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Entomology Department

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ENTOMOLOGY DEPARTMENT

By C. B. WILLIAMS

The reduction of damage by insect pests can be either direct—by insecticides and other chemical methods, or indirect—by agricultural methods and biological control, just as in Medicine there are the curative, and preventative or “Public Health” services. As there is in Rothamsted a separate Insecticides Department, the work of the Entomology Department is definitely biased towards indirect methods.

The staff consists of five Scientific Officers, two scholarship students of the Agricultural Research Council, four Experimental Officers and two overseas research students.

The work can be roughly divided into :

- (a) Fundamental work on the causes of insect outbreaks.
- (b) Special problems of particular pests or crops.

FUNDAMENTAL WORK ON THE CAUSES OF INSECT OUTBREAKS

The effect of weather conditions on the activity and abundance of insects (C. B. Williams, R. A. French and B. P. Singh)

Measurements of the changes in insect numbers have been collected for many years, chiefly by means of traps. Light traps have been the standard, but bait traps have been tried, and suction traps have recently been developed.

The figures have been analyzed statistically and it has been possible to calculate the effect of different weather conditions on the immediate activity of the insects, and also on the size of the future populations. Results so far show that it is possible to account for 70 per cent of the variance of the total insect population in summer and autumn by the effect of the rainfall and temperature of the three previous months. The work is throwing considerable light on the relative importance of weather, parasites, and food supply in determining outbreaks. It is proposed to carry on with the analysis of special groups of insects, and of certain species which are sufficiently abundant for statistical analysis. A much more efficient form of light trap, using a mercury vapour lamp, has recently been tested and with this it will be possible to get much larger numbers of certain species.

Mr. Singh is using suction traps (designed by Dr. Johnson) to obtain samples for comparison with the light trap results. The suction trap also makes possible the comparison of day and night conditions.

The relative abundance of different species of insects (C. B. Williams and R. A. French)

The relative abundance of different species of insects and other animals in mixed wild populations, is also being studied, chiefly from the trap samples, and it is found to be consistent with some relatively simple mathematical laws. For many years there has been talk of the “Balance of Nature,” now we seem to be beginning to understand what it means. Two alternative mathematical series are at present being tested—the logarithmic series and the log-

normal series. With small samples the theoretical differences are very small, it is only with large samples that the differences will be measurable. The Statistical Department are co-operating with some fundamental work on sampling from a log-normal distribution.

Arising out of this work has come the conception of the "Diversity" of a population as an important ecological factor, which is found to be the basis of many previously ill-understood properties of populations; such as, for example, the distribution of plant species in quadrats. Work is now directed to getting very large samples of animal populations from a limited area in a short time. The new traps will help considerably in this. With such samples it should be possible to distinguish between the validity of the two alternative formulae.

Migration and drift

The distances which insects can regularly move is of fundamental importance in all questions of insect control and of quarantine for insect pests. Most recommendations about the rotation of crops seem to be based, so far as insects are concerned, on a complete misunderstanding of their capabilities of distribution. Our work is divided into two sections—*Migration* (C. B. Williams) and *Drift* (C. G. Johnson).

At Rothamsted *migration* has been studied in all insects (except locusts) from all parts of the world, but the majority of records are in the Lepidoptera. Insects can migrate of their own accord, by their own power, and irrespective of the direction of the wind, distances frequently over 100 miles and occasionally over 1,000 miles. Our Cabbage White Butterflies come over the North Sea from Central Europe, and our Silver-Y Moth and many others come from the Mediterranean area. Work consists at the moment chiefly of acting as a centre for the collection and study of records. A return flight has been shown by our work to exist in many species but the problem of "orientation" has not yet been solved. A book on the Migration of Insects is in preparation for the "New Naturalist" Series.

Related to migration is the problem of *Phase Colouring in Caterpillars* (D. B. Long).

About 30 years ago Uvarov discovered that grasshoppers and locusts can exist in two "phases" or forms which differ in colour, relative dimensions, activity, behaviour and metabolic rate from each other. The "Gregaria," dark-coloured phase is produced as a result of crowding, and the pale "Solitaria" phase by isolation of the individuals in the early larval stages.

About six years ago phase differences were found in three South African caterpillars by Faure.

We have recently found definite evidence of phase differences in the larvae of the Silver-Y Moth (*Plusia gamma*) an immigrant noctuid moth which is at times a pest of field peas, beans and other crops. Crowded larvae become dark-coloured and active, isolated larvae become pale and inactive. There are also associated differences in rate of development and colour and state of maturity of the adult moths. It is curious that these phases have been found almost entirely in migratory insects.

The work is continuing and Long is trying to find similar phase differences in other caterpillars, including those of non-migratory species.

Drift of insects (C. G. Johnson and L. R. Taylor). Dr. Johnson has studied for some years the drift of small insects, especially Aphididae, in air currents, and particularly their distribution in the upper air. Trap nets attached to the cables of barrage balloons, at Cardington, have resulted in the capture, on warm summer days, of up to ten or twenty living Aphididae per hour in a net three feet across. Thus the distances that thousands of these smaller insects can travel must normally be measured in tens or hundreds of miles.

Owing to the unreliability of simple nets at low wind speed, suction traps have been developed in which air is sucked or blown through a net by means of an electric fan. Thus a fixed amount of air is sampled each hour irrespective of wind velocity. These traps are being specially used to find the population density in the air at night when wind speeds are usually very low. Similar traps have also been used at ground level to study the activity of Aphids. It seems that in many species there is a double peak of activity in the day, one in the morning and one in the early evening. Special studies have been made on the Aphididae with the help of Mr. Judenko and Mr. V. Eastop; on the lacewings (*Chrysopidae*) with Mr. C. J. Banks; and the Heteroptera with Mr. L. R. Southwood.

Suction traps have also been made, loaned and maintained for Dr. Broadbent's work on Aphididae, for Dr. Hull's work on sugar-beet near Bury St. Edmunds; and for red spider work at East Malling.

Consultation has been established with the Blackburn and General Aircraft Company for the problem of small insects sticking to the surface of high speed aircraft and causing surface drag.

Biological control

The interrelation of host, parasite and predator relationships was being studied by Mr. Banks, in the special case of Aphididae, and their ladybird, hover-fly and lace-wing enemies.

Unfortunately Mr. Banks has been away ill for over a year, but he returned in October and this work will be resumed and extended.

Population changes in Gall Midges (H. F. Barnes)

For twenty-four years Dr. Barnes has measured the population density of two gall midges which attack the wheat on Broadbalk. The results indicate a periodic abundance and scarcity. Years of peak abundance were 1931, 1936, 1941 and 1946. The year 1951 is forecast to be another year of abundance. Similar series of observation are very rare, but very necessary for the understanding of population fluctuations.

Dr. Barnes has shown that the midges can remain underground for as long as nine years and this long diapause may perhaps have something to do with the periodic outbreaks.

Population studies in Aphididae (C. G. Johnson)

The estimation of bean-aphis infestation by dilution and photographic methods, and the pattern of aphis infestation of fields in

relation to wind direction have been under investigation, together with a general study of population ecology.

SPECIAL PROBLEMS

Soil invertebrates and their relation to soil fertility (F. Raw, G. O. Evans, J. E. Satchell and B. R. Lawrence).

(a) A grant from the Forestry Commission has enabled Evans to study the relation of soil arthropods to soil fertility with special reference to forest soils and forest litter. With soils with such a high percentage of vegetation the flotation method does not work so well and Evans is now using Tullgren's modification of Berlese funnels. In coniferous and deciduous stands at Ampthill and Woburn he has found populations reaching 400 million insects (chiefly *Collembola*) and 700 million mites per acre. Identification of these is a major problem. The soil mites—in fact mites in general—have been so little studied in this country that Evans has had to do a considerable amount of work on this group. He is also making life history studies of representative species. It is a long and difficult problem and only slow progress can be made.

(b) *Insects and dung*. B. R. Lawrence is making a study of the insect fauna of dung, and the rate of breakdown by different types of coprophagous insects.

(c) *Earthworms*. Considerable progress was made in the study of earthworms and their relation to soil fertility by Dr. A. C. Evans a few years ago. The different species were sorted out and methods were found to identify most of the immature forms. The species were partly sorted according to their ecological requirements, and studies were made in the rate of turnover of soil by those species which form worm-casts on the surface.

Since A. C. Evans left, the work has been carried on by J. E. Satchell. His problem has been chiefly that of developing a new technique for bringing earthworms to the surface. A. C. Evans used the method of watering with a dilute solution of potassium permanganate. The new method now being tested makes use of an electric current. It brings up more worms per square foot than the potassium permanganate method, and in particular is more efficient in bringing up deep living species such as *Lumbricus terrestris*. Worms brought to the surface are unharmed, whereas using potassium permanganate the worms die rapidly after surfacing. A great advantage is that it is also applicable to areas—such as Park Grass—where it is not desirable to use chemicals. It is hoped later to have a portable generating set which can be used for field sampling.

The general result of our work to the present is that certain species of earthworms are of considerable value in permanent grassland by turning over and aerating the soil, but that in arable land their value is negligible.

(d) *Wireworms*. Dr. Raw has collaborated with the Insecticides department in the wireworm experiment in Hoosfield by sampling the plots at intervals to test the effect of the treatments on the wireworm population. The large soil washing machine designed at Cambridge and tested at Rothamsted has been overhauled with the help of Mr. French, and now that this is in operation future soil work will be facilitated. The sampling to date shows that the wire-

worm population on all plots has fallen considerably as a result of cultivations and this fall has masked any treatment effects. It may be, however, that the treatments, which had marked results as measured by yields, acted as repellants, and a fall in population may not follow or may only follow after some time as a result of starvation.

Though advances have been made in chemical control of wireworms, they remain a major problem. There is a great need for more information about their general ecology, in particular the factors affecting their distribution and dispersal and the build-up of populations in leys. In this connection two lines of work are in hand.

The changes in wireworm populations are being followed in the ley-arable experiments on Highfield and Fosters, beginning on the one hand with the high population characteristic of permanent grassland and on the other hand with the low population characteristic of old arable land. This is a long-term study and it is hoped to be able to extend it to leys of longer duration and to other soil types.

Factors affecting the distribution and dispersal of wireworms are being studied in Park Grass. A limiting factor in this work is the small amount of sampling permitted. The data collected so far do not permit of any conclusions being drawn beyond the tentative suggestion that the percentage of weeds is important. In this work use is being made of the vegetation analyses made by the Botany Department; more data on the physical environment would be useful.

The work on Park Grass is being extended to other arthropod groups. Sampling necessitates modification in techniques as the present flotation method which is accurate for estimation of number of arthropods larger than 2 mm. is not accurate for smaller forms such as mites and *Collembola*; Berlese funnels are subject to empirical errors especially when used for heavy clays. The flotation technique holds the greater prospect of final application, and modified chemical and physical means of dispersing the soil prior to flotation are being investigated.

Gall Midges of economic importance (H. F. Barnes and B. M. Stokes)

Dr. Barnes has been for many years a recognized authority on the group of Diptera known as the *Cecidomyiidae* or Gall Midges, which include a number of very serious pests of crops. He is writing a monograph of the habits and control of these insects throughout the world. Of this, five volumes out of a projected eight, have already appeared. Enquiries come from all over the world and he has a unique collection of nearly 7,000 microscope slides, which is continually being increased.

Two special problems of gall midges are being particularly investigated. First the fluctuations in population numbers already referred to, and secondly the host plant range of several injurious species, and particularly the Swede midge.

It is of the utmost importance for the agricultural entomologist to know the range of food plants of any pest. Dr. Barnes has recently shown that the Swede midge will breed on the wild yellow flowered water-cress and almost all the cultivated brassicas and raphanus.

The recent appointment of Miss Stokes has helped on with this work and she has shown that damage to *Sisymbrium*, Woad, *Lepidium* and Mustard, is probably produced by the Swede midge although previously attributed to other species of gall midges. The same midge can also make a variety of galls on flowers, inflorescences, fruits and leaves.

This work is being extended and similar work should be carried out in the tropics where there are a number of gall midges which eat scale insects, associated, for example, with die-back of cocoa and cloves. Their host range and distribution are very little known, although they may be important factors in the control of scales.

Slugs (H. F. Barnes and B. M. Stokes)

For some years Dr. Barnes had studied the slugs in his garden at Harpenden, working out their life history and examining methods of control. Recently—when he moved to Bedford—he carried on the work with particular reference to the Grey Field Slug which is the most widespread and common pest among the slugs, and the earthworm-eating slugs *Testacella*.

1,000 Grey Field Slugs were introduced into a slug-free garden and they have been under regular observation for a year, and the population changes here are being compared with those in a garden where the slugs are naturally established.

The *Testacella* slugs have a very tiny shell and this has made possible marking experiments. Marked *Testacella* have been recovered up to 580 days after marking. Miss Stokes is breeding the slugs in the laboratory and has already succeeded in getting eggs and young from two species of *Testacella*.

STAFF

The head of the Department, C. B. Williams, was invited by the French Government to take part in a small International Colloquium on "Ecology," in Paris, in February, 1950.