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The value of biodiversity to integrated pest management

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The idea of integrated pest management (IPM) is not new. In the last 50 years, advances in chemistry have created a range of products that vary in cost, efficacy and spectrum of insects killed. This has provided a relatively simple approach to pest management. However, before the development of these synthetic pesticides, reliance on predatory insects and novel farming practices were the most common approach to controlling pests.

IPM involves integrating three types of control measures: using naturally occurring invertebrate predators, parasites and pathogens; farm management practices that encourage beneficial species and/or suppress pests; and the strategic use of selective or targeted insecticides (Horne & Page 2008). IPM is not widely practised in broadacre cropping and grazing in south-west Victoria, where the control of pests usually involves broad-spectrum insecticides or baits, generally in response to visual plant damage or to safeguard a crop or pasture against possible attack. This usually provides immediate control of a pest problem but often kills beneficial insects or mites that could provide long-term and ongoing biological control within an IPM program.

Insecticide spraying is the common practice, but there is growing interest by farmers and advisors in IPM. Feedback from IPM workshops run by Southern Farming Systems indicates several reasons for this:

- increasing consumer demand for products grown with minimal or no insecticide use;
- avoiding insect resistance to current products (most farmers are familiar with herbicide-resistant weeds and don't want to see this happen with insect pests);
- reducing the potential hazard to farmers (most hate using pesticides);
- creating new insect problems when targeting a particular pest (secondary insect flares);

- reducing costs (the reduction in chemicals and application costs can be weighed against the additional time required for monitoring).

For IPM to work, farmers require knowledge about the life stages, timing and population dynamics of pests and beneficial species. Based on this knowledge and regular monitoring, strategies can be developed to favour the beneficial species and suppress the pests. This case study describes research carried out in south-west Victoria by Southern Farming Systems, a farmer-managed non-profit research and extension organisation, in partnership with 650 farmers and consultant entomologists (IPM Technologies Pty Ltd). The aim was to find out more about local populations of pests and beneficials as a basis for developing an IPM strategy.

ASPECTS OF DIVERSITY THAT SUPPORT AN IPM APPROACH

All crops and pastures have a range of invertebrate species living in them at any time. Most do not cause significant economic damage to the crop or pasture. However, some insects are capable of damaging crops and pastures and become pests by:

- dramatically increasing in numbers, e.g. lucerne flea (*Sminthurus viridis*) or red-legged earthmite (*Halotydeus destructor*);
- being present when plants are at a vulnerable stage in their lifecycle such as germination or flowering, e.g. slugs;
- changing feeding habits during their lifecycle, e.g. black-headed cockchafer (*Acrossidius tasmaniae*);
- transmitting viral diseases, e.g. barley yellow dwarf virus (BYDV) transmitted by aphids.

IPM is not about eradication of a pest. It is about ensuring there are sufficient beneficial insects to reduce pest populations so they do not cause significant damage to the crop or pasture. Many predators feed on more than one species of prey and so do not depend on just one pest to survive. A low-level population of pests is often required to provide food for some predators and parasitic wasps.

There is a range of beneficial species that feed on pests, and one of the first things we needed to do was learn which beneficial insects feed on which pests. It was also important for us to appreciate there are two types of beneficial insects and pests –resident insects and transient insects.

Consultant entomologists told us that resident insects such as slugs, earwigs and red-legged earth mites live in the crop or pasture from one year to the next. They are incapable of moving large distances, usually because they are flightless, and successful breeding is the primary reason for an increase in a resident pest population. The same is true for resident beneficial species. Their population is determined by their success in breeding.

In contrast, transient pests (and beneficial predators) fly in and infest a paddock. Population increases are usually dramatic, as is their later decline. It is common to see rapid rises in pest populations followed by similarly large increases in beneficial predators a short time later.

Some of the common beneficial insects identified as preying on major pests of crop and pasture in our region are listed in Table 11.1.

We needed to learn the difference in function and habit of similar-looking insects. For example, we have several species of slugs. Two look very similar and both cause damage in

Table 11.1: Common pests of crops and pastures in south-west Victoria and beneficial species associated with their control

Common pest of crops and pasture	Residency	Beneficial species
Aphid (*F. aphididae*)	Transient	Brown lacewing (*Micromus tasmaniae*) Ladybird beetles (*Harmonia, Coccinella, Hippodamia*) Parasitic wasps (*Aphidius* spp.)
Black-headed cockchafer (*Acrossidius tasmaniae*)	Resident	Carabid beetle (*F. carabidae*)
Blue oat mite (*Penthalaeus major*)	Resident	Predatory mites (*Bdellidae* and other species) Native earwig (*Labidura truncata*) Possibly predatory beetles (*Carabidae*) and true bugs (various *Hemiptera*)
Diamondback moth (*Plutella xylostella*)	Transient	Damsel bug (*Nabis kinbergii*) Parasitic wasps (many species) *Harmonia, Coccinella, Hippodamia*)
European earwig (*Forficula auricularia*)	Resident	Carabid beetle (*Geoscaptus*)
Heliothis caterpillars (*Helicoverpa armigera, Helicoverpa punctigera*)	Transient	Damsel bug (*Nabis kinbergii*) Shield bug (*Oechaelia schellenbergii*) Parasitic wasps (many species)
Lucerne flea (*Sminthurus viridis*)	Resident	Predatory mites (*Bdellidae* and other species) Native earwig (*Labidura truncata*)
Red-legged earth mite (*Halotydeus destructor*)	Resident	Predatory mites (*Bdellidae* and other species) Native earwig (*Labidura truncata*)
Rutherglen bug (*Nysius vinitor*)	Transient	No known beneficial predators
Slugs (*Deroceras reticulatum, Milax gagates*)	Resident	Carabid beetles (*Rhytisternus, Notonomus*)
Wireworm, false wireworm (*Elateridae* and *Tenebrionidae* spp.)	Resident	Carabid beetle (*F. carabidae*)

crops, but one can cause 20 times more damage than the other (*Milax gagates* compared with *Decroceras panormitanum*). So, instead of thinking, 'We've got slugs and we have got to do something about it', farmers need to know the type of slug, its lifecycle stage and the stage of the crop before taking action.

Similarly, we found out there are different types of earwigs: the European earwig (*Forficula auricularia*) does a lot of damage to crops, particularly canola; a native earwig (*Labidura truncata*) controls a lot of pests; and an unnamed earwig locally known as the 'fatbum earwig' plays no role in the crop production cycle (Figure 11.1). As a result of our surveys, farmers are reacting differently when they see earwigs. They are now asking whether they are Europeans, natives or fatbums. This is a huge shift. Farmers who typically say 'I'm not a greenie' are now down on their hands and knees checking their pitfall traps and working out the ratios of the different species.

QUANTIFYING THE DIVERSITY AND DISTRIBUTION OF BENEFICIAL SPECIES IN CROPS AND PASTURES

The distribution and proportion of beneficial species in crop and pasture land in south-west Victoria is poorly understood, yet for IPM to work those species had to be present in sufficient populations for adequate pest control.

Figure 11.1: Entomologist Paul Horne showing farmers specimens of pest and beneficial insects found in crop, pasture and native grassland habitats of south-west Victoria

In 2005 and 2006 IPM Technologies and Agvise Services undertook a survey in an area approximately 50 km west and north-west of Geelong to give some indication of the distribution of some beneficial species in different ecosystems across the region. Four different grassy ecosystems were surveyed: winter crops such as wheat, barley and canola; improved exotic pasture; 'native pasture' as identified by the participating farmers; and remnant native grassland on roadsides which had experienced minimal disturbance from cultivation or grazing. Details of the experimental method, site locations, sampling period and detailed findings are described in Nicholson and Horne (2007).

A selection of five carabid beetles and one native earwig were chosen for analysis. These are regarded as key species that prey on many common agricultural pests such as caterpillars, aphids, earwigs, slugs and possibly mites. The five carabid species (*Rhytisternus liopleurus, Notonomus gravis, Geoscaptus* spp., *Sarticus* spp. and *Promocoderus* spp.) were chosen due to their presence in an earlier survey (Horne 2007). Two earwig species were observed, the predatory native earwig (*Labidura truncate*) and the European earwig (*Forficula auricularia*), a known pest in canola.

Carabid beetles and native earwigs captured over 12 months were used to compare sites based on previous research (Horne, pers. comm.) which indicated that 'year catch' (total insects captured in 12 months) is a good measure of carabid beetle and earwig populations.

In 37% of the crop and pasture sites, few or no carabid species or native earwigs were recorded. In the remaining 63% of sites where beneficial species were captured, the relative proportion of each carabid subspecies depended on the ecosystem type.

The remnant native grassland contained four of the five carabid subspecies (Figure 11.2). *Promecoderus* spp. was recorded at each site in reasonable proportions (30–60% of the total catch). However, the total number of species was low in contrast to collections from the pasture and crop paddocks. The remnant native grassland sites had a fraction of the total of any key species found in crop or pasture habitats. For example, one remnant grassland site at Shelford had a total catch of 35 carabid beetles and earwigs compared to a total catch of 364 in the adjacent cropping paddock.

The cropping paddocks were dominated by one subspecies of carabid (*Rhytisternus*) and the beneficial native earwig (*Labidura truncate*) (Figure 11.2). All sites had significant populations of these two species and they were the significant subspecies present.

In contrast, the improved pasture paddocks were dominated by a different subspecies of carabid beetle (*Promecoderus*). This beetle was found at all sites and ranged between 17% and 92% of the total beneficial carabid and earwig populations (Figure 11.2). Similar to the cropping sites, the abundance of beneficial species in one pasture site (Ballan) was approximately 10 times higher than a nearby native remnant grassland.

The fourth ecosystem type was identified by participating farmers. This was an unimproved grassland paddock (referred to as a 'native' paddock). The abundance of each beneficial species was measured and compared to the remnant native grassland, crop and pasture profiles. Four of the five profiles more closely matched the numbers and proportions found on improved perennial pastures, not the roadside native vegetation sites. A fifth native grassland site at Warrambeen contained the common pasture carabid beetles *Promecoderus* and *Geoscaptus* but in numbers 20 times lower than the average of the other native grassland sites. It more closely matched the remnant native grassland profile.

A botanical analysis was conducted on the farmer-selected native paddocks. Most of these nominal native paddocks were found to actually be dominated by exotic annual grasses and broadleaf plants. In contrast, at Warrambeeen the plant composition was 66% native species including wallaby-grass (*Austrodanthonia* spp.), kangaroo grass (*Themeda australis*), pink bindweed (*Convolvulus* spp.), sheep's burr (*Acaena ovina*), bluebell (*Wahlenbergia* spp.), snowgrass (*Poa* spp.) and small scurf-pea (*Cullen parvum*).

Collections during the study clearly showed that crops, pasture and remnant native vegetation contain different types and abundance of carabid beetle and native earwigs, enabling a population profile to be established.

The reasons for the difference are speculative, but they may include insecticide use, herbicide use, crop rotation or changing habitat structure. Altered habitat structure such as changing from tussocks to crop stubble or to heavily grazed pasture will modify habitat complexity. While this change in habitat structure is obvious and may be the dominant factor, the additional reasons are also likely to contribute to the resulting invertebrate composition. The relative influence of these factors is yet to be determined.

Remnant native grasslands contained a greater diversity of carabid beetles but in much lower numbers than the cropping or pasture paddocks sampled. This finding has four important implications. The first is that the number of beneficial individuals is unlikely to be sufficient for direct biological control in adjacent paddocks; they are likely to be outnumbered by the pests residing in the crop or pasture.

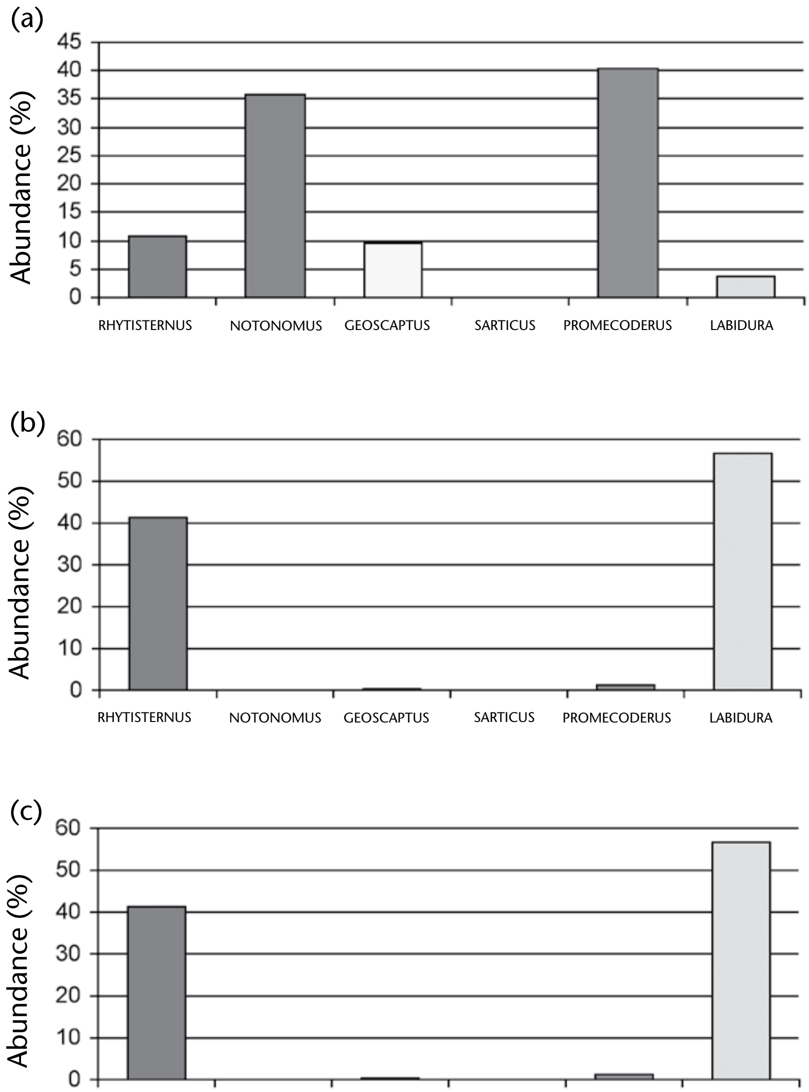

Figure 11.2: The relative abundance of five beneficial carabid beetles and the earwig *Labidura*. (a) At three roadside remnant native grassland sites. (b) At seven cropping sites. (c) At seven pasture sites

The second is that at least one species of resident carabid beetle and earwig found in remnant native grassland is favoured by the environment created by cropping or pasture. These individual species are likely to move out of the native vegetation areas and breed successfully in the crop or pasture (assuming other actions are also taken to avoid killing them in the crop or pasture). This will eventually increase numbers in the crop or pasture to a level sufficient for some natural pest control.

Third, maintenance of remnant native grasslands and establishment of new areas of native grasslands is important to provide a reservoir of beneficial insects to repopulate crop and pasture areas.

Figure 11.3: Farmers examining plots of native grassland pasture established as refuges for beneficial insects on cropping farms in western Victoria

Finally, it appears unwise to conclude that every location referred to locally as native pasture will necessarily have the same characteristics as remnant native grassland in good condition and therefore be a good source of native biodiversity, especially of the key beneficial species discussed here.

TURNING FARMERS ON TO BIODIVERSITY THROUGH IPM

The farmers involved in this study became interested in IPM but as their farming system involves rotations (changing paddocks from crops to pastures) they needed some way of repopulating those pasture and crop paddocks. They came to realise that remnant native grassland or newly established stands of native grassland can act as pools or reservoirs for repopulation.

As a consultant, the exciting bit for me was having farmers ask, 'How do I re-establish these native grasslands around my farm? I've only got a small patch left. How do I get it somewhere else on the farm?' This is a very different approach from the purely conservation view, which is to protect the little bits left for their own sake. This view recognises the role of native grasslands as a refuge and source of beneficial insects; farmers are now trying to re-establish this once-dominant ecosystem strategically around their farms. This is a significant change in thinking for a large number of farmers, certainly in south-west Victoria. Some of these farmers are now practising full IPM on more than 2000 acres on their farms, with both crops and pastures.

To assess the response of farmers in south-west Victoria, the Grain & Graze program (Grain & Graze 2007) invited six farmers who pioneered the application of IPM to broadacre farming in that region to explain their interest in the approach. These selected quotes provide some insight into the future of IPM and the opportunity to turn biodiversity and native vegetation into an accepted part of mainstream farming. Full transcripts can be found in Nicholson (2006).

> *I have been concerned for some time about the amount of chemicals we use in our cropping program. So when Agvise approached me with a proposal to start using IPM, and having the outline of the methods used in IPM explained to me, I thought that this is a very positive step in the right direction and we should be involved. The main reasons for implementing the IPM program have been insects becoming resistant to chemicals, the damage insecticides do to the environment, the financial benefit of not having to spray insects, by encouraging natural predators to deal with the problems pests, and improving the farm environment (James Richardson, 'Terrinallum', Darlington).*
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> *We became interested in an IPM approach due to our ongoing effort to continually become more environmentally friendly. We were worried that over time 'spraying the s*** out of everything' probably wasn't the best thing to do. We were concerned about a pest, in this case aphids, building up a resistance to the chemical and the chemical residue levels that may be passed on to the consumer of the grain, in this case the pigs. We didn't think that we could continue farming using these practices and also liked the idea of less work, and letting mother nature do some of the work for me so that I could have the weekends off (Stephen Menze, cropping manager for Charles IFE Piggeries near Ballarat).*
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> *I am not a Greenie. My previous approach has been 'The only good bug is a dead bug'. After observing the amount of herbicide resistance happening in farming I decided a new approach was necessary. Frequent applications of insecticides would lead to similar situation in our pests. Weeds don't have predators but insects do, so it seemed a natural progression to try and harness these whereever possible. IPM has become a fundamental part of our farming practice and it is our intention to expand its application across our entire cropping operation as our knowledge and confidence grows (John Hamilton, 'Leighview' Inverleigh).*
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> *I have slowly come to realise that, in the main, killing bugs with a boom spray doesn't work. When you start to think that some insects are eating other insects and not your crop you have a whole different outlook! Balance is the key and you will not achieve it with a boom spray (Robert Meek, 'Strathleigh', Shelford).*

CONCLUSION

This chapter shows that the IPM approach is an enormous opportunity to engage mainstream farmers in biodiversity in a way that means something to them and their farm business. There are direct benefits to profitability, with gross margins improving at $10–20 per hectare at paddock-scale up to a gain of $30 000 a year over a farm that has moved to full IPM. But it is more than just the economic benefits. Managing and improving diversity is now a passion for these farmers and many more are following. This work has led to an IPM course being offered in south-west Victoria (www.rist.com.au) which is giving farmers, consultants and advisors the skills and confidence they need to try IPM.

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