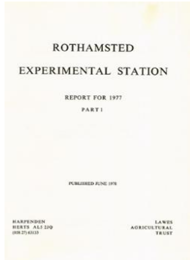
Report for 1977 - Part 1

Full Table of Content


ROTHAMSTED

EXPERIMENTAL STATION

REPORT FOR 1977

PART 1

Entomology Department

T. Lewis

T. Lewis (1978) *Entomology Department ;* Report For 1977 - Part 1, pp 89 - 112 **- DOI: https://doi.org/10.23637/ERADOC-1-134**

ENTOMOLOGY DEPARTMENT

T. LEWIS

Staff

Head of Department T. Lewis, PH.D.

Senior Principal Scientific Officer
L. Bailey, SC.D.

Principal Scientific Officers
R. Bardner, B.SC.
J. Bowden, PH.D.
G. J. W. Dean, PH.D.
C. A. Edwards, PH.D.
J. B. Free, D.SC.
R. A. French, J.P., B.SC.
J. Simpson, PH.D.
L. R. Taylor, D.SC.
J. R. G. Turner, D.PHIL.

Senior Scientific Officers
I. F. Henderson, PH.D.
J. R. Lofty
E. D. M. Macaulay, B.SC.
J. W. Stephenson, M.SC.
C. Wall, PH.D.
N. Wilding, PH.D.

Higher Scientific Officers
Mrs. Janice B. Cole, B.SC.
A. M. Dewar, PH.D.
K. E. Fletcher, PH.D.
Mrs. Joan Nicklen
P. L. Sherlock, PH.D.
R. A. Welch
Mrs. Ingrid H. Williams, PH.D.
I. P. Woiwod, B.SC.

Scientific Officers
Brenda V. Ball, B.SC.
Mrs. Susan K. Best
Patricia J. Brobyn, B.SC.
Maureen J. Dupuch
A. W. Ferguson, B.A.
Barbara A. Jones
H. Loxdale, B.SC.
Dolores M. Sturgeon, M.SC.
P. W. Tomkins
A. E. Whiting

Assistant Scientific Officers
J. Ashby
J. E. Bater
M. P. Bentley
C. P. Brookes
Mrs. Janice L. Browning
J. L. Doran
D. G. Garthwaite
Barbara Goult
R. P. Hadley
Carole A. Horne
P. D. J. Hugo
Susan M. Jones
J. I. Laband
A. P. Martin
R. Moore
Theresa Onufryk
Mrs. Susan J. Parker
Alison M. Pickard
Adrienne K. Smith

Temporary Workers
Mrs. Wendy E. R. Barrow, B.SC.
D. D. Burke, B.SC.
Anne L. Cameron, B.SC.

Secretary
Mrs. Brenda I. Cox

Clerical and other staff
Mrs. Marjorie Bellingham
Mrs. Valerie Humphreys
Mrs. Patricia Roberts
S. A. Wright

Introduction

The most significant event for the Department during the year was the long-awaited move to the new Daniel Hall Building in June. This has allowed the complete integration of staff working on many biological and ecological aspects of insect pests and beneficial insects, including bees, and as well as providing better accommodation, the easier interchange of ideas and equipment should further stimulate productive research.

The opening ceremony was performed by the Hon. J. J. Astor, MBE, DL, JP, Chairman of the ARC in the presence of guests representing the Lawes Trust, the Architects, Contractors and Builders, and the local planning authority. It was a pleasure to welcome two former Heads of the Entomology Department, Dr C. G. Butler, OBE, FRS, and Dr C. G. Johnson, OBE, especially as the latter's superb murals depicting the history of entomology at Rothamsted grace the entrance hall of the new building.

https://doi.org/10.23637/ERADOC-1-134

Inevitably, the year has been one of transition and re-organisation. Much established long-term work has continued, but several new lines have been started, including work on the genetics of aphid resistance to insecticides, on the evaluation of honeybee pheromones for improving pollination, and on cutworm biology. One highly productive long-term project, the Rothamsted Insect Survey (RIS) was fittingly acknowledged with the award to L. R. Taylor of the Royal Agricultural Society's Research Medal for 1977. During the year the first full season of work on the North Farm cereal eco-system project in Sussex was completed, and this will form the basis of a more detailed programme in 1978.

There has been an increasing involvement with research bodies in Europe. Several senior staff have attended and organised meetings on the Continent concerned with pest forecasting, integrated control and soil animals. The Entomology Department combined with the Insecticides and Fungicides Department to host a very successful meeting of the International Organisation for Biological Control (IOBC)/WPRS Working Party on Insect Pheromones attended by 48 delegates from ten countries. As a result of these contacts, combined research between Rothamsted and many Continental groups is either under way or planned for 1978, including an extension of the methods of the RIS into more countries together with experiments on pheromone trapping, control of pests in sugar beet and field beans, and the effects of pesticides on soil animals. This outward-looking approach will certainly be to the advantage of Rothamsted's work providing that it continues to be sustained by basic research within the Department.

The involvement of staff in tropical and semi-tropical problems in applied entomology continued with no fewer than six advisory visits made by staff to 11 countries.

Entomologically, the year was not as exceptional as the previous one. Generally, aphid occurrence was delayed, though when they eventually did appear most important species were more abundant than usual. The many ladybirds that overwintered successfully apparently had little impact on the early aphid populations, but large numbers of hover flies, mainly of one species, were abundant in the south, earning 1977 the distinction of being a 'syrphid' rather than a 'coccinellid' year. The wet weather greatly decreased cutworm populations, and a quick change from hot, dry to cooler, wet weather in July produced interesting effects on bean aphid populations artificially infected with pathogenic fungi. Another effect of the weather was to ensure the best supply of slugs for experimental work for several seasons.

Thus, after a year in which re-housing and re-equipping the Department have received considerable attention, we stand poised to reap the fruits of past effort and forge ahead on new lines over the next few years.

Pest detection and surveying

The routine sampling of aerial populations with suction and light traps continued, and the experimental aspects of this work developed as the sequence of annual records gradually accumulate. For aphids, especially, considerable effort was put into interpreting changes in aerial density in terms of crop infestation, and into exploring ways of using the suction trap system for forecasting aphid abundance.

Aphid surveying

Aphid occurrence. The cold, wet spring and summer delayed migration; few individuals were caught before the end of May, and for most species the summer migration was about a month late. Numbers did not decrease as much as expected in August and September, and the autumn migration, encouraged by some mild dry weather, was larger

https://doi.org/10.23637/ERADOC-1-134

than for the last 3 years (Appendix Tables 1 and 2, pp. 108 and 109 and *Rothamsted Report for 1977*, Part 2, 79–112.

The peach-potato aphid (*Myzus persicae*) arrived late everywhere, especially in the Midlands and North, and numbers continued to increase until the beginning of August; catches were above average in the South-West, but other areas had less than half the usual total.

The potato aphid (*Macrosiphum euphorbiae*) was early in the South-West but late elsewhere; numbers were greater than average in the South-East, and very much greater in the South-West especially at Rosewarne in the beginning of July.

The rose-grain aphid (*Metopolophium dirhodum*) was very late everywhere, particularly in the Midlands and North. It was abundant in the South-West, especially at Starcross, and about normal in the South-East, but rare elsewhere.

The grain aphid (*Sitobion avenae*) was late in all areas, and reached a peak in mid-July in East Anglia, the end of July in the Midlands and South-East, and mid-August in the South-West and North. Numbers were above average in the South-West, but there were fewer than normal elsewhere.

Rhopalosiphum spp. were more common this year than last. The bird-cherry aphid (*R. padi*) was late everywhere, but abundant with twice the usual numbers in the South-East and Midlands. The oat-apple aphid (*R. insertum*) was early in the North; numbers were greater than average in the South-East and Midlands. *R. maidis* was early and more common than usual, except in the North.

The rosy-apple aphid (*Dysaphis plantaginea*) was the only other species which arrived consistently early in 1977. *Myzus ornatus*, *M. ascalonicus*, *M. certus*, *Aulacorthum solani*, *Brevicoryne brassicae* and *Metopolophium festucae* were very late with extremely small numbers. The hop aphid (*Phorodon humuli*) was late, but abundant, especially in the South-East.

The black-bean aphid (*Aphis fabae*) occurred in above average numbers in the South-West and the South-East though the North had few. It was late everywhere, especially in the Midlands and North. The autumn migration in the South was slightly larger than last year, but still comparatively small. (Taylor, R. A. French, Woiwod and Cole)

Forecasting aphids. The number and time of arrival of migrant *Myzus persicae*, the main vector of aphid-borne virus diseases in potatoes, varies greatly from year to year. Work on developing a virus warning system has followed two main lines: standardising suction trap catches against the crop infestation, and investigating the overwintering survival of anholocyclic aphids.

Numbers of alate *M. persicae* on the crop rose and fell with changes in the aerial population as monitored by the suction traps, suggesting that in this species there is frequent exchange between the crop and aerial populations. However, the numerical relationship between the two is not constant throughout the season since the changing physiological condition of the host plants affects aphid landing behaviour and host plant selection. The young potato crop is a favourable environment for aphids so perhaps they accumulate there, in which case catches in the suction traps may underestimate populations early in the season.

Mapping of the three seasonal migrations of *M. persicae* throughout Great Britain has shown that the summer migration is largely confined to the potato and beet growing areas. In contrast, the autumn migration is geographically random, with a fairly uniform distribution, whilst the spring migration is restricted to the South East. The great overwintering mortality in most areas may be due to moisture on the plant hosts in the West and mortality of the frost-susceptible hosts in the North. The high overwintering survival in the London basin, including the Chilterns, could explain why the virus yellows forecast

https://doi.org/10.23637/ERADOC-1-134

of Watson, Heathcote and others has usually been most effective when based on Rothamsted weather, rather than that of the cropping areas.

Mrs Lindsay A. D. Turl of the Department of Agriculture and Fisheries, Scotland (DAFS), East Craigs, in collaboration with RIS, has been investigating the importance of early spring temperatures in the timing of migration of holocyclic aphids, as measured by the RIS traps in Scotland. There is now a prospect for forecasting spring migration times of *Myzus persicae*, *Macrosiphum euphorbiae*, *Aulocorthum solani*, *Sitobion avenae*, *S. fragariae*, *Metopolophium dirhodum*, *M. festucae*, *Rhopalosiphum padi* and *R. insertum* in Scotland with varying degrees of accuracy. These forecasts will eventually provide a means of investigating the factors that cause erratic deviations from expectation in some years.

Winter mortality in aphid populations affects the size of infestations on crops in spring and early summer. For this reason the survival of viviparously overwintering *Myzus persicae* was investigated on plots of sugar beet, winter oilseed rape, chickweed and groundsel. The plots were protected from rain or from frost by field cages, or were left unprotected. The plants were artificially infested with aphids and left undisturbed during the winter until March, when they were thoroughly searched for aphids. Large numbers of aphids survived on chickweed, mostly on protected plots but very few were recovered from frost-protected groundsel, only one from frost-protected sugar beet, and none from oilseed rape. The success of chickweed as an overwintering host plant is attributed to the shelter provided in the dense mat formed by this plant.

In a joint project with Mr C. I. Carter of the Forestry Commission Research Station, the migration of the green spruce aphid (*Elatobium abietinum*), as measured by the RIS traps, has been shown to persist longer at higher latitudes and the median date for migration can now be forecast with some accuracy by accumulating day-degree values over 8°C from 1 January up to a total of 115 day-degrees.

In collaboration with Professor M. J. Way and Mr. M. E. Cammell of Imperial College, the prospects for forecasting the likelihood of *Aphis fabae* reaching pest proportions on beans is also being investigated. Since 1970, forecasts have been based on the number of aphids collected from spindle trees and spraying dates recommended accordingly. It now appears likely that the RIS aerial samples can also be used to forecast the need to control.

The separation of migrations is a preliminary stage in many analyses concerning aphid forecasting. Often there is considerable overlap between the migrations, making manual separation time-consuming and often inaccurate. In collaboration with K. E. Bicknell of the Computer Department, programs have been developed to automate the process. The programs fit Gaussian curves to suction trap records enabling estimates to be made of the size and timing of migrations. (Taylor, R. A. French, Woiwod, Cole, Cameron and Nicklen)

Cereal aphids. The main effort on cereal aphids was made for the first time at the North Farm site in Sussex.

Two suction traps were installed and operated continuously at 12·2 m and 1·2 m from April 1977 at a site on the Farm. Catches from the tower trap were listed in the *Rothamsted Aphid Bulletin*.

In addition, populations of cereal aphids on North Farm were sampled weekly in 11 cereal fields (six wheat, two barley and three oats) using a D-vac suction sampler and by taking plant samples, and the results compared with the number of cereal aphids caught in the 12·2 m suction trap.

Cereal aphid populations in the surrounding fields were slow to build up, and all early indications suggested that infestations would be small. However, a hot weekend at the

https://doi.org/10.23637/ERADOC-1-134

end of June caused populations to increase rapidly and to such an extent that substantial yield losses had occurred before spraying could be completed.

There were significant correlations between the total number of *Sitobion avenae* caught in the D-vac and the 12·2 m trap indicating that the aerial catch was a useful indicator of populations on the crop.

Differences between crops were apparent, wheat being by far the most heavily infested as populations reached an average of over 50 per ear, before spraying. Neither barley nor oats supported these 'epidemic' populations possibly due to the morphology of the plants. Wheat ears offer aphids ample protection from inclement weather, whereas the smoother ears of barley and exposed ears of oats, together with their more flexible tillers, afford less protection when the weather is bad.

At Rothamsted, *Sitobion avenae* was first noticed on winter wheat and spring barley at the very end of May and populations of this species and *Metopolophium dirhodum* increased very slowly until the first week in July. Thereafter, numbers increased rapidly to a peak in mid-July. Coccinellid and syrphid predators were common by the end of the month, but parasitism was rare (<1%). (Dewar, M. Jones and Dean)

Syrphid abundance. An interesting quantitative assessment of syrphid populations was obtained from the suction trap catches, which, contrary to press reports, showed that the summer was not exceptional for syrphids in general, but only for *Epistrophe balteatus*.

Over 3000 Syrphidae were caught in Survey traps at 12·2 m and another 1400 in the 1·4 m trap at Rothamsted.

The most abundant species was *Metasyrphus corollae* which comprised nearly 60% of the catch in Survey traps and 50% in the low-level trap. Maximum catches usually occurred during the first 2 weeks of August, but at Rosewarne, Starcross and North Farm they were slightly earlier. No trap north of Rothamsted caught substantial numbers (data for Aberystwyth are not available) except Hereford which caught the most, including 995 *M. corollae*.

The Survey data reveal a situation strikingly different from that obtained by general observation; neither the high- nor the low-level catches reflected the phenomenal abundance of *E. balteatus*. The probable explanation for this lies in the different profiles of vertical distribution for each species. *M. corollae* is the species trapped most frequently and in largest numbers in all traps and at all heights, but its dominance is accentuated in high-level traps because it has the flattest height profile of any common species. The Hereford trap caught 40% more than the Rothamsted low-level trap; the Starcross, Silwood and Rothamsted tower traps caught 70, 60 and 40%, respectively, of the low-level catch. For *E. balteatus*, comparable figures are 80, 3, 70 and 20%, suggesting a steeper profile than that of *M. corollae*. By contrast, 182 *Syrphus vitripennis* were taken at low level, only six in all other traps; 126 *Scaeva pyrastri* at low level, 28 in all others, and *Syrphus ribesii* and *Sphaerophoria scripta* only at low level. A few aphidophagous species are trapped consistently, particularly in southern England; the dominant species in this group again being *M. corollae*. These aphidophagous species are caught in the same weeks—Rothamsted Standard Weeks 31 and 32—every year irrespective of trapping method or locality. (Bowden)

Tipulid phenology. Catches of adult *Tipula paludosa* in two light traps at Rothamsted totalled 1338 in 1977 compared with 1117 in 1976 and 1384 in 1975. First adults appeared in traps in late June and peak populations occurred in mid-September, earlier than the peak in 1976 which was delayed by the hot dry summer. This also severely affected those species whose adults emerge and oviposit in late spring and early summer. Fewer adults of *Nephrotoma* spp. and *Tipula oleracea* and *T. scripta* were trapped than in any year

https://doi.org/10.23637/ERADOC-1-134

since 1970, whereas late summer or autumn species such as *T. paludosa*, *T. marmorata*, *T. obsoleta* and *T. pagana* were as, or more, numerous than in previous years. (Bowden)

Pheromonal monitoring of moths

Monitoring and spray trials for pea moth. The experimental monitoring system initiated in 1976 (*Rothamsted Report for 1975*, Part 1, 126) was continued and extended. In contrast with 1976, moths appeared in traps much later than usual and larvae were found in crops well into August. A modified spray trial design was used and this produced promising results despite a low infestation in the controls. Experiments aimed at producing a long lasting and reliable attractant for monitoring were continued; (E)-10-dodecenyl acetate at a dose of 1000 μg on rubber (*Rothamsted Report for 1975*, Part 1, 125) proved successful in the monitoring scheme and was also shown to be active after 3 months' field exposure, with or without the addition of antioxidants. (Macaulay and Wall, with Greenway, Insecticides and Fungicides Department)

Pheromone trap spacing. The range of attraction of pheromone traps should be considered in the planning of experimental work involving their use; failure to do so could result in interference between inadequately spaced traps.

A series of trapping experiments for the pea moth was completed during the 1977 flight season. Catches in solitary traps were compared with those in traps surrounded by similar traps at different spacings. Triangular traps containing 100 μg of (E,E)-8, 10-dodecadienyl acetate (*Rothamsted Report for 1975*, Part 1, 123–124) were used at an emergence site (wheat after peas). The results showed conclusively that these traps can mutually interfere even when spaced at 100 m; traps flanked by two others at this spacing caught 20–30% fewer moths than solitary traps, whether the line of traps was along or across the mean wind direction. In lines of traps along the wind the upwind trap always caught significantly more moths than the other traps. It is clear that the range of attraction of these traps is at least 100 m, though wind speed may affect this. (Wall, with Perry, Statistics Department)

Pest economics. This year the economics of pea moth monitoring and control have been examined. It was concluded that the widespread use of pheromone traps to assist the timing of insecticide sprays was likely to decrease the present average losses by about 25% and increase profits by about 3–10%. There would also be a big decrease in the number of crops with very severe damage, and some saving of spray costs in districts where infestations were shown to be absent. (Bardner)

Pest populations and damage assessment

Work on this broad topic covered pollen beetles and seed weevils on oilseed rape, pea and bean weevils on field beans, cutworms on potatoes and a preliminary investigation of the pest complex on clover.

Pests of oilseed rape. Four years' data on oilseed rape pests has now been analysed to produce a realistic assessment of their importance to this rapidly expanding crop.

A total of ten crops of winter rape and two crops of spring rape were sampled for insect pests and pest damage once or twice a week from green bud stage to just before harvest. The most common pests were pollen beetle (*Meligethes aeneus*) and seed weevil (*Ceuthorhynchus assimilis*); the former was usually the more numerous, especially on spring rape crops. Stem weevil (*C. quadridens*) and pod midge (*Dasyneura brassica*) were less abundant. *C. assimilis* and *M. aeneus* immigrated to winter rape crops when tem-

https://doi.org/10.23637/ERADOC-1-134

peratures exceeded 15°C. Because of yearly variations in temperature, maximum infestation of *M. aeneus* occurred either at green bud stage, when flowering began, or at full flower; maximum infestation of *C. assimilis* occurred during flowering, from mid- to late May. Immigration to spring rape usually occurred at green bud stage.

The two methods used for sampling pests, sweep nets and water traps, gave different results. Water trap collections primarily reflected pest flight, and were not necessarily related to the pest population of the crop.

During immigration, the adults of all pests infested crop edges more than crop centres, particularly in large fields, irrespective of the presence of wind breaks. Early in the season there were relatively more adult *M. aeneus* and *C. assimilis* at the crop edge than in the crop; larvae were more evenly distributed over fields than adults.

Attack by *M. aeneus* was not the only cause of podless stalks but in winter rape crops there were correlations between the percentage of podless stalks per plant and the number of *M. aeneus* present. Similar correlation occurred between the percentage of pods infested with larvae and adults of *C. assimilis*. In two fields infested with *D. brassicae* both adults and split pods decreased progressively from the crop edge to the centre. The larvae of *D. brassicae* were largely confined to the edges of crops.

On both winter and spring rape numbers of *M. aeneus* declined during flowering and likewise *C. assimilis* declined while pods were maturing. Their decline on winter rape was associated with emigration to new host plants. New generation *M. aeneus* emerged before winter and spring rape were harvested, and new generation *C. assimilis* emerged before spring rape but not winter rape were harvested.

Plants were capable of much compensation; only those with more than 60% podless stalks or from which 60% of the buds had been removed, yielded less.

Late removal of buds or pods sometimes caused greater yield loss than early removal, and late pod removal resulted in more immature pods at harvest. However, most pollen beetle injury occurs before flowering when adults feed and lay in the buds, thus plants can compensate for damage caused at this early stage. By contrast, seed weevils prefer to lay their eggs in pods of medium length and because injury increases as the larvae grow, compensation for late seed weevil injury may result in immature pods at harvest, making control desirable. (Free and Williams)

Pea and bean weevils on field beans. Infestations were studied on both winter and spring bean crops. Although overwintering adults of *Sitona lineatus* have previously been obtained from the soil of Rothamsted arable fields, none were found at the site of the experiments. In the early spring, adults were feeding on vetch at the uncultivated edges of the field, before the late-sown and backward winter beans had completely emerged. Typical feeding notches on the leaves of bean plants were first seen near the vetch, and subsequent sampling showed that infestations were slow in reaching the centre of the field.

The contrast between the hot dry summer of 1976 and the cool wet summer of 1977 was reflected in the infestations of bean crops. In 1976, egg laying had finished by 11 June, whereas eggs were still being laid on 7 July in 1977. Likewise, larval populations reached their peak on 1 June in 1976, but not until 11 July in 1977. The numbers of larvae rose and fell in rough synchrony with the development and senescence of the root nodules in both winter and spring beans, and both crops also had similar numbers of late-instar larvae and pupae at the end of the attack, namely 2·35 per root for winter beans and 2·65 per root for spring beans. Despite this, the total weight of nodules on winter beans was about twice that on spring beans.

Although larval populations were considerably less than the maximum of 13 larvae per root in the previous year, mortality in the late larval and pupal stages was much less

https://doi.org/10.23637/ERADOC-1-134

in 1977 so the population of adults emerging in the late summer was similar in both years.

Samples of roots were obtained in late July from ten sites in the main bean-growing areas of Essex and Suffolk. Although this was too late to determine maximum larval numbers, extensive signs of injury were found on all samples, a mean of 48% of root nodules being damaged (maximum 75%, minimum 28%). These results, together with the control experiments reported last year, confirm the view that infestations of *Sitona* larvae are widespread and are causing significant but largely unrecognised losses in the yields of field beans. (Bardner, Fletcher and Grubb)

Cutworms. The renewed interest in cutworms in the Department following the large infestations in 1975 and 1976 has already produced useful background data for the proposed long-term study (*Rothamsted Report for 1976*, Part 1, 120).

Adults caught in the four light traps at Rothamsted have, for the first time, been segregated into sexes, and all females dissected. The four species of main interest, *Agrotis segetum*, *A. exclamationis*, *Euxoa nigricans* and *Noctua pronuba*, were all less common in 1977 than 1976; half as many *A. segetum* amd *N. pronuba* were caught and only one-sixth as many *A. exclamationis* and *E. nigricans*. Sex ratios were strongly biased towards males, especially *N. pronuba*. (Table 1). However, both sexes were almost equally re-

TABLE 1

Sex ratios of noctuid moths in light traps at Rothamsted

Species	Sex ratio, ♂ : ♀
Agrotis segetum	1 : 0·39
Agrotis exclamationis	1 : 0·11
Euxoa nigricans	1 : 0·40
Noctua pronuba	1 : 0·04

presented in the earliest catches; dissection showed early females to be immature, while the few caught later were all ovipositing individuals, suggesting that mature females seeking oviposition sites are less likely to be caught in light traps. This inference is supported by catches of *Plusia gamma*, which also showed a sex ratio near unity and in which every female caught was unfertilised and immature.

Many larvae were received from widespread localities in early 1977. *Noctua pronuba* was as frequent as *Agrotis segetum*. Larvae of all five species recorded resumed normal activity within a few hours of exposure to room temperature (15 °–20 °C), suggesting that interruption of development in winter is a temperature-controlled hibernation, not obligatory diapause.

Some fields of potatoes at Rothamsted unharvested in autumn 1976 were sampled in January and February 1977 and one, formerly Allotments, which in February had an average of ten larvae of *Agrotis segetum* per 3 m of row length, was monitored until June, when the population had pupated and declined to 2 per 3 m. The June sample also showed 1·2 larvae of *Euxoa nigricans* per 3 m. To encourage establishment of a population of *A. segetum*, the potatoes on ex-Allotments were left to crop in 1977, but sampling showed only 2·8 larvae per 3 m in September declining to 0·5 in October, when a small population of *N. pronuba* was also present. There was no damage to a very small crop.

The sampling system adopted as standard was to dig out to a depth of about 30 cm and hand sift ten lengths of row each 3 m long, alternating north-east to south-west and north-west to south-east diagonals at successive samplings. In April the row sample method was compared with core samples; 10 × 10 cm cores bracketing each of 10 × 3 m row samples, a total of 100 cores, were taken. Forty larvae were recovered from row samples, six from cores. These recoveries are equivalent to about 25 000 and 9000 larvae

https://doi.org/10.23637/ERADOC-1-134

ha^{-1} respectively. Another comparison made with row-sampling, by following tractors at harvest on ex-Allotments and Great Harpenden and collecting exposed larvae, suggests that row-samples give a fair estimate of numbers. On both fields, samples immediately prior to harvest showed low numbers, confirmed by the small number of larvae recovered at harvest.

An attempt was made to establish a population of *A. segetum* on potatoes on part of Great Harpenden. Eggs, first/second and fourth instar larvae were introduced in August and the area sampled in the first week of October. Only three larvae were found in 25 3-m lengths. The probable causes of failure are that eggs and young larvae were introduced only just before the beginning of a very wet, cool spell when the crop was too mature for them to establish. (Bowden and Sherlock)

Clover pests. Although clover is important for grassland productivity, near Rothamsted it was infested by few insect pests in 1977. Slight damage to the leaves was caused by weevils; *Apion* spp. on mature white clover in mid-July (4·1%) and *Sitona* spp. on seedlings by early August (2·9%). Very few weevil larvae were found in the root nodules, or midge larvae in the seeds and leaves, while aphids (*Acyrthosiphum pisum*) and leaf-eating caterpillars (*Cnephasia interrectana*) were also very scattered. Hymenopterous parasites of aphids and *C. interrectana* were common, whereas their hyperparasites were not, and predators (mainly *Coccinella 7-punctata*, *Propylea 14-punctata*, Staphylinidae) were often seen. No nematodes (Greet, Nematology Department) or viruses (Plumb, Plant Pathology Department) were detected. (Dean)

Pesticide use

Work continued on the short-term control of pests with insecticides and on the long-term effects of pesticides and their residues on grassland productivity and the soil fauna.

Control of pea and bean weevils. Various non-systemic insecticides were compared for possible future use in the 'Factors affecting bean yield' multidisciplinary experiment (see Field Experiments Section, p. 124), for which fonofos at 4·48 kg a.i. ha^{-1} is at present the standard treatment. Insecticides used were: carbophenothion, chlormephos, diazinon, HCH, methiocarb, triazophos and fonofos as a standard, all applied to the soil at 2·24 and 4·48 kg a.i. ha^{-1} and cultivated in immediately before sowing. The smallest larval populations were on the plots treated with fonofos, though chlormephos and triazophos also gave good results. (Table 2).

TABLE 2

Number of pea and bean weevil larvae per root with different insecticide treatments, 5 July 1977

	kg a.i. ha^{-1}		
Insecticide	2·24		4·48
Carbophenothion	3·63		6·38
Chlormephos	3·75		0·50
Diazinon	5·50		4·13
Fonofos	1·50		0·13
HCH	4·63		7·13
Methiocarb	2·25		2·88
Untreated		5·31	
SED between treatments		1·69	
between control and treatment		1·46	

https://doi.org/10.23637/ERADOC-1-134

In another experiment, systemic insecticides were used at low doses to try to develop an economic control method for *Sitona* larvae, using insecticides applied to the drill furrow or the seed. Phorate, aldicarb, oxamyl and carbofuran were used as furrow treatments at 2·24 kg a.i. ha^{-1}, and phorate and oxamyl were also applied as seed treatments at 0·75 and 0·25 kg ha^{-1}. (Table 3). Oxamyl was disappointing, but all other treatments decreased larval numbers by 60–99%, and also decreased notching of the

TABLE 3

Insecticides tested for control of Sitona *larvae*

		Number of larvae per root 5 July 1977
Aldicarb	Furrow treatment 2·24 kg a.i. ha^{-1}	2·0
Carbophenothion	Furrow treatment 2·24 kg a.i. ha^{-1}	0·3
Oxamyl	Furrow treatment 2·24 kg a.i. ha^{-1}	3·4
Phorate	Furrow treatment 2·24 kg a.i. ha^{-1}	0·1
Oxamyl	Seed treatment, 0·25 kg a.i. ha^{-1}	3·9
Oxamyl	Seed treatment, 0·75 kg a.i. ha^{-1}	3·6
Phorate	Seed treatment, 0·25 kg a.i. ha^{-1}	1·0
Phorate	Seed treatment, 0·75 kg a.i. ha^{-1}	0·3
Untreated		5·7
SED	Between treatments	1·76
	Between treatments and untreated	1·52

leaves by adults. However, in the 'Factors affecting bean yields' experiment, two sprays of permethrin at 150 g a.i. ha^{-1}, applied to control *Apion* adults, unexpectedly gave excellent control of *Sitona* larvae (see Field Experiments Section) and the merits of this compared with seed or soil treatments will need further investigation. Yields are not yet analysed. (Bardner and Fletcher, with Griffiths, Insecticides and Fungicides Department)

Pests of grassland and forage crops. The investigations into the effects of insects on grassland productivity continued in close collaboration with the Grassland Research Institute, Hurley, with investigations at both Institutes, and at field sites elsewhere in England and Wales.

The experiment to examine the consequences of long-term suppression of soil and foliage invertebrates in a perennial ryegrass sward (*Rothamsted Report for 1969*, Part 1, 231) has now completed its ninth year. Accumulation of surface litter and compaction of the soil are now pronounced on treated plots, so that although they outyielded the untreated plots at two of the five harvests, their total annual dry matter (DM) output for the first time was not significantly different from that of the controls.

The series of field experiments on upland pastures (enclosed hill grazing around the 300 m level) was ended after 3 years (*Rothamsted Report for 1975*, Part 1, 126). Sampling in mixed-composition swards at ten localities in Wales, and the Pennines as far North as Cumbria, revealed generally lower population densities of most grassland insects than on lowland sites, and yield responses to insecticide treatment were smaller and more variable.

The most pronounced improvements in sward performance in response to insect control have been recorded in experiments with ryegrass, especially Italian ryegrass. Control of dipterous stemboring larvae (mainly *Oscinella* spp.) resulted in large increases in annual yield, improved persistence of the sown species and consequent reduction in the rate of weed invasion. Further work using 23 current varieties of Italian and hybrid ryegrass has shown pronounced varietal differences in susceptibility to pest damage: work continues on plant resistance as a method of minimising the deleterious effects of insects on sward performance.

Cost-effective and environmentally acceptable methods of pest control for pastures were investigated in experiments with a number of limited-persistence insecticides

https://doi.org/10.23637/ERADOC-1-134

including organophosphorus, carbamate, pyrethroid and other types, on a perennial ryegrass sward. Effectiveness in controlling stemboring dipterous larvae and the yield response of treated swards varied. The greatest effect on yield was given by the synthetic pyrethroid, permethrin, a compound which combines a high level of insecticidal activity with very low mammalian toxicity. (Henderson and Welch, with Mr. R. O. Clements, Grassland Research Institute)

Pesticides and the soil fauna. In 1977, three pesticides were applied to field plots, which were then thoroughly cultivated and sown to grass. The effects on populations of invertebrates were assessed by sampling at monthly intervals after treatment, and extracting the animals, identifying and counting them. The pesticides tested were a potent contact nematicide and insecticide, aldicarb (10 kg ha^{-1}), a new systemic nematicide and insecticide, Cyanamid 'AC64475' (20 kg ha^{-1}) and a new acaricide and insecticide 'Cyanamid AC85258' (1 kg ha^{-1}). These studies were supplemented by field trials on a number of different soil types involving aldicarb (10, 30 and 50 kg ha^{-1}) and 'AC64475' (5, 7·5, 10 and 15 kg ha^{-1}).

'AC64475' was toxic to many soil invertebrates. Populations of Acarina and Collembola were considerably decreased by 'AC64475' when applied to clay loam and sandy loam soils but much less so when applied to peaty loam, probably because of adsorption on organic matter. By contrast, 'AC85258' had almost no effect on populations of any soil invertebrates.

Effects on earthworms were similar and were confirmed in box tests; 'AC64475' was very toxic, but 'AC85258' had little effect. In these tests only 30% of worms survived exposure to 3 kg ha^{-1} 'AC64475'.

Because dead birds have sometimes been found in association with dead earthworms after applications of aldicarb to sugar beet, aldicarb has been suspected of driving earthworms to the surface where they die. Experiments in 1965–67 showed only moderate mortality of earthworms after treatment with aldicarb in both field and box tests, and insufficient to account for the observed field incidents.

In an attempt to resolve this doubt, earthworms were kept in soil with a range of five moisture contents (26, 28, 31% (optimal), 34 and 37% (flooded)) and the soil treated with 30 or 50 kg ha^{-1} of aldicarb. The results showed that the effect of the pesticide on the worms was very dependent on the moisture content of the soil to which it was applied. Only 1% of the worms survived for 1 month at the two wetter water regimes whereas 25 and 32% survived in the two driest soils and 40% survived at the optimal water regime (31%). By comparison, 85% survived in the control at 31% moisture content.

The earthworms took up aldicarb rapidly from solution reaching equilibrium with the pesticide in less than 24 hours.

There was also evidence that when aldicarb was applied to water-logged soil, earthworms came to the surface within 24 hours. From the accumulated evidence it seems likely that bird deaths may occur when aldicarb is applied to very moist soil; in these circumstances it is taken up rapidly into earthworm tissues and the irritation caused by the chemical brings worms to the soil surface where they die and/or are eaten by birds. (Edwards, Lofty, M. French, with Briggs, Insecticides and Fungicides Department, and Mr. P. Brown, Pest Infestation Control Laboratory, Slough)

Integrated control of pests of sugar-beet seedlings. A collaborative experiment of the Integrated Control of Soil Pests Working Group of the IOBC/WRPS is being done in Ireland, Belgium, France, West Germany, Switzerland and The Netherlands. Rothamsted is also participating in a joint project with Broom's Barn. Two parts of the project implemented in 1977 were investigations of the interactions caused by applications of

https://doi.org/10.23637/ERADOC-1-134

herbicides, HCH (1 kg ha^{-1}) and aldicarb (1 kg ha^{-1}) applied with sugar beet seed, either in a continuous sugar beet cropping or a sugar beet/cereal rotation. All the treatments produced effects, the use of the herbicide and of HCH increasing attacks by some seedling pests. The effects of the treatments on soil invertebrates, pests, predators, nematodes and plant pathogens were fully assessed. Many interactions between different groups of organisms occurred as a result of the treatments.

In other experiments, the use of the entomophilic nematode, *Neoplectana*, was tested as a means of controlling seedling pests of sugar beet. Although results were more variable in this experiment than in Swiss and Dutch trials there were indications that the nematode has potential for controlling these pests. For 1977/78 further experiments are planned using a wider range of dose rates. (Edwards and Lofty, with Oswald, Nematology Department and Dunning, Broom's Barn)

The responses of slugs to plant constituents. The Department has long had an interest in baits for slug control. With this background, the search has continued for plant attractants which could perhaps be used in baits to enhance their acceptability.

The acceptability of aqueous maize-meal extract to *Deroceras reticulatum* has been shown to be attributable to one fraction of the extract isolated by gel filtration chromatography on 'Sephadex G 25' and containing several sugars. These and any other compounds present will be identified and quantified, and their role in slug feeding assessed.

Aqueous carrot-root extract is also readily accepted by *D. reticulatum*, (*Rothamsted Report for 1975*, Part 1, 130), and as the flavour-producing compounds in this extract are known, it has been possible to test the palatability of the individual compounds in feeding trial bioassay. The amount of filter paper treated with a solution of the test compound eaten under standard conditions was compared with the amount of untreated filter paper eaten. Nine amino acids were tested; some decreased feeding, others produced up to a 2·3-fold increase. Three sugars were tested; all increased feeding, sucrose by three times. It is not yet clear whether the responses produced by the chemicals resulted from phagostimulation or increased palatability. (Stephenson, with Pickett, Insecticides and Fungicides Department)

Cultural and biological control

The wide range of basic laboratory studies and field experiments concerned with investigating and developing non-insecticidal methods of control continued. This approach is necessarily long term so though no spectacular breakthrough can be recorded, steady progress was made.

Cultural control

Effects of direct-drilling on the soil fauna. Populations of small invertebrates, surface-living arthropods, slugs, earthworms and stemborers were compared in ploughed and direct-drilled plots of the rotational experiments at Englefield, Northfield and Compton Beauchamp organised by the Letcombe Laboratory. Similar assessments were made on the continuous cereal experiments of the National Institute for Agricultural Engineering at Rothamsted, Silsoe and Boxworth, and an ADAS experiment at Fakenham. Results confirmed those for previous years; earthworm populations continued to increase in direct-drilled plots and were three times larger than in ploughed at Silsoe and Rothamsted and twice as large at Boxworth. Numbers of small arthropods were about twice as large in direct-drilled plots at all sites. Boxworth was seriously attacked by slugs in direct-drilled plots and at Compton Beauchamp there was a relatively heavy attack by stemborers in the ploughed plots. Carabid beetles continued to be more active in ploughed plots.

https://doi.org/10.23637/ERADOC-1-134

An attempt was made to extend the results of the effects of direct-drilling on populations of soil invertebrates (*Rothamsted Report for 1976*, Part 1, 130) on to a farm scale. Populations of all soil invertebrates were assessed in April 1977 in five cereal fields that had been ploughed and five similarly cropped fields that had been direct drilled, on Lee Farm, Sussex. Although attacks by shoot borers were low there were more in ploughed fields than in direct-drilled. Earthworm populations were small over the entire area but tended to be slightly larger in direct-drilled fields although numbers were very variable. The most consistent results were those for carabid and staphylinid beetles, more being trapped in ploughed fields than in direct drilled ones. (Edwards and Lofty)

Strawburning. The long-term study on the effects of strawburning continued and although it was confirmed that burning has little influence on the true soil fauna, it is now becoming obvious that effects on the surface-living fauna can be drastic and long-lasting. The dry autumn and winter of 1976/77 delayed breakdown of unburnt straw residues. This influenced numbers of invertebrates associated with the residual decaying straw and there were still greatly differing populations on the surface of the burnt and unburnt plots at harvest 1977. The experiment will be modified in the 1977/78 season to determine whether a degree of straw incorporation in the unburnt plots influences the invertebrate populations in them. (Edwards, Lofty and B. Jones)

Biological control

Carabids as predators of cereal aphids. An experiment to determine the importance of ground-living carabids as predators of cereal aphids was repeated for the third year.

Metal barriers protruding 0·6 m above ground and inserted to a depth of 15 cm were placed around plots 5 m square in a spring wheat crop in late May. Eight pitfall traps were placed in each plot. From four plots (in a random block of 12 plots) all beetles trapped were removed on Mondays, Wednesdays and Fridays, and these beetles were added equally to four other plots. Four plots were left with normal beetle populations. Populations of cereal aphids were assessed at least once a week in June and early July.

As in previous years there was a close inverse correlation between numbers of beetles in plots and numbers of cereal aphids. In previous years, *Agonum dorsale* has been identified as the most important predator with *Pterostichus melanarius* and *Harpalus rufipes* of secondary importance. In 1977, populations of beetles were small, and of cereal aphids, large. The only beetle species found to be important was *P. melanarius* which depressed aphid populations by about 20%. All the evidence indicated that it is predation early in the season that is most important. (Edwards and Parsons, with Messrs. K. S. George and T. D. Heilbroon, MAFF Plant Pathology Laboratory)

Carabid phenology. The study of the phenology and sexual maturation of carabid beetles captured in pitfall traps on Stackyard (*Rothamsted Report for 1976*, Part 1, 131) was repeated. In May, the earliest female *Pterostichus melanarius* and *P. madidus* caught were old beetles which had already laid eggs the previous year, while towards the end of June and in early July the new generation emerged. Old females matured their eggs first, but almost all eggs from old and young females, were laid in August and September. A few overwintering *H. rufipes* occurred in early June, and the eggs of individuals emerging in June were laid from July to mid-September. In mid-September, newly-emerged males and females of *H. rufipes* and *H. aeneus* appeared. *Agonum dorsale* was common in June and July and eggs were laid until early August; in September a few young specimens occurred. Young *Nebria brevicollis* were active during May and June but disappeared during July; at the end of August this species reappeared and laid eggs during September

https://doi.org/10.23637/ERADOC-1-134

and early October. *Bembidion lampros* laid in May and June and *Trechus quadristriatus* in September and October.

Attractants for rape pests. At present, only pesticides are used to control pollen beetles and seed weevils on oilseed-rape crops. To explore the possibility of other methods of control, studies were made of the factors eliciting responses of these pests to oilseed rape, their relative responses to this and other plants, and of the importance of wild host plants for maturation and survival of pests.

Seed weevils were restricted almost entirely to cruciferous species and the presence of exudate of non-cruciferous plants could deter feeding. They infested verge plants sooner than crop plants. There was no innate preference for particular plant species, but seed weevils soon became conditioned to the plants on which they were feeding and subsequently preferred them. Seed weevils were much less willing than pollen beetles to oviposit in wild crucifers than in rape.

There was no indication that any of the wild species visited by pollen beetles or seed weevils were sufficiently preferred to rape for them to be useful as bait crops. Open rape flowers and yellow buds were preferred to green buds and individual beetles and weevils appear to respond to the sight of others, causing aggregations on racemes.

Pollen beetles and seed weevils were attracted to traps baited with extracts of cruciferous plants or allylisothiocyanate. Although the attraction to the allylisothiocyanate-baited traps was not sufficiently great to be used for control purposes, perhaps more efficient traps and baits could be developed. (Free and Williams)

The natural incidence of cutworm diseases. With the help of staff from Broom's Barn and several ADAS centres, cutworms were collected in 1975, 1976 and 1977 from potato, carrot, sugar beet or various horticultural crops throughout the country. From a sample of 1200, almost all were *Agrotis segetum*, and about 32% died in cultures before adults emerged.

Very few of the cutworms that died displayed signs of infectious disease. The most widespread pathogen was a nuclear polyhedrosis virus (NPV). It was detected microscopically in cutworms from one site in 1975, from two sites in 1976, and in larvae fed on extracts of dead cutworms from two sites in 1975. Also, the apparently healthy cutworms from one site in 1976 were carrying an NPV, presumably as an inapparent infection.

A microsporidan and two fungus species which have not yet been identified, another fungus, *Fusarium solanii*, and a granulosis virus have also been detected. (Sherlock)

Entomophthora *species controlling bean aphis.* In 1975 and 1976, aphid pathogenic fungi of the genus *Entomophthora* became established after being distributed in populations of *Aphis fabae*, on field beans. However, the fungi failed to multiply probably because conditions were too dry (*Rothamsted Report for 1976*, Part 1, 131–132). The experiment was repeated in 1977. For the third successive year, the natural aphid population was small and supplemented on 1 June with aphids reared in the glasshouse. By 14 June, 59% of the plants were infested with aphids in spite of a large resident population of adult coccinellids. Living aphids infected with *E. aphidis* and *E. fresenii* were distributed on 21 June and by 4 July, 47% of a sample of adult apterae recovered from treated plots and only 2% from control plots were infected. *E. aphidis* was the dominant species but during the succeeding 2 weeks the proportion of those infected with *E. fresenii* increased after hot weather in early July, supporting observations elsewhere that *E. fresenii* is important in warm climates. Following a return to cooler conditions, *E. aphidis* predominated again and by 25 July, 90% of the apterae in treated plots and 23% in control plots were infected. Thereafter, there were very few living aphids in the treated plots. The proportion of

https://doi.org/10.23637/ERADOC-1-134

infected aphids in control plots reached 80% by 8 August but many of the plants had been killed and deserted by the aphids. The grain yield of the treated plots was twice that of the control plots but only half that of adjacent insecticide-treated plots.

These results show that the proportion of aphids infected by *Entomophthora* can be increased by distributing the fungus into an aphid population earlier and/or more systematically than occurs naturally. They confirm that the weather is not the only factor that limits the establishment of the fungi in aphid populations.

***The effect of fungicides on* Entomophthora.** Fungicides applied for the control of plant pathogenic fungi supposedly increase aphid numbers through the suppression of fungi that kill aphids. However, in a supplementary field experiment to that described in the previous section, there was no difference in the incidence of infection by *Entomophthora* nor in the mean number of *A. fabae* per plant between the control plots and adjacent plots treated each week with mancozeb (1·3 kg a.i. ha^{-1}) or captafol (1·76 kg a.i. ha^{-1}), two of the implicated chemicals. The yield, however, was slightly, though not significantly, less for the fungicide-treated plots than for the control plots.

In the laboratory, the cadavers of aphids killed by *E. aphidis* were dipped in mancozeb at 2·24 g a.i. $litre^{-1}$, or captafol at 8·8 g a.i. $litre^{-1}$, corresponding to the concentrations recommended for application in the field. This treatment did not decrease the number of conidia that were subsequently discharged from the aphids. However, in another test, germination of the conidia on agar media containing the fungicides, was totally inhibited by mancozeb and partially by captafol at one-tenth of the field concentrations. Furthermore, the chemicals inhibited growth *in vitro* of *E. aphidis* though they did not kill the fungus. These results emphasise that the effects of fungicides on *Entomophthora* spp. in the field should be derived from laboratory results only with care. (Wilding, Brobyn and Best)

Suppression of potato aphid populations. The use of short wavelength light to repel potato aphids was investigated by growing early potatoes under an extensible polythene film. The polythene to some extent reflects sky colour and may therefore interrupt the aphids' highly efficient host-finding behaviour. It may also act as a physical barrier to aphids although the perforations in the sheet are large enough for winged aphids to walk through on to the plants. Preliminary results were encouraging; there were fewer aphids under the film and growth of the plants was not retarded. (Cameron)

Slug mucus. Hitherto, poisons used in slug baits have largely depended for their effect on ingestion. A toxicant that did not have to be eaten would be useful, and with this in mind a basic study of the physiology of mucus production and function has started.

The normal mucus secretion is clear and watery but when irritated, slugs secrete large amounts of coloured, sticky, viscid mucus (alarm mucus) which hinders the penetration of contact toxicant. In *Deroceras reticulatum* and *Arion hortensis*, alarm mucus was found to be discharged from large (approximately 250 $\mu m \times 60$ μm), very numerous, subcutaneous mucocytes evenly distributed over the surface of the skin. In neither species was the alarm discharge mediated by the central nervous system. This implies that there is either a local nerve circuit in the dermis, or that each mucocyte detects and responds to adverse stimuli independently. The suggestion that calcium ions may be responsible for the high viscosity of alarm mucus was not substantiated.

Work is continuing on assessing the rate of production of normal mucus during locomotion and in ascertaining the role of mucus in the sexual behaviour of *D. reticulatum*. (Burke)

https://doi.org/10.23637/ERADOC-1-134

Honeybees

Effort has been concentrated on the bee diseases and aspects of the control of colony organisation by pheromones.

Pathogens of bees

European foulbrood. Samples of dead larvae of *Apis mellifera* received from South Australia and from Victoria, Australia, contained bacteria that were culturally and serologically indistinguishable from all strains of *Streptococcus pluton* that have previously been isolated at Rothamsted. This is the first time that European foulbrood has been diagnosed with certainty in Australia, although it is uncertain whether the disease has been introduced there only recently. *Streptococcus pluton* has now been isolated at Rothamsted from samples sent from all continents where there are honeybees. (Bailey)

Virus diseases

Egyptian bee virus. Samples of sick adult honey bees from Egypt were slightly infested with *Acarapis woodi*, and contained some particles of chronic paralysis, sacbrood and black queen-cell viruses. The viruses were detected by infectivity tests, using pupae in the laboratory, and by serology. None of these pathogens, which are common in Britain, have previously been reported from North Africa. However, they seem less likely to have caused the observed sickness than a previously undescribed virus that was abundant in the bees. This virus, which has isometric particles 30 mm in diameter and contains RNA and three major proteins, is unrelated to any other known bee virus. It was propagated successfully in injection into young bee pupae which died shortly before they were due to emerge. The particles of this virus are difficult to isolate in comparison with those of other bee viruses, being especially prone to aggregate and to lose their nucleic acid during purification processes. Their stability was fairly good in 0·5 M-phosphate buffer at pH 8·0. (Bailey and Ball, with Carpenter and Woods, Plant Pathology Department)

Apis iridescent virus. Almost every individual in samples of adult specimens of *Apis cerana* suffering from a disease manifested by the clustering and crawling of bees and the ultimate death of affected colonies, were infected by *Apis* iridescent virus, identified recently at Rothamsted (*Rothamsted Report for 1975*, Part 1, 132–133). Infections by other pathogens were too slight to account for the sickness. *Apis* iridescent virus has so far been found only in specimens of *A. cerana* from North India and Kashmir. Almost all tissues of naturally-infected individuals of *A. cerana* were found infected, so there are many possible ways in which the virus is transmitted. (Bailey and Ball)

Other viruses. A survey for viruses in local bee colonies using infectivity and serological tests has confirmed preliminary observations (*Rothamsted Report for 1976*, Part 1, 132–133), that black queen-cell virus occurs very commonly in spring, in apparently healthy colonies, and that its occurrence decreases during the summer. The next commonest viruses were of sacbrood and of chronic bee-paralysis, in that order. The most abundant viruses in dead bees collected in late winter, were black queen-cell virus followed by chronic bee-paralysis virus. Black queen-cell virus was also detected in samples of bees sent from Guernsey in spring. Black queen-cell virus, but not chronic bee-paralysis virus, was closely correlated with severe infection of the bees with *Nosema apis*.

Other viruses found sporadically in these surveys were those of acute and of slow bee-paralysis. Many isometric virus-like particles that were unrelated to those of previously identified viruses from bees were sometimes obtained. They were of three sizes,

https://doi.org/10.23637/ERADOC-1-134

with diameters of about 35, 30 and 17 nm but none of them were cultivated successfully. (Bailey and Ball)

Mechanism of queen influence within colonies. When each of several colonies was divided by a wire screen into a section containing the queen and no food, and one with food but without the queen, queen rearing remained inhibited in the sections without the queens; thus it appeared that the queens' inhibitory effect could be transmitted in the opposite direction to that of the movement of food.

In an observation hive, movement of workers to and from a queen was not proportionately greater than movement of workers to and from another part of the colony. In an observation hive colony with a laying queen, workers could distinguish between workers that had been with a queen and workers that had not. However, when the queen was tethered in the centre of a large cage within the colony, workers outside the cage showed hostility to workers inside it only so long as the captive workers formed a continuous chain leading from the queen to the cage wall. When the chain broke, hostility of the free bees towards those caged with the queen, ceased. Workers in an observation hive never appeared to be aware of the position of a queen except when they were within 5–10 mm of her where possibly they were able to perceive a pheromone gradient in the atmosphere by moving their antennae. It appears that a queen's influence is not transmitted only in food and may travel over or through the bodies of stationary workers as well as being carried by moving workers. (Simpson)

Overseas work

Visits were made by Rothamsted-based staff to advise on applied entomological problems in West Africa, Bangladesh, India, Australia, New Zealand, Seychelles and the South Pacific.

Monitoring the vector of River Blindness. River blindness (onchocerciasis) is a widespread, wasting and potentially lethal disease of western and northern Africa which often denies human access to large areas around drainage lines. It is transmitted by a biting fly (*Simulium damnosum*). At the request of the World Health Organisation (WHO), suction traps were sited, and a trapping routine organised, in the Haute Volta, Republic of Mali and Côte d'Ivoire during March–April in order to monitor the migration of this vector and its probable re-invasion of previously controlled areas. (Dean, for Centre for Overseas Pest Research, with Dr. C. G. Johnson, on behalf of the WHO, Onchocerciasis Control Programme)

Pest outbreaks in Bangladesh. At the request of the government of Bangladesh, their agricultural organisations and available data were examined during September–November in an attempt to assess the prospects for forecasting outbreaks of some major crop pests, mainly noctuid and pyralid moths. (Dean, for Centre for Overseas Pest Research)

Pollination of pigeon pea in India. During a visit to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India, observations were continued on the behaviour of insects visiting the flowers of pigeon pea (*Cajanus cajan*) to determine the isolation distances required between plots of cultivars to prevent cross-pollination between them. (Free and Williams)

European foulbrood in Australia. At the request of the Honey Industry Advisory Research Committee and the Minister for Primary Industry, Canberra, a short visit was

https://doi.org/10.23637/ERADOC-1-134

made by L. Bailey to examine diseased honey bee colonies at several places in South Australia, New South Wales and Victoria. The severe brood disease found in all three States was identified as European foulbrood and recommendations were made accordingly. (Bailey)

Control of crazy ant in the Seychelles. A 3-year research and control programme on the crazy ant, *Anoplolepis longipes*, in the Seychelles was concluded and the work prepared at Rothamsted for publication.

The ant was introduced to Seychelles about 1962 and has become a serious domestic nuisance and a pest in agriculture; it invades homes, irritates livestock and increases the occurrence of sap-feeding insects and sooty mould growth.

Successful control around homes and in agriculture was achieved using toxic baits, which usually killed about 90% of ants within the first few days of baiting. Spray treatment with bendiocarb was recommended in situations where rapid knockdown of ants was required (e.g. in hospitals, hotels and food-processing plants); a single spray treatment indoors gave effective control of ants for two months or more.

Complete eradication of *A. longipes* was not feasible, but there were indications that the ant would eventually decline naturally and reach equilibrium with its environment. The use of baits and sprays was therefore recommended only for local relief and to control possible outbreaks of ants on other islands in the Seychelles group. (I. H. Haines and Jennifer B. Haines, with the Ministry of Overseas Development (ODM))

Soil pests in the South Pacific. A survey of soil pests on six island groups in the South Pacific was made from June to September as part of a larger FAO survey begun in 1973. (Edwards, seconded to ODM, with Mr. A. R. Thompson, National Vegetable Research Station)

Staff

It was with great pleasure and pride that we learned of the award of the Royal Agricultural Society's Research Medal for 1977 to L. R. Taylor for his work on aphid monitoring through the Rothamsted Insect Survey, and we congratulate all the contributors to this work over many years on a fine effort, appropriately acknowledged.

T. Lewis was appointed Special Professor of Applied Entomology at the University of Nottingham.

We are pleased to record that A. M. Dewar obtained a PhD Degree at the University of Glasgow. Wendy E. R. Barrow was awarded an ARC research studentship to work on interactions between pest infestation and crop yield.

Margaret G. Jones retired after making a valuable contribution over many years to the ecology of pests and beneficial insects in cereal crops and Doris E. Jolly also retired after long service as a typist.

J. R. G. Turner joined the Department from Stonybrook, New York, to work on the genetics of aphid resistance, and I. H. and Jennifer B. Haines returned, as visiting workers, from an ODM project in Seychelles to complete writing-up.

R. C. Coulter, Jane Oliver and B. G. Withers resigned. A. W. Ferguson and H. Loxdale joined the scientific staff and A. P. Martin, Alison M. Pickard and S. Wright were appointed as assistants and Valerie Humphreys as a typist. J. Grubb, Nichola Parsons, P. Sapsford and M. Winder worked as sandwich course students and M. French and P. Skinner as Voluntary Workers.

T. Lewis, C. Wall and E. D. M. Macaulay, with members of the Insecticides and Fungicides Department organised the 2nd Meeting of the OILB Working Group on the Use of Insect Pheromones in Integrated Control, held at Rothamsted.

https://doi.org/10.23637/ERADOC-1-134

R. Bardner attended meetings of the OILB Working Group on Integrated Control in Cereals at Versailles.

A. M. Dewar presented a paper on behalf of I. F. Henderson at the Symposium on Grassland Fauna at University College, Dublin and a paper on cereal aphids at an OILB Conference in Zurich on cereal aphid forecasting.

C. A. Edwards attended the International Congress of Plant Protection in Ghent, Belgium in April 1977, presented an invited paper on 'Environmental Aspects of the Usage of Pesticides in Developing Countries' and organised the 5th Meeting of the IOBC Working Group on Integrated Control of Soil Pests in Zurich, which R. Bardner also attended. C. A. Edwards participated in the Expert Panel on Pesticides in the Environment organised by FAO in Rome in September and acted as rapporteur, and attended the IOBC/WPRS General Assembly in Athens, Greece from 3–8 October as the ARC delegate. He convened a small Working Group at Cambridge to organise a collaborative experiment on control of nematodes by pathogens (sub-group of the IOBC Working Group on Soil Pests), presented a paper to the Association of Applied Biologists in October on the direct and indirect effects of herbicides on the soil fauna, and another at an EEC meeting on pesticide registration requirements in West Berlin in December.

J. B. Free and Ingrid H. Williams presented papers at the International Congress of the International Union for the Study of Social Insects at Wageningen, Holland.

T. Lewis presented invited papers at the European Plant Protection Organisation (EPPO) Conference on Forecasting in Crop Protection held in Paris, the 9th British Insecticide and Fungicide Conference and the Meeting of the British Association for the Advancement of Science at Aston.

L. R. Taylor gave invitation papers at the Royal Entomological Society's Symposium on Insect Diversity, the Institute of Biology Symposium on Regulation of Animal Populations, and at the Federation of British Plant Pathologists' Symposium on Plant Disease Epidemiology and Dispersal of Plant Parasites.

C. Wall, E. D. M. Macaulay and A. R. Greenway (Insecticides and Fungicides Department), and J. W. Stephenson and C. A. Edwards gave papers at the Association of Applied Biologists' Meeting held at the University of Sussex, and C. Wall also became a convenor for the Entomology Group of the AAB.

https://doi.org/10.23637/ERADOC-1-134

APPENDIX TABLE 1

Time of arrival of first aphid in 1977 compared with mean dates for the previous 8 years' catches, by regions

	Annual mean date of arrival					1977 days earlier (+) or later (−) than mean				
	All traps	SE	Mid-lands	N	SW	All traps	SE	Mid-lands	N	SW
A. pisum	2/6	17/5	27/5	19/6	5/6	−15	−15	−26	−23	−1
A. fabae grp.	9/6	27/5	7/6	26/6	6/6	−15	−9	−27	−27	−4
Aphis spp.	2/6	26/5	20/5	22/6	29/5	−8	−14	−15	−6	−6
A. rubi	16/6	7/6	12/6	6/7	7/6	−10	−15	−16	+3	−17
A. solani	27/5	19/5	16/5	23/6	15/5	−36	−30	−51	−52	−24
B. helichrysi	18/5	12/5	17/5	1/6	10/5	−13	−12	−11	−11	−15
B. brassicae	30/6	15/6	18/6	7/8	15/6	−46	−45	−51	−50	−44
C. aegopodii	21/5	16/5	19/5	3/6	15/5	−7	−7	+1	−8	−6
Cinara spp.	22/6	8/6	21/6	4/7	23/6	−2	−6	−11	+1	+1
D. platanoidis	17/5	15/5	13/5	20/5	17/5	−9	−11	−13	−4	−11
D. plantaginea	20/7	17/6	3/7	29/8	22/7	+19	+3	+12	+9	+34
E. abietinum	14/5	13/5	13/5	20/5	9/5	−11	−12	−21	−4	−10
E. ulmi	15/6	10/6	10/6	21/6	19/6	−5	−8	−8	−7	+4
H. pruni	16/6	10/6	14/6	24/6	16/6	−4	−2	−7	−5	−2
H. lactucae	4/6	24/5	31/5	23/6	28/5	−10	−7	−10	−15	−7
M. euphorbiae	27/5	18/5	22/5	16/6	21/5	−8	−7	−24	−10	+3
M. viciae	30/6	18/6	29/6	10/7	2/7	−50	none	none	−40	none
M. dirhodum	23/5	16/5	16/5	14/6	13/5	−22	−11	−53	−26	−9
M. festucae	12/5	2/5	8/5	2/6	3/5	−54	−36	−62	−83	−56
M. ascalonicus	28/4	20/4	16/4	14/5	28/4	−29	−21	−52	−29	−36
M. certus	27/5	17/5	26/5	17/6	21/5	−38	−31	−59	−45	−31
M. ornatus	18/5	15/5	15/5	17/6	23/4	−37	−16	−56	−51	−29
M. persicae	29/5	18/5	21/5	26/6	17/5	−23	−7	−44	−31	−19
N. ribisnigri	5/6	26/5	1/6	21/6	31/5	−20	−8	−21	−42	−19
Pemphigus spp.	29/6	23/6	28/6	7/7	29/6	−12	−1	−7	−20	−21
P. fragaefolii	1/7	6/7	20/6	16/7	23/6	−46	none	−116	none	−24
P. humuli	9/6	25/5	30/5	1/7	6/6	−2	−5	−6	−2	−7
P. fagi	4/6	29/5	4/6	4/6	11/6	−8	−9	−7	−7	−11
R. insertum	30/5	30/5	18/5	9/6	26/5	−1	+1	−11	+7	−7
R. maidis	19/7	5/7	6/8	27/7	14/7	+13	+9	+23	−1	+31
R. padi	9/5	1/5	11/5	30/5	24/4	−17	−21	−27	−5	−16
S. avenae	23/5	15/5	19/5	12/6	13/5	−7	−6	−15	−4	−2
S. fragariae	31/5	20/5	22/5	24/6	24/5	−15	−16	−25	−27	−17

SE = ADAS South-eastern and Eastern Regions
Midlands = ADAS East and West Midland Regions and Lancashire
N = Yorkshire, the ADAS Northern Region and Scotland
SW = ADAS Wales and South-western Regions

https://doi.org/10.23637/ERADOC-1-134

APPENDIX TABLE 2

Levels of pest aphid populations in 1977 compared with mean values for the previous 8 years' catches, by regions

	Annual mean per trap					1977 as % of annual mean				
	All traps	SE	Mid-lands	N	SW	All traps	SE	Mid-lands	N	SW
A. pisum	97	219	63	43	20	145	144	125	28	385
A. fabae grp.	434	673	525	355	180	155	228	80	26	126
Aphis spp.	175	231	205	167	94	100	116	108	21	196
A. rubi	9	10	10	5	15	100	130	60	140	33
A. solani	19·5	18	50	10	21	56	111	12	20	57
B. helichrysi	699	1086	1201	215	647	83	90	61	53	71
B. brassicae	183	334	270	25	164	11	6	6	8	31
C. aegopodii	358	577	792	131	195	188	215	99	83	224
Cinara spp.	12	17	13	10	7	133	76	77	140	414
D. platanoidis	725	501	1234	956	481	38	42	59	29	11
D. plantaginea	28	53	22	2	34	100	89	177	100	82
E. abietinum	264	104	63	492	245	25	13	60	5	94
E. ulmi	54	104	187	73	30	52	27	26	44	17
H. pruni	583	1015	423	497	184	115	114	208	12	310
H. lactucae	43	66	58	21	39	135	117	131	38	221
M. euphorbiae	88	100	161	80	51	193	180	89	73	673
M. viciae	4	7	7	2	3	3	0	0	15	0
M. dirhodum	903	1372	1291	820	213	68	82	11	17	364
M. festucae	133	185	331	84	45	20	29	5	1	49
M. ascalonicus	74	115	142	41	36	12	14	6	5	14
M. certus	20	27	59	6	13	60	81	17	25	92
M. ornatus	12	15	11	6	18	15	27	18	33	33
M. persicae	226	322	512	138	99	58	41	44	33	186
N. ribisnigri	17	22	17	9	23	165	132	135	111	261
Pemphigus spp.	447	303	269	315	910	34	89	50	26	8
P. fragaefolii	2	1	2	4	2	10	0	15	0	38
P. humuli	418	752	1224	6	201	512	696	120	50	218
P. fagi	93	90	47	165	15	15	26	17	8	20
R. insertum	1711	1164	1224	1967	2304	73	140	148	51	24
R. maidis	21	24	7	23	17	81	113	114	22	141
R. padi	5187	4386	4190	6143	5343	164	231	207	110	153
S. avenae	2170	3588	3705	1114	1075	85	75	26	59	260
S. fragariae	127	198	154	54	124	45	26	72	28	74

SE = ADAS South-eastern and Eastern Regions
Midlands = ADAS East and West Midland Regions and Lancashire
N = Yorkshire, the ADAS Northern Region and Scotland
SW = ADAS Wales and South-western Regions

https://doi.org/10.23637/ERADOC-1-134

Publications

Book

1 Free, J. B. (1977) *The social organisation of honeybees*. London: Edward Arnold, iv, 66 pp.

Thesis

2 Dewar, A. M. (1977) Morph determination and host alternation in the apple-grass aphid, *Rhopalosiphum insertum* Walk. Ph.D. Thesis, University of Glasgow. 235 pp.

General Papers

3 (Clements, R. O.) & Henderson, I. F. (1976) Some consequences of a prolonged absence of invertebrates from a perennial ryegrass sward. *Proceedings of the XIIIth International Grassland Congress*, Leipzig, 1976, pp. 129–134.

4 Edwards, C. A. (1977) Nature and origins of pollution of aquatic systems by pesticides. In: Pesticides in aquatic environments. *Proceedings of XV International Congress of Entomology* 11–38.

5 Edwards, C. A. (1978) Environmental aspects of the usage of pesticides in developing countries. *Proceedings of the International Congress of Plant Protection*, Gent, *Mededelingen de Faculteit handbouwwetenschappen, Rijksuniversiteit, Gent* 42/2, 853–867.

6 Edwards, C. A. & Lofty, J. R. (1977) The influence of invertabrates on root growth of crops grown with minimal or zero cultivation. *Ecological Bulletin* (*Stockholm*) **25**, 348–356.

7 Free, J. B. (1977) The construction and use of comb in a honeybee colony. *Report of Central Association of Bee-Keepers*. 8 pp.

8 Free, J. B. (1977) The seasonal regulation of drone brood and adult drones in a honeybee colony. *Proceedings of the 8th International Congress of IUSSI*, Wageningen, The Netherlands. pp. 207–210.

9 Free, J. B., Gennard, D., Stevenson, J. H. & Williams, I. H. (1977) The value of the flora of motorway verges to beneficial insects. In: *Symposium: 'Motorways and the biologist'*. North East London Polytechnic, pp. 67–70.

10 Free, J. B. & Williams, I. H. (1977) The pollination of crops by bees. Bucharest: Apimondia and International Bee Research Association, 14 pp.

11 Henderson, I. F. (1977) Assessing the effect of invertebrates on grassland productivity. *Scientific Proceedings of the Royal Dublin Society* Ser. A. **6**, 209–215.

12 Lewis, T. (1978) Prospects for monitoring pests using behaviour controlling chemicals. *Proceedings 1977 British Crop Protection Conference—Pests and Diseases*, 847–856.

13 Lewis, T. (1977) New approaches to surveying insect pests. *Proceedings of the British Association for the Advancement of Science. 1977.*

14 Taylor, L. R. (1977) Aphid forecasting and the Rothamsted Insect Survey. *Journal of the Royal Agricultural Society of England* **138**, 75–97.

15 Taylor, L. R., French, R. A. & Woiwod, I. P. (1978) The Rothamsted Insect Survey and the urbanisation of land. In: *Perspectives in urban entomology*. Schmid, McCormick, Berwyn, Pennsylvania.

16 Taylor, L. R. & (Taylor, R. A. J.) (1978) The dynamics of spatial behaviour. In: *Population control by social behaviour*. Ed. F. J. Ebling & D. M. Stoddart. London: Institute of Biology, pp. 181–212.

https://doi.org/10.23637/ERADOC-1-134

17 Williams, I. H. (1977) Exposure of the Nasonov gland by the worker honeybee (*Apis mellifera* L.). *Proceedings of the 8th International Congress of IUSSI.* Wageningen, The Netherlands, pp. 160–161.

Paper in Rothamsted Report, Part 2

18 Taylor, L. R. & French, R. A. (1978) Rothamsted Insect Survey. Ninth annual summary. *Rothamsted Experimental Station. Report for 1977*, Part 2, 79–112.

Research Papers

19 Bailey, L. & Woods, R. D. (1977) Two more small RNA viruses from honey bees and further observations on sacbrood and acute bee-paralysis viruses. *Journal of General Virology* **37,** 175–182.

20 Bardner, R., Fletcher, K. E. & Jones, M. G. (1977) The activity and distribution of wheat bulb fly (*Delia coarctata*) (Diptera: Anthomyiidae) in cereal crops over fallow land. *Annals of Applied Biology* **86,** 329–337.

21 Bardner, R., Fletcher, K. E. & Stevenson, J. H. (1978) Pre-flowering and post-flowering insecticide applications to control *Aphis fabae* on field beans: their biological and economic effectiveness. *Annals of Applied Biology* **88,** 265–271.

22 Bowden, J. & Dean, G. J. W. (1977) The distribution of flying insects in and near a tall hedgerow. *Journal of Applied Ecology* **14,** 343–354.

23 Brobyn, P. J. & Wilding, N. (1977) The invasive and developmental processes of *Entomophthora* species infecting aphids. *Transactions of the British Mycological Society* **69,** 349–366.

24 (Campicn, D. G., Bettany, B. W., McGinnigle, J. B.), & Taylor, L. R. (1977) The distribution and migration of *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae), in relation to meteorology on Cyprus, interpreted from maps of pheromone trap samples. *Bulletin of Entomological Research* **67,** 501–522.

25 (Carter, C. I.) & Cole, J. (1977) Flight regulation in the green spruce aphid (*Elatobium abietinum*). *Annals of Applied Biology* **86,** 137–151.

26 Dewar, A. M. (1977) Assessment of methods for testing varietal resistance to aphids in cereals. *Annals of Applied Biology* **87,** 183–190.

27 (Dutton, R.) & Simpson, J. (1977) Producing honey with *Apis florea* in Oman. *Bee World* **58,** 71–76.

28 Edwards, C. A. (1978) Investigations into the influence of agricultural practice on soil invertebrates. *Annals of Applied Biology* **87,** 515–520.

29 Henderson, I. F. & (Clements, R. O.) (1977) Grass growth in different parts of England in relation to invertebrate numbers and pesticide treatment. *Journal of the British Grassland Society* **32,** 89–98.

30 Henderson, I. F. & (Clements, R. O.) (1977) Stem-boring Diptera in grassland in relation to management practice. *Annals of Applied Biology* **87,** 524–527.

31 (Humber, R. A., Soper, R. S.), Wilding, N. & (Remaudière, G.) (1977) The identification of certain widely studied strains of *Entomophthora* pathogenic for aphids. *Mycotaxon* **5,** 307–310.

32 Lewis, T. & Sturgeon, D. M. (1978) Early warning of egg hatching in pea moth (*Cydia nigricana*). *Annals of Applied Biology* **88,** 199–210.

https://doi.org/10.23637/ERADOC-1-134

33 MACAULAY, E. D. M. (1977) Field trials with attractant trap for timing sprays to control pea moth. *Plant Pathology* **26,** 179–188.

34 MACAULAY, E. D. M. & LEWIS, T. (1977) Attractant traps for monitoring pea moth, *Cydia nigricana* (Fabr.). *Ecological Entomology* **2**, 279–284.

35 (RAW, A.) & FREE, J. B. (1977) The pollination of coffee (*Coffee arabica*), by honey-bees. *Tropical Agriculture* (*Trinidad*) **54,** 365–370.

36 TAYLOR, L. R. (1977) Migration and the spatial dynamics of an aphid, *Myzus persicae*. *Journal of Animal Ecology* **46,** 411–423.

37 TAYLOR, L. R. & (TAYLOR, R. A. J.) (1977) Aggregation, migration and population mechanics. *Nature*, *London* **265,** 415–421.

38 TAYLOR, L. R., WOIWOD, I. P. & PERRY, J. N. (1978), The density-dependence of spatial behaviour and the rarity of randomness. *Journal of Animal Ecology*, **46,** 361–383.

39 (WAY, M. J., CAMMEL, M. E., ALFORD, D. V., GOULD, H. J., GRAHAM, C. W., LANE, A., LIGHT, W. ST. G., RAYNER, J. M.), HEATHCOTE, G. D., FLETCHER, K. E. & (SEAL, K.) (1977) Uses of forecasting in the control of the black bean aphid, *Aphis fabae* Scop., on spring-sown field beans, *Vicia faba* L. *Plant Pathology* **26,** 1–7.

40 WILDING, N. (1976) Determination of the infectivity of *Entomophthora* spp. *Proceedings of the First International Colloquium on Invertebrate Pathology*, Queens University at Kingston, Canada, 1976, pp. 296–300.

41 WILLIAMS, I. H. (1977) Behaviour of insects foraging on pigeon pea (*Cajanus cajan* (L.) Millsp.) in India. *Tropical Agriculture* (*Trinidad*) **54,** 353–363.

https://doi.org/10.23637/ERADOC-1-134