Occurrence and control of borers in Hunter Valley vineyards

FINAL REPORT to
GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **DAN 5**

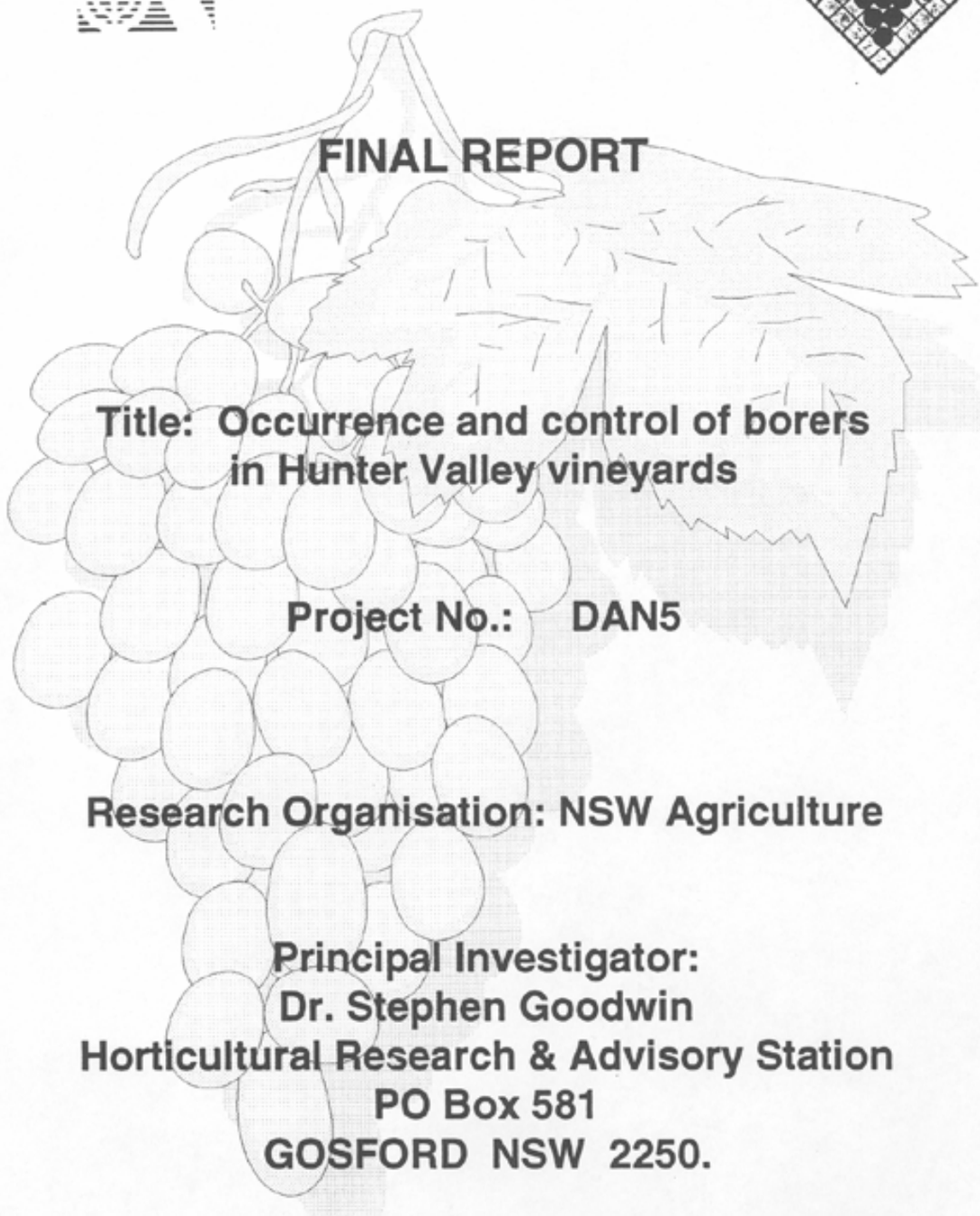
Principal Investigator: **Dr. Stephen Goodwin**

Research Organisation: **NSW Agriculture**

Date: **1989 - 1993**

NSW AGRICULTURE

G.W.R.D.C.



FINAL REPORT

Title: Occurrence and control of borers in Hunter Valley vineyards

Project No.: DAN5

Research Organisation: NSW Agriculture

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GRAPE & WINE RESEARCH & DEVELOPMENT CORPORATION
FINAL REPORT

Project Number: DAN 5

Project Title: Occurrence and control of borers in Hunter Valley vineyards.

Field of Research: Other (grape) **Field Code:** 6

Organisation: NSW Agriculture

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Time Span: Project funded from July 1989 to June 1993.

Aims: Conduct annual surveys of infestation levels and distribution of *Acalolepta vastator*.

Study the biology and ecology of *Acalolepta va.5tator*.

Investigate adult monitoring methods for *Acalolepta vastator*.

Investigate chemical and biological control methods against *Acalolepta vastator*.

Investigate side-effects of chemical control methods used against *Acalolepta vastator* on mite populations in vineyards.

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CONTENTS

SUMMARY 4

BACKGROUND 5

OBJECTIVES 6

INTRODUCTORY TECHNICAL INFORMATION 6

METHODOLOGY AND RESULTS 6

1. Annual surveys of A. vastator 6
2. Relationship between site and grape characters and infestation 6
3. Survey of natural vegetation for borers 6
4. Relationship between frass and infestation level 6
5. Studies into the biology and ecology of A. vastator 7
   - 5.1 Distribution and spread 7
   - 5.2 Ovipositional activity of A. vastator 7
   - 5.3 Developmental studies 7
   - 5.4 laboratory culturing of A. vastator 7
   - 5.5 Distribution of A. vastator in the grapevine 7
6. Monitoring adult activity 7
   - 6.1 Light trapping 7
   - 6.2 Sex pheromenes 7
   - 6.3 Plant attractants 8
     - Experiment 1: Food plants 8
     - Experiment 2: Plant extracts 9
     - Experiment 3: Plant extracts 9
     - Experiment 4: Plant extracts 9
     - Experiment 5: Olfactometer study 10
7. Non-chemical control measures 10
   - Experiment 1: Microwave treatment – exposed larvae 10
   - Experiment 2: Microwave treatment of larvae in wood 11
   - Experiment 3: Parasitic nematodes 11
   - Experiment 4: Parasitic nematodes 12
   - Experiment 5: Parasitic nematodes 12
   - Experiment 6: Parasitic nematodes 12
8. Chemical control measures 13
   - Experiment 1: Internal butt treatment 13
   - Experiment 2: Internal butt treatment 14
   - Experiment 3: Granular systemic insecticides 14
   - Experiment 4: Granular systemic insecticides 14
   - Experiment 5: Adult spraying trials 15
   - Experiment 6: Adult spraying trials 16
   - Experiment 7: Azinphos methyl paste formulation 16
   - Experiment 8: Azinphos methyl paste formulation 17
   - Experiment 9: Young larval treatment 17
   - Experiment 10: Young larval treatment 19

Experiment 11: Ovipositional repellence 20
Experiment 12: Insecticides trial 20
Experiment 13: Dormant treatment 21
Experiment 14: Late season treatment against young larvae 21
Experiment 15: Grower tests on NSW A recommendation 21
Experiment 16: Monitoring effect of recommendation 22
Experiment 17: Effect of insecticides on mite populations 24
Experiment 18: Effect of insecticides on mite populations 30

DISCUSSION 31

IMPLICATIONS AND RECOMMENDATIONS 34

ACKNOWLEDGMENTS 34

SUMMARY:
The lamiine cerambycid, fig longicorn *A. vastator,* has been known to attack vineyards in the Hunter Valley through most of this century (Froggatt 1919). The Hunter Valley of New South Wales is an important wine producing region and threats to the economic viability of its vineyards are viewed with concern. In the Lower Hunter Valley, an outbreak of *A. vastator* is causing serious damage to vineyards. The current infestation, known in this area since 1985 has, in 1993, spread to many vineyards in the Pokolbin district with up to 70% of vines infested in some vineyards.

Extensive research funded by the Hunter Valley Vineyard Association and the Grape and Wine Research & Development Corporation (formerly G&WR Council) was conducted on this pest problem between 1989-1993.

Ecological study demonstrated that the life cycle of this univoltine cerambycid pest species presented only a narrow window of opportunity to achieve successful control. The I-III larval instars are present in a relatively exposed position on the surface of, and just under, the bark where they are best able to be contacted by insecticide sprays. Initially the development of chemical control recommendations was restricted to insecticides currently registered for use in grapes in NSW. Reasons for this are given in the report. To this extent, azinphos methyl, chlorpyrifos and methidathion applied to barked areas of grapevines were found to provide field control against young larvae of *A. vastator* .A management strategy for this pest, based on these components, was prepared and growers were advised of this information. An Agnote, which is regularly updated, was produced and provided to each grower experiencing this pest problem. .

The difficulty of studying borer pests because of their inaccessibility in woody hosts has resulted in few effective control programs that prevent serious economic loss from being developed. This is reflected in the large number of topics that were considered in this study. Many avenues of approach were investigated, with a number proving fruitless. However, it is considered that the control strategy developed in this program offers an effective and practical approach to dealing with this problem providing the advice is followed. Unfortunately, this relies on a heavy usage of organophosphate insecticide. The spraying demands and concerns over the frequent use of these chemicals are causing a problem for a number of growers and alternatives are being investigated. Further study into the side-effects of these insecticides on beneficial pest mite populations can also be justified.

Progress in this project has been reported to Hunter Valley growers at biannual viticultural seminars conducted by the Hunter Valley Vineyard Association in Spring 1989, Spring 1990, Autumn and Spring 1991, Autumn and Spring 1992 and to meetings of the Technical Committee, HVVA and to the HVVAAGM.

BACKGROUND:

Fig longicorn *Acalolepta* (= *Dihammus) vastator* (Newman) has been the subject of research by NSW Agriculture since 1988. This study was funded by the Grape and Wine Research and Development Corporation, (formerly Grape and Wine Research Council) during the period 1989-1993 (DAN5). In this time, funds were also provided by the Insect Disinfestation Fund (a special deposits account of NSW Agriculture) and the Hunter Valley Vineyard Association (Table 1).

Table 1. External funding for A *vastator* project 1989-93

	IDF	HVVA	GWRDC
1989-90	$20,111	$3,000	$8,000
1990-91	$21,343	$25,459	$6,000
1991-92			$23,520
1992-93		$5,100	$22,377

There has been no previous attempt to study borer pests in grapevines in Australia, although a number of species have been recorded attacking this crop. Prior to 1988, reports were received of increasing borer damage to vineyards in the Lower Hunter Valley. In 1988, a research program was initiated by NSW Agriculture commencing with a survey of Hunter Valley vineyards to identify the extent of the problem and the species involved.

The Information recovered from these was used as the basis for field evaluation of infestations. Five borer species were identified.

Fig longicorn, *Acalolepta vastator (Cerambycidae)*

Elephant weevil, *Orthorhinis cylindrirostvis (Curculionidae)*

Vine weevil, *O. klugi (Curculionidae)*

Common augur beetle, *Xylopsocus gibbicollis (Bostrychidae)*

Fruit tree borer, *Cryptophasa melanostigma (Xyloryctidae)*

Analysis of the information sheets indicated that an area of the Lower Hunter Valley around Pokolbin was infested with *A. vastator,* while scattered areas of the Upper Hunter Valley displayed signs of infestation by O. *cylindrirostris.* None of the other species were considered of economic significance.

It was apparent from this survey that the present economic borer problem was due solely to the activities of *A. vastator,* a cerambycid lamiine species which had been recorded infesting grapevines in this region for most of this century (Froggatt 1919). It was clear from inspections of severely infested blocks that vine vigour was being adversely affected. The Hunter Valley is a nationally important wine region annually producing approximately 20,000 t of high value grapes. The area also supports a strong tourist industry with several million dollars being invested in recent years. Threats to the economic viability of the vineyards of this area were viewed with concern and a research program was embarked upon.

The current borer infestation was first recognised in 1985 although grape growers in the area consider the outbreak to have occurred 2-3 years earlier during a drought. Since 1989, considerable effort has been put into understanding the behaviour of this species in the field and to developing an effective control strategy. Studies have been conducted into a range of topics including ovipositional

activity, population development, population dispersal, adult monitoring, various approaches to control and the side-effects on mite populations of chemical usage applied for *A. vastator* control. Two papers have been published to date and they are used to report on some of the studied subjects (Appendix 1).

It should be noted that the nature of attack makes boring insects difficult to study, consequently there is a shortage of information on these species. This lack of attention is also indicative of the degree of difficulty in controlling these types of pests. Earlier control techniques such as the use of dieldrin as a butt treatment are no longer acceptable and alternative control methods are required.

OBJECTIVES:

The objectives have varied over the time of this study. Over the four years of this funding period they have been to:

1. Conduct annual surveys of infestation levels and distribution of *AcaIolepta vastator*.
2. Study the biology and ecology of *Acalolepta vastator.*
3. Investigate adult monitoring methods for *Acalolepta vastator.*
4. Investigate chemical and biological control methods against *AcaIolepta vastator.*
5. Investigate side-effects of chemical control methods used against *Acalolepta vastator* on mite populations in vineyards.

INTRODUCTORY TECHNICAL INFORMATION:

At the commencement of this research program, other than a general description of aspects of *A. vastator* biology, nothing was known about this species. There was no evidence to suggest that adult activity could be monitored to assist with control strategies. Data on seasonal adult emergence, ovipositional activity, larval feeding activity and developmental rates of immature stages, and the existence of parasites and predators was unavailable. Many avenues were investigated in this study, a number without success. Some were considered but not proceeded with owing to the cost.

Because of the varied topics addressed in this study, each subject has been discretely dealt with in the following section on methods and results.

METHODOLOGY AND RESULTS:

1. Annual surveys of *A. vastator:*

Described in Goodwin *et al.* (1994), (Appendix 1).

2. Relationship between A. *vastator* abundance and grape variety, Site slope and site aspect: Described in Goodwin *et at.* (1994), (Appendix 1).

3. Survey of natural vegetation for borer species:

Described in Goodwin *et at.* (1994), (Appendix 1).

4. Relationship between externally visible frass and *A. vastator* infestation in grapevines: Described in Goodwin *et at.* (1994), (Appendix 1).

5. Studies into the biology and ecology of *A. vastator:*

5.1 Distribution and spread of A. vastator.
Described in Goodwin *et at.* (1994), (Appendix 1).

5.2 Ovipositional activity of *A. vastator* in laboratory study and in the field. Described in Goodwin and Pettit *et al.* (1994), (Appendix 1).

5.3 Determination of larval stages, development of immature stages, adult emergence patterns, sex ratio and dimorphism, and seasonal activity and mortality in *A. vastator* in the field.

Described in Goodwin and Pettit *et at.* (1994), (Appendix 1).

5.4 Development of a laboratory culturing method for A. vastator

Described in Goodwin and Pettit et at. (1994), (Appendix 1).

5.5 Larval and pupal distribution of *A. vastator* in the grapevine.

Described in Goodwin and Pettit *et at.* (1994), (Appendix 1).

6. Investigations into methods for monitoring adult activity:

6.1 Light Trapping:

A collaborative light trapping study to investigate the attractiveness of various wavelengths *of A. vastator* was conducted with the University of New England. The latter organisation undertook this study as an honours project supervised by Dr. P. Gregg. Visible light and different wavelengths at the blue end of the spectrum were compared in a replicated study on two properties where *A vastator* was present in the grapevines.

Light sources driven by solar powered batteries were fixed to posts just above canopy height. Trap catches were initially obtained on a daily basis and then weekly, for a period extending between December, 1988 -March, 1989. A further trap was also mounted at ground level in the centre of an inflatable child's wading pool to determine whether adult beetles were simply being attracted to the light but landing nearby. Throughout this study not one adult of this species was trapped. Data were retained by the UNE and are not presented here. It was concluded that this species was not attracted to light.

6.2 Sex pheromones:

Adult *A. vastator* are known to fly at night but are not attracted to light. A comprehensive literature survey was conducted into six pheromone studies in Coleoptera, particularly Cerambycidae, to determine the potential of this approach as a means of monitoring adult flying activity, to provide a better understanding of ovipositional periods for timing of spraying programs and possibly to act as a means of interfering with reproductive behaviour with a view to causing mating disruption in the field. Previous studies of a congeneric *species A.luxuriosa* Bates, Udo borer, and *Xylotrechus pyrrhoderus* Bates, a borer pest of grapes in Japan, suggested that male and female sex pheromones would be present in *A. vastator*. The isolation and identification of such chemicals was beyond the scope of the facilities at Gosford. Discussions were held with the CSIRO, Division of Entomology, to identify the presence of chemically-modified behaviour between adult A. *vastator*. NSW Agriculture was to develop a bioassay technique that would guarantee reproducible dose responses to candidate pheromones in adult *A. vastator*.

A flight chamber modelled on the design successfully used by the CSIRO was constructed and set up in a constant temperature room at Gosford HRAS. Event-recording software was developed to handle data from these studies. A large culture of over 1,000 specimens to provide adult material for this study and for other unrelated laboratory studies was maintained in the laboratory. Unmated males and females were used in preliminary studies conducted in darkened conditions at constant temperature approximating summer evenings. Studies were conducted to determine a standardised bioassay procedure. Unmated, sexually active males and females failed to consistently elicit a flight response under the above conditions with a slight headwind. The CSIRO estimated that a preliminary

study would cost $15,000 and further detailed studies would cost $30,000 p.a. The poor outcome in the flight tunnel experiments discouraged any further expenditure on this subject. Both Japanese studies isolated and identified the same chemicals, octanediol and octanone, from both cerambycid pest species, but no evidence was presented of measured flight responses to these pheromones or of their use in the field. These studies have also been terminated.

6.3 Identification of attractants:

Experiment 1:

Glasshouse investigations were conducted into the attractiveness of some alternative plant materials (2 pieces of pecan wood; 3 pieces of fig wood; 4 fig fruits (2 cut); 2 plums (cut open) and 2 pieces of butternut pumpkin) to *A. vastator*. Several pieces of different plant materials were placed in a netted cage in a temperature-controlled glasshouse. Seven newly-emerged adults, each numbered for identification, were released and observed at 30 minute intervals over a five-hour period to determine any apparent preferences. Some of the beetles were not present on any of the plant material on offer at each assessment time. Data are presented in Table 1.

Table 1. Response of adult *A. vastator* to potential food sources.

Observation	Pecan wood	Fig wood	Fig fruit	Plum	Pumpkin
1	1	1	1	-	-
2	1	1	1	-	-
3	1	1	1	-	-
4	2	1	1	-	-
5	2	2	-	-	-
6	2	2	-	-	-
7	2	2	-	-	-
8	1	2	-	-	-
9	1	2	-	-	-
10	2	1	-	-	-

Adults not recorded at assessment were elsewhere in the cage.

The trial failed to demonstrate an overwhelming preference for any of the plants on offer. There was an even response to the wood and leafy material, while the fig fruit had a small attraction with two small patches of chewing damage visible on two of four fruits offered. The plums and pumpkin were removed on the second day and replaced with two pieces of grape wood. Data on the second day (Table 2) demonstrated a preference for fig wood over pecan and grape wood. Overall, a preference was shown for wood material, although fig fruit had some attraction with two small patches of chewing damage visible on two of the four fruit on offer.

Table 2. Response of adult *A. vastator* to potential food sources.

Observation	Fig wood	Pecan wood	Grape wood
1	3	1	1
2	3	1	1
3	3	1	1

A further attempt to identify food preferences was conducted in the laboratory. Volatile components in wood and leaf materials of fig *(Ficus carica* L.) and wood and bark materials of grape *(Vitis uinifera)* were extracted in organic solvents using Soxhlet apparatus. Laboratory experiments were conducted to test adult response.

Experiment 2:
Spots of plant extract, were applied in a circle around the outside of a 10 cm diameter filter paper and allowed to dry. The filter paper was placed in a Petri dish with a single adult beetle in the centre and the lid placed over to confine the beetle. Each treatment was replicated three times and randomly arranged. Ten dishes were set up and observations of adult movement in relation to the plant extract spots was made at 10- minute intervals at first, extending to hourly and overnight periods. No preference to any of the extracts by either sex was recorded. These results were confirmed when subjected to comparison in Y -tube olfactometer experiments in the laboratory (Experiment 5).

Experiment 3:
Further tests were conducted in enclosed boxes 21 cm x 28.5 cm. Each box was set up with 1 cm discs of filter paper impregnated with extracts of fig and grape with four replicates of each treatment and an untreated control randomly arranged. There were eight discs per box and each disc had 0.25 ml (one drop) of plant extract or distilled water (control) applied. An adult *A. uastator* was placed at the centre of each box equidistant from the discs and the beetle position was recorded every 10 minutes for one hour, then every 30 minutes for four hours. There was no apparant attraction to plant extracts.

Experiment 4:
Trial 3 was repeated using two large pieces of filter paper impregnated with 0.5 ml of extract on distilled water (control). Tests using single-aged beetles and freshly-emerged beetles were conducted. after one hour the beetles were monitored every hour for four hours and then overnight. Two fig and two grape extracts were tested each with a male and a female. The males and the female (fig) showed no interest in the disc impregnated with extract. The female (grape) did move towards the disc impregnated with extract after 4.75 hours but made no attempt to feed. The common observation was almost no movement for 2-3 hours after release. This experiment was inconclusive.

Experiment 5:
Y -tube ocfactometer experiments were conducted to test fig and grape extracts for attractance by adult *A. uastator*. A single filter paper disc impregnated with 0.2 ml of plant extract was located at one of the two arems, randomly selected for each pest. Results in Table 3 indicate that none of the tests produced any response to either of the fig or grape extracts.

Table 3. Response of adult A *vastator* to fig and grape extracts.

Test no.	Plant extract	Beetle sex	Response[1]
1	Fig	F	0
2	Fig	M	0
3	Fig	F	0
4	Fig	M	0
5	Grape	F	-
6	Grape	M	0
7	Grape	F	0
8	Grape	M	0

[1]+ attracted to arm containing extract sample
- attracted to arm with no extract sample
0 no response.

7. Investigations into non-chemical control measures:

Experiment 1:
To test the mortality effect of microwave treatment against *A. uastator* larvae. Five mature larvae of *A. uastator* were placed on the turntable in a microwave oven and exposed to 650 W microwave treatment for one, two, five, seven and 10 second intervals with an untreated control. Each test was replicated three times giving 15 larvae per treatment. Results given in Table 4 below demonstrated that 60% mortality was recorded 15 minutes after treatment with a five second exposure period, while a seven second exposure period increased the mortality to 100%. After 72 hours, 80% mortality was recorded in the five second exposure treatment with a 100% mortality after five days.

Table 4. Mortality effect of microwave treatment to exposed A *vastator* mature larvae.

Exposure period (sec.)	Treated		Control	
	Total treated	% mortality	Total treated	% mortality
1	10	0	2	0
2	10	0	2	0
5	10	60	2	0
7	10	100	2	0
10	10	100	2	0

Experiment 2:

Short lengths of grapevine trunk wood each containing a live *A. uastator* mature larva were exposed to microwave treatment for five seconds and seven seconds. Tests at both exposure periods were replicated three times and wood of two diameter sizes was tested. Assessment was made by splitting the wood after three weeks. Results in Results demonstrate that while exposure to microwave directly onto *A. uastator* larvae can be lethal (Table 4), it has almost no effect on larvae within the grapevine (Table 5).

Table 5. Mortality effect of microwave treatment of A. *vastator* mature larvae contained in grape wood

Exposure treatment (sec.)	Replicates	Wood size (cm diam.)	
		2-5	5-6
5	1 2 3	A A A	A A A
7	1 2 3	A A -	A A D
Control		A	A

A = alive
D = dead

Experiment 3:

Investigations into the effectiveness of nematodes against A. *vastator* larvae, 1991-92: Nematode treatments were applied in late January by spray application and assessed one month later. Nematode strains 319 and BW were compared with an untreated control and each treatment was applied to five vines. Nematode application was done according to CSIRO instructions and at the time of application, weather conditions were ideal for nematode survival. The same evaluation was conducted at another property, although fewer vines were used and assessment was by close inspection of each vine.

On property 1, which was assessed by destructive sampling, the BW strain produced 60% mortality, the 319 strain produced 40% mortality, while in the control there were no deaths recorded.

Experiment 4:

In a second trial the same two strains of nematodes were compared with the aim of the trial to investigate the use of oils plus gum as an additive to the nematode spray mix to improve the survival and penetration of nematodes. One million nematodes were applied per vine and two vines were treated per strain. The assessment showed both strains of nematode each killed one larva, an inconclusive result. The oil was used at the rate of 0.5% and the gum was used at 0.01%.

Experiment 5:

This trial was undertaken to investigate the effectiveness of nematode treatments at intervals after application. This trial was conducted using only the BW strain and oil and gum were added to the

mixture. Ten vines were sprayed on 5th March. These vines were destructively sampled on 13th March and assessments were made on 16th, 19th and 23rd March at 11, 14 and 18 days after treatment respectively.

At assessment 1, after 11 days, three vines were inspected and three live and one dead larvae were found. At assessment 2, 14 days after treatment, four vines were inspected and five live and one dead larvae were found. The dead larvae contained live nematodes demonstrating that this strain was capable of killing longicorn larvae. At assessment 3: 18 days after treatment, three vines were inspected and two live larvae were found. All of the live larvae were retained and reassessed at 21 days after treatment, when an additional larva had died and at 28 days after treatment when no further dead larvae were found.

A similar number of control vines with only oil and gum mixed in water were inspected 25 days after treatment. Three of the vines had dead larvae, with 12 live larvae present at the first inspection, but only six larvae remained alive 10 days later.

Experiment 6:

Investigations into extending the drying period of the nematode additive spray have been conducted at Gosford without any real progress being achieved. Although four treatments were conducted under optimal spraying conditions, it seems evident that further work needs to be done to prolong the drying period. Laboratory trials are looking at different additives to achieve this. It would appear from field data obtained this season that these nematode strains are capable of killing longicorn larvae in the field, but that the variable results are probably due to the inability of the nematodes to reach the longicorn larvae before they desiccate.

8. Investigations into chemical control measures:

Different approaches to chemical control of *A. vastator* were investigated during this study including:

* internal butt treatment (Experiments 1-2)
* granular systemic insecticide(Experiments 3-4)
* adult spraying (Experiments 5-8)
* strategically-timed treatments against young larvae (Experiments 9-16)
* side-effects of borer treatments against mite populations (Experiments 17-18).

Experiment 1:

Internal butt treatment: Growers enquired about the possibility of squirting pesticide solution into the trunks of the vines to kill the larvae of this pest. During the course of larval development, sawdust and larval excrement ("frass") is forced out through cracks in the trunk. This can be seen on the outside of the trunk, and at the base, where it falls and collects. However, these cracks are not obvious to the naked eye and do not provide a clear opportunity through which pesticides can be readily applied.

To test this strategy as a viable method of control, an investigation was conducted into the effectiveness of insecticide treatments applied as a CO_2 propelled spray. Dichlorvos 50 g/kg (INSECTIGAS D), chlorpyrifos 18% w/w (RELDON 500 EC) and chlorpyrifos 18% (LORSBAN 500ULV/EC) was applied into the trunk of an infested vine by crack and crevice handgun injection device. The CO_2 formulated insecticides and the handgun applicator were supplied by CIG. Three treatments and an untreated control were replicated three times in a randomised block design with three vines to each treatment plot.

Assessments were made by frass indexing technique on three occasions and by destructively sampling a single vine per plot. All frass was removed from the surface of the vines by hand before treatment application. Data given in Table 6 show some positive signs, but the difficulty of application and health dangers with this method of application, suggests that this approach has limited potential.

Table 6. Toxicity of CO_2 propelled insecticides against A *vastator* larvae in grapevines

Treatment	% Infested vines		
	Visual assessment	Destructive assessment	
		Dead	Alive
Dichlorvos	33	33	33
Chlorpyrifos (Reldon)	67	33	33
Chlorpyrifos (Lorsban)	0	10	0
Control	67	0	67

Experiment 2:
A laboratory experiment was conducted using vine cuttings infested with A. *vastator* to test the effect of dichlorvos (INSECTIGAS-D) applied using a crack and crevice device against mature larvae. Vine cuttings were treated for 20 or 40 seconds or untreated as a control. Results in Table 7 demonstrate no obvious effect.

Table 7. Toxicity of CO_2 propelled insecticides against A *vastator* larvae in grapevines.

Treatment	No. cuttings	Empty vines	% mortality
Dichlorvos20 sec.	15	11	25
Dichlorvos40 sec.	15	9	17
Untreated	15	12	33

Experiment 3:
Granular insecticide trials: Trials with granular systemic insecticides were conducted in 1988/89 and 1989/90. *A. vastator* larvae are present on and near the surface of the vine for only a short period of time before boring into the heartwood where they complete their development. Unfortunately for many larvae, this period occurs prior to vintage, when such insecticides could not be used. Following entry by the larva into the heartwood, much of its subsequent feeding activity occurs in this non-conductive plant tissue, which also poses a problem with this approach.

In 1989, trials were conducted on five properties to compare four granular systemic insecticides against A. *vastator* larvae. The insecticides were applied at their recommended rates by placing a measured dose in a shallow trench down either side of the vine row. The trenches were filled in after the granules had been applied. The aim was to directly apply the chemical into the root zone to facilitate rapid uptake. Assessment was made be frass indexing of approximately 100 vines for each

chemical per property. Results are given in Table 8. The granular systemic insecticides evaluated in this study provided erratic control with none of the treatments different from the control. Treatment application is limited to post vintage to avoid residue accumulation in the fruit. However in this trial pesticides were not applied until March. While optimally, granule application should be timed to coincide with the presence of the rapidly-growing larvae which feed in the vascular tissue underneath the bark, this is often difficult to achieve.

Experiment 4:

A trial was conducted in 1990 to further evaluate aldicarb (15 kg/ha, 30 kg/ha) and terbufos (11 kg/ha, 22 kg/ha) in the varieties Chardonnay, Shiraz and Semillon on two properties. Again, application was delayed due to inclement weather during vintage.

Treatments were applied in late February, 1990 using a tractor-mounted granule applicator. The rate of chemical applied was determined by a wheel-controlled rota- system fixed to the standard hydraulic system of the tractor. The applicator consisted of a front tyre to dig a shallow furrow, followed by a rubber tube feeder attached to a back tyre, which delivered the specified rate of granular insecticide to the furrows. The applicator was provided by Cyanamid. Application was delayed due to heavy rain at vintage and treatments were not applied until 27th-28th February. Each variety was trailed in two blocks with each block having five treatments. Each treatment was replicated three times per block into an average row length of 50 vines.

Unfortunately, the insecticides were withdrawn negating the need for assessment. No further work was undertaken with granular insecticides. Granular insecticides have a systemic action and a single application represents a simple control method.

Table 8. Effects of granular systemic insecticides against *A. vastator* larvae infesting grapevines.

Treatment and Rates (kg prod./ha)	% free of infestation					
	A	B	C	D	E	Mean
Carbofuran 25.0	70.5	66.1	-	74.7	47.3	64.7a
Aldicarb 15.0	65.5	72.1	54.7	82.8	54.8	66.0a
Terbufus 6.0	76.3	63.3	73.2	70.7	-	70.9
Phorate 9.0	72.3	77.7	67.3	81.2	-	74.6a
Control	80.7	76.2	67.9	72.5	-	74.3a

Experiment 5:

Adult spraying trials: To test the effect of chlorpyrifos and azinphos methyl residues against A. *vastator* adults infesting treated grapevines. Potted grapevines in 5 L nursery bags were treated with insecticide spray to incipient runoff and allowed to dry. Four vines were each treated with azinphos methyl WP (140 gil00 L), chlorpyrifos 50 EC (50 ml/l00 L) and an untreated control. All vines were treated on 3rd December, 1990. Single adult beetles were caged on the vines after one day, one week, two weeks, three weeks, four weeks and six weeks.

Results given in Table 9 demonstrate that chlorpyrifos had no residual effect against the adults while azinphos methyl gave 100% mortality up to six weeks after vine treatment.

Table 9. Mean percent residual mortality of azinphos methyl and chlorpyrifos against A *vastator* adults infesting caged potted grapevines under shadehouse conditions, 1990.

Treatment	No. treated	Mean % mortality					
		1 d	1 wk	2 wks	3 wks	4 wks	6 wks
Azinphos methyl	4	100	100	100	100	100	100
Chlorpyrifos	4	0	0	0	0	0	0
Control	4	0	0	0	0	0	0

Experiment 6:
Three insecticides, all registered for use in grapevines in NSW, were tested for toxicity to adult *A. vastator* at Gosford HRAS. Carbaryl, chlorpyrifos and methidathion were each applied by knapsack sprayer at their respective registered rates, with chlorpyrifos, also at twice the registered rate, to three beetles contained in a netted cage. After treatment the sprayed adults were recaptured and held in 500 ml plastic containers for observation and to record mortality. Results were recorded as dead, reduced co-ordination, affected generally and unaffected. Data given in Table 10 demonstrate that carbaryl was non- toxic, chlorpyrifos produced 100% mortality within 24 hours at both rates, while methidathion gave 100% mortality within two hours.

Table 10. Results of spraying trials against caged A *vastator* adults.

Pesticide	Concentration / 11	Post treatment assessment (hr.)						
		1	2	3	4	6	24	48
Carbaryl 80Wp	1.3g	3-	3-	3-	3-	3-	3-	3-
Chlorpyrifos 50EC	0.5 ml	3A[1a]	3a[2a]	3A[1a]	3A[1a]	3A[1a]	3D	3D
Chlorpyrifos 50EC	1.0 ml	3A	3A[1a]	3A[1a]	3A[2a]	3A[1a]	3D	3D
Methidathion 40EC	1.25g	3A[1a]	3D	3D	3D	3D	3D	3D
Control		4-	4-	4-	4-	4-	4-	4-

D = Dead
RC = Reduced co-ordination
A = Affected generally
- = Not affected

Experiment 7:
To test the effectiveness of azinphos methyl formulated in paste against *A. vastator* adults. December, 1990 to June, 1991. Azinphos methyl formulated in paste was smeared onto black plastic strips of 2.5 cm and 10 cm widths by spatula. Individual beetles were prompted to contact the paste by walking across the width of the treated plastic strips.

"

Beetles were then held individually in a Chinese takeaway container for observation. Assessment was made after 16 hours.

Results given in Table 11 demonstrated that azinphos methyl was highly effective against adult A. *uastator* when used in this manner.

Table 11. Mortality response of adult A *vastator* through tarsal contact to azinphos methyl paste formulation, 1990-91.

Tarsal contact distance (cm)	Treated adults	% mortality after 16 hours
2.5	3 males	100
	2 females	100
10	2 males	100
	3 females	100

Experiment 8:

In a further experiment with azinphos methyl paste, six plates smeared with paste were set up in a tray and six single adult A. *uastator* were encouraged to walk over separate surfaces. After exposure, adults were caged and assessed for mortality after 17 hours. Another set of plates was set up and held under rain shelter conditions for exposure to the climate without rainfall for four days.

Results given in Table 12 show that 100% mortality was recorded 17 hours after exposure and also in the later trial when exposed to the paste after four days weathering.

Table 12. Mortality response of adult A *vastator* through tarsal contact to azinphos methyl fresh and weathered paste deposits conducted under rain shelter conditions.

		No. dead adults	
Trial No.	No. Adults	After 17 hrs	After 4 days
1	6	6	-
2	6	6	-
2	6	-	6
3	6	-	6

Experiment 9:

Evaluation of strategically-timed chemical control recommendations against young larvae: Field studies into the ecology of A. *vastator* demonstrated that peak egg-laying occurred between January and March and that newly-hatched larvae existed within the bark area for approximately the first month of their life. Development is rapid and larvae appear to tunnel into the heartwood from the IV instar, normally 4-5 weeks after eclosion and become relatively inaccessible to contact acting or systemic insecticides.

A field trial was conducted to test the effectiveness of insecticide treatments against *A. vastator* young larvae and copper hydroxide as an ovipositional repellent against *A vastator* adults.

The trial was conducted between November, 1989 and March, 1990 in a commercial vineyard. The block of grapevines used in the trial was assessed for infestation by *A. vastator* before treatments were applied. Every second vine was examined by frass indexing and an overall infestation rate of 60% was determined. Six treatments were tested and compared against an untreated control with 10 Vines per treatment plot and three replicates with treatments arranged in a randomised block design. Treatments were hand-applied along both sides of the trunk and arms to run-off using a double-nozzled jet according to the schedule in Table 13.

The trial was assessed by frass indexing six weeks after the final application. Data subjected to ANOVA given in Table14 show a significant reduction in larval numbers due to the insecticide treatments. Chlorpyrifos and methidathion worked equally well and they were no less effective when applied at monthly intervals (four sprays between December and March) than when applied fortnightly (seven sprays between December and March) providing a 35-40% reduction in infestation level. The mean control infestation level was 57.9% and the mean insecticide treated infestation levels were 18.3-18.8%. The use of summer oil as a dispersant was of no value. The use of copper hydroxide as an ovipositional repellant also provided a significantly lower infestation level than the untreated control. However, the remaining control level was unacceptably high (33.8%).

Table 13. Trial schedule to compare chemical treatments against A. *vastator* infesting grapevines, 1989-90.

Treatment	Rate	Time interval	Date applied
1 Control	-		
2 Methadathion	125 ml/100L	Monthly	4/12/90;2/1/90;27/2/90 27/3/90
3 Chlorpyrifos + Oil	50 ml/100L	Monthly	4/12/90;2/1/90;27/2/90 27/3/90;
4 Chlorpyrifos + Oil	50 ml/100L	2-weekly	4/12/90;18/12/90; 2/1/90;16/1/90; 27/2/90;13/3/90;27/3/90
5 Copper hydroxide		2-weekly	4/12/90;18/12/90; 2/1/90;16/1/90; 27/2/90;13/3/90;27/3/90
6 Copper hydroxide		Monthly	4/12/90;2/1/90;30/1/90 27/2/90;27/3/90
7 Chlorpyrifos	50ml/100L	Monthly	4/12/90;2/1/90;27/2/90 27/3/90

Table 14. Mean percent infestation of *A. vastator* in grapevines following seasonal treatment with organophosphate insecticides, 1989-90.

Treatment		% Infestation
1. Control		57.9 a
2. Methidathion	monthly	18.3 c
3. Chlorpyrifos + Oil	monthly	18.5 c
4. Chlorpyrifos + Oil	2-weekly	17.6 c
5. Copper hydroxide	2-weekly	33.8 b
6. Copper hydroxide	monthly	42.4 b
7. Chlorpyrifox	monthly	20.2 c

Treatments followed by the same letter are not significantly different (P>0.05)

Experiment 10:

A replicated trial to further evaluate methidathion and chlorpyrifos as a trunk and arm treatment against young *A. vastator* larvae and the efficacy of azinphos methyl, was conducted on a block of Semillon grapes at Pokolbin in 1990/91. Treatments including azinphos methyl (350 g/kg @ 140 g/100 L), chlorpyrifos (500 g/kg @ 50 ml/100 L) and methidathion (400 g/kg @ 125 ml/100 L) were hand applied as described in Trial 1 at two- weekly and monthly intervals. Treatment plots were approximately 40 vines and each treatment was replicated three times. Applications were made between 12th December, 1990 and 26th March, 1991. Data subjected to ANOVA, given in Table 15, and show that methidathion applied at fortnightly intervals was the only treatment to produce a significant reduction in larval numbers. It was different from methidathion (monthly) and the control (P<0.05). Azinphos methyl (fortnightly and monthly) and chlorpyrifos (fortnightly) were not different from the above treatment or the control and methidathion (monthly) and chlorpyrifos (monthly) were not different from the control (P>0.05).

Table 15. Mean percent infestation of *A. vastator* in grapevines following seasonal treatment with organophosphate insecticides, 1990-91.

Treatment		Mean % vine infested
Azinphos methyl	fortnight	14.6 ab
Azinphos methyl	monthly	15.0 ab
Methidathion	fortnight	6.7 a
Methidathion	monthly	17.6 b
Chlorpyrifos	fortnight	11.3 b
Chlorpyrifos	monthly	16.5 ab
Control		18.6 b

Treatments followed by the same letter are not significantly different (P>0.05).

Experiment 11:
An unreplicated trial to evaluate the ovipositional repellence of lime sulfur against *A. vastator* adults was conducted on Shiraz grapes at Pokolbin in 1989/90. Four blocks of Shiraz grapes, adjacent to blocks of Pinot Noir, were treated by high-volume sprayer on the arms and trunk of each vine with a lime sulfur wash at the recommended rate at pre-bud burst to test the ovipositional repellant effect of this chemical. Lime sulfur usage was suspected on the basis of anecdotal evidence of having contributed to previous declines in *A. vastator* populations. The Pinot Noir vines were uninfested with A.*vastator* and had previously been treated with lime sulfur, whereas the Shiraz vines had not previously been treated with lime sulfur and were infested with this borer pest.

Assessment was done on three of the blocks of Shiraz vines by frass indexing using a 10% sample of vines as adopted in annual surveys. The mean infestation level was 31.0%, an increase of 18.7% over the mean infestation level in 1989.

It was concluded from this field experiment that lime sulfur was of little value as an ovipositional repellent when applied as a pre-bud burst treatment. Further, this insecticide is known to burn foliage and has no other applications in grapevines.

Experiment 12:
A replicated trial to evaluate the efficacy of three insecticides against *A. vastator* young larvae was conducted on Trebbiano grapevines at Pokolbin. Ethoprophos (20 ml/L), single application; thiodicarb (0.75 ml/L)' fortnightly, and methomyl (1.5 ml/L), fortnightly, were applied by thoroughly spraying trunks and arms of vines using a hand wand attached to a Silvan Ute-pack sprayer. Treatments including a control applied between 13th December, 1990 and 26th March, 1991, were replicated four times with each plot consisting of 20 vines. Treatments were randomised within each block. Assessment was made at a later date by frass indexing. Data subjected to ANOVA given in Table 16 show all three insecticides significantly reduced larval numbers when compared with the control ($P<0.05$), but not with each other. Although significant reductions in larval numbers were recorded, the remaining infestation levels were unacceptably high.

Table 16. Mean percent infestation of A *vastator* in grapevines following seasonal treatment with insecticide, 1990-91.

Treatment		Mean % vine infested
Thiodicarb	applied fortnightly	30.58
Ethoprophis	single application	21.9
Methomyl	applied fortnightly	16.1
Control		47.7

Treatments followed by the same letter are not significantly different ($P>0.05$).

Experiment 13:
A replicated trial to evaluate the efficacy of a single dormant insecticide application against *A. vastator* was conducted at Pokolbin in 1990. Lime sulfur .(recommended rate) and cyfluthrin (8 m1/L, four times recommended rate) were hand-applied to dormant vines using a high-volume sprayer in August, 1990. Treatments, including a control, were replicated four times with each plot consisting of 30-57 vines.

Treatments were randomised within each block. Assessment was made at a later date by frass indexing. Data subjected to ANOVA given in Table 17 demonstrate that neither of these treatments gave a significant reduction in the larval population level of the subsequent generation. Lime sulfur was tested as an ovipositional repellant and cyfiuthrin as a larval toxicant.

Table 17. Mean percent infestation of *A. vastator* in grapevines after dormant treatment of vines with insecticide, 1990-91.

Treatment		Mean % vine infested
Lime sulfur	recommended rate	5.4 a
Cyfluthrin	four times recommended rate	5.2 a
Control		9.5 a

Treatments followed by the same letter are not significantly different (P>0.05)

Experiment 14:

A replicated late-season trial to compare the effects of some new insecticides with azinphos methyl against *A. vastator* young larvae was conducted on Chardonnay grapevines at Pokolbin in 1990. Cyfiuthrin 500 ml/100 L, methomyl 150 ml/100 Land azinphos methyl 140 g/100 L were tested with a control including wetter and an untreated control including oil and gum. Each of the insecticide treatments contained wetter while cyfluthrin also had a treatment with oil and gum. Treatments applied to plots of 40-45 vines were replicated five times and randomised within each replicate. The oil was Ampol LOVIS oil used at 0.5% and the gum was Kelgum powder used at 0.01%. The trial was conducted to investigate the efficacy of two insecticides previously unused against *A. vastator* with azinphos methyl. Treatments were hand-applied using a Silvan Ute-pack sprayer. Assessment was made by frass indexing. Data subjected to ANOVA in Table 18 show that none of the treatments were significantly different from each other and from the control.

Experiment 15:

To evaluate the effect of recommended insecticide treatments applied by grower spraying equipment against *A. vastator* populations in 1990-91. Unreplicated one-acre blocks of Semillon grapevines at Pokolbin, were sprayed monthly with azinphos methyl and chlorpyrifos at the recommended rates between December, 1990 and March, 1991, with a third block untreated for *A. vastator,* as a control, between the two insecticide treated blocks.

In early winter 1991 when larval activity was visually evident, an assessment of *A. vastator* population levels was made in each block by frass indexing. Five rows per block were assessed for infestation.

Data given in Table 19 demonstrated that azinphos methyl was significantly more effective than chlorpyrifos against *A. vastator.*

Table 18. Mean percent infestation of A *vastator* in grapevines following treatment with some insecticides and spray additives, 1990-91.

Treatment	Mean % infestation	the
Methomyl + wetter	18.32	2.72
Azinphos methyl + wetter	11.65	2.24
Control + wetter	12.80	2.99
Control + oil and gum	11.54	3.62
Cyfluthrin + oil and gum	12.87	2.36
Cyfluthrin + wetter	12.50	2.29

Table 19. Mean percent infestation of A. *vastator* in grapevines after seasonal treatment with azinphos methyl and Chlorpyrifos by grower spraying equipment, 1990-91.

Treatment	No. vines assessed	Mean % infestation
Azinphos methyl	414	6.0 b
Chlorpyrifos	365	20.5 a
Control	359	14.2 a

Experiment 16:
Seasonal monitoring program to evaluate the effectiveness of the recommended longicorn control measures when applied by grower spraying equipment. A further study was conducted on two properties where 4-7 grower-applied insecticide applications of either azinphos methyl or chlorpyrifos against *A. vastator* infesting grapevines were applied in 1991-92.

Monthly assessments of the treated and untreated blocks of grapevines were conducted between early December 1991 and late March, 1992, and a final examination to determine infestation rate was made on 22nd April, 1992. On each assessment, five rows were randomly selected with five consecutive vines per row inspected for presence of new adult emergence holes, presence of fresh frass indicating active old generation larvae, visible evidence of new egg-laying, presence of eggs or newly-hatched larvae, signs of new egg- laying sites where newly-hatched larvae had perished and signs of adult chewing considered to be a precursor for egg-laying. Data summarised as percent vines with live infestation, percent dead larvae and percent adult chewing activity for each assessment are given in Figures 1 to 4.

All blocks were sprayed prior to the first assessment. Post treatment sprays were applied on 25th February and 2nd April, 1992 on Vineyard A and 22nd February, 12th March and 16th April, 1992 on Vineyard B.

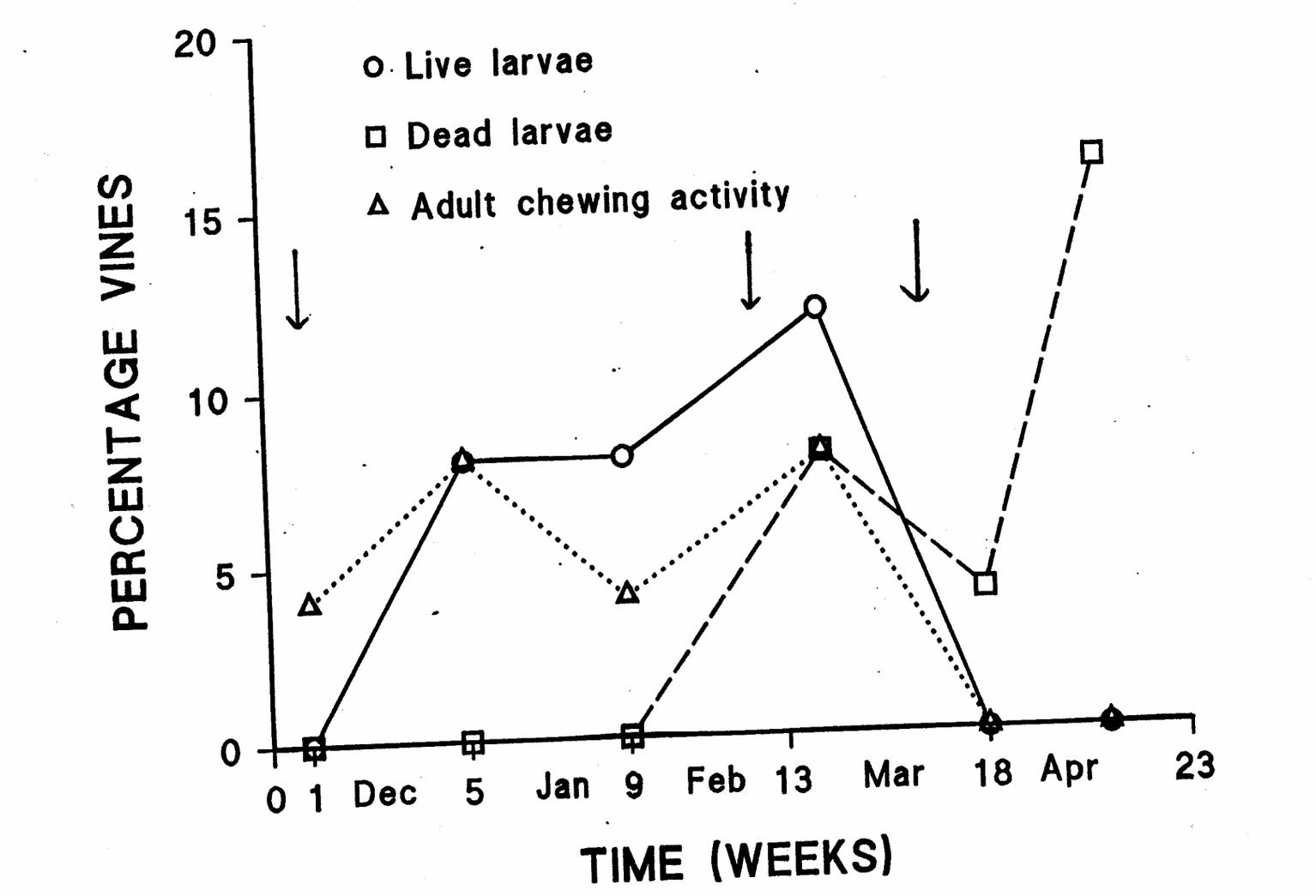


Figure 1. Monitoring data for *A. vastator* from grapevines sprayed with azinphos methyl for the first time, Vineyard A, 1990-91.

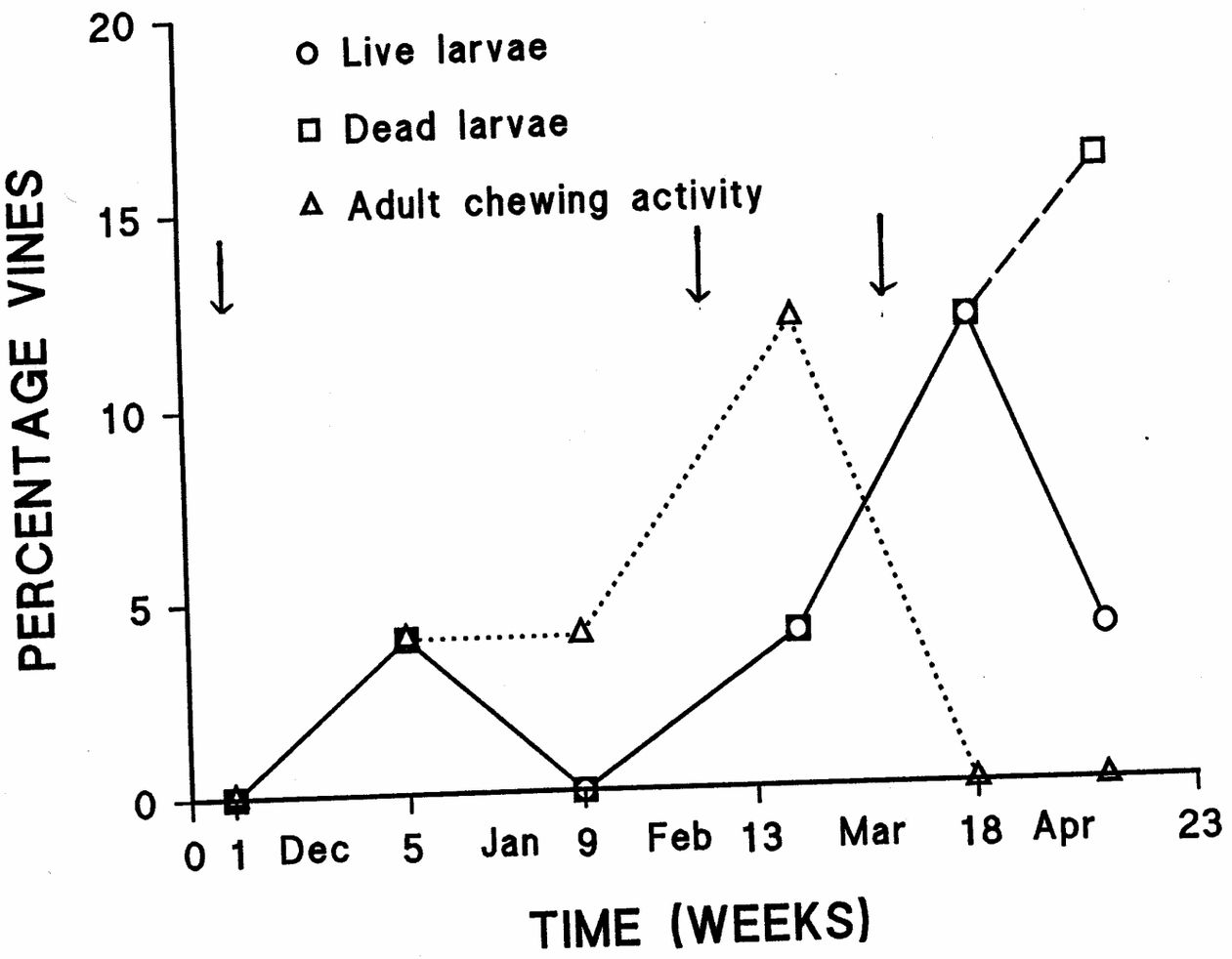


Figure 2. Monitoring data for *A. vastator* from grapevines sprayed with azinphos methyl in consecutive years, Vineyard A, 1990-91.

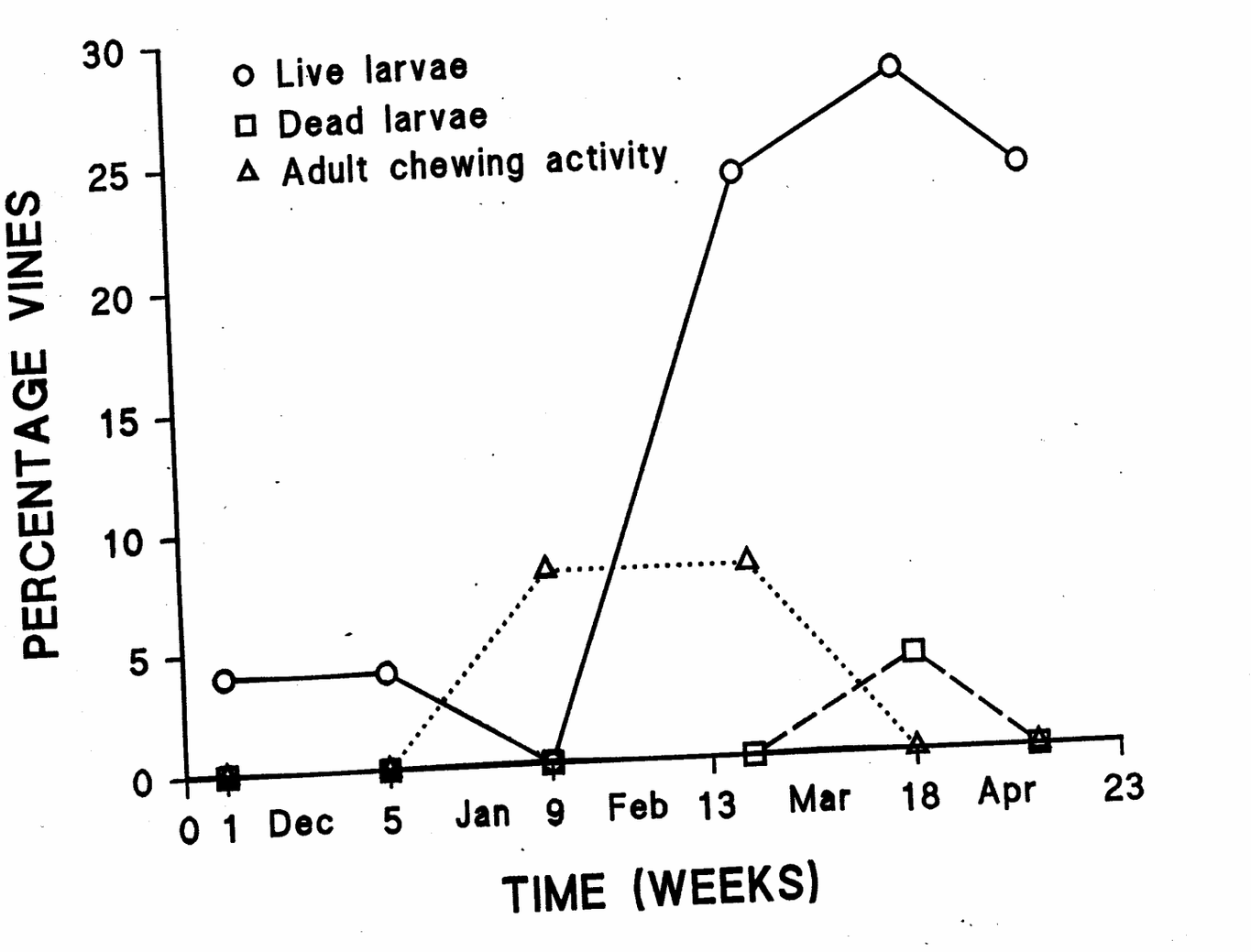


Figure 3. Monitoring data for *A. vastator* from grapevines not sprayed with azinphos methyl, Vineyard A, 1990-91.

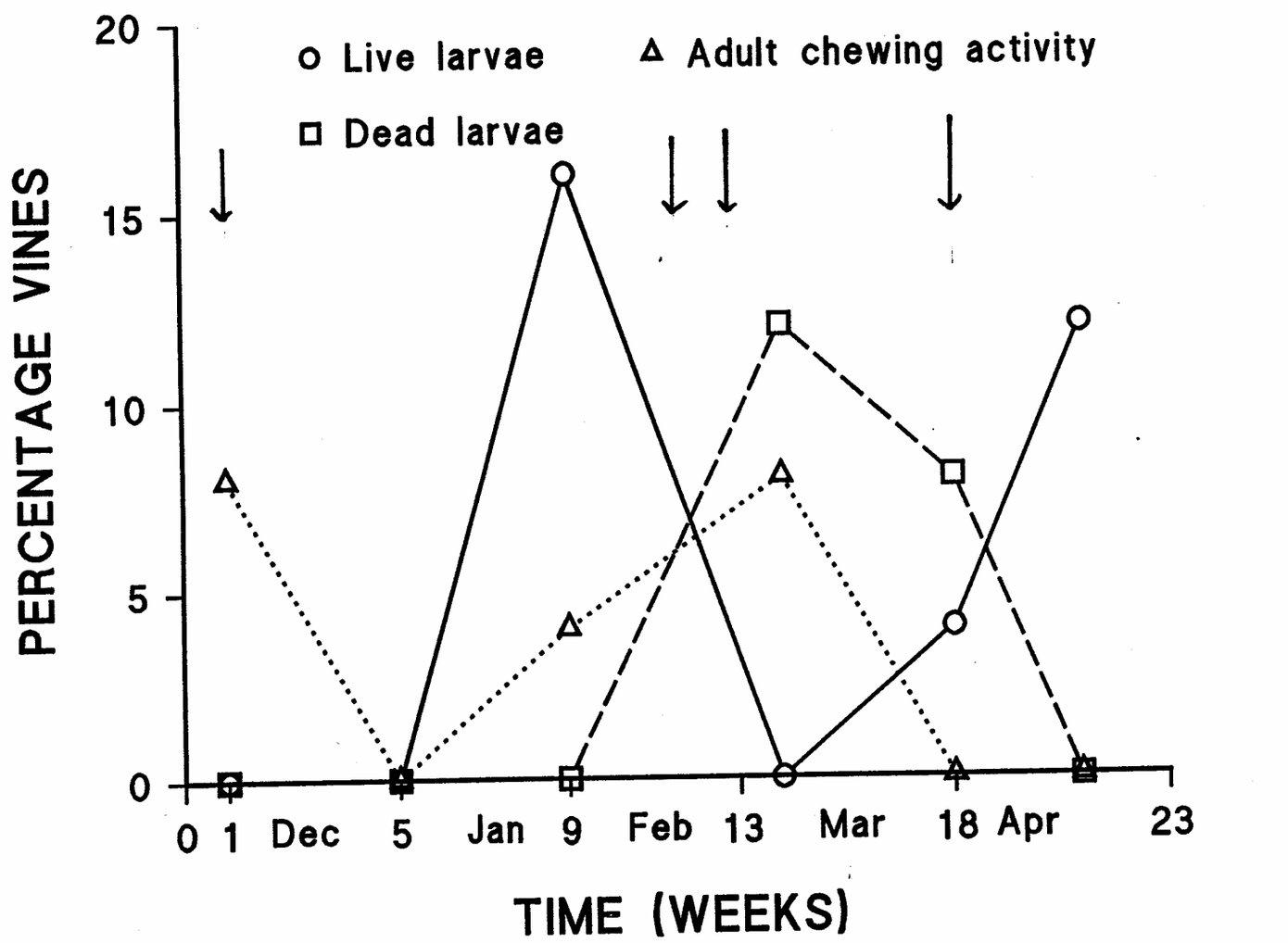


Figure 4. Monitoring data for *A. vastator* from grapevines sprayed with azinphos methyl, Vineyard B, 1990-91.

In Vineyard A, monthly sprays applied in December, January, February and April resulted in a lower population in the block treated with azinphos methyl in the previous two years than in the block treated with azinphos methyl in only the previous year. The effectiveness of the treatments can be judged against the untreated control where no larval mortality was recorded during the trial period.

In Vineyard B, seven sprays were applied between November and April. Large numbers of live larvae were recorded in late January, but intensive spraying during the following five weeks effectively suppressed these populations. This is indicated by the numbers of dead larvae and the increase in the adult chewing activity over the final two months. Both of these factors indicate the presence of egg-laying populations and therefore, young larvae, and the lack of the latter indicates the effectiveness of the chemical treatments.

A final assessment was done on 22nd April, 1992 and results are given in Table 20. On Vineyard A, the block where azinphos methyl had been used in only the previous year, nil live infestation and 16% recent kill was recorded, while in the block where azinphos methyl had been used in each of the previous two years, 4% live infestation and a 16% recent kill was recorded. This is an average of 2% live infestation over both azinphos methyl treatment blocks as against a vineyard mean infestation of 10% recorded in the 1991 survey. On Vineyard B, a 12% live infestation was recorded with no new kills. The larvae were all mature in arm or butt locations. The infestation was 4% less than the previous year.

Overall, this monitoring trial has demonstrated the effectiveness of spray recommendations for *A. vastator* by significantly decreasing the population.

Table 20. Effect of seasonal spraying program against *A. vastator* following application of insecticides by grower spraying equipment, 1991-92.

Vineyard	Treatment	% infestation	% new kill	% change from previous year
A	Azinphos methyl	12	0	-4.0
B	Azinphos methyl-1st year treatment		16)	
	Azinphos methyl 2nd year treatment	4	16)	-4.7
	Chlorpyrifos 2nd year treatment	12	12)	
	Control	24	0	

Experiment 17:

Study to monitor the influence of organophosphate insecticide treatments used against *A. vastator*, on populations of pest and beneficial mites with particular emphasis on twos potted mite and its naturally-occurring predators, 1991-92. The frequent use of organophosphate insecticides against *A. vastator* would appear to have promoted an outbreak of twospotted mite *Tetranychus urticae.*

This was considered to have been due to the toxic affect of these insecticides on the naturally-occurring predatory mites. A two- year study of the mite fauna and their relationship with insecticide spraying programs was commenced in 1991.

A survey was conducted to investigate the distribution and abundance of pest and beneficial mite species, both in the grapevine and in the surrounding grassed environments including headland and inter row areas, under sprayed and unsprayed conditions. Nine blocks were selected from five vineyards including Pokolbin (Vineyards A, B, C), Dalwood (Vineyard D) and a site in the Upper Hunter (Vineyard E), to assess mite populations in the Hunter Valley. The Lower Hunter and Pokolbin areas are influenced by coastal weather effects and have a generally higher rainfall and humidity level than the Upper Hunter. The environmental variations between these sites may influence mite distribution. Spraying schedules for *A. uastator* in each vineyard block are given in Table21.

Table 21. Spraying schedules for *A. vastator* used in five vineyards in the Hunter Valley, 1991-92.

Vineyard block	Spraying schedule for *A. vastator*
A - sprayed with azinphos methyl in Previous year	Sprayed with azinphos methyl
Pokolbin sprayed with azinphos methyl in Previous 2 years	Sprayed with azinphos methyl
- unsprayed for A. vastator in previous 2 years	Unsprayed
sprayed with chlorpyrifos in previous 2 years	Sprayed with chlorpyrifos
B, Pokolbin	Unsprayed
C, Pokolbin	Unknown
D, Branxton	Sprayed with azinphos methyl
E, Upper Hunter	Unsprayed

In vineyard A, four trial areas were identified within one large block. These were identified as blocks 1-4 and had been treated separately prior to this study (see previous trial description). In each of vineyards B, D and E, one block was identified for a particular set of conditions. In vineyard C, two blocks were selected for direct comparison.

The study began with an assessment of the over-wintering population in the wood of dormant grapevines, followed by samples of developing buds. Once full leaf was established grapevine leaves were sampled.

These collections allowed assessment of the population throughout the growing season and continued until leaf fall the following autumn. Mite populations in the grasses interrow and headland areas adjacent to the vines were also sampled.

Method used for sampling mites from overwintering wood:
For each block, 20 bolts of wood were randomly selected, each 20cm long, and removed to the laboratory. Each sample was then divided into three sub samples of approximately equal weight, and transferred to Tolgren funnels for 72 hours where the warmth from the light above caused the mites to drop into a collection beaker containing 70% alcohol. Each sample was then taxonomically sorted.

Method used for sampling mites from grapevine buds:
Twenty randomly selected buds per sample were cut from each block of grapevines. Weekly samples were until the full leaf stage existed. Bud samples were sealed in plastic bags and held at 5°C until extraction using Tolgren funnels for periods of 48 hours. Buds were gently opened prior to placement in the funnel. This extraction period was previously determined to be the optimum time needed to extract all mites from a sample. Samples were then taxonomically sorted.

Method used for sampling mites from grape leaves:
Leaf samples were collected from the nine blocks of grapes on nine occasions over a 31 week period at two-weekly intervals from early October until the end of October, then monthly from November until May, 1992. Ten leaves were selected from the middle and op canopy from each of 20 vines. Vines were randomly selected in each block Leaves were removed to the laboratory, brushed and mites were stored in 70% alcohol for sorting and identification.

Method used for sampling mites in grassed interrow and headland areas in vineyards:
Commencing in January 1992, sampling was carried out using a vacuum system. Samples were placed in plastic bags and removed to the laboratory. The contents of each bag was washed and the mites were stored in 70% alcohol prior to sorting and identification. The vacuum sampler swept an area of approximately 20 m2. Samples were collected from three sites per vineyard block in areas between the rows of grapevines and from one site on the grassed headland areas adjacent to each block. The headland areas were mainly unsprayed and were relatively undisturbed by viticultural practice

Results:
Data on mite species identified from the grapevine samples are given in Table 22. The predatory mites *Phytoseiulus persimilis, Amblyseius masiaka .A. peltatus, .A.. lentiginosus* and *Phytoseius fotheringhamie* belong to the family Phytoseiidae, which is implicated in spider mite control. It is possible that one or more of these species may provide effective biocontrol of twospotted mite infesting grapevines under natural conditions or with selective pesticide usage. The first mentioned is an interesting record. This species was first discovered in Australia in 1979 and has since been commercially reared for use against *T. urticae* infesting horticultural crops, yet it is not known to have been previously released into Pokolbin.

Table 22. A list of mite species identified from five vineyard sites in the Hunter Valley, 1991-92.

Species name	Description
Brevipalpus sp. (bunch mite)	**Pest species**
Tydeidae sp.1	Small species, not described in Australia
Amblyseis masiaka	Phytoseiid predatory mite
Calepitrimerus vitis (rust mite)	Pest species
Raphignathidae sp.	Species not described from Australia
	Predatory type
Glycyphagidae	Free-living species, associated with insects and small mammals, fungal and detrital feeders
Tarsonemidae sp.	Pest species, attacks many plant hosts, causing distortion
Tetranychus urticae (twospotted mite)	Pest species
Acaridae	Fungal feeder
Acardae	Fungal feeder
Oribatidae	Previuosly unknown
Bdellidae	Predatory type
Erythraeidae	May be predatory type
Anystidae	Free-living predator
Cheyletidae	Phytoseiid predatory mite
Amblyseis peltatus	Previuosly unknown
Tudeidae sp.2	
Erythraeidae sp.2	Unknown
Oribatidae sp.2	
Bryobia sp.	Phytoseiid predatory mite
Phytoseius fotheringhamiae	Probably predatory
Mesostigmata sp.1	
Erythraeidae sp.3	
Mesostigmata sp.2	
Penthaleus major (Duges)	Blue oat mite
Stigmaeidae (ACAR)	Predatory species
Stigmaeidae sp.	Beneficial species
Amblyseius lentiginosus	Phytoseiid predatory mite
Phytoseius persimilis	Phytoseiid predatory mite
Mesostigmatid, Olaelaps tasmanicus (Womersley 1956)	Predatory type
Erythraeidae sp.4	

Data from grape leaf samples given in Figures 5-9 show little evidence of phytoseiid mites. However, their presence m all blocks, sometimes numerous, suggests that an indigenous population is surviving despite insecticide usage. A summary of this data presented in Table 23 would suggest no clear relationship between insecticide application and predatory mite occurrence and abundance. No detailed experiments have been conducted to provide clarification. Details on pesticide usage on each property are given in Table 24 .

Table 24. Details on pesticide usage in the five vineyard sites, 1991-92.

Vineyard	Pesticide	No. applications
B	Wettable sulfur	4
	Promecarb	1
	Cooper curit	3
A	Copper oxychloride	6
	Wettable sulfur	4
	Azinphos methyl/Chlorpyrifos	4
D	Mancozeb	5
	Wettable sulfur	3
	Carbaryl	1
	Azinphos methyl	4
	Dicofol	1
	Triadimefren	4
	Carbendazin	2
	Iprodione	1
	Copy oxychloride	3
E	Wettable sulfur	3
	Mancozeb	4
	Dicofol	1
	Carbendazin	1
	Iprodione	1
	Chlorpryifos	1
	Triademefren	2
	Copper oxychloride	2
	Vinclozobin	1
C	Unavailable	

Raw data can be further viewed on the basis of species diversity throughout the season.
The data in Tables 25 and 26 indicate the diversity of mite species and the occurrence of phytoseiid predatory mites in these samples from three vineyard sites in Pokolbin (Vineyard B), Branxton (Vineyard D) and in the Upper Hunter Valley (Vineyard E).

Samples from grassed areas were taken between September and June 1992. Some sites were unavailable for sampling due to the practice of maintaining a freshly- cultivated condition between rows in the Vineyard, while other sites could only be sampled for part of this period.

Overall, data indicate the general presence of phytoseiid predatory mites between February and May. At Vineyard A, *A. masiaka* was frequently present in samples from each of the treatment blocks during this period. However, *A. peltatus* was more prevalent and occurred in every sample. Both species were numerous during this time. *A. peltatus* was also present and numerous in most samples at the other three sites (Vineyards B, C and D) during this time, while *A. masiaka* was recorded only at Vineyard D. *A. peltatus* was the dominant species in this sampling period.

Table 23. Summary of mite incidence in vine mite study conducted on five vineyard sites, 1991-92.

Vineyard/No. blocks		Main pest mites	Phytoseids	Pesticides
A	3	TSM high - peak February-March Rust, bunch, tarsonemid low - peak March	**Am, Ap** even and good numbers February and March.	Fungicides plus range of FL sprays (azinphos methyl, chlorpyrifos, none)
B	1	Rust high - peak January Bunch low - peak February Few TSM, tarsonemids - March	**Am** predominant, **Ap** also good numbers - February and March	Fungicides to December. No FL sprays.
C	2	Rust high - peak January Bunch low - peak February TSM, tarsonemid present March	**Am** present February	FL sprays +/-
D	1	Rust, bunch, tarsonemid low	**Am, Ap** present February and March	Fungicides plus FL (azinphos methyl)
E	1	Bunch low - peak February Rust, tarsonemid - present	**Am, Ap** present April	Fungicides plus FL (chlorpyrifos)

Am = *A. masiaka;* Ap = *A. peltatus.*

Figure 5:

Vineyard A, Block 1, (sprayed with azinphos methyl the previous year). Normal pest and disease control measures and monthly azinphos methyl treatments against A. *vastator* applied, 1991-92.

Vineyard A, Block 2, (sprayed with azinphos methyl the previous two years). Normal pest and disease control measures and monthly azinphos methyl treatments against A. *vastator* applied, 1991-92.

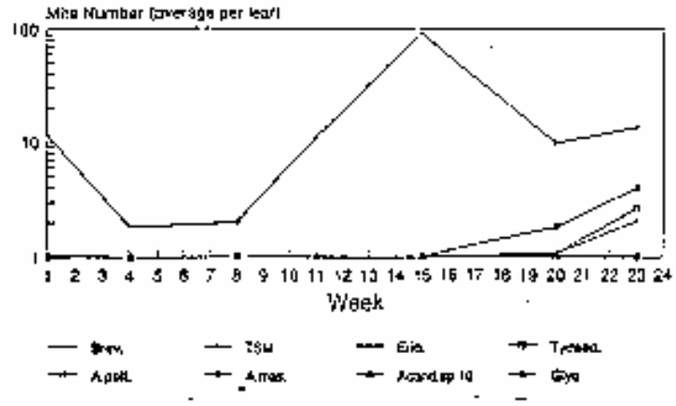
Vineyard A, Block 3, (not sprayed for A. *vastator* the previous two years). Normal pest and disease control measures applied, but untreated for A. *vastator,* 1991-92.

Vineyard A, Block 4, (sprayed with chlorpyrifos the previous two years). Normal pest and disease control measures and monthly chlorpyrifos treatments against A. *vastator* applied, 1991-92.

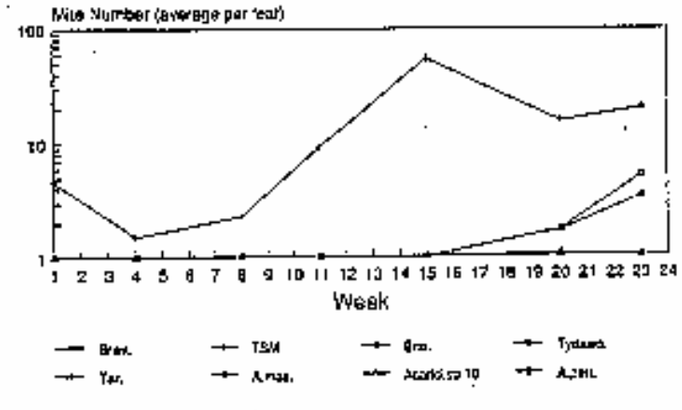
Note: Specific spraying details, where available, given in figures.

I Key:
S = sulfur spray
IF = other fungicides
I = insecticide *(not* for A. *vastator* control)
C = copper spray
D = dipel spray
A = azinphos methyl

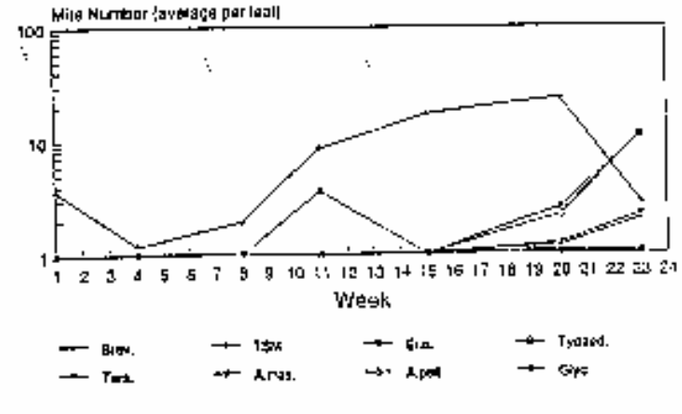
Block 1



Block 2



Block 3



Block 4

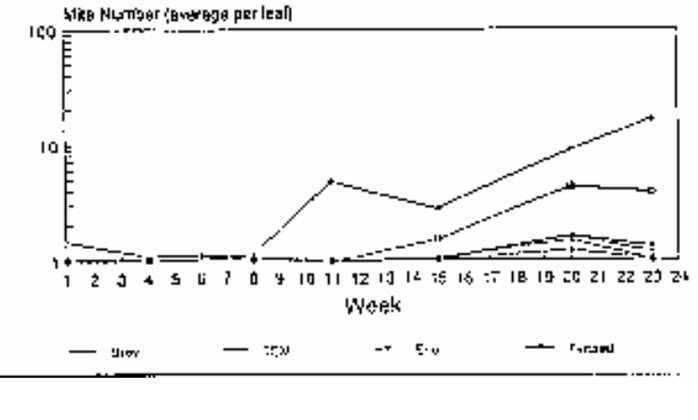


Figure 6 **Vineyard B, Normal pest and disease control measures, but unsprayed for A. vastator, 1991-92.**

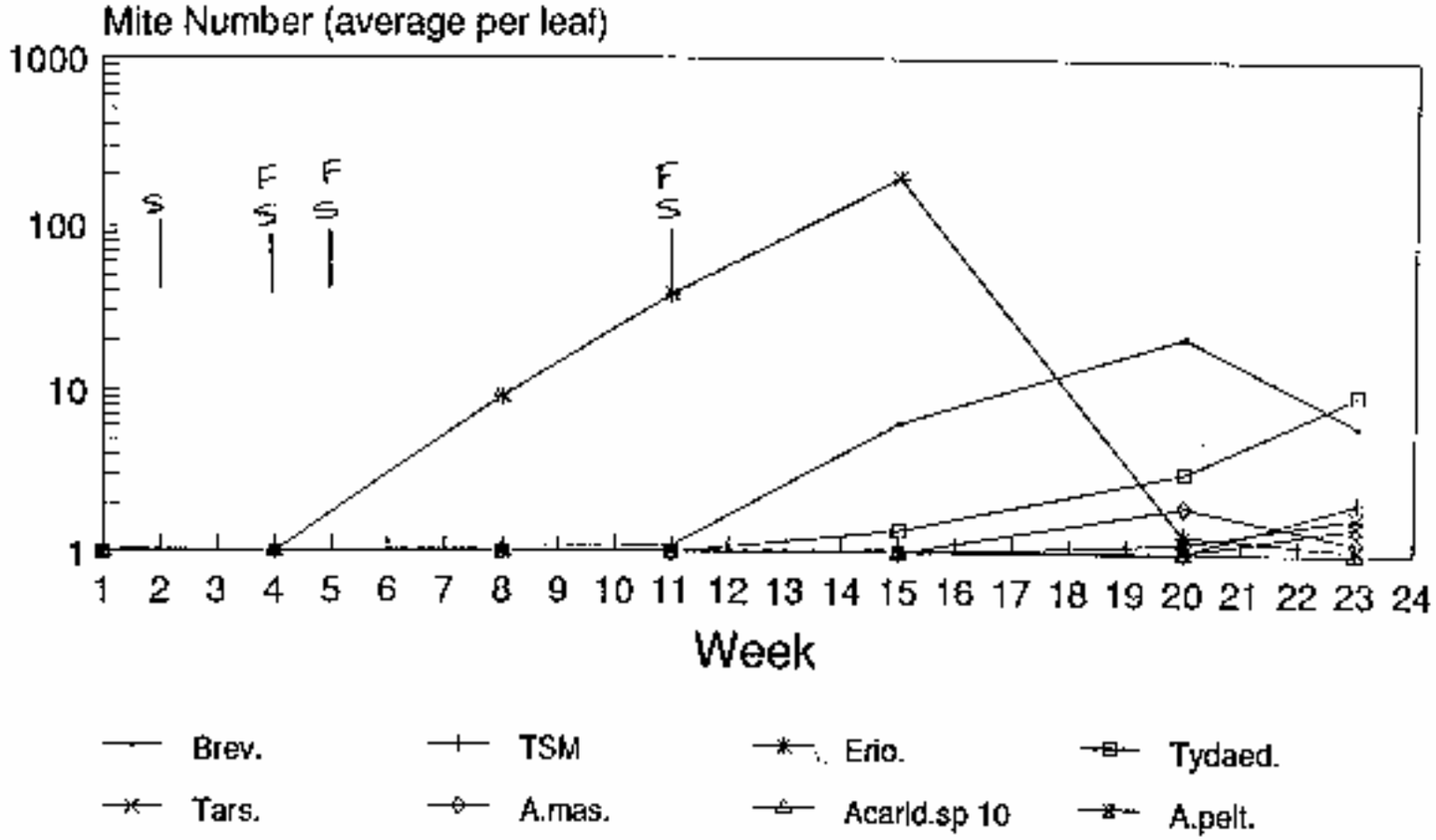
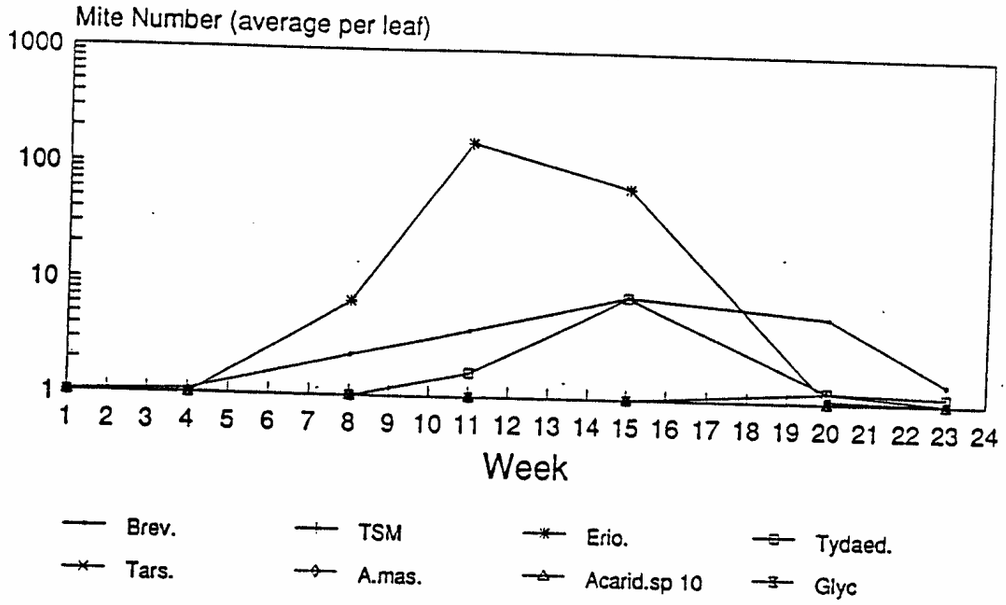


Figure 7 **Vineyard C, Block 1, Unsprayed, 1991-92.**



Vineyard C, Block 2, Normal pest and disease control measures, but unsprayed for *A. vastator*, 1991-92.

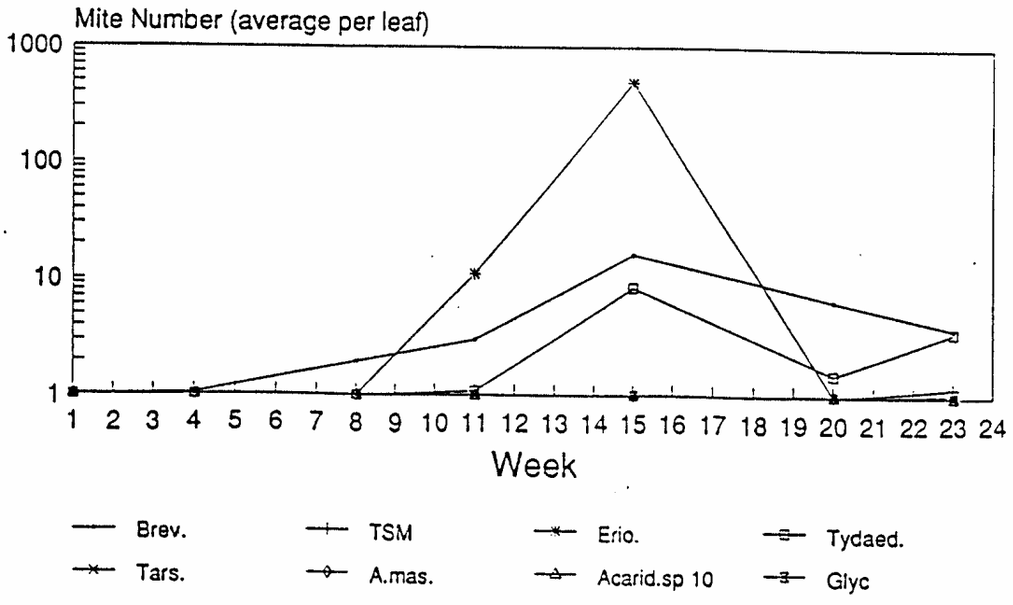


Figure 8 **Vineyard D, Normal pest and disease control measures and sprayed with azinphos methyl against *A. vastator*, 1991-92.**

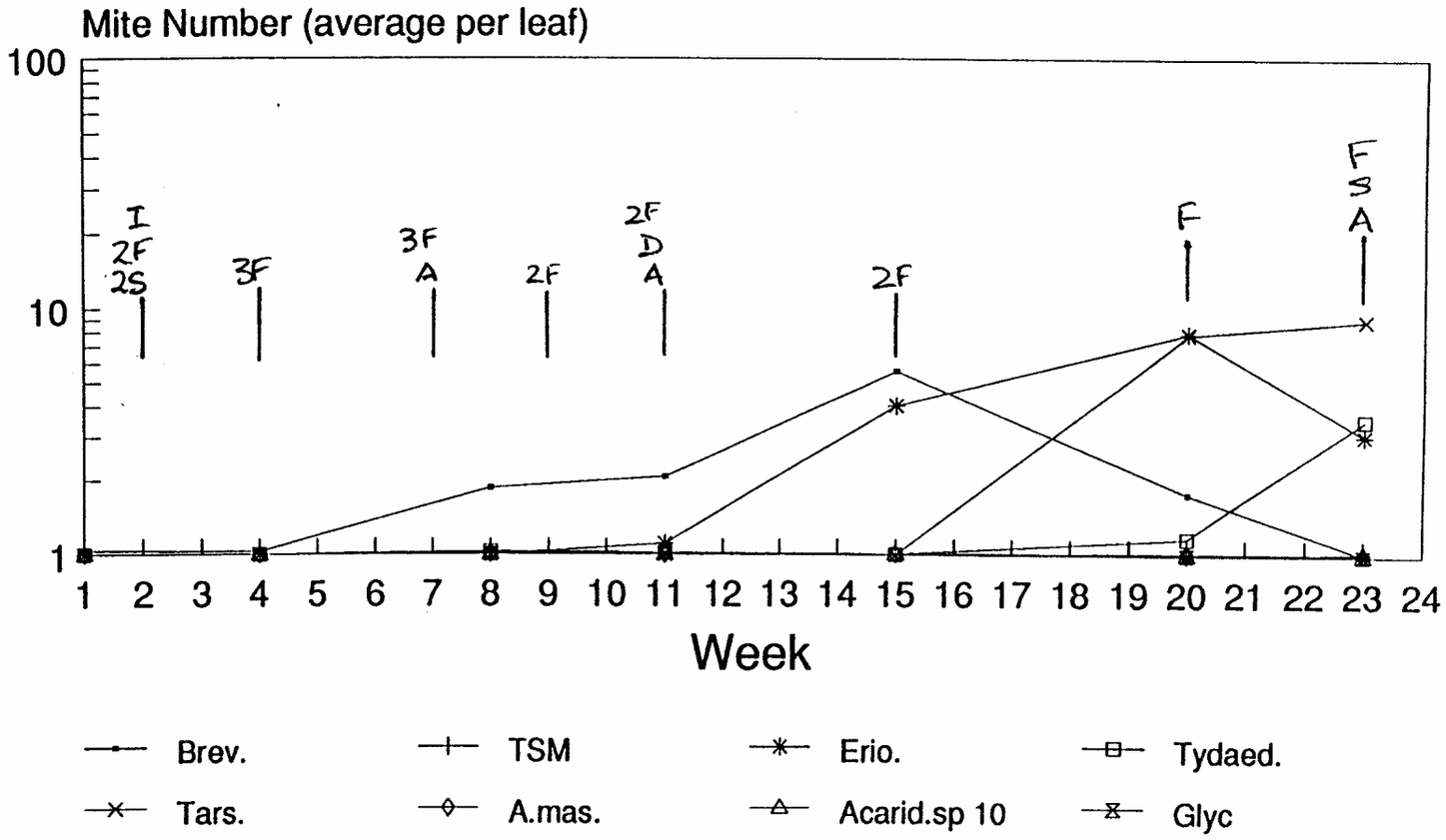
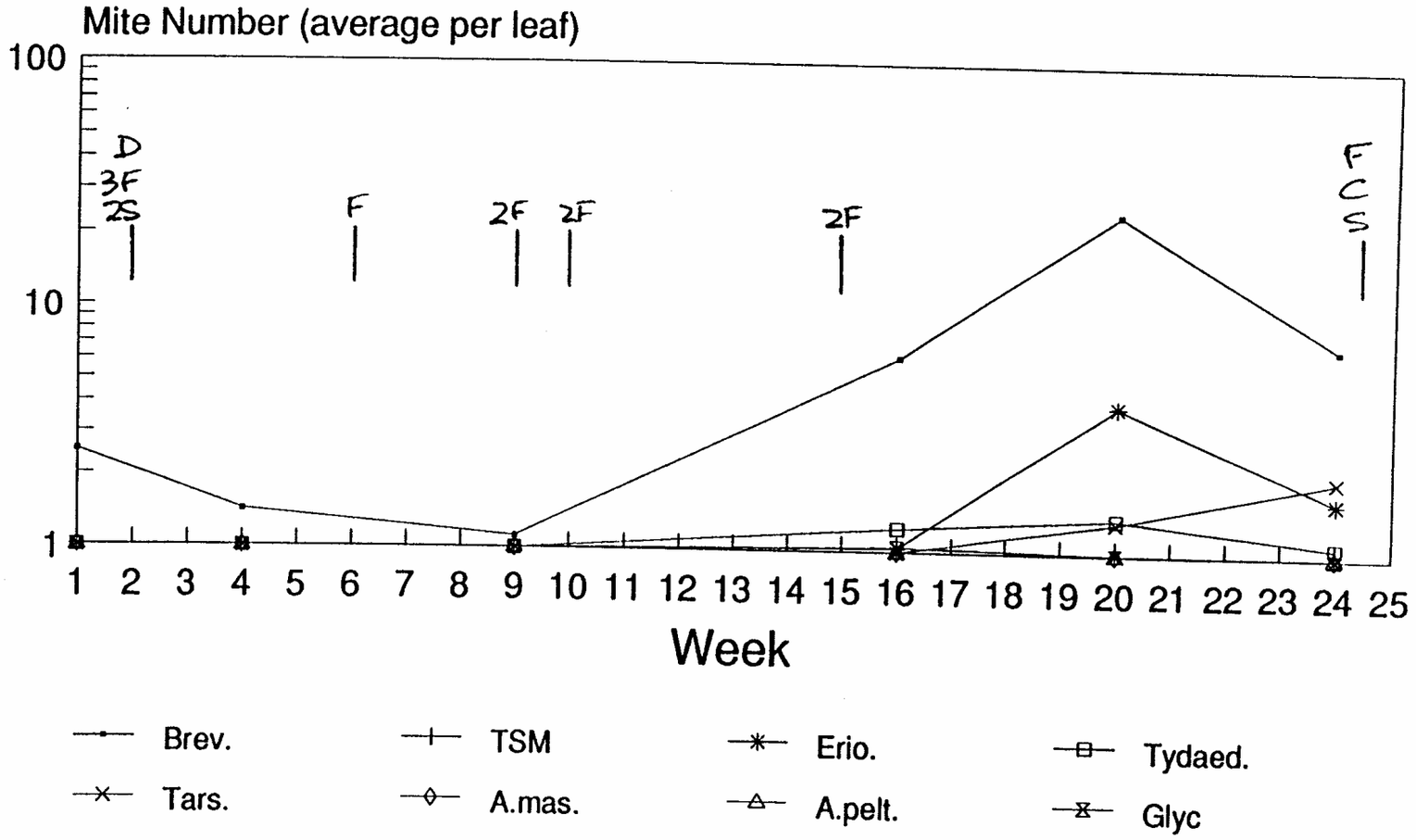


Figure 9 **Vineyard E, Normal pest and disease control measures, but unsprayed for *A. vastator*, 1991-92.**



Data from 20 samples of grape wood from the four vineyard sites indicate a small number of A. masiaka overwintering in the bark at each site. Of the pest mite species, grapevine bunch mite Brevipalpus sp. Appeared also to overwinter in bark.

Few records of phytoseiid predatory mites and *T. urticae* were obtained from the six bud samples taken between Ausgust and late September, 1991. *A. peltatus* and *A. masiaka* were each recorded singly at vineyards B and C, respectively, while *T. urticae* was recorded at Vineyard A in the final bud sample.

Table 25. A comparison of mite species diversity and phytoseiid predatory mite occurrence in consecutive years in Vineyard B, Pokolbin, 1991-92 and 1992-93.

Vineyard B			
Week	1991-92 No. of species	Week	1992-93 No. of species
1	3	1	1
4	2	5	3
8	2	7	4
11	4	11	8**¦ x
15	5	16	8**¦ x
20	8**	18	9*¦ x
23	10**¦	20	8**¦
		23	7*¦ x
		26	9**

Experiment 18:

A reduced study to monitor mite populations on only two properties was conducted in 1992-93. The same sampling procedures were used but only grape leaf and grasses area samples were taken on 10 occasions over a 26-week period between 27th October,1992 and 20th April,1993. Data from grape leaf samples given in Figures 10-17 show substantial numbers of the phytoseiid species *P. fotheringhamiae*, *A. lentiginsus* and *A. masiaka* were present at Vineyard B. However, *T. urticae* was not present in the crop. Again the phytoseiid representation in Vineyard A is not apparent in Figures 10-17, due to the scale and low mean numbers per leaf. In fact, all three species mentioned above were also recorded in samples from early January, 1993 until the end of sampling in vines sprayed with azinphos methyl and chlorpyrifos and in vines not treated with organophosphate insecticides. Some of the properties are represented by more than one figure due to the number of mite species recorded in the samples.

Table 26. Mite species diversity and phytoseiid predatory mite occurrence at two vineyard sites in the Hunter Valley, 1991-92.

Vineyard E, Upper Hunter		Vineyard D, Lower Hunter	
Week	1991-92 No. of species	Week	1991-92 No. of species
1	3	1	1
4	1*	4	1
9	4**	8	2*
16	4	11	6
20	4	15	5*
24	7**	20	6**
		23	8**

* *Amblyseius masiaka* ¦ *phytoseius fotheringhamiae*
** *A. peltatus* X *A. lentiginosus*

Suction samples were collected from grassed areas in vineyards over a 41 week period between 8th September, 1992 and 3rd June, 1993. Data of occurrence of phytoseiid mite species are given in Table 27. A. *lentiginosus,* A. *masiaka,* A. *peltatus* and P. *fotheringhamiae* were recorded in Vineyard B, while the last mentioned was not recorded in Vineyard A. These data basically reflect the results from the grape leaf samples.

Conclusion:
It is clear from grower reports that T. *urticae* has become an entrenched problem in vineyards in the Lower Hunter Valley and that this problem appears to have developed with the heavy usage of organophosphate insecticides against A. *vastator*. A detailed sampling program at five vineyard locations in the Upper and Lower Hunter Valley in 1991-92 and repeated at two of the Lower Hunter sites in 1992-93 failed to identify a relationship between organophosphate insecticide usage and pest and beneficial mite populations.

Phytoseiid species appeared in numbers following the withdrawal of sprays prior to vintage and did not appear to be particularly influenced by the presence or absence of the organophosphate insecticides used against A. *vastator*. It appears that other sprays used against pest and diseases in grapevines in this region may contribute as much or more to the T. urticae problem that has emerged in vineyards in parts of the Lower Hunter Valley. Further investigation needs to be done to identify the responses of those phytoseiid species to specific pesticide sprays.

Figure 10: Vineyard A, Block 1

Figure 11: Vineyard A, Block 2
Figure 12: Vineyard A, Block 3a

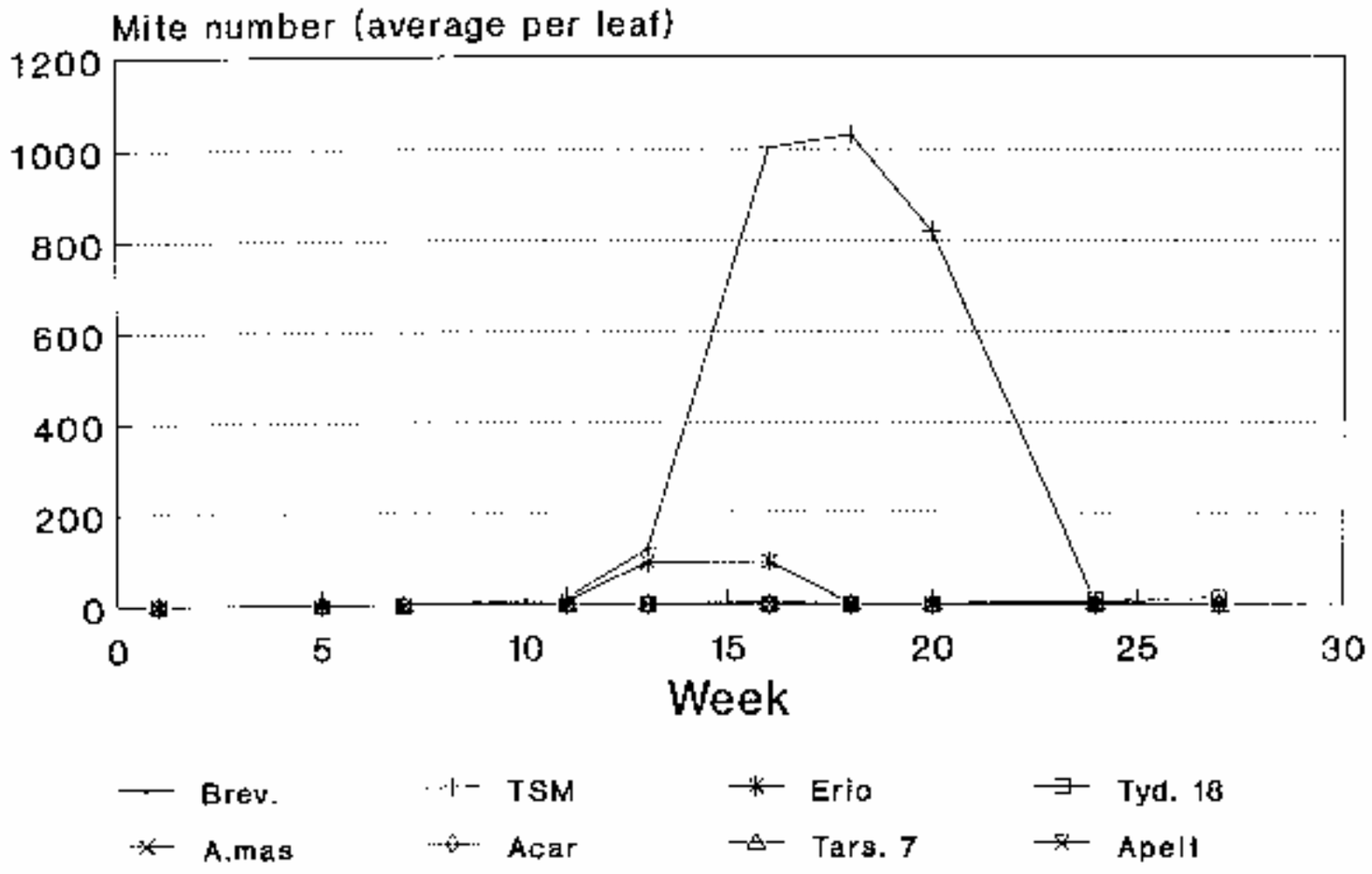
Figure 14: Vineyard A, Block 3b

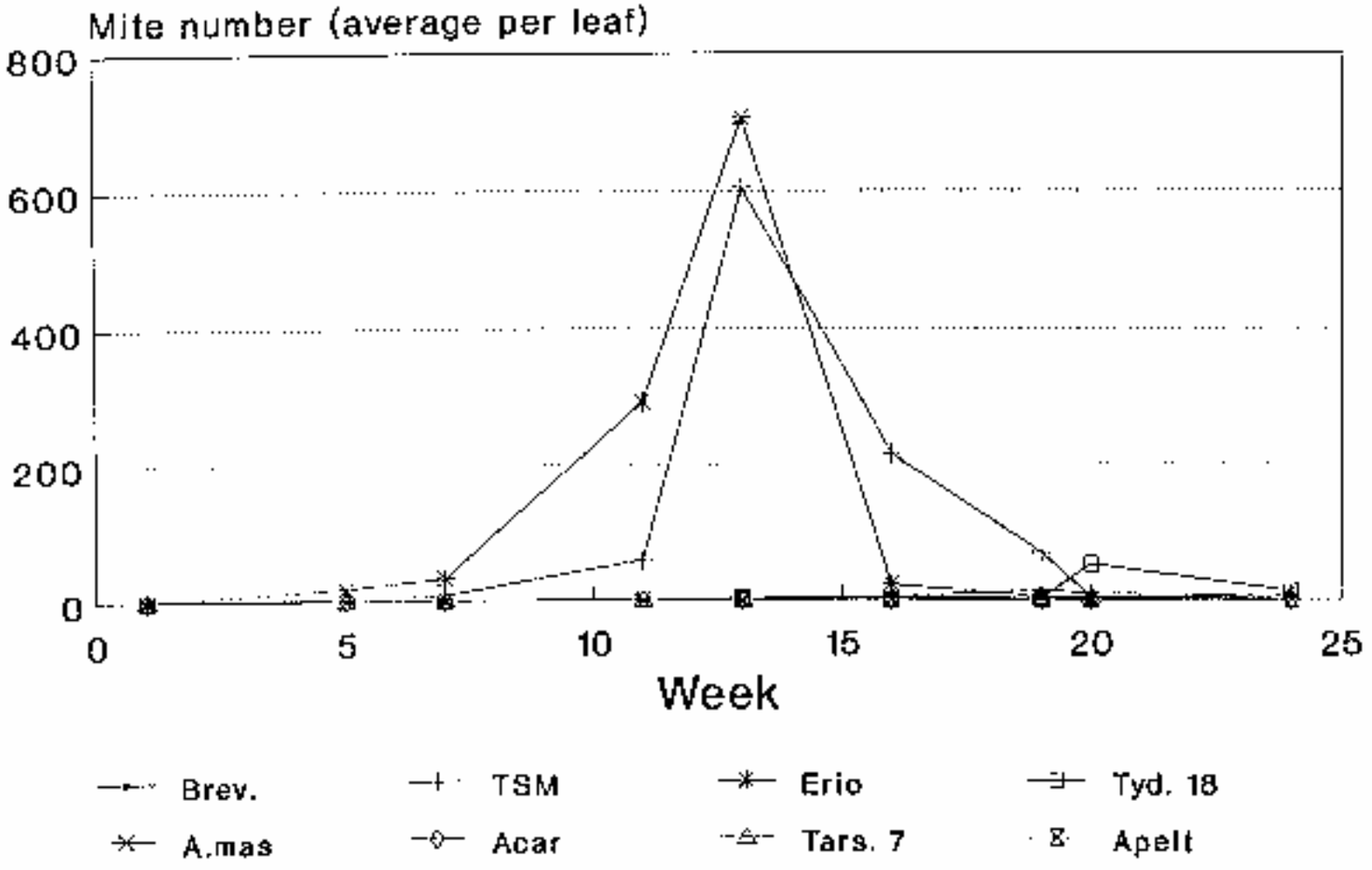
Figure 15: Vineyard A, Block 3c

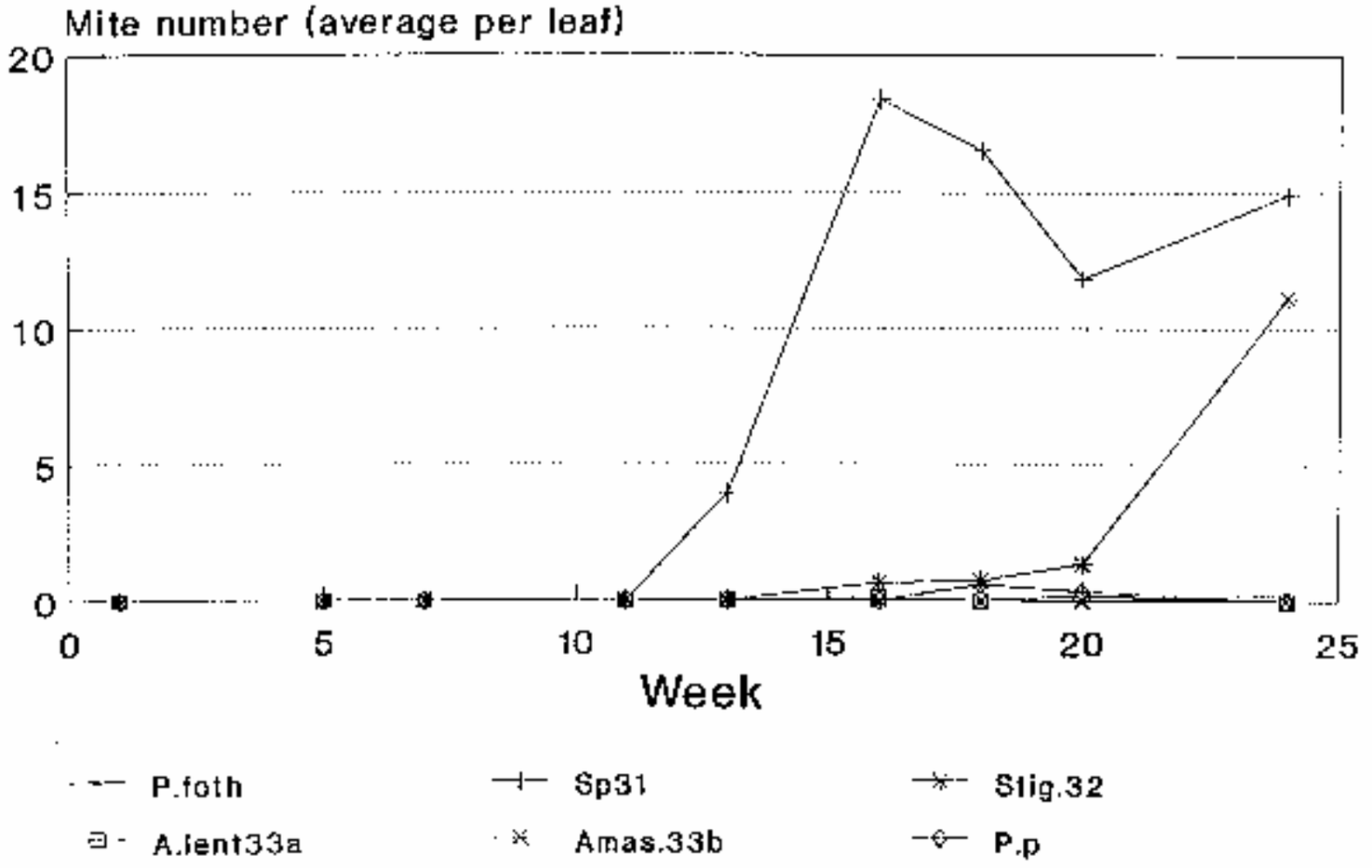
Figure 16: Vineyard B, Block 1a

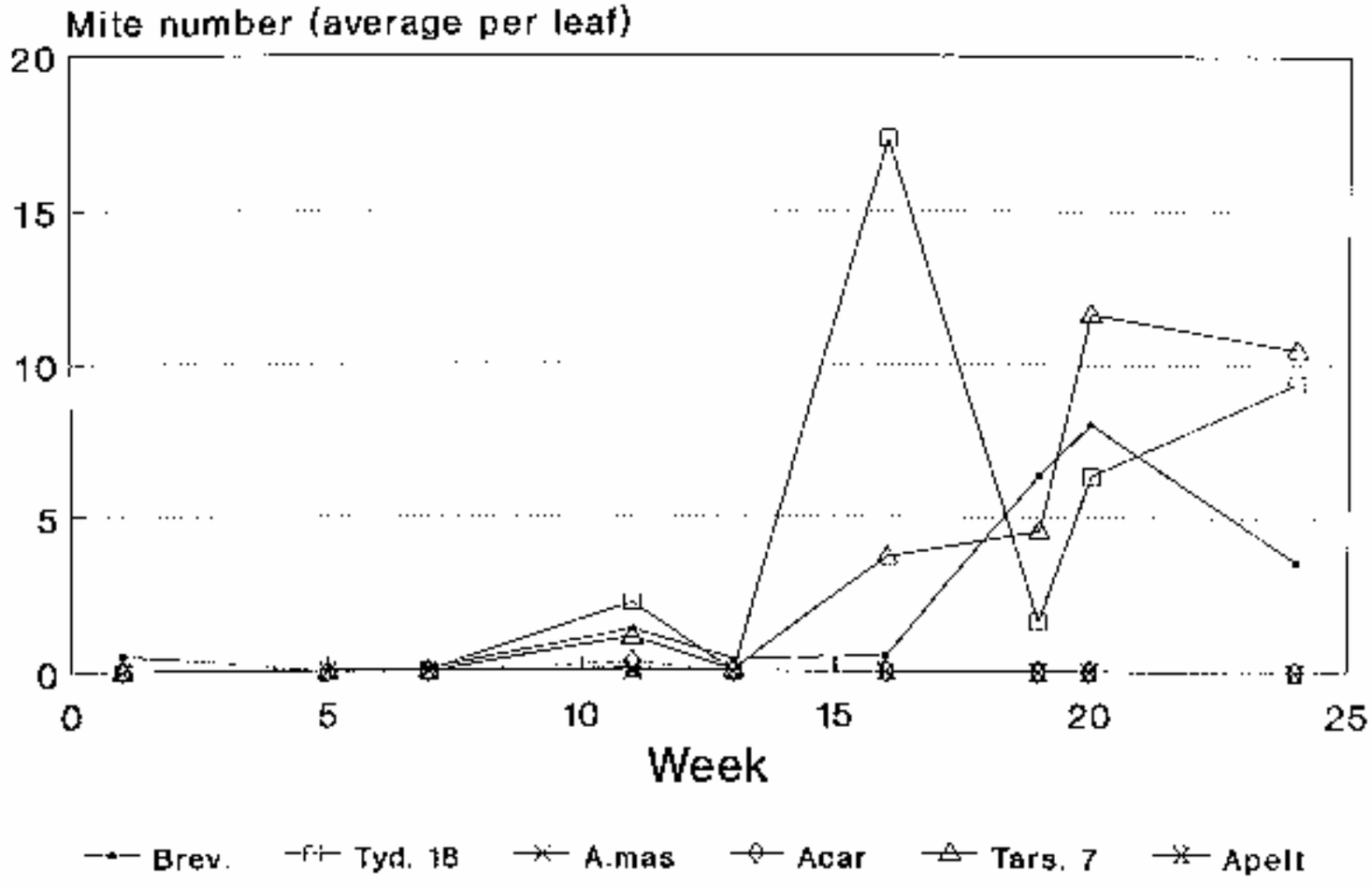
Figure 17: Vineyard B, Block 1b

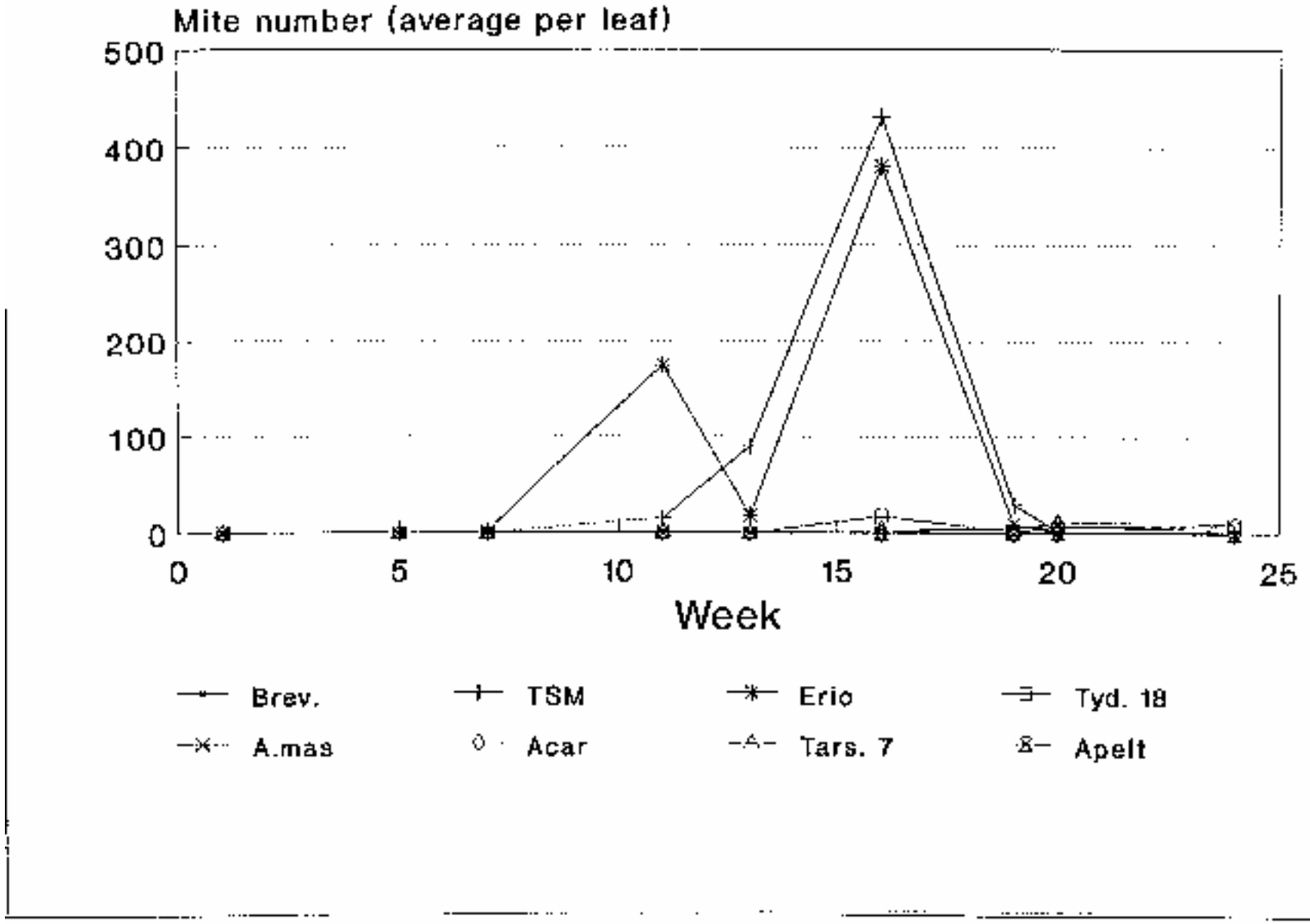
Blocks with the same number represent different scales and to accommodate numbers of species collected in samples.

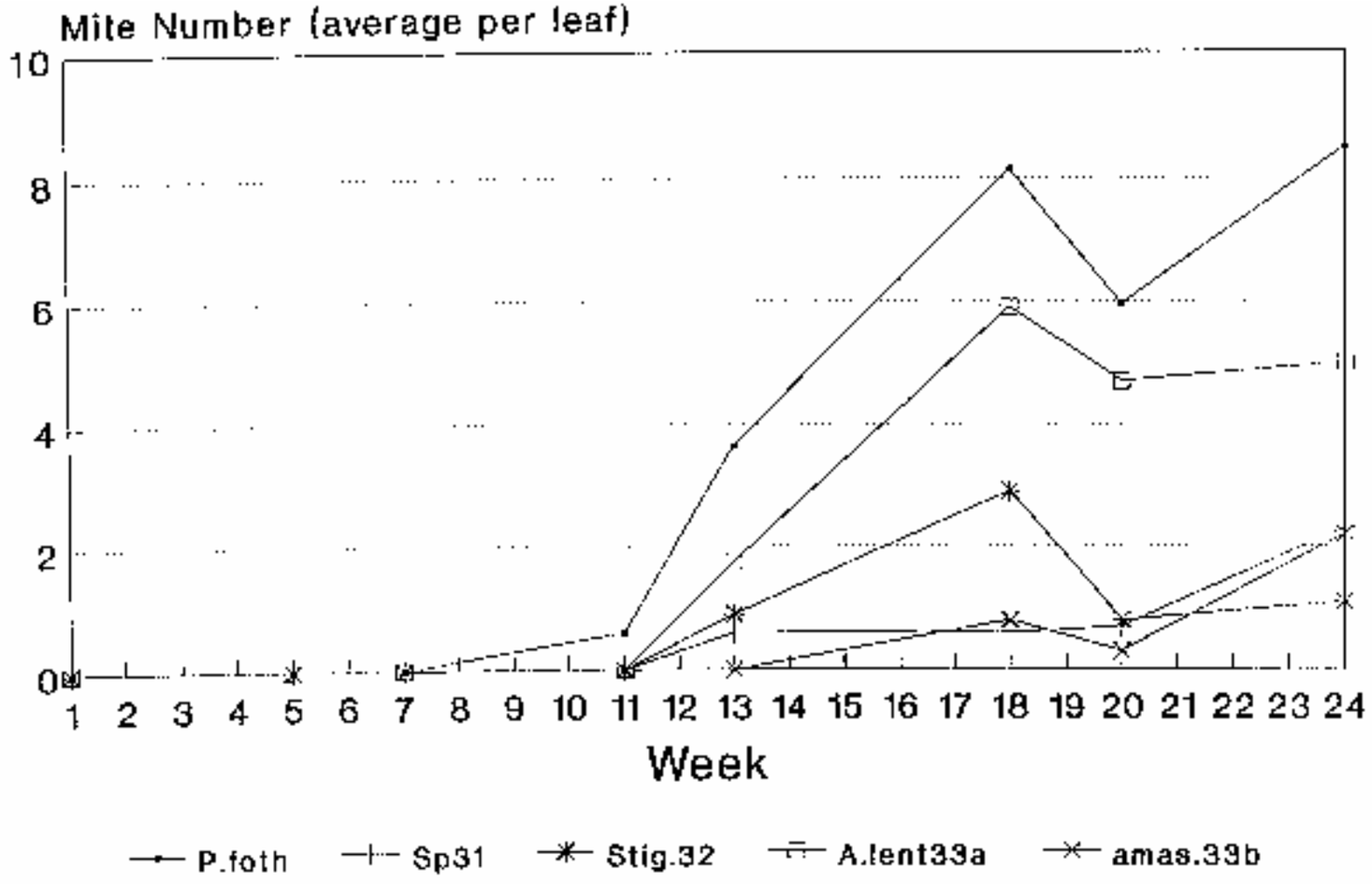

Mite number (average per leaf)
1200
1000
800
600
400
200
0
0
5
10
15
20
25
30
Week
Brev.
TSM
Erio
Tyd. 18
A.mas
Acar
Tars. 7
Apelt

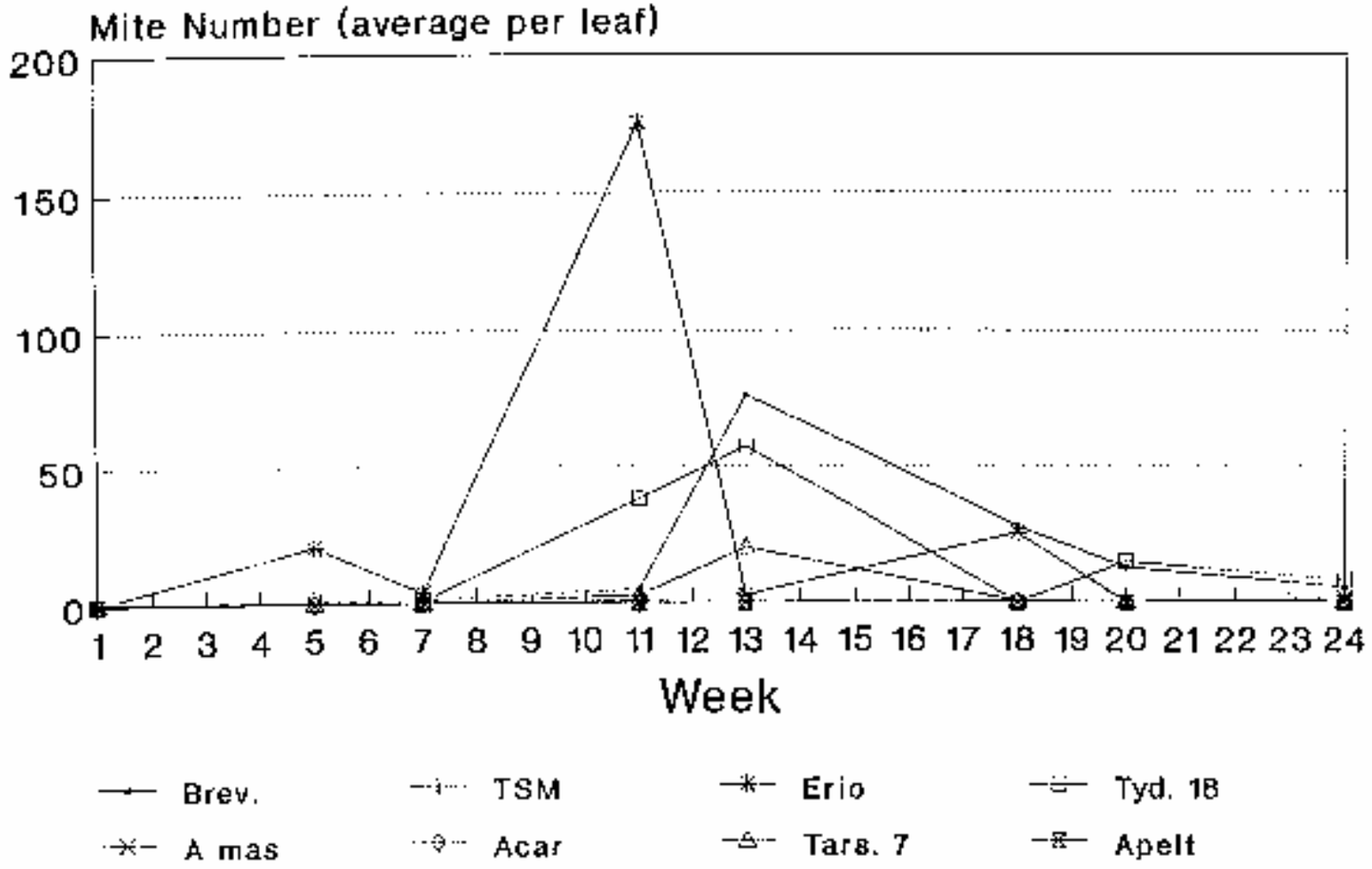

Mite number (average per leaf)
800
600
400
200
0
0
5
10
15
20
25
Week
Brev.
TSM
Erio
Tyd. 18
A.mas
Acar
Tars. 7
Apelt


Mite number (average per leaf)
20
15
10
5
0
0
5
10
15
20
25
Week
P.foth
Sp31
Stig.32
A.lient33a
Amas.33b
P.p


Mite number (average per leaf)
20
15
10
5
0
0
5
10
15
20
25
Week
Brev.
Tyd. 18
A.mas
Acar
Tars. 7
Apelt


Mite number (average per leaf)
500
400
300
200
100
0
0
5
10
15
20
25
Week
Brev.
TSM
Erio
Tyd. 18
A.mas
Acar
Tars. 7
Apelt


Mite Number (average per leaf)
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week
P.foth
Sp31
Stig.32
A.lent33a
amas.33b


Mite Number (average per leaf)
200
150
100
50
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Week
Brev.
TSM
Erio
Tyd. 18
A mas
Acar
Tars. 7
Apelt

Vineyard	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May
Vineyard A Azinphos methyl					A.m. A.p. A.1.	A.m. A.1.	A.m.	A.m.	A.m.
Chlorpyrifos		A.p.		A.p.	A.m.	A.m. A.1.	A.m.	A.m.	A.m.
Unsprayed		A.p.		A.m. A.p.	A.m.	A.m.	A.m. A.p.	A.m. A.1.	A.m. A.1.
Vineyard B					A.p A.1. P.p.	A.m. A.1.	A.1.	A.m. A.1.	A.m. A.1.

Table 27. Occurrence of phytoseiid predatory mite species in Vineyards A and B under varying spraying conditions, 1992-93.

Key: A.m. = *Amblyseius masiaka;* A.p. =*A. peltatus;*
A.I. = *A. lentiginosus* P.f. = *Phytoseius fotheringhamiae*

DISCUSSION:

The lamiine cerambycid borer pest fig longicorn, *A. uastator,* which has a host range of seemingly unrelated plant types has adapted to grapevine and become domiciled as a serious pest problem for grape growers in the lower Hunter Valley. Although it is recorded as occurring in most states of Australia it is currently found attacking grapes only in this region. It is the only cerambycid borer pest recorded infesting grapes in Australia, although another cerambycid, grape borer, *Xylotrechus pyrrhoderus,* is recorded infesting grapes in Japan. Attempts to identify the source of the current infestation failed with no sign of its presence in surrounding native vegetation.

A. vastator was found generally distributed in vineyards and an analysis of data demonstrated no preference for aspect or slope of site or grapevine variety. Annual survey of the infestation since 1988 demonstrated progressive spread of the population with the level increasing up to the introduction of a control strategy in 1991, when it declined over the next two seasons. However, it has since increased and growers have expressed their concern over the perceived inadequacy of the departmental recommendation.

The control strategy was developed following extensive research into the biology and ecology of this species and into chemical control measures. Ecological study showed that this univoltine species was present in the adult stage between October and April with more males than females initially present, but the subsequent increase in females coinciding with a peak in egg-laying in January to March. Eggs hatched within a week and early larval development was rapid with instars I-III taking 4-5 weeks in total. During this time the young larva is in its most exposed position occurring in, and just under, the bark. For the remainder of its larval development it disappears into the heartwood where it cannot be reached by insecticide treatment. It was concluded that this early larval phase represented the best chance for control by contact-acting pesticides.

Various approaches to control were investigated with non-chemical methods such as microwaves, adult sex pheromones and parasitic nematodes proving inadequate as commercial prospects. Currently, control recommendations rely on chemical control measures. Although *A. uastator* is an important pest problem for grape growers in the infested area, it occurs in a small area of NSW and initially proved of little interest to chemical companies as far as developing recommendations from insecticides currently not registered for use in grapes in NSW was concerned. This meant that, in the first instance, they had to be developed from insecticides, which were registered for grapes in NSW.

Chlorpyrifos, azinphos methyl and methidathion were tested in small-scale experiments and extensively in the field in replicated trials and then unreplicated grower demonstration blocks. Significant reductions in field populations of *A. uastator* were achieved in the first replicated trial, but this result was not able to be repeated in the following year. However, the preferred insecticides, azinphos methyl and chlorpyrifos, subsequently produced better control ($P<0.05$) than an untreated block when applied by grower high volume spray equipment. In the following year (1991-92), the effects of this practice were monitored in monthly assessments. Data showed mortality after spraying with both insecticides and the final infestation level was considerably lower than in the previous year. Currently, the NSW Agriculture control strategy relies on chlorpyrifos and azinphos methyl with a preference for the latter. In cage experiments at Gosford HRAS, adult *A. uastator* were exposed to residues of these two insecticides. Chlorpyrifos failed to induce mortality after 17 hours, while azinphos methyl gave control for up to six weeks after vine treatment. In other studies both insecticides were found to kill *A. uastator* when applied directly to adults.

The control strategy thus targets young larvae and not adults, but the residual adult mortality is regarded as a bonus that places azinphos methyl to advantage over chlorpyrifos. Contact adult mortality was not considered important as adults can be protected from sprays by the vine canopy.

To summarise, on the basis of ecological and chemical control studies, the NSW Agriculture control strategy for *A. uastator* targets young larvae inhabiting the barked area of the trunk and arms and does not require growers to spray the canopy. Growers in the Hunter Valley have been provided with this advice in an Agnote , which is issued annually (Appendix 2). Husbandry advice that is considered important in the management of this problem is also included in the Agnote.

Since the introduction of the control recommendations, growers have expressed some reservations about the frequent application of organophosphate insecticide against *A. uastator*. There was concern over the impact of such residues on wine sales particularly in wine destined for export, and also, on populations of the naturally-occurring beneficial mite fauna. The latter concern arose from the emergence of two spotted mite *T. urticae* as a pest problem in grapes in the Pokolbin area. This pest mite had not previously been recorded as an economic problem in Hunter Valley Vineyards.

A substantial decline in the *A. uastator* infestation level as measured in an annual survey conducted since 1988, resulted, following the introduction of the control recommendation. Mean district population levels of 46.4, 35.6, 39. 7% recorded between 1988-1990 inclusive respectively, fell to 7.7% and 5.8% in 1991 and 1992 respectively. Although outside the term of this funding period, this level increased to near 20% in 1993 causing concern among growers about the adequacy of the advice and claims that the reductions above may not have been due to the recommendation introduced in 1991.

It is believed there is a rational explanation to the fluctuation in infestation level between 1992 and 1993 and that inadequate advice was not the contributory factor. The decline in 1991 and 1992 produced an infestation level that growers were comfortable with and could accept. Further, protracted heavy rain in 1993 around vintage, produced a cessation in ovipositional activity and a resumption thereafter. This was reflected in the larval population, normally in the VII instar during winter, being divided in age with 0.3 attaining this stage of development, but 0.67 only attaining III-IV instar.

This led to a situation in the 1992/93 season where, for some or all of the reasons given above, some growers considered restricting spraying against *A. vastator* to post postharvest applications, while many adopted practices such as spraying every second row and only down one side of a row. This, I believe, caused the flare-up in the infestation level and not so much the inadequacy of the control advice. Notwithstanding that, although outside of this report, It should be noted that action has been taken to address this concern. The Hunter Valley Vineyard Association has provided financial support to investigate alternative insecticides that may not be currently registered in grapes in NSW, for use against *A. vastator*.

The issue of control has always been paramount in this research and development program, and while many avenues have been investigated, currently there are no alternatives beyond intensive spraying with organophosphate insecticides. Unfortunately this has been implicated by association, and not by experimental evidence, with the above mentioned outbreak of *T. urticae* on some properties. Prior to the current usage of organophosphate insecticides against *A. vastator, T. urticae* was not known in these vineyards. Organophosphates are known to cause outbreaks of *T. urticae* through disruption to naturally occurring beneficial insect and mite fauna. It was therefore not unreasonable to associate the two together. A mite sampling program conducted between 1991-1993 monitored several vineyards in Pokolbin, Dalwood and in the Upper Hunter with varying chemical control programs for *A. vastator* and other pests and diseases, for some explanation of this recent occurrence. Five species of phytoseiid predatory mites, *Phytoseiulus persimilis, Phytoseius. fotheringhamiae, A. masiaka, A. peltatus* and *A. lentiginosus* were recorded. These species were prevalent during the period following the withdrawal of pesticide usage during vintage. Data did not specifically Implicate the organophosphates in a reduction m phytoseiid population, rather it seemed circumstantially that other pesticides may also be involved. To better understand this relationship will require specific investigation of the responses of the phytoseiid species to individual chemicals used for pest and disease control in grapes in this area.

IMPLICATIONS AND RECOMMENDATIONS:

Fig longicorn A. *vastator* is a serious pest of grapevines in the Hunter Valley. Although currently affecting approximately 300 ha of grapes it poses a threat. To the long-term prospects for this area. Certain national companies with vineyard ownership in this area are known not to be prepared to further invest in vineyard development until this problem is satisfactorily resolved. Research to date has developed a management strategy, which is regarded as effective against *A. vastator,* but difficulties continue to be experienced. Possible reasons for this have been discussed in the report. Further work is being conducted to investigate possible improved chemical control advice. Attempts to develop a biological control strategy were unsuccessful in their search for funds. The use of parasitic nematodes as a biocontrol approach was also unsuccessful. For the foreseeable future it would appear that insecticides will have to be relied upon to achieve reductions in infestation levels.

ACKNOWLEDGEMENTS:

Merrilee Pettit, Technical Officer (Scientific), Gosford HRAS, is sincerely thanked for her countless hours of demanding field work undertaken without complaint. Tony Wellham, Technical Officer (Scientific), Gosford HRAS, is also thanked for his assistance with the project in the field and in the laboratory. Lorraine Spohr, Technical Officer (Biometrics), Gosford HRAS, is thanked for her biometrical assistance. The Grape & Wine Research & Development Corporation and the Hunter Valley Vineyard Association are thanked for their financial support of this project.

Appendix 1.

Reprints of publications on *Acalolepta vastator* produced from research conducted in this project (DAN5).

Goodwin, S. Pettit, M.A. and Spohr, L.J. 1994. *Acalolepta vastator* (Newman) (Coleoptera: Cerambycidae) infesting grapevines in the Hunter Valley, New South Wales. 1. Distribution and dispersion. J. Aust. ent. Soc. 33: 385-390.

Goodwin, S. and Pettit, M.A. 1994. *Acalolepta vastator* (Newman) (Coleoptera: Cerambycidae) infesting grapevines in the Hunter Valley, New South Wales. 2. Biology and ecology. J. Aust. ent. Soc. 33: 391-397 *Acalolepta vastator* (Newman)

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