Conservation biological control of insect pests

Conservation biological control (CBC) is increasing the impact on the pest of natural enemies that are already present in the agroecosystem. This contrasts with ‘classical biological control’, which involve importing a new natural enemy from a foreign country.

The dramatic success in 1888 of the classical biological control of the cotton cushion scale (*Icerya purchasi* Maskell) moved the emphasis of biological control away from CBC and to importing new natural enemies from foreign countries.

We distinguish two approaches to CBC.

1- The first is ecological engineering of agroecosystems. The approach involves improving the environment to the benefit of natural enemies.

2- The second approach is a technique of the conservation or partial conservation of natural enemies, when insecticides are used in such a way that they have a greater impact on the pest than on its natural enemy(ies)

Ecological engineering of agroecosystems

We have four main tools in this approach. How they are deployed in CBC will be described later:

(1) Provision of flowers, from which the adults of many natural enemies feed on pollen and/or nectar to mature their eggs and increase their growth (if immature) and longevity.

(2) Increasing plant biodiversity encourages insect herbivores (alternative prey) on which natural enemies can sustain themselves when the pest is scarce.

(3) Establishing alternate (as opposed to alternative) prey – where natural enemies require more than one species of prey at different times of their annual life cycle.

(4) A adapting microclimate in the crop tends to benefit natural enemies.

All four tools have been known for many years. Already in 1938, the importance of flowers for natural enemies was shown regarding the braconid parasitoid *Orgilus obscurator* (Nees), which provides effective biological control of the pine shoot moth (*Rhyacionia buoliana* in the UK. Newly emerged parasitoids are repelled by the smell of pine oil, and so leave the trees to feed and mate on flowers outside the forest. When the eggs are mature, behaviour reverses. Pine oil odour is now attractive, and so the females are pulled back into the forest to parasitise the pine shoot moth caterpillars.

An early report of the value of alternative prey comes from Finland and concerns the gypsy moth (*Lymantria dispar* (L.). This pest has occasional outbreak years in which the caterpillars can potentially defoliate oak forests.

These outbreaks are naturally controlled by a complex of some six parasitoid species, provided these have been able to survive on alternative hosts during the years between gypsy moth outbreaks. In the Finnish work, 34 alternative hosts were identified in the oak canopy, but even more (45 species) were found on the vegetation on the forest floor of forests that were not managed too intensively.

These examples of the four tools we use in ecological engineering were all recorded over 70 years ago, but at that time made no impact on how pests were controlled in agriculture and horticulture. There are four main explanations for this lack of interest:

(1) Insecticides were highly effective, and their problems had not yet become an issue.

(2) The mindset was still that biological control meant importing foreign natural enemies.

(3) Floral diversity on farms was equated with encouraging weeds.

(4) Reaching for the spray gun was a lot simpler than trying to get one’s head around biodiversity.

Provision of flowers as sources of pollen and nectar

Adding pollen and nectar sources to farmland has been practised widely in both the Northern and Southern Hemispheres. Buckwheat (*Fagopyrum esculentum* Moench) is frequently the flower of choice, and New Zealand is just one country where this plant is often grown as a strip at the edges of cereal fields (Fig. 1) to provide adult food for parasitoids in general as well as for hover flies, the larvae of which are voracious predators of aphids. Two other flowering plants commonly used in this way are sweet alyssum (*Lobularia maritima* (L.) *Desvaux*) and white mustard (*Sinapis arvensis* L.). However, even though such plantings usually increase the numbers of natural enemies, reductions of pest populations are less consistently demonstrated.

Figure 1. Buckwheat grown at the edge of a cereal field to provide pollen and nectar, particularly for adult hover flies.

Provision of alternative prey

When crops such as cereals are harvested and there is a gap before planting the new crop, perhaps as part of a rotation, herbivores in the edge vegetation and other adjacent uncultivated land provide prey for a reservoir of natural enemies available to move onto the new crop when this is attacked by pests arriving from.

Improved microclimate

Ground beetles (Carabidae) are important predators of the eggs of a variety of root pests such as carrot fly and cabbage root fly. In cereals, they feed on the many aphids that drop off the plant onto the soil and may even climb plants to feed on aphids on the stem and leaves. In the autumn, they seek drier sites to overwinter and are found particularly in grass tussocks at the crop edges. To increase arable acreage, many farmers have replaced hedges between fields by post and strand fencing. Grass tussocks (known as ‘beetle banks’) can be created under such fencing, but when beetles move out of these in the spring, they do not penetrate far into the crop. For some years wheat prices made it economically viable to build long ridges sown with grass across a field. These grassy mounds, known as ‘conservation ridges’ (Fig. 6), were built to allow the passage of tractors at each end and would last several years before the need for restoration. Some farmers turned them into diversity strips by adding flower seeds to the seed mix.

Selective insecticide use

This second approach to conservation biological control may appear to be contradictory in terms. However, using insecticide to improve biological control is based on a very simple concept, that the ratio of natural enemies to pests is more important than their number. This is illustrated in the cartoon of 15 aphids and 5 ladybirds. If a broad-spectrum insecticide kills the same proportion of pests and natural enemies. biological control is not affected, since the ratio of aphids to ladybirds has not changed from 3:1. However, if the insecticide is just slightly selective and kills one more aphid, the ratio for biological control has improved to 2.5:1.

The tools for using insecticides proactively to improve biological control are as follows:

(1) Use of a selective or partially selective insecticide.
(2) Applying the insecticide at a reduced dose.
(3) Using time of application to achieve selectivity.
(4) Restricting the area to which the insecticide is applied.

Selective insecticides

Selective or at least partially selective insecticides, less toxic to the natural enemies than to the pests, are sometimes discovered by the agrochemical industry. A good example is the carbamate pirimicarb. Industry does not like such insecticides because the market can be limited. For this reason, pirimicarb was not marketed when it was discovered, but it was recovered from the industrial ‘recycle bin’ when a crisis with insecticide-resistant aphids in glasshouses created a profitable market for the chemical in combination with biological control. It was then used in other situations to maximise CBC. It is also very safe for humans, but has been ‘tarred with same the brush’ as other carbamate compounds and has mostly been banned.

Selectivity in time

Time of day for insecticide application can be used to achieve selectivity.

Selectivity in space

Today, GPS and receivers on tractors make it possible to envisage spraying almost to the level of an individual pest-infested plant, as some insects cause subtle colour changes that can be recognised by satellites.