Acalolepta vastator (Newman) (Coleoptera: Cerambycidae) Infesting Grapevines in the Hunter Valley, New South Wales 1. Distribution and Dispersion

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ABSTRACT An outbreak of fig longicorn, *Acalolepta vastator*, currently causing economic damage to grapevines in the Hunter Valley, New South Wales is reviewed. Annual surveys showed populations infesting up to 70% of vines in some vineyards with mean annual percentage of vines infested within the outbreak ranging from 35.6-46.4% between 1988-1990. In 1991 the population fell to 7.7% of vines infested and further declined to 5.8% in 1992. We postulate that a newly introduced control strategy was the main contributing factor. Dispersion of *A. vastator* occurred up to 150 m in a single year by flight and by walking, with the latter the preferred option as a means of dispersal in this habitat. Dispersal was along vine rows rather than randomly, in the vineyards. *A. vastator* showed no preference for particular vine varieties or site aspect, although significantly greater numbers were recorded in steeply sloped sites than in level sites.

Introduction

Borers are chronically damaging pests with few effective control programs available to reduce economic losses (Nielsen 1981). In most areas where grapes are grown, various endemic cerambycids will attack the vines (Linsley 1959). In the Lower Hunter Valley, New South Wales (NSW), an outbreak of a lamiine cerambycid, fig longicorn (*Acalolepta vastator* (Newman)), is causing serious damage to vineyards. The Hunter Valley is a nationally important wine producing region with around 20,000 t of high value wine grapes produced annually and threats to the economic viability of its vineyards are viewed with concern. Fig longicorn is not new to the vineyards of this area with the NSW Government Entomologist recording infestations in grapevines in the 1910s (Froggatt 1919b) and long-time inhabitants and grape-growers recording outbreaks periodically since then (M. Tyrrell pers. comm.). The current infestation has been known in this area since 1985, although grape-growers consider the outbreak to have commenced 2-3 years earlier during a drought.

Fig longicorn is recorded from mainland Australia (New South Wales, Queensland, South Australia, Victoria), Kangaroo Island, Lord Howe Island, the Philippines, Samoa (Duffy 1963); Sri Lanka, India, Malay Archipelago (Froggatt 1919a), and it has an unusual range of host plants in different families including *Araucaria* sp., *Cymbidium* sp., *Pinus halepensis*, *P. radiata*, *Agathis robusta*, *Flindersia australis*, *Laportea gigas*, *Maba fasciculosa*, *Cassinia aculeata*, *Helichrysum ferrugineum*, *Cedrela australis*, *Ficus* spp., *Passiflora* spp., and *Wistaria* sp. (see Duffy 1963, Froggatt 1930). To date however, there has been little information obtained on the phenology of economically damaging populations. The current outbreak of *A. vastator* is the subject of an extensive research program and this paper reports on its distribution in the Hunter region and dispersal within the infested vineyards.

Materials and methods

Survey. At the commencement of the study in 1988, the regional distribution of the current *A. vastator* outbreak was established by contacting growers of vines followed by an entry and inspection survey. All growers in the region were asked to identify the presence or absence of the borer on their properties. Those properties positively identifying borer infestion were then visited and inspected to verify the accuracy of the grower's opinion, and properties on the periphery of the apparent infestation area were also inspected to determine the extent of the outbreak. Infested vineyards were located in the Pokolbin area adjacent to the Brokenback Range.

The level of infestation in a vineyard was determined by visual inspection of each infested block of grapevines. A random selection of 10% of the vines in each block, up to a maximum of 100 vines for large blocks, was made. Each selected vine was examined for the external sign of larval *A. vastator* infestation, which is the presence of fresh frass or sawdust extruded from the bored tunnels out through cracks in, or damage to the vine's trunk, or other weaknesses in the wall and which often collects at the base of the vine. This procedure is known as frass indexing. Per cent infestation was recorded for each varietal block of vines. The reliability of frass indexing was determined by a comparison between 30 infested and 30 uninfested vines as determined by visual inspection. Each vine was then destructively sampled and the trunk and arms carefully split to determine the presence or absence of live grubs. This showed conclusively that frass indexing was a reliable method for assessing *A.*

vastator infestation of vines in the field (Table 1). Frass indexing was used from 1988 to 1992 to assess abundance and distribution of the outbreak, and to determine the longicorn's dispersal within and between vineyards. Newly reported areas of infestation were similarly assessed.

Table 1. Relationship between frass indexing and infestation level of *A. vastator* in grapevines.

	Frass Indexed vines	
	Infested	Uninfested
No. containing grubs	29	0
No. empty	1	30

Throughout the outbreak area, per cent infestation was recorded for eight varieties separately with varying numbers of blocks per variety. Slope and aspect of each block were also recorded. These data were used to assess the influence of terrain and grape variety on rate of infestation using generalised least squares analysis and Student-Newman-Keuls (SNK) treatment comparison technique.

Rainfall records for Pokolbin for the period 1968-1991 were obtained in an effort to provide an explanation for the reputed commencement of the outbreak of *A. vastator.*

A study was conducted in native vegetation adjacent to the infested vineyards to determine the possible source of infestation. This survey consisted of three 20 m transects, 2 m wide, conducted at each of two locations adjacent to infested vineyards. Observations were made of the shrubs and trees within each transect and each resident plant was inspected for borer activity. Borers collected as either larvae or adults were identified as closely as possible.

Within vineyard distribution. The distribution and spread of *A. vastator* in a newly infested vineyard was studied in an area of grapevines comprising seven blocks of different varieties of vines in 1989 and 1990. The vineyard area totalled 2.6 ha, while the overall area including headlands examined, was about 3 ha. Blocks A, C and F contained 22 rows aligned east-west and were 66 m long, blocks B, D and E, similarly aligned, comprised 40 rows and were 120 m long, while block G was oriented at 90° to these and contained approximately 30 vines per row running north-south and was 36 m long. Sampling was conducted by randomly selecting a number of rows in each block, or vines in each row in the case of block G, and recording the rate of infestation in each row by frass indexing. In this way annual population movement could be monitored to determine, from the extent and direction of spread as indicated by this method, whether flight might be a major factor in dispersion of *A. vastator* in this habitat.

Results

Survey. Annual surveys by frass indexing showed that the outbreak area increased slightly from 6.4 km^2 in 1988 to 7.1 km^2 in 1989, but then expanded to a maximum of 32.7 km^2 in 1990 including all the reported new infestations which were investigated in that year. However in 1991, although the outbreak area remained the same as in 1990, the population suffered a sharp decline (Table 2). Rainfall data for Pokolbin for the October to March period for each year from 1968 to 1991 (Table 3) show dry periods in 3 out of 4 years between 1979 and 1983, with the driest period occurring in 1990/91.

Table 2. Levels of infestation of grapevines by *A. vastator* in the Hunter Valley 1988-1992.

Vineyard	Number of blocks	Mean percentage infestation of grapevines				
		1988	1989	1990	1991	1992
A	30	45.7	33.6	29.9	3.6	6.7
B	17	68.8	60.0	45.8	3.1	1.7
C	16	42.9	46.2	45.9	10.1	8.0
D	7	28.2	32.1	30.2	8.8	6.1
E	9	—	15.1	45.1	16.3	8.4
F	6	—	26.4	41.5	4.3	4.1
Mean		46.4	35.6	39.7	7.7	5.8

Table 3. Total rainfall (mm) for the adult activity period (Oct.-March) of *A. vastator* infesting grapevines recorded at Pokolbin 1968-1991.

Year	Rainfall (mm)	Year	Rainfall (mm)
1968/69	295	1980/81	307
1969/70	446	1981/82	739
1970/71	725	1982/83	262
1971/72	314	1983/84	653
1972/73	567	1984/85	449
1973/74	706	1985/86	457
1974/75	420	1986/87	367
1975/76	654	1987/88	551
1976/77	643	1988/89	435
1977/78	548	1989/90	526
1978/79	450	1990/91	163
1979/80	285		

The levels of infestation of vines on the six main properties within the outbreak area between 1988-1992 are given in Table 2. Percentage infestation varied between vineyards from year to year. Of the four properties surveyed in 1988, infestation ranged from 28.2% to 68.8%. The survey was extended to include a further two properties from 1989 and because these were more lightly infested the mean annual infestation level fell to 35.6%, although levels in the original four sites fluctuated around 40% from 1988 to 1990. In 1990 a dramatic population increase in vineyards E and F resulted in an increase in the mean annual infestation level to 39.7%. Throughout this study only one property showed a consistent downward trend in the population, although all properties experienced a substantial decline in 1991. A further general decline was recorded in 1992. During the survey period mean vineyard infestation levels reached nearly 70% of grapevines in one property, while the mean annual infestation level for the entire area was 46.4% (1988), 35.6% (1989), 39.7% (1990), 7.7% (1991) and 5.8% (1992).

The influence of grapevine variety on the level of infestation is given in Table 4. Analysis showed that there was no significant difference ($P > 0.05$) in the level of infestation between varieties within the same year. Subjectively though, some varieties represented by more than two blocks such as Cabernet Sauvignon (1988 and 1989) and Shiraz and Trebbiano (1988, 1989 and 1990), consistently appeared to be more heavily infested than other varieties like Chardonnay and Semillon.

The influence of terrain on the rate of infestation is given in Tables 5 and 6. Less than one quarter of the blocks were level with nearly two-thirds of the sloped blocks being moderately steep to very steep. The degree of infestation followed a similar pattern from year to year and vines grown on very steep slopes were significantly more infested than those grown on level ground ($P < 0.05$) in 1988 and 1989 (Table 5). However, aspect did not have any statistically significant influence on level of infestation ($P > 0.05$) (Table 6).

Flora and insect borer data from the native vegetation survey are given in Table 7. Twelve woody stemmed species were recorded along the

Table 4. Influence of variety on rate of infestation of grapevines by *A. vastator* in the Hunter Valley 1988-90.

Variety	Mean percentage infestation of grapevines (Number of blocks shown in brackets)		
	1988	1989	1990
Cabernet Sauvignon	62.83 (4)	48.63 (4)	29.43 (4)
Chardonnay	43.08 (4)	25.88 (5)	32.16 (5)
Merlot	—	17.50 (1)	24.50 (2)
Pinot Noir	31.50 (1)	20.04 (1)	26.02 (5)
Semillon	46.37(17)	31.68(24)	36.55(28)
Shiraz	52.95(23)	49.83(29)	43.65(33)
Traminer	60.00 (1)	36.75 (2)	29.60 (2)
Trebbiano	84.70 (1)	48.48 (4)	53.33 (4)

% infestation on different varieties was not significantly different ($P = 0.05$).

Table 5. Influence of slope of vineyard site on rate of infestation of grapevines by *A. vastator* in the Hunter Valley 1988-90.

Slope	Mean percentage infestation of grapevines (Number of blocks shown in brackets)		
	1988	1989	1990
Very steep	68.81 (8)^{a}	57.70 (8)^{a}	44.08 (9)^{a}
Mod. steep	51.45(26)^{ab}	39.02(37)^{ab}	35.92(38)^{a}
Gentle	55.44 (7)^{ab}	47.59(11)^{ab}	40.91(16)^{a}
Level	32.83(11)^{b}	26.98(18)^{b}	38.89(20)^{a}

Influence of slope in the same year followed by the same letter are not significantly different ($P = 0.05$).

Table 6. Influence of aspect of vineyard site on rate of infestation of grapevines by *A. vastator* in the Hunter Valley 1988-90.

Aspect	Mean percentage infestation of grapevines (Number of blocks shown in brackets)		
	1988	1989	1990
North	39.75 (8)	42.29(16)	35.65(21)
South	44.40 (5)	40.05 (6)	40.20 (6)
East	54.44 (8)	37.60 (8)	33.83 (8)
West	69.80 (3)	42.92 (6)	37.28 (8)
North-West	68.05(11)	46.90(14)	39.39(14)
North-East	64.43 (3)	57.50 (3)	52.13 (2)
South-West	41.60 (1)	41.70 (1)	14.60 (1)
South-East	53.95 (2)	41.35 (2)	67.65 (2)
Level	32.83(11)	26.98(18)	38.89(20)

Influence of aspect in the same year was not significantly different ($P = 0.05$).

Table 7. Results of survey of insect borers infesting native vegetation adjacent to vineyards infested by *A. vastator*.

Plant species	Number of times recorded	Number of plants with insect borers
Acacia lanigera	1	0
A. mearnsii	9	6
Breynia oblongifolia	6	0
Bursaria spinosa	13	1
Cassinia sp.	6	0
Casuarina torulosa	1	0
Cypress sp.	1	0
Eucalyptus moluccana	11	1
E. saligna	31	3
Exocarpus cupressiformis	1	0
Macrozamia sp.	1	0
Pultenaea cunninghamii	15	2
Total	96	13

Table 8. Population changes in *A. vastator* in a newly infested vineyard over a 2-year period.

Block	Variety	No. Rows	Length of row (m)	Approx. area (m^2)	Mean percentage infestation of grapevines			
					1989		1990	
					% Infested vines of infested areas	% Area infested	% Infested vines of infested areas	% Area infested
A	Merlot	25	36	2700	17.5	100	40.6	100
B	Semillon	60	36	6480	12.7	20	17.7	100
C	Trebbiano	25	36	2700	73.3	100	79.2	100
D	Shiraz	60	36	6480	0	0	21.6	100
E	Trebbiano	60	36	6480	30.8	20	31.0	70
F	Shiraz	30	15	450	5.3	20	20.8	100
G	Shiraz	15	48	720	0	0	8.5	100

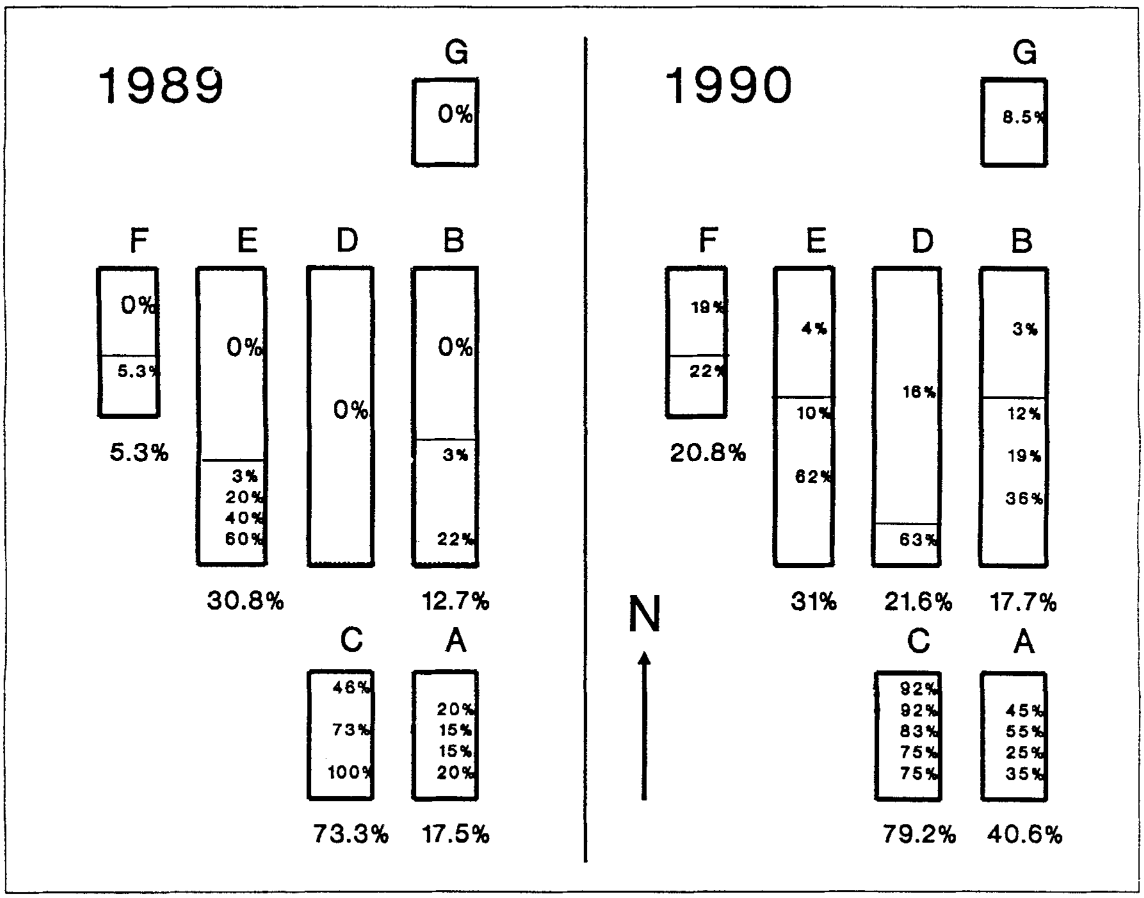

Fig. 1. Dispersive capacity of *A. vastator* in a newly infested vineyard in the Hunter Valley 1989-90.

line transect. The 240 m^2 of surveyed land was lightly wooded with 96 woody stemmed plants. Only 13 of these plants comprising five species contained insect borers, including *Bostrychopsis jesuita* (F.) (Bostrychidae), *Platyomopsis* sp. (Cerambycidae) and *Melobasis* sp. (Buprestidae). However, *A. vastator* was not recorded in any of the native plant species.

Within vineyard distribution. The distribution of *A. vastator* larvae in a vineyard in consecutive years is shown in Fig. 1. Infestation levels from 1-2 rows are given for some lightly infested blocks (1989—B, F; 1990—D, E, F) and for some of the smaller blocks (G). In other blocks (1989—A, C, E; 1990—A, B, C, E), a greater number of row samples were taken from the infested area. The edge of the infestation is marked in each block with a horizontal line. The data suggest that the infestation entered the area from the south and gradually dispersed across rows in a northerly direction. Mean infestation levels increased in the smaller blocks A and C, but while the mean infestation level more than doubled from 17.5 to 40.6% in block A from 1989-90, there was no similar marked increase in block C which by 1989 already had 73.3% of vines infested. However, there was considerable increase in infestation level at the northern end of block C where a greater number of samples were taken. The outbreak of *A. vastator* dispersed by approximately 150 m northward during the 1990/91 season (Fig. 1).

The mean percentage of vines infested and percentage area infested for each block in 1989 and 1990 in a newly infested vineyard are given in Table 8. Mean annual percentage infestation over the entire area increased from 10.6% from 12.2% in 1989 to 22.8% in 1990. Dispersion of the infestation expanded from 37% to 96% of the area by 1990 and there were no uninfested blocks.

Discussion

There is no certain explanation for the appearance and spread of the current outbreak of *A. vastator* other than the generally held view that vines stressed under drought conditions are more susceptible to attack and the prolonged period of drought between 1979-1983 could be used to explain the reputed start of this outbreak. However, the origin of this pest outbreak is unknown, as the longicorn was not found in native woody stemmed vegetation in an area adjacent to the infested vineyards. This concurs with earlier observations by Froggatt (1919b) who also found no trees in the same area that could have provided a source of this species. The common name, fig longicorn, suggests that the pest was initially discovered infesting figs. In the Hunter Valley, native *Ficus* spp. are not present in the surrounding districts, while cultivated figs are found only on a few properties and they have not always been infested by this pest. It is unlikely that the survival and source of this pest is correlated with the occurrence of figs in the area.

Since the outbreak was first recognised in 1986 as an economic problem in Hunter Valley vineyards, distribution and percentage infestation of *A. vastator* has continued to steadily increase until control recommendations were introduced in 1990/91. These involved spraying chlorpyrifos, methidathion or azinphos methyl onto vine trunks and arms during the period of adult activity and oviposition. The strategy targeted the young larvae, present in exposed positions on and in the bark during the first three instars, and prior to their entry into the heartwood as IV instars, where they are inaccessible to contact sprays.

During 1988-91, larval populations infested up to 70% of vines in some vineyards, with mean percentage of vines infested annually over the outbreak area peaking at 46.4% in 1988. This greatly exceeds the early report of 10% infestation levels which, even at that level, were considered to have caused serious damage to grapevines in this region (Froggatt 1919b), and this is an indication of the important economic problems created by the current high levels of this pest for growers. Although grower reports indicate that earlier outbreaks had been self-regulating, previous reductions in pest levels were more likely to have been due to the use of organochlorine insecticides as a trunk treatment and other cultural practices, rather than by natural causes.

Available evidence from laboratory and field experiments during this study (Goodwin, unpublished data) suggest that flight may not be an essential mode of dispersal for adult *A. vastator*. This also appeared to be the case from the slow spread of the population shown in the annual surveys and in the slow movement across rows in the study conducted in 1989 and 1990. A stronger tendency of ovipositing females to fly rather than to walk would have produced a more random and extensive pattern in the latter study. Observations in this study indicated considerable movement along rows, supporting the hypothesis that females of this species prefer to walk. Adult *A. vastator* were observed to walk along arms of vines and from vine to vine and only initiated flight from shoot tips, flying only to the nearest vine. Sustained flight has not been observed in *A. vastator*. Laboratory studies conducted on *A. vastator* further indicated a reluctance to fly for both sexes (Goodwin unpublished data). Males were placed 1-2 m from females, a distance previously found to induce flight in males of another cerambycid *Xylotrechus chinensis* Chevrolat (Iwabuchi *et al.* 1987), but even this failed to stimulate flight of male *A. vastator*. Other lamiine species have also shown a preference for walking (Banerjee and Nath 1971; Yamane 1981; Akutsu and Kuboki 1983). For instance, Yamane (1981) observed that adult *Monochamus* *alternatus* Hope had a strong tendency to walk upwards and onwards to shoot tips whereupon flight occurred downwind to the nearest object in the flight path. For the majority of cerambycids flight has been characterised as slow, quiet and direct (Linsley 1959), and for many lamiine species, flight may be complementary to a preference for walking, as was inferred from this study. Thus it is possible that *A. vastator* was pre-adapted to hosts cultivated in trellised rows where dispersal, mating behaviour and oviposition can occur without the necessity to take flight. However, until the native source hosts of this species in the Hunter Valley are discovered this cannot be confirmed.

During this study, in 1990 and 1991 the survey isolated outbreaks on small numbers of infested vines at Dalwood, up to 30 km from the main area of infestation, in a vineyard not previously infested by *A. vastator*. Our experience suggests that this was unlikely to have been achieved by flight as in this outbreak the longicorn infested blocks of vines were where a mechanical harvester was first used after it had worked on another infested block. Possibly the spread of the infestation to this new area may have been due to the use of harvesters in this grape growing area, given that the period of grape harvest coincides with the peak of adult activity when the cerambycids could be readily swept up into the harvesters.

Although chemical feeding stimulants are involved in other cerambycids attacking other plants, e.g. *Pinus* (Dyer and Seabrook 1978; Yamane 1981), the unrelated host range in *A. vastator* indicates that this is unlikely to be the factor explaining the infestation of vines.

Detailed assessment of the distribution of *A. vastator* showed that local factors of terrain, aspect and grape varieties had little or no effect on its dispersal throughout the area or within a vineyard. However, very steep slopes were found to be more infested than level sites. Although drought may initiate infestation of grape vines by *A. vastator*, this outbreak has progressively increased to a high level of infestation without any apparent preference for particular vines or sites that could satisfactorily explain this phenomenon. Within the area of distribution, dispersal does not appear to respond to any obvious environmental stimulus. In, and perhaps between vineyards, dispersal could depend more on mechanical means such as harvesting equipment. This may explain why the pest is not widely distributed in vineyards.

Acknowledgments

We thank Tony Wellham for technical assistance. The Hunter Valley Vineyard Association and the Grape and Wine Research and Development Corporation (previously G&W Research Council) are gratefully acknowledged for providing financial assistance. Drs Alan Clift and Victor Rajakulendran are thanked for critically reviewing the manuscript.

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(Accepted 4 July 1994)