Integrated Pest Management in cropping and pastures

Course notes

South West Victorian Pilot Program
About these notes
These course notes were collated and edited by Cam Nicholson of the Grain and Graze program from text provided by Dr Paul Horne and Jessica Page from IPM Technologies Pty Ltd.

The course notes are intended to assist participants develop skills in the planning and application of Integrated Pest Management (IPM).

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Introduction

Why use an Integrated Pest Management approach

The idea of Integrated Pest Management (IPM) is not new. Before the development of a wide range of synthetic pesticides in the 1950’s, biological and mechanical farming practices were the most common approaches to control pests. The last fifty years has seen advances in chemistry that have allowed a range of products to be manufactured that vary in cost, efficacy and the spectrum of insects killed.

This course is not intended to reject the use of insecticides or to be critical of past practices. It is designed to provide broad-acre farmers with an additional approach to their pest management.

There are several aspects that make IPM attractive. These include:

- Consumer demand for products grown with minimal or no insecticide use.
- Avoiding insect resistance to insecticides.
- Reducing the potential hazard farmers may face when using insecticides.
- Reducing secondary insect flares.
- Potential reduction in costs (although sometimes the reduction in chemical and application costs are replaced by the additional times required with monitoring).

What is Integrated Pest Management

Integrated Pest Management involves integrating three types of control measures:

- naturally occurring invertebrate predators, parasites and pathogens
- farm management practices that encourage beneficials and/or suppress pests
- strategic use of selective or targeted insecticides.

Knowledge on the life-stages, timing and population dynamics of pests and beneficial species is required for IPM to work. Strategies can then be developed to favour the beneficial species and suppress the pests. Regular monitoring is an essential part of this strategy.
Contents of the workshop notes

The workshop notes are designed to provide information on the essential elements of adopting an IPM approach. The elements are:

- The identification and understanding of the life cycle of pests – both beneficial and benign species.
- The impact various farm practices can have on pest and beneficial populations.
- The impacts of different insecticide (and herbicide) applications on pest and beneficial populations.

With this knowledge strategies can be developed to achieve IPM.
Section 1: Identifying and understanding the life cycle of pest, beneficial predators and benign invertebrates.

All crops and pastures accommodate a range of invertebrate species at any one time. Most of these do not cause significant economic damage to the crop or pasture, however there are some insects that are capable of damaging crops and pastures and become pests when:

- They dramatically increase in numbers eg lucerne flea or red legged earthmite
- plants are at a vulnerable stage in their life cycle, such as at germination or flowering (for example slugs)
- feeding habits change during their life cycle (e.g. black headed cockchafer)
- they are vectors for viral diseases (e.g. Barley Yellow Dwarf Virus (BYDV) transmitted by aphids)

IPM is not about the eradication of a pest. It is about ensuring sufficient beneficial insects to reduce the existing pest populations so they do not cause significant damage to the crop or pasture.

Many predators feed on more than one species of prey; they do not depend on just one pest to survive. A low level population of pests may be required, however, to provide food for some beneficial predators and parasitic wasps to survive.

There is a range of beneficial species that feed on pests and it is important to understand which beneficial insects feed on which pests. It is also important to appreciate there are two types of beneficial insects and pests: resident and transient insects.

1.1 Resident and transient pests and beneficial predators

**Resident** insects such as slugs, earwigs and red legged earthmite live in the crop or pasture from one year to the next. They are incapable of moving large distances, usually because they are flightless. Therefore an increase in the population relies upon successful breeding. The same is true for the resident beneficial species.

In contrast the **transient** pests and beneficial predators fly in and infest a paddock. Population increases are usually dramatic, as is their later decline. Rapid rises in pest populations are often followed by similarly large increase in beneficial predators a short period later.

Some of the common beneficial insects that prey on major crop and pasture pests are presented as resident (table 1) and transient (table 2) insects.
### Resident Pest | Beneficials that help control the pest
---|---
Redlegged earth mite | Predatory mites (*Bdellidae* and other species)  
Native earwigs (*Labidura truncata*)
Blue oat mite | Predatory mites (*Bdellidae*. and other species)  
Native earwigs (*Labidura truncata*)  
Possibly predatory beetles (*Carabidae*) and true bugs (*various Hemiptera*)
Lucerne flea | Predatory mites (*Bdellidae* and other species)  
Native earwigs (*Labidura truncata*)
Slugs (*Deroceras reticulatum*, *Milax gagates*) | Carabid beetles (*Rhytisternus*, *Notonomus*)
Wireworm, false wireworm | Carabid beetles (*F. Carabidae*)
European earwigs | Carabid beetles (*Geoscaptus*)
Black headed cockchafers | Carabid beetles (*F. Carabidae*)

Table 1: Some beneficial species that prey on resident pests of crops and pastures.
Integrated Pest Management in cropping and pastures – course notes

<table>
<thead>
<tr>
<th>Transient Pest</th>
<th>Beneficials that help control the pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heliiothys caterpillars</td>
<td>Damsel bugs (<em>Nabis kinbergii</em>),</td>
</tr>
<tr>
<td></td>
<td>Shield bugs (<em>Oechelia schellenbergii</em>),</td>
</tr>
<tr>
<td></td>
<td>Parasitic wasps (many species)</td>
</tr>
<tr>
<td>Rutherglen bugs</td>
<td>No known beneficial predators</td>
</tr>
<tr>
<td>Diamondback moth</td>
<td>Damsel bugs (<em>Nabis kinbergii</em>),</td>
</tr>
<tr>
<td></td>
<td>Parasitic wasps (many species),</td>
</tr>
<tr>
<td></td>
<td>Ladybird beetles (<em>Harmonia, Coccinella, Hippodamia</em>).</td>
</tr>
<tr>
<td>Aphids</td>
<td>Brown lacewings (<em>Micromus tasmaniae</em>)</td>
</tr>
<tr>
<td></td>
<td>Ladybird beetles (<em>Harmonia, Coccinella, Hippodamia</em>)</td>
</tr>
<tr>
<td></td>
<td>Parasitic wasps (<em>Aphidius</em> species)</td>
</tr>
</tbody>
</table>

Table 2: Some beneficial species that prey on transient pests of crops and pastures.

Little is known about the specific benefits of spiders to an IPM approach, however spiders are broadly classified as voracious predators and current research has shown that significant populations of spiders exist in cropped land. By inference the presence of spiders in crops or pasture would be expected to assist with both resident and transient pests.

1.2 Identification and life cycle of some beneficial species and pests

Accurate identification of insects in a crop or pasture is as essential element of an IPM program. In particular there is a need to be able to identify:

- Insects at different stages of maturity, as their appearance can change dramatically through their lifecycle. For example an immature ladybird is distinctly different to a mature ladybird beetle.

- Differences between the same group of insect. For example, the black keeled slug (*Milax gagates*) and the grey field slug (*Deroceras reticulatum*) are far more serious problems (per individual) than the common striped slug (*Lehmannia nyctelia*) or brown slug or chestnut slug (*Deroceras panormitanum*).
1.2.1 Resident pests

These mites look similar but have important differences in their biology and physiology that affects their control. Both are mites which means they have only one body segment (spiders have two, insects have three) and eight legs. They have red legs and their bodies are velvety blue to black, but the BOM has a red oval patch on its back. Nymphs look like adults. Their feeding damage causes silvering of leaves, and so cotyledons can be severely affected.

RLEM usually have four generations per year, while BOM have two generations. Both become active in autumn following rain, and continue to be active over winter. Both RLEM and BOM produce summer diapausuing (resting) eggs but they produce these at slightly different times, so the TimeRite® strategy does not work for BOM. Also, BOM is far more tolerant of insecticides than RLEM. (For more information about TimeRite® refer to www.timerite.com.au).

Capeweed and other broad-leaf weeds encourage a higher population of these mites as they provide a favourable environment for feeding and breeding.

To reduce RLEM and BOM populations we can:

- Control broadleaf weeds in the years before vulnerable crops
- Plant resistant varieties
- Consider border sprays or plant species that are unfavourable to RLEM around the paddock borders
- Don’t kill predators of these mites.

Notes:
Lucerne fleas are not actually fleas but Springtails, which are closely related to insects. Adults are about 2.7mm long with pale green globular bodies. They jump like fleas when disturbed (hence the name). Nymphs look like smaller versions of the adults.

Like RLEM and BOM they have summer tolerant eggs which hatch in autumn following rain. They have up to five generations per year, between autumn and spring, and typically feed on the underside of leaves causing small holes or silvering the leaf. Lucerne is the preferred feed however they also feed on a range of winter crops and weeds such as capeweed, chickweed, shepherds purse and wild radish.

To reduce lucerne flea populations we can:

- Avoid killing predators of lucerne flea
- Consider resistant varieties

Notes:
Slugs

There are several types of slugs found in crops and pasture. Rather than repeat details here, readers are referred to the GRDC BackPocket Guide 2006.

Notes:

Wireworms and false wireworms *Elateridae and Tenebrionidae*

Wireworms are so called because the worm-shaped larvae are actually very tough-skinned insects. They are beetles, not soft worms. The two names refer to the larval stages of two different groups (families) of beetles.

True wireworms are juvenile click-beetles (*Elateridae*) while false wireworms are juvenile tenebrionid beetles (*Tenebrionidae*). There are actually thousands of species in each of these families and only a very few are actually recorded as pests. Pest species include several species of *Gonocephalum, Pterohelaeus, Adelium* and the smaller *Isopteron punctatissimus*. *Isopteron* has been regarded as a serious pest of canola but it is often difficult to find because of its small size.

Both wireworms and false wireworms are relatively long-lived native species with generation times ranging from one to seven or more years. The juvenile stages live in the soil for slightly less than one year to more than seven years depending on the species.

The larvae can damage germinating seed below the soil surface and the aggregating adults can also damage newly emerged seedlings. Despite this, the natural food source for these insects is probably rotting plant material.

Pest species of both wireworms and false wireworms appear to prefer poorly drained paddocks and they move vertically in the soil following moisture. They move up when the soil profile is wet in winter and down when the soil is dry in summer. This means they are near the soil surface when seed is planted after rains in autumn.
False wireworms are probably encountered as pests more than true wireworms. Adult beetles of these pest species like to come together (aggregate). Adult false wireworms such as *Gonocephalum* aggregate under shelter on the soil such as under clods of earth, rocks or timber. Many true wireworms aggregate at times in the same places or under bark.

Nothing known at present to reduce wireworm populations.

**Notes:**

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**European Earwig *Forficula auricularia***

![European earwigs](image)

Adult European earwigs grow to 12 to 15mm long and they have long, slender bodies with a pair of forceps on the tail. Males and females have different shaped forceps (males more solid and curved than the females). The wings are folded under wing covers on their back. Their bodies are dark red-brown and their legs are pale. Nymphs look like smaller versions of the adults.

There is one generation a year, with adults being inactive over summer, often forming aggregations in sheltered places. Nests of juveniles become active in winter and mature over spring. Sheltered positions such as cracked ground or under rocks, or paddocks with retained stubble will favour European earwigs.

Other earwigs can be beneficial (*Labidura truncata*) or minor pests (*Nala lividipes*) or benign (*Euborellia spp*).

To reduce European earwig populations we can:

- Bait before a susceptible crop is sown
- Avoid killing predators of pest earwigs.
Notes:

Blackheaded pasture cockchafer: *Acrossidius tasmaniae* (formerly *Aphodius tasmaniae*)

![Figure 7: Blackheaded cockchafer](image)

Adult beetles are shiny, dark brown to black beetles about 10 to 12 mm long. The females prefer to lay eggs in bare ground, and will lay more if they feed on animal dung, where sheep or cattle camp are likely to be more severely affected. Large flights of adult beetles occur on warm nights in summer.

Larvae are stimulated to hatch by rain in autumn. Initially the tiny larvae feed on organic matter near the soil surface and later feed on living plants. They form tunnels in the soil and emerge onto the soil surface at night to collect plant material. They take this material down their burrows to feed. One generation occurs per year, and larvae cease to feed around September when they turn into pupae.

Larvae are white-cream coloured C-shaped grubs with a shiny black or brown head. They have three pairs of legs.

To reduce blackheaded cockchafer populations we can:

- Avoid bare ground and overgrazing
- Concentrate insecticide use at the autumn break if insecticides are to be used.

Notes:
1.2.2 Resident beneficials

Predatory mites (*Bdellidae* and other species)

![Predatory mite](image1.png) ![Predatory mite and Red legged earthmite](image2.png)

The range of Australian native mites is extensive, many of which have not been named. The knowledge regarding identification and lifecycles is therefore incomplete. It can be assumed, however, that native mites are short lived and likely to have multiple generations per year.

Identification is difficult however as a generalisation if they look like a mite, are red and fast moving then they are probably predators and beneficial in an integrated pest management program.

To favour predatory mite populations we can:

- Avoid killing them with broad-spectrum insecticide applications.

**Notes:**

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Native earwigs *Labidura truncata*

*Figure 10: Native earwig (note orange marking behind the head)*

*Labidura truncata* (common brown earwig) is a predatory earwig with a distinctive orange triangular marking behind the head. The males have larger forceps than the females. There is only one generation per year, so populations can be slow to recover from a disturbance. Juvenile earwigs have the same body shape as adults, but are smaller.

The preferred food of these insects is soft-bodied prey such as caterpillars, but aphids and mites are also eaten.

To favour native predatory earwigs we can:

- Avoid killing them with broad-spectrum insecticide applications

**Notes:**
Carabid beetle

Figure 11: Carabid beetles (F. Carabidae) *Rhytisternus, Notonomus, Geoscaptus, Promecoderus*

Beetles in the family Carabidae are called carabid beetles or ground beetles. They are commonly black, with large forward-facing jaws and are usually predatory. The four genera described in Table 1 are those commonly found in western Victorian crops, but each district has its own particular set of species. They are relatively long-lived, with only one generation per year. Juveniles live in the soil and are long and worm-like.

Each species is favoured by certain conditions and so some are more abundant in crops than pastures. Some, such as *Rhytisternus* and *Notonomus* are generalists, that will scavenge dead species as well as eating live prey. These insects have received very little study until now.

To favour carabid beetle populations we can:

- Avoid killing them with broad-spectrum insecticide applications
- Maintain native plants on the farm (grassland as well as trees)

Notes:
1.2.3 Transient pests

Heliothis caterpillars (*Helicoverpa armigera; Helicoverpa punctigera*)

There are two species of Heliothis (now more precisely called *Helicoverpa*) that cause problems in Australian crops. One is a native species called native budworm and the other is an insecticide resistant pest that is becoming more significant each year (corn earworm).

Heliothis moths usually migrate on warm winds in late spring and autumn. The female moths lay eggs about the size of a grain of sand and a caterpillar can hatch in about a week (depending on temperature). The caterpillars grow larger and can reach pupal stage in three to four weeks.

Damage can occur when the caterpillars begin feeding on the heads of cereals or pods of other crops.

There is little that can be done to prevent heliothis moths invading crops, but control can be improved by:

- Monitoring for the moths with pheromone traps
- Targeting small caterpillars if they are present
- Maintaining predators and parasites in the crop
- Use selective insecticides

Notes:
Armyworms:

![Figure 13: Armyworm](image)

There are three species common in southern Australia. These are:

- Common armyworm (*Mythimna convecta*)
- Southern armyworm (*Persectania ewingi*)
- Inland armyworm (*Persectania dyscrita*).

Adult moths fly on warm nights in autumn and again in September – October and lay eggs in dried grass. The eggs take from one to three weeks to hatch and then the caterpillars begin feeding.

Armyworms can be distinguished from other caterpillars by the following features:

- three white stripes behind the head and on the tail,
- three light stripes running the length of their bodies and
- no obvious hairs.

They can occur in large numbers in cereals and pasture grasses and when they have locally depleted supplies of food, march into adjacent areas (hence the name). Caterpillars range in size from 2 to 40 mm long.
Armyworm caterpillars normally feed on leaves and in winter, cereal crops can be affected. In spring, seed-heads may be lopped (particularly barley).

To reduce armyworm caterpillar populations we can:

- Monitor for small caterpillars
- Monitor for large caterpillars moving along borders

Notes:

Cutworms (Agrotis munda, Agrotis infusa, Agrotis ipsilon).

Figure 14: Cutworm
There are several species of moths that have caterpillars known as cutworms. The most well known of these moths is the Bogong moth (*Agrotis infusa*). Depending on the species and time of year, cutworms can have a life-cycle of a few weeks or many months. The caterpillars are plump and greasy-looking and when disturbed they curl up in a spiral, sheltering in the soil during the day and come out to feed at night. They ‘cut’ leaves or stems of seedlings and attempt to drag these underground. These caterpillars are very tough and can even survive rotary hoeing in horticultural crops.

To reduce cutworm caterpillar populations we can:

- Ensure ground is weed free before planting a new crop
- Monitor for cutworm caterpillars in fodder crops ahead of cereals or canola.

**Notes:**

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**Rutherglen bugs** *Nysius vinitor*
Adult Rutherglen bugs are narrow-bodied, grey-brown insects approximately 3 to 4mm in length with the wings folded flat along the back. Juveniles are dark red and look rounded or swollen. From egg to adult can take as few as four weeks under ideal conditions, although typically only one generation occurs in southern Victoria.

Rutherglen bugs overwinter as adults and commence breeding in spring. Large migratory flights occur in November - December as their host plants dry out. They are a true bug and so are sap-sucking insects like aphids. They can cause direct damage by feeding or be a grain contaminant due simply to their presence.

Rutherglen bugs breed on weeds such as wireweed and capeweed. Their habit of invading en masse tends to overwhelm resident predators. There are no useful biological agents for Rutherglen bug control.

To reduce Rutherglen bug populations we can:

- Consider border sprays
- Reduce capeweed and wireweed

Notes:
Diamondback moths *plutella xylostella*

![Diamondback moth caterpillar](image)

Diamondback moths are small grey-brown moths with a distinctive diamond pattern on their wings. Wings are held close to the body, not out flat like many other moths. Eggs are yellow, laid on brassica plants, where they develop from tiny caterpillars to large green caterpillars (about 12mm long) that curl into a horse-shoe shape if disturbed. The pupa spins an elaborate lace-like cocoon. From egg to adult can take as little as three weeks in warm weather but can be more than eight weeks over winter.

To reduce diamondback moth populations we can:

- Remove brassica weeds
- Remove any flowering weeds
- Encourage predators and parasites

Notes:
**Aphids**

*Aphididae*

Aphids are sucking insects that feed on plant sap. This is a protein-poor diet which causes the aphids to excrete a sugary waste called honey-dew, deposits of which encourage sooty-mould in crops and pastures. Aphids can form large colonies of wingless individuals (often all females) and only form winged individuals when they detect that the season or the plant conditions require that they migrate away from the plant.

To reduce aphid populations we can:

- Avoid planting vulnerable crops such as BYDV susceptible barley when major flight activity is known to occur.
- Use a seed dressing

**Notes:**

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1.2.4 Transient beneficials

These true bugs\(^1\) *F. Hemiptera* are voracious predators that kill prey by stabbing them with their curved mouthparts, then sucking up the contents of the unfortunate victim. They are slender, pencil shaped insects, the adults have wings that are folded along the body and the immature nymphs look like smaller, wingless versions of the adult. All stages are a grey-brown colour. Their preferred food is caterpillars.

To favour damsel bug populations we can:
- Avoid the use of broad-spectrum insecticides

Notes:

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\(^1\) A true bug is a scientific term for insects in the family *Hemiptera*
Shield bugs *Oechalia schellenbergii*

![Figure 19 Shield bug](image)

The shield bug is similar to the damsel bug in that it is a predatory species of true bugs with sucking mouthparts. The adult shield bug is easily recognised by the large spikes behind the head (its ‘shoulders’). The immature nymphs have bright red marks on their backs that are not visible on the adult. They are larger and more stout than damsel bugs. Shield bugs are also known as stink bugs.

The eggs of this species are laid in closely packed batches and are metallic black with white spines around the rim of each egg. They are usually laid in multiples of fourteen.

A closely related species is the glossy shield bug (*Cermatulus nasalis*). Adults are similar to the predatory shield bug without the spikes behind the head. The eggs of the glossy shield bug are also metallic coloured with white spines, however they are usually laid in batches of fifty and have short white spines.

To favour shield bug populations we can:
- Avoid the use of broad-spectrum insecticides

**Notes:**

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Parasitic wasps

There are many different species of parasitic wasps. They are usually very host specific so there are quite a few species that are important in different systems. The wasp attacks by stinging the host and in doing so lays one or more eggs inside the prey. The maggot stage of the wasp develops inside the host until it kills it which may take several weeks. The maggot then forms a pupa, either inside or just outside the host. In some species many wasps may develop in the one host.

To favour parasitic wasps we can:
- Avoid the use of broad-spectrum insecticides

Notes:
Ladybird beetles

Four species which occur in Victorian crops are the common spotted ladybird (*Harmonia conformis*) the transverse ladybird (*Coccinella transversalis*), the minute two-spotted ladybird (*Diomus notescens*) and also the recently introduced species, *Hippodamia variegata*.

The common spotted ladybird is larger than the others, and is orange with black spots. The transverse ladybird can be orange or red with black blotches rather than spots. The minute two-spotted ladybird is, as its name suggests, a very small black ladybird with two orange-red spots. Hippodamia has two small white patches just behind the head. The juvenile ladybird is very different to the adult.

To favour ladybird populations we can:
- Avoid the use of broad-spectrum insecticides

Notes:
Brown lacewings *Micromus tasmaniae*

Native brown lacewings are abundant in many crops and native vegetation. The adults have delicate, lacy brown wings and are about 10 mm long. The immature stages (larvae) look completely different to the adults with long, thin bodies and prominent jaws at the front of the head. They are sometimes called ‘insect crocodiles’ because of the shape. They lay cream-coloured eggs singularly (and flat) on the underside of leaves.

To favour brown lacewing populations we can:
- Avoid the use of broad-spectrum insecticides

Notes:
1.3 Benign invertebrates.

Many insects in a pasture or crop are benign, pose no threat to the crop or pasture and therefore can be ignored. Common benign invertebrates found in crops and pastures include many thousands of species of flies and wasps, soil dwelling mites and many beetles.
Section 2: Monitoring of pest and beneficial predators.

The purpose of monitoring is to collect information on pest and beneficial numbers in a paddock in order to make informed decisions about what actions, if any, are necessary. Monitoring needs to be conducted on a regular basis so that decision-making can be precise, timely and take into account pest and beneficial numbers, their maturity and population trends.

Monitoring can be further enhanced by combining pest counts with observations of crop damage.

It is important to remember that the presence of a pest does not necessarily indicate a pest problem.

2.1 Identification and maturity of pest and beneficial predators

The first and fundamental role of insect monitoring in crops and pastures is to correctly identify pests and beneficial predators. Many apparent control failures may be due to inappropriate treatment because of mis-identification of the pest or an apparent beneficial predator.

Section 1 should assist in making the identification of:
- important crop and pasture pests and their stage of maturity
- important beneficial predators for the crop and pasture pests and their stage of maturity
- insects that are of no consequence (benign) and can be ignored.

2.2 Numbers of pests and beneficial predators

The monitoring needs to take into account an approximate number of pests and beneficial species. For the larger species such as slugs and earwigs they are relatively easy to see. However for the smaller insects such as red legged earth mite and lucerne flea a hand-lens (magnifying glass) is required to distinguish pests from beneficials.

In an IPM approach population thresholds are not used to determine what action to take. The critical factor is the relative number of beneficial species and target pest. For example if monitoring reveals pests, even at low numbers, but no beneficials, then consideration of chemical support would be justified. However, if the same number of pests occurred but there was also a range of beneficial species present, then the decision may be different.
2.3 Trends

Monitoring needs to examine the trends in pest and predator populations rather than absolute numbers of pests. That is, are the relative numbers of pests increasing or decreasing in relation to the appropriate beneficial species? This can only be determined if regular monitoring is undertaken and the result of each inspection is recorded.

2.4 Symptoms of crop damage

The first signs of pest problems are often symptoms of damage rather than observations of large numbers of pests. It is important to recognise that almost identical symptoms can be caused by a range of pests and therefore it is necessary to identify the cause of the damage. For example in a canola crop slugs, european earwigs, birds and tenebrionid beetles cause identical damage to the crop and can all be active at the same time of year. Therefore it is vital to work out which of these are the primary cause of the crop damage (usually this is only one or two pests) and whether the less prevalent pests need treating as well (unusual but possible).

Monitoring for crop damage can have its limitations, especially at crop establishment as the pest can often remove all of the emerging plant material. However for some establishing crops, damage to the leaf can help identify the pest species that are present.

The signs of damage caused by slugs, European earwigs, lucerne flea and red legged earthmite is illustrated.

![Figure 28 Crop damage caused by slugs](image1)
![Figure 29 Damage to emerging canola leaves caused by Earwigs](image2)
![Figure 30 Damage to canola leaves caused by Lucerne flea](image3)
![Figure 31 Damage to clover leaves caused by red legged earthmite](image4)
Observed crop damage can be further complicated by other factors such as herbicide burn, effects of seed dressings, hail damage and waterlogging, especially in young plants.

While it is unrealistic to expect high levels of detail about all species in a crop or pasture, these aspects must be considered.

2.5 Monitoring in the field

Different monitoring methods are required for different pests and beneficials which can be used to build an accurate picture of the beneficial and pest populations over time. This needs to correspond to the lifecycle and habits of the designated pest.

Some common monitoring methods that can be used to look for invertebrates:

- Ceramic tiles
- Hessian sacks
- Under the leaves of broadleaf plant
- Puddles after rain
- Yellow sticky fly paper
- Sweep nets
- Direct search

2.5.1 Monitoring for pests

Monitoring is generally best undertaken from the autumn break to before the onset of summer. For some species (eg slugs) cold times during mid winter should be avoided, while for others (eg RLEM) winter is a useful time. The suggested monitoring time and method for a range of crop and pasture pests is listed in table 3.
### Table 3: Suggested monitoring methods and timing for pest invertebrates.

<table>
<thead>
<tr>
<th>Pest</th>
<th>Type</th>
<th>Monitoring method</th>
<th>When to look</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redlegged earth mite</td>
<td>Resident</td>
<td>Check on broadleaf plants.</td>
<td>Mid winter until mid spring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Puddles of water</td>
<td></td>
</tr>
<tr>
<td>Blue oat mite</td>
<td>Resident</td>
<td>Check on broadleaf plants.</td>
<td>Mid winter until mid spring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Puddles of water</td>
<td></td>
</tr>
<tr>
<td>Lucerne flea</td>
<td>Resident</td>
<td>Damage symptoms</td>
<td>Mid winter until mid spring</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slugs (black keel slug, grey Field slug)</td>
<td>Resident</td>
<td>Ceramic tiles or sacks</td>
<td>September to October</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wireworm</td>
<td>Resident</td>
<td>Ceramic tiles</td>
<td>In the previous season (once or twice a year would be sufficient).</td>
</tr>
<tr>
<td>False wireworm</td>
<td>Resident</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>European earwig</td>
<td>Resident</td>
<td>Ceramic tiles or sacks</td>
<td>October</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black headed cockchafers</td>
<td>Resident</td>
<td>Emergence tunnels</td>
<td>After the break</td>
</tr>
<tr>
<td>Heliothis caterpillars</td>
<td>Transient</td>
<td>Pheromone traps</td>
<td>September to May</td>
</tr>
<tr>
<td>Rutherglen bugs</td>
<td>Transient</td>
<td>Direct search</td>
<td>Late spring-early summer</td>
</tr>
<tr>
<td>Diamondback moth</td>
<td>Transient</td>
<td>Sweep net Pheromone traps</td>
<td>Spring to autumn</td>
</tr>
<tr>
<td>Aphids</td>
<td>Transient</td>
<td>Yellow sticky traps attached to the fence. This should be done weekly during flight times.</td>
<td>Autumn (if we have had an early break) and in early spring (avoid winter).</td>
</tr>
</tbody>
</table>
2.5.2 Monitoring for beneficial species

The monitoring of beneficial species is critical in an IPM approach. The suggested monitoring time and method for a range of beneficial species is listed in table 4.

**Table 4: Suggested monitoring methods and timing for beneficial invertebrates.**

<table>
<thead>
<tr>
<th>Beneficial Type</th>
<th>Type</th>
<th>Monitoring method</th>
<th>When to look</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carabid beetles (Rhytisternus, Notonomus)</td>
<td>Resident</td>
<td>Ceramic tiles</td>
<td>All year</td>
</tr>
<tr>
<td>Carabid beetles (Geoscaptus)</td>
<td>Resident</td>
<td>Ceramic tiles</td>
<td>All year</td>
</tr>
<tr>
<td>Predatory mites (Bdellidae and other species)</td>
<td>Resident</td>
<td>Puddle of water</td>
<td>All year</td>
</tr>
<tr>
<td>Native earwigs (Labidura truncata)</td>
<td>Resident</td>
<td>Ceramic tiles</td>
<td>Direct search</td>
</tr>
<tr>
<td>Brown lacewings (Micromus tasmaniae)</td>
<td>Transient</td>
<td>Sweep net</td>
<td>Early spring</td>
</tr>
<tr>
<td>Ladybird beetles (Harmonia, Coccinella, Hippodamia)</td>
<td>Transient</td>
<td>Sweep net</td>
<td>Direct search</td>
</tr>
<tr>
<td>Parasitic wasps</td>
<td>Transient</td>
<td>Sweep net</td>
<td>Spring - autumn</td>
</tr>
</tbody>
</table>
Section 3: Development of possible IPM strategies.

Integrated Pest Management involves combining three control methods to achieve pest control. These are:

- beneficial predators and parasites as primary control agents
- appropriate farm practices to encourage beneficial populations and discourage pests
- the strategic use of selective insecticides.

There are often several beneficial species (refer to tables 1 & 2), a range of farm practices as well as several insecticide options that could be used to control specific pests. Some farm practices and insecticide options need to be adopted in earlier crops to reduce pest populations before the susceptible crop is sown. This means there are many possible combinations that could be employed to achieve pest control. Consequently it is not possible to give a ‘recipe’ of how to control a certain pest in a crop or pasture. These notes describe a logical process to adopt when developing an IPM approach.

Sections 3.1 to 3.3 describe a range of control options under the headings of beneficial predators, farm management practices and insecticides.

Section 3.4 provides an example of how an IPM approach for a specific crop can be developed, with additional blank worksheets to create further IPM strategies.

3.1 Beneficial predators

The identification of some beneficial species that prey on crop and pasture pests has been dealt with in section 1.1. In this section there is a distinction between resident and transient insects. Appreciating the difference between resident and transient insects is important as it can influence the effectiveness of some farm practices. It can also influence the choice of insecticide that might be used.

3.2 Farm Management Practices

Many farm management practices can be used in an IPM program. The objective of adopting these practices is to create an environment that is hostile to the pest and/or favourable to the beneficial predators we wish to encourage. Understanding the life cycle of both the pests and beneficial predators is essential. Section 1.1 provides some background that can be used when considering the impact of different farm practices. Identifying the ‘Achillies heal’ of the pest and trying to exploit this weakness is the key to effective management practices.

Some of the common farm management practices that can be used in an IPM approach and the desired effect of these practices are discussed briefly. This is not an exhaustive list, other options are also possible.

3.2.1 Burning

The objective of burning is to remove food and shelter for pests. It also removes shelter for beneficial species such as predatory earwigs and carabid beetles however, so may not achieve a positive response in the long term.
3.2.2 Cultivation
Cultivation can be used to physically damage the pest, expose them to predation, destroy food, shelter and breeding habitat. However, as for burning, it can have detrimental effects on beneficial species as well.

3.2.3 Rolling
Rolling has been used by some farmers to target slugs and snails. The rolling crushes the pest but requires the species to be active on the surface when rolling is undertaken.

3.2.4 Retaining organic matter on the soil surface
Increasing organic matter has two effects. Firstly it improves the shelter offered to beneficial species and also provides the prospect of increased food supply. The improvement in food and shelter is known as increased habitat complexity and does enhance beneficial species populations. Unfortunately it also favours the survival and breeding of some pests.

3.2.5 Weed control
Weed management can assist with control of pests. Removal of certain weeds can reduce the source of feed as well as disrupt breeding sites. For example the removal of capeweed can reduce populations of red legged earthmite and lucerne flea and residual grasses affect the populations of cereal aphids.

Optimising the benefits of weed removal generally means spraying well before the susceptible crop is planted. The may require control a year or more before to prevent oversummering survival of pests such as red legged earthmite and cockchafers.

3.2.6 Grazing
Grazing can be used to remove foliage on which pests are feeding. Grazing management is also critical in the control of both blackheaded and redheaded pasture cockchafers and cutworm caterpillars. The adults of each species have distinct preferences for where they lay their eggs. Adult blackheaded cockchafers prefer bare ground while adult redheaded cockchafers and cutworm moths prefer standing stubble or rank pasture. Grazing will also help reduce large populations of red legged earthmite.

3.2.7 Crop rotations
Crop rotations can have a massive impact on pest numbers. Some rotations will favour pests, others will hinder their increase. The reduction in pest numbers may be a result of reduction of a food source, but it can also involve a specific crop favouring predators and parasites. Consideration should also be given to current crop selection in a rotation where pests may not be causing current economic damage but will in subsequent susceptible crops.

3.2.8 Time of planting
Planting times can influence the potential economic damage caused by pests. For example a late sowing of cereals can avoid pests such as cereal aphids by planting after the time the aphids have flown. In contrast, early sowing of crops such as canola allows for rapid plant growth, reducing the time the crop is in the vulnerable stage and susceptible to pest damage.

3.2.9 Pest resistant crops
Variety selection can completely eliminate the need for insecticides to control certain pests. There are many examples of aphid resistant strains of plants including lucerne and cereals.
The resistance either prevents the pest from feeding on the plant so they starve or prevents their ability to reproduce.

3.2.10 Alternative food sources for pests
Trap crops have been used by some cotton farmers to help reduce the number of pests attacking the main crop or pasture. This involves establishing a plant that is more attractive to the pest than the sown crop, for example lucerne, so the pests preferentially attack the lucerne crop being grown. Caution needs to be taken if adopting this approach to ensure the alternative food source does not simply improve the pest population. This requires a sound knowledge of the pest, its preferences and breeding cycles. There are no commonly used trap crops known for crop and pasture production systems at the moment.

3.2.11 Others approaches
Press wheels are a very useful tool in cropping to reduce problems from establishment pests. They improve the speed of germination, reducing the time the crop is in its most vulnerable establishment phase. They also improve soil-seed contact, which creates a physical barrier that prevents some pests reaching the germinating seed.

3.3 Insecticides
Insects and mites are the main beneficial species in an IPM program. They are affected (killed) by almost all of the commonly used insecticides and miticides in cropping and pasture programs. These beneficial species are often more vulnerable than the target pests because the predators will often consume dead and dying insects and be killed by secondary poisoning. They are also usually killed by lower doses of insecticide than the target pests.

Insecticides can be used to great effect in an IPM program. More consideration however is given in this type of program to the way an insecticide is delivered to the target pest, for example through baiting, seed dressings or border sprays, and to the degree of selectivity and residual nature of the chemical used.

3.3.1 Broad spectrum insecticides
As the name suggests broad spectrum insecticides kill a wide range of species, both pests and beneficial species. Many also have long periods of residual action.

Some commonly used crop and pasture insecticides are listed (table 5).

Table 5: Commonly used pesticides in crops and pastures, their toxicity to beneficial species and residual action

<table>
<thead>
<tr>
<th>Insecticide group</th>
<th>Examples from the group</th>
<th>Toxicity to beneficial species</th>
<th>Residual action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthetic Pyrethroids</td>
<td>Ambush, Fastac, Dominex, Cymbush, Karate</td>
<td>High</td>
<td>Long</td>
</tr>
<tr>
<td>Organophosphates</td>
<td>Lorsban, Malathion, LeMat Rogor</td>
<td>High</td>
<td>Long</td>
</tr>
<tr>
<td>Organochlorine</td>
<td>Endosulfan</td>
<td>High</td>
<td>Short</td>
</tr>
</tbody>
</table>
Broad spectrum insecticides can have far reaching effects on the insect population in any crop and pasture environment. One application can impact upon resident beneficial species that have long breeding cycles such as carabid beetles. Affecting how quickly populations of resident beneficial species begin to increase after spraying. This is less of a concern with transient species as they can be expected to arrive in every crop each year.

An insecticide targeted at one pest (eg aphids) can detrimentally affect the beneficial species helping to control other pests (eg carabid beetles controlling slugs).

Secondary pest problems can be created by the use of an insecticide. This is called pest flare and is well documented for a range of pests in horticulture. The same response is seen in crops and pastures. For example in barley, sprays are commonly used at four and eight weeks post sowing as a preventative measure to combat aphids which carry the Barley Yellow Dwarf Virus (BYDV). This approach can create an outbreak of another pest that originally was not a problem (figure 32). Figure 32 shows that the population of lucerne flea increased in areas where the barley crop was treated for aphids, whereas the numbers of lucerne flea increased, but not to the same extent in another area of the same crop that was left untreated. In the untreated area the lucerne flea were controlled by a natural predator (lacewings) already present in the crop. It appears that the broad spectrum insecticide removed the natural predator of the lucerne flea, creating an outbreak of an insect peststhat were initially not of concern.

Figure 32: Comparison of the number of lucerne flea trapped per week after sowing barley with application of broad spectrum insecticide for aphid control at 4 weeks and 8 weeks compared to no spraying.

Source: Bree Walshe, LaTrobe University
3.3.2 Selectivity of insecticides

There are very few selective or ‘softer’ insecticides registered for use in broad acre crops and pasture. The products are usually more expensive than the broad spectrum insecticides.

The selective pesticides currently registered in crops and pastures are listed (table 6). Refer to the label for information on the target pests, application rate and timing.

**Table 6: Selective pesticides in crops and pastures, their toxicity to beneficial species and residual action.**

<table>
<thead>
<tr>
<th>Insecticide group</th>
<th>Examples from the group</th>
<th>Toxicity to beneficial species</th>
<th>Residual action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pirimicarb</td>
<td>Pirimor</td>
<td>High to parasitic wasps</td>
<td>Short</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low to most predators</td>
<td></td>
</tr>
<tr>
<td>BT <em>(Bacillus thuringiensis)</em></td>
<td>Delfin, Dipel, XenTari</td>
<td>nil</td>
<td>nil</td>
</tr>
</tbody>
</table>

A wider range of selective insecticides are used in the horticulture industry but unfortunately are not currently registered for crops and pastures. Information is available on the control of certain pests and the impact the insecticide will have on other beneficial species. Useful sources of this information are:

- Good Bug Book (Australasian Biological Control Inc)
- www.koppert.com

New information on selective herbicides is constantly emerging. To cater for this a blank table is provided to record changes in insecticide registrations (appendix 1).

3.3.3 Timing of insecticide delivery.

The timing of insecticide application can influence both the type and dose of insecticide required. Targeting an appropriate life stage can significantly reduce the amount or effectiveness of insecticide required. Examples include TimeRite® for the control of red legged earthmite, which targets the pest when all insects have hatched but before over summer egg laying occurs or using BT sprays where at the recommended does rate is more effective on small caterpillars rather than larger individuals.

3.3.4 Alternative methods of insecticide delivery.

Boom spraying is not the only method that can be employed to deliver both broad spectrum and selective insecticides. The most common is the use of baits and seed dressings, but border sprays can also be effective for certain pests.

3.3.4.1 Baits

Baits are intended to targeting specific pests while minimising contact with species. This can enable some broad spectrum (harsher) insecticides to be used. Baits in broad acre
cropping and grazing are either pre-prepared for example slug baits, or formulated, commonly using grain as a base.

The most common use of baits are for slugs, earwigs, grasshoppers and crickets.

3.3.4.2 Seed dressings
The use of insecticide seed dressings in crops and pastures is a rapidly emerging practice. The primary aim is to provide protection to the newly emerging plant at the vulnerable seedling emergence stage. Currently the most common seed dressing for crops and pastures is Imidacloprid and is registered for use in cereals, canola, forage brassicas and pastures.

Seed dressing insecticides are often mixed with fungicides and other products for example inoculants, which make the potential combinations of products and interactions complex. It is recommended that information from the manufacturer is consulted before mixing seed dressings.

3.3.4.3 Border spraying
Border sprays can be effective for pests that invade crops from adjacent areas. Pea weevils are the most common pest treated with border sprays, but this approach can also be effective for red legged earthmite and blue oat mite.

3.4 IPM strategies for specific crops

The range of beneficial predators, farm practices and insecticides makes it impossible to take a ‘recipe book’ approach to pest control. The alternative is to identify the range of practices and approaches that are likely to have success in a certain crops or pasture and then, depending on the circumstances, adopt appropriate actions.

Suggested steps for developing a crop pest strategy:

Step 1: Choose a crop

Step 2: List the common pests for the crop.

Step 3: Identify the beneficial species that can help control the pest (section 1, tables 1 & 2).

Step 4: Identify farm practices that discourage pest populations and encourage beneficial species (section 3.2). A description of insect life cycles (section 1.2) is valuable in formulating appropriate actions to undertake, both for the pest and beneficial species. Also be aware that some actions may need to be taken the season before establishment.

Step 5: List the insecticides that can be used in conjunction with the application method and possible timing eg boom spray, bait or seed dressing (section 3.3).

Step 6: Identify the appropriate monitoring techniques and timing for the pests and beneficial species (section 2.5).

An example for a sown lucerne pasture is provided (table 7). Additional blank sheets are contained in appendix 2 to complete other crops and pasture of choice.
**Table 7: Hypothetical IPM strategy for lucerne**

**Crop type: Lucerne (step 1)**

<table>
<thead>
<tr>
<th>Pests commonly found in target crop (step 2)</th>
<th>Beneficial predators of the identified pests (step 3)</th>
<th>Possible farm practices to discourage pests and/or encourage beneficial species (step 4)</th>
<th>Possible insecticides to use (step 5)</th>
<th>Monitoring methods (step 6)</th>
</tr>
</thead>
</table>
| Red legged earthmite                        | Predatory mites (*Bdellidae* and other species) Native earwigs (*Labidura truncata*) | Before establishment:  
  - Broadleaf weed control, especially capeweed the year before sowing  
  After establishment  
  - Grazing to remove foliage  
  - Border spray if pest is invading from a neighbouring area. | Seed dressing with Imidacloprid | Check on broadleaf plants and puddles of water the season before  
  Check soil surface and cotyledons after sowing  
  Check silvering of leaves on older plants |
| Lucerne flea                               | Predatory mites (*Bdellidae* and other species) Native earwigs (*Labidura truncata*) | Before establishment:  
  - Broadleaf weed control, especially capeweed the year before sowing. | Seed dressing with Imidacloprid | Damage to cotyledons after sowing and mature leaves |
| Aphids                                     | Brown lacewings (*Micromus tasmaniae*) Ladybird beetles (*Harmonia, Coccinella, Hippodamia*) Parasitic wasps (*Aphidius* species) | After establishment  
  - In mature stands graze foliage to reduce feed source. | Seed dressing with Imidacloprid | Yellow sticky traps attached to the fence, weekly during flight times.  
  Check for distortion of plant leaves (weekly basis). |
4. Deciding which IPM tactics to use

The strategies developed in section 3 identified a range of tactics that could be used in an IPM program. A decision still needs to be made if any of these tactics should be implemented.

The decision to adopt a certain IPM approach is not based on simple pest thresholds. In IPM, decisions are made based on a judgment of the risk that the pest will cause economic damage and that the control options chosen are the most cost effective in both the short and long term. Some of these decisions may involve adopting preventative measures and may rely on previous experience of pests and crop damage.

The Flow chart presented in Figure 33 may assist in determining the actions to take. After completing the flow chart, the only option may be to use a non selective insecticide. If this is the case then the following considerations should be given when choosing the insecticide to use:

- What will the non-selective insecticide kill in terms of beneficial species and what pest problems may occur as a result of their loss (secondary pest flare)?
- What is the cost of control of these pests in the near future or in the next crop? Is it possible that the more expensive insecticide could be less costly than trying to treat on-going pest problems, especially if insecticide resistant pests are involved.
- What residual toxicities do the insecticides that are available for use have? Choosing an insecticide with the least residual activity will allow re-invasion of beneficial species more rapidly than would occur with a longer residual chemical.

Even if a broad spectrum insecticide is used, it is important to continue monitoring to determine the impact on other pests and the beneficial species.
Figure 33: Flowchart to assist with IPM decision making

1. **Identify the pests.** Previous monitoring and paddock history will help inform this decision (consider both the primary pest and other pests).

2. **Are there beneficial species that could control the pest in the short-term or long-term?**

3. **Are there sufficient pests to cause an economic loss (not just crop damage)?** This is a judgement each individual will have to make – see appendix 3.

4. **Are there selective, cost effective insecticides available to spray?**

5. **Are there baits, seed dressings, border sprays or other farm practices that could be used?**

   - **YES**
     - **SPRAY SELECTIVE INSECTICIDE**
     - **Continued Monitoring**
   - **NO**
     - **USE BAIT, SEED DRESSING, BORDER SPRAY OR OTHER FARM PRACTICES**
     - **USE A NON SELECTIVE INSECTICIDE**
5. **Paired paddock program**
This course is designed to give participants the confidence to adopt the principles of IPM. This requires knowledge but also the experience of seeing IPM in action.

A ‘paired paddock’ approach is an important part of this course, groups apply an IPM approach to part of a paddock and to compare this to the traditional approach that might have been used in the past.

The areas selected for comparison is not prescribed, nor are the treatments you may wish to compare. It is up to the individual to choose the comparison (with expert support) and then monitor the effect.

A diary will be supplied to all participants to record information about the paddock being treated.
Appendix 1: New pesticides for use in crops and pastures

<table>
<thead>
<tr>
<th>Insecticide</th>
<th>Target pests</th>
<th>Toxicity to beneficial species</th>
<th>Residual action</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>
Appendix 2: Tables for completing IPM strategies

Crop type:

<table>
<thead>
<tr>
<th>Pests commonly found in target crop</th>
<th>Beneficial predators of the identified pests</th>
<th>Possible farm practices to discourage pests and/or encourage beneficial species</th>
<th>Possible insecticides to use</th>
<th>Monitoring methods</th>
</tr>
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<tbody>
<tr>
<td></td>
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Tables for completing IPM strategies

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Crop type:

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### Tables for completing IPM strategies

**Crop type:**

<table>
<thead>
<tr>
<th>Pests commonly found in target crop</th>
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Tables for completing IPM strategies

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Integrated Pest Management in cropping and pastures – course notes
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Tables for completing IPM strategies

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*Integrated Pest Management in cropping and pastures – course notes*
Appendix 3: A method of assessing pest risk to a crop or pasture

Many organizations use standard risk analysis to inform the decisions they make. The widely accepted definition of risk involves considering the likelihood of damage occurring and the consequences if it does occur. That is:

**Risk = Likelihood X Consequence**

Assessing the likelihood of pest attack

Assessing the likelihood of a pest attack needs to take into account results from insect monitoring, paddock history and seasonal conditions. In the case of IPM, the monitoring must include correct identification of the target pest, the stage in its lifecycle and also the abundance of beneficial predators of that pest. It is important to also identify other pests that may increase if beneficial predators are inadvertently killed when trying to control the target pest (secondary pest flare).

Collecting accurate numbers of pests and predators is often difficult, so it is useful to think about the pests and predators in descriptive terms. A scale can be developed to assess the likelihood of crop damage by a target pest (table A3.1)

Table A3.1: Descriptions of likelihood of crop damage by a target pest

<table>
<thead>
<tr>
<th>Likelihood of crop damage</th>
<th>Description</th>
</tr>
</thead>
</table>
| Certain                   | o Target pest is present in very high numbers or is at a development stage that could cause major damage.  
o Very few or no beneficial species are present.  
o Paddock history suggests the pest is a major problem.  
o Other secondary pests are also present.  
o Conditions / season is very conducive to target pest |
| Likely                    | o Target pest is present in high numbers or at a development stage that could cause damage.  
o Some beneficial species are present  
o Paddock history suggests the pest has been a problem in the past.  
o Other secondary pests are also present but so are beneficial species of that pest.  
o Conditions / season is conducive to the target pest |
| Possible                  | o Target pest is present but not in large numbers or at a development stage that could cause major damage.  
o Beneficial species are present  
o Paddock history indicates the pest has been a problem on occasions but not each year.  
o Very few secondary pests but some beneficial species are present.  
o A change in seasonal conditions may alter pest populations |
| Unlikely                  | o Target pest is present in low numbers or at a development stage that will not cause significant damage to the crop.  
o Beneficial species are present in good numbers |
o Paddock history indicates the pest has only been a problem on odd occasions.
o Very few secondary pests but some beneficial species are present.
o A change in seasonal conditions will have little or a negative impact on pest populations

Rare
o Difficult to find the target pest and beneficial predators of the pest are in abundance.
o Paddock history would indicate no prior problems with this pest
o Very few or no secondary pests and good populations of beneficial predators of these pests
o Climatic and seasonal conditions are not favourable to pest build up.

Assessing the consequence of pest attack on a crop

Assessing the consequence of a pest attack is more straightforward (table A3.2)

Table A3.2: Descriptions of the consequence of pest damage to a target crop

<table>
<thead>
<tr>
<th>Consequence of pest damage</th>
<th>Description</th>
</tr>
</thead>
</table>
| Catastrophic               | o Target crop is wiped out and has to be resown.  
o Economic loss is total |
| Major                      | o Target crop is severely damaged and many plants will not recover.  
o Economic loss is significant |
| Moderate                   | o Target crop shows visible signs of damage and there is some loss of the target crop, however some plants will survive and eventually recover from the pest attack.  
o Some economic loss |
| Minor                      | o Patches of damage in target crop and visual signs of pest damage to other plants, but crop should recover.  
o Minor economic loss |
| Insignificant              | o Very minor visual damage to target crop and plants will recover.  
o No economic loss expected. |

Assessing crop risk

Combining the likelihood and consequence ratings provides an indication of risk. To simplify the risk assessment the following table has been developed (table A3.3).

Table A3.3: Descriptions of the consequence of pest damage to a target crop
Consequence of pest damage to a target crop

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Catastrophic</th>
<th>Major</th>
<th>Moderate</th>
<th>Minor</th>
<th>Insignificant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain</td>
<td>VH</td>
<td>VH</td>
<td>H</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Likely</td>
<td>VH</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>L</td>
</tr>
<tr>
<td>Possible</td>
<td>H</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td>Unlikely</td>
<td>M</td>
<td>M</td>
<td>M-L</td>
<td>L</td>
<td>VL</td>
</tr>
<tr>
<td>Rare</td>
<td>L</td>
<td>VL</td>
<td>VL</td>
<td>VL</td>
<td>VL</td>
</tr>
</tbody>
</table>

VH = Very high  
V = High  
M = Moderate  
L = Low  
VL = Very low

The risk assessment should then guide if any IMP tactic or tactics should be employed. The higher the risk, the more important it is to choose one or more tactics identified in the IPM strategies developed in section 3.