Assessing naturally occurring vineyard plants for enhanced biocontrol of pests

Project managed by
Hawkes Bay Grape Growers

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Funders: Skelton Ivory, Lincoln University,
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1.0 Introduction

"Why should I spend time and money spraying out my weeds when they could actually be useful for beneficial insects? Using something that's already there seems to make much more sense than sowing in a crop each year" (a Hawkes Bay grape grower)

Growers are interested in the potential value of naturally-occurring vineyard "weeds". Some of these may encourage predatory and parasitic beneficial insects for mealybug and leafroller caterpillar control, if they are managed in the vineyard, thereby, providing a habitat and a food (nectar) source.

2.0 Background

The Hawkes Bay Sustainable Winegrowing Discussion Group comprises growers and industry representatives who meet on a regular basis. The group first met in 2002.

During 2004, group members discussed that they did not know whether naturally occurring vineyard plants would enhance beneficial insects. The growers felt that they wanted to encourage what already existed in the vineyard, rather than go to the expense and inconvenience of sowing a cover crop each year. There may be plant species that could have the same value as annual drillings of cover crops. In this case they would need to be managed selectively.

After initial invesitigations, it was quickly concluded that little research work had been done on naturally occurring vineyard plants. The growers decided to start a small project, where key plants were identified and flowering time recorded. It was thought that if the time of flowering was known, then this could be related to when the key beneficials needed plant resources (food and/or habitat).

However, with vineyard time and financial constraints the recording was not carried out fully over the 2004 season. At the 2005 July meeting, growers again discussed the usefulness of such a project and it was decided to pursue funding.

3.0 Project Objectives

The project has four key objectives.

1. To survey the main weed species in each selected vineyard;
2. To collect and identify the key insects;
3. To assess which insects are visiting which weed flowers; and
4. To identify which weed species should be further analysed.

4.0 Summary

The inter-row weed flora of five Hawkes Bay vineyards were quantified using quadrat assessments of percentage cover in early-, mid- and late-season. Arthropod 'densities' associated with this flora were observed using yellow sticky traps and a motorized suction sampler. Floral abundance changed markedly through the season and also differed between vineyards.

Invertebrates were dominated numerically by ants, mites and spiders. Of the groups sampled, spiders and parasitic wasps had the greatest biocontrol potential. However, the former group has no major association with flowers, apart from crab spiders.

The nectar of an abundant weed, evening primrose, was analysed for the concentration of three common sugars. These concentrations were compared with existing data for native and non-native New Zealand plant species. Evening primrose had a high sucrose/(fructose + glucose) ratio, identifying it as having real biocontrol-enhancement potential if it flowers in late summer.

5.0 Further investigations

This initial research project has indicated a direction for future research into naturally occurring vineyard plants for enhanced bio-control.

Laboratory bioassays should be conducted, to examine the extent to which evening primrose enhances 'the fitness' of key natural enemies of vineyard pests in Hawkes Bay. These results will be compared with positive (buckwheat) and negative controls (mustard).

Further research of the weed/arthropod interactions should be continued over the upcoming season. Attention should be focused on species flowering over the whole season, or late in the season.

6.0 Method

6.1 Research sites

Five vineyards were used for the research project:

Prospect Vineyard – Maraekakaho Road, Hastings

Fernhill Holdings – State Highway 50a, Fernhill

Craggy Range Vineyard – State Highway 50, Fernhill

Seascape – Clifton Road, Te Awanga

Eskwood – State Highway 2, Esk

Three rows were chosen and tagged at each research site. The sites were selected in consultation with the owner/manager to minimize any impacts on management practices over the season.

6.2 Data collection

Data were collected on the following dates.

Site	Early season	Mid season	Late season
Prospect	20 & 27 November	19 January	24 March
Fernhill	22 November	29 January	24 March
Craggy	24 November	19 January	16 March
Eskwood	21 November	1 February	31 March
Seascape	27 November	30 January	9 March

6.3 Weed survey

Each owner/manager was asked not to mow or herbicide the research rows for a few weeks prior to collecting data. The rows were mowed as per normal management schedule outside these times. The last mow before the project commenced at all sites, was over the period 12-18 October, 2006.

A 50 cm x 50 cm quadrat was randomly placed in the middle of each of the three research rows. The key plant species were identified and percentage cover estimated. The quadrats were repeated until variation was minimized. The presence of flowers was recorded

Grasses were not individually identified, but recorded as “grasses – NS”.

6.4 Insect collections

Early morning or late afternoon were the preferred collection times, especially in the hotter months.

A motorised insect suction machine was used to suck up insects from the mid-row into a collection pottle. Each sample comprised five five-second sub –samples, and covered a 0.1m² area. Care was taken not to walk on the mid-row or cast shadows on the area that was used for collection.

Random collections were taken down each of the three test rows.

Alcohol was placed into each collection pottle to preserve the invertebrates for later identification. Each sample was transferred to a screw top jar and labeled.

The invertebrate samples were separated from debris in the lab using a concentrated salt solution, to leave arthropods for later identification.

6.5 Plant and insect interactions

The interactions were observed at a sixth vineyard site, Matapiro Road, Crownthorpe. This site was chosen because almost all of the main weed species observed at the test sites during the project period were present, and in flower at the same time.

The species selected were chosen at a time of high growth and arthropod activity. Mid-row weed clumps were selected, to be as similar to the research sites as possible. A yellow sticky trap (10 cm x 12 cm) was pinned to a short bamboo stake; placed into the middle of each weed clump, at no more than flower height; for one week in January 2007. Arthropods were identified at Lincoln University.

7.0 Results

7.1 Weeds

The 2006/2007 season was dry in Hawkes Bay, which influenced plant longevity and time of flowering. This in turn influenced sward composition, particularly by the end of the season.

The weed percentage cover data for each site are given in Table One. Individual grass species were not identified as wind pollinated plant species such as these do not produce nectar.

Table 1: Weed and grass composition recorded over the 2006/2007 growing season in five Hawkes Bay vineyards

Vineyard	Mid-row composition	Early season (%)	Mid season (%)	Late season (%)
Esk	Weed	57	35	33
	Grass	43	65	64
Craggy	Weed	78	50	39
	Grass	22	50	61
Fernhill	Weed	65	35	43
	Grass	35	65	57
Seascape	Weed	58	61	43
	Grass	42	39	57
Prospect[2]	Mid-row weed	35	25	15
	Mid-row grass	65	75	85
	Under-row weed	75	75	sprayed
	Under-row grass	25	25	sprayed

2: Mid- and under-row at Prospect Vineyard were recorded separately due to variable plant composition

Sward composition

The key points to note are:

- all sites had a mix of permanent grass and annual weeds;
- there was an increasing proportion of grass and a decreasing proportion of broad-leaved weeds over the season;
- weeds were most visible at the start of the season. Weeds were easier to identify when they had flowers, or when plants were bigger with determining features; and
- other species would have been present, but were either too small or unable to be identified at the vegetative stage.

Site differences

Sward composition differed between site. Each site had: one or two main weed species; a variety of other weed species in smaller proportions; and a grass mixture. The dominant weed species changed over the season, depending on the plant's annual cycle and available soil moisture.

Some sites had a predominantly grass sward, for example, mid-row at the Prospect vineyard. Others, such as Seascape, had a wide variety of weed species until the end of the season, when grasses dominated.

Table 2: Weed species and number at the study sites

Site	No. of different weed species	Main weed species (over 10% cover)
Fernhill	12	White clover, creeping mallow
Esk	15	Creeping mallow, dovesfoot (early)
Seascape	23	Plantain, white clover (early), creeping mallow (mid)
Prospect	18	Mid-row: no species over 10%. Under row: dovesfoot, groundsel, small flowered mallow, portulaca
Craggy	16	Haresfoot, dovesfoot (early), jersey cudweed (mid)

Appendix One lists all weed species identified in each vineyard site over the season.

Timing of flowering

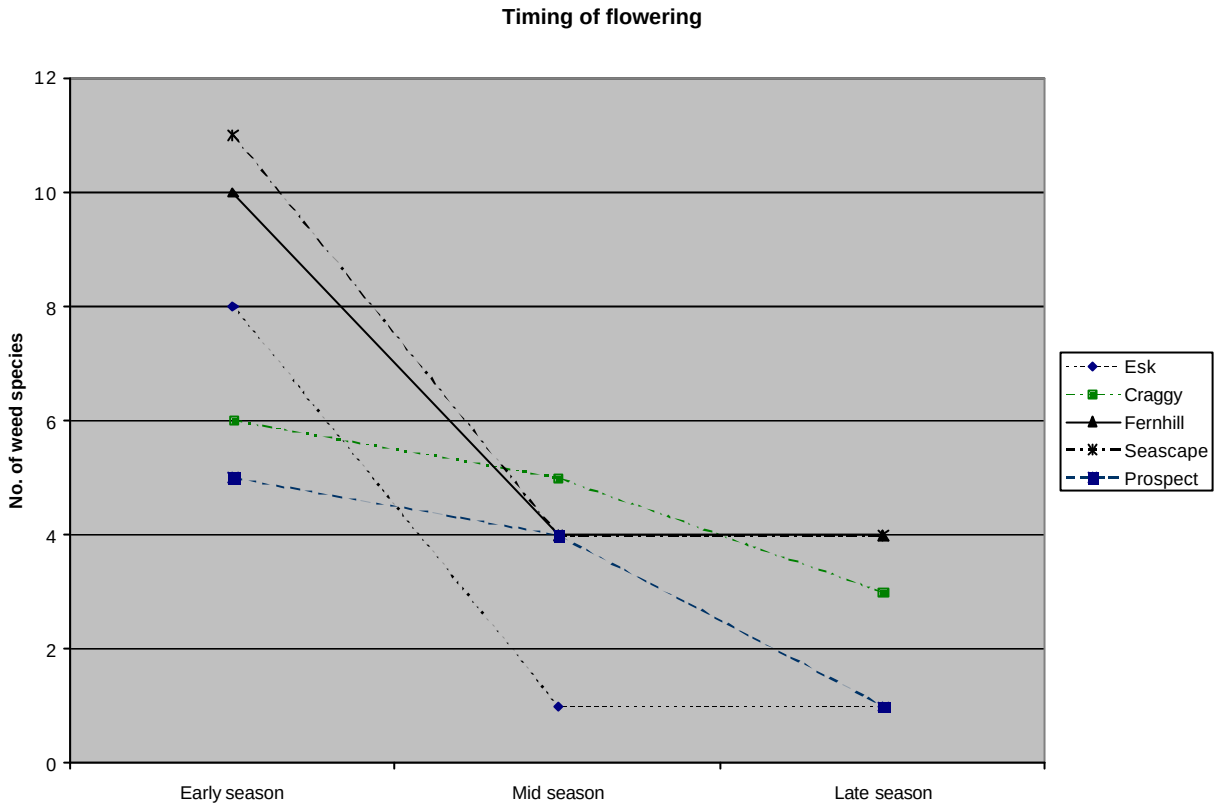
The key points to note are:
- flowering depends on the site and the plant; and
- the proportion of plants flowering decreases over the season.

Early season: all sites had flowering plants
- a high proportion of plants in each species were flowering
- approximately half of the weed species at all five vineyards were flowering.

Late season: few species were flowering
- only a few individual plants of each species were flowering
- three vineyards had approximately 20% of their weed species flowering
- two sites had less than 1% of the weed species flowering

Table 3 and Figure One illustrate these trends.

Figure One: Number of weed species flowering over the study period



Site dictated whether plants flowered over the whole season. Dandelion flowered over the whole season at almost all sites.

Table 3: Weed species flowering over most of the study period

Site	Weed species flowering over whole season
Fernhill	Dandelion, white clover
Esk	None
Seascape	Dandelion, plantain, creeping mallow
Prospect	Dandelion
Craggy	Dandelion, dovesfoot

7.2 Plant nectar quality

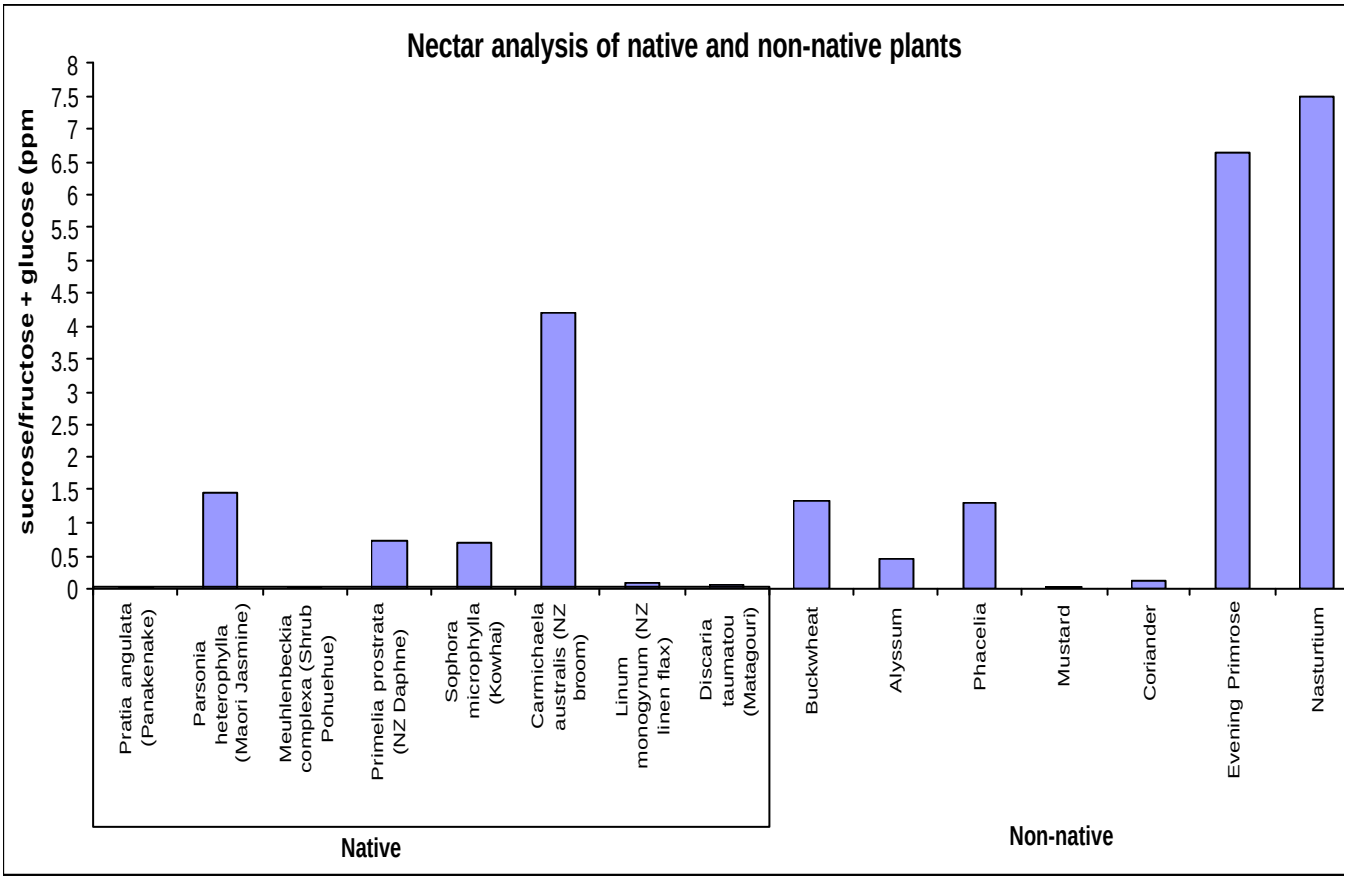
Lincoln University has been investigating the nectar quality of a range of native and non-native plant species. Measurements of sucrose, fructose and glucose concentrations have been made in these species.

Each plant nectar has particular sugar ratios, dominated by the ratio of sucrose, fructose and glucose. It is believed that there is a particular sugar ratio that is ideal for beneficial insects. Buckwheat's nectar enhances beneficial insect fitness the most, and it is possible that buckwheat's sugar ratio is the most ideal for these natural enemies of insects.

Nectar analysis has also been made of evening primrose (*Oenothera glazioviana*) plants, taken from Two Gates Vineyard, Highway 50, Hawkes Bay. Evening primrose has a higher sugar ratio than buckwheat, however, it is likely that too much sucrose would cease to be of any use to the insect .

Evening primrose could potentially be better than buckwheat for attracting and sustaining beneficial insects. Further investigations into evening primrose's potential are high priority.

Figure Two: Nectar analysis of some native and non-native plant species.



7.3 Invertebrates

Invertebrates were counted and recorded in the following groups. These invertebrate groups include species that are all potential natural enemies of vineyard pests.

spiders
hoverflies
mites
beetles
lacewing (adult)
lacewing (larvae)
parasitic wasps
ants (which also enhance mealybug populations)

Differences in natural enemy number and distribution varied between vineyards and over the season. Figures three to seven (overleaf) illustrate these vineyard and species differences.

Vineyard differences

The main factors causing the differences between vineyards are:

- viticultural management practice (for example, pesticide history);
- local features (for example, aspect and local micro-climate); and
- proportional differences between bare ground and weed/grass.

Species differences

Species differences were also recorded over the season. Some of the key points to note are:

Hoverflies: none recorded, as the insects fly away when they hear the motorised sucker
Lacewing larvae: none recorded indicates insufficient aphid numbers
Ants: high numbers usually indicate high numbers of mealybugs
Spiders: common for numbers to peak in late season as reproduction occurs in spring and summer

Figure Three: Invertebrate numbers at Craggy Range Vineyard over the 2006/2007 season

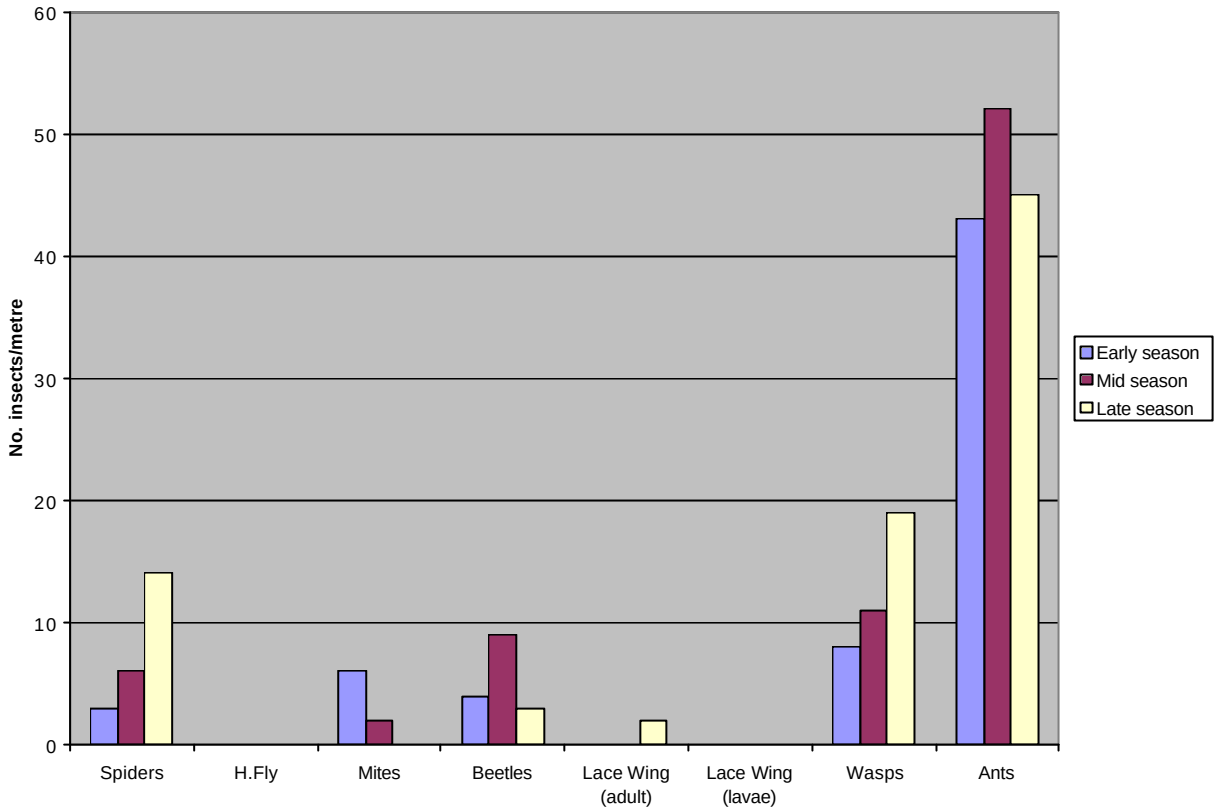


Figure Four: Invertebrate numbers at Eskwood Vineyard over the 2006/2007 season

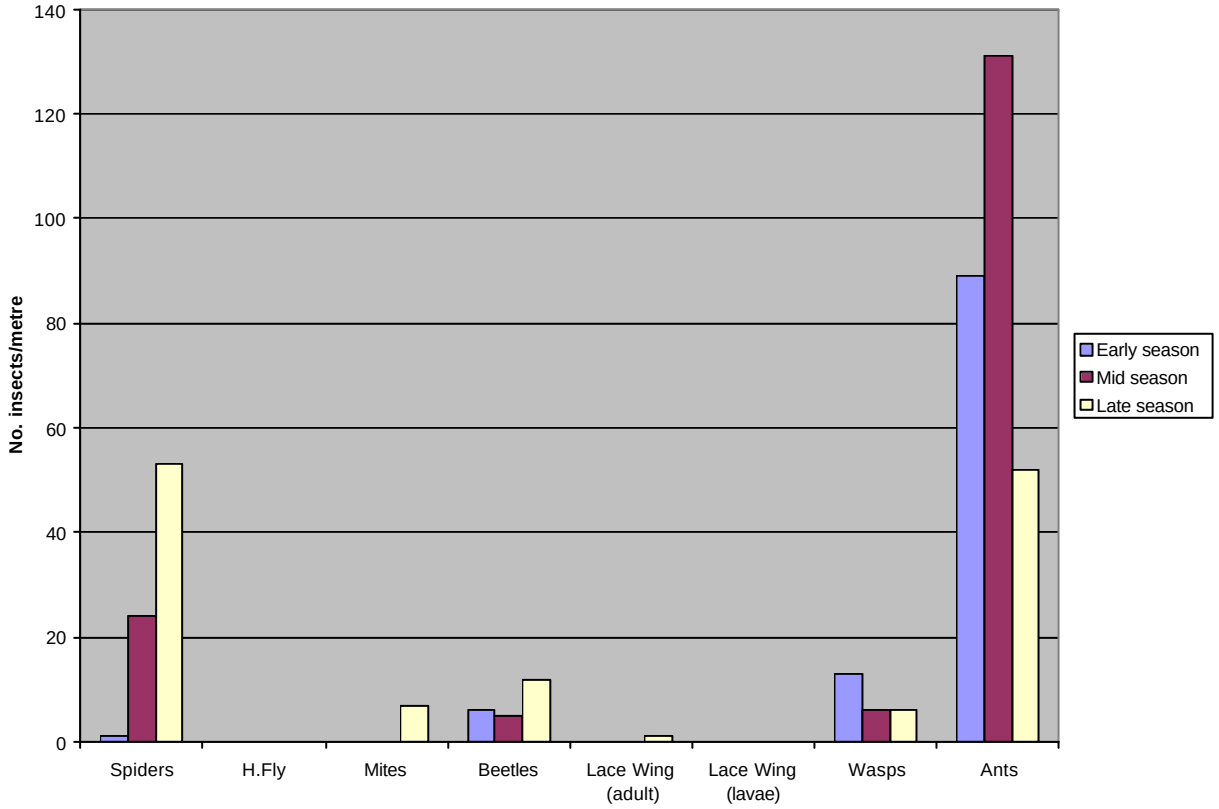


Figure Five: Invertebrate numbers at Fernhill Vineyard over the 2006/2007 season

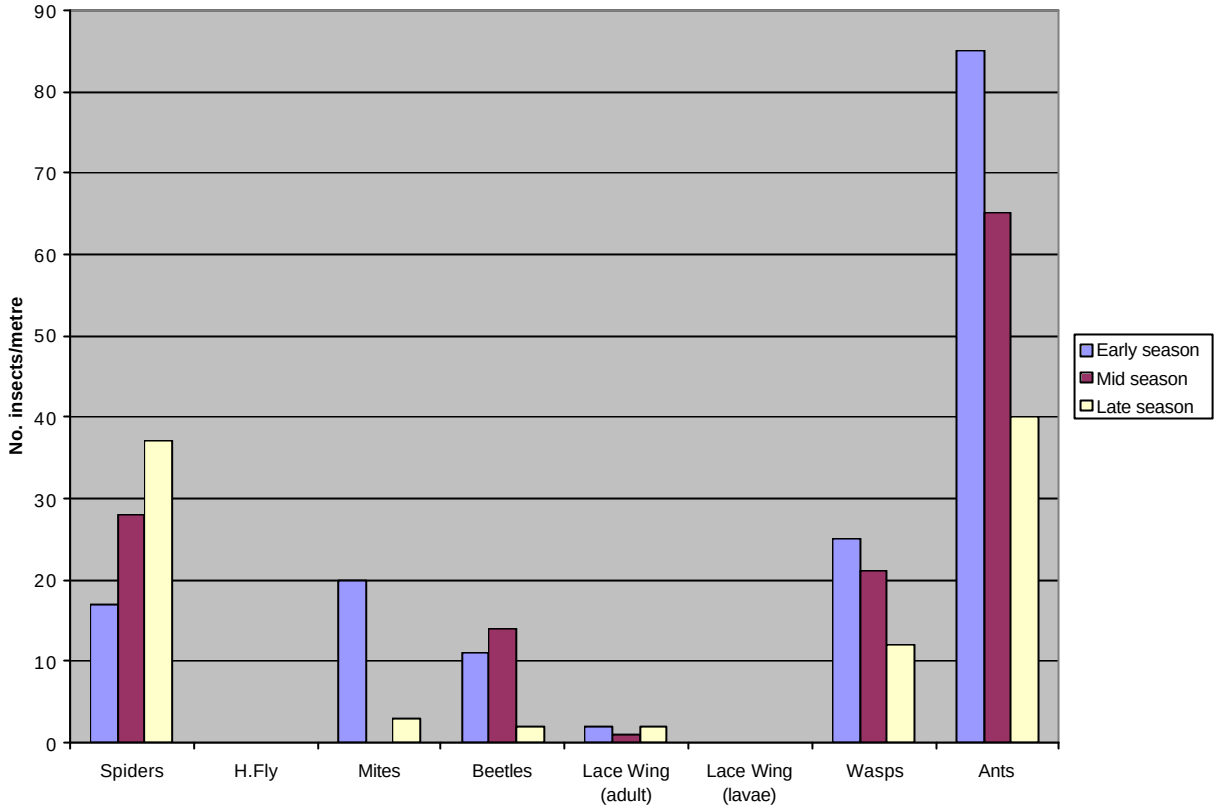


Figure Six: Invertebrate numbers at Prospect Vineyard over the 2006/2007 season

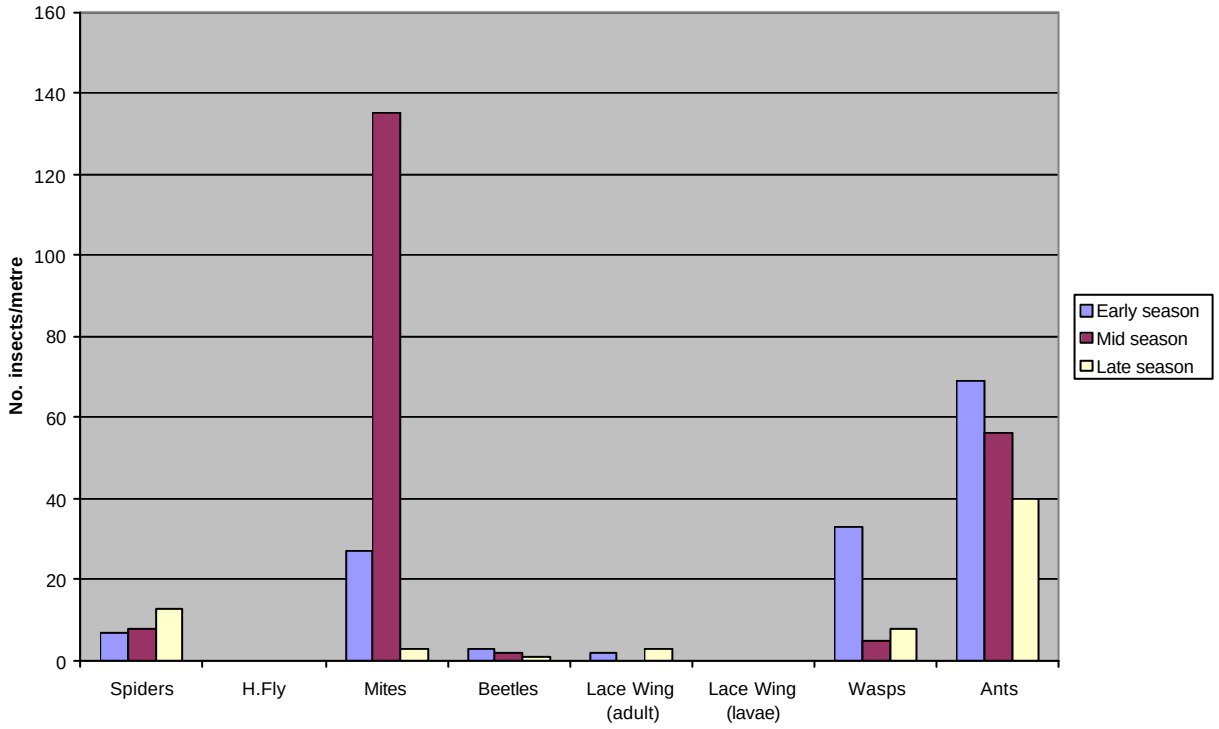
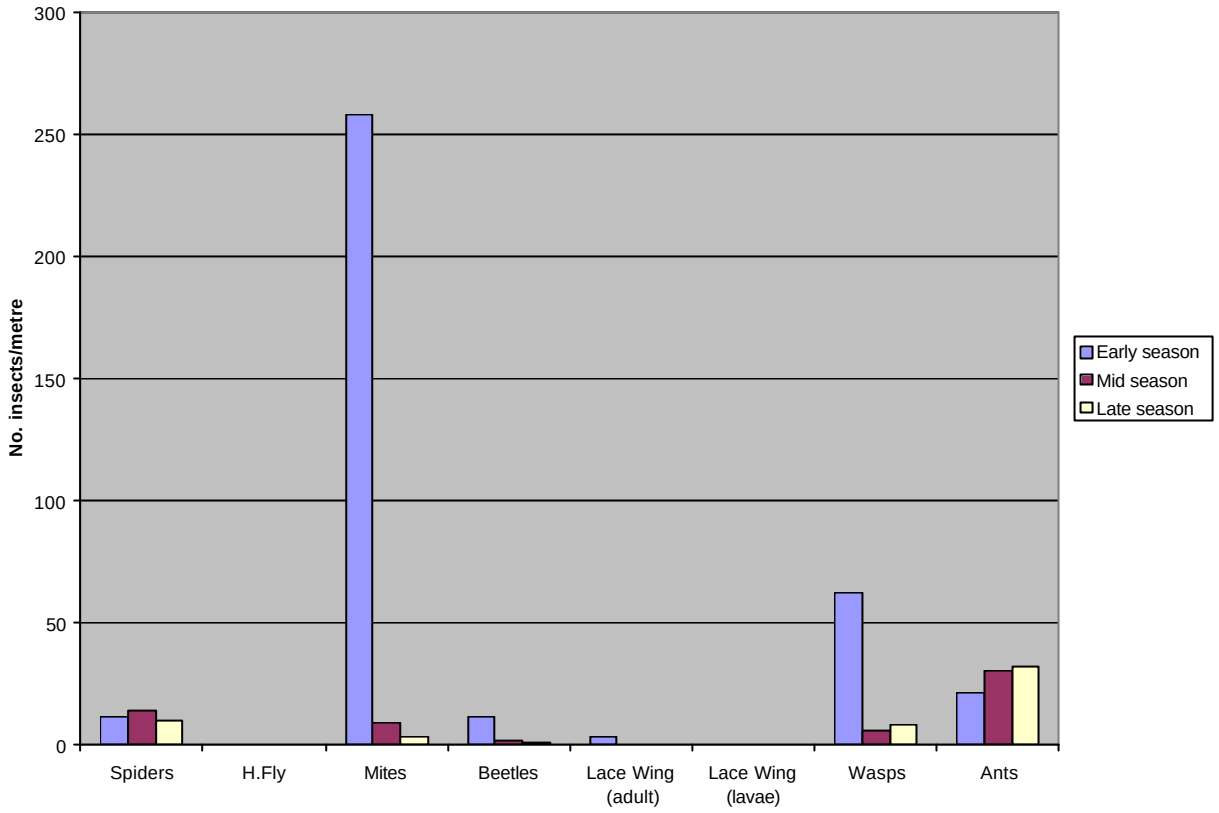


Figure Seven: Invertebrate numbers at Seascape Vineyard over the 2006/2007 season


300
250
200
150
100
50
0
No. insects/metre
Spiders
H.Fly
Mites
Beetles
Lace Wing (adult)
Lace Wing (lavae)
Wasps
Ants
Early season
Mid season
Late season

7.4 Weed/invertebrate interactions

Assessing which invertebrates visited which flowers proved more difficult in practice than was initially anticipated. Most invertebrates were small, which made identification extremely difficult. It was decided to place sticky traps into clumps of flowering weeds and then identify which insects were present in those plants at that time.

The results were inconclusive. Too few invertebrates were recorded to enable any significant differences between species to be noted.

This method will be modified in future by:

- using bigger sections of sticky trap
- taking more sticky trap measurements per plant species
- taking measurements over a longer period in the season

8.0 Discussion

This work has shown that Hawkes Bay vineyards harbour a wide diversity of flowering plants, some of which continue to have nectar available to beneficial insects late in the season, when key pests are most damaging. Invertebrates sampled in this work included most major predatory and parasitic groups, with the exception of hoverflies and lacewings.

The high sucrose ratio in the nectar of evening primrose indicates that more work, including laboratory bioassays with key parasitic wasp species, needs to be done. Future work, in conjunction with Hawkes Bay based PhD student David Reid, should explore the phenology, abundance and insect fauna of this plant species.

9.0 Appendix One

Table One: Main weed species identified in Seascape Vineyard over the 2006/2007 season

Table Two: Main weed species identified in Craggy Range Vineyard over the 2006/2007 season

Table Three: Main weed species identified in Eskwood Vineyard over the 2006/2007 season

Table Four: Main weed species identified in Fernhill Vineyard over the 2006/2007 season

Table Five: Main weed species identified in Prospect Vineyard over the 2006/2007 season

Table One: Main weed species identified in Seascape Vineyard over the 2006/2007 season

Species common name	Flowering time	Early season (% cover)	Mid season (% cover)	Late season (% cover)
White clover	Early	13.7	3.8	1.3
Dandelion	Early, mid, late	4.8	4.8	2.7
Buttercup	Early	3	0	0
Plantain	Early, mid, late	25.9	25	18
Purple cudweed	Early	1.7	0	0
Broad leaf dock	Early	0.2	0	0
Creeping mallow	Early, mid, late	4.1	16.6	8
Furry leaf weed	Early	0.2	0	0
Purple leaf verain	Early	0.9	0	0
Cut leaf geranium	Early	2.2	0	0
Scarlet pimpernel	Early, mid	1.3	1.1	0.3
Dwarf Mallow		0	0.5	0
Wild carrot		0	3.6	0
Thistle		0	0.2	0.3
Rue		0	1.4	0
Sheep sorrell		0	2.7	0
Purple cudweed		0	1.4	0
Wireweed		0	0	3
Horned oxalis		0	0	1.7
Yarrow	Late	0	0	4.7
Fiddle dock		0	0	2
Dovesfoot		0	0	0.7
Fleabane		0	0	0.3
Total weeds		**58**	**61.1**	**43**
Grasses		**42**	**38.9**	**57**

Table Two: Main weed species identified in Craggy Range Vineyard over the 2006/2007 season

Species common name	Flowering time	Early season (% cover)	Mid season (% cover)	Late season (% cover)
Jersey cudweed	Early, mid	5.4	10.7	0
Haresfoot	Early, mid	41.5	17.1	4.4
Dovesfoot	Early, mid, late	19.7	3.3	2
Sheeps sorrell	Early, mid	3.1	3.8	7.7
Portulaca		0	2.1	7.4
Storksbill		0	1.2	0
Dandelion	Early, mid	3.8	7.4	9.7
Cornbind	Mid	0	0.5	0
Shepherds purse		0	1.7	0
White clover		1.9	0.5	0.8
Horned Oxalis	Mid, late	0	2.1	0.8
Cut leaf geranium	Early	2.3	0	0
Clammy goosefoot		0	0	0.4
Slender bedstraw		0	0	4.4
Thistle		0	0	1
Yarrow		0	0	0.4
Total weeds		**77.7**	**50.4**	**39**
Grasses		**22.3**	**49.6**	**61**

Table Three: Main weed species identified in Eskwood Vineyard over the 2006/2007 season

Species common name	Flowering time	Early season (% cover)	Mid season (% cover)	Late season (% cover)
Creeping mallow	Early	20.9	30.3	21.3
Plantain	Early	1	0.7	0
Horned oxalis		0.5	3	8.7
Wild carrot	Mid	0	1.3	0
Dandelion	Early	2.5	0	0.3
Red clover		0	0	0.6
Yarrow	Late	0	0	0.7
Dovesfoot	Early	18.7	0	1.7
White clover	Early	1.5	0	0
Speedwell	Early	0.3	0	0
Suckling clover	Early	0.5	0	0
Wireweed	Early	0.5	0	0
Amaranth		0.3	0	0
Chicory		4	0	0
Hairy birdsfoot trefoil		0.5	0	0
Other weed - unidentified		5.8	0	0
Total weeds		**57**	**35.3**	**33.3**
Grasses		**43**	**64.7**	**66.7**

Table Four: Main weed species identified in Fernhill Vineyard over the 2006/2007 season

Species common name	Flowering time	Early season (% cover)	Mid season (% cover)	Late season (% cover)
White clover	Early, mid, late	32.3	12.3	10
Creeping mallow	Early, mid	10.3	18.7	28
Dovesfoot	Early	4	0	0
Dandelion	Early, mid, late	5.3	2	1.7
Cranesbill	Early	2	0	0
Buttercup	Early, mid	2	0.3	0
Thistle - NS	Early	1.7	0	0
Speedwell	Early	4.5	0	0
Horned oxalis	Early	1.3	0	1.7
Furry leaf weed, no flower	Early	1.6	0	0
Fleabane		0	1.7	1
Hydracotyle		0	0	0.3
Total weeds		**65**	**35**	**42.7**
Grasses		**35**	**65**	**57.3**

Table Five: Main weed species identified in Prospect Vineyard over the 2006/2007 season

Species common name	Flowering time	Early season (% cover)	Mid season (% cover)	Late season (% cover)
Mid-row				
Creeping mallow	Early	5.9	2.8	5
Dovesfoot	Early, mid	9.1	3.3	0
Plantain	Early	1.8	0	0
White clover	Early, mid	9.1	5	3.3
Amaranth	Early	3.2	3.7	0
Dandelion	Early, mid, late	5.9	6.5	5.7
Black Medic	Mid	0	0.5	0
Portulaca		0	0.9	0.3
Horned oxalis		0	1.4	0
Dock		0	0.9	0
Wireweed		0	0	0.7
Total weeds		35	25	15
Grasses		65	75	85

Species common name	Flowering time	Early season (% cover)	Mid season (% cover)	Late season (% cover)
Under-row				
Dovesfoot	Early	27.8	1	0
Speedwell	Early	10.9	4.5	0
Purslane (Portulaca)		6.4	21	0
Groundsel	Early, mid	13.6	24.5	0
Dandelion	Early	0.9	0	0
Amaranth		1.8	0	0
Small flowered mallow	Early	7.7	22.5	0
Creeping mallow	Early	2.7	0	0
Thistle		0.5	0	0
Clover		0	0	0
Fathen		2.7	0	0
Shepherds purse	Mid	0	0.5	0
Cranesbill	Mid	0	0.5	0
Total weeds		75	74	0
Grasses		25	26	0