Wine Australia for Australian Wine

THE UNIVERSITY OF MELBOURNE

GOVERNMENT OF WESTERN AUSTRALIA
Department of Primary Industries and Regional Development

CLARIFYING THE BIOLOGY OF PEST SNAIL. WHAT NEW TOOLS AND TECHNIQUES FOR THEIR SUSTAINABLE MANAGEMENT CAN BE INVESTIGATED?

FINAL REPORT FOR INCUBATOR PROJECT

Project number: **UM 2100**

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1. Abstract

Snails cause significant damage to viticultural and broadacre crops across many parts of Australia. The current strategy of poisoning with snail baits is not providing the level of control that growers are seeking. A systematic literature review of the biology and control of key pest snails that affect vineyards was conducted. This research highlights the limited information available on snails' prevalence, impact, and management in vineyard ecosystems both in Australia and overseas. Current knowledge and knowledge gaps have been identified and recommendations for priority areas of research have been made.

2. Executive Summary

Mediterranean snails are causing major issues in many Australian viticultural regions. A systematic review of the literature revealed significant gaps in the current understanding of the biology and management of snails in vineyard ecosystems. Current management practices and recommendations for control of snails in vineyards have been primarily derived from research into snails in broadacre crops. There is evidence that *Cornu aspersum* is a key pest species in many viticultural regions; whilst, in broadacre crops it does not appear to be a major issue. Effectiveness of control measures may differ between species and faunal regions and may be impacted by the phenology of the host crops. This report has identified a current need for research on the key pest species across the various faunal regions in Australia. Future research on improvements to current management practice and new alternative management practices may be guided by research on other perennial horticulture crops, such as citrus and apples. This project was funded by the Wine Australia Incubator Initiative Program (UM2100), with the support of The University of Melbourne and the Department of Primary Industries and Regional Development, Government of Western Australia.

3. Aims and Background

Cornu aspersum (Müller, 1774), the brown garden snail and *Cochlicella barbara* (Linnæus, 1758), the small pointed snail, are a major current concern for many viticultural regions in Western Australia. They cause plant damage (Nash, 2014; Wine Australia, 2018), crop contamination (Nash, 2014; Wine Australia, 2018), and even management issues such as blocking of irrigation lines (Elders, 2021). The principal method of control has been application of toxic baits; however, some of the active ingredients of baits are being withdrawn from the market due to environmental concerns leading many growers to seek alternative control methods.

3.1. Research Aims

The objectives of this research are as follows:

1. Quantify the current level of understanding of the biology of snails in vineyards, identifying any potential gaps in the current knowledge.
2. Engage with industry stakeholders to determine the high priority areas of need.
3. Develop a road map identifying key strategies for
    a. further improving current knowledge of the life cycle of pest snails in vineyards;
    b. monitoring and management their impacts on production;
    c. scoping current and potential alternative management strategies.

4. Materials and Methods

4.1. Project Design Summary

This research was designed in consultation with the regional partner Richard Fennessy, Research Scientist (Grape and Wine), Department of Primary Industries and Regional Development (DPIRD), Government of Western Australia. The core of the project was designed to comprise a literature review, communication with stakeholders in Western Australia and development of a strategic road map.

Stage 1. Engage with Western Australian Stakeholders

I originally planned to Western Australia to engage with key industry stakeholders to observe the impact of the snails on viticulture production in Western Australia and identify the high priority needs from the grower's perspective. This was not possible due to travel restrictions therefore alternative strategies were sought to engage with industry stakeholders. Formal interviews or surveys require approval from the institutional Human Ethics Committee and there was insufficient time for this to be done prior to the 2022 and we were advised that growers would not be available during the busy harvest period from February to April. It was agreed that contacting growers prior to harvest would be the preferable option within the scope and timeframe of this project, thus the decision was made to proceed with a scoping study. Informal discussions were held with 9 stakeholders' groups via telephone/computer. These discussions broadened my understanding of the topic and will enable me to design future survey to assess and report growers' views.

Stage 2: Literature Review

A comprehensive review of current literature was conducted to identify current knowledge and knowledge gaps, with a focus in the principal pest snail species. The core of this research project was a comprehensive systematic review of the literature on snails in vineyards ecosystems using the Preferred Reporting for Systematic and Meta-Analysis (PRISMA) framework (Page et al., 2021). The specific objectives were

a) summarise current understanding of the biology and management of snails in vineyard ecosystems;
b) determine current research gaps; and
c) provide recommendations for further research.
d) This review quantified the current knowledge and knowledge gaps of the biology, impact, and control of snails in vineyards. A copy of the review is attached to this report.

Stage 3: Road map

The current knowledge and knowledge gaps based on the information obtained in the literature review have been summarised and recommendations future research has been made.

5. Results and discussion

5.1. Biology of Snails

Mollusca is the second largest phylum of the animal kingdom (Smith & Kershaw, 1979). Molluscs are typically coelomate (coelom cavity present) soft-bodied (invertebrate; lack a skeleton) animals (Smith & Kershaw, 1979). Marine, freshwater and terrestrial snails and slugs are members of the class Gastropoda, the only class of Mollusca to have successfully "*conquered the land*" (Pg. 1, Smith & Kershaw, 1979).

Air-breathing land (terrestrial) snails and slugs belong to the order Stylommatophora , which have evolved from a marine environment to overcome a wide array of physiological and environmental challenges (Smith & Kershaw, 1979). They have a long pedal gland that produces mucus providing lubrication for locomotion (Smith & Kershaw, 1979). They have pallial cavity lined with richly supplied blood vessels that functions as a lung, enables extract gaseous oxygen from the air (Smith & Kershaw, 1979). They also have two retractile tentacles on their head, the upper pair house stalked eyes and the lower pair house olfactory organs.

Table 5.1. Summary of the taxonomy of most terrestrial snails and slugs (Source: Atlas of Living Australia, 2022)

Scientific Classification		Description
Kingdom:	Animalia	• Multicellular eukaryotes • Do not possess chlorophyll or a cell wall
Phylum:	Mollusca	• Invertebrate • Soft body • Triploblastic (three embryonic layers) • Bilaterally symmetrical • Coelomate (coelom cavity present between gut and outer body wall)
Class:	Gastropoda	• Snails and slugs

Order:	Stylommatophora	• Long pedal gland that produces mucus for locomotion
		• Two pairs of retractile tentacles on the head
		  ○ Upper pair – tentacles house stalked eyes
		  ○ Lower pair – olfactory organs

5.1.1. Endemic Terrestrial Snails in Australia

There are a diverse range of endemic species of terrestrial snails in Australia, varied climate and habitat across Australia resulting in great variation and regionality (Smith & Kershaw, 1979). For non-marine molluscs, Australia can be broken up into six faunal regions (Smith & Kershaw, 1979), with Australian wine regions fall predominately in the Leeuwinian, Peronian and Oxleyan regions, and Centralian transition zones (Figure 5.1). The transition between zones is not abrupt instead there is a transition zone gradual change takes place (Smith & Kershaw, 1979). Each region has a different dominate endemic species.

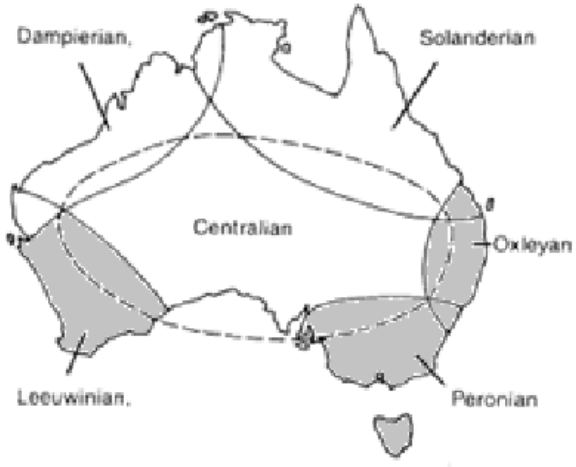


Figure 5.1. Six faunal regions for non-marine molluscs in Australia. Areas where vineyards are primarily located are indicated in grey (Adapted from:Smith & Kershaw, 1979)

5.1.3. Invasive Terrestrial Snails in Australia

In Australia, four key species have been identified as problems in wine and table grapes: *Cornu aspersum* (Müller, 1774), the brown garden snail*, Cochlicella barbara* (Linnæus, 1758), the small pointed snail, *Theba pisana* (Müller, 1774), the white Italian snail, and *Cernuella virgata* (Da Costa, 1778), white Italian snail (DAFWA, 2015; Fisher & Learmonth, 2007). There are various synonyms for the key pest species, thus this report has adopted a standardised taxonomy (Table 5.2).

Table 5.2. Taxonomy and synonyms for common pest snail species causing issues in vineyards (Note: this is Table 1 in the attached systematic literature review).

Scientific Classification	**Common Garden Snail or Brown Garden Snail**	**White Italian Snail**	**Vineyard Snail or Common White Snail**	**Small Pointed Snail**
Kingdom	Animalia	Animalia	Animalia	Animalia
Phylum	Mollusca	Mollusca	Mollusca	Mollusca
Class	Gastropoda	Gastropoda	Gastropoda	Gastropoda
Order	Stylommatophora	Stylommatophora	Stylommatophora	Stylommatophora
Family	Helicidae	Hilicidae	Hilicidae	Hygromiidae
Genus	*Cornu*	*Theba*	*Cernuella*	*Cochlicella*
Species	*C. aspersum*	*T. pisana*	*C. virgata*	*C. barbara*
Source	(Müller, 1774),	(Müller, 1774),	(Da Costa, 1778)	(Linnaeus, 1758)
Synonyms	*Helix aspersa* (Müller, 1774), *Cantareus aspersa* (Müller, 1774) *Cantereus aspersus Cryptomphalus aspersus*	*Helix pisana* (Müller, 1774)	*Helicella virgata* (Da Costa, 1778)	*Prietocella barbara* (Linnaeus, 1758) *Helix ventricosa* (Draparnaud, 1801) *Helix barbara* (Linnaeus, 1758) *Helix (Cochlicella) ventrosa* (Férussac, 1821)

This issue of snails in Australian vineyards, was reported as early as the 1970s (Furness, 1977). Furness (1977) conducted a survey of citrus growers and examined citrus orchards to determine the key pest species, their impact and management. Whilst observations were made of *C. aspersum, C. virgata* and *Cochlicella acuta* in the citrus orchard, *C. aspersum* was the only species to cause significant damage to the trees (Furness, 1977). This report mentioned vineyards but did not specify the species causing issues in vineyards. There is evidence that *C. aspersum* is a priority issue in vineyards in Western Australia (Liao & Fennessy, 2021), Tasmania (Nash, 2014) and South Australia (Wine Australia, 2018).

5.1.4. Biology of Key Pest Species

According to Sanderson and Sirgelz (2002), at the time of publication there was no research on the biology of *C. aspersum* in vineyards. The systematic review of literature on the biology and management of snails indicates this is still largely the case today for all of the major pest species. Sanderson and Sirgelz (2002) also indicate the phenology of *C. aspersum* in Australia is '*somewhat different'* to *C. aspersum* populations in South Africa. Within Australia, vineyards are located across multiple non-marine mollusc faunal regions (Section 5.1.1), it is possible the phenology of pest species such as *C. aspersum* may differ between viticulture regions. Furthermore, there may be differences in the crop phenology of the host crops and differences between pest species could exist. Further research into the key pest species in viticulture is required across the various faunal regions of Australia.

Reproduction

Snails are hermaphrodites, and while they are self-fertile, most snails mate with another snail with both snails producing clutches of eggs (Johnstone, 2020). Timing of the development of the albumen gland has been used to assess the timing of breeding (Micic et al., 2020). In 2017-19, Micic et al. (2020) measured the gland length of *C. barbara* from paddocks in southern Western Australia each month. Regardless of rainfall the gland length increased the most during March or April, reaching peak size in May for most sites. This observation has led to the recommendation that baiting for snails in broadacre crops should be conducted prior to May, ideally in March or April. In citrus, according to Johnstone (2020) most laying occurs in Winter, but it can still occur during spring if the soil is moist.

Aestivations/Dormancy

Under certain conditions snails will enter dormancy, a period of inactivity where they withdraw into their shells (Pomeroy, 1968). Pomeroy (1968) define '*dormancy'* as any period of activity where a snail withdraws into their shells, whilst '*aestivation'* is used to indicate a period of dormancy (several days or more) that occurs in summer. Aestivation can last anywhere from a few days to months (Johnstone, 2020). During, summer rainfall can trigger snails to move from the canopy and feed temporarily (Johnstone, 2020), with *C. aspersum* is reported to be more active during summer than other pest species (Johnstone, 2020). This is supported by observations in vineyards in Coomealla in Southwest, New South Wales during 1992-1994, where *T. pisana* moved the canopy in late spring and early summer to avoid heat and became active during period of summer rainfall often descending to the ground to feed.

5.2. Scoping Alternative Management Strategies

In a systematic review of invertebrate pests in broadacre crops, 55 articles were collated on snails (Macfadyen et al., 2019). In this research, the articles comprised total of four pest species, of which *C. aspersum* was not one of them. The effectiveness of management strategies may differ between species and may be impacted by differences in the phenology of the host crop. This section provides an initial scoping of literature on management of snails in perennial horticulture crops.

Copper/Copper Sulphate

Copper acts as a repellent to snails. Johnstone (2020) recommends for banding the citrus trees with copper foil or copper sulphate to deter snails from climbing the trees or spraying the canopy to drive the snails down to the base of the tree during baiting. It is recommended that copper sprays are used before baiting, as snails are less likely to eat baits contaminated with copper (Johnstone, 2020).

Bait Chain

Recent research conducted in apple orchards in South Africa, has shown promise for a novel method of applying metaldehyde, 'Baitchain', to control *C. aspersum* (Pieterse et al., 2020). Baitchain comprises of metaldehyde pellets arranged in a cord that is tied around the trunk of the apple tree, acting both as a physical and chemical barrier to the snails (Pieterse et al., 2020). This research compared the efficacy of Baitchain to traditional metaldehyde pellets (Sluggit), with Baitchain showing higher mortality rates when applied on its own or in combination with Sluggit.

Mineral Oil Barriers

Mineral oil barriers has shown promise as an effective alternative to chemical control of *Helicella candeharica* (Citrus white snails; Sepasi et al., 2019) and *Caucasotachea lencoranea* (Citrus brown snails; Kheirodin et al., 2012) in citrus orchards in Northern Iran. The mineral oil is applied to the lower 10-15 cm of a plastic foam sheeting that is tied to the tree trunks about 20 cm above the soil surface in a cone shape (Kheirodin et al., 2012; Sepasi et al., 2019).

6. Conclusions and recommendations

This work has highlighted a significant knowledge gap exists regarding robust research on snails specifically in vineyards. Most of the information about pest mollusc management seems to have been drawn from broadacre cropping, particularly from the grains and oilseeds industry. We are now in an excellent position to do the study with stakeholders about management of mollusc pests in growing environments. The plan would be to design a survey that can be delivered online via Redcap or Qualtrics. It would consist of a series of open and closed questions about the current challenges encountered by the industry regarding pest management, their current control strategies, factors that inform their decision-making and shortfall with management options. This can be done through an online survey and then in-depth follow-up interviews. The results of this work will inform development of interventions that will best serve the needs of the industry. While some of this might have been conducted within the current project, the literature review, human ethics training and the informal interviews already conducted are the foundation for the larger study.

7. Extension

Progress of the project has been regularly communicated to the Regional Partner Richard Fennessy. A copy of the literature review on the biology and management of snails in vineyard ecosystems will be available.

8. Researchers benefit and feedback

I have primarily been working in academic teaching since completing my PhD in 2019. This project provided me with a brilliant opportunity to commence my post-doctoral research career. Through this project I was able to develop strong relationships with the industry stakeholders in Western Australia despite the challenges of not being able to visit Western Australia due to COVID 19 restrictions. Informal telephone conversations with industry stakeholders provided me with valuable insights into the challenges the industry is facing and how my research can support them. This process helped me develop my skill communication skills and I gained confidence in discussing my scientific research. I completed the training required to do research involving human participants and I hope to submit a full ethics application to do surveys.

The literature review presented in this report was conducted using the Preferred Reporting for Systematic Review and Meta-Analysis (PRISMA) frame work (Page et al., 2021). Systematic literature reviews that follow the principles laid out by the PRISMA framework are becoming more mainstream in agriculture literature. Learning this reviewing technique was a valuable experience, and I will certainly use this approach again. The lack of peer reviewed material available on the topic created challenges, and the scope of the review was extended to include non-peer-reviewed literature (e.g., industry newsletters and industry websites). This taught me valuable skills in summarising and reporting of information from non-peer-reviewed literature sources. Skills gained in this process will benefit my future research.

There were some difficulties managing the timing of the project. I had expected to commence the work in July 2021 however there were lengthy delays in processing contracts within the university and by the time it was clear that human ethics committee approval was going to be required for surveys, the university was shutting down for the summer break and there was not sufficient time to get approval before the harvest period. Extending the duration of incubator initiative grants could improve the outcomes for early career researchers and their projects when unanticipated delays occur. Extending the duration would allow more time to complete regulatory requirements associated with engaging and reporting on stakeholder engagement. It would also provide more time for stakeholder engagement, with restricted availability of stakeholders during peak periods such as harvest.

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