

The Ecology of Mealybugs in Gisborne Vineyards

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Executive summary

Two mealybug species were collected during sampling. Most *P. calceolariae* were living in clover and all *P. longispinus* were living on the grape vine. *P.*

calceolariae were very rare on the vine. The numbers of *C. montrouzieri* found in the research vineyard in 2000/1 were far fewer than seen in previous seasons. The predator arrived in January, made measurable reductions in the mealybug population and had dropped to low levels by the following month.

The only site that provides long-term stable food supply for *C. montrouzieri* was under the clover clumps. Large numbers of *P. calceolariae* were found in this site throughout the year. *C. montrouzieri* were active on the ground under the shelter of the clover leaves and stems. The predators ability to feed on the mealybugs was restricted by the activities of ants.

The rapid growth in number of mealybugs on the leaves from December to February is exactly paralleled by the increase in the bunches. This explosive growth shows that the leaves and grapes provide a much superior habitat than the bark. The growth in the mealybug population continues until the habitat disappears.....the bunches are picked and the leaves senesce and drop off. There are therefore two habitats that are continuously available and have a permanent mealybug presence (clover and vine bark) and two habitats that are temporary but allow rapid growth of a mealybug population (vine leaves and bunches).

Barriers to movement(sticky bands) do not prevent colonisation of the vines.

Attempts to develop a bio-assay system for ant-specific insecticides failed.

Introduction

Mealybugs are one of the two key pests of wine-grapes. Three species are commonly found on grape vines in New Zealand. They are *Pseudococcus longispinus* (Targioni-Tozzetti), *P. calceolariae* (Maskell) and *P. affinis* (Maskell) (Charles 1989). The species present in each grape growing region can vary markedly.

Charles (1989) found *P. calceolariae* to be the dominant species in Gisborne vineyards with *P. longispinus* much less common. *P. longispinus* is the common species in Auckland and *P. affinis* in Hastings. Charles (1981) found small numbers of mealybug feeding on sward plants in Auckland vineyards.

The first successful introduction of the predator *Cryptolaemus montrouzieri* (Mulsant) from Australia was achieved by a A.T. Potter, an amateur entomologist and Whangarei grape-grower in 1898, (Charles 1989). This predator is locally common from Auckland North but has not been recorded from Southern horticultural regions for many years(op.cit.).

Preliminary data on mealybug ecology had been gathered from Gisborne vineyards during earlier leafroller research. Large numbers of *C. montrouzieri* were found in December 1999 on the vines and these predators successfully reduced the mealybug populations to less than the economic threshold by harvest. Harvesters sometimes

return from gathering grapes festooned with *C. montrouzieri*and if mis-identified as large mealybugs would result in the block being sprayed with an OP-insecticide. Large numbers of this predator were present in a neighbouring organic vineyard. *C. montrouzieri* was observed on the ground under the shelter of the clover leaves and stems near groups of mealybugs in four Gisborne vineyards and two Hastings vineyards in the middle of the growing season in 1999/2000. The aim of this study was to provide a systematically collected data set that would form the foundation of an ongoing program to control mealybug with natural enemies.

Materials and Methods

The trials were set out in two Gisborne vineyards in Papatu (barrier trial) and Back Ormond (mealy bug ecology) road. The owners of both vineyards preferred to avoid the use of synthetic insecticides. The Papatu vineyard had used an IGR spray (Applaud) 3-4 years previously but was currently free of insecticides.

Numbers of *P. calceolariae* were collected from clover clumps in the sward. Thirty sample sites (three per row) were made, monthly from October to March, then three monthly through winter. A trenching tool was used to dig a section of sward approximately 20 cm long x 15 cm wide x 20cm deep, containing all or part of a clump of clover.

Twenty leaves and if present twenty bunches were examined on a vine next to the dug sample. All mealybugs and predators uncovered were counted. The presence of sooty mould was noticed.

A section of bark (approximately one metre long) was stripped of the flaky outer layers and all mealybugs, parasitoids and predators uncovered were counted.

A sample of large sections of vines that had been cut out during vineyard renovation was available on the 14th June, 2001. These vines were dissected and mealybug and predator numbers collected.

The Norfolk pines on the Gisborne esplanade between the Waikanae beach and the port were checked for the presence of *C. montrouzieri* on the 14th June.

A trial was set up to test if control of mealybugs could be effected by preventing movement of mealybugs on to the vine from the surrounding environment. The trial was set up on a Riesling block on the Papatu rd. vineyard. Sticky barriers to movement were placed on the vine trunks just above the soil surface and similar barriers around the wooden posts and wires that marked of a unit of four vines on October 15th, 2000. Five replicates were set up, each with a unit of four vines (one bay) in the control and a nearby bay (two bays away) of four vines in the test. These bays were assessed on the 18th December. Twenty leaves, twenty bunches and a section of bark were examined on both dates.

An attempt was made to set up miniature “bio-spheres” with ants, mealybugs and *C. montrouzieri* back at the Auckland laboratory. These bio-spheres would be an ideal tool to test the effects of different pesticides and dosages that would kill or incapacitate the ants without harming the predator either directly or indirectly via eating poisoned mealybugs. Tests of insecticides directly in the orchard would have been difficult to interpret.

One hundred samples of a whole clump of clover rooted in a block of soil complete with mealybug and ants were collected on each visit. When available samples with the predator in place were also collected. These samples were set up back in the Auckland laboratory in 2-litre plastic boxes with vented and un-vented lids. Some were set up in clip-lock plastic bags.

Results

Mealybug (*Pseudococcus calceolariae*) can be found living on clover clumps in Gisborne and Hastings vineyards (fig.1). During winter (June-September-October) samples the insects are attached to the roots under the soil surface. They are often attached to the roots next to the root nodules. They move up to the ground surface by November with the bulk of the population at the soil-air interface. Fluff nests appear for the first time in November as reproduction begins. A small proportion climb one to two cm. up the clover leaf stems. Large individual mealybugs could be found at the base of the clover with a cluster of much smaller individuals clinging to the stem above. Mealybug colonies always contained a large size range of mealybug with larger individuals more common in winter. Mealybug colonies were retreating below ground surface level in March.

Fig. 1 Mealybug (*Pseudococcus calceolariae*) attached to the roots of clover. During the summer they are found at the soil-air interface, in winter they live underground 1-10cm deep.

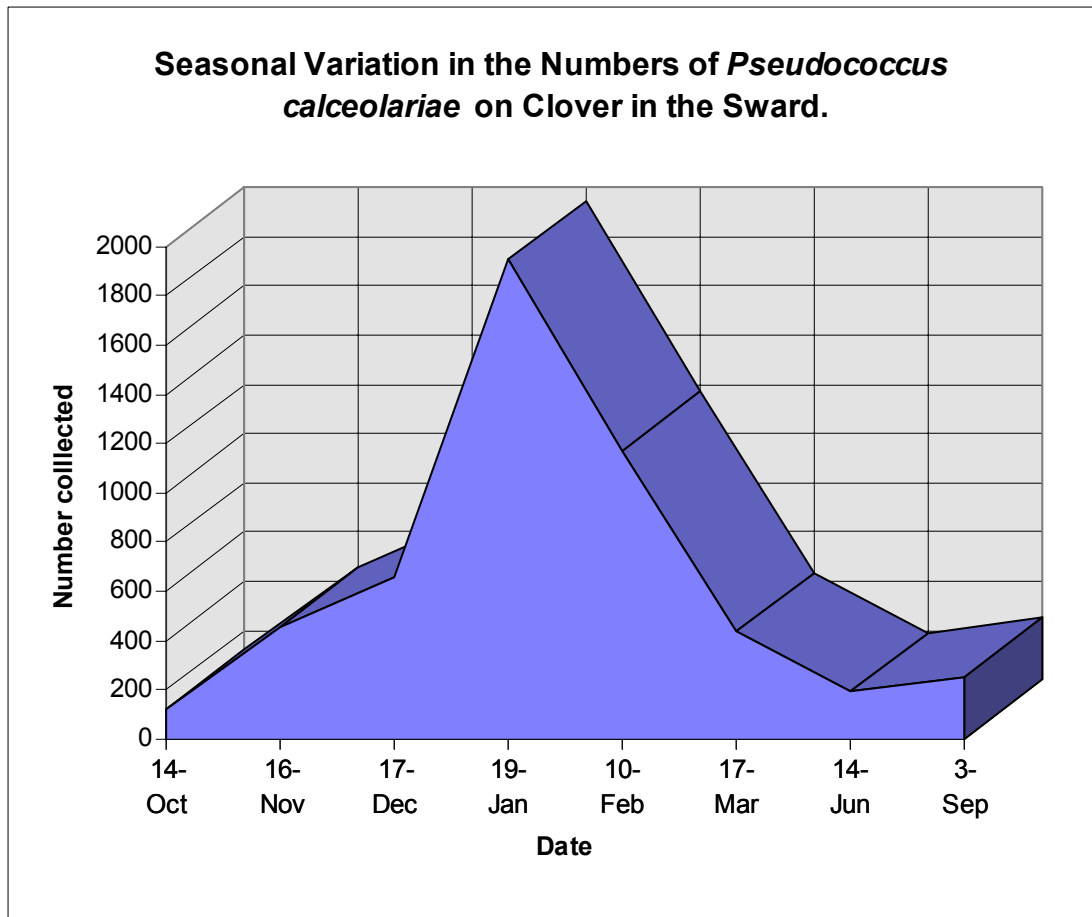


Fig.2 Numbers of *P. calceolariae* collected from clover clumps in the sward. Thirty sample sites (three per row) were made, monthly from October to March, then three monthly through winter.

A population of mealybug are always present on clover in the sward (fig.2). Numbers increase gradually from October to December then increase sharply to a peak in January before decreasing to a low point in June. The population shows a ten-fold change over the season.

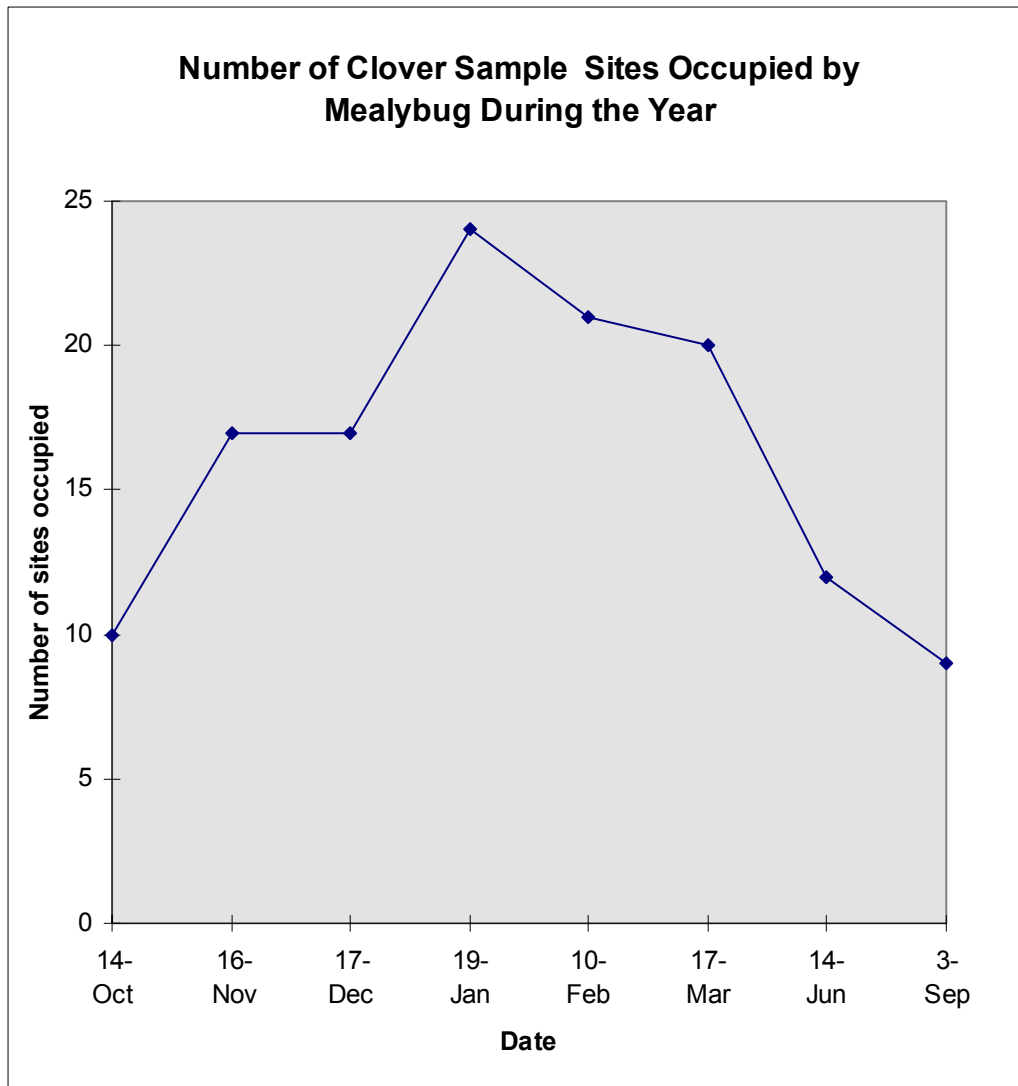


Fig. 3 Number of occupied sites out of a sample of 30.

The proportion of clover clumps occupied by mealybug during the season ebbs and flows. A third of the clumps (9-10/30) have mealybug at the low point (September-October). Occupancy increases as the season progresses to a high point (24/30) in January. There is a two and a half fold difference between the high and low point and as there is a ten fold increase in population over the season (see fig.2), populations at each site increase on an average of four times.

P. calceolariae is almost exclusively an inhabitant of the clover clumps. Single individuals were collected on vine leaves in November and February and under the bark in January.

Table 1 Numbers of *P. longispinus* in the leaves, bunches and bark from a sample of 30 vines from the Back Ormond rd. vineyard..

	leaf	bunch	bark
14-Oct	0		0
16-Nov	1		0
17-Dec	0	1	6
19-Jan	98	70	3
10-Feb	194	107	15
17-Mar	610		12
14-Jun			7
3-Sep			3

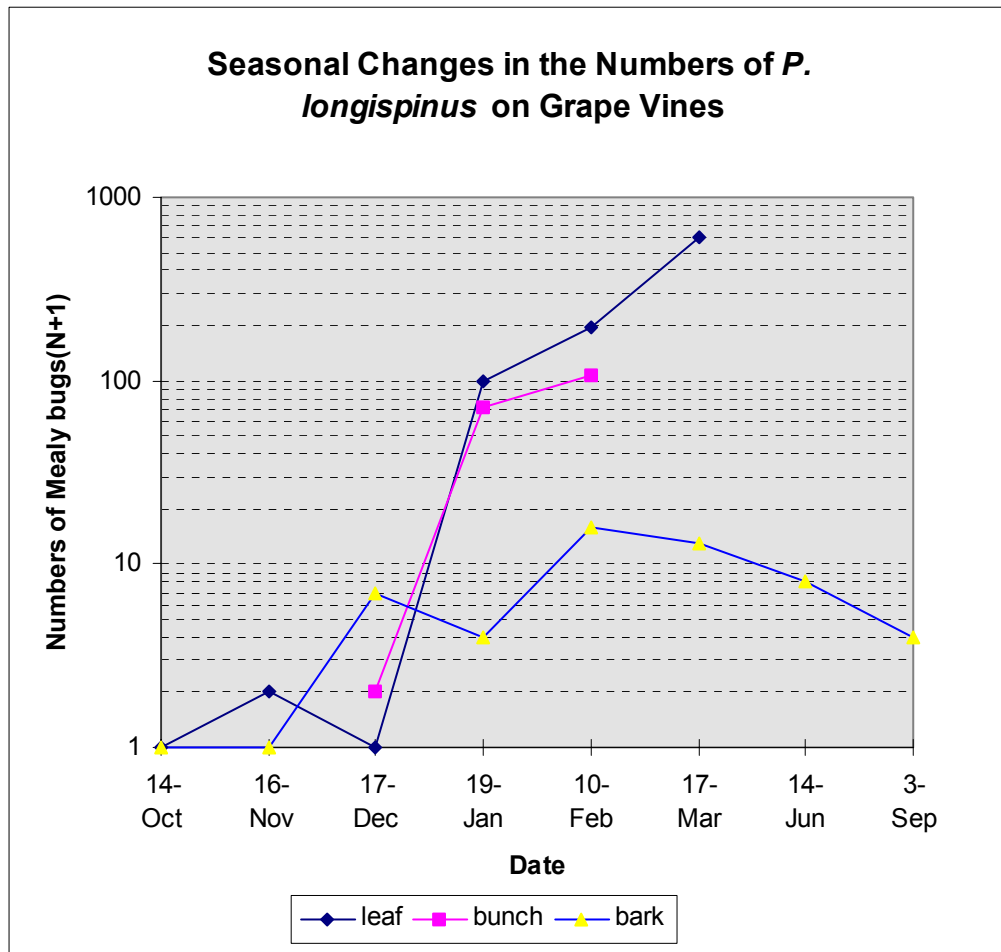


Fig. 4 Logarithmic graph of the changes in the population of *P. longispinus* on leaves, bunches and bark of grapevines.

The population of *P. longispinus* under the bark is relatively constant and small in numbers (fig.4, table 2). Split vines were preferred over intact and areas where branches crossed. These sites would have provided more space than the clean limbs. *C. montrouzieri* were also found in bark splits. Mealybugs could also be found where new growth was emerging from the old cordon. Younger vines where the bark was more tightly attached and less flaky provided poor bark habitat. Fluff-nests were seen under the bark from January and the bark in autumn is littered with nest debris.

None were found in October and November. Numbers slowly increase from November till February when a slow decline to September is seen. More were collected in September at the end of the study than in October at the beginning. This would suggest that a larger than usual population of mealybugs had infested the vineyard and that this had left a larger than usual population in the bark over winter. This was in agreement with the observations of the growers.

Numbers on the leaves are low during October (when new growth begins) and till December when the full flush of leaf growth is observed. Rapid increases in numbers are seen from December to January and on to March. The grape bunches are available for colonisation for a relatively brief period. The berries are exposed in December as the remnants of the flowers are shucked. Harvest was early this season in a desperate attempt to salvage the rain-split fruit. The rapid growth in number of mealybugs on the leaves from December to February is exactly paralleled by the increase in the bunches. Numbers increase on the leaves and bunches until the habitat effectively disappears. There is a dramatic difference in the way in which numbers change on leaves and bunches compared with the changes in numbers under the bark.....indeed a logarithmic graph is needed to place both types of curve on the same piece of paper (fig.4). Leaf shelters vacated by leafroller caterpillars are common and a very good site for mealybugs. Two hundred small mealybug were found in one leafroller shelter.

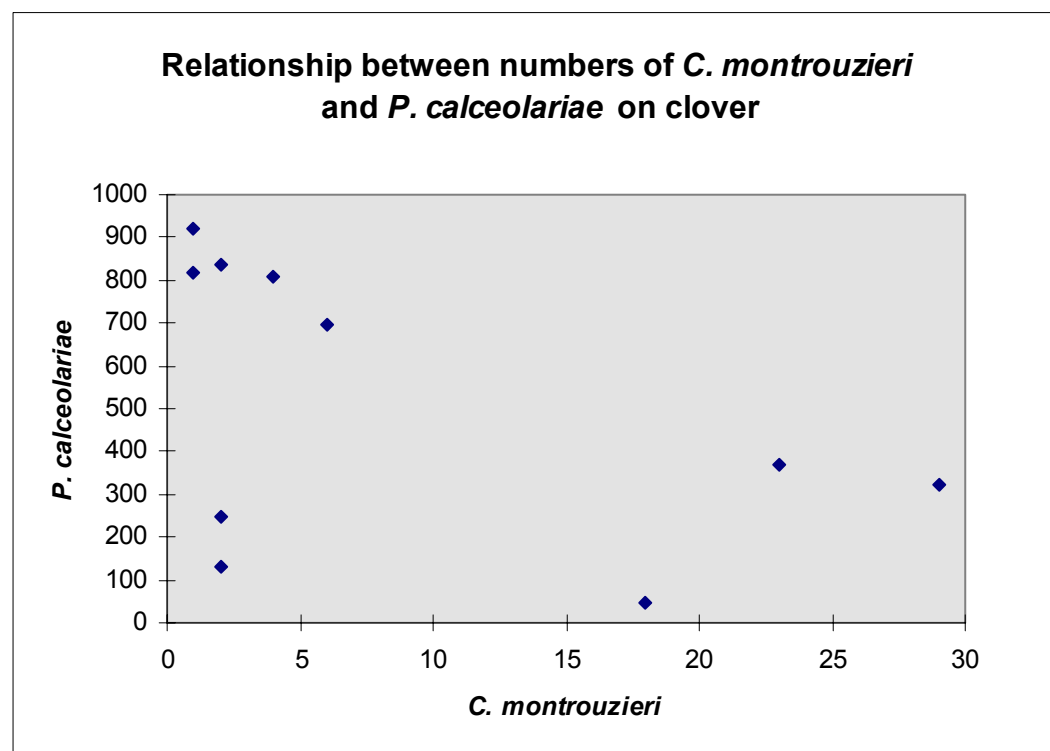


Fig. 5 Relationship between the numbers of *C. montrouzieri* and *P. calceolariae* on clover

The plot of numbers of predator versus prey produces a weak at best overall relationship (fig.5).

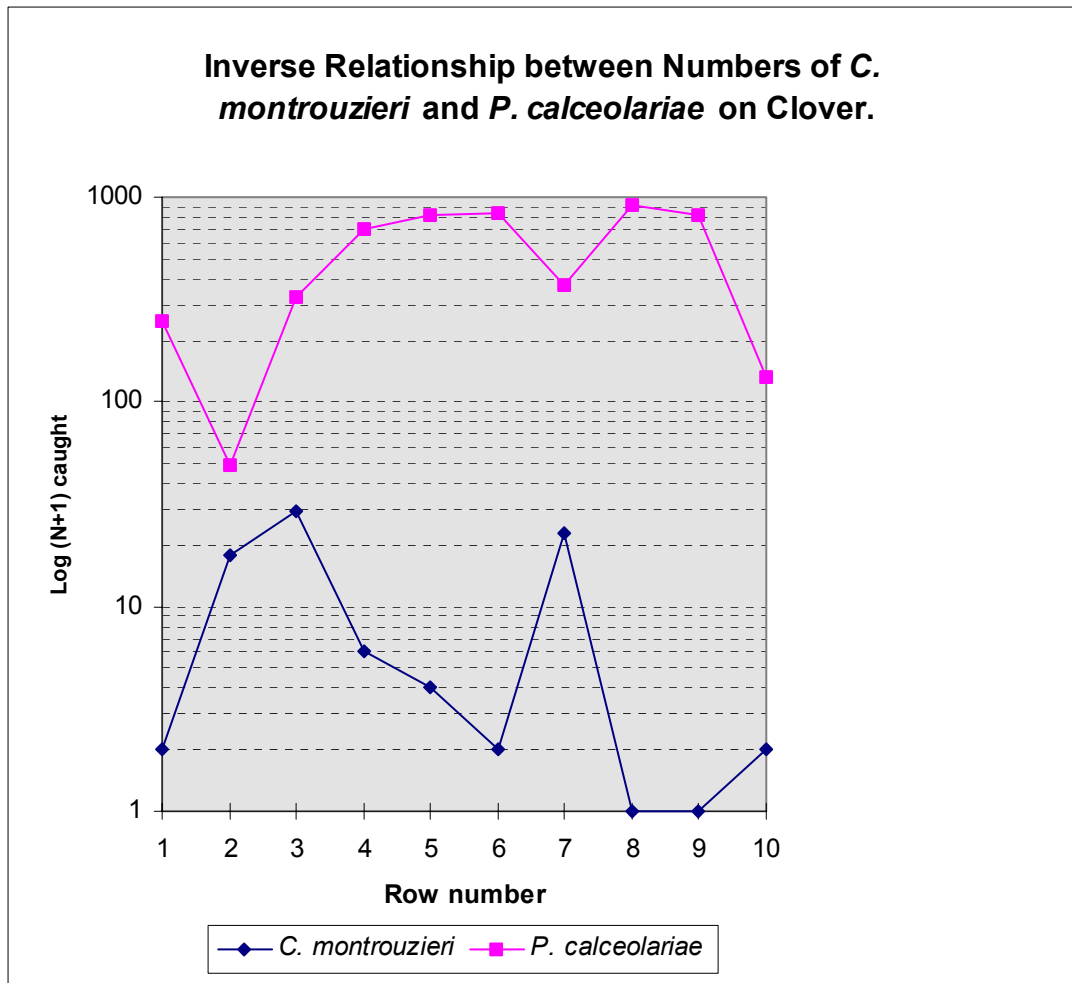


Fig. 6 Relationship between the numbers of *C. montrouzieri* and *P. calceolariae* on clover matched row by row.

When the numbers of predator and prey are scored on a row by row basis, a clear relationship appears. The numbers of predators increase in rows 2-3, 7 and 10 exactly matching the dip in mealybug numbers in rows 2, 7 and 10.

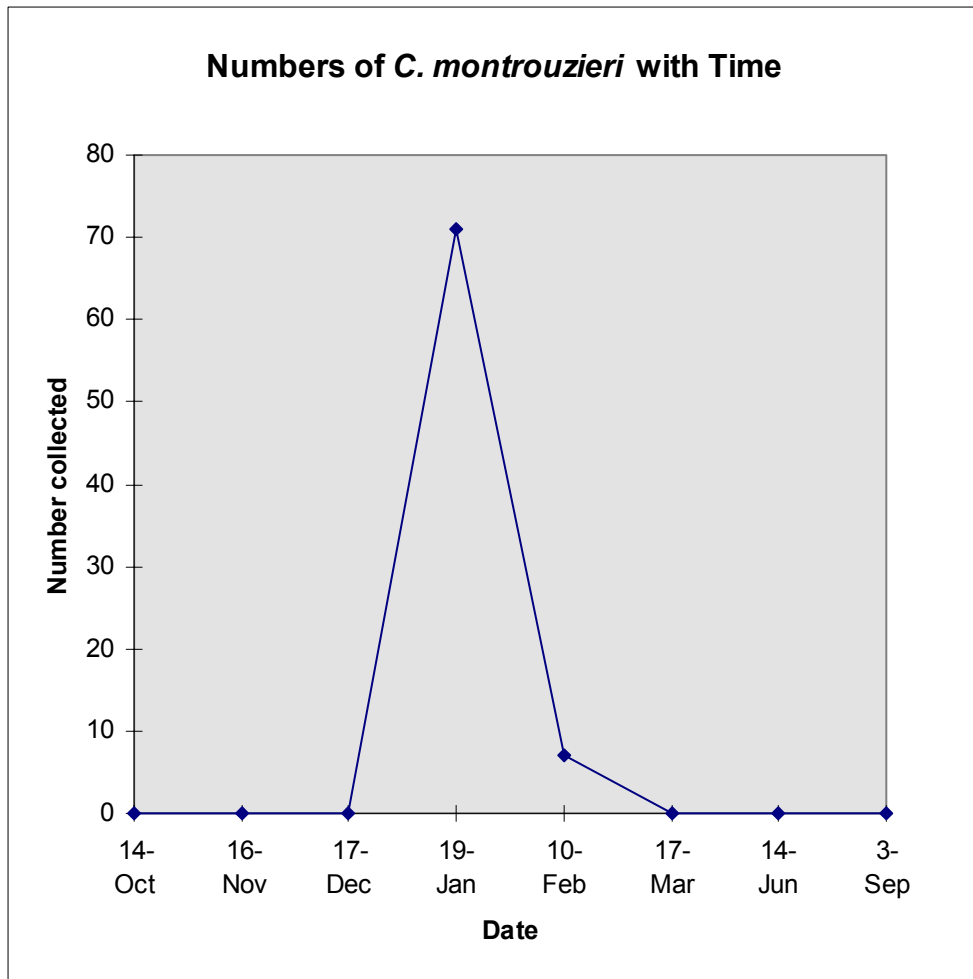


Fig. 7 Changes in numbers of *C. montrouzieri* with time. Samples of 30 clumps of clover collected monthly over the growing season and three-monthly over the winter.

A sharp peak of *C. montrouzieri* was observed passing through the clover patches in the clover sward in January (fig.7). Clover clumps with *C. montrouzieri* contained fewer mealybugs (average of 28 per clump in 12 clumps) than clumps where the predator was absent (average of 115 in 14 clumps). Neither were present in 4 clumps. The ratio of predator to prey differed on the vine and in the clover (1 *C. montrouzieri* to 225 mealybugs on the vine and 1 *C. montrouzieri* to 67 mealybugs in the clover).

Few *C. montrouzieri* remained in February. Only two clover clumps contained the predator. Site 83A held two mealybug, six *C. montrouzieri* and a large number of ants.

Ants were present with all mealybug colonies on clover clumps. Two species were present, *Iridomyrmex anceps*, a larger active black species and *Technomyrmex albipes*, the white-footed house ant. The groups of mealybugs were closely intermingled with the ant colony. Nodulated clover roots passed through smooth-walled chambers up to 10 cm. below ground. Large mealybugs were attached near the nodules and groups of worker ants were around them, frequently touching the mealybugs. Ants were seen to pick up and carry small mealybugs on the ground and

along the vine and down the entrance to the ant tunnel in the ground. Large ant colonies were also found in the dry stumps of vines allowed to remain after re-planting. The black ant colonies were producing winged forms (alates) in September.

The close association between the two species continued above ground. Mealybugs attached to the clover stem bases were surrounded by worker ants. The stems and leaves of the clover plants formed an “umbrella”-like shelter around the plant. Larval *C. montrouzieri* were found near the outer rim of the umbrella at a distance from the mealybugs. Ants and *C. montrouzieri* were observed to touch on several occasions.....the *C. montrouzieri* would immediately “freeze” and not move again for several minutes. All interactions between ants and *C. montrouzieri* were very brief (> 1 sec.). *C. montrouzieri* would move away from the mealybugs when it started to walk again.

Other predators were seen. The predatory bug *Nabis kinbergi* and centipedes were found under the clover from January onwards. The tiger beetle *Cicindella* sp. is an active hunter running over bare ground surface and sheltering under the clover leaves as dusk falls.

Small numbers of an unusual green caterpillar were collected from the clover clumps and reared to adults. These insects were identified as the common blue butterfly *Zizina otis labradus*. These butterflies are an associate of ants and the caterpillar bears a gland that provides secretions that are fed on by ants (Gibbs 1980). The caterpillars of the Light Brown Apple Moth (*Epiphyas postvittana*) were also seen feeding on clover together with an adult leafroller parasitoid, (*Dolichogenida tasmanica*).

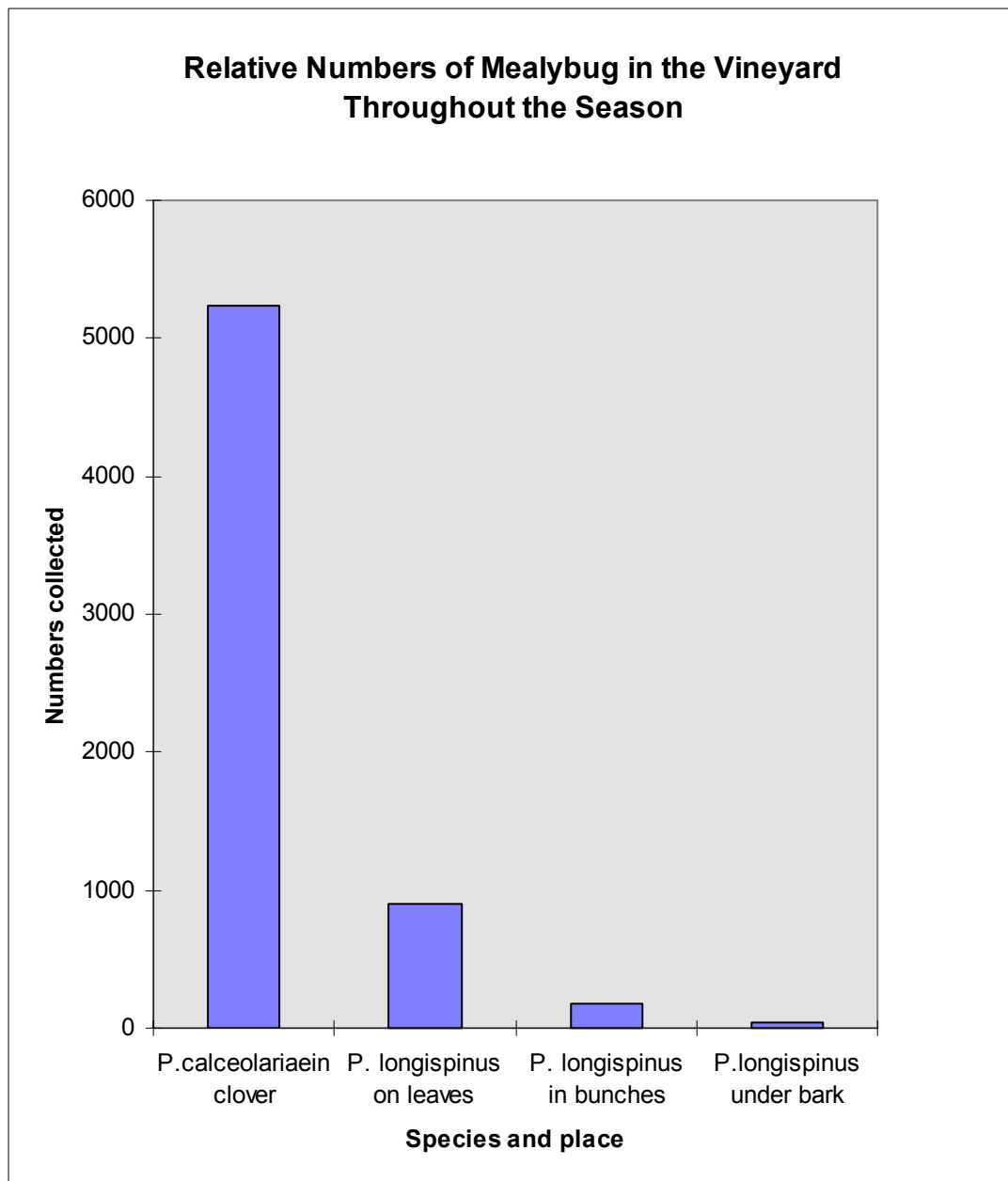


Fig.8 Relative numbers of mealybug in different habitats in the vineyard.

The numbers of mealybug in the different habitats provide a measure of the quality of each habitat and the length of time it is available to the mealybug. Large numbers would indicate that the habitat offers large amounts of food for long periods. The clover patch's provide permanent, high quality (nitrogen rich) food, intense ant protection and support the largest population of mealybug (fig.8). While the habitats on the leaves and the bunches are available, they provide good nutrition but the short period available means these populations are evanescent. The bark habitat can be inferred to be of low quality (or of limited space?) as the population collected here was the smallest seen.

Table 2 Numbers of mealybugs and predators from a sample (N=23) of large sections of Muller Thurgau vines removed from the vineyard in June 2000. Pupal exuviae can be mistaken for dead larvae as this species retains the last shed larval skin as an outer covering on the pupae. All were dissected to confirm that they were exuviae.

<i>P. longispinus</i>	<i>C. m</i> larvae	<i>C. m</i> pupae	<i>C. m</i> exuviae
43	1	2	5

Forty three *P. longispinus* (and no *P. calceolariae*) were collected from the 23 sections of vine (av. = 1.9/vine)(table 2). Most of the predators had completed pupal development, leaving their exuviae behind. The Norfolk pines on the Gisborne esplanade between the Waikanae beach and the port were checked on the 14th June and all *C. montrouzieri* had similarly completed development and departed. The population had been very large, the most exuviae collected under one bark curl was 20!!

Two live pupae and a single live larvae were also collected. This gives a ratio of 1predator to 14 mealybug.

Table 3 Barrier trialNumbers of *P. longispinus* mealybugs in the control and test. Trial set out on 15th October and assessed on 18th December. Five replicates, each with a unit of four vines (one bay) in the control and a nearby bay (two bays away) of four vines in the test. Each of the vines in the test had a thick sticky barrier around the trunk just above the soil surface. The base of the supporting posts and the wires where they passed on to the next bay were also treated with sticky material.

		15-Oct	18-Dec
Test	leaves	0	12
	bunches	0	9
	bark	9	4
Control	leaves	0	9
	bunches	0	2
	bark	7	8

When the barrier trial was set out, a small number of mealybug were found under the bark in both control and test. Three mealybug in the test had perfectly circular holes drilled in them, indicating the emergence of a *Coccophagus gurneyi* parasitoid. Similar numbers of mealybugs were found in test and control when assessed two months later(slightly more in the test vines). The only *C. montrouzieri* was found under the bark of one control vine.

The clover in the sward of the Papatu rd. vineyard did not appear to support a population of *P. calceolariae*. The soil was very compacted and this may have had a bearing on the suitability of this vineyard for clover mealybug populations.

None of the bio-spheres provided a sustainable life-support system for ants, clover, mealybug and predators and more complex systems will need to be designed for the next attempt.

Conclusions

The distribution of mealybug species was clear cut. *P. calceolariae* were living in clover and *P. longispinus* were living on the grape vine. This the opposite of the findings of Charles (1989) who found *P. calceolariae* to be the dominant species in the vine in Gisborne. In the current study *P. calceolariae* was very rare on the vine. *P. calceolariae* was found in large numbers on Pinot Noir grapes in the Wairarapa.

The numbers of *C. montrouzieri* found in the research vineyard in 2000/1 were far fewer than seen in previous seasons. The predator arrived in January, made measurable reductions in the mealybug population and had dropped to low levels by the following month.

Mealybug (*P. calceolariae*) can be found living on clover clumps in Gisborne and Hastings vineyards. During winter the insects are attached to the roots under the soil surface and often attached next to the root nodules. This location would provide a relatively nitrogen rich food supply. Sucking insects enjoy a carbohydrate-rich food supply but tend to have insufficient nitrogen. A food-flow sufficient to provide adequate nitrogen produces an excess of sugars which are excreted to provide a food for ants and sooty moulds. There is a two and a half fold difference between the high and low point of numbers of occupied clover clumps and a ten fold difference between high and low total number of mealybug on the clover.

The rapid growth in number of mealybugs on the leaves from December to February is exactly paralleled by the increase in the bunches. This explosive growth shows that the leaves and grapes provide a much superior habitat than the bark. The growth in the mealybug population continues until the habitat disappears.....the bunches are picked and the leaves senesce and drop off. There are therefore two habitats that are continuously available and have a permanent mealybug presence (clover and vine bark) and two habitats that are temporary but allow rapid growth of a mealybug population (vine leaves and bunches).

The only site that provides long-term stable food supply for *C. montrouzieri* was under the clover clumps. *C. montrouzieri* was observed on the ground under the shelter of the clover leaves and stems. The predators ability to feed on the mealybugs was restricted by the activities of ants. I expect that the key to long-term stable bio-control of mealybugs in grapes is a selective means to kill the ants without impacting on the predator.

It is very difficult to apply the same sampling pressure to very different sites. Exactly how much bark needs to be sampled to be equivalent to the sample of 20 leaves or 20 bunches? How should the two-dimensional habits (leaves and bark) be compared with the three dimensional habitats (grape bunches and clover roots)?

The failure of the barrier experiment was not surprising in view of the results that show that there appears to be little migration of mealy bugs between vine and sward. Each population of mealybugs appears to remain in its own habitat, *P. calceolariae* on the clover and *P. longispinus* on the vine. As there is little or no migration, a barrier can have no significant impact on the ecology of the mealy bug. Very small numbers

of the first species were found on the vine in the Gisborne experimental vineyard, but this species was present in large numbers in a Pinot Noir block in the Wairarapa. Clearly regional differences are important.

The development of methods to effectively control ants in the vineyard and identification of the over-wintering sites of the predator, the place of other predators and parasitoids in the bio-control of mealybug are future directions for this study.

Acknowledgments

I thank D and D. Bell, J. and A. Millton for the opportunity to work on their vineyards and for their interest and support. The photograph in fig. 1 was taken by William Biddulph. I thank Dr. Chris Green (Dept of Conservation) for identifying the ant species. Funding was provided by the Winegrowers of New Zealand and by the Gisborne Regional association.

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