BIOLOGICAL CONTROL OF APHIDS

E. W. VALENTINE

*Entomology Division, Department of Scientific and
Industrial Research, Nelson*

Summary

The aphids of agricultural importance in New Zealand are all alien, having been accidentally introduced from other countries. Their natural enemies include parasitic hymenoptera in the families Aphidiidae and Aphelinidae, predators in the families Coccinellidae, Syrphidae, Cecidomyiidae, Hemerobiidae and Nabidae and fungi in the genus *Entomophthora*. With the exception of a few predators these are also alien. A survey, by the Entomology Division, of the insect natural enemies is in progress, with the aim of determining their true identities and of assessing the probable value of the introduction of other species. Natural enemies, on their own, are seldom effective in checking aphid populations, so that under commercial conditions some other control methods must be devised. Chemical treatments adversely affect biological controls and often result in the development of resistance and secondary pest problems. To minimize these difficulties, attempts should be made to combine the advantages of biological, cultural and chemical methods.

INTRODUCTION

THE ABUNDANCE of insects in nature is determined by their interactions with their environment. Climate, availability of food in a suitable habitat, competition with other organisms, natural enemies and diseases tend to limit their distribution and abundance. These physical and biological pressures help to maintain them in equilibrium so that they can survive only at a certain level within a complex set of factors. The equilibrium is, of course, not static but is constantly varying according to the direction of various pressures. If, however, the equilibrium is greatly disturbed, these regulating factors can be thrown out of balance. One of the most disruptive influences on stability is man's modification of natural environments, particularly in the removal of mixed vegetation and the development of monocultural systems of agriculture. Large areas of a single crop provide abundant food and for an almost unrestricted development of certain species. Regulating factors still continue to operate but in the new situation the biological agents seldom exercise sufficient control of destructive species to maintain their populations at a low level.

Many of our agricultural pests have been inadvertently introduced from other countries and for a variety of reasons — more suitable climate, longer growing seasons, more abundant food, and particularly the absence of naturally occurring biological controlling agents — have become more important as pests than in their countries of origin. One method of restoring some control is the introduction of natural enemies from the same countries. Success has been achieved by this method in New Zealand in the control of a number of important pests but little attention has been paid to this aspect in aphid control. A notable exception was the introduction, in 1921, of *Aphelinus mali* Haldeman (Aphelinidae) a parasite of woolly aphid (*Eriosoma lanigerum* Hausman) which was an outstanding success in

biological control. Only one other aphid parasite, *Mesidiopsis subflavescens* (Westwood) (Aphelinidae) parasitic on the oak aphid (*Tuberculoides annulatus* (Hartig)) was purposely introduced.

All aphids of agricultural importance in New Zealand are alien and, in the absence of specific native natural enemies, to achieve the most effective biological control it is necessary to rely on the natural enemies of these pests from their countries of origin. Many of these species are already established in this country probably coming at the same time as their hosts. A preliminary survey of these is now in progress. Initially, the aim is to determine the species which either parasitize or feed upon aphids and the exact relationships between them and their hosts.

NATURAL ENEMIES OF APHIDS

1. PARASITES

The most important groups are the parasitic wasps in the family Aphididae and the genus *Aphelinus* in the family Aphelinidae. These are parasites of aphids only, some are highly specific attacking only one species of aphid, or a group of closely related species, while other may parasitize as many as twenty or thirty different species. The adult female parasite deposits an egg in the body of younger stages of the host. On hatching, the parasite larva feeds on the fat body and after passing through several larval stages cuts a slit through the ventral side of its host and cements the aphid's body to the plant. It then spins a cocoon inside or under the host skin and passes through the pupal stage. The fully grown wasp cuts a circular hole in the host skin and emerges to mate and start off another cycle. One generation can extend over a period of less than two weeks to more than five weeks, depending on the weather at the time, or for several months during the winter while the mature parasite larva is in a resting or diapause state until the return of more favourable conditions in the spring. Adults feed on honeydew from aphids, scale insects, etc., and on nectar from flowers.

2. PREDATORS

Predators are distinguished from parasites in that they do not develop internally in their hosts but actively seek out, capture and devour their prey. They are not limited in their attack to any particular species, most being rather general feeders. The best known predators of aphids are the ladybird beetles. Both larvae and adults feed voraciously and a single individual may eat many hundreds of aphids during its lifetime. The eleven-spotted ladybird, *Coccinella undecimpunctata* Linnaeus, the orange-spotted ladybird, *C. leonina* Fabricius, and the two-spotted ladybird, *Adalia bipunctata* Linnaeus, are the only species in New Zealand which habitually feed on aphids, the others having a preference for scale insects and mealybugs. Among the Diptera, the syrphids or hover-flies are the most important. The greenish, maggot-like larvae of *Syrphus novae zealandiae* Macquart and *Melanostoma fasciatum* (Macquart) feed on aphids of all stages while other predatory species in the family confine their attentions to small caterpillars. Adults feed mainly on pollen. A minor group of flies, but still of importance, are certain species of midges (Cecidomyiidae). These are relatively small species, the larvae or which are often found in heavy infestations of aphids. They attach their mouthparts to intersegmental membranes, usually of the legs, and suck the juices from their hosts. Other general predators such as the brown lacewings, *Micromus tasmaniae* Walker

and *Drepanacra binocula* Newman (Neuroptera: Hemerobiidae) and the nabid bug, *Nabis capsiformis* (Germar) (Nabidae), include aphids as a major part of their food and can at times have a significant effect in limiting populations.

3. DISEASES

Parasitic fungi belonging to the genus *Entomophthora* attack various aphids in New Zealand. Under favourable conditions of temperature, humidity and of high density of the host, particularly during the autumn peak of population, the fungus can be responsible for very rapid reductions in populations. The aphids infected by fungus collapse, flatten against the leaf, and become covered with a brownish fungal growth. When the fungus becomes established, it is transmitted to all stages of the host by wind-blown spores which are released from the fruiting bodies. Resting spores are formed during the colder months, and these aid in the survival of the fungus during periods of low population density.

Present knowledge indicates that agricultural aphids are not adequately restricted by natural enemies, but, in the absence of exact knowledge of the mechanisms by which certain potentially damaging species are held in check, it is difficult to assess the value of the parasites and predators that do exist. In the present survey, parasites have been reared from twenty-five different species of aphids. The identities of these have not yet been determined, but they belong mostly in the family Aphidiidae in the genera *Aphidius*, *Diaeretiella*, *Ephedrus*, *Praon* and *Trioxys*, and the genus *Aphelinus* in the family Aphelinidae. Very few of these appear to be specific to particular hosts and the low levels of parasitism of certain species of aphids may indicate that they are not preferred hosts. The recorded species may therefore not be the most efficient parasites of the aphids involved. A better knowledge of the true relationships between them and their hosts, their specificity or host range will help in assessing their effectiveness and in deciding on the probable value of the introduction of other species.

The factors which tend to limit the effectiveness of aphid parasites and predators are extremely complex. Perhaps the most important is the fact that the reproductive potential of aphids is much greater than that of any of their natural enemies. This, coupled with the very marked fluctuations in the size of aphid populations, makes it very difficult for the natural enemies to adjust. Parasites operate more effectively in relatively low host populations and predators realize their potential only in high densities of the host. Another very important factor is that most, if not all, of the natural enemies are themselves parasitized. The Aphidiidae all appear to be parasitized by a number of non-specific "hyperparasites". Two species of *Lygocerus* (Ceraphronidae), two species of *Charips* (Cynipidae), and the pteromalid *Pachyneuron siphonophorae* (Ashmead) have been reared from aphids parasitized by primary aphidiids. The eleven-spotted ladybird, *C. undecimpunctata* Linnaeus, (adult) is frequently parasitized by the braconid *Perilitis coccinellae* (Shrank). Most, if not all, the predatory syrphids are attacked by the ichneumonid *Diplazon laetatorius* (Fabricius) and few of the brown lacewings escape from parasitization by the figitid *Anacharis zealandica* Ashmead. The activities of these "hyperparasites" place a limitation on the ability of the natural enemies to build up sufficient numbers to have a significant effect on aphid populations.

Despite these limitations, biological agents are an important factor in the ecology of aphids, and the combined effects of parasites, predators and diseases can eventually bring infestations under control. However,

under commercial conditions of crop production, if an aphid infestation develops to a damaging level, the grower cannot afford to speculate on the possibility of eventual control by natural means and must resort to some other measures. An obvious solution is the use of insecticides. These usually provide a solution to an immediate problem, but, as has so often been experienced, their unwise use has created new and unexpected problems. Chemicals not only affect the pests that need to be controlled, they affect the whole fauna in that environment. Apart from the development of resistance to insecticides, the destruction of biological controls of the pest species or of a potential pest in the same environment can lead to resurgences and secondary pest problems. This can result in the continued commitment to the use of insecticides, added expense and a possible aggravation of the problems which arise from their use.

In order to minimize the problems and to avoid a complete dependence on chemicals, attempts should be made to devise systems of control which take advantage of all those factors which tend to limit the development of aphid populations. Chemical controls are not incompatible with biological and cultural controls and with care can be made complementary. The use of selective insecticidal materials (which are less harmful to natural enemies), or the application of insecticides in a more selective way by better timing or adjustments in the rates of application, tends to preserve the value of biological controls. This is the basis of integrated control, a system which has been successfully applied to a number of pest problems. In the field of aphid control, the integration of chemical and biological controls of the alfalfa aphid in California is a good example. Early summer application of a selective insecticide reduces the aphid population to a low level without adversely affecting the natural enemies which can subsequently keep the pest in check for the rest of the season. Highly toxic or non-selective insecticides applied at the same time virtually eliminate the natural controls, so that the infestation builds up again to a damaging level which requires repeated chemical treatment.

Before deciding on a system of control, the ecology of the crop and its insect fauna must be taken into account. All those factors which influence population changes must be understood, whether these are seasonal, climatic, cultural, biological or chemical. The control measures should be arranged in such a way as to take full advantage of all those factors which tend to limit the population. Each pest problem and each crop has its own peculiar biological and ecological characteristics and an ecological approach will in the long run provide the most satisfactory method of insect control.