life onwards the young worker honeybee is concerned with the collection of water, pollen and nectar. She finds her way back to her hive from a foraging site by means of at least three senses, a sense of direction, a sense of distance travelled and also a sense which enables her to locate visual landmarks near her hive and to orientate herself correctly thereto. Bees do not wander at random over any given crop but confine their attention to a small area of the crop. These " fixation areas " of individual bees overlap to some extent and thus some cross-pollination is effected. It is nevertheless difficult to see at first sight how cross-pollination is effected in an orchard, as we know it is, where a single tree or even a part of a tree may serve as the " fixation area " of an individual bee. It has been found, however, that if the population of pollinating insects, and therefore the degree of competition, is sufficiently great, then there is a " wandering " population of bees seeking " fixation areas " of their own, superimposed upon the " fixed " population. It is this " wandering " population, which is mainly composed of young bees, which provides the cross-pollinators. It is now considered to be best for fruit growers to place colonies of bees maintained in their orchards for purposes of pollination together in one or more groups somewhere near the centre of each 30 acres of orchard, irrespective of the number of colonies available, rather than to scatter them about throughout the orchard. If this is done the grower can, over several years, find out the necessary number of colonies of bees of any given strength required if full production is to be obtained. Seed growers, whose problems are different, can none-the-less also use honeybees to advantage in many districts and also determine how many colonies of bees they will require.

12. BUTLER, C. G. 1945. *The influence of various physical and biological factors of the environment on honeybee activity. An examination of the relationship between activity and nectar concentration and abundance.* J. Exp. Biol., **21**, 5-12.

Both nectar abundance and concentration appear to have considerable effect upon honeybee activity. From the data at present available, it appears reasonable to conclude tentatively that nectar concentration decides in the first instance which species of plants will be visited in preference to others in flower at the same time, and that nectar abundance then determines the proportion of the foraging population of a colony which will work the flowers in question.

13. BUTLER, C. G. and COCKBILL, G. F. 1942. *Preliminary investigations on the value of electric heating of beehives.* Ann. Appl. Biol., **29**, 34-42.

The general effect of all intensities of heating appeared in these experiments to be to reduce the area of brood present in mid April and to increase the winter consumption of stores, in direct contradiction to any belief in a beneficial effect on the colony.

14. BUTLER, C. G. and FINNEY, D. J. 1942. *The influence of various physical and biological factors of the environment on honeybee activity. An examination of the relationship between activity and solar radiation.* J. Exp. Biol., **18**, 206-212.

A review of the literature shows that those who have studied the influence of solar radiation on honeybee activity are agreed that it is an important limiting factor. Fresh analysis of some of this data, however, throws doubt upon some of the conclusions previously reached. New data were, therefore, collected which clearly show an association between variations in honeybee activity and the radiation of clear light.

15. BUTLER, C. G., FINNEY, D. J. and SCHIELE, P. 1943. *Experiments on the poisoning of honeybees by insecticidal and fungicidal sprays used in orchards.* Ann. Appl. Biol., **30**, 143-150.

Of the common constituents of spray mixtures only lead or calcium arsenate were found to be likely to cause serious honeybee poisoning, though Derris emulsion may cause slight poisoning. Lime sulphur, nicotine sulphate and copper sulphate are all repellent to bees. Concentrations of 1/500 lime sulphur or 1/2000 nicotine sulphate were sufficient to reduce the uptake of M/1 sucrose to less than 10 per cent. of that of unadulterated sucrose solutions. The presence of lead arsenate in these solutions appeared to make them even more repellent. Lead arsenate solutions were found to be no more attractive to bees than distilled water. Bees may collect arsenic when visiting fruit trees, or plants growing beneath or near the trees, for pollen and water, contaminated water apparently being the chief cause of poisoning. The addition of 1 per cent. lime sulphur was sufficiently deterrent to prevent bees collecting contaminated water. The other cause of arsenic poisoning is the collection by the bees of contaminated pollen and can be most serious. This form of poisoning can only be prevented by growers refraining from spraying open blossom.

16. BUTLER, C. G. JEFFREE, E. P. and KALMUS, H. 1943. *The behaviour of a population of honeybees on an artificial and on a natural crop.* J. Exp. Biol., **20**, 65-73.

In an experimental field filled with dishes of syrup to represent flowers, individual bees were observed to visit one chosen dish with great regularity provided that the supply of syrup did not become exhausted. Bees were deterred from collecting syrup from dishes placed even partially in shade and they very seldom worked beneath the shade of trees. Over the range of distances covered (160-400 yards) there were always more visitors to the nearer than to the more distant dishes ; the extent of the difference, however, varied from day to day. Bees accustomed to collect syrup from the dishes furthest from the hive did not move to sites nearer home when the weather became unfavourable. There was some evidence, however, that bees working a long way from the hive were more easily deterred from foraging by unfavourable weather than those working close to the apiary. Bees marked on a patch of *Epilobium augustifolium* situated in the midst of a fairly large crop of this plant, were usually recovered within 5 yards of the point of marking. Such bees remained " fixed " to this area for days. The same was found to be true with other plants.

17. FABERGE, A. C. 1943. *Apparatus for recording the number of bees leaving and entering a hive.* J. Sci. Inst., **20**, 28-31.

An apparatus giving a continuous record of the number of honeybees leaving and entering a hive is described. Bees pass through a trap, producing electrical impulses. The recording part consists of a magnetic escapement causing a cursor carrying a type figure to travel above the paper. At regular time intervals the position of the cursor is printed, and it is brought back to the zero position. By actual test it was found that the escapement was capable of resolving a pair of impulses 1/100 second apart with certainty ; the resolution may be higher.

18. KRISHNAMURTI, B. 1939. *A brief analysis of eleven years* (1928-38) *records of scale-hives, at the Rothamsted Bee Laboratory.* Bee World, **20**, 121-123.

On the assumption that high temperature, long hours of sunshine and low rainfall are desirable for honey production, a rough classification of the weather conditions in the different years was made. This method, although only a rough one, immediately separated out the best years both for weather and honey production. It was found that years of favourable weather conditions appear to be succeeded by unfavourable ones more or less regularly.

19. MILNE, P. S. 1941. *Wax-moth and bald-headed brood.* Bee World, **23**, 13-14.

It was observed that larvae of *Achroia grisella* Fabr. are sometimes found lying alongside pupal honeybees contained in cells from which the normal cappings are missing. Masses of faecal pellets of the wax-moth larvae were found adhering to the pupae, many of which developed with deformed limbs. Burrows from cell to cell were observed. The large number of faecal pellets present and the absence of damage to the mid-rib of the comb suggests that the "Bald-headed" appearance is due to the cappings having been eaten away from below by the wax-moth larvae.

20. MILNE, P. S. 1943. *Brood diseases of the honeybee.* Ann. Appl. Biol., **30**, 191-194.

A discussion of the pathogenic organisms, etc., responsible for Chalk Brood, American Foul Brood, and European Foul Brood, and the methods by which these diseases are carried from one colony to another. The attempt to control the two Foul Brood diseases by mutual co-operation between beekeepers and the aid of insurance schemes, and latterly by means of legislation, are described.

21. MILNE, P. S. 1943. *The spread of American foul brood.* Brit. Bee J., **71**, 298-300.

A discussion, with a diagrammatic representation of eleven ways in which *Bacillus larvae* becomes distributed within a hive of bees, and of ten ways by means of which the disease spreads from one colony of bees to another.

22. MILNE, P. S. 1945. *Brood diseases in the three counties.* Wilts, Hants and Dorset Beekeepers' Federation 1945 Year Book, 6-11.

During 1944, 706 apiaries of bees in Wilts, Hants and Dorset were visited by officers appointed under the Foul Brood Disease of Bees Order, and 2,253 colonies of bees in these apiaries were examined. Foul Brood was found to be present in approximately 1 in 4 of the apiaries visited, and in 1 in 8 of the colonies examined. For England and Wales as a whole the corresponding figures are 1 in 6 and 1 in 14 respectively, based on reports from 52 counties and on inspection of 23,000 colonies of bees in 6,000 apiaries.

23. MILNE, P. S. 1945. *Sulphonamides and American foul brood disease of bees.* Nature, **155**, 335.

In 1944, Prof. Haseman of the University of Missouri, Columbia, reported that sugar syrup containing sulphathiazole fed to bees enabled them to raise healthy brood in combs containing the "scales" of larvae which had died of American Foul Brood. In 1943 a beekeeper, Mr. Ekins of Surrey, claimed to have obtained similar results with sulphapyridine. Trials, with sulphapyridine for the eliminaton of A.F.B. from colonies of bees, carried out at Rothamsted in 1944, yielded promising but not conclusive results. It appeared that during the course of treatment, progress of the disease within the colony was arrested, and that only healthy brood was being reared in combs where the disease had previously been established.

Other Publications :

24. BUTLER, C. G. 1945. *Beekeeping.* Bull. No. 9. Ministry of Agriculture and Fisheries.

25. BUTLER, C. G. 1945. *Advice to intending beekeepers.* Leaflet 283. Ministry of Agriculture and Fisheries.

26. BUTLER, C. G. and MILNE, P. S. 1945. *Diseases of bees.* Bull. No. 100. Ministry of Agriculture and Fisheries.

27. MILNE, P. S. 1944. *Foul brood.* Leaflet 306. Ministry of Agriculture and Fisheries.