Department of
Natural Resources
and Environment

Minimising the Impact of European Wasps on the Grape and Wine Industry



FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **DAV 99/1**

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Research Organisation: **Department Of Natural Resources and Environment, Keith Turnbull Research Institute**

Date: **14 December, 2001**

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Purpose
The purpose of research reported here was to minimise the impact of European wasps on the grape and wine industry in Australia.

Acknowledgment of funding sources
Project DAV99/1 was jointly funded by the Grape and Wine Research and Development Corporation and Department of Natural Resources and Environment, Agriculture Division.

December 2001

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Summary

- European and English wasps are introduced pests that impact on urban areas, natural ecosystems, and certain agricultural industries in Australia. The grapegrowing and winemaking sector is one of the agricultural industries most affected by wasps.

- European wasps are generally considered a more serious pest than English wasps because of their abundance and broader distribution. During vineyard trials in the Yarra Valley and Mornington Peninsula regions of Victoria, only European wasp nests were recovered.

- In the grape and wine industry European wasps can become a serious pest problem in years of high abundance. However, little information is available regarding the impact of European wasps in grape growing areas. Preliminary survey information reveals that grapegrowers and winemakers face several problems from European wasps; occupational health and safety issues with stings to workers, a nuisance to customers at the cellar door and restaurants, and crop damage and loss of quality in wine.

- Biological, chemical and physical control measures have been considered to minimise the impact of European wasps, however wasps are difficult to manage during periods of high abundance. A biological control for European wasps, the parasitoid *Sphecophaga vesparum vesparum* was released in southeastern Australia in the late 1980's and early 1990's. Establishment of this parasitoid has not been demonstrated. More recent research efforts have concentrated on the development of effective baits for the introduced European and English wasps.

- Interstate and overseas research has shown baiting programs using the insecticide fipronil can be successful in suppressing wasp numbers. Baiting trials using fipronil were conducted on vineyards in the Yarra Valley and Mornington Peninsula (Victoria) during March and April 2001. Initial trials determined the concentration of fipronil most effective in reducing wasp numbers. Further trials utilising this concentration (0.1%) reduced wasps by 70-82%, and killed 100% of monitored European wasp nests after a single application of toxic baits. Reductions in wasp numbers were achieved within hours of the poison baits becoming available to foraging wasps, and the reductions were evident up to two weeks later when monitoring ceased.

- Non-chemical control techniques that may further reduce the impact of European wasps, including habitat modification (sanitation and proofing), physical trapping, and modifying workplace practises, were investigated. There is a need for follow up information to determine whether such techniques are useful in the industry.

- Areas requiring further research are outlined and prioritised. Impact surveys to identify the specific costs associated with the control of European wasps and the damage they cause would be invaluable to accurately gauge the economic damage caused by this pest in the grape and wine industry. Extension material should be updated as new technologies, such as baiting techniques, become available.

1. General introduction

1.1 Biology and life-cycle of European and English wasps

The European wasp *Vespula germanica* (F.) (Hymenoptera: Vespidae) is native to Europe, North Africa and temperate Asia, but has spread to North America, New Zealand, South Africa, South America and Australia (Spradbery & Maywald 1992). The English wasp *V. vulgaris* (L.) (Hymenoptera: Vespidae) is closely related to the European wasp, and in Australia has established in Victoria and Tasmania (Lefoe & Ward 2001, Matthews *et al.* 2000). Within Victoria and Tasmania the range of English wasps is believed to be more restricted than European wasps, although mis-identification is probably common where their ranges overlap. European wasps are generally considered the more serious pest in Australia because of their abundance and widespread distribution (see Section 1.2).

Queens of introduced *Vespula* spp. spend the winter in hibernation. They emerge during warm spring weather to look for nesting sites. Predators, lack of food, unsuitable nest sites and sudden cold weather contribute to the failure of most queens to establish nests (Spradbery 1973). Survival of queens at this stage may determine whether there will be large wasp outbreaks in summer. Nests are usually underground in holes dug in the soil (Figure 2) but may be amongst stacked materials, in compost, tree trunks, hedges or unused sheds. Many nests are found in cavity walls or roof spaces of buildings. Each queen begins her nest by constructing a cluster of hexagonal cells hanging downward and laying one egg in each cell. A protective layer of paper encloses the cells. The material used by her, and later by the worker wasps, contains wood fibre from dead trees or timber, chewed to a pulp and carried back to the site (Spradbery 1973). The outer covering of European wasp nests has the appearance of cardboard and is grey in colour. English wasp nests are similar but have a grey-brown striped appearance. The first batch of the white grub-like larvae raised by the queen reach maturity after several weeks. Their cells are briefly sealed for pupation, and wasps then emerge as adult workers (sterile females). These take over the work of enlarging the nest and feeding the larvae, leaving the queen to continue egg-laying throughout the season (Spradbery 1973). There is continuous enlargement of the nest during summer and early autumn. Although each worker lives only several weeks, but there may be several thousand workers present at any one time.

Introduced *Vespula* spp. will fiercely defend their nests. If a nest is disturbed, the workers swarm out to attack the intruder. Vibration, rather than sound, alerts workers. Once a victim is attacked, chemical cues guide more wasps to the site of the attack.



Figure 1. Honeybee (left), European wasp worker (middle) and European wasp queen (right)



Figure 2. A typical European wasp nest entrance (left), and a partly exposed nest in the ground (right)

Foraging by the workers usually occurs within 50 to 250 metres of the nest. Wasps seek out almost any carbohydrate or protein food source, including nectar, fruit, invertebrates (flies, spiders, grubs), or carrion, which is taken back to feed to larvae. Towards the end of the season the workers build larger cells in which the next generation of several hundred queens and males (drones) are reared. Queens and drones take part in mating flights during autumn, and queens then seek winter shelter to hibernate (Spradbery 1973). Males die off, as do the remaining nest occupants, leaving the nest empty. However, if there is sufficient warmth and food, the occupants of some nests may remain active throughout winter, occasionally building up the nest to an extremely large size in the next summer.

European and English wasps are sometimes confused with honeybees, *Apis mellifera* (Hymenoptera: Apidae), as they are about the same size (Figure 1). However European and English wasps have more conspicuous markings and are less hairy. Introduced European and English wasps can be distinguished from native wasps by lemon-yellow banded markings on their black body, and their large communal nests.

1.2 The spread of European and English wasps in Australia

The English wasp was first discovered in Australia at Malvern, Victoria, in 1958. The nest was destroyed, but more were found in 1960. Despite attempted eradication, English wasps continued to spread in an easterly direction, reaching the Dandenong Ranges in the early 1970s, and West Gippsland by the late 1970s. Very little information is available on the recent spread of English wasps in Victoria, however their distribution is considered to be more restricted than that of European wasps. English wasps are now also present in southeastern Tasmania, including Hobart, where they're thought to have arrived as recently as 1995 (Bashford 2001).

European wasps possibly arrived in Australia from New Zealand, where they had been accidentally introduced and established earlier (Spradbery & Maywald 1992). The first record of European wasps in Australia was in 1954 at Sydney, where hibernating queens were discovered in a timber consignment from New Zealand (Chadwick & Nikitin 1969). The first nests were discovered in 1959 in Hobart, Tasmania, and later in New South Wales (1975), Western Australia (1977), Victoria (1977) and South Australia (1978) (Spradbery & Maywald 1992). European wasps have continued to spread across south and southeastern Australia. They have quickly become widespread in Tasmania, Victoria and New South Wales (Spradbery & Maywald 1992). Crosland (1991) estimated unaided queen dispersal at only 730-815 metres per year. European wasps can spread more rapidly though, through accidental human transportation of hibernating queens (Crosland 1991). In South Australia, European wasps remain a predominantly urban problem, although their numbers have increased steadily. Repeated introductions have occurred in Western Australia, with a large outbreak in Perth in 1990, however European wasps are not yet considered established in that State (Widmer & Van Schagen 1995). In Queensland reports of European wasps occurred during 1988 and 1991, and the first nest was found in 1992 (Spradbery & Maywald 1992).

Modelling suggests the potential distribution of European wasps in Australia could extend as far north as Rockhampton in Queensland (Spradbery & Maywald 1992). Two factors that may limit their spread are the prolonged hot conditions over central and northwestern parts of the country, and wet summers on the northeast coast. Inundating rainfall often leads to flooding of underground nests, and many European wasp nests may not survive heavy tropical rainfall (Spradbery & Maywald 1992).

1.3 Impact of European and English wasps

European and English wasps impact on a number of different sectors in the community. European wasps can cause serious injury, with hospitalisations due to stings increasing in Australia (Levick *et al*. 1997). European and English wasps are particularly aggressive when their nest is threatened, and accidental disturbance of wasp nests poses a considerable threat to rural workers and animals. No human deaths have been reported from stings by European or English wasps in Australia, however seven fatalities have occurred from wasps over a 20 year period (unidentified wasps, probably not V*espula* spp.), all involving men in rural settings (McGain *et al*. 2000).

In urban areas, the major concern is wasp stings, although disruption to outdoor activities and the cost of control add to the impact of wasps. Crosland (1991) estimated local councils, pest controllers and state agriculture departments spent $517,000.00 across Australia to destroy wasp nests in 1989. This figure was based on an estimate of $25.00 for the destruction of one nest. Most local councils now refer enquiries

from the general public to commercial pest control operators. The cost of nest destruction from a pest control operator ranges between $75.00-$115.00 for the Melbourne metropolitan area (based on approximate 2001 prices).

Most information on the deleterious impacts of wasps in natural ecosystems comes from studies conducted in New Zealand (Beggs & Wilson 1991, Harris & Oliver 1993, Beggs & Rees 1999). In natural ecosystems wasps prey on native invertebrates, may compete with native animals for food, disrupt natural ecosystem processes, and can pose a health risk to Parks staff and visitors. However there is very little detailed information on the impacts of wasps in Australian ecosystems. In Tasmania, European wasps prey on the threatened Ptunarra brown butterfly (M. Driessen personal communication). Bashford (2001) reported that the number of calliphorid flies caught in Malaise traps at Warra, Tasmania, declined as the number of *Vespula* spp. increased. Continued studies at the site may determine whether introduced *Vespula* wasps have any long term impact on populations of calliphorid flies and other prey species.

Honeybees and soft-fruit industries can be seriously affected by European and English wasps. Akre (1982) reported that during years of high wasp abundance, stings from vespid wasps are common among fruit industry field workers. Time and productivity can be lost as field workers fail to perform their jobs effectively due to the fear of being stung (Akre 1982). Wasps can be pests of the honey industry by robbing hives, killing bees, and competing with bees for food resources. In New Zealand for example, around 8-9% of beehives are destroyed or seriously affected by wasps each year, and controlling wasps contributes to the overall operating costs of beekeepers (Clapperton *et al.* 1989). The estimated cost of wasps to the New Zealand beekeeping industry was approximately NZ$650,000.00 in 1989. In Tasmania, wasps can cost the beekeeping industry 1.5 % of their total production (Crosland 1990).

During years of high wasp abundance, wasps can seriously affect the grapegrowing and winemaking industry. Edwards (1980) reported that wasps are a pest of grape and stone-fruit industries in a number of countries. In North America Akre (1982) claimed that *Vespula* wasps can be responsible for near total devastation of grape crops, but failed to provide evidence to support this claim. In Victoria, some grapegrowers reported significant losses due to wasps during the autumn of 1998 (Darby *et al.* 1998). Wasps were a major problem in Tasmania in 1999, where one estimate of yield losses in vineyards was 10-20% (M. Williams, personal communication). Bashford (2001) reported that several southern Tasmanian vineyards suffered a loss of grape production of up to 25% during the 1999/2000 growing season. It has been suggested that European wasps affect some grape varieties, such as Pinot Noir, more than other varieties. Further studies are necessary to determine susceptibility of different varieties to wasp damage. Unfortunately no detailed assessment of losses to wasps has been completed in Australia.

One survey of grapegrowers and winemakers, conducted by the Victorian Department of Natural Resources and Environment (DNRE) in 1998, obtained basic information about the industry's perception of European wasps. The respondents estimated that 81% of workers were harassed or stung while harvesting fruit during that growing season (1997/98), 21% reported that European wasps were a nuisance to tourists at wineries and restaurants, and 7% reported that wasps interfered with farm work. The survey further found that 87% of respondents believed European wasps were an extremely serious or serious problem in the industry (Darby *et al.* 1998). The maximum financial cost per grower from the impact of European wasps was $1069.00 (58 respondents) in a year of high wasp numbers. However, it is unclear from this survey whether respondents included all financial costs in their estimates (eg. crop damage, cost of buying workers gloves and protective clothing, cost of buying wasp control products, lost earnings at the cellar door/restaurant as tourists leave). Also, growers do not experience high numbers of wasps every year. Future surveys should identify and assess specific costs to obtain a more accurate estimate, and should be conducted over several years.

1.4 Management of European and English wasps

An efficient way to manage European and English wasps, and other pests, is through the development of an Integrated Pest Management (IPM) strategy. IPM is a sustainable approach to managing pests that combines biological, chemical, and physical techniques in a way that minimises economic and environmental risks, while optimising control of the target pest. The IPM approach uses knowledge of pest and crop biology, and environmental conditions, to select the best combination of management strategies for short and long-term control. A limitation in the development of an IPM strategy for European and English wasps in Australian vineyards however, has been the suitability and effectiveness of existing controls.

Direct nest destruction with an insecticide registered for use against European wasps is the most effective control method currently available. This is a simple and inexpensive control when the nest location is known. However nests are often difficult to locate, particularly over large areas, and considerable time may be spent searching for signs of a nest entrance (Figure 2).

One way of finding wasp nests is by walking around a property searching for them. Nests are commonly found near a water source such as a dam, creek, or river, and are usually underground with only the entrance hole showing (Figure 2). Nests can also be found aboveground in buildings and other structures, refuse and debris, and hedges. Although difficult to spot, nest entrances can be recognised by the constant flow of wasps entering and leaving the nest. Observing foraging wasps and identifying their flight path to the nest may assist in narrowing down the search area. Considerable time and patience is needed when many nests occur on a property, and close cooperation with neighbours is necessary as wasps often invade from adjoining properties.

Landowners and researchers have, in the past, experimented with bits of string tied to wasps, dyed wasps with bright colours, or fed large pieces of meat to wasps to slow them down as they return to the nest. The aim is to make it easier to follow wasps. The usefulness of these techniques is questionable, and there is no single technique that is widely used. Some grapegrowers and members of the public have inquired about the use of radar or electronic techniques to track European wasps. Currently these methods are considered impractical for industry conditions because they are either very expensive to set-up, or have limited mobility or range.

Although a variety of wasp traps are available from commercial outlets, trapping alone will rarely reduce the overall wasp population when wasp numbers are high. However, traps may alleviate wasp problems sufficiently to be useful in certain situations and, together with other non-chemical controls, may help in reducing the impact of wasps (see Section 3).

A baiting system that attracts wasps to a food source containing insecticide has considerable potential for situations where nests cannot be easily located. The aim is to encourage foraging wasps to collect sufficient toxin to destroy a nest (Edwards 1980). Insecticides must be sufficiently slow acting to allow foraging wasps time to make several trips to collect bait. If the action of the insecticide is too rapid, little bait will get to the nest before the foraging wasp dies. Baiting systems can be a very useful strategy in controlling wasp numbers because nests do not need to be located. Ideally, baiting systems should be easy to implement.

1.5 European and English wasp research

1.5.1 Research in Australia

Because of the greater pest status of European wasps in Australia, most research has been directed towards this species. It is often assumed that research directed towards controlling European wasps will also be applicable to English wasps. The impact of European wasps in urban areas, and their potential impact on natural and agricultural systems, prompted early research into the distribution and life history of European wasps in Australia by the CSIRO and others (Spradbery & Maywald 1992, Crosland 1991). This work included climate modelling which attempted to predict the potential distribution of European wasps in Australia. Spradbery & Maywald (1992) found that European wasps have the potential to establish from Rockhampton in northeastern Australia, along the southern coast to Carnarvon in Western Australia.

A biological control program commenced at the Keith Turnbull Research Institute (KTRI), Melbourne, in the late 1980's and early 1990's. A parasitic wasp, *Sphecophaga vesparum vesparum* (Curtis) (Hymenoptera: Ichneumonidae) was imported, tested for host-specificity, mass-reared, and released. Between 1989-1993 over 120 000 parasitoids were distributed as dormant cocoons to parts of southeastern Australia. The parasite has not been recovered from release sites however and its establishment is not confirmed. Other biological control options, such as potential pathogens, have been examined at the University of Adelaide and in New Zealand.

In September 1997 a European wasp strategy meeting was held in Melbourne and agreed to improve community awareness and establish a European wasp task force to prioritise ideas for future control and research. Responsibility for European wasp management was assigned to the Australian and New Zealand

Environment and Conservation Council (ANZECC) in 1998. ANZECC identified the most important issues for wasp management as:

- improved community awareness,
- coordinated and cooperative research,
- continued assessment of biological control options,
- assessment of the impacts of European wasps in urban, agricultural, and conservation areas, and
- development of a baiting system to destroy nests without the need to locate them.

Since 1999, researchers from Australia and New Zealand have met annually to coordinate research into European and English wasps (these meetings were held in Canberra 1999, Hobart 2000, and Adelaide 2001). An effective biological control agent still eludes researchers, however development of a wasp baiting system has benefited from the collaboration between researchers in Victoria, South Australia, Tasmania, New Zealand, and at Aventis CropScience.

1.5.2 Overseas research

European and English wasps arrived in New Zealand in 1945 and the 1970s respectively (Donovan 1984). New Zealand now has some of the highest densities of *Vespula* wasps in the world (Barlow *et al*. 1996). Consequently much of the information on the biology, impact, and control of European wasps comes from New Zealand researchers (Moller 1991, Harris & Oliver 1993, Spurr 1995, 1996). Competition and predation by wasps in New Zealand has had a detrimental effect on endangered birds and native invertebrates (Beggs & Wilson 1991, Harris & Oliver 1993, Beggs & Rees 1999). The wasp parasitoid *Sphecophaga vesparum vesparum* was released at a number of sites throughout New Zealand in the late 1980s however it has only established at two sites, and infests an average of 8.5% of nests per year (Beggs *et al*. 1996).

There is some information from the USA on the impact of wasps and the problems they cause (Akre 1982, Stein & Wrensch 1988). A number of researchers in the USA have tested attractants for wasp traps and baits (Davis *et al*. 1967, Wagner & Reierson 1969, Howell *et al*. 1974, Ross *et al*. 1984). In Hawaii several studies have looked at the impact of wasps on natural ecosystems (Gambino *et al*. 1987, 1990, Gambino & Loope 1992).

1.5.3 Research targeting the grape and wine industry in Australia

Small-scale chemical baiting trials have recently been conducted in South Australian and Tasmanian vineyards (G. Wood personal communication, M. Statham personal communication). Baits tested in South Australian vineyards were found to be effective at reducing the impact of European wasps (G. Wood, personal communication), and findings from both States tend to support the results of baiting trials conducted in Victoria (Section 2).

1.6 Objectives and outcomes of the project

1.6.1 Objectives of the project

♦ Development of European wasp management techniques and support materials for use in vineyards and winemaking areas.

♦ Incorporation of European wasp management strategies into vineyard systems.

1.6.2 Anticipated outcomes

♦ Effective management strategies to reduce the impact of European wasps on the grape and wine industry.

♦ Development of management tools and support materials for effective adoption of wasp management techniques by industry.

♦ "Effective management of European wasps in vineyards and wineries" - a module for the IPM Viticulture Research to Practice™ manual.

2. Baiting trials

2.1 Introduction

A baiting system that attracts wasps to a food source containing insecticide has considerable potential for situations where nests cannot be easily located. The aim is to encourage foraging wasps to collect, and take back to the nest, sufficient insecticide to destroy the nest (Edwards 1980). Ideally a baiting system should be effective against target pests, in this case European and English wasps, have little or no impact on non-target species, and be easy to implement.

Considerable research effort has been directed towards developing a safe and effective baiting system in New Zealand (Spurr 1991, 1995, 1996, Beggs *et al*. 1998, Harris & Etheridge 2001). Much of this work was conducted in New Zealand's beech forests. When applying these techniques to Australian vineyards, considerations include:

- identifying an insecticide that can destroy a nest, but is sufficiently slow-acting to allow foraging wasps to make several trips between the bait station and nest,
- identifying a bait that is attractive to wasps but not honeybees,
- identifying a bait that is attractive to wasps even when their food preferences change, or in the presence of competing food sources (ie. grapes),
- identifying a bait that will not perish too quickly in an Australian summer or autumn (which may render it unattractive to foraging wasps),
- minimising non-target impacts through the selection of the safest combination of bait, insecticide, bait delivery system (ie. one that excludes birds, reptiles and mammals), and application practises,
- ensuring any baiting system developed is "user friendly",
- ensuring any baiting system developed has a reasonable chance of being registered for use in Australian vineyards, and of being adopted by the grape and wine industry.

A number of insecticides have been trialed for use in wasp baits. Wagner & Reierson (1969) tested eleven organochlorine, organophosphate and carbamate insecticides against the Western Yellowjacket *V. pensylvanica* (Saussure) but found that all except one (mirex) imparted varying degrees of repellency to baits. Restrictions on the use of organochlorine insecticides, such as mirex, prompted further research into alternative insecticides. Although repellent to wasps, Ennik (1973) and Chang (1988) found diazinon to be reasonably effective against *V. pensylvanica* when encapsulated. In New Zealand, Spurr (1991) successfully used sodium monofluoroacetate (1080) in baits against European and English wasps. However concentrations of 1080 effective against wasps are highly toxic to vertebrates, especially dogs (Spurr 1991). New Zealand researchers next studied hydramethylnon and sulfluramid, which were considered safer for use in wasp baits, but took longer to control nests (Spurr 1991, Beggs *et al*. 1998). Recently the insecticide fipronil has been proposed for use in wasp baits (Harris & Etheridge 2001). When comparing fipronil to sulfluramid, Harris and Etheridge (2001) found fipronil to be faster acting, and equally as toxic to wasps as sulfluramid, but at concentrations 1000 times lower than sulfluramid. In field trials at a 300ha beech forest site in New Zealand, 0.1% fipronil reduced wasp colony (nest) activity by 99.7% in the treated area, whereas sulfluramid had minimal effect on colony activity. Researchers in South Australia have experimented with a 0.01% fipronil in European wasp baits, but found 0.1% fipronil more effective (G. Wood personal communication), while New Zealand researchers have used 0.1% and 0.2% fipronil with success (J. Beggs personal communication). The concentration of active ingredient in baits is important. A concentration that is too low may not markedly affect nests, or may allow nests to recover quickly, while a concentration that is too high could kill foraging wasps taking the bait back to the nest, thus limiting the amount of toxic bait the nest receives.

Another critical component of a successful baiting system is the attractant. European and English wasps can be attracted to carbohydrate (ie. sucrose solution) or protein-based (ie. meat) baits, however carbohydrate baits also attract large numbers of non-target organisms, particularly honeybees (Spurr 1996). Honeybee repellents mixed with carbohydrate baits also repelled wasps (Spurr 1996). To eliminate the potential impact on honeybees, most researchers have studied protein-based baits such as fish, beef, chicken and other meats (Wagner & Reierson 1969, Ennik 1973, Chang 1988, Spurr 1991, 1995). Spurr (1995) rated the attractiveness of a number of different protein sources and found canned sardine cat food to be most attractive to English and European wasps in New Zealand. Attractiveness of different baits varies however, and can depend on the time of year, presence of alternative food sources, the wasp species present (European or English wasps), and rainfall (Harris *et al.* 1991, Spurr 1995). In South Australia for example, kangaroo mince has been used in European wasp baiting trials with some success

(G. Wood personal communication). However meat or fish baits remain fresh for only 1-3 days in New Zealand (Spurr 1995). Baits that putrefy or desiccate become unattractive to wasps, and must be replaced regularly until sufficient insecticide has been collected to destroy nests in the area. Attempts have been made to increase the shelf and field-life of wasp baits (Spurr 1995, 1997). Harris & Etheridge (2001) concluded however that the ability of fipronil to kill nests rapidly, before baits could spoil, largely overcame this problem.

Based on the early results of work by Harris & Etheridge (2001), and trials conducted by the South Australian Research and Development Corporation (SARDI) in urban areas of Adelaide (G. Wood, personal communication), fipronil was selected for evaluation in vineyards in the Yarra Valley and Mornington peninsula regions of Victoria. During the Yarra Valley trials two rates of fipronil were tested, 0.1% and 0.025%. The higher rate has been shown to be effective against European and English wasps (Harris & Etheridge 2001), whereas the 0.025% rate was included to determine whether a concentration lower than 0.1%, but higher than 0.01% fipronil, could control wasp nests effectively. Two attractants (fish and chicken), were tested in vineyards in the Yarra Valley region of Victoria. Further trials in vineyards on the Mornington peninsula, Victoria, concentrated on the most promising combination of bait (chicken mince), fipronil (0.1%), bait delivery system (ie. one that excludes birds, reptiles and mammals, Figure 3 b,c), and application procedure.

2.2 Materials and Methods

Trials were conducted at four vineyards in the Yarra Valley, Victoria, from 1st - 10th March 2001, and at three vineyards on the Mornington Peninsula, Victoria, from 26th March - 9th April, 2001.

The baiting system employed comprised three basic components, the attractant (protein-based), the insecticide (fipronil, Aventis CropScience), and the delivery system or bait station (Figure 3 b,c). The attractant and insecticide were provided pre-mixed by Aventis CropScience. During these trials the bait station design remained constant. Two concentrations of fipronil were tested initially in the Yarra Valley, however only one concentration was subsequently tested on the Mornington peninsula (Table 1). Two meat-based attractants were trialed in the Yarra Valley, fish and chicken meat (Table 1). Only chicken meat was used on the Mornington peninsula.

Table 1. Treatments applied to vineyards in the Yarra Valley, March 2001, and Mornington Peninsula, April 2001.

Region	Vineyard	Attractant	% fipronil
Yarra Valley	1	chicken	0.025
	2	fish	0.025
	3	fish	0.1
	control	none	n/a
Mornington Peninsula	1	chicken	0.1
	2	chicken	0.1
	control	chicken	0

2.2.1 Locating wasp nests

Nests were located by walking around vineyards, particularly near a water source (dams, banks of creeks and rivers) and following the flight paths of wasps to their nests. A registered insecticidal powder was applied to all nests after each experiment was completed.

2.2.3 Bait station design and layout

Bait stations were hung from a wire, connected to a metal bracket attached to a star picket, and were approximately 1.5m above the ground (Figure 3 b, c). The bait station consisted of a top and bottom plastic lid (20cm diameter) connected together with a 2.5cm x 2.5cm wire mesh to exclude birds and other animals (including pets). The top lid protected the bait from sun and rain, but was removable to allow baits to be easily replaced. Ten bait stations were used at each vineyard, and were placed 50m apart, which is considered adequate spacing for a baiting program using fipronil (Harris & Etheridge 2001, G. Wood personal communication). The stations were situated between the edge of the property and the grapevines.

2.2.4 Baiting procedure

Approximately 30g of attractant was placed into a bait station, and was replaced with fresh attractant each morning. Attractants were placed out between 9-11am each day, and monitoring of wasp numbers was completed between 10am-5pm.

Yarra Valley trial

Non-toxic baits were used in bait stations for the first three days to attract wasps, toxic bait was placed out on day four, and non-toxic baits were placed in bait stations on the next six days to monitor wasp numbers after poisoning at the three toxic-baited vineyards. At the control vineyard no baits were placed out and wasp numbers were monitored by wasp traffic at nests only.

Mornington peninsula trial

Non-toxic baits were used in bait stations for the first two days to attract wasps, toxic bait was placed out on day three, and non-toxic baits were placed in bait stations on 1, 2, 3, 5, and 12 days after poisoning at the two toxic baited vineyards. This allowed wasp numbers to be monitored

over a longer period to ensure wasp nests were killed (or at least severely weakened) by the poison and to measure re-invasion from areas outside the property. At the control vineyard non-toxic baits were placed out on all days.

2.2.5 Measures of wasp abundance and baiting impact

Wasp numbers were monitored before and after poison baiting by recording:

(i) **wasp counts** - the number of wasps simultaneously present on non-toxic or toxic baits (5 counts/bait station/day), and
(ii) **wasp traffic** - the number of wasps entering and leaving a wasp nest per minute (10 minutes/nest/day).

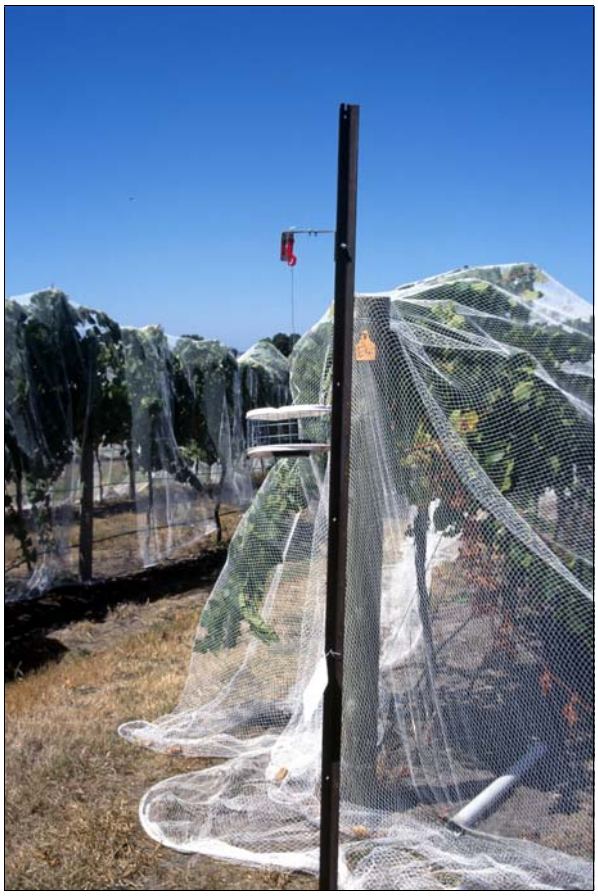
Assessment of potential non-target impacts was by observation of insects and other fauna on baits during wasp counts.

2.2.6 Statistical analyses

The number of wasps before and after toxic baiting was determined to examine the change in wasp numbers as a result of toxic baiting. Tables and figures provide the percentage (%) change in wasp numbers and the patterns of change through time.



(a) Wasp on Shiraz grapes



(c) Bait station amongst vines



(b) Close-up of bait station



(d) Wasp workers collecting bait.

Figure 3. European wasp baiting trials, 2001 (a) - (d)

2.3 Results

2.3.1 Yarra Valley Trial

The highest wasp counts on baits (pre-toxic) were recorded on chicken mince (vineyard #1, Table 2), even though no wasp nests were discovered in that vineyard. A decline in average daily wasp counts on baits of 50-72% was measured after the application of baits containing 0.025% fipronil, and a decline of 80% after the application of baits containing 0.1% fipronil (Table 2). As no baiting was conducted at the control vineyard, a wasp count comparison was not possible. Wasp counts on baits decreased immediately after the toxic bait was applied (day 4) regardless of treatment, but slowly recovered at vineyards where 0.025% fipronil was used (Figure 4). Wasp counts remained low at the single vineyard where 0.1% fipronil was used (Figure 4).

There was a reduction in wasp nest traffic at two of the vineyards (Yarra Valley vineyards #2 & #3) where toxic baits were used (decline of 19-33% after toxic baiting), and an increase in wasp nest traffic at the control vineyard (Table 2). Over the length of the trial however, wasp nest traffic was quite variable at each site (Figure 5).

2.3.2 Mornington Peninsula Trial

On the Mornington peninsula, the number of wasps on baits (wasp counts) declined at the two vineyards where toxic baits were used (vineyards #1 and #2, decline of 82% and 70% respectively) (Table 2). A small decline (14%) was also recorded at the control site, which may represent a normal fluctuation in wasp numbers or foraging activity, or increased attractiveness of other food sources (ie, ripening and/or damaged grapes). Wasp counts (Figure 6) decreased immediately after the toxic bait was applied (day 3), recovered slowly over the following three days, but declined to very low levels by the end of the trial.

There was a large reduction in wasp traffic at vineyard #1 following the application of toxic baits (decline of 93%, Table 2). By the end of the trial all nests that were found, and monitored, at vineyard #1 had been killed (Figure 7). Unfortunately no nests were discovered at vineyard #2. Wasp traffic at the control vineyard increased by 31% during the trial (Table 2).

Table 2. The average number of European wasps on the days before toxic-baits were used (pre-toxic), the days after the toxic bait had been used (post-toxic), and the % change in wasp numbers. Wasp numbers were measured by wasp counts (5 counts/bait station/day) and wasp traffic/minute (10 minute/nest /day).

Trial Area	**Wasp Counts**			**Wasp Traffic (number of nests)***		
Yarra Valley	**Pre-Toxic**	**Post-Toxic**	**Change**	**Pre-Toxic**	**Post-Toxic**	**Change**
#1 (0.025% chicken)	10.8	3.1	72% decline	- (0)		
#2 (0.025% fish)	2.2	1.1	50% decline	11.5 (1)	9.3	19% decline
#3 (0.1% fish)	2.0	0.4	80% decline	22.7 (1)	15.4	33% decline
Control	-	-	-	33.2 (2)	39.6	19% increase
Mornington Peninsula	**Pre-Toxic**	**Post-Toxic**	**Change**	**Pre-Toxic**	**Post-Toxic**	**Change**
#1 (0.1% chicken)	4.4	0.8	82% decline	59.9 (5)	4.3	93% decline
#2 (0.1% chicken)	2.8	0.8	70% decline	- (0)		
Control	1.3	1.1	14% decline	77.4 (2)	101.0	31% increase

* Only *V. germanica* nests were recovered from vineyards.

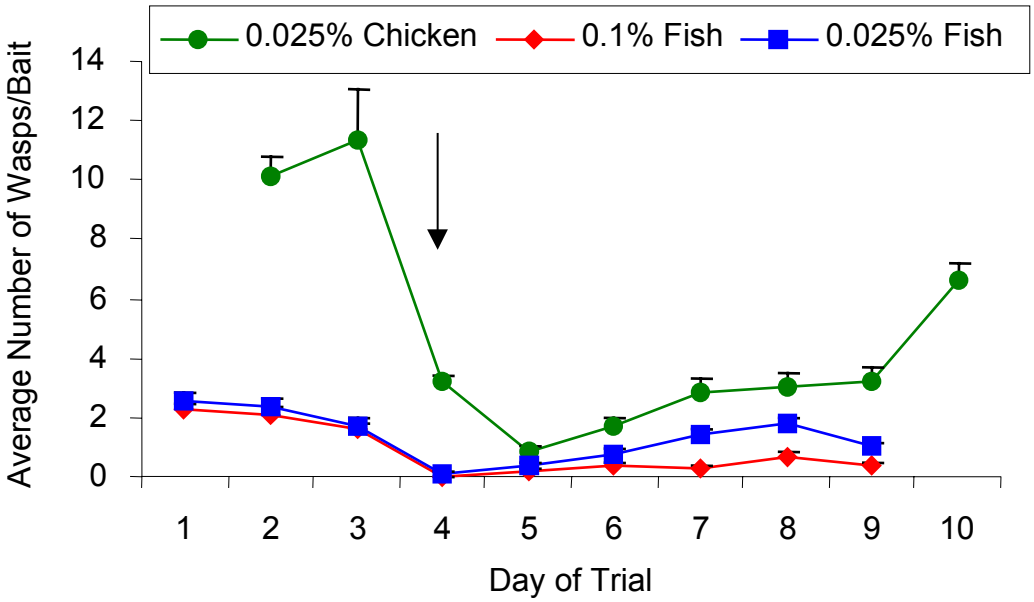


Figure 4. Wasp counts, Yarra Valley - the number of wasps on baits (average 5 counts/bait station, 10 bait stations/vineyard) for each day of the Yarra Valley trial. Toxic baits were placed out in bait stations on day four (arrow). Error bars represent the standard error.

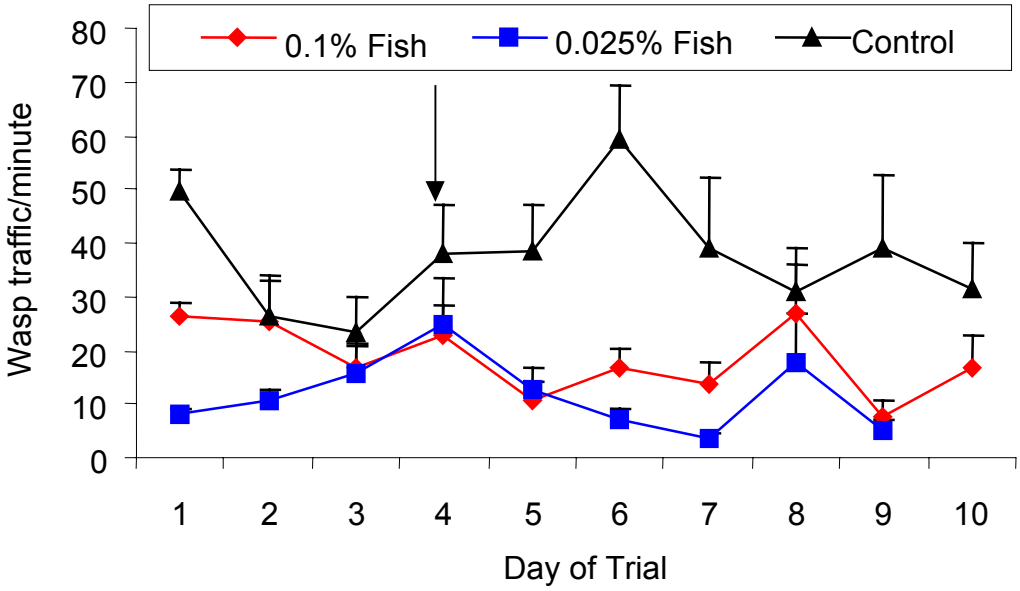


Figure 5. Wasp traffic, Yarra Valley - wasp nest traffic/minute (average 10 minutes/nest) for each day of the Yarra Valley trial. Toxic baits were placed out in bait stations on day four (arrow). Error bars represent the standard error.

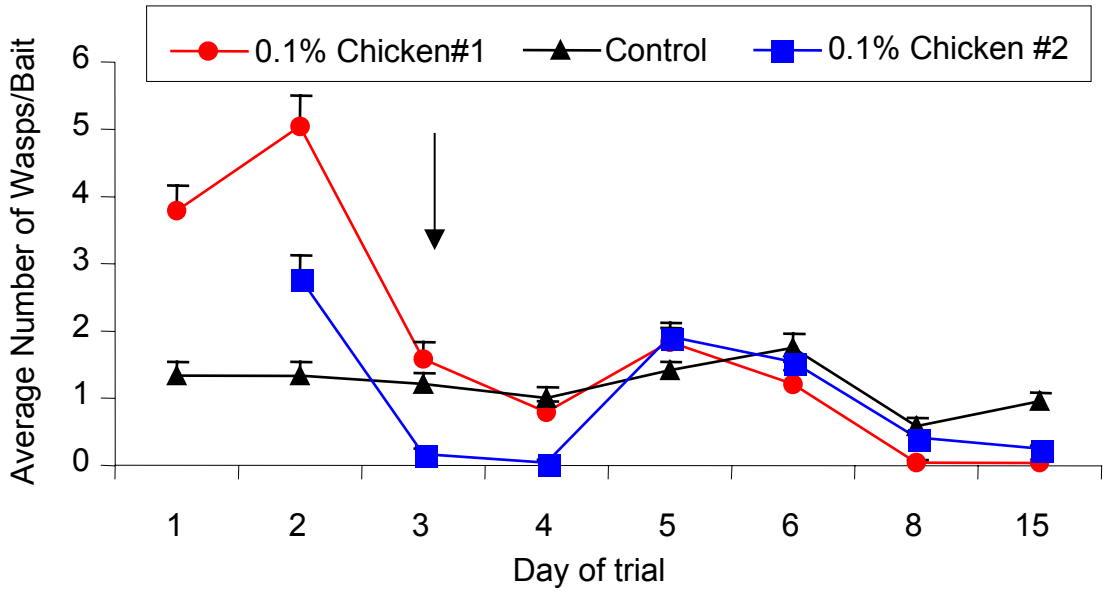


Figure 6. Wasp counts, Mornington peninsula - the number of wasps on baits (average 5 counts/bait station, 10 bait stations/vineyard) for each day of the Mornington Peninsula trial. Toxic baits were placed out in bait stations on day three (arrow). Error bars represent the standard error.

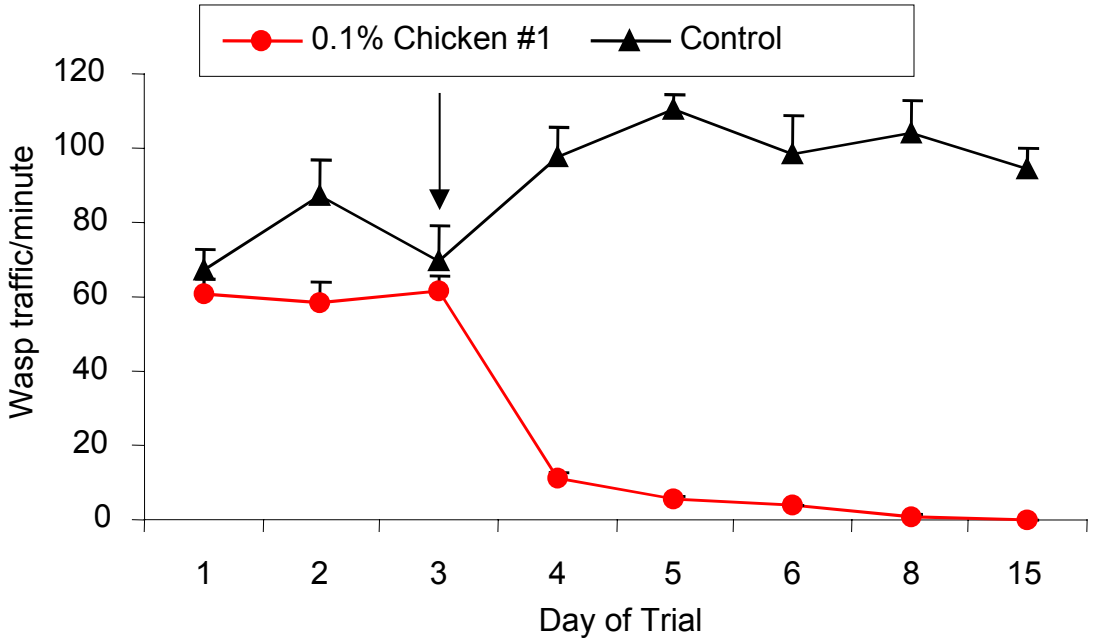


Figure 7. Wasp traffic, Mornington peninsula - wasp nest traffic/minute (average 10 minutes/nest) for each day of the Mornington Peninsula trial. Toxic baits were placed out in bait stations on day three (arrow). Error bars represent the standard error.

2.4 Discussion

2.4.1 Yarra Valley Trial

The highest wasp counts on baits (pre-toxic) were recorded on chicken mince (vineyard #1, Table 2), even though no wasp nests were discovered in that vineyard. In vineyards where fish was used as the attractant, and where European wasp nests were known to occur, lower numbers of wasps were counted on baits (Table 2). However there is insufficient evidence to conclude that chicken mince was more attractive to European wasps than fish. There may have been many more wasp nests just outside the property boundary of vineyard #1 than occurred near the other vineyards, or there may have been nests in vineyard #1 that weren't detected. However the result did indicate that European wasps could be attracted to bait based on chicken mince, despite the presence of ripening grapes. No non-target species were observed on baits.

Although wasp counts on baits declined following the application of toxic baits, wasp counts recovered somewhat at vineyards #1 and #2, and reductions in wasp traffic were not correspondingly large. In New Zealand, Spurr (1991) noted that reductions in wasp nest traffic are often lower than reductions in wasp counts on baits, and suggested this was because foraging wasps collecting toxic baits are more likely to be directly affected by the poison and killed than wasps in the nest. Two possible explanations why greater reductions in wasp nest traffic were not achieved are:

1. Low bait visitation rates at two vineyards (average of ~2 wasps/bait station), therefore few wasps were taking toxic bait back to the nest. This may have been due to low wasp numbers or low attractiveness of fish to European wasps in these vineyards. Low numbers of wasps feeding on baits has been identified as a problem for the effectiveness of baiting systems in New Zealand (Spurr 1991, Harris & Etheridge 2001). Harris & Etheridge (2001) have suggested increasing bait station density to overcome low bait visitation rates.

2. Poor efficacy of toxic baits containing the low concentration of fipronil (0.025%). Although wasp nests, and particularly foraging wasps, may have been affected by baits containing 0.025% fipronil, there may have been insufficient active ingredient to destroy nests, thereby allowing nests to recover.

Based on the Yarra Valley trial results, toxic bait containing 0.1% fipronil in chicken mince was selected for further testing in vineyards on the Mornington peninsula, Victoria.

2.4.2 Mornington Peninsula Trial

Large declines in wasp counts on baits and wasp traffic were achieved in the Mornington Peninsula trials.

The number of wasps counted on baits (Figure 6) seemed to follow a pattern whereby wasp counts;

1. were highest during non-toxic pre-feeding,
2. declined immediately after poisoning as worker wasps collecting the toxic bait and taking it to the nest became affected and died,
3. rebounded as new worker wasps replaced those affected by the toxin, and finally,
4. declined as entire nests were affected and died.

Wasp counts in the control vineyard remained relatively constant (Figure 6).

Measures of wasp traffic (Figure 7) show the impact of the baiting program on nests in vineyard #1, where all monitored nests were killed by a single application of toxic baits. This result was achieved despite the presence of ripening grapes, which were also attractive to wasps. Wasp traffic declined within hours of toxic baiting, however lows levels of nest activity were still evident for up to 12 days after toxic baiting, by which time all activity ceased. Nest traffic at the control vineyard increased over the duration of the trial (Table 2).

No non-target insects were observed on baits, and bait stations apparently excluded larger fauna such as birds, reptiles, and mammals. Nb: The Government of South Australia is currently seeking a patent on a European wasp bait station (D. Hopkins personal communication). There is currently little information available on the scope, validity, or status of this claim, or the possible implications for registration of a European wasp baiting system in Australia.

These results indicate that baits containing 0.1% fipronil in chicken mince can provide effective control of European wasps, and possibly English wasps, in vineyard situations. Control was achieved in mid-Autumn, when European wasps are highly active. This is also a period during which grapes are ripening and providing an alternative food source. Despite the presence of ripening grapes, sufficient numbers of foraging wasps were attracted to baits to effect control of European wasp nests.

To further refine a wasp-baiting program for vineyards, and around wineries, future trials should consider:

1. Whether pre-feeding is always necessary,
2. The relative effectiveness and range of this bait at different times of the year,
3. The optimal bait station density, which may depend on wasp visitation to baits, and
4. Minimum amount of bait required per bait station,

Strategies to minimise the impact of reinvasion by wasps from outside the treated area should be further investigated. Harris and Etheridge (2001) for example, concluded that increased edge effects could occur where baiting programs are restricted in area, such as may occur with small vineyards. The smaller the baiting program (in area), the greater the potential impact of reinvasion of wasps from outside the treated area. They went on to suggest that a large-scale initial baiting program, perhaps in conjunction with neighbouring properties, may be more effective in suppressing wasp populations than repeated small-scale baiting programs. (Harris & Etheridge 2001).

Although there are currently no wasp baits registered for use in Australia, application for registration of a baiting system for European and English wasps is likely in the near future (P. Morrow personal communication).

3. Non-chemical Control Options

3.1 Introduction

Non-chemical controls can include biological, cultural and physical control techniques. Although attempts have been to introduce the parasitoid *S. vesparum* to control European and English wasps, this predator has apparently failed to establish, or is having very little impact, on *Vespula* spp. in Australia (unpublished data). Investigations into other parasitoids or potential pathogens are yet to produce an effective biological control agent (Glare *et al.* 1996, A. Reeson personal communication). Other non-chemical controls however, when used as part of an integrated wasp management program, may assist in reducing the impact of wasps on the grape and wine industry. Information on non-chemical controls for wasps was obtained from a variety of sources, and an attempt made to identify those controls most appropriate for alleviating wasp problems in vineyards and wineries.

3.2 Materials and methods

In 1998 a Department of Natural Resources and Environment (DNRE) survey, designed to evaluate the pest status of European wasps to the grape and wine industry, was sent to vineyards in the Yarra Valley, Mornington Peninsula and Macedon Ranges. Non-chemical control techniques employed to reduce the impact of wasps in areas of particular concern for grape growers and wine makers were identified by;

(i) Collating questionnaire data obtained from grape and wine industry personnel, and
(ii) Surveying literature and the internet, for relevant examples of non-chemical control techniques.

3.3 Results

3.3.1 Collation of Questionnaire Data

The survey identified three main areas where European wasps have an impact in the grape and wine industry (and thus control options can be directed towards):

(i) damage to grapes,
(ii) a severe nuisance (for example wasps can annoy tourists at wineries and restaurants), and
(iii) stings to, and harassment of workers.

The survey also found that 72% (43/59) of respondents had attempted some kind of wasp control. The main control techniques used were destroying nests (95%), trapping (26%) and modifying workplace practices (17%).

3.3.2 Literature and Internet Search

Four non-chemical control strategies were identified that can reduce the impact of European wasps, and which may be appropriate for vineyards and wineries. However, use of these controls has not been evaluated in grape growing areas, nor are they specifically targeted at the grape and wine industry.

Habitat modification - Sanitation

Garbage and food scraps are important food sources for wasps (Edwards 1980). Garbage, and the odours garbage emits, should be removed as quickly as possible. Garbage containers should have tight fitting lids, and be emptied and cleaned frequently.

Donovan (1997), in New Zealand, found that an important limitation for English wasps may be the availability of suitable nesting sites. Removing man-made nesting sites such as piles of wood, disused garden sheds, and other debris (e.g. old cars) can be a simple way to reduce the nesting success of queens.

Habitat modification - Proofing

In Australia up to 20% of wasp nests can occur in the roofs and walls of buildings. To limit wasp infestations inside buildings, repair windows and insect screens, and caulk holes in building sidings, window frames, and eaves (Edwards 1980). Fit doors with “plastic strips” to deter the entry of wasps and

other insects. When undertaking inspections for pests such as rats, mice, and termites, ensure entry points for wasps, and possible nesting sites, are considered.

Trapping

A variety of traps have been used to capture and kill foraging wasps. Sticky traps can be fixed to fences or walls where a wasp problem exists. Net traps have been used in Britain to prevent wasps entering factories (Edwards 1980). Wasps are attracted to ultraviolet light and electric traps. Many trap designs used in Australia consist of a lightweight container that allows the entry of wasps, but which wasps cannot easily exit. The success of these traps is dependent on the attractiveness of the bait, which is usually liquid. Traps can capture other fauna, such as honeybees and native insects, and this should be considered when selecting a trap and attractant. There may be restrictions on the type of attractant used, for example some pest traps and barriers using chemical attractants may require registration. Check with the National Registration Authority (NRA) for Agricultural and Veterinary Chemicals. Restrictions may apply to the use of honey in baits and advice should be sought from State government departments of Agriculture or equivalent.

Modifying Workplace Practises

Darby *et al*. (1998) noted that due to the impact of wasps some wineries were forced to cover harvested grapes to prevent large numbers of wasps descending into bins. In Tasmania, picking has been brought forward by up to several weeks to minimise crop losses (Bashford 2001). Where pickers are employed, gloves have been issued at the time of harvesting to prevent stings. Erickson and Estes (1992) provide details on protective measures for firefighters against wasps that may be of value to workers in other industries.

3.4 Discussion

Concerns associated with European wasps in the grape and wine industry include;

(i) occupational health and safety issues with stings to workers,
(ii) the nuisance to tourists at the cellar door and restaurants, and
(iii) damage to crops and loss of wine quality.

A number of non-chemical controls are available to growers and winemakers. Modifying workplace practises will be useful in some instances; for example gloves may be useful to avoid being stung. However bringing the harvest forward to reduce damage to grapes must be weighed against the impact on the quality of wine, and therefore may only be considered in a year of extremely high wasp numbers. Wasp traps have little impact on overall wasp numbers, but may be useful for diverting wasps away from sensitive areas (e.g. cellar door, restaurant). General sanitation and insect proofing are particularly useful around buildings, but may have little impact on wasp numbers in crops. Although these controls are not specific to the grape and wine industry, and may be ineffective on their own, they can be integrated with other control measures to reduce the overall impact of wasps. Feedback on the usefulness of these techniques, through surveys for example, would be of benefit to others in the industry seeking to reduce the impact of European and English wasps.

4. Technology Transfer

In State affected by wasps, State Government departments of Agriculture (or equivalent), museums, and local government offices usually provide information on the biology and management of European and English wasps. Industry specific information is generally not readily available. Information directly concerning the Australian grape and wine industry can be communicated more effectively to industry personal through;

1. Timely reporting of research
2. Development of support materials for effective adoption of wasp management techniques.

4.1 Reporting of research

The grape and wine industry has been informed of the progress of research into the management of European wasps (DAV99/1) through;

(i) Regular progress reports to the Grape and Wine Research and Development Corporation,
(ii) A media release prior to the commencement of vineyard trials (Appendix 2), and
(iii) Liaising with industry personal in grape growing regions affected by wasps.

In addition, the project leader has attended meetings of Australian and New Zealand wasp researchers in Canberra, Hobart and Adelaide. These meetings have provided a forum for the discussion of advances in wasp research. Sharing of information due to the establishment of closer links between researchers has gone a long way towards eliminating duplication of research effort.

4.2 Development of support materials for effective adoption of wasp management techniques

It is anticipated that the development of effective wasp management strategies will be readily adopted by industry because;

(i) Many sectors of the industry demand more effective wasp management strategies,
(ii) The most effective control currently available, direct nest destruction, is time consuming and often inadequate for the management of European wasps in many vineyards and winemaking areas,
(iii) An established technology transfer mechanism, IPM Viticulture Research to Practise can be utilised,

A module titled "European wasps" was developed for the IPM Viticulture Research to Practise manual (Appendix 1), and should be updated once a baiting system for European and English wasps is registered for use in grape-growing and winemaking situations in Australia.

Industry specific training in the implementation of baiting programs, and additional publications and information, may also be considered at that time.

5. Conclusions

5.1 General Discussion

In areas where they are established, European and English wasps have an impact in the grape and wine industry every year, although the severity of the impact may vary from year to year, and from one region to the next. However information regarding the specific impacts of European wasps on primary industries in Australia, or overseas, is scarce. It is difficult, therefore, to accurately determine the financial costs associated with European and English wasps.

At present the best control option for wasps is direct nest destruction with an insecticide. However locating nests can be very time consuming and difficult. An effective baiting system, which eliminates the need to find nests, would represent a major advance in the control of European wasps. The baiting system used in the Mornington peninsula trial can substantially reduce wasp numbers after only a short period of time. The baits worked effectively even though an abundance of other food was available (i.e. grapes). To maximise the efficiency of a baiting system, further collaboration between growers, scientists, and Aventis CropScience is suggested.

Baiting is only one control option though, and must be used as part of an integrated pest management strategy. However the development of effective European wasp management techniques, support materials for use in vineyards and winemaking areas, and their incorporation into vineyard systems, will benefit grape growers and wine makers by reducing;

- occupational health and safety risks with stings to workers,
- the nuisance to tourists at the cellar door and restaurants, and
- damage to crops and loss of wine quality.

Future priorities to further reduce the impact of European and English wasps on the grape and wine industry in Australia include:

Impact Surveys

Information on the specific costs associated with the control of European and English wasps and the damage they cause would be valuable to accurately gauge the economic damage caused by these pests. Information required includes

- The financial costs of control and damage each year,
- Whether certain grape varieties are more susceptible to wasp damage than others,
- Whether both European and English wasps are pests of vineyards and winemaking areas,
- Whether certain conditions, such as hail or high rainfall, predispose grapes to increased damage from wasps,

These surveys should be conducted over several years to gain accurate information (because wasp numbers are not constant from year to year in an area).

Information Surveys

It would be useful to survey grape growers to determine their knowledge of European wasp management and whether they are aware of the potential control options available to them. In addition, information regarding the effectiveness of different control options under industry conditions is essential to further develop and update management strategies. For example, information on the effectiveness of non-chemical control options is not known. Furthermore, when a chemical baiting system becomes commercially available to growers, there is a need for follow up research with the industry to determine the ease of use of the baiting system, its effectiveness under different situations, and whether there is a requirement for further trials or industry-specific training.

Baiting techniques

To further refine a wasp-baiting program for vineyards, and around wineries, future trials should consider:

- Whether pre-feeding is always necessary,
- The relative effectiveness and range of this bait at different times of the year,
- The optimal bait station density, which may depend on wasp visitation to baits,
- The minimum amount of bait required per bait station, and
- Strategies to minimise the impact of reinvasion of treated areas.

It is further recommended that:

- Registration of a baiting system for European and English wasps in vineyard situations and around wineries is supported by the Grape and Wine industry.

- Extension material, particularly the "Research to Practise - European wasp" module, be updated following registration of a baiting system for European and English wasps in Australia.

6. Acknowledgments

The Grape and Wine Research and Development Corporation and the Victorian Department of Natural Resources and Environment (NRE) Agriculture Division funded this project.

Many thanks to Yarra Ridge Winery, Fergussons Vineyard and Winery, Nick Butler at Montrose, Ed & Amanda Williams at Brockspurr, Stumpy Gully Vineyard, Woolandoon, and Willow Creek Vineyard for allowing access to their properties during baiting trials. Thanks also to Paul Bennett (Parks Victoria), Ian and Anne McClean (Yarra Yarra Vineyard), Malcolm and Jane Calder, and El and Aline Bruzzese for allowing access to their properties to collect wasp nests. Thanks to Glenys Wood (SARDI) for her advise on baiting program specifics, Dennis Hopkins (SARDI) for information on South Australian research, and Jacqueline Beggs (Landcare Research, NZ) for information on New Zealand research. Phil Morrow (Aventis CropScience) supplied materials for the baiting trials. Andy Reeson (University of Adelaide) provided information on potential pathogens of wasps. Mick Statham and Margaret Williams provided notes on the impact and control of wasps in Tasmania. Kym Butler (NRE) provided statistical advise and the analysis of data. Mike Driessen (DPIWE, Tasmania) provided information on predation of the Ptunarra brown butterfly. David Braybrook and Alan Shanks (NRE) compiled information for the Research to Practise module.

7. References

Akre, R. D. (1982) Economics and control of Yellowjackets (*Vespula, Dolichovespula*). *The Biology of Social Insects*. In: Proceedings of the 9th Congress IUSSI (eds. MD Breed CD Michener & HE Evans). pp109-113. Boulder, Colorado, USA.

Barlow, N. D., Moller, H. & Beggs, J. R. (1996) A model for the effect of *Sphecophaga vesparum vesparum* as a biological control agent of the common wasp in New Zealand. *Journal of Applied Ecology* 33: 31-44

Bashford, R. (2001) The spread and impact of introduced vespine wasps *Vespula germanica* (F.) and *Vespula vulgaris* (L.) (Hymenoptera: Vespidae: Vespinae) in Tasmania. *Australian Entomologist* 28(1): 1-12

Beggs, J. R. & Wilson, P. R. (1991) The kaka *Nestor meridionalis*, a New Zealand parrot endangered by introduced wasps and mammals. *Biological Conservation* 53: 23-28

Beggs, J. R., Harris, R. J., & Read, P. E. C. (1996) Invasion success of the wasp parasitoid *Sphecophaga vesparum vesparum* (Curtis) in New Zealand. *New Zealand Journal of Zoology* 23: 1-9

Beggs, J. R., Toft, R. J., Malham, J. P., Rees. J. S. Tilley, J. A. V., Moller, H. & Alspach, P. (1998) The difficulty of reducing introduced wasp (*Vespula vulgaris*) populations for conservation gains. *New Zealand Journal of Ecology* 22(1): 55-63

Beggs, J. R., & Rees, J. S. (1999) Restructuring of Lepidoptera communities by introduced *Vespula* wasps in a New Zealand beech forest. *Oecologia* 119: 656-671

Chadwick, C. E., & Nikitin, M. I. (1969) Some insects and other invertebrates intercepted in quarantine in New South Wales. Part 2. Arthropoda (excluding Coleoptera) and Mollusca. *Journal of the Entomological Society of Australia (N.S.W.)* 6: 37-56

Chang, V. (1988) Toxic baiting of the Western Yellowjacket (Hymenoptera: Vespidae) in Hawaii. *Journal of Economic Entomology* 81 (1): 228-235

Clapperton, B. K., Alspach, P. A., Moller, H., & Metheson A. G. (1989) The impact of Common and German wasps (Hymenoptera: Vespidae) on the New Zealand beekeeping industry. *New Zealand Journal of Zoology* 16: 325-332

Crosland, M. W. J. (1990) The present and future impact of European wasps on beekeeping in Australia. *The Australian Bee Journal* January: 18-23

Crosland, M. W. J. (1991) The spread of the social wasp, *Vespula germanica*, in Australia. *New Zealand Journal of Zoology* 18: 375-388

Darby, S., Braybrook, D., & Lefoe, G. (1998) The impact of European wasps on the grape and wine industry in Australia. *The Australian Grapegrower & Winemaker* September: 49-53

Davis, H. G., Eddy, G. W., McGovern, T. P., & Beroza, M. (1967) 2,4-Hexadienyl Butyrate and related compounds highly attractive to Yellow jackets (*Vespula* spp.). *Journal of Medical Entomology* 4: 275-280

Donovan, B. J. (1984) Occurrence of the Common wasp, *Vespula vulgaris* (L.) (Hymenoptera: Vespidae) in New Zealand. *New Zealand Journal of Zoology* 11: 417-427

Donovan, B. J. (1997) Availability of suitable nest sites as a determinant of the density of nests of *Vespula vulgaris* (L.) (Hymenoptera: Vespinae) *New Zealand Entomologist* 20: 55-57

Edwards, R. (1980) *Social Wasps*. Rentokil, Great Britain.

Ennik, F. (1973) Abatement of Yellowjackets using encapsulated formulations of Diazinon and Rabon. *Journal of Economic Entomology* 66 (5): 1097-1098

Erickson, E. H. & Estes, J. B. (1992) Fire fighters and paramedics can easily subdue attacking bees and wasps. *American Bee Journal*. August: 513-524

Gambino, P., Medeiros, A .C., & Loope, L. L. (1987) Introduced vespids *Paravespula pensylvanica* prey on Maui's endemic arthropod fauna. *Journal of Tropical Ecology* 3: 169-170

Gambino, P., Medeiros, A. C., & Loope, L. L. (1990) Invasion and colonisation of upper elevations on East Maui (Hawaii) by *Vespula pensylvanica* (Hymenoptera: Vespidae). *Annals of the Entomological Society of America* 83: 1088-1095

Gambino, P. and Loope, L. (1992) Yellowjacket (*Vespula pensylvanica*) biology and abatement in the national parks of Hawaii. Technical Report 86, University of Hawaii, Honolulu

Glare, T. R., Harris, R. J., & Donovan, B. J. (1996) *Aspergillus flavus* as a pathogen of wasps, *Vespula* spp. in New Zealand. *New Zealand Journal of Zoology* 23: 339-344

Harris, R. J., Moller, H., & Tilley, J. A. V. (1991) Weather-related differences in attractiveness of protein foods to *Vespula* wasps. *New Zealand Journal of Ecology* 15 (2): 167-170

Harris, R. J., & Oliver, E. H. (1993) Prey diets and population densities of the wasps *Vespula vulgaris* and *V. germanica* in scrubland-pasture. *New Zealand Journal of Ecology* 17: 5-12

Harris, R. J., & Etheridge, N. D. (2001) Comparison of baits containing fipronil and sulfluramid for the control of *Vespula* wasps. *New Zealand Journal of Zoology* 28: 39-48

Howell, J. O., McGovern, T. P., & Beroza, M. (1974) Attractiveness of synthetic compounds to some eastern *Vespula* species. *Journal of Economic Entomology* 67: 629-630

Lefoe, G., & Ward, D. F. (2001) European and English wasps. *Landcare Note PA0078*, Department of Natural Resources and Environment, Melbourne

Levick, N. R., Winkel, K. D., & Smith, G. (1997) European wasps: an emerging hazard in Australia. *Medical Journal of Australia* 167: 650

Matthews, R. W., Goodisman, M. A. D., Austin, A. D. and Bashford, R. 2000 The introduced English wasp, *Vespula vulgaris* (L.) (Hymenoptera: Vespidae) newly recorded invading native forests in Tasmania. *Australian Journal of Entomology* 39: 177-179

McGain, F., Harrison, & Winkel, K. D. (2000) Wasp sting mortality in Australia. *Medical Journal of Australia* 173: 198-200.

Moller, H. (1991) Foreward. *New Zealand Journal of Zoology* 18: i-iii

Ross, D. R., Shukle, R. H., & MacDonald, J. F. (1984) Meat extracts attractive to scavenger *Vespula* in eastern North America (Hymenoptera: Vespidae). *Journal of Economic Entomology* 77: 637-642

Spradbery, J. P. (1973) *Wasps*. Sidgwick & Jackson, Great Britain

Spradbery, J. P., & Maywald, G. F. (1992) The distribution of the European or German wasp, *Vespula germanica* (F.) (Hymenoptera: Vespidae), in Australia: Past, present and future. *Australian Journal of Zoology* 40: 495-510

Spurr, E. B. (1991) Wasp control by poison baiting: experimental use of hydramethylnon in canned sardine bait. In: *Proceedings of the 44th NZ Weed and Pest Control Conference*. Pp42-46

Spurr, E. B. (1995) Protein bait preferences of wasps (*Vespula vulgaris* and *V. germanica*) at Mt Thomas, Canterbury, New Zealand. *New Zealand Journal of Zoology* 22: 281-289

Spurr, E. B. (1996) Carbohydrate bait preferences of wasps (*Vespula vulgaris* and *V. germanica*) (Hymenoptera: Vespidae) in New Zealand. *New Zealand Journal of Zoology* 23: 315-324

Spurr, E. B. (1997) Freeze-dried bait for wasp control. *Proceedings of the New Zealand Plant Protection Conference*

Stein, K. J., & Wrensch, D. L. (1988) The pest status of Yellow-jackets in Ohio (Hymenoptera: Vespidae). *The Great Lakes Entomologist* 21: 83-89.

Wagner, R. E. & Reierson, D. A. (1969) Yellow jacket control by baiting. 1. Influence of toxicants and attractants on bait acceptance. *Journal of Economic Entomology* 62: 1192-1197.

Widmer, M., & van Schagen, J. (1995) European wasps - eradicating an unwanted pest. *W. A. Journal of Agriculture* 36: 119-123

Appendix 1: Research to Practise module

European wasp

Pest species
Vespula germanica



Queen



Worker

Common names
European wasps

European wasps (*Vespula germanica*) and the closely related English wasps (*Vespula vulgaris*) have been present in Australia since the 1970's and 1950's respectively. Favourable climatic conditions, the absence of natural predators or parasites, and an abundance of food has allowed European wasps to flourish in Australia.

Eradication programs were attempted initially in most capital cities, but it was soon realised that existing control measures were not able to arrest the spread of these wasps. European wasps have now been found throughout Australia with the exception of the Northern Territory. Queensland and Western Australia continue surveillance and destruction of European wasp nests in an effort to prevent their spread in those States. According to climatic research it is unlikely that European wasps will establish in the tropical regions of Australia. English wasps have a limited distribution in Victoria and Tasmania.

European wasps are now present in many viticultural regions and have been reported to cause crop damage and loss as well as posing a threat to vineyard and winery personnel.

*Prepared with the assistance of Greg Lefoe and Sue Darby

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Characteristics of European wasps

Size:	Queens–20 mm, Males–17 mm, Workers–15 mm
Colour:	Bright yellow and black
Behaviour:	Common around picnics, barbeques, and on soft fruit. Flies swiftly making little noise. Aggressive when threatened.
Costs	Wasps are a danger to humans and animals cause problems to many horticultural and manufacturing industries and may be a threat to native ecosystems.

Pest life cycle

European wasps are social insects living in large, well-organised colonies. The colony is initiated in spring by a single queen wasp who constructs a small papery nest. Eggs are layed in cells, and when these hatch, she feeds the young larvae for about two weeks, after which time the larvae pupate and later emerge as adult female wasps or workers. The newly emerged workers take over the nest building duties, tend to the collection of food, and feed the larvae and queen. During this time the queen continues laying eggs.

The nest continues to grow over summer producing large numbers of workers. Commonly a mature nest can contain 20,000 to 30,000 cells. In late summer and autumn male wasps and new queens are produced. The males and new queens leave the nest and mate; the new queens then seek winter shelter. The founding queen and the other occupants of the nest die, leaving it empty.

Although large numbers of queens are reared in each nest, many of these fail to survive or produce a successful nest the following season. Mortality during winter is high, and queens are also vulnerable to attack when establishing their nest and tending their young in spring. Occasionally, when sufficient food and mild weather conditions prevail, a new queen can continue the activities of the nest resulting in the phenomenon of the overwintering nest. The largest of these overwintering nests recorded to date was from New Zealand. It contained more than 4 million cells, and was a staggering 4.5 m high and 1.5 m wide!

Damage and loss

Damage to fruit by wasp feeding has been reported from many areas, with some growers reporting significant economic losses. Whether wasps penetrate undamaged fruit, or whether they will only enter damaged fruit, is still being debated. However, observations of wasps in Tasmanian vineyards suggest that thin-skinned grape varieties are easily damaged with yield losses of 10–20%. Reports from a number of vineyards suggested that wasp damage was responsible for bringing the harvest date forward by up to two weeks in some cases.

'Looks like'—other similar insects

European honeybees;

Size	15 mm
Colour	dark yellow-orange and black
Behaviour	common around flowers. Flies slowly making a loud buzzing noise.
Benefits	bees pollinate orchards and other crops, produce honey and bees wax.

- Native paper wasp

Size	15–25 mm
Colour	generally orange and brown
Behaviour	common around garden plants. Flies swiftly making little noise.
Benefits	the 34 Australian species of paper wasps are an important part of the ecosystem and help control pests.

- Hoverfly

Size	10 mm
Colour	golden yellow and black
Behaviour	common around flowers. Flies swiftly and hovers in mid-air.
Benefits.	an integral part of the native ecosystem, they help by feeding on aphids.

- Bird damage

Often associated ie. bird damage then wasps move in, but some reports of wasps being primary cause of damage.

Conditions favouring infestation

Wasp numbers can vary, from one season to the next and from one region to another. Weather patterns during spring and early summer can have a major influence on the success of nest establishment. Rainfall and temperature are often cited as possible explanations for fluctuations in wasp populations. European wasps frequently nest in the ground and heavy rainfall can flood nests, particularly during spring when newly established nests are most vulnerable.

Colder than normal temperatures may also play a role in reducing the number of queens which successfully over-winter, although there are often more than enough surviving queens to initiate nests the next season. Researchers in Australia and overseas have suggested other factors that may impact on wasp populations, such as the availability of insect prey, and competition between queens for suitable nesting sites. In its native range, predators and parasites may also regulate wasp numbers to a small degree, however this is not thought to be significant in Australia. In general, mild winters and dry summers favour wasps.

Varietal susceptibility

Very little information is available on the susceptibility of different grape varieties to damage by European wasps. Some thin-skinned varieties however, such as Chardonnay, Traminer, Riesling, and Schoonberger are reportedly more vulnerable to wasp attack than other varieties.

Management considerations for European wasps

Treating nests

Direct nest destruction with an insecticide registered for use against European wasps is effective whenever nests can be easily located. If carried out prior to the dispersal flight of new queens in autumn, the potential for large numbers of nests establishing the following season is also reduced. This method can be inefficient though and sometimes inadequate, as it requires that all nests in an area be located. Co-operation with neighbours is therefore important.

Warning!
Use the precautions and equipment outlined below:

- do not make physical contact with the nest;
- do not use aerosols or dusts in a confined area as the fumes may be harmful;
- if you are not confident about treating a European wasp nest, do not proceed;
- only treat nests that are easily accessible and allow a quick and easy retreat. do not treat the nest yourself if you think you are allergic to wasps, bees or ants. (In this case, contact your local council or a pest controller who is licensed to apply pesticides); and
- use only chemicals registered for use against wasps in your state and read all labels before use.

Equipment required

1. Loose fitting clothing
   - long sleeved jumper;
   - long pants;
   - gauntlet gloves;
   - gumboots;
   - floppy hat or bee veil.

2. A torch with a red filter or covered with red cellophane

3. Insecticide registered for use against European wasps, available from hardware stores and supermarkets.

Guidelines for treating nests

1. All nests should be treated at night when the wasps are least active.

2. Cover yourself fully with clothing and use a red-covered torch, because wasps cannot see red light.

3. Approach the nest quietly,
   - If using an insecticide dust, point the dust down the entrance hole and give several good shakes, NB: Insecticide dust is less effective if the ground is wet, if there is excessive wind, or if the dust is washed away by rain. If these conditions occur, reapplication is necessary.
   - If using a liquid spray or aerosol: apply the spray through the nest entrance hole.
   - If the nest is disturbed and wasps emerge during treatment, quickly leave the area and wait for wasps to settle down before approaching again.

4. Wasp activity around the nest should cease after a day or two. If wasps continue to be active after four or five days, reapply the insecticide.

5. The hole can be filled in after a few days. There is no need to remove the nest once it has been destroyed.

Toxic baiting

(Chemical registrations vary between states. Check the product label for appropriate use in your vineyard.)

Research is underway in Australia to develop a safe and effective toxic baiting system for European wasps. Toxic baits have been successfully trialed in New Zealand to control English and European wasps however there are no products currently registered for this use in Australia.

The advantage of baiting is that a toxin can be collected by European wasp workers and taken back to the nest without the necessity of locating it. An effective toxic baiting system should be simple to use, be attractive to European wasps but not other species, and allow wasp workers to carry sufficient toxin back to the nest to ensure nest destruction.

Trapping

A variety of wasp traps are available commercially at hardware stores and nurseries. A critical factor determining the success of trapping is the type of attractant used, which may be either carbohydrate or protein-based. The diet of wasps can vary throughout the season, so further research is required to identify the most effective attractants, and most appropriate timing of trap deployment.

Trapping queen wasps in spring and early summer, for example, may be more effective than trapping workers. Trapping workers alone will rarely reduce the overall wasp population, because nests can produce greater numbers of wasps per day than are trapped. Trapping will also have little effect where there is an abundance of a preferred food.

Natural enemies

Natural predators or parasites of European wasps have the potential to reduce wasp numbers. Queen wasps searching for nesting sites are vulnerable to predation by generalist predators such as birds. Generalist predators though, may not provide sufficient control when wasp numbers are high. In an attempt to provide a more effective and long term control, a natural enemy of the European wasp, the parasitoid *Sphecophaga vesparum vesparum* was imported in the late 1980's.

Agriculture Victoria's Keith Turnbull Research Institute tested the parasitoid to ensure it did not attack native insects, and then mass-reared and released it in Victoria and Tasmania. Its establishment and impact to date is unknown, although monitoring conducted at Victorian release sites has failed to detect the parasitoid in these areas. It may be possible to import new strains of this biological agent that are better suited to Australian conditions, however further research and evaluation is required.

Occupational Health and Safety

The close association between wasps and humans has contributed to the pest status of European wasps. Wasps may sting vineyard and winery workers, especially pickers, and tourists visiting wineries.

Sting Treatment

1. If stung, move to another area, preferably indoors, as soon as possible.

2. Apply an ice pack to the sting site, but don't put ice directly onto the skin. A bag of frozen vegetables or a plastic bag containing ice and water makes a good ice pack.

3. Antihistamine tablets available from the chemist are useful to reduce general symptoms, but advice should be sought from the pharmacist on possible side effects.

4. Monitor the symptoms to ensure that the reaction to the sting is not worse than normal. A normal reaction involves local pain and swelling lasting several hours, which may be followed by itching. Only a small number of people become allergic to wasp venom.

5. If in doubt about the symptoms, consult a doctor. People with more severe symptoms require assessment by a specialist allergist, as they may need treatment to prevent and manage possible future stings.

   Products containing anti-inflammatory, anti-itching or pain relief compounds may help reduce the pain, swelling and itching.

Note:
Care must be taken to avoid stings in the mouth or throat. Always check food and drinks before consuming them.

Always be aware of potential nesting sites. Disturbing a nest may result in multiple stings.

Appendix 2. Media release - prior to baiting trials

Media Release

Natural Resources and Environment

AGRICULTURE
RESOURCES
CONSERVATION
LAND MANAGEMENT

15 January 2001

TRIALS PLANNED TO RID VINEYARDS OF EUROPEAN WASPS

A special study funded by the Department of Natural Resources and Environment and the Grape and Wine Research Development Corporation will research ways of minimising the impact of European wasps on grapes and vineyards.

The Department's Keith Turnbull Research Institute's Darren Ward will conduct short duration, baiting trials in vineyards where wasps are present.

Vineyard managers willing to take part in the trials or who require further information should contact Darren Ward, KTRI, PO Box48, Frankston 3199, or Ph: 9785 0179 or email darren.ward@nre.vic.gov.au.

Research using wasp baits in South Australia and New Zealand has had encouraging results.

Mr Ward said ideal sites for the trials are those where there are high numbers of wasps present. The non toxic baits are introduced to the wasps at feeding stations and when numbers are sufficient, a toxin which affects wasps only is introduced. The wasps take the bait back to their nests killing the developing larvae.

Birds, mammals and reptiles are not affected and the bait is not attractive to honeybees.

"Although baiting is done for only a short period the trial will monitor through the current wasp season to ensure that the wasps do not recover. Ultimately, the project aims to develop a strategy to reduce the impact of wasps on the grape and the industry," Mr Ward said.

European wasps, *Vespula germanica*, are now found in many southeastern Australian vineyards and as well as causing crop damage, they also threaten vineyard staff. The tourism potential of the vineyards is also affected.

In bad years grape growers have been forced to cover their grapes to protect them from the wasps and spend valuable time finding and destroying wasps' nests, Mr Ward said.

For more information please contact Darren Ward, KTRI. Ph: 9785 0179.