ROTHAMSTED RESEARCH

Report for 1957

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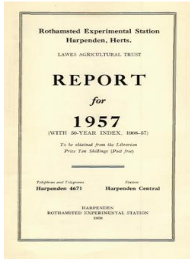
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Bee Department

C. G. Butler

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BEE DEPARTMENT

C. G. Butler

General

During the year the research work of the department has continued along the lines discussed in previous reports. Members of the department have also lectured to scientific societies, beekeepers' associations, etc., have given assistance at short courses for beekeepers and others and have served on various committees, such as the Ministry's Bee Disease Advisory Committee.

In June C. G. Butler reviewed the work of the department on the social behaviour of honeybees at a meeting of the Royal Society.

In July J. B. Free attended the III Congrès de l'Union Internationale pour l'Etude des Insectes Sociaux in Paris and read two papers of his own and one for J. Simpson, who was unable to attend.

During the year Elizabeth Booth resigned in order to devote her time to domestic duties and Yvette Spencer-Booth joined the scientific staff.

Bee Behaviour

Swarming

J. Simpson has made an analysis of records collected from colonies throughout the summer of 1956. These include the sizes of the colonies, the amounts of brood and numbers of queen-cell cups present in them, and the numbers of colonies making preparations to swarm. It is concluded that the tendencies of colonies to prepare to swarm, the amount of brood in colonies and the availability of nectar and pollen in the field all show a similar distribution throughout the summer. Thus the common belief that the maxima of brood rearing, swarming and honey storage form a sequence in the summer cycle of behaviour of honeybee colonies appears to be untrue. The onset of queen rearing appears to occur more frequently in colonies in which the amount of brood is increasing than in those in which it is decreasing, although there is some evidence of a tendency for breeding to decline after queen rearing has begun.

Drifting

The drifting of bees from one colony to another can result in the transmission of disease and, if extensive, can render honey production records, and breeding programmes based on them, useless. J. B. Free has been using marked bees of known ages to study the degree of drifting that occurs in different circumstances.

Young bees making their orientation flights drift the most frequently; established foragers drift comparatively little. But when their hives are moved to new sites considerable numbers of foragers may drift.

In experiments in which the hives in an apiary were arranged in blocks of four, each hive being at the corner of a square and facing outwards, it was found that bees are more likely to join a colony whose hive is in a corresponding position to their own in an adjacent block than to drift into one of the other three hives in their own block.

When four hives were arranged in pairs (1 foot separating the hives of a pair and 6 feet the pairs) more bees drifted into the hive in the corresponding position to its own in the neighbouring pair than into the other hive of its own pair. Similarly, when four pairs of hives were arranged in a row, eight times as many bees drifted into the hives in other pairs in corresponding positions to their own as into the remaining hives. The bees belonging to the two centre pairs of colonies drifted more than those in the two outside pairs, with the net result that the populations of the outside colonies increased at the expense of the centre ones. Similar results were obtained in experiments in which five colonies were placed singly at intervals of 6 feet in a straight row.

In other experiments small and large colonies were placed side by side and the amount of drifting that occurred between them ascertained. Although on the average more marked bees drifted from the small to the large colonies, so that proportionately more bees drifted from the small colonies than from the large ones, the relative sizes of the colonies were such that the much greater number of bees foraging from the large colonies resulted in net gains in the populations of the small colonies.

In further experiments attempts were made to reduce the amount of drifting that takes place by painting the hives different colours. It was found that when these variously coloured hives all faced the same direction the bees drifted to hives of the same colour as their own very much more than to hives of other colours. When hives all of the same colour faced in different directions the majority of the bees who drifted joined colonies whose hives faced the same direction as their own. When a comparison was made between the number of bees who drifted to hives of the same colour as their own but facing in the opposite direction and the number who drifted to hives of different colour to their own but facing in the same direction, it was found that over five times as many bees drifted into the latter as into the former, demonstrating that, in this connection, the direction in which a hive faces is more important than its colour.

From these and other experiments the practical conclusion was reached that drifting of bees between the hives in an apiary can be reduced to a minimum by arranging the hives in irregular formations, painting them different colours and facing them in different directions. A full account of this work is being prepared for publication.

Orientation to hive

It is commonly believed that if a colony is moved to a new site within foraging distance of the old, many of its bees return to the old site and are lost. J. B. Free has carried out experiments in which colonies containing marked foragers were moved at dusk to new sites 5 yards, 15 yards, $\frac{1}{4}$ mile and 1 mile from their old ones; no other colonies being situated near the sites from which the experimental colonies were moved.

He found that when colonies were moved 5 yards, an average of 94 per cent of the marked bees successfully returned to their colonies in the new sites, and that at the greater distances an average of over 80 per cent of the bees did so, but in each experiment many of the bees returned to the old site of their colony before proceeding to the new one.

When a colony was moved to a site outside flight range of the old one for a few days before being moved to a site within 15 yards of the original one, fewer bees visited the old site than when the colony was moved directly to a new site.

Queen substance

Although C. G. Butler had obtained strong circumstantial evidence, much of which was of a quantitative nature, in favour of his theory that an adequate supply of a substance which the worker bees of a colony obtain from their queen—" queen substance "—inhibits them from rearing new queens, no direct experimental evidence has been available. This has largely been due to lack of sufficient queens from which to attempt to extract this substance. During 1957, however, thanks to the kindness of Mr. T. Palmer-Jones of the New Zealand Department of Agriculture and of a number of New Zealand honey-farmers, sufficient queens were obtained for extracts to be prepared. It thus became possible for C. G. Butler and Doreen A. Gibbons to demonstrate that an ethanol extract of queen honeybees when given to a group of queenless worker bees, either in sugar syrup on the bodies of a few dead workers attached to a piece of comb or in their drinking-water, was sufficient to inhibit them from constructing emergency queen cells—i.e., from attempting to rear a new queen.

It is tentatively assumed that the effective agent in such ethanol extracts of queen honeybees is identical with the queen substance postulated by C. G. Butler.

A paper describing the results of this work has been prepared for publication.

C. G. Butler has shown that the number of emergency queen cells produced by a queenless colony of honeybees of a given strain is dependent on the number of adult bees present. It has now been demonstrated that the bees obtain some substance from open queen cells containing female larvae and, to a much smaller extent, from sealed queen cells, which inhibits development of their ovaries and the production of further queen cells. This substance is the factor which prevents the worker bees of a colony which loses its queen from producing a very large number of emergency queen cells. It is likely that this substance is very similar to, if not identical with, queen substance.

General Research

Salivary glands

(a) *Mandibular glands.* In experiments in which he fed adult worker honeybees with sugar syrup containing the dye Nile Blue Sulphate, J. Simpson has been able to confirm the finding of Örösi-Pál (Örösi-Pál, Z. (1957), *Bee World*, **38**, 70–73) that with this treatment the contents of the bees' mandibular glands become coloured blue. His further conclusion that the gland contents are added to wax which the bees manipulate with their mandibles was not confirmed, since new combs built by dye-fed bees were only coloured where coloured syrup was stored in them, other parts of the combs remaining white. Possibly the quantity of dye ingested by the bees was insufficient to colour the contents of these glands strongly enough for the colour to appear in the comb. When bees in cages were fed on candy containing a solution of Sudan III in olive oil it was found that not only the new wax which they produced, but also the bees' bodies and the walls of the cage, became coloured with the dye. Thus the observations of Örösi-Pál that the wax scales secreted by bees fed on this dye are coloured red may well have been due to external contamination rather than to passage of the dye through the wax glands.

(b) *Labial glands.* Although present evidence suggests that the saliva used by worker bees when feeding on dry sugar or thick honey, or when licking their queens, is produced by the labial-gland system (post-cerebral and thoracic glands), J. Simpson has not yet succeeded in demonstrating the function of the oily substance which these glands often contain—particularly in old bees—in addition to the watery saliva.

When a solution of the water-soluble dye Light Green was painted on a queen and allowed to dry the worker bees were able to dissolve it in saliva and remove it easily in a few minutes, whereas when the fat-soluble dye Sudan IV was applied to a queen in the same way, the bees took several hours to remove it and apparently did so by abrasion. No oil could be detected in finely powdered dry sugar which bees had licked nor in the honey-stomach contents of the bees who had been licking it. It was possible to show, however, that some bees had considerable quantities of oil on their tongues. This oil appeared to be held by capillarity between the bristles of the tongue so that perhaps it may not be readily deposited together with the watery portion of the saliva on surfaces the bees are licking. Simpson has suggested that it is possible that the oil is retained by the bristles of the tongue when the saliva is discharged and may serve to keep soft the integument of the tongue and possibly other parts of the bee's body.

The mesh of wire-gauze for queen introduction cages

J. B. Free and C. G. Butler have investigated the size of the apertures in wire-gauze through which bees can feed one another. Worker bees were confined in cages which differed only in the size of the apertures of the wire-gauze from which they were made. The cages of bees were suspended between the brood combs of colonies. After 48 hours the number of bees who had starved to death in each cage was determined. It was found that the bees in the cages were only fed by the bees of the recipient colonies when the apertures in their wire-gauze walls were 2·5 mm. square or larger. It is concluded that cages used to introduce queens to colonies should be constructed of wire-gauze with apertures not less than 2·5 mm. square so that the workers of a recipient colony may be able to feed the queen and lick queen substance from her body while she is inside the cage.

Wax extraction

Beeswax is difficult to extract from old combs in which brood has been reared because it has to be separated from the mass of cocoons left by the bee larvae which have pupated in the combs. The most effective method of separation (other than extraction by a solvent such as chloroform, which is unsatisfactory as it removes an excessive quantity of material other than wax) is to apply pressure to the mass of cocoons under boiling water. Since this method is not popular with small beekeepers, because it is tedious and messy and requires a special wax press and other apparatus, the efficacy of some of the simpler methods that can be used is being investigated by C. G. Butler and J. Simpson. So far, no method has been found which removes as much wax as can be obtained with a press, but some evidence has been obtained which indicates that the efficacy of methods of extraction with boiling water or steam, which normally give very poor results, can be substantially increased if whole combs are treated in such a way that they are broken up as little as possible during the extraction process. Success with this procedure seems to depend on getting the wax of the comb mid-rib to melt and run out without being absorbed by the cocoons.

Pollination

Inge Riedel and Doreen Wort (*née* Gibbons) have studied the adequacy of pollination of field beans on the Rothamsted farm. Under normal conditions only a small proportion of bean flowers give rise to mature pods, and it has been suggested that this proportion would be increased by more effective pollination. However, observations in 1956 suggested that this was not the case, since the initial set of pods on the plants was more than twice the number that reached maturity, thus suggesting that the number of mature pods obtained was the maximum the plants could carry. This hypothesis was verified in 1957. Removal of flowers from those parts of the plants on which most of the pods are normally produced resulted in compensatory increases in the number of pods and beans produced by the remaining flowers.

In another experiment part of a crop of beans was covered with a large nylon screen-cage to exclude bees. Despite the absence of bees, the plants in the cage produced more mature pods and about three-quarters as many beans as the plants outside. The plants inside the cage were taller, however, and the pods they carried were distributed throughout the lengths of their stems instead of being concentrated on the lowest inflorescences as is the normal crop. This suggests that increased growth and development of pods on the upper parts of the plants was made possible by the failure of the lowest inflorescences to produce the normal number of pods because of inadequate pollination. Since, however, the abnormal growth of the plants in the cage may possibly have been due to the conditions in the cage, it is planned to repeat the experiment during 1958 with cages containing colonies of bees as controls.

J. B. Free has continued his experiments to determine the effectiveness of the technique of "directing" bees to crops requiring pollination.

Bee Diseases

Nosema disease

L. Bailey has continued his work on Nosema disease. In the spring 1957 he found that approximately 35 per cent of the department's colonies were infected to some extent with this disease; this was a considerable increase over the percentage infected in the previous spring, despite continued fumigation with acetic acid of spare combs during the intervening period. However, the weather in 1956 was exceedingly poor, and such conditions are known to encourage the development of this disease. Furthermore, during this same period many colonies were frequently, and severely, disturbed in the course of experiments, and this also promotes infection. Comb fumigation has been carried out regularly, however, and it is hoped and expected that infection will be found to have been reduced to a lower level again by the spring of 1958, after the more favourable weather of 1957.

Acarine disease

Further experiments, similar to those described in the last report, were carried out by L. Bailey in 1957. Again it was found that over-wintered infected bees died in spring slightly earlier than over-wintered non-infected individuals of the same age groups. A marked reduction of infection coincided with the moderately good nectar-flow of 1957, and this agreed with the results of an analysis of records of acarine infection at Rothamsted during the previous few years; it was found, for example, that the proportion of infected colonies had diminished spontaneously and very significantly after the very good nectar-flow of 1955 and had increased significantly after the outstandingly bad season of 1956. During average years, the proportion of infected colonies remained about the same; but in such years the proportion of infected bees in individual colonies varied markedly throughout the active season, rising during periods of nectar scarcity and falling again when the nectar-flow had commenced.

The likelihood of the death of any infected colony, during the winter of 1956–57, appeared to increase if over 30 per cent of its bees were infected, and death seemed certain if 70–80 per cent were infected. But, at Rothamsted, during the past 7 years, even after the worst seasons, no more than 15 per cent of colonies to which no treatment has been applied have had more than 10 per cent of their members infected; the number of colonies with more than 70 per cent of their bees infected in the autumn has ranged between nil and 4 per cent during the last 3 years.

European Foul Brood

L. Bailey has continued his experiments to establish the cause of this disease. He has again shown that this disease only appeared extensively in healthy colonies after cultures of both *Streptococcus* *pluton* and *Bacterium eurydice* were sprayed over their brood. Two distinct strains of *B. eurydice* were used; either of which, together with *S. pluton*, caused disease. On one occasion a very limited infection (three sick larvae) occurred in a colony which had been inoculated three times between April and June with heavy doses of pure cultures of *S. pluton*; but *S. pluton* and *B. eurydice* were both isolated from the sick larvae. It was, therefore, considered probable that *B. eurydice* was already present in this colony, and a search was made for the bacterium in many colonies which had not been in contact with disease. As a result, it was found to be commonly present, in summer, in the mouth-parts and honeystomachs of adult bees and in the freshly collected loads of pollen-gatherers; newly emerged bees of the same colonies were not infected with this bacterium. This confirms some of the findings of Burri, although his opinion that *B. eurydice* is converted into *S. pluton*, under unknown conditions, has not been confirmed.

The incidence of *B. eurydice* in adult bees may show a seasonal variation; it appears to be scarce in winter.

The organism does not survive for more than a few days in pollen stored in the hive nor in any medium, such as honey, where it is dormant. It seems likely that *B. eurydice* survives from year to year in the alimentary canals of adult bees, and constantly grows there, possibly obtaining nutriment from pollen which its hosts have eaten.

The reappearance of European Foul Brood in an infected colony in late spring and its rapid decline in late June, or after the start of a good nectar-flow, may be associated with the rate at which larvae, in contact with dormant cells of *S. pluton*, receives *B. eurydice* in the food given them by adult bees. *S. pluton* is able to survive long periods of dormancy—probably for more than a year.

The distribution of *B. eurydice* in "healthy" colonies, its seasonal variation and its geographical distribution in the British Isles are being investigated.

Further attempts to control this disease by feeding infected colonies with quaternary ammonium compounds in syrup were made in the autumn of 1956 with variable results. Some of the treated colonies did not exhibit the disease at all in 1957, others showed no improvement. But all the infected, untreated, control colonies showed the disease again. Variable results were also obtained in large-scale trials in commercial apiaries. Colonies suffering from this disease were much more seriously affected in 1956 than they had been in 1955 when the first, much more successful, trials with quaternary ammonium compounds were made; this may account for the unsatisfactory results obtained after treating colonies in the autumn of 1956. It is possible that these compounds kill *B. eurydice* in adult bees and thereby suppress the disease; but trials have indicated that dormant cells of *S. pluton* on the combs are probably unaffected. In this case, similar results may be expected by feeding antibiotics, such as terramycin, to which *B. eurydice* is sensitive. But if *B. eurydice* is widespread among bees, European Foul Brood may eventually recur. In fact, in 1957 this disease reappeared in one colony which, on being found with the disease, had been fed with quaternary ammonium compounds in the autumn of 1955 and had shown no trace of the disease in 1956. The well-known suppression of European Foul Brood by antibiotic treatment in spring may in fact be largely due to suppression of *B. eurydice* in the adult bees, although tests have shown that growth of *S. pluton* in cultures is prevented by terramycin. Thus the antibiotic may also exert a direct effect on both organisms growing in the bee larvae.