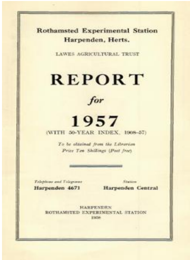
ROTHAMSTED RESEARCH

Report for 1957


Rothamsted Experimental Station
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REPORT
for
1957

Entomology Department

K. Mellanby

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ENTOMOLOGY DEPARTMENT

K. MELLANBY

GENERAL

Barbara M. Stokes (now Mrs. J. Hirst), Lois M. Cherry, J. C. da Silva Dias, D. L. Milne and M. A. Zaher left, and Margaret K. Arnold, Jane A. Cochrane (Robert Donaldson Scholar, University of Glasgow), Joan Riches (Agricultural Research Council Scholar) and B. Gerard joined the department. C. G. Johnson was absent from Rothamsted for the whole year during his period of secondment to the West African Cocoa Research Institute in Ghana.

K. Mellanby attended the first meeting as a member of the editorial board of the new journal *Entomologia Experimentalis et Applicata* in Amsterdam in October. P. W. Murphy, who is a member of the Zoology Committee (Biology Commission) of the International Society of Soil Science, attended a meeting in Geneva to discuss the organization of the International Colloquium on Research Methods in Soil Zoology to be held at Rothamsted in July 1958. R. M. Dobson gave a course on "Animal Life in the Soil" at Flatford Mill (Field Studies Council) in August. Many papers were read by members of the department at conferences and meetings of scientific societies, for example, R. M. Dobson, D. B. Long, Barbara Stokes and F. Raw each made a substantial contribution to the Symposium on the wheat-bulb fly held by the Association of Applied Biologists in January.

The University of London awarded the degree of Ph.D. to M. A. Zaher and D. L. Milne, and that of M.Sc. to Lois Cherry.

The constant-environment rooms in the West Building have at last been completed, and are providing much-needed facilities for experimental work, but the problems caused by the noise made by the machinery for the rooms in the Entomology Department (where no cellars are available to house motors and compressors) have not yet been solved. The glasshouses and insectaries are still being erected; the official date for their completion was December 1957, and we hope to occupy them sometime in 1958.

INSECTS AND CLIMATE

Effects of climatic factors on metabolism and behaviour (K. Mellanby and R. A. French)

Observations have continued on the plots on Bones Close and Furzefield (selected as likely to have different microclimates), where cabbage white caterpillars have been studied on brussels sprouts. Unfortunately the plot on Furzefield is adjacent to Knott Wood, and birds from the wood have consumed so many of the experimental insects that few results have been obtained. However, the extent to which birds may control caterpillars has been studied. A " hide " was erected, and the plot was kept under observation for several periods from before sunrise to after sunset. The most important period of bird activity was from 10 minutes before sunrise to 20 minutes after; different species of birds entered the crop at different, and fairly regular, times. The plot on Bones Close is farther (about 300 yards) from any wood, and here very few caterpillars were ever eaten by birds.

In the laboratory, work has continued on effects of temperature and humidity. Many larval insects have been found to drink water in considerable quantities. They store this water in their tissues, and can then survive exposure to unfavourable temperatures. Even plant-eating larvae, which are usually believed to obtain ample supplies of water with their food, have been found to drink water when they are somewhat dehydrated, which happens if they feed on partially wilted leaves. Several species of soil-inhabiting larvae, including some of agricultural importance (e.g., the frit fly), seem often to drink water. A paper on "The importance of drinking water to larval insects" was read to the Conference of the Society for Experimental Biology in London in December.

Experiments have been continued on activity and survival at low temperatures. It has been confirmed that acclimatization may occur very rapidly (partially within 3 hours, completely within 24 hours) and that although this is as rapidly reversed at temperatures where activity is possible, at 0° C. (where chill coma occurs in many species) insects briefly acclimatized beforehand may retain this quality for many weeks. The significance of this in relation to the winter survival by pest insects is being studied.

Fat metabolism and temperature (Lois M. Cherry, R. A. French and K. Mellanby)

Work has continued on the analysis of fat from insects reared at, or acclimatized to, different temperatures, and also on the effects of differences in diets on the composition of the fat reserves. Although it was found possible to obtain fat reserves with very different properties in one species of insect, and although similar conditions of diet and temperature during growth gave repeatable results, the nature of the fat seemed to have little direct relation to the ability of the insects to withstand high temperatures.

Insect Pests at Rothamsted and Woburn

(R. A. French and K. Mellanby)

The only really important damage caused by insects in 1957 appeared to be that due to aphids, particularly *Aphis fabae*. These arrived on the crops in great numbers in early spring, and only the earliest planted beans had developed sufficiently to give a crop after the aphid attack developed. However, during spring and early summer parasites and predators increased also, and achieved some measure of control.

The Bean weevil *Sitona lineata* was very common on beans which were grown on fields which bore the same crop in the previous year, but the comparatively heavy infestation (the edges of almost all the leaves of the young plants were "scalloped") did not seem to reduce the yield, but other factors (e.g., aphids) complicated the picture. More work on this species is urgently needed.

Most other common pests have been found in small numbers, insufficient to be likely to cause serious damage to crops.

Frit Fly Investigation

(Joan Riches and K. Mellanby)

Work on the biology and ecology of the frit fly has begun with a survey of infestation on parts of Rothamsted farm, and with experiments on development and survival in the laboratory.

Gall Midges of Economic Importance

(H. F. Barnes, Barbara M. Stokes, D. L. Milne and Margaret K. Arnold)

The long-term study concerning the two wheat blossom midges, having passed its thirtieth successive year, was modified so as to allow the descent of the larvae from the ears on Broadbalk to be compared with their descent on other fields on the Rothamsted Farm and elsewhere. The main features of the study have, of course, been retained. Thanks to the co-operation of Professor M. McG. Cooper and Mr. A. D. Rivett, samples of Square Heads Master (the variety sown on Broadbalk) were received from Cockle Park, Durham, for the first year in this proposed 5-year study of the phenology of the wheat-blossom midges on autumn-sown wheat in two widely separated areas. On Broadbalk the larval descent occurred 9–12 July, whereas at Cockle Park it apparently took place about 22–25 July. However, on spring-sown wheat (Koga II) on Harwoods Piece there were still plenty of *C. tritici* larvae up in the ears on 25 July. It had been noticed previously that oviposition did not start on Harwoods Piece until it had practically finished on Broadbalk and that the ears of wheat were correspondingly later in appearing in this field of spring-sown wheat. As regards the infestation of Broadbalk, 1957 was, as expected, a trough year, there being only 4,596 *C. tritici* and 602 *S. mosellana* per 500 ears, representing a 4·2 and 2·1 percentage grain infestation respectively.

A further advance has been made in the biological testing of sorghum midge from tropical countries. Some years ago midges were reared from the Gambia. This year midges were reared from Ghana in West Africa and from Mysore State in India. Experiments showed that inter-mating would take place between midges from these two continents, but no evidence was obtained concerning the fertility, as no sorghum plants were in the right stage of growth at the time of the midges' emergence. It is hoped to make another start in the investigation when the new heated glasshouses are available.

It has been demonstrated from inter-breeding experiments between Hessian Fly from Kansas, U.S.A., northern Germany and Harpenden, involving just over 10,000 emergences, that they will inter-breed successfully up to and including the fourth generation. First crosses, back crossings and selfing of crosses all resulted in

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fertile offspring. There is now no reason to doubt, taking into consideration the range of variation in morphological characters and this establishment of the fact that Hessian Fly from the two continents will inter-breed, that the true Hessian Fly, *Mayetiola destructor* (Say), does occur in Europe.

The maintenance of stocks of Hessian Fly on wheat, barley, rye and couch grass preparatory to testing the possible development of host-plant races has been discontinued. It is hoped, however, to continue testing the validity of the described species of *Mayetiola*.

Observations and breeding experiments have shown that the *Stenodiplosis* found ovipositing on timothy grass inflorescences in 1956 is none other than the well-known *S. geniculati* Reuter of foxtail grass. This midge was studied about 1929 on foxtail grass and discovered in 1938–39 to be also breeding on cocksfoot grass in various parts of England and Ireland. The second flight of the year, derived from the first generation on foxtail, emerges at Harpenden too late to re-infest foxtail, but just at the right time to attack timothy grass inflorescences. An investigation has been started to determine how widespread is this breeding on timothy grass.

The life history study of the new *Contarinia* species of timothy grass inflorescences, received originally from Finland, although previously known from larvae to exist in England, has shown that there is but one generation a year.

The investigation of the gall-midge fauna of clover flower heads has been brought to a conclusion, the results being incorporated in the thesis presented to London University by D. L. Milne. Four new species, one of which does primary damage to seed formation, have been described. They belong to the genera *Tricholaba*, *Clinodiplosis*, *Giardomyia* and *Isodiplosis*.

Stocks of pea midge (*C. pisi*) larvae have been accumulated preparatory to studying the phenology of this injurious species.

The collection of gall midges (now containing upwards of 13,000 slides), as well as the card indexes, has been considerably increased, although there is an increasing back-lag in the identification and taxonomic service which H. F. Barnes provides.

Some idea of the extent of the advisory and consultant work that is carried on can be gauged from the fact that in the first 3 months of the year just over a hundred letters dealing with gall midges were received from twenty-two different countries. Mr. K. M. Harris, on leave from Nigeria, spent 2 weeks studying gall midge, particularly the new sorghum stem midge.

Studies on Slugs

(Jane A. Cochrane and H. F. Barnes)

Three species of slug, *Milax budapestensis*, *Agriolimax reticulatus* and *Arion hortensis*, are being collected weekly from a garden in Harpenden. Records of weight, numbers and stage in sexual development (determined by dissection) are being kept in order to elucidate more fully the life cycle of these species. An existing slug ovicide is being tested on the eggs of all available slug species. Preparations are being made to start a programme of work shortly, whereby slugs will be marked with radio-active iodine in an attempt

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to estimate total populations. The absence of a method of estimating populations has for many years hampered the testing of slug poisons in the field.

Wheat-bulb-fly Studies

Alternative host-plant studies (Barbara M. Stokes and F. Raw)

Observations were made on a natural infestation of alternative host plants on Bones Close fallow in spring 1957. This fallow plot, 400 yards away from a known source of wheat-bulb flies, was found to have an infestation of about 11 eggs/sq. ft. just prior to hatching. Grasses and weeds germinated on the fallow during the mild winter, and by spring the plant density gave about 100 shoots/sq. ft. In early April all the plants from eighteen quadrats 1 foot square were examined for wheat-bulb-fly larvae or symptoms of damage. Only three larvae were found, two in volunteer wheat plants and one in *Dactylis glomerata*. Five shoots of *Poa annua*, three of wheat, two of *Agropyron repens* and one of *Dactylis glomerata* showed damage characteristic of wheat-bulb fly.

This low infestation supports the results of some laboratory experiments on host-plant preferences which suggest that some alternative host plants are less readily infested than winter wheat. In pot experiments the percentage infestation of alternative host plants relative to wheat was:

Agropyron repens	Barley	*Agrostis tenuis*	Rye	*Festuca pratensis*	*Poa pratensis*
133	83	57	26	23	18

Field studies (F. Raw and J. R. Lofty)

The experiment on Broadbalk carried out previously in 1954–55, to estimate the effect of infestation on yield by screening strips of plots to prevent oviposition, was repeated. On the fallow section of plots 2, 3, 5, 7 and 10 two strips each 6 feet wide and running the width of the plots were screened with mosquito netting during the oviposition period in 1956. Counts in spring 1957 showed that 3 per cent of the plants in the previously screened strips were infested compared with 25 per cent in similar unscreened strips. At harvest no significant differences in yield between screened and unscreened strips was detected.

Previous work has shown that soil conditions greatly affect wheat-bulb-fly oviposition. In a factorial experiment on fallow at Rothamsted (*Rep. Rothamst. exp. Sta. for* **1954**) more eggs were laid in a rough tilth than a smooth tilth and more in plots which were cultivated during the oviposition period than in undisturbed plots. It has also been shown that the different levels of infestation established in this way may be used to investigate the effect of infestation on yield (*Rep. Rothamst. exp. Sta. for* **1955**). There is some circumstantial evidence from plant counts that the survival of wheat-bulb-fly larvae on hatching may be affected by the numbers of wheat shoots available for infestation even when there are more shoots than larvae. To obtain further data on these aspects of the wheat-bulb-fly problem two field experiments have been started on farms in Essex where heavy infestations frequently occur.

In each experiment four treatments in five randomized blocks of four plots each were applied to fallow during the oviposition period. They were:

(1) rough tilth cultivated at 7–10-day intervals;
(2) undisturbed rough tilth;
(3) undisturbed smooth tilth;
(4) screening with mosquito netting to prevent oviposition.

In early October each experiment was drilled with Cappelle wheat at two seed rates on split plots to give contrasted shoot densities in spring. At one site the seed rates were 3 bushels/acre and 1 bushel/acre, at the other 3 bushels/acre and $\frac{2}{3}$ bushel/acre.

The response to the fallow treatments has been estimated by taking twenty soil samples each $2\frac{1}{2}$ inches diameter and 8 inches deep from each plot and extracting the wheat-bulb-fly eggs by a standard flotation method. The results show a striking response to the different tilths.

Numbers of wheat-bulb-fly eggs (thousands per acre)

Tilth	Herkstead Hall	Fowes Farm
Rough cultivated	1,400	3,000
Rough undisturbed	650	1,400
Smooth undisturbed	150	500

Estimates of plant infestation and larval survival will be made in spring, and plot yields will be recorded at harvest.

Field studies on emergence, survival and activity (R. M. Dobson)

The Pennells Piece cage experiment was repeated with considerable improvements in technique. This experiment involves carrying out a marking and recapture experiment on a small population which is prevented from dispersing by being confined within a cage of mosquito netting (dimensions 24 × 12 × 6 feet). In the 1956 experiment the cage was erected in an infested wheat field, and all the flies which emerged inside it were marked according to their date of emergence and were then released. They were subsequently recaptured and re-released at 3-day intervals. From the data obtained, information on emergence and longevity could be derived. In the 1957 experiment the flies emerging inside the cage were considerably augmented by introducing flies derived from pupae collected on Broadbalk, and for marking, special nitrocellulose paints (kindly provided by Imperial Chemical Industries Ltd.) were used. These paints proved superior to the oil paints used previously. Each fly was marked so that it could be distinguished individually by applying three spots of paint to the dorsum of the thorax in the form of a triangle. Seven different colours were used, so that 343 (i.e., 7^3) different combinations could be obtained. This proved adequate, but had more combinations been required it would only have been necessary to have altered the configuration of the spots. As flies were now recognizable individually, it was not necessary to touch them on " recapture " days, and hence any possible deleterious effects of handling were eliminated. This meant that " recapturing " could be carried out daily so that more precise data could be obtained.

Information on activity was derived from the daily records and also from continuous observations over 24-hourly periods. The data are now being analysed in co-operation with Marjorie G. Morris of the Statistics Department.

Larval studies (D. B. Long)

The spring survey of larval infestations in the first wheat crop after fallow showed some of the lowest levels since they were begun in 1954. The population on the alternate wheat and fallow plots had fallen from 583,000 in 1956 to 193,000 larvae/acre infesting 10·2 per cent of the plants, whilst on Broadbalk there was a decrease from 635,000 to 370,000 larvae/acre infesting 30·6 per cent of plants. In both years the larval infestation in wheat following a preceding wheat crop was slightly under 2 per cent of the infestation in the first crop after fallow.

The maximum population on Broadbalk coincided with the period of maximum tillering. Plant damage by wheat-bulb fly was not necessarily associated with increased tillering, and increased tillering did not result from experimental damage to shoots.

In the experiment set up on the alternate wheat and fallow using seed rates of $\frac{1}{3}$ and 3 bushels/acre, the larval population on the low-density plots was little more than one-half of that on the high-density plots, indicating a higher larval mortality on the former, although the surviving larvae were more advanced in their development. When compared with the high-density plots, the low-density plots had 77·3 per cent of their shoots damaged in contrast to 20·0 per cent, but carried 3·7 in contrast to 2·1 shoots per plant. At harvest the low-density plots carried one-third of the number of stems, but the ears contained three times the number of grains and yielded 9·1 cwt./acre in contrast to 10·3 cwt./acre.

Pot experiments on the mechanism of host-plant location by newly hatched larvae suggest that the larvae move upwards at a fairly steep angle from the egg site and then move horizontally in the surface layers of soil. Plant location did not appear to be assisted by the root extremities but to depend on attractant material exuded by the plant into the root zone close to its base and into the soil surrounding the stem. The results indicated that the attractive root zone may possibly interfere with successful infestation. Direct observation of larval movements in the laboratory confirmed the attractive function of the root and stem exudates and also showed the leaf-tip guttation droplets to be attractive. The exudates were found to contain a thermolabile component which was responsible for about one-half of their attractiveness. It had earlier been observed in the field that larvae tended to attack fresh plants in preference to those already infested. Laboratory experiments showed that this was due to the exudate being less attractive and not to the production of a repellent substance. The work is being continued.

Adult studies (D. B. Long)

In nutrition studies the female was found to survive longest on a diet of honey, old bee pollen and water; on this diet the largest number of eggs per female was also produced. Diets simulating food conditions within wheat fields offering fresh wheat pollen, wheat washings and water were associated with the shortest survival times and a failure to mature eggs. The studies confirmed earlier findings suggested the probable importance of a source of food containing sugars for continued life and egg maturation. Such a source is not normally freely available in wheat fields, and suggests that the daily dispersion of flies from the crop earlier observed may be due to their foraging for food.

It had been observed that flies brought into the laboratory were frequently parasitized by fungus, and this was responsible for 50 per cent of deaths of females used for breeding in 1956, of which 35 per cent was caused by an entomogenous fungi which had been recorded only once previously in another Anthomyid fly. This fungus characteristically caused the formation of a hollow cyst in the abdomen which eventually opened to the exterior through the ventral surface of the abdomen a day or two before death occurred. Particular attention was given to this fungus and two others which destroyed the abdominal contents.

In collaboration with E. W. Buxton (Plant Pathology Department), several fungi were isolated and cultured; inoculation tests were carried out on 2,630 flies freshly caught in the field, of which 1,670 were female. The tests were carried out in the laboratory using glass breeding jars and outside in the open air in terylene cages. A further account of this work, which is being continued, is given by E. W. Buxton.

Aphid Ecology and Insect Dispersal

Dispersal and meteorology (C. G. Johnson)

The material obtained in previous years' trapping is gradually being sorted and analysed. The essential nature of wind-directed and assisted dispersal in aphids is already apparent. The meteorological conditions associated with dispersal at different levels have been dealt with in a preliminary analysis using the earlier trap catches, and a definite association between height of dispersal and a measure of atmospheric instability was shown to exist.

Dispersal and periodicity (L. R. Taylor)

The general pattern of dispersal in aphids, as it appears from the study of flight periodicity by trapping, was compared with the conclusions drawn from the observational work done on locust dispersal in a talk given before the Linnean Society. It appears that, in spite of the great difference in size and flight power of the insects, and the consequent difference in the methods used for their study, the dispersal processes could be fundamentally the same.

Some of the problems involved in this type of dispersal are common to all sizes of insects and also to plant spores, particularly those associated with crossing the layer of relatively still air near the ground before free circulation can be entered.

The establishment and growth of aphid populations (L. R. Taylor and A. J. Cockbain)

Aphid dispersal can be regarded as having three main stages which require separate investigation. The processes involved in take-off and getting airborne have been largely dealt with and the work published. The second stage of aerial dispersal has been tackled mainly by trapping, and is discussed above. The final stages are alighting and the establishing and growth of a new colony. Although the analysis of the middle stage is not yet completed, the exceptionally large spring migration gave a good opportunity to begin field investigations on the third stage. Large numbers of aphids are essential for this, because the losses during migration must be of a very high order. Work has therefore been started on several aspects of this stage of aphid dispersal.

Aphids' migratory behaviour leads to wide dispersal and produces a very large element of chance in host finding. Also behaviour relating to secondary take-off is complex and field records are limited. A quantitative study of the alighting and taking off again of aphids on various host and non-host plants has therefore been started.

Analysis of the initial stages of growth of *Aphis fabae* populations on beans and other hosts suggests that the attractiveness of the host may be judged in terms of the resulting population structure. The growth pattern of field populations is also being analysed. The length of the four instars is very similar, and by using this period as a time unit a provisional study of reproductive rates is being made independent of growth rates. Rate of growth will be re-introduced later when the temperature relationships of growth and reproductive rates have been elucidated.

Population-growth curves in the field must eventually be related to time and therefore to temperature. This is being investigated for *A. fabae* in the laboratory, but, as little is known about the limits of reproductive capacity of alienicolae, this is first being investigated at 20° C. in apterae and also in alatae. With alatae the problem of the effect of flight on reproduction must also be dealt with.

An investigation of the morphological characters associated with the several nymphal stages of *A. fabae* and with the phases of adult life has been almost completed. This is necessary to ensure accurate analysis of field populations. There is a considerable overlap of size in the four instars and segregation on this basis was found to be unsatisfactory. The characters chosen must be easily visible under the low-power binocular for dealing with large colonies and, of the several features investigated, cornicle length is probably the safest and easiest to use in practice. A curious feature of the apterous alienicolae is the long post-reproductive phase in which size, lost during reproduction, is regained before a final collapse.

Effect of planting date on the growth of aphid populations (L. R. Taylor, A. J. Cockbain and K. Mellanby)

An experimental plot of field and broad beans, with randomized, replicated rows, sown fortnightly from January to May, produced a crop with every stage of plant growth from seedling to full flower during the primary aphid migration.

Inspection several times during the migration showed that the relationship between the number of primary migrants found on a plant and plant age and distribution was not simple; it varied more between the inspection on different dates than between different treatments at the same inspection. Subsequent colony growth was followed on each plant in one row of each treatment, but a better understanding of the way in which colonies develop is required before full use can be made of this information.

Yield was measured and as expected was low, for the infestations were heavy (100 per cent plants infested), and in addition there was a high incidence of several virus diseases. One interesting feature was the control, by parasites and predators, probably bred on the earlier infestations, of the aphid populations on the last sown rows. These bean plants had not appeared during the primary migration and were only infested when the apterae from the nearby earlier sown rows began to spread. The aphid populations were, as a result, later, and were controlled naturally before they killed the plant. Regeneration was possible, but too late to save the flower, and the yield was small and failed to ripen.

Temperature and moulting (J. C. da Silva Dias)

The effect of temperature on the time taken for an alate aphid (*A. fabae*) to escape from the skin of the last nymphal instar was investigated. This act is performed successfully at temperatures down to 2·5° C. Above about 34° C. the resulting alates are usually subnormal and above 35° C. death usually ensues. The curve relating rate to temperature has the nature of an activity rather than a developmental process. It remains now to see how the physiological processes preceding this act in ecdysis respond to the same temperature range.

Earthworm Studies

Rehabilitation of marginal grassland (F. Raw and R. M. Dobson in conjunction with E. Crompton of Durham University)

Observations are continuing on the field experiments at Lancaster laid down in 1954 to investigate the influence of earthworms on the rehabilitation of marginal grassland. The experiment at Rivington has been discontinued.

At Lancaster the grass on all the plots was burned in spring 1957 because analysis showed that residues of arsenic in the herbage on plots treated with lead arsenate in autumn 1955 were still too high to permit grazing. Afterwards the second dressing of phosphate, artificial fertilizers and farmyard manure was applied to the appropriate plots. Subsequent tests showed that the plots could be safely grazed, and since summer they have been well grazed by cattle and horses.

Differences in plant growth and soil characteristics associated with the fertilizer treatments are becoming apparent, and samples taken in spring 1957 also showed differences in earthworm populations associated with the treatments. In particular, the population of the plots which received lime and phosphate now greatly exceeds that of untreated plots. So far eight species of worms are known to occur on the plots.

Samples were taken in autumn 1957 to estimate numbers of earthworms and smaller samples were taken to estimate numbers of

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cocoons. The examination of this material was still in progress at the end of December 1957.

Earthworm populations in orchards (F. Raw and J. W. Stephenson)

The effect of repeated applications of fungicides and insecticides on the earthworm population of orchards and the rate of removal of surface litter is being investigated in four orchards near Wisbech, where J. M. Hirst of the Plant Pathology Department is studying the epidemiology of apple scab.

These orchards were chosen because they have been found to differ in the rate at which apple leaves are removed from the soil surface during winter and because they receive different manurial treatments and varying amounts of fungicide. An estimate of the earthworm populations made in autumn by the permanganate sampling method is summarized below.

Orchard	Coleman	Garforth	Hudson	Ayers Orchard	Paddock
Manurial treatment	Compost up to 10 tons/acre	$(NH_4)SO_4$ 1 cwt./acre	Dung and straw alternating 10 tons/acre	Dried sewage sludge 3 tons/acre	None
Fungicide used	Captan and mercury preparations	Bordeaux low rate	Bordeaux medium rate	Bordeaux high rate	Drift from orchard
Earthworms, thousands/acre	520	480	300	1·4	80

Six species of earthworm were found in varying abundance in the different orchards. A pot experiment has been set up to investigate the rate at which these species take down apple leaves.

Biological studies (B. M. Gerard, F. Raw and K. Mellanby)

Experiments on earthworm biology and behaviour in the laboratory have been started. It is hoped to extend these to observations on microplots in the near future.

Effect of Insecticides on Soil Fauna

(R. M. Dobson)

Identification of the material taken from the field experiment at Haslemere (Plant Protection Ltd.) to investigate the long-term effects of BHC on the soil fauna is still in progress. It is hoped that this work will be completed in 1958.

Studies on Beetles

(R. M. Dobson)

Routine identification of *Carpophilus* spp. (Nitidulidae) has continued. In other respects this work has been held in abeyance during the current year.

Ecological Studies on the Natural Enemies of Aphids

(C. J. Banks)

Studies on the association of the Garden Ant, *Lasius niger*, with the Bean Aphid, *Aphis fabae*, and on the effects of the ant on the aphid's insect enemies, were continued in 1957.

When the aphids are attended by ants their excretion behaviour alters and the normal dispersal of the apterae from the young apical growth of the bean plants is considerably delayed.

Experiments confirmed that *A. fabae*, when attended by *L. niger*, multiplies more than ant-free aphids on bean plants, in the absence of insect enemies. The average difference in numbers recorded was about one-third, the maximum being 70 per cent. No doubling or trebling of aphid numbers, as claimed by Herzig (1937), was ever recorded.

Herzig attributed the increased multiplication of ant-attended aphids to a direct stimulation by the ants of the aphid's excretion and feeding rates. Experiments were made in collaboration with H. L. Nixon of the Plant Pathology Department to test whether *A. fabae* on bean leaves excrete more when attended by *L. niger*. Young bean plants were put into water-culture solution containing P^{32} (300 μc./litre solution). Small groups of aphid nymphs feeding on the undersurface of a leaf became radioactive, and the honeydew excretion was taken from them by successive ants. The radioactivity of the ants was then compared with that of the honeydew discharged on to filter-paper by ant-free aphids on control plants. In twenty-eight experiments of this kind the attendance times varied from 19 to 158 minutes, the mean numbers of aphids were thirty-four (ant-attended) and thirty-two (ant-free), and the average number of ants was four.

The radioactivities of the aphids of the two groups did not differ significantly; but the activity of the honeydew collected by the ants was twice as much as that from the control aphids.

The "extra" radioactivity of the honeydew from the ant-attended aphids can be explained only by assuming that they absorbed more sap, thus supporting Herzig's hypothesis that the excretion and feeding rates of the aphid are stimulated by ant-attendance.

But no significant differences were found between the numbers of nymphs produced by individual ant-attended and ant-free aphids living on leaves of the same age; in contrast, the numbers were significantly affected by the age of the plant tissue on which the aphids were feeding.

It is suggested, therefore, that ant-attended aphid colonies multiply more because most of the aphids feed for a much longer time on young plant tissue, where they reproduce more, instead of moving on to older leaves, where they reproduce less. The aphid's reproduction rate is apparently not affected appreciably by the direct stimulation of feeding which results from ant-attendance.

Control of *Aphis fabae* by its Natural Enemies

(C. J. Banks)

This work was continued in collaboration with M. J. Way of the Insecticides Department.

Overwintering eggs of *A. fabae* on spindle (*Euonymus europaeus*) began hatching in mid-February, instead of late March as in 1956. The warm winter and the continuing favourable conditions enabled the primary migration of the winged aphids to begin in early May.

As expected, large populations of aphids developed on spring-sown beans in June, but there was a sharp fall in numbers in early

July. Small populations continued on beans until late August, and at the same time colonies appeared on other host plants, notably *Chenopodium album*. Many aphids returned to spindle in September and October, and more eggs were laid there than in 1956. If the winter of 1957–58 should be mild, large aphid populations on beans in the summer of 1958 may be expected.

Studies of natural and artificial infestations of the bean aphid and of its natural enemies on *Euonymus*, beans, sugar beet and *Chenopodium* were resumed, using the caging method of 1956. Sticky traps were also used to estimate activity and abundance of aphids and predators during the year. Predators were especially abundant in early July, and the cage experiments showed that the predators were important in keeping aphid numbers low during July. This was confirmed by experiments in which attempts were made to keep plots free of predators by hand-picking.

Effects of Population Density on Insects

(D. B. Long and M. A. Zaher)

Experiments carried out on the effects of larval population density on adult *Plusia gamma* and *Pieris brassicae* have been continued. Although crowding which affects the larval colour produces various morphological differences in the resulting adult, the colour and wing pattern remain unaffected. The crowded adults not only live longer than their counterparts from solitary larvae but in the case of *P. gamma* consume less water as well as food.

A distinct relationship was found to exist between the relative lengths of the larval, pupal and preoviposition periods. In *P. gamma* crowded larval conditions which appreciably shorten the larval period resulted in a slightly longer pupal period, but were followed by a shorter preoviposition period than occurred in their solitary counterparts. In *P. brassicae*, however, crowding shortened both the larval and pupal periods but lengthened the preoviposition period. It is suggested that the relative duration of these growth stages reflected differences in the effect of crowding on the rates of somatic and gonadial development.

The crowded cultures of *P. brassicae* laid fewer eggs per female, and the egg clusters were generally smaller. Crowded *P. gamma*, on the other hand, laid more eggs, but as in *P. brassicae* these eggs had a lower mean weight, and the total weight of eggs laid was less than in the solitary cultures.

When the adults were crowded at low densities the effect on the longevity of the male was doubtful, but it was reduced in the female, and this may have been related to the reduction in the preoviposition time and the increased number of eggs laid.

Generally the effects of crowding in both larval and adult stages were most marked in the female.

Forest Soil Investigations

(P. W. Murphy)

A pilot experiment to test a technique for the determination of the rate of disappearance of beech litter from the forest floor has proved successful. Leaves were marked with a spot of paint containing the isotope, Tantalum 182, and it was possible to recover them up to about 1 year after marking. Two further experiments were established during the autumn months of the present year. In the first leaves were marked *in situ*, and in the second, marked leaves from five beech woods with different humus forms have been placed under the same conditions, to find if there is any difference in rate of disappearance of leaves from different sites.

Leaf sampling indicated that rate of disappearance during the first 6 months was very slow indeed, but it is probable that there was a marked acceleration during the second 6 months. Weather conditions may play an important part, and for this reason it would be unwise to generalize at this stage.

Mr. D. S. Madge, an undergraduate student of Sheffield University, made a short laboratory study of the length of survival of certain species of oribatid mites in dry air, and at relative humidity levels of 25–40 per cent. Eight species associated with contrasting habitats were chosen for these experiments. In dry air the length of survival of the species studied varied greatly. At 10° C. *Nanhermannia nana* (Nic.) survived the shortest time, 50 per cent of the population dying in 1 hour. With *Oribatella quadricornuta* (Mich.) and *Belba* spp., 50 per cent of the population survived for periods of 48–60 and *c.* 66 hours respectively. At a temperature of 20° C. these times were usually very much shorter. On the whole, the results corroborated the evidence available concerning the environmental conditions of habitats favoured by these species. *N. nana*, for example, is normally associated with very wet places, such as sphagnum bog, and the evidence of this experiment indicates that it can only survive a short exposure to dry air. *O. quadricornuta*, on the other hand, is commonly associated with very dry places, such as stone walls, and it is therefore not surprising that it should survive exposure to a dry atmosphere for a very much longer time. It should be remembered, however, that the relative-humidity level within moss cushions on a wall may be quite frequently within the region of 70–80 per cent. The results for *Belba* are somewhat anomalous, as they are usually considered to be mesophyllous mites, and are found in leaf litter. Size of species and behavioural pattern appeared to have a marked effect on length of survival, and these may explain why the large *Belba* spp. survived for an unusually long time.

Laboratory studies of the biology of oribatid mites have been continued, and cultures of a number of species have been maintained. It has been found that *Fuscozetes fuscipes* (Koch) feed very readily on insect larvae. This is a rather surprising observation, as oribatid mites are generally considered to be detrital or fungal feeders. In collaboration with C. C. Doncaster of the Nematology Department, investigations of possible predators of nematodes and nematode cysts have been continued.

In April Dr. P. A. Ryke of the University of the Orange Free State, Bloemfontein, Union of South Africa, spent a short period at Rothamsted to gain experience of techniques used in ecological studies of soil fauna in forest soils.

Insect Migration

(R. A. French)

1957 will probably be shown to have been one of the poorest years for migrant insects in Great Britain since 1930, when the systematic collection of migration records began. In spite of the mild winter of 1956–57 and the fact that some species were observed quite early in the year, the major immigrations that usually take place in late spring and early summer were almost entirely absent. It is, however, possible that there was an immigration of at least one species, *Vanessa atalanta*, at the end of August and the beginning of September. In spite of the large numbers of *Herse convolvuli* and *Acherontia atropos* which were recorded in September and October 1956, there is no evidence that they survived the following winter and produced a further generation.