CHAPTER I

INTRODUCTORY

The need for an up-to-date textbook on agricultural entomology has been apparent for many years. Although there are now in existence one or two modern books dealing with the insect pests of farm crops in Great Britain, yet these are elementary in character and from their nature are unable to deal as fully with the subject as could be wished in view of the valuable information on applied entomology which has accumulated during the last two decades. Curtis' *Farm Insects* published in 1860 remains the standard textbook on agricultural entomology in the British Isles but this is now long out of date.

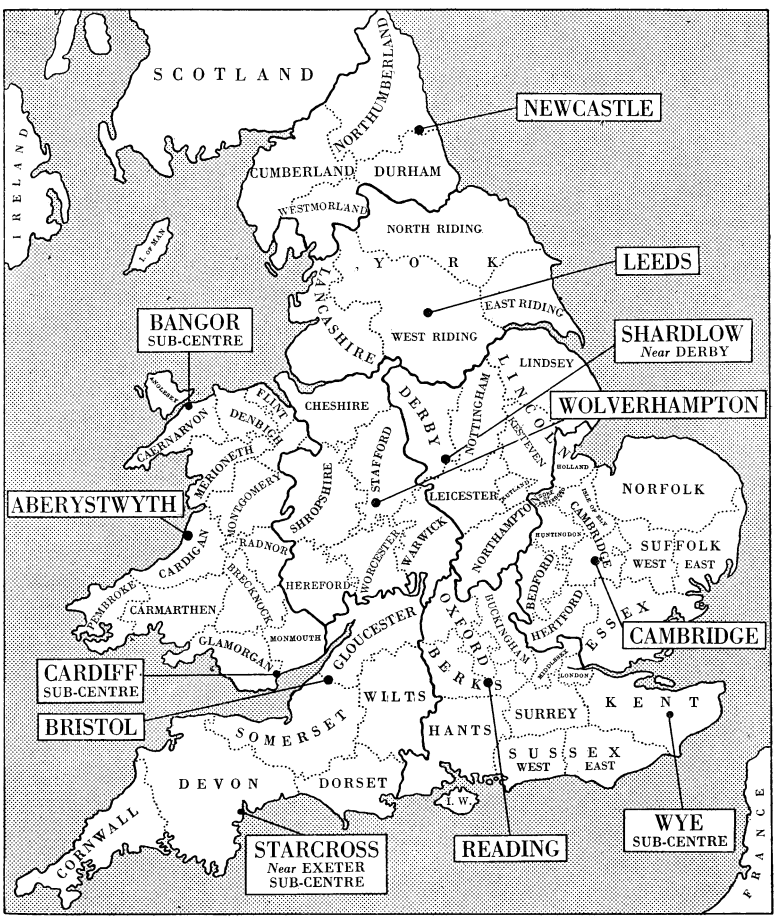
Although under present conditions of high cost of production, the publication of as large and profusely illustrated a volume as Curtis' *Farm Insects* would be a matter of great difficulty, yet it is this book which the writer has had in mind in the preparation of the present volume. An attempt has been made to give as complete and up-to-date an account of each insect dealt with as the limitations of space would allow. The descriptions of the adult insect and its various stages are given in some detail, together with the salient facts in its life history. Special attention has been paid to control methods, and though descriptions must necessarily be brief, the writer has endeavoured to give essentials. In each case the more important farm weeds which act as alternate hosts for many insects are given and also the natural enemies so far as these are known. The book is based upon the results of much original work, and it is hoped that the information thus assembled and the manner of its presentation will render it of use to two classes of readers, both the agriculturist and the agricultural entomologist. The writer has omitted any introductory account of the elements of entomology as there are already a number of excellent books on the subject, to which references will be found at the end of this chapter. No attempt has been made to deal with the insect pests of fruit, partly because they could not adequately be described in a volume of this size and partly because there already exist two comprehensive books,

F. V. Theobald's *Insect Pests of Fruit*, and A. M. Massee's *Pests of Fruits and Hops*. Insecticides play a comparatively small part in the control of insect pests of the farm and in consequence there is no separate chapter dedicated to their description and preparation. Where it is considered that sprays or dusts would be of use, instructions for their preparation are given in the section on control for the insect concerned.

It will not, perhaps, be out of place in a book of this nature to give a short description of the organisation of agricultural entomology in England and Wales at the present time. Since this book was first published the Phytopathological Service, which included entomology and mycology, has been replaced by the National Agricultural Advisory Service which changes the status of the Advisory Entomologist from county to national employment. The new features of this national service include the setting up of Provisional Centres to provide specialist advice to the counties within the province (see Fig. 1), increased numbers of specialist officers and in due course the establishment of experimental farms where new products, machinery or methods can be tried out under practical conditions.

The activities of the National Agricultural Advisory Service may be set out under three heads: first, there is the individual problem or difficulty which crops up from time to time on the particular holding and which must be dealt with as it arises. Secondly, there is a large and rapidly growing body of scientific and technical knowledge that bears upon the business of farming and food production and which must be conveyed, in practical terms, to food producers. Thirdly, there are the many questions that may fairly be asked by practical men but to which science has at present no answer; here the advisory officer must either set on foot his own investigations or, if his facilities are unequal to the task, must state the problem to the research workers and invite their help. (J. A. S. Watson (1946), *Agric. Lond.*, LIII, 375–380). The following is a list of some of these research institutes: Rothamsted Experimental Station at Harpenden; East Malling, Kent; Long Ashton, Bristol; Cheshunt in the Lea Valley; the Imperial College of Science and Technology, London; and a number of stations attached to the School of Agriculture, Cambridge. As regards the Plant Pathological Laboratory at Harpenden, among its main duties are the provision

of a scientific basis for the Orders issued under the Destructive Insects and Pests Acts and the collection and distribution of information regarding the spread of pests and diseases.



(From J A. S. Watson, *Agriculture*, London, 1946.)
Fig. 1.

In addition to the above organisations, there exists the Imperial Institute of Entomology, the headquarters of which are at the British Museum (Natural History). This was founded in 1913 for

the purpose of encouraging and co-ordinating entomological work throughout the British Empire, in relation to agriculture and also to human and animal diseases. The Institute publishes a quarterly journal, the *Bulletin of Entomological Research*, and a monthly journal, *The Review of Applied Entomology*. The latter appears in two parts: (A) Agricultural: (B) Medical and Veterinary and summarises the current entomological literature. This is an invaluable publication to the agricultural entomologist and enables him to keep in touch with entomological progress in all parts of the world.

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CHAPTER II

METHODS OF INSECT CONTROL AND THEIR APPLICATION IN FARMING PRACTICE

Modern insect control may be approached from four main standpoints and these will be briefly reviewed in their application to the insect enemies of agricultural crops. There is, firstly, the direct application of chemicals, otherwise insecticides, to kill or deter the insect; secondly, there are what may be termed 'cultural methods', where the agriculturist by variation in his farm practice endeavours to put the insect continually at a disadvantage. The third method, known as 'biological' or 'natural' control, invokes the aid of parasites and predators which are artificially introduced into the neighbourhood of the pest in question. Lastly, the importation of foreign insects and the movement of resident pests within a country are restricted by means of legislation.

CHEMICALS. The use of insecticides in the agricultural practice of the British Isles is very limited and is governed largely by the question of price, the profit on the average farm crop, especially at the present time, allowing small margin for expenditure on insecticides. The use of chemicals and sprays, however, has been found practical and efficacious in the case of certain insects and some of these instances are briefly indicated. The most recent development is the control of leatherjackets (*Tipula* spp.) and cutworms (*Euxoa*, *Feltia*, etc.), by the use of Paris green (acetoarsenite of copper) as a poison bait. (See pp. 74, 161.) This has proved a cheap and practical method of control for these two serious agricultural pests. The use of calcium cyanide as a soil insecticide is practicable under certain conditions and though too expensive for application on a large scale, it may be used for poisoning wireworms which have previously been assembled in a small area by the use of bait crops. (See p. 108.) Crude naphthalene has also proved its worth as a cheap soil insecticide in certain cases. As regards vegetables some success has been achieved with the use of tar oils as deterrents and of mercury compounds as poisons against

Dipterous pests. (See p. 221.) Certain chemicals have been proved efficacious for killing the larvae of the warble fly in the backs of cattle; among these may be mentioned derris-iodoform and vaseline and a mixture of nicotine sulphate, calcium hydrate and water. (See p. 203.)

CULTURAL CONTROL. The farm operations which can be utilised or manœuvred to place potential or actual insect pests at a disadvantage are mainly the following: (*a*) time of sowing; (*b*) crop rotation; (*c*) cultivation of the ground; (*d*) manuring; (*e*) harvesting; to which may be added (*f*) farm hygiene.

(*a*) *Time of sowing*. By timing the growth of a crop so that the vulnerable vegetative period does not coincide with the maximum numbers of the insect pest, much damage may be avoided. Early sowing is generally an advantage with spring-sown crops in order that the young plants may have become established before the appearance of the insect pests; a good example of this is the early sowing of spring oats to avoid the frit fly. It is important, however, that such early sowing be done with due consideration of the local climatic conditions, otherwise the plants may not have made the necessary progress at the time of appearance of the insect and the desired effect will not be attained. In districts where oats suffer seriously from attacks by leatherjackets, early sowing is not always an advantage. In this case early sowing lengthens the period before the formation of the adventitious roots, a period when the oat is particularly susceptible to attacks by the larvae, and so renders the oat liable to attack for a longer time than if sown later. In districts where the carrot fly (*Psila rosae*) is prevalent, it has been found advantageous to sow carrots later than the usual practice; by this means the growth is so arranged that the carrots are not above ground until the majority of the first brood of carrot flies have disappeared and the number of potential enemies is thus appreciably reduced.

(*b*) *Crop rotation*. By variation in the rotation and arrangement of his crops the farmer endeavours to avoid growing a crop in or near to a field which has been infected with a certain pest the previous year. An example of the benefit accruing from the careful selection of crops is seen in the case of *Hylemyia coarctata*, the wheat bulb fly. This insect has the habit of ovipositing in the bare soil, particularly of fields carrying potatoes or in bare fallow, and

therefore wheat, which is a susceptible crop, should follow grass or beans or some crop which covers the surface of the ground, rather than potatoes or bare fallow.

Although tending to reduce local loss from insect damage, Wardle(9) considers that crop rotation in practice probably has little influence upon the degree of infestation over the whole area, chiefly because of the variation in crop rotation on different farms and because insect pests are rarely specific to one plant host and also often have strong migratory powers.

(*c*) *Cultivation of the ground*. By proper cultivation of the soil the insect pest is affected in two ways, *indirectly* by producing a medium for rapid growth and the production of a healthy plant, better able to withstand attack; and *directly* by disturbing the insects in their habitat and exposing them to the influence of adverse weather conditions and the attacks of their natural enemies.

That the production of a fine tilth may sometimes be disadvantageous is demonstrated by the behaviour of the cutworm. This larva is thought to have been originally a surface living creature but the cultivation of the ground has enabled it to live and progress below the top layer of soil and thus to be protected from its natural enemies. This condition may be counteracted to a certain extent by consolidating the soil surface by rolling, which tends to bring the insects to the surface. Rolling, in itself, is a useful measure against attacks by certain insects, particularly wireworms, leatherjackets and the wheat bulb fly. The effect of the rolling is to prevent easy migration through the soil from plant to plant, and, in the case of wheat bulb fly, to promote tillering of the plants. In rolling it is important to begin in time; as soon as possible after the first signs of attack are noticed. (*Journ. Min. Agric.* xxxv.)

(*d*) *Manuring*. By the use of manures and stimulating dressings applied at the right time the crops are helped to withstand or grow away from insect attack. A case in point is the resistance afforded to onions against attacks by *Hylemyia antiqua*, the onion fly, by liberal dressings of artificial manures. In areas where the gout fly (*Chlorops taeniopus*) is prevalent, manuring the barley is useful but must be carried out with discrimination; while small dressings of nitrogenous manures may reduce infestation, large dressings on the other hand encourage attack by retarding the growth of the ear. (See p. 235.) In some cases also, the use of farmyard manure

is inadvisable as it may attract certain insect pests such as the mangold fly (*Pegomyia hyoscyami*).

(*e*) *Harvesting*. The method of harvesting the crop is sometimes important, particularly in the case of certain cereal pests, such as the Hessian fly (*Mayetiola destructor*), where the pupae may be gathered with the grain, and the wheat stem sawfly (*Cephus pygmaeus*), where the hibernating larvae remain in the stubble. The following statement in regard to harvesting and insect infestation is quoted from Wardle and Buckle (10): "It may be laid down as a general procedure that cereals should be threshed as soon as possible after harvesting and that the seed product should be stored under insect-proof conditions, and if in any way infested by pests should be disinfected as soon as possible".

(*f*) *Farm hygiene*. Clean cultivation has so often been quoted as a cure for various insect pests that it has come to be looked upon as a mere platitude. Nevertheless, though in no sense a cure for insect epidemics, farm hygiene is a valuable preventive measure. A glance through the lists of wild host plants given in this book will show how easy it is for insects to exist upon weeds till the favoured crop comes round again and thus defeat the purpose of crop rotation. Again, the cleaning out of dirty and overgrown ditches and the removal of rubbish heaps will reduce the amount of shelter for hibernating insects. In farm hygiene, then, may be included such recommendations as the removal and burning of rubbish, the destruction of unnecessary grass and the elimination, so far as practicable, of weeds and the cleaning out of ditches. In conclusion, it must be pointed out that in all these cultural methods of control, co-operation is essential; in view of the migratory powers possessed by many insects it is little use adopting these measures in isolated areas.

BIOLOGICAL CONTROL. Natural, or biological, control invokes the aid of the natural enemies, either parasite or predator, of the insect pest in question. The parasites or predators are bred artificially in large numbers and introduced into the country or district of the pest to be controlled. One of the first and most successful cases of such biological control was the almost complete eradication of the fluted scale (*Icerya purchasi*) in California by the introduction of the Australian Coccinellid beetle *Vedalia cardinalis*. Since that time the degree of control of serious insect pests attained by this

method has not, perhaps, risen to expectation. There is, however, interplay of many complex factors governing the introduction and successful establishment of parasites in new districts or countries, and when these are better understood, greater success may be anticipated. Up to the present, the introduction of natural enemies of specific insects has been most successful in island areas, such as the Hawaiian Islands where many serious pests of the sugar cane have been eradicated by this means (Imms (3)). Thompson (6) gives three main reasons for this comparative failure to effect control of pests in continental areas. The first is based upon the similarity between the faunas and floras of such continental areas as Europe and North America, and it would therefore seem that the transfer of a phytophagous insect from Palearctic to Nearctic regions and vice versa should not produce any marked change in its economic status. The second reason is the phyptophagous habits of many parasites and the third is the behaviour of hyperparasites in relation to introduced primary parasites. The parasite which is most likely to survive on introduction to a new country and effect the desired control of a particular pest is one which is superior to its host in rapidity of development, adaptability to environment and powers of flight and dispersal. It should also be confined in its parasitic habit to as few host species as possible. In England, attempts at biological control have so far been confined to two insects, neither of which is of agricultural importance. The first is the woolly aphis of the apple (*Eriosoma lanigera*), and the parasite in question the Chalcid *Aphelinus mali* (Stenton (5)); the second is the greenhouse whitefly (*Trialeurodes vaporariorum*) and its parasite the Chalcid *Encarsia formosa* Gahan (Speyer (4)).

For a good general account of biological control the reader should consult Wardle and Buckle, *The Principles of Insect Control*, and Wardle, *The Problems of Applied Entomology*; while the papers of W. R. Thompson (7) (8) give an account of the principles underlying biological control.

LEGISLATIVE CONTROL. Control by legislation has two aspects; there is firstly legislation against the entry into the country of foreign pests on imported plants or other goods, and secondly legislation to control movement within a country or district of resident pests.

As regards the efforts to prevent the importation of foreign