I SPY

This document is part of a larger publication "I Spy – Insects of Southern Australian Broadacre Farming Systems Identification Manual and Educational Resource" (ISBN 978-0-6482692-1-2) produced under the National Invertebrate Pest Initiative (NIPI) and is subject to the disclaimers and copyright of the full version from which it was extracted. The remaining sections and the full version of this publication, as well as updates and other legal information, can be found at https://grdc.com.au/ by searching for "I SPY".

The development of this edition of I SPY has been possible due to the financial support from:

NATIONAL INVERTEBRATE PEST INITIATIVE

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Plant Health AUSTRALIA

cesar

Government of South Australia
Primary Industries and Regions SA

SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

GOVERNMENT OF WESTERN AUSTRALIA
Department of Primary Industries and Regional Development

SECTION 2

Basic Insect Taxonomy, External Anatomy, Lifecycles and Development

The key taxonomic features that separate invertebrates from other groups of organisms are presented in this section. The overall body plan is illustrated, as well as the two distinct insect lifecycle types and associated morphology.

Taxonomy – a filing system for all living things

Understanding some basics about taxonomy will help you understand the different terms for invertebrate groups, what they mean and how to identify them.

Taxonomy is the branch of science that sorts all organisms into groups (or taxa) based on their overall similarity and relatedness.

The hierarchy (Linnaean hierarchy) that all living organisms fit into has a minimum of seven levels (kingdom, phylum, class, order, family, genus, species), although there can be many more levels.

Table 2.1 (p. 3) lists the main taxonomic levels along with the broad classifications (distinguishing features that separate groups) for invertebrates.

The most distantly related organisms will be in different kingdoms (e.g. plants and animals) and the most closely related organisms are likely to be classified into the same genus. **No two creatures share the same scientific name**. The unique formal two-word scientific names we see are a creature's genus and species names.

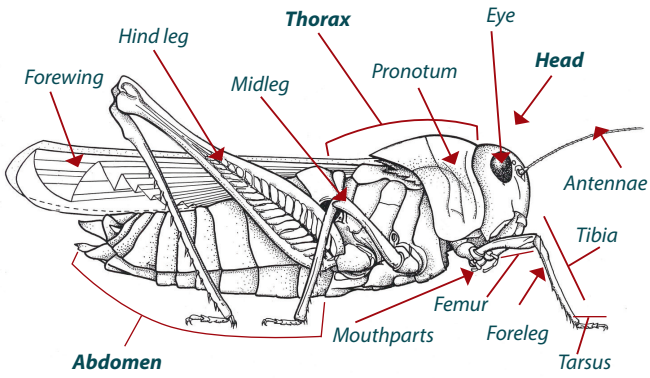
The generic (genus) is always given with a capital letter and the specific (species) is always lower case. Both are written in italics and after the first use in text, the genus name is often abbreviated to the first letter of the genus, e.g. *Myzus persicae* to *M. persicae*. Where the species name is not known with certainty, the genus name is given followed by 'sp.' for one species and 'spp.' for more than one species.

Insect body structure

Adult body form

To identify insects it is important to know their basic anatomy. Identification keys and insect classifications are often based on the adult form.

There are three distinct regions that make up the overall body plan of an adult insect; the head, thorax and abdomen. Some parts may be more distinct than others and particular insect orders/families/genera may have some structures absent, reduced or greatly modified.



Source: Modified from CSIRO (1991)

The **HEAD** is designed for both feeding and sensory purposes and consists of:

- one pair of compound eyes and up to three simple eyes (ocelli);
- one pair of antennae;
- mouthparts. Look for differences between chewing/biting, sucking and piercing mouth types (refer to section 3) - these are very important in identification.

The **THORAX** (middle division) is designed for locomotion and is made up of three segments (not always distinct). Each thoracic segment (pro-, meso- and meta-thorax) has a pair of legs (resulting in a total of six legs) and in almost all winged insects the last two segments of the thorax support a pair of wings. Wings are particularly important in identification. Flies only have one pair of wings that are carried on the middle thoracic segment. Some adults can have wingless forms (e.g. aphids).

The **ABDOMEN** (rear section) is the largest and softest of the three body parts and is designed to hold most of the internal organs vital to insect survival and reproduction. It contains:

- internal organs for respiration (spiracles) and digestion (stomach);
- reproductive structures which can often be used in identification (e.g. the presence of specialised stingers in wasp species);
- specialised appendages in some cases (e.g. pincers on earwigs).

Immature body form

It is often the juvenile stages that are the most damaging.

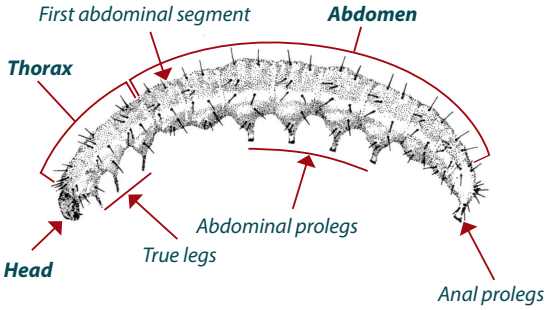
Juvenile insects can either look similar but smaller than mature adults or they can look completely different to the adults they will become.

While the head, thorax and abdomen are usually distinct in juvenile insects (nymphs) that undergo partial change (incomplete metamorphosis), they can appear merged in juvenile insects (larvae) that undergo a complete change (complete metamorphosis) with a pupal stage (see Lifecycles and development, p. 5, 6).

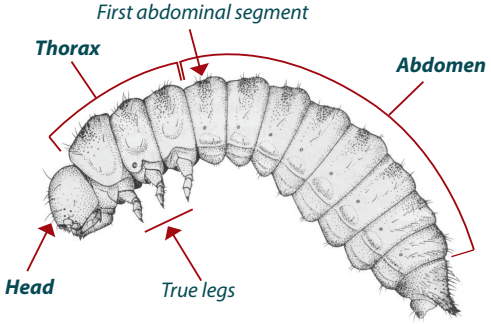
An easy way to locate the separate body regions in larvae is to look for the legs. True legs (which also become the adult legs) are always attached to the thoracic segments. However, not all insect larvae have 'true' legs (e.g. weevil larvae and fly larvae). Some insect larvae, particularly moth caterpillars, have fleshy projections on their abdomen that resemble legs. These are called abdominal or ventral **prolegs** and assist in locomotion and grasping. There can also be anal prolegs, so-called because they appear near the end of the abdomen. The number of prolegs can be important in identification.

These general body structures do not hold true for all invertebrates, only insects. Others, such as mites, spiders, worms, slugs and snails will have different anatomies and life stages. For more information see the relevant species pages in section 4.

Moth larva



Beetle larva



Source: Modified from CSIRO (1991)

Table 2.1 Taxonomic category

Taxonomic category	
KINGDOM	There are six kingdoms of living creatures - Fungi, Plants, Animals, Eubacteria, Archae-bacteria and Protista. The last three kingdoms are comprised of simple, mostly unicellular organisms.
PHYLUM	**Vertebrata and Invertebrata** Humans along with fish, amphibians, reptiles, birds and other mammals, are classified into the sub-phylum Vertebrata (phylum Chordata), meaning they have a backbone. These are called vertebrates. The Invertebrata includes all animals without backbones such as jellyfish, insects, spiders, slugs, snails, millipedes, mites, crabs, worms etc. These are called invertebrates. **Phylum Arthropoda** Arthropod means jointed-foot. *Arthro* as in arthritis, a joint disease, and *pod*, as in podiatrist, a foot doctor. Arthopods are a group of invertebrates including insects, springtails, mites, spiders, ticks and other creatures that are characterised by the presence of: • an exoskeleton (hard outer plate coverings) joined by softer tissue (i.e. hard on the outside, soft on the inside); • jointed limbs (segmented legs). The remaining invertebrates (other Phyla) consist of worms, slugs and snails. Unlike arthropods, these animals lack segmented legs and are generally soft-bodied. **Phylum Mollusca (snails and slugs)** The Mollusca includes snails, slugs, clams, octopuses, squid, oysters, chitons and other creatures that share, or are characterised by, the presence of: • a muscular foot; • non-segmented mouthparts; • a radula (set of hooked teeth); • a well-developed head.

Table 2.1 Taxonomic category *continued*

Taxonomic category	
CLASS	**Class Insecta (insects)** Insecta is the largest class of organisms and accounts for over 75% of all animal species. Insecta share or are characterised by: • a hard outer skin (exoskeleton); • a three segmented body (head, thorax and abdomen); • six legs (paired segmented limbs arising from the thorax); • bilateral symmetry (each side of the body is a mirror image of the other); • adults with antennae and two pairs of wings arising from the thorax (wings maybe modified or absent). **Class Arachnida (mites, ticks, spiders and scorpions)** Arachnida share or are characterised by: • two body divisions (cephalothorax and abdomen); • adults with four pairs of legs (immature stages have three pairs); • a lack of antennae and wings. Arachnida includes the orders Acarina (mites and ticks) and Araneida (spiders). **Some other non-insect arthropod classes** class Collembola (springtails) class Diploda (millipedes) class Chilopoda (centipedes) class Malacostraca (slaters) class Crustacea (crabs, lobsters, shrimps, barnacles) class Gastropoda (meaning 'belly feet') is the only class of agricultural interest in the phylum Mollusca.
ORDER	This level of classification is most useful when it comes to separating invertebrates into broad groups. e.g. Lepidoptera (moths and butterflies) Worldwide, there are almost 30 insect orders, and almost all of them are represented in Australia. Refer to **Table 3.2** Key characters of insect orders of agricultural importance, section 3 p. 7.
FAMILY	Families within certain insect orders can be important in terms of pest management. Within the order Lepidoptera, the family Noctuidae contains many moth pests such as native budworms, armyworms and cutworms. e.g. Noctuidae Common suffix for super families: - tera or -oidea Common suffix for family: - idae Common suffix for sub family: - inae
GENUS	Genus name is always italicised and first letter capitalised. e.g. *Helicoverpa*
SPECIES	Species name is always italicised and all lower case. e.g. *punctigera* Different species within the same genus can have significant biological differences. For example, two moth pests - native budworm (*H. punctigera*) and corn earworm (*H. armigera*)- belong to the genus *Helicoverpa*, but *H. armigera* shows insecticide resistance and has a different plant host range to *H. punctigera*.

Lifecycles and development

Having a basic understanding of a pest's lifecycle and development is important to effectively manage pests. By looking at a pest's lifecycle you can predict the occurrence of the most damaging stage to minimise/ avoid crop damage, or alternatively to target control at the most vulnerable life stage.

Most insects have the same basic lifecycle, progressing from an egg through several immature stages until finally becoming an adult, capable of mating and reproduction. In the insect world there are two main ways to complete this lifecycle. These are described as either incomplete or complete metamorphosis, a Greek word meaning change.

Nymphs or larvae hatch from eggs and their survival and development is dependant on environmental factors (particularly temperature and humidity) and the availability of suitable food. For example, the diamondback moth lifecycle in relation to temperature is as follows:

- at 12 ^{O}C - lifecycle takes approx. 60 days
- at 15 ^{O}C - lifecycle takes approx. 36 days
- at 25 ^{O}C - lifecycle takes approx. 12 days
- at 28 ^{O}C - lifecycle takes approx. 11 days

Nymphs and larvae grow through a series of moults (immature stages). Entomologists refer to these different immature stages as instars, i.e. 1st instar = just hatched, 2nd instar = 2nd immature growth stage, 3rd instar = 3rd immature growth stage and so on. The number of moults will vary depending on the species, but there are typically four to eight moults between hatching and becoming either an adult (for the nymph) or pupa (for the larva).

In some species, only one cycle or generation occurs per year (e.g. the vegetable weevil) whilst in other species one generation can take years to complete (e.g. some cockchafer species). Multiple generations can also occur in one year depending on seasonal conditions (e.g. diamondback moth and aphids). Where several generations occur in a year, you can often find multiple lifestages of a species in a crop at the same time.

Lifecycles

Incomplete metamorphosis

(Hemimetabolism - gradual or partial change)

Insects develop in **three stages** within this lifecycle:

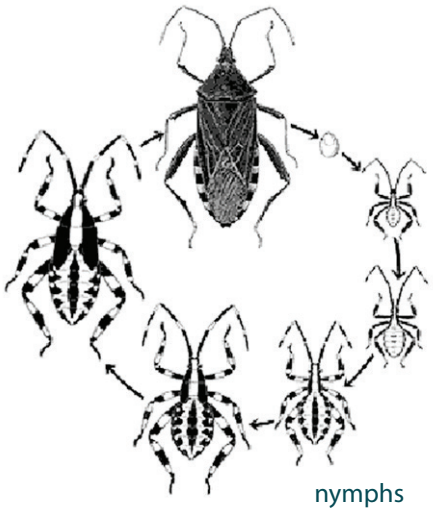
egg -> nymph -> adult

An immature organism within this lifecycle is referred to as a **nymph** (plural nymphs).

Incomplete metamorphosis is a development process in which the immature insect hatches from an egg (or is born live in some insects) and gradually turns into an adult through a series of moults. Nymphal stages resemble miniature adults but with some lack of development in general structure (e.g. wings). Their colour and markings can be very different. There are usually six to eight nymphal stages (moults) depending on the species and each successive nymph stage is slightly more developed and bigger in size than the previous stage. Nymphs usually have similar habits to adults.

Insects that develop with incomplete metamorphosis include grasshoppers and locusts (Orthoptera), bugs (Hemiptera) and cockroaches (Blattodea).

Hemiptera



Complete metamorphosis

(Holometabolism - complete or abrupt change)

Insects develop in four stages within this lifecycle:

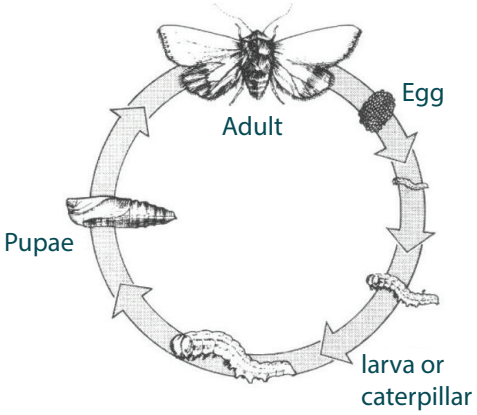
egg -> larva -> pupa -> adult

An immature organism within this lifecycle is referred to as a **larva** (plural larvae).

Complete metamorphosis is a development process in which the immature insect bears no visual resemblance to, and acts differently from, the adult form. The larval stages (instars) are frequently grub-like in appearance. Wing-buds develop internally and cannot be seen in older larvae. The pupa (plural pupae) is a transition stage (often contained within a cocoon/capsule), where larval characters are lost and the adult features develop.

Insects that develop with complete metamorphosis include moths e.g. budworms, armyworms (Lepidoptera), flies e.g. hoverflies and onion maggot flies (Diptera), beetles e.g. cockchafers and weevils (Coleoptera), and wasps e.g. parasitoids of aphids and moths (Hymenoptera).

Lepidoptera



Coleoptera