

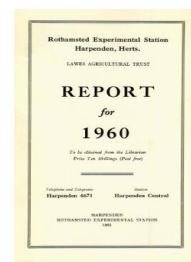
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Entomology Department

K. Mellanby

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ENTOMOLOGY DEPARTMENT

K. MELLANBY

The sudden death on 5 February of H. F. Barnes, who had been a member of the department for thirty-three years, was a profound shock to all. His entomological work formed a substantial part of the research of the department, and his publications, both in quality and quantity, were such that few Entomologists anywhere equalled his contribution to science. The unique Barnes collection of Gall-midges has been transferred to the British Museum (Natural History), where it will be available for study by specialists from all over the world. Unfortunately the eighth and last volume of his monograph on the Gall-midges was not written when he died, but Dr. W. Nijveldt of Instituut voor Plantenziektenkundig Onderzoek, Wageningen, a friend and collaborator of Barnes, has undertaken to complete this work.

C. G. Johnson received special promotion to Senior Principal Scientific Officer in July; this well-merited honour has given his colleagues in the department and elsewhere much pleasure.

C. A. Edwards joined the department in March. D. S. Madge, an Agricultural Research Council Scholar in the department, was appointed to the staff in October. D. B. Long, who for twelve years has been a most active member of the department and who has contributed greatly to our knowledge of wheat-bulb fly ecology and of the effects of environmental factors on insects, left at the end of the year. Joan Riches left on appointment as entomologist to Reckitt & Sons, Hull, and B. M. Gerard went to the West African Cocoa Research Institute in Ghana. Imam El Khidir from Khartoum and K. Tarman from Ljubljana in Yugoslavia joined the department. C. J. Banks continued his period of secondment to the Central Treaty Organisation Nuclear Centre in Persia.

Nine of the scientific staff attended the XI International Entomological Congress in Vienna in August, though only four of these were fortunate enough to receive grants from the Agricultural Research Council. K. Mellanby visited Nigeria, as the guest of the Federal Government, to attend the celebrations on the attainment of Independence on 1 October.

The University of London conferred the degrees of M.Sc. on Joan Riches, and Ph.D. on B. M. Gerard.

GALL-MIDGES OF ECONOMIC IMPORTANCE

The death of H. F. Barnes meant that much of the work on Gall-midges has stopped.

Broadbalk was sampled for wheat blossom midges for the 34th consecutive year. The infestation was small, 0.6% of ears showing attack by *Contarinia tritici* and 3.9% by *Sitodiplosis mosellana*.

Previous experiments showed that a German winter wheat variety, Marquardts brauner Dickkopf, had a low infestation by

wheat-blossom midges, but it was difficult to decide whether this was because it is unattractive or because it flowers late. Earlier sowing caused somewhat earlier flowering, and in 1960 the attack on this variety was higher than in 1959, but even with early sowing only 22% of ears had burst at the time of the *C. tritici* peak. Escape from infestation probably depends on its late-flowering habit.

Hessian fly (*Mayetiola destructor*) were bred during the winter in a heated greenhouse under regulated conditions, in an attempt to get further information on the factors influencing its speed of development. Under what appeared to be optimum conditions of temperature, light and humidity, individual flies in two successive generations completed their development from egg to adult in 29 days, a speed comparable to that found at midsummer. However, other individuals develop more slowly or cease developing for some weeks, and the cause of this is still not understood.

Material of *S. mosellana*, *C. tritici* and *C. pisi* set up in emergence pots by H. F. Barnes in earlier years remained in the insectary. An attempt was made to extract surviving larvae from some pots, but it proved impossible to separate them from the peat. Emergences from selected pots were recorded; one *S. mosellana* emerged after 19 years.

The transfer of the Barnes Collection to the British Museum, and queries from workers in other countries which continue to arrive, caused a good deal of work. Help was received from G. W. Heath, who worked as an Agricultural Research Council Scholar under Barnes in 1952-54, and who was therefore familiar with the Collection and records. (Arnold.)

Work on swede-midge (*Contarinia nasturtii*) ecology, started elsewhere, was continued with the assistance of Heather M. Twigg of the Ministry of Agriculture, Fisheries & Food Plant Pathology Laboratory. This work was also correlated with other observations in several National Agricultural Advisory Service Provinces.

In plot trials two varieties of kale and savoy, and one each of cauliflower, swede and cabbage were regularly sampled for incidence of midge attack. Only Hungry Gap kale and swedes proved to be susceptible. Crops were sown at weekly intervals, and the results of the sampling showed that the earliest sown crops were most heavily attacked. The form of damage, i.e., "many-neck", "crumple-leaf" and swollen base of the petiole, could be related to the stage of growth at which the plant was attacked. Plants often recovered well from attack even when the initial damage was severe. There was evidence that symptoms apparently typical of swede midge may be caused by other pests.

Traps placed on infested soil and over the crops were sampled daily and showed three peaks of emergence at Rothamsted, approximately on 28 July, 17 August and 30 September 1960. (Edwards.)

THE FAUNA OF THE SOIL

The very wet weather made autumn sampling difficult or impossible in several experiments, for soil that is waterlogged or submerged cannot be treated by normal methods. This means that results for

several experiments are not available, and that extra sampling will be necessary, if it is possible, in the spring of 1961.

Any quantitative study of the soil fauna, and of its biological importance, depends on a proper identification of at least the more important animals. This department now contains members able to identify to species level most insect pests and also the earthworms, slugs, centipedes, millipedes, spiders, Collembola, and a beginning is being made with the mites. There are still gaps in this soil fauna list, the most serious forms omitted being the Enchytraeid worms and the free-living Nematoda, but it is hoped that work on these will begin in 1961.

Long-term bare fallow plots

The bare fallow plots at Rothamsted and Woburn, started in 1959 and described in last year's report, have been efficiently maintained by the farm staff in spite of the weather, though it proved impossible to prevent a substantial amount of growth on the ploughed-up grass in Highfield. By 1961 it should be easier to keep this plot really free from weeds and grass, and significant effects on the fauna and flora should then begin to be seen. (Mellanby.)

The fauna of Barnfield

The end of the classical root-crop experiment on Barnfield in 1959 made it possible to sample for soil fauna, and the collections then made are being identified. This is proving a long process, but the earthworm collection has now been dealt with. Seven species were found, *Allolobophora caliginosa*, *A. chlorotica*, *A. terrestris*, *Lumbricus castaneus*, *L. terrestris*, *Eisenia rosea* and *Octolasion cyaneum*. Numerically *A. caliginosa* and *A. chlorotica* were dominant, but there was a greater weight of *L. terrestris* than of any other species. An estimate of the total weight of worms in the plots (Table 1) shows a much greater weight of worms in the plots receiving dung than in the other plots. Where sulphate of ammonia is

TABLE 1
Fresh weight of earthworms in Barnfield plots
(lbs of worms per acre)

	Dung (14 tons p.a.)	Minerals P, K, Na, Mg	No manure
Series AC, nitrate of soda + rape cake	703	172	215
Series N + sulphate of ammonia	947	15	22
Series A + nitrate of soda	557	270	91
Series O, no nitrogen	442	5	35

applied without dung the population is similar to that of plots receiving no additional nitrogen (series O). There is no obvious explanation for the greater weight of worms found in the plot which receives sulphate of ammonia and dung than in the other plots which receive dung. (Raw.)

The Collembola of which there were very many, are being identified. (Edwards.)

Earthworm populations in orchards

The experiment done in 1958–59 to measure the amount of leaf litter buried by worms in five grass and two arable orchards near Wisbech, by placing a known number of weighed leaves on the ground beneath wire cages at leaf fall and recording the number and weight of leaves remaining in spring (*Rep. Rothamst. exp. Sta.* for 1959), was repeated in 1959–60 in a modified form to test whether the amount of leaf litter buried depended on the amount supplied. To do this, twice as many leaves were put under five cages in each orchard as under the other five. This experiment confirmed the results of the previous experiment by showing that, in grass orchards, the number and weight of leaves buried was closely correlated with the weight of the population of *L. terrestris* and was somewhat less than in similar arable orchards. In each orchard more leaves were buried in the five cages with twice as many leaves as in the other five.

In an orchard with a long history of heavy spraying with copper fungicides, which had few earthworms and a surface mat of partially decomposed leaf litter with an abnormally high copper content (1,500–2,500 p.p.m. Cu), an experiment was started (with C. Bloomfield of the Pedology Department) to investigate methods for decomposing the mat by cultivation, with and without additional organic manure. Laboratory experiments were started to see whether earthworms can feed on this mat and, if so, whether any of the copper bound to the organic matter is released. (Raw and Lofty.)

Similar experiments are being made to study the feeding habits of some Collembola which are abundant in the mat. (Tarman and Raw.)

Chemical control of wireworms

Although seed dressings containing BHC will protect wheat from wireworm attack, field experiments have shown that they do this without measurably affecting the wireworm population and that, with heavy wireworm infestations, such seed dressings give less protection than combine-drilling insecticide with the seed. The amount of BHC which can be applied safely as a seed dressing is limited because it is phytotoxic, but this is not so with other insecticides such as aldrin and dieldrin. When Claycroft field was ploughed in spring 1960 it was found to have a high wireworm population, so an experiment was started with wheat as test crop to investigate the effectiveness for wireworm control of BHC seed dressings and seed dressings with standard and increased amounts of aldrin and dieldrin, and to investigate the effect of such seed dressings on the survival and behaviour of wireworms. (Raw and Lofty, with Potter and Bardner, Insecticides Department.)

Wireworm biology

Experiments are in progress to study the effect of temperature on the growth and development of wireworms. The results may help to explain the long larval life of wireworms (3–4 years) and their limited geographical distribution. (Raw and Lofty.)

Rehabilitation of marginal grassland

The experiment at Winder in Lancashire, started in 1954 to study the effect of earthworms in the process of improving hill pasture, continued. Counts in November 1959 confirmed that earthworms are becoming re-established in the plots initially treated with lead arsenate and that these plots will need to be retreated. They also showed that the population of the other plots was only one-third of that of the previous year, possibly a result of the very dry summer of 1959. Such a large change in population could easily mask any effect the fertiliser treatments might have on the earthworm population. Although all plots that have received lime and fertiliser are now much better than the untreated plots, no effects which can be related to the soil fauna have yet been demonstrated. (Raw and Lofty.)

Swift moths

Caterpillars of the Garden Swift Moth (*Hepialus lupulinus*) and of the Ghost Swift Moth (*H. humuli*) live in the soil and feed on plant roots. They seem omnivorous, and economic damage to grass and vegetable crops has been reported. Little information about their biology and ecology exists.

The flight period was assessed by light-trap catches at Flamstead. The Garden Swift moth was caught from 17 May to 24 June with a peak catch of 260 individuals on 6 June. The catch was predominantly males except at first. The Ghost Swift moth was caught between 5 and 22 June; more females were caught than males, and the catch was much smaller than of the Garden Swift moth. It appeared to be important to put the trap on the ground because similar traps put on platforms above ground level caught fewer. Moths marked with coloured paint were released at different distances from the trap, but only very few were recovered in the trap.

Female *H. lupulinus* in the laboratory laid from 50 to 200 eggs and *H. humuli* from 200 to 700. Temperature greatly affected the incubation periods of eggs of both species; they were 9–16 days for *H. lupulinus* and 11–18 days for *H. humuli* at 20°. At 5° eggs did not hatch, but remained viable for over 6 months.

Larvae were cultured in jars containing a base of moist plaster of Paris. After the fourth instar, peat moss was added to the jars, as the larvae sometimes burrowed into the plaster of Paris. Cultures were kept at 5°, 10°, 15°, 20° and some were buried in soil outdoors. The development of the larvae depended greatly on the temperature; larvae developed at 20° approximately twice as fast as at 10°, and at 5° they did not develop beyond the first instar in 5 months. Outdoors when food supplies are adequate, both species probably complete their life cycle in one year. Feeding cycles of the larvae showed a typical growth curve, with a non-feeding phase of 4–5 days before moults. (Edwards.)

Symphyla

Many specimens were received from and identified for workers in various parts of the world, particularly Canada, West Africa and Surinam. (Edwards.)

Earthworm biology

Sampling in a grass field (Pastures) at Rothamsted continued until April 1960. This completed a 2-year period, during which areas of 18×18 inches were periodically dug out in 3-inch layers to a depth of at least 12 inches, to determine if vertical movements of the worms, particularly *Allolobophora caliginosa* and *A. chlorotica*, are affected by temperature and dryness. In other experiments, plots were kept unnaturally dry (by covering with Dutch lights) or the soil was kept at field capacity by irrigation, to see how these conditions affect earthworm movement, population dynamics and reproduction (determined by the recovery of the egg capsules). It was perhaps unfortunate that there was no severe cold weather in 1958, 1959 and 1960, so the effects of really low temperatures could not be observed.

Laboratory experiments on the effects of temperature and moisture on egg capsules, immature and mature worms were continued, as were observations on the effects of light, temperature and moisture on worm activity in the field. *Lumbricus terrestris* came out of its burrow at any hour, provided the ground was moist, light excluded and the temperature was above 5° . (Gerard, Raw and Mellanby.)

Slug investigations

The detailed life histories of *Arion hortensis* and *Milax budapestensis* are being worked out using the culture methods evolved during last season. The rate the young develop at constant and fluctuating temperatures, and the feeding rate of *M. budapestensis* at constant and fluctuating temperatures, are being studied.

Damage to Majestic and Arran Pilot tubers was assessed in a crop grown at Rothamsted Lodge for the second year. The results provide an interesting comparison between a dry season, 1959, and a wet season, 1960. A new technique capable of giving quantitative results has been devised, based on measuring the size of the holes made by slugs in the potatoes.

Three insect repellents, dimethyl phthalate, dibutyl phthalate and benzyl benzoate, and salicyl aldehyde (both the naturally occurring and the synthetic forms) were tested against slugs. All were repellent and toxic to slugs, and the possibility of using them as seed dressings was explored. Unfortunately all the compounds have some phytotoxicity, but at low concentrations they decreased the hollowing of wheat grain by *Agriolimax reticulatus*.

A preliminary experiment was started to explore the possibility of assessing slug populations more accurately from the results of trapping. Square-yard quadrats were sealed off by driving metal plates into the soil to a depth of 1 foot, and the slugs coming to fresh bran/meta bait in these traps were collected daily. Slugs immobilised under wet sacks placed adjacent to the quadrats were also collected daily. This allows the catches on the bran baits to be related to slug activity and temperature on any particular night, and it is hoped the results will show how many nights' continuous trapping within the quadrats are needed before the slug population, both surface and subterranean, can be estimated. (Stephenson.)

Experiments to find the effects of low temperatures on slugs, and the biological zero, were begun. *A. reticulatus*, a pest of winter wheat in late autumn, is particularly adapted to life at low temperatures. (Mellanby.)

Mite investigations

The feeding behaviour and digestion of Oribatid mites, the correlation between food habits (i.e., microphagous, macrophagous, wood eating) and digestive processes, were studied by histological and histochemical methods. (Tarman.)

Ecological work near Woburn included taking monthly samples from (a) lichen in between *Calluna* tussocks in heathland, (b) ground moss from an adjacent oak-chestnut woodland; samples of litter and humus from Geescroft Wilderness at Rothamsted were also regularly examined. Temperatures and other data were recorded, and the mites are being extracted from the samples for identification.

Results from laboratory investigations on the physiology and behaviour of the different species of Oribatid mites are being related to the microclimatic conditions of the natural sites of the mites. The water balance of several species was studied, together with the anatomy of the respiratory system and the structure of the cuticle. (Madge.)

Biology of forest soils

Work continued on the changes in weight of the leaf litter under beech and oak. Labelled leaves of beech (in an 18-year-old stand which has achieved closed canopy) and oak (from both an 18-year-old stand and from a 50-year-old natural regenerated oak-dominant woodland) were sampled at 14-day intervals for 12 months. The samples consisted of small disks of leaf lamina punched from the labelled leaves. During the 12 months the dry ash-free weight per unit area of leaf lamina has not varied, and no significant loss in weight was detected at the end of the year. No attempt was made to put the leaves in any particular stratum of the litter layer, and so much of the time they were on the surface. Observations indicated the lamina break down or fragment at the bottom of the litter layer. Experiments were therefore started in which large disks of beech and oak leaves were placed at the bottom, middle and top of the litter layer. Sampling of this experiment should measure the rate and extent of leaf fragmentation. An associated experiment with similar disks will give information on the removal of leaf material by earthworms.

The respiration rates of soil animals were again measured. The apparatus used maintains constant O_2 partial pressure by generating oxygen on demand electrolytically; this output can be recorded daily. In experiments with Isopods oxygen demand was between 0.10 and 0.30 $mm^3 O_2/hr./mg.$ of body weight. The apparatus is not yet sensitive enough for animals as small as the litter-living mites, but it is being improved. With a small core of soil containing Collembola in the respirometer the oxygen demand was between 0.02 and 0.04 $mm^3 O_2/hr./ml.$ of soil. The soil animals in the core survived in the respirometer for several weeks.

Leaf traps in the young oak and beech stands at Rothamsted

showed that in both stands the amount of organic matter falling on to the woodland floor during autumn was about 2,500 lb./acre of dry matter. The percentage total carbon of this material will be estimated as it decomposes. Preliminary observations suggest that the measurement of respiration rate of the soil milieu and its animal population, taken in conjunction with changes in the total carbon content of the litter, may be the most profitable line in elucidating the role of the soil fauna in forest soils. (Heath.)

INSECT DISPERSAL AND MIGRATION

Work was mainly devoted to drawing together, into a general system, the diverse aspects of dispersal and migration of insects and to continuing the analysis of the many results on the vertical distribution of various insect species (especially aphids) collected over the past 10 years at Cardington.

Progress towards a general functional system of insect dispersal and migration was helped by the recognition that many classical "migrations" begin at a breeding site by the newly emerged adults often on their first flight or on one relatively soon afterwards. In this respect such migrations resembled the normal initial dispersal process from the breeding site of many insects not generally recognised as migrants. It is true that so-called mass "migrations" in some species are made also by much older adults, already with a flight history, as from hibernation or aestivation sites, but the post-teneral migration flight from the place of birth is nevertheless apparently common to all. This introduces a new perspective to a hitherto diffuse subject, and the possibility appears of making a general functional system of migration and dispersal for a very wide range of insect species. Mass flights (a characteristic of many migrations) can be linked with mass emergence, and with the recently constructed mechanism of post-teneral daily flight rhythms, as in aphids. Migration and dispersal (hitherto seen as distinct processes) are recognised as aspects of the same process, and the spectacular orientation and persistence of some migratory flights can now be seen not, as is customary, as a general feature but as a very special one. Thus both "dispersal" and "migration" are processes for redistributing populations from the original breeding site. The methods by which this is achieved range from spectacular feats of orientation and persistence by strong fliers to drift on the wind by weak ones.

The task now is to systematise the mass of existing information within this perspective and to distinguish general from special problems. (Johnson.)

ECOLOGICAL STUDIES ON WHITEFLIES

Work on the cabbage Whitefly (*Aleyrodes brassicae* Walk.) began in April with special attention to flight activity. A 9-inch segregating suction trap, working in a cabbage plot from 15 August to 28 September, showed a daily flight periodicity with a maximum near midday. Little flight occurred at night, probably because of low temperature rather than of darkness, for when temperatures rose above the flight

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threshold at night the insects flew. The temperature threshold for take-off was approximately 9°.

Numbers caught per hour and ambient temperature are not always correlated positively, as the catch may rise with a falling temperature, and vice versa. As with aphids, this may reflect changes in population level rather than changes in behaviour; the relation between the moulting into adults and take-off is being studied in the greenhouse to elucidate this point. Emergence is rhythmic, usually occurring maximally between 8.5° and 16.5° with a threshold of 6°. The difference between emergence and take-off thresholds tends to make new adults accumulate while waiting to take-off. Females are usually about 10 times as numerous as males in the trap. Collections from the crop itself show that this is only partly because of an absolute preponderance of females, for the crop contains proportionally more males than are present in the traps. This suggests the flight behaviour of the sexes differs. (Imam El Khidir and Johnson.)

SAMPLING LIMITS FOR SUCTION TRAPS

To make the best use of suction traps it is necessary to know how insects are distributed in the air. Like all sampling devices, we want to know within what limits reliability can be placed on any given catch or sample. This is being investigated. It seems that, at any specific instant, the distribution of most insects in the air is approaching random; in other words, most insects in flight are quite independent of each other, and this is true for most of the common orders. However, the chronological changes in distribution are highly interdependent, as might be expected, and this dependence differs between orders. It is expected that tables of limits of accuracy for catches will be published shortly.

In the course of this investigation it was necessary to find a suitable method for transforming catches before statistical analysis. The logarithmic transformation $[\log(n+1)]$ is often used, but is not entirely satisfactory. This led to an examination of published work, and a general transformation was found for any degree of aggregation. It is based on the empirical relation: variance is proportional to the mean raised to a positive fractional power (b), where b is a measure of aggregation, i.e., $s^2 = am^b$. This also has considerable biological interest, in the use of b as an Index of Aggregation, making it possible to compare the degree of aggregation in different species, or in the same species in different habitats. The relation also contains another parameter a which is affected by sampling and computing procedure. The several aspects of this problem will be investigated in collaboration with M. J. R. Healy of the Statistics Department. (Taylor.)

FLIGHT THRESHOLDS IN *APHIS FABAE*

The minimum air temperature at which free horizontal flight occurred was 10°; 50% of test insects flew horizontally at 13°. For upward flight the minimum air temperature was 12°; 50% flew upward at 16°. The higher temperature threshold for upward

flight is probably caused by higher metabolic requirements. There was no evidence that aphids kept previously for 24 hours at 5°, 10° and 15° were acclimatised towards lower flight thresholds than aphids kept at 20°. These results apply only to the first few seconds of flight.

Wing-beating occurs at temperatures below the threshold for successful flight; tethered aphids beat their wings, generally at low stroke amplitude, at 3–7°. In nature such movements may decrease sinking and so aid dispersal. Below 9°, however, wing-beating is maintained for less than 15 minutes. (Cockbain.)

A FUNGUS PATHOGENIC TO THE BED-BUG

Bed-bugs (*Cimex lectularius*) kept at 30° and 90% relative humidity became naturally infected with *Aspergillus flavus*; this is apparently the first record of a fungus attacking *C. lectularius*. When the insects died, yellow hyphae grew through the ventral body surface and through the joints of the appendages. Sometimes the fungus emerged and began to sporulate before the insects died. All insects died within 18 days of the outbreak.

Pathogenicity tests with 2nd instar nymphs and adult bugs from an uncontaminated culture showed that inoculated bugs died sooner than controls. Bugs kept at 30° and 50% relative humidity, and 20° and 90% relative humidity, did not show the fungus externally; at 30° and 90% relative humidity, which is probably near the optimum for fungal growth in the bug, hyphae penetrated to the outside of the cuticle. (Cockbain, with Hastie, Plant Pathology Department.)

WHEAT-BULB FLY

Larval studies

A mean population of 298,000 larvae/acre in wheat after fallow on Broakbalk, following the smallest recorded population for that field of 55,000 larvae/acre in 1959, demonstrates the ability of wheat-bulb fly to multiply. The distribution of the population across the field was similar to that observed 5 years previously, with numbers decreasing from the middle of the field to the southern boundary.

The detailed study of the interaction between larva and plant undertaken with the collaboration of Marjory G. Morris of the Statistics Department shows that local plant density is important, both for the success of the developing infestation and for crop recovery. Thus, in wheat sown at low density, a population was only one-twenty-fifth as successful in passing through the larval stages up to pupation as a comparable population in wheat sown at the normal rate, largely from two factors associated with low-density wheat: first, many more larvae died in the plants (although they tillered more freely), and secondly, more larvae died in the transition from shoot to shoot. The results of the new technique used in 1959 suggested that crop recovery depended principally upon compensatory development in undamaged plants. Damage retarded plants up to 4 weeks and, although they subsequently produced more buds

and shoots than undamaged plants, they failed to replace all the damaged shoots and fewer survived to harvest in such plants than in those undamaged.

To continue the study in 1960 a new field technique was developed for observing the progress of the infestation in the experiment on Alternate Wheat and Fallow. This depended on the integration of the results of three sets of independent observations. On seven successive occasions 480 samples, each comprising 1 inch of row, were taken from 16 30-inch sectors of row and examined in the laboratory. Thus larval and plant growth could be related to the spatial distribution of damaged and undamaged plants in the field. In another series of 30-inch sectors the spatial distribution of 500 plants was recorded, when they were individually marked as damaged or undamaged and the progress of the larval infestation and plant growth in the field were observed until pupation. At harvest these labelled plants were removed to the laboratory, where the lengths of the straw and ear, and the number of grains and their weight, were recorded. The possible effect of shoot-age affecting the distribution of larval infestation was also investigated by a "choice" experiment in which 650 tubes each containing a young wheat seedling and a single-shooted older plant were each inoculated with a single larva. The age of the larvae and their subsequent distribution between young and older plants were recorded. The analysis of the results of these and earlier experiments is being continued by Marjory G. Morris. (Long.)

Adult studies

The diurnal rhythm of activity affects both movements within crop and the dispersal of the fly. Much of the behaviour appears to be influenced by changes in light intensity, and activity is maximal at very low intensities. Experiments on the opto-motor responses of the fly in relation to light intensity had to be abandoned because of the wet weather. (Long.)

POPULATION DENSITY EFFECTS

The effect of larval population density on the development of the subsequent generation, indicated previously with *Plusia gamma*, was investigated on a larger scale. From a common stock solitary and crowded cultures were set up as independent lines and bred through four generations. By reversing the culture density in one-half of each line in F_2 and F_4 generations, the effect of the parental experience could be studied by comparing the development of larvae reared under similar conditions of population density. The study was extended in the F_4 generation to include the maturity period, fecundity and lifespan of the adult moth. The results, which await statistical analysis, do not show the clear differences in the number of instars between the two lines observed in 1958.

Experiments on the effect of pairing and adult population density under constant temperature on maturation period, fecundity and lifespan are being completed, and results obtained to date suggest that copulation stimulates egg laying. They also confirm previous findings that nearly twice the number of eggs per female laid by single

pairs are laid when two pairs are kept together and suggest that this happens because of stimulation by another laying female rather than by the presence of another male. (Long.)

INSECT MIGRATIONS

The records of migrant lepidoptera show that almost all species were rare in 1960. Reports of the Red Admiral (*Vanessa atalanta* L.) in January, February and March indicate the ability of this butterfly to overwinter successfully in the south of England, particularly during a mild winter such as that of 1959-60. A few individuals of other "migrants", especially the Humming-bird Hawk Moth (*Macroglossum stellatarum* L.), may also have survived the winter. That these overwintering insects contribute little to the summer population is indicated by the scarcity of records throughout the rest of the year. In addition to the above insects, all the other regular migrant lepidoptera, except one, were present in only small numbers. The exception was the Convolvulus Hawk Moth (*Herse convolvuli* L.), which was more numerous than usual because of an immigration from the south at the beginning of September.

Among the scarcer immigrants, two species are of particular interest, the Rannoch Looper (*Itame brunneata* Thunb.) and the Great Brocade (*Eurois occulta* L.). Seven specimens of the former were caught in south-east England, six of them on the nights of 25 and 26 June. All the moths were of the pale continental form, as opposed to the dark Scotch form. *E. occulta*, another Northern species, was recorded at the beginning of August in several localities where it is unlikely to have bred; some of these specimens, too, were identified as of the continental form.

During the first week of August movements of Syrphids were reported from several localities in south-east England. Although Syrphids were, in fact, common over much of England, the migrations were noticeable, particularly along the coast from the Isle of Wight to Lincolnshire. The direction of flight varied between localities, but the insects were usually recorded as coming in from the sea. On the few occasions when the species were identified they were principally aphid-eating species. (French.)

SCIOMYZID INVESTIGATIONS

Prof. C. O. Berg of Cornell revisited Rothamsted, staying from 17 June to 11 July. During the first week he was accompanied by Mr. Ll. Knutson. The work on *Pherbellia schoenherri* started in 1959 was completed, and the results are being written up. Additional members of the Sciomyzidae were taken in the United Kingdom by Prof. Berg on collecting trips. On these the biology of *Verbekea* sp., *Ditaenia cinerella*, *Pherbina coryleti* and *Sciomyza albocostata* has been in part worked out. Information has also been obtained on the host range of the larvae of these species. (Stephenson.)

SPIDERS

Field surveys at Rothamsted showed rather few spiders (about 50,000/acre, compared with more than 4,000,000/acre in some habitats). It was felt that work on the economic importance of such populations would be difficult, so the main effort was devoted to laboratory experiments and study of a natural infestation in the glasshouse corridor.

An attempt is being made to determine the amount of food consumed by the spider *Zygiella x-notata*, and the effects of different feeding regimes on its growth and survival. Spiders, individually in glass tubes, are kept at 10°, 15°, 20° and 25° and fed on *Drosophila*. Different groups of spiders receive different numbers of flies, and the actual amount of food taken is estimated by removing the fly corpses and analysing them. (Tallack.)

FRIE FLY

Work on the frit fly in the field and in the laboratory continued for the third successive year. On Geescroft an experiment similar to one made in 1959, planned to make possible the forecasting of frit-fly attack, was made in collaboration with Mr. A. H. Strickland and Mr. K. S. George of the Ministry of Agriculture, Fisheries and Food Plant Pathology Laboratory. Two randomised blocks of 2 plots, with 2 replicates, were sown on 17 March, 7 April and 21 April. Fly numbers and fly behaviour were studied throughout the season; the results are being compared with observations in other parts of England.

An analysis of damage to the oat panicle was completed, and the results published (10.25.) (Riches.)

The seasonal population change and diurnal flight pattern of the frit fly (*Oscinella frit* L.) were studied in 2 acres of late-sown Sun II oats in Great Field II, by the use of a disk-dropping suction trap, which was initially buried in the ground, but raised during the growing season to keep its mouth at crop level. Hourly catches show that the flies become active about 3 hours after sunrise and stop flying about sunset, with a peak of flight between 1400 and 1600 hours G.M.T. These times varied little over the whole trapping period from May to September. The flight pattern is being further analysed to see the effects of air temperature, light intensity and wind speed. Over most of the season the catch contained more males than females; but during two short periods considerably more females than males were caught. Adult flies emerged most abundantly from pupae in freshly collected oat spikelets at about 0800 hours G.M.T.

Fewer eggs were laid on panicles exposed either before or after flowering than on panicles exposed during flowering.

The nematode parasite, *Howardula oscinellae*, occurred in 3-4% of the flies examined.

A cage of terylene net, 24 feet square and 6 feet high, was placed over part of the crop, before the panicle generation emerged, to isolate this area in an attempt to measure movement into or out of the crop during this period. The infestation inside the cage was

lower than outside, particularly in panicles which were late in flowering.

Work began to study the overwintering of frit fly larvae in winter oats, sown on 29 July, 10 August and 26 August. All three sowings were infested by adult frit flies emerging from the panicles of the spring-sown crop, and the infestation was particularly large in those sown on 10 August. The infestation in this crop is being followed by dissecting samples at intervals to see the effect on the plant and the mortality of the frit larvae. Up to the end of 1960 no pupae were found, and larval mortality has varied considerably, but not consistently, with time. Tillering has continued and increased in proportion to the number of damaged shoots. (French, Bull and Mellanby.)

Some of the frit fly population studies have contributed to the general problem of insect trapping. The white glass sticky traps ("Ibbotson" traps) and white or yellow water traps clearly attract frit fly and other diptera. This is useful to detect attracted insects when they are scarce, but the results require careful interpretation. When water traps are painted "grass-green" (to a special formula advised and tested for reflection and radiation by Miss D. L. Tilleard of the Paint Research Station, Teddington) the catch is quite different, and is perhaps more nearly a random sample. It is of interest that white water traps sometimes caught many honeybees, to the concern of our colleagues in the Bee Research Department; the green traps in the same situations caught very few.

Green tray water traps were placed at 25 sites spread over Rothamsted farm, and the catches are being compared with those obtained by suction traps. (Calnaido.)