Section 2 – Biology and ecology of pest snails

Overview

Four species of introduced snails are significant pests of grain crops, pastures and other crops in Australia, and are the focus of this management manual:

- the vineyard snail, *Cernuella virgata*;
- the white Italian snail, *Theba pisana*;
- the conical snail, *Cochlicella acuta*; and
- the small pointed snail, *Cochlicella barbara*.

As they share many characteristics, a general understanding of snail biology can facilitate management of all four species.

Damage

The four pest species feed on dead and living organic matter. Snails damage crops by direct feeding (Figure 3.10). Establishing crops and pastures are most susceptible to damage. Contamination of harvested grain is the most widespread problem caused by snails. Snail contamination of grain can clog harvest machinery, downgrade grain quality and threaten export markets. Livestock reject pastures heavily contaminated with snail mucus[1].

Origins and distribution

The pest snails featured in this manual originated in the Mediterranean Basin in Europe. They are now found in all grain-producing regions in the southern half of Australia (ala.org.au). Introduced pest snails have not yet colonised all potentially suitable sites in Australia.

Pest snails can be found on all soil types but often reach high abundances on alkaline soil types where calcium carbonate is freely available, either naturally or where lime has been applied to acidic soils[2]. Snails require calcium for shell growth and reproduction[2,3,4]. Abundance is strongly correlated with soil moisture levels and the amount of soil organic matter[5]. Stubble-retention farming practices provide a favourable habitat for snails.

All species have expanded their Australian distributions by hitchhiking on vehicles and farm machinery, and have become locally abundant in agricultural areas. Aestivating (dormant) snails resting on farm equipment are readily transported to new sites when equipment is moved. This has important implications for farm-level biosecurity, even from paddock to paddock.

Seasonal activity

Snails display a seasonal pattern of activity. Key monitoring times for snails depend on the snails' life cycles and time of year (Figure 1.1). They are mostly inactive in summer and active when soils are moist throughout the rest of the year. Breeding typically commences shortly after sufficient rain has fallen in late summer or autumn. Activity is significantly affected by rainfall, humidity and evaporation, so the actual timing of snail activity is dependent on local conditions that differ each year.

Moisture and snail behaviour

Moisture and humidity levels strongly influence snail behaviour and reproduction. Snails are highly susceptible to dehydration but have adapted to minimise this risk in several ways. Movement usually occurs when the ground is wet, but not saturated[5]. Snails are inactive when conditions are dry and hot, and restrict activity when moisture and humidity levels are low[5]. They absorb water through their skin when humidity exceeds 95 per cent[6].

Aestivation, or dormancy, is an adaptation that allows snails to survive unfavourable conditions in spring and summer[5]. Snails pass this period of dormancy in various ways, depending on the species. Round and conical snails rest above the ground on stubble, tree trunks, fence posts and other objects. They also shelter under rocks, fallen trees and other objects, at the base of plants or on plant roots, or burrow into the soil. Conical snails display more cryptic behaviour than round snails, and hide in cooler, dark refuges near ground level. Snails often aggregate during aestivation.

Prolonged periods of dryness and high temperature trigger aestivation or dormancy in late spring or early summer. Snails attach their shells to the substrate, seal the shell aperture, withdraw into their shell and remain inactive. As the shell aperture is sealed during aestivation, little water is lost[6,8]. This is a survival strategy against desiccation, as even when food is present, it is not available to snails unless the ground is sufficiently moist to permit activity[9,10]. Mortality over summer is thought to be primarily due to starvation[9] or exposure to heat extremes[11], but not dehydration[9], indicating the effectiveness of dormancy in preventing water loss.

Summer survival is enhanced where crop stubble has been retained (Figure 1.1). Stubble allows snails to rest in a cooler location above ground level, and escape potentially lethal soil surface temperatures in summer[12]. Summer rains can trigger short periods of activity, but no breeding occurs until the end of summer or early autumn[13]. In autumn, snails begin feeding and their reproductive organs mature. Mating typically starts two to three weeks after the first rains in late summer or autumn[12–16].

Movement

Snails move by producing waves of muscular contraction of their sole or 'foot' as they move over their mucus trail[17]. Most movement occurs at night when moisture is present[9] and relative humidity exceeds 80 to 90 per cent (Table 2.1). Snails tend to move at lower relatively humidity levels as seasons change from summer to autumn.

The daily timing of snail movement varies according to season (Figure 2.2). Most snail activity occurs after midnight to soon after sunrise. When timing snail management practices, it is helpful to use predictions of snail movement based on weather conditions.

Table 2.1: Percentage ground level relative humidity predicted to cause high snail movement[13].

Species	Feb	Mar	Apr	May
Vineyard snail	>95%	>90%	>80–85%	>80–85%
White Italian snail	>90%	>90%	>85–90%	>85–90%
Small pointed snail		>95%	>95%	>95%

Reproduction and life cycle

Snails are hermaphrodites, which means they have both female and male reproductive organs, and all snails can lay eggs. They must copulate with another snail before they lay fertile eggs[10].

Snails must grow to a minimum size, typically reached after one year, before they can reproduce. They continue to grow throughout their lifespan.

Soil moisture is crucial for reproduction[18]. Pest snails lay clutches of eggs in moist topsoil[18]. The eggs absorb water and swell as they develop. Laboratory experiments show that egg-laying commences one to six weeks after exposure to moisture, suggesting that similar intervals may occur after natural autumn rains[16,19]. Snail eggs hatch and emerge in autumn about two to four weeks after they are laid. Young snails grow and develop through the winter and spring.

Snails reproduce from autumn to spring, but lay most of their eggs by early winter[13,16,19,20,21] (Figure 2.3). The amount of reproduction varies between locations, possibly in response to different food sources and climate. Most pest snails exhibit a biennial pattern of reproduction, that is, they can survive to reproduce in a second year.

The reproductive potential of pest snails varies among species. The vineyard snail can produce the most eggs, followed by the white Italian snail and the conical snail (Table 2.2). The reproductive potential of the small pointed snail has not been studied.

Snails have an albumen gland that enlarges when they breed. Seasonal variation in the size of the albumen gland indicates how the timing of reproduction varies from year to year (Figure 2.4).

Rainfall affects the onset of reproduction, but this is not well understood. In general, sufficient rain needs to fall at the end of summer or afterwards to stimulate breeding[13].

Population dynamics

Rainfall is a key driver of snail reproduction[20]. Abundance typically peaks in late spring when most snails are immature. Crucially, snail abundance at harvest is not related to snail numbers in the preceding autumn[20,21]. Large numbers are sometimes found at paddock margins, which suggests that local snail invasions arise from dense populations in adjacent pastures.

Recruitment refers to the combined effects of egg production, survival and maturation of immature snails. There is greater recruitment of vineyard snails, white Italian snails and conical snails in pastures than in crops[20,21,22]. Grower observations suggest that conical snails can increase following a canola phase.

Figure 2.1: Effects of wheat stubble (height 15 centimetres) and trash on survival of two snail species over summer[11].

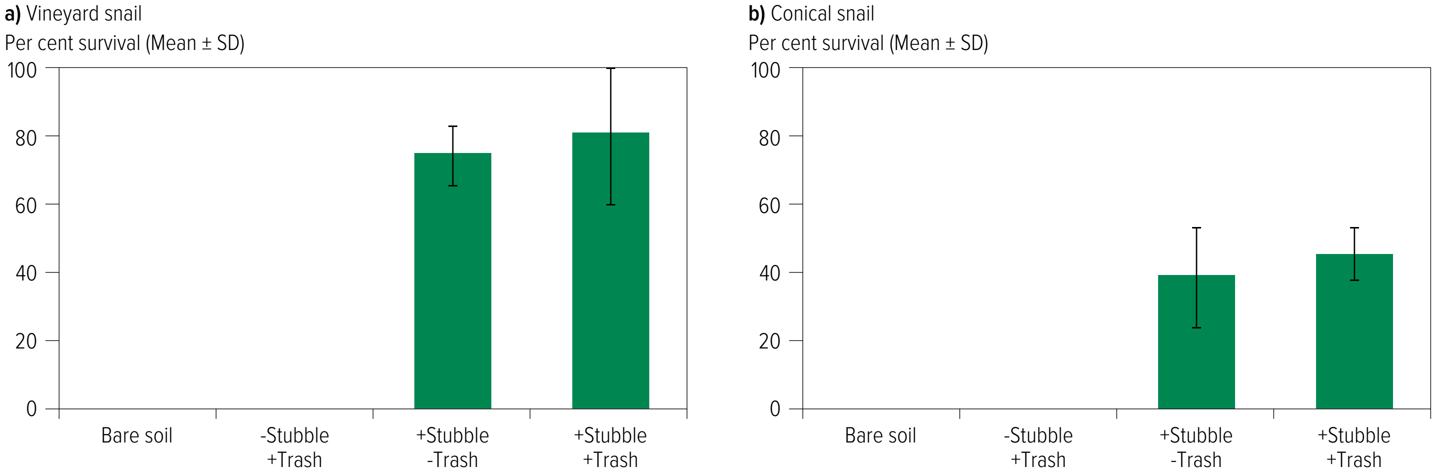


Figure 2.2: Example of distances travelled by white Italian snails throughout one year at a site at Warooka, South Australia. Note the peak of activity after midnight in March, circled in red[13].

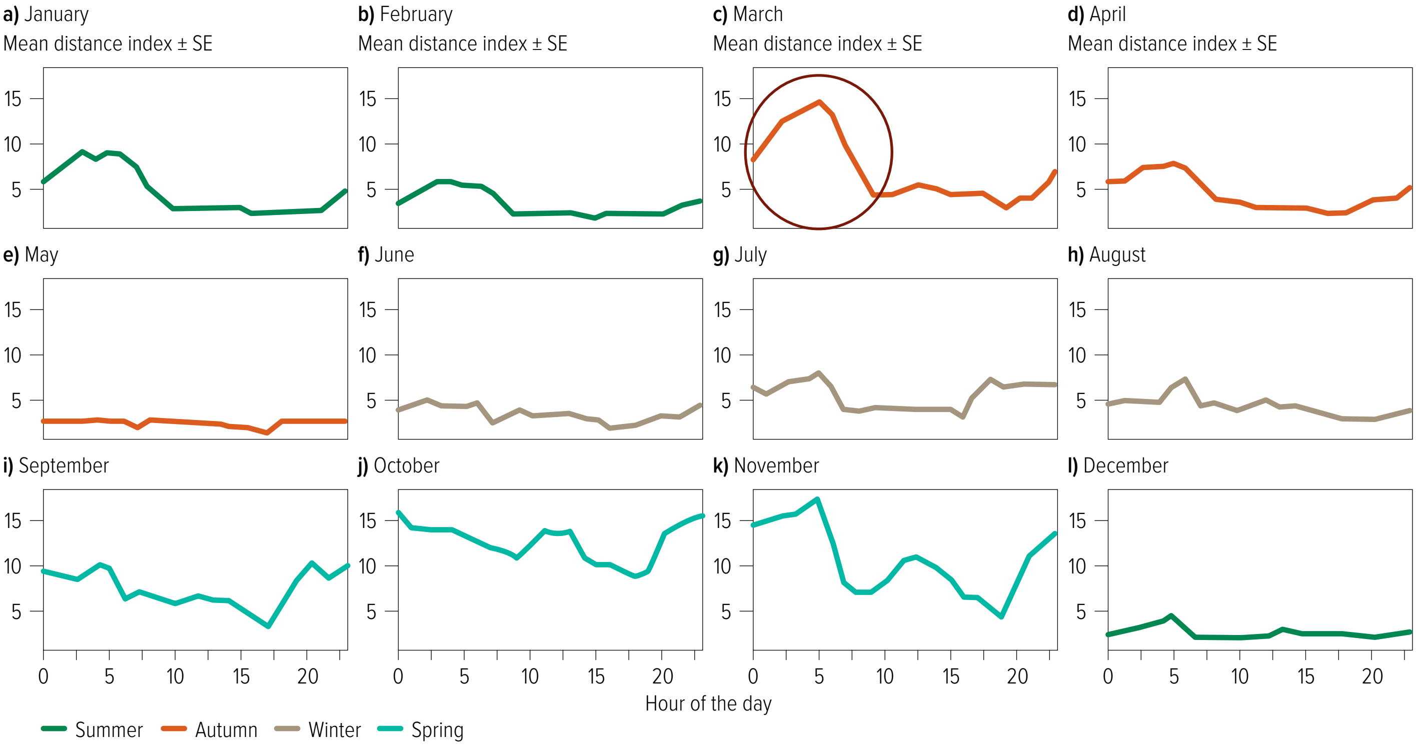


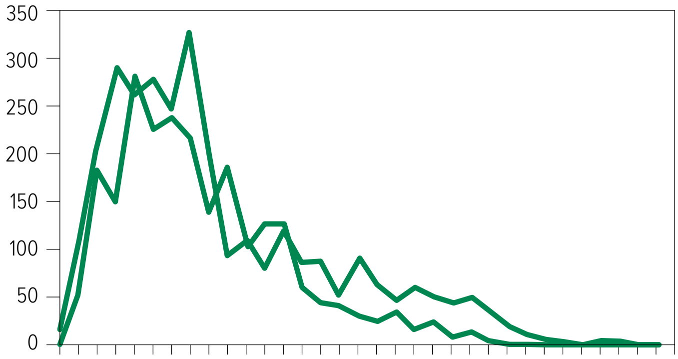
Table 2.2: Reproductive potential of pest snails in Australia. Values shown are ranges of means per pair of snails from different locations.

Species	Weeks to first clutch†	Lifetime egg production	Eggs per clutch	Number of clutches	Reference
Vineyard snail	1–6	2529–3239 (range 50–8268)	60–66 (range 1–257)	42–49 (range 9–96)	Baker 1991
White Italian snail	2–6	1324–3051 (range 694–4566)	70–89 (range 2–225)	19–34 (range 11–46)	Baker 1991
Conical snail	2–5	258–373 (range 117–405)	36–41 (range 29–51)	7–9 (range 2–13)	Baker et al. 1991

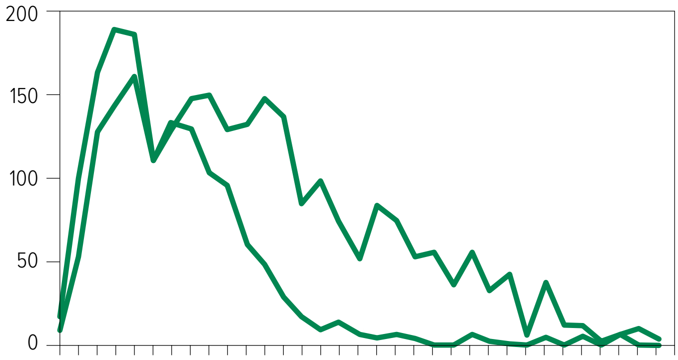
†Number of weeks after snails were exposed to wet soil before they laid the first egg clutch.

Figure 2.3: Seasonal patterns of snail reproduction based on laboratory studies of three snail species. Lines represent separate experiments[16,19].

a) Vineyard snail



b) White Italian snail



c) Conical snail

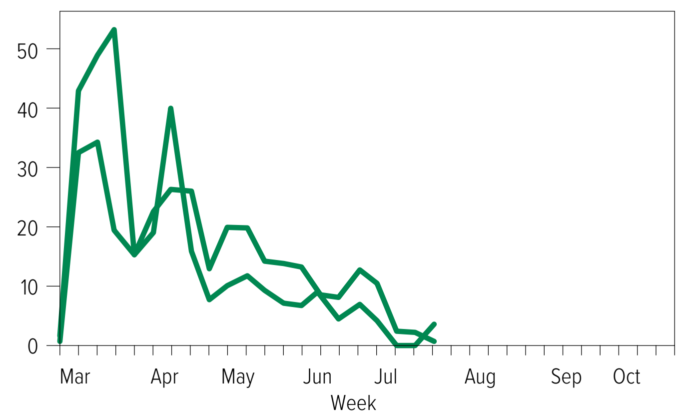
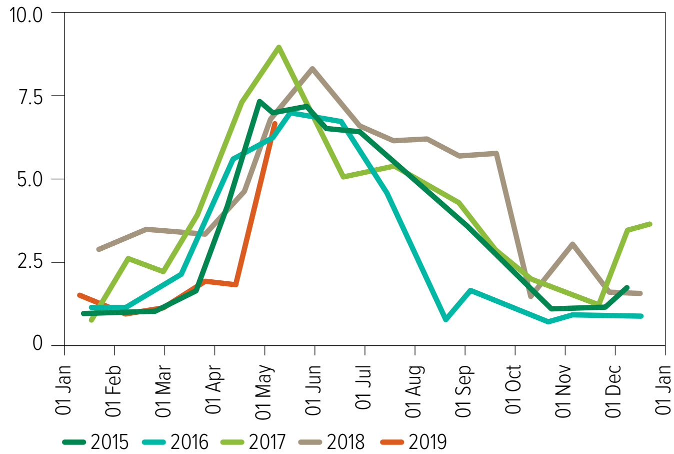


Figure 2.4: Seasonal variation in length of the albumen gland in the vineyard snail at one site. Albumen glands swell when snails are breeding[13].



Identification

Snails can be identified by their shell shape and size characteristics. The four pest snail species are either helical (a round spiral) or conical (cone-shaped). Snail colour and shell markings vary widely from place to place, so these characters are less useful for identification.

The two round snails can be distinguished by the shape of the umbilicus (central hollow space). The vineyard snail has an open, circular umbilicus (Figure 2.5). It is classified in the family Geomitridae and tribe Cernuellini[23]. The white Italian snail has a semicircular or partially closed umbilicus. It is in the family Helicidae and tribe Thebini[23].

The two conical snails are in the family Geomitridae and tribe Cochlicellini[24,25]. They are distinguished by the ratio of shell length to diameter.

Figure 2.5: Comparison of the shape of the umbilicus in a) the vineyard snail and b) the white Italian snail.

a) Vineyard snail

b) White Italian snail

Source: Herbert Zell

Vineyard snail, *Cernuella virgata*

Image: Herbert Zell

This species has an open circular umbilicus. Reproductive snails have a diameter greater than 9 to 10 millimetres (mm)[13]. The white shell may have brown bands around the spiral, but there can be considerable variation in shell colour. Under magnification, regular straight etchings can be seen across the shell.

The vineyard snail feeds on green foliage and dead organic matter. It can damage young cereals, canola and pulse crops. This species mainly over-summers off the ground on plants, stubble, fence posts and other objects. The vineyard snail has a biennial life cycle[19].

Conical snail, *Cochlicella acuta*

Image: Herbert Zell

This species is recognised by the shape of its shell. The ratio of shell length to diameter is always greater than 2:1. Reproductive snails have shells greater than 10mm in length[13]. They are fawn, grey or brown in colour.

The conical snail feeds on dead organic matter, and occasionally on green foliage. It mainly over-summers under stones, stumps and plants, as well as on fence posts and vegetation[7]. It contaminates grains and fouls harvest machinery. The conical snail has a biennial life cycle[16].

White Italian snail, *Theba pisana*

Image: Herbert Zell

This species has a semicircular (partly closed) umbilicus. Reproductive snails have a shell diameter greater than 10 to 12mm[13]. The white shell may have broken brown bands around the spiral, whereas some specimens are entirely white. Under magnification, cross-hatched etchings can be seen on the shell.

The white Italian snail feeds on green foliage and dead organic matter. It can damage emerging crops and pastures. This snail mainly over-summers off the ground on plants, stubble, posts and other objects, and is commonly found on green weeds. The white Italian snail has a biennial life cycle[22].

Small pointed snail, *Cochlicella barbara*

Image: Herbert Zell

This species is recognised by the shape of its shell. The ratio of shell length to diameter is always less than 2:1. Reproductive snails have shells greater than 6 or 7mm in length[13]. They are fawn, grey or brown in colour.

The small pointed snail feeds on green vegetation and dead organic matter. It is recorded as a pest of lucerne and also contaminates grains. This species typically over-summers in leaf litter on the soil surface, just below the soil surface, under stones and other objects, and can also be found on posts and vegetation. The biology of this species is poorly understood. It has an annual life cycle in Europe[26], but its life cycle has not been studied in Australia.

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