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Entomology Department

C. B. Williams

C. B. Williams (1954) *Entomology Department ; Report For 1953*, pp 117 - 125 - DOI:
<https://doi.org/10.23637/ERADOC-1-75>

ENTOMOLOGY DEPARTMENT

C. B. WILLIAMS

STAFF

During the year J. E. Satchell and M. M. Hosni have left, and R. M. Dobson has joined the staff.

M. M. Hosni obtained the degree of Ph.D. at London University for a thesis on the effect of environmental conditions on populations of insects.

B. R. Laurence (now at Birkbeck College) obtained the degree of Ph. D. London for work done at Rothamsted on the insect fauna of dung.

C. J. Banks obtained the degree of Ph.D. at the University of London for a thesis on the effect of predators, particularly Coccinellidae and Syrphidae, on populations of the black bean aphid (*Aphis fabae*).

D. B. Long obtained the degree of Ph.D. at the University of London for a thesis on the effect of population density on the physiology and behaviour of lepidopterous larvae.

P. W. Murphy obtained the degree of D.Phil. at Oxford University for a thesis on the rôle of certain insects and mites in determining the fertility of forest soils.

Dr. K. K. Nayar, senior lecturer in the Department of Zoology, University College, Trivandrum, who has been on study leave for one year for advanced post-doctoral work and training, spent most of the summer here working on gall midges before going to Leeds, Oxford and Cambridge Universities.

Dr. Raw attended the 14th International Congress of Zoology in Copenhagen and read two papers—"The extraction of small arthropods from soil samples by a flotation method" and "The abundance of Protura in grassland". Summaries of these will be published in the *Proceedings* of the meeting.

EFFECT OF WEATHER CONDITIONS ON INSECTS

(C. B. Williams, R. A. French, M. M. Hosni and Samira El-Ziady)

The continuous trapping of insects by light traps was brought to a conclusion in March 1953 and the results included in a thesis by M. M. Hosni. During the summer a detailed experiment was carried out to test the differences between two types of light traps (the Rothamsted and the Robinson) and two types of illumination (ordinary electric light and a mercury vapour bulb) for different orders of insects. The mercury vapour lamp, rich in ultra-violet light, was two to three times as attractive as ordinary light for all groups of insects. The Robinson trap was definitely more efficient than the original Rothamsted type for larger insects such as the Macrolepidoptera, but much less efficient for the Diptera, which are mostly small or very small insects.

Miss Ziady has continued her study of the population of flying insects at 5 feet and at 30 feet by means of suction traps, and the

results of the past two years' work are now being studied; there is new evidence of a lunar periodicity of catches in the suction traps.

INSECT MIGRATION

(C. B. Williams and R. A. French)

The most important work during this year was the planning and carrying out of a short expedition to the Pyrenees in September and October to study the autumn southward movement of insects that had recently been observed in this area. C. B. Williams and R. A. French, with several voluntary assistants, took observations at various localities from the Mediterranean coast to over 9,000 feet in the Gavarnie area over a period of nearly six weeks, and southward movements of insects were seen on almost every fine day. The insects included about ten species of Lepidoptera and four species of Diptera (with others in smaller numbers), but very few dragonflies were seen. Among the Lepidoptera were large numbers of the small cabbage white (*Pieris rapae*) and the silver Y moth (*Plusia gamma*), both crop pests in Britain and Central Europe. Among the Diptera were two species of hoverflies (Syrphidae), one a well-known predator on Aphididae.

These results are of importance from the economic point of view, and also from the scientific angle, as they demonstrate the reality of the to-and-fro movement of great numbers of species and individuals of insects to the north in the spring and to the south in the autumn, much more resembling the migrations of birds than has been previously accepted.

We wish to acknowledge the receipt of a grant from the New York Zoological Society, which helped to defray the costs of this work.

EFFECTS OF POPULATION DENSITY ON INSECTS

(D. B. Long)

Further experiments have been carried out involving the effects of population density on lepidopterous larvae. The faster rate of development occurring in crowded cultures when compared with their solitary controls is of particular interest. Associations of as small a number as two larvae of *Plusia gamma* can result in a marked increase in the growth rate of the individuals. The egg-laying habits of the adults are of prime importance amongst the factors governing larval associations. Eggs which are laid in loose or tight clusters, such as those of *P. gamma* and *Pieris brassicae*, afford suitable conditions for subsequent larval association, and may be contrasted with eggs which are laid singly or in occasional pairs. The larval association of *P. brassicae* typifies one class of association in which the larvae form dense masses, whilst the larvae of *P. gamma* illustrate the other class, in which the larvae are more dispersed though still retaining a loose association.

A study has been made, both in the laboratory and in the field, of some of the factors responsible for the formation and maintenance of larval associations. The silk-spinning habit of the larvae of *P. brassicae* assists their aggregation, whilst strong gregarious tendencies result in the maintenance of the association

and the development of a mass feeding and resting rhythm. The presence of this rhythm in crowded cultures is probably largely responsible for the marked difference in the rates of development occurring between crowded and solitary cultures. The gregarious tendency is weakened by conditions of prolonged isolation.

The larvae of *P. gamma* are only slightly gregarious. Larval aggregation is built up and maintained by the reaction to larval proximity which induces feeding. This reaction appears to be more developed in crowded cultures. Under crowded conditions in the field the larvae show little tendency to disperse until the food plant is completely defoliated. It had previously been observed that a darkening of larval colour occurred in crowded cultures only, and it has now been found that this darkening is dependent on a sense of contact between larvae, and therefore also involves the question of larval proximity.

GALL MIDGES OF ECONOMIC IMPORTANCE

(H. F. Barnes, Barbara M. Stokes, K. K. Nayar and
G. W. Heath)

The twenty-seventh successive annual sampling of the wheat on Broadbalk showed that the numbers of larvae of the wheat blossom midges in 1953 remained at about the same level as in 1952, in spite of the fact that ten times as many *Sitodiplosis mosellana* emerged from the 1941-51 samples of larvae in 1953 as in 1952. However, the ratio of midges to parasites indicated that an increase may be expected in 1954.

A good start has been made to an investigation into the biology and host plant range of the *Mayetiola* species recorded as attacking the lower part of the stems of cereals and grasses. A species obtained from *Agropyron repens* has already been reared successfully on several different plants, including various species of *Triticum* and also on barley and rye. Tests are also in progress on the host plant range of *Mayetiola dactylidis*.

Improved techniques to ascertain the incidence of various grass-seed midges have also been evolved, while preparations have been made to carry out control experiments in the coming year at the Grassland Research Station, Hurley.

A successful start has been made in the study of the Lucerne Leaf Midge (*Jaapiella medicaginis*) by the development of a sampling technique to ascertain its prevalence in commercial stands of lucerne.

The biology of the black medick or "Trefoil" gall midge (*Dasyneura lupulinae*) has been worked out, and tests have been made to see if it would attack lucerne. These latter experiments gave negative results in every case.

It has been demonstrated by inter-mating and breeding experiments that the Shasta daisy midge (*Contarinia chrysanthemi*) is the same species as that which occurs on wild ox-eye daisy, and that it will breed on *Chrysanthemum carinatum* and *C. frutescens*. It has also been shown that the *Dasyneura* species recently discovered in wild ox-eye daisy flowers will breed on commercial Esther Read. The survey of the distribution of the gall midges of wild ox-eye daisy flowers has been extended to include those of cultivated

Chrysanthemum species, as well as those in the National Chrysanthemum Species Collection at Wisley and Dr. G. J. Dowrick's collection at Bayfordbury. In this way, in addition to obtaining further information regarding the distribution of the three previously found primary species, a fourth primary gall midge has been discovered.

Further tests have been carried out on the host-plant range among violets and pansies of the two species *Dasyneura affinis* and *D. violae*.

New gall midges have been described from the Jew's ear fungus (*Auricularia auricula-judae*) found in Buckinghamshire by Professor P. A. Buxton, and from lavender, the latter midge was reared in the south of France by Dr. R. Pussard and is closely related to the raspberry cane midge. Two other new gall midges have been described from *Coprosma* (Rubiaceae); they were reared by Mr. K. P. Lamb in New Zealand.

Among the numerous gall midges that have been received for identification, perhaps the most interesting ones have been several reared from Myxomycetes by Professor P. A. Buxton. The most important are undoubtedly the Sorghum Midge and other gall midges reared from various *Sorghum* species, *Panicum* and *Eleusine* in Uganda, Gambia and Nigeria. The possibility of carrying out biological studies on these midges at Rothamsted is being explored. The danger of these midges being transported in infested heads from country to country has been demonstrated by breeding midges during April-May and October-December from a single small head of guinea corn received from Gambia during the previous December.

APHID PROBLEMS

(C. G. Johnson, Bruce Johnson, Elsa Haine and L. R. Taylor)

It was shown last year that a principal factor determining fluctuations in numbers of aphids flying from hour to hour was the periodicity and rate of moulting of nymphs into alatae. Superimposed on this are flight behaviour changes. An analysis of both these factors, population and behaviour changes, is being made, both in the laboratory and in the field.

Dr. E. Haine is studying the factors which cause rhythmical changes in moulting and variation in length of the teneral period under laboratory conditions, with *Aphis fabae*, *Myzus persicae*, *Brevicoryne brassicae* and *Adelges* spp. She is also studying the take-off behaviour in wind. Contrary to accepted beliefs, it is found that aphids will, under certain conditions, take-off in wind well above their own flight-speed.

Mr. Bruce Johnson is working on the interaction of flight and reproduction and on the influence of flight on the behaviour of alatae *Aphis fabae*. Young, unflown alatae will not settle even on the most satisfactory host plants. After short flights the aphids undergo a behavioural change, and will settle and reproduce. The factors affecting the rate of birth of larvae by aphids which have flown is being studied. After the birth of a number of larvae the ability to fly is lost, and this is coincident with the autolysis of the flight muscles.

Dr. C. G. Johnson and Mr. L. R. Taylor continue the work on

dispersal of aphids at high altitudes and on the design and standardization of suction traps for this purpose. It has been necessary to construct extremely large and very powerful traps in order to sample adequately the low concentrations of aphids found at the higher altitudes.

These low concentrations are of great importance when studying the sequence of changes which occur throughout the day and night in the atmosphere and in the elucidation of factors responsible for the descent of aerial populations each day and their relation to weather.

THE NATURAL ENEMIES OF APHIDS

(C. J. Banks)

Field studies on the natural enemies of aphids were continued during 1953, and additional information on the abundance of various species of predators throughout the year was obtained for comparison with results of earlier years.

Methods of rearing hoverfly larvae (Syrphidae) were investigated in the spring.

Some of the causes of the high mortality in the field of ladybird larvae (Coccinellidae) have been investigated. Causes of mortality in 1952 included cannibalism and predation by birds, but a shortage of food (aphid prey) was not considered a satisfactory explanation. It was considered, however, that larvae might not reach a food supply if they should search in an inefficient manner.

Experiments in the laboratory and in the field suggest that ladybird larvae, having found a supply of the prey, remain close to it; but while they are capable of making a thorough search of their surroundings, they appear to be inefficient in finding the prey, and this is advanced tentatively as being a contributory cause of the high mortality of the early-stage larvae.

The behaviour of larvae newly-emerged from the eggs has an important influence on their survival, for some larvae manage to procure food by attacking unhatched eggs. Such larvae probably have an advantage over the others if they can live longer and search a greater area for food. Experiments show that newly-hatched larvae fed on one egg of their own species can live, on the average, almost twice as long as unfed larvae, and the lifetime is extended even more by the provision of two or three eggs. This work continues.

THE ECOLOGY OF THE HETEROPTERA

(T. R. E. Southwood)

Attention has been concentrated on the species commonly occurring in hedgerows and the marginal land around fields; for it is these sites that provide a reservoir of both the predatory and phytophagous species.

Weekly samples of adults and nymphs from a strip of waste ground in the centre of Great Field have provided detailed information on the life histories of twenty species from the families Lygaeidae, Nabidae, Anthocoridae and Miridae. Samples were also taken from the margin of pastures. A large part of this year's work has

been the identification and description of the various instars of the nymphs of these species. Dissections of the last instar nymphs have disclosed parasitism by the larva of a Euphorine; this was frequently of a fairly high order, for example, 48 per cent in *Stenotus binotatus* Jak. on 6th July from Pastures.

A study of the structure and water requirements of the eggs is being made; and in connection with this it has been found that the structure of the egg is of considerable importance in the higher classification of the Heteroptera.

THE WHEAT BULB FLY (*LEPTOHYLEMYIA COARCTATA* FALL.)

(Barbara M. Stokes, D. B. Long and F. Raw)

Preliminary work was started on breeding a stock of wheat bulb flies for an investigation into their host plants. Healthy flies were maintained on several different diets, including one which consisted of fresh wild flowers and water only, and oviposition continued throughout the summer.

The wheat bulb fly has been known to occur, though not severely, on Broadbalk for some years, particularly affecting the wheat in the first year after fallow. In preparation for an investigation of the larval populations of this pest a survey has been made of the adult flies in the fields in the Broadbalk area. In late June and early July both male and female flies were abundant on Broadbalk. Few males were found outside Broadbalk, and none was found anywhere after the third week in July. During July and early August, with one exception, the female fly was found on all the crops examined. Apart from Broadbalk, it appeared to be most numerous on potatoes and sugar beet.

In the laboratory eggs were successfully obtained from adults bred from pupae and fed on milk, honey, pollen and water.

Following this year's wheat bulb fly attack on Broadbalk, soil samples were taken during December from those sections of selected plots which were fallowed in 1953 and those which were four years after fallow. It is hoped that these samples will yield data on the extent of egg-laying and the oviposition preferences of the flies.

SOIL ARTHROPOD PROBLEMS

Agriculture (F. Raw, R. M. Dobson and J. W. Stephenson)

The study of wireworm populations on the Ley and Arable Experiment in Highfield and Fosters field has been continued. The plots were sampled in September 1952 and September 1953. When the 1953 samples have been examined the results to date will be written up.

During April and May a marking and recapture experiment was carried out on the Ley and Arable Experiment in Highfield to obtain data on the abundance of *Agriotes* adults and their range of movement. Sixty traps were laid out, each consisting of a depression in the ground filled with chopped vegetation from the plot. The traps were examined every other day, the beetles marked individually, and liberated within 1 yd. of the trap in which they were caught. Over 1,000 beetles were caught in this way, and about 20 per cent were recaptured, some up to four times, but the results

have not yet been fully analysed. It appeared that there were real differences in population on different plots, and that where there was a dense cover of vegetation the beetles did not move far.

The Geescroft experiment on the chemical control of wireworms, carried out in collaboration with Insecticides Department, was continued to test the residual effect of treatments applied in the autumn 1951. Wheat was again used as a test crop, and as there had been no appreciable wireworm damage in 1952 the seeding rate was reduced to $2\frac{1}{4}$ bushels/acre to increase the effect of wireworm damage. Plant counts made in the spring showed little effect of wireworm feeding, but damage developed later, and was assessed by visual inspection. At harvest the yields of grain from the aldrin, chlordane, BHC and DDT plots were significantly greater than those from the BHC seed dressing and control plots. Wireworm counts made after harvest showed population differences which corresponded to the differences in crop yield.

1953 results

Treatment :	O	S	G	A	C	D
Yield of grain, cwt./acre ..	21.6	22.9	30.2	34.6	32.9	26.7
Wireworms per sq. ft. ..	11.9	10.0	3.9	1.0	2.9	3.3

O = untreated

S = BHC seed dressing at 2 oz. of the dressing/bushel

G = 3.5% BHC dust combine drilled with seed at 56 lb./acre

A = Aldrin combine drilled with seed at 200 lb./acre

C = Chlordane combine drilled with seed at 100 lb./acre

D = DDT combine drilled with seed at 150 lb./acre

A more detailed account of the yields obtained is given in the report of the Insecticides Department.

A study of the biology of the snake spotted millipede, *Blaniulus guttulatus*, by J. W. Stephenson has continued, but has been handicapped by the difficulty of obtaining material and of finding the apparently critical conditions for reproduction.

Experiments have shown that grassland species of millipedes prefer decomposing vegetation to fresh material, as do forest species. The palatability of a particular grass may be different for different species, and different grasses may differ considerably in palatability for the same millipede, e.g., *Alopecurus pratensis* is about twenty times more palatable to *Cylindroiulus londinensis* than is *Poa annua*.

Forestry (P. W. Murphy)

Dr. Murphy is at present engaged in analysing and collating the data obtained in an investigation of the meio- or meso-fauna of a heathland habitat in the Allerston Forest area, North-east Yorkshire. The main project has been a soil faunal survey of natural and afforested heathland. The fauna were extracted with a split-funnel extractor, a modified Berlese funnel. The sampling method consisted in taking blocks from heathland and forest sites, and cutting cores which were placed in the funnels, in an undisturbed condition. In a previous report reference has been made to experiments to test the efficiency of the extraction method. It is hoped to publish the results of this investigation in the near future.

A total of fifty-three species of Acarina have been recorded from natural heathland and forest plantings in the Allerston area. This total includes two new species, two new British records of genera (*Mycrotydeus* and *Eupalopsis*) and five new specific records. In the natural and undisturbed heathland the most common and abundant species are *Nanorchestes arboriger* Berl. (Endeostigmata), a small, active, saltatorial mite, *Carabodes minusculus* Berl., *Tectocephus velatus* (Mich.) and *Chamobates* sp. (Oribatoidea). When compared with other habitats, the most striking feature is the small size of the heathland species. It is noticeable, too, that the Trombidiformes are frequently more numerous than in other situations.

The most important pedological attributes influencing the fauna in raw humus appear to be pore space and water content. Although the pore volume of the raw humus layer is usually in the region of 75 per cent of the total volume, much of it is either too small for the fauna or is occupied by water, and thus denied to these aerophilous creatures. The apparent density or volume weight of the raw humus milieu, that is, the ratio between the dry weight of a given volume of undisturbed soil and the weight of an equal volume of water, is a useful indication of the pore space available. Table 1

TABLE 1

Apparent densities, moisture contents and populations of Acarina and Collembola occurring in raw humus in natural, undisturbed heathland (litter excluded)

Depth (inches)	Numbers Acarina and Collembola		Apparent density (g./c.c.)	Moisture content, % of fresh volume	Moisture content, % of fresh weight
	Numbers	%			
0- $\frac{3}{8}$	460	82.1	0.19	45.4	70.9
$\frac{3}{8}$ - $\frac{7}{8}$	65	11.6	0.28	61.0	68.8
$\frac{7}{8}$ -1	16	2.9	0.45	76.1	62.7
1-1 $\frac{1}{16}$	13	2.3	0.45	44.2	49.5
1 $\frac{1}{16}$ -2 $\frac{1}{16}$	6	1.1	0.86	51.3	37.4

Note: These apparent densities are calculated on the basis of extraction dried weights, and are therefore somewhat higher than the values obtained from oven dry weights.

gives the apparent densities of the raw humus covering, and it will be seen that the ratio increases as one proceeds down the profile. In animal ecological studies moisture contents are usually expressed on a weight basis, but it is obvious that the apparent density gradient will affect these values and give a false impression of the water regime. Expression of water content on a volume basis overcomes this difficulty and indicates that the pore space in part of the raw humus layer is almost completely occupied by water. The larger populations occupying a greater volume of the drier raw humus resulting from "cultivation" and the presence of trees is additional evidence that water is an active competitor for living space.

From this study it is concluded that the meiofauna of the natural, undisturbed heathland is composed of large populations with a relatively small number of small species, which are confined to a narrow surface and subsurface zone of the raw humus. There

seems reasonable evidence for stating that water content, lack of suitable food material and perhaps lack of oxygen form effective barriers to any expansion of the faunistic structure or the appearance of larger species in this biome. These findings cast doubt on some of the pedological theories concerning the mechanism of development and maintenance of mor raw humus formations.