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Barley Yellow Dwarf Virus Infectivity of Cereal Aphids Trapped at two Sites in Victoria

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Abstract

Alate cereal aphids, *Rhopalosiphum padi*, *R. maidis* and *Macrosiphum miscanthi avenae*, caught in suction traps at Horsham and Burnley for two successive years (1977–78), were tested individually for infectivity with barley yellow dwarf virus (BYDV). *R. padi* was most numerous, making up 73·1–98·7% of the total number of cereal aphids trapped at either site in either year. 22·6–61·3% of *R. padi* caught were infective, with a larger proportion infective at Horsham than at Burnley in both years. 9·4·43–5% of *M. miscanthi avenae* were infective, but there was little difference in the proportion infective between sites. *R. maidis* were trapped only at Burnley, and only in 1978 were they infective, when 7·8% transmitted BYDV to test plants.

Seasonal variation in the catches of *R. padi* differed at the two sites. At Horsham most aphids were trapped from August to October, whereas at Burnley most were caught from March to November.

Introduction

Barley yellow dwarf virus (BYDV) occurs sporadically in cereal crops in Victoria, the incidence usually being greater in the south than in the north of the state (Price 1970). These differences in incidence of BYDV have been attributed to differences in the activity and infectivity of *Rhopalosiphum padi*, the principal vector of the virus in Victoria (Anon. 1969; Price 1970; Anon. 1971; P. R. Smith unpubl. data). However, it is also possible that the larger area of perennial grasses in southern Victoria provides a bigger reservoir of infection for cereal crops growing nearby.

The work described in this paper investigated the first of these possibilities: the importance of flights of infective cereal aphids at different times.

Materials and Methods

Live, alate cereal aphids were caught in suction traps in 1977 and 1978 at two localities in Victoria, at Burnley near Melbourne, and at Horsham, 300 km north-west of Melbourne in the Wimmera.

Each suction trap was constructed by using an exhaust fan with a 400 mm propeller (Model D, HD16, Lawrence & Hansen, Melbourne), mounted horizontally 1 m above ground in a 1 m^3 framework made of 3 by 3 cm square plastic tubing, 'Cubeline', (Filtrite Industries, Melbourne). The fan speed was 1260 rev min^{-1} and air flow in free air 185 000 l min^{-1}. The fan drew air into a cone made of 30 by 30 mesh stainless steel, 0·56 m in diameter at the top, narrowing to 0·1 m at the base. Aphids were collected in a 1 l. plastic jar, lined with muslin to minimize their desiccation, fixed to the bottom of the cone; the muslin also aided the emptying and sorting of the catch. A modification was to catch aphids only in a muslin bag fitted to the cone with elastic bands. This prevented aphids from drowning, which sometimes occurred in heavy rain when a jar was used. The traps were emptied twice daily (around 8 a.m. and 4 p.m.), except at weekends. Alate aphids were placed individually in stoppered glass vials (1·3 by 5 cm), and examined under a dissecting microscope. Those identified as *R. padi*, *R. maidis* or *Macrosiphum miscanthi avenae* were placed singly on individual oat seedlings, cv. Algeribee, and allowed to feed for a minimum of 2 days. At the end of the test feeding period aphid survival and reproduction were recorded as a measure of their ability to invade and colonize field crops. The oat test plants were kept for 4–6 weeks to allow symptoms of BYDV to develop.

The trap catches were monitored during the cereal-growing season, from March to December at Burnley and April to December at Horsham. Trapping stopped when hot, dry weather prevented aphid flight.

In 1978, single plots (6 m by 10 m) of oats, cv. Algerian, and wheat, cv. Olympic, were sown adjacent to the suction traps. These plots were sown on 20 March, 20 April, 20 June and 1 August at Burnley, and on 21 March and 19 April at Horsham. The incidence of BYDV and alate cereal aphids in these plots was recorded regularly.

Table 1. The number of cereal aphids and the proportion carrying BYDV at Burnley and Horsham in 1977 and 1978

Locality	Year	*R. padi* Number caught	*R. padi* % infective	*R. maidis* Number caught	*R. maidis* % infective	*M. miscanthi avenae* Number caught	*M. miscanthi avenae* % infective
Burnley	1977	163	31·8[A]	12	0	48	20·0
Horsham	1977	368	61·3[B]	0	—	5	40·0
Burnley	1978	833	22·6[C]	38	7·8	138	9·4
Horsham	1978	560	48·2[D]	0	—	115	43·5

[A] First *R. padi* and first infective *R. padi* caught on 22 May and 23 May, respectively.
[B] Dates 22 June and 28 August, respectively.
[C] Dates 13 March and 7 May, respectively.
[D] Dates 3 April and 5 June, respectively.

Results

The numbers of cereal aphids trapped at the two sites and the proportions carrying BYDV in each year are given in Table 1. *R. padi* was always the most numerous species, comprising 73·1–98·7% of the total caught at either site in either year. *M. miscanthi avenae* was caught more frequently at Burnley (13·7–21·5%) than at Horsham (1·3–17·1%). *R. maidis* was trapped only at Burnley (3·8–5·4%).

R. padi was always the species with the largest proportion infective (22·6–61·3%), and a larger proportion of those caught at Horsham were infective than of those caught at Burnley. *M. miscanthi avenae* was the next most commonly infective species (9·4–43·5%), although few were caught at Horsham in 1977. *R. maidis* was infective only in 1978 (7·8%).

The weekly catches of *R. padi* and the numbers that transmitted BYDV are shown in Figs 1*a,d.* In both years alate aphids were most active at Horsham in spring, from late August to October (Figs 1*a*, *c*), whereas at Burnley alatae were active for most of the growing season (Figs 1*b*, *d*).

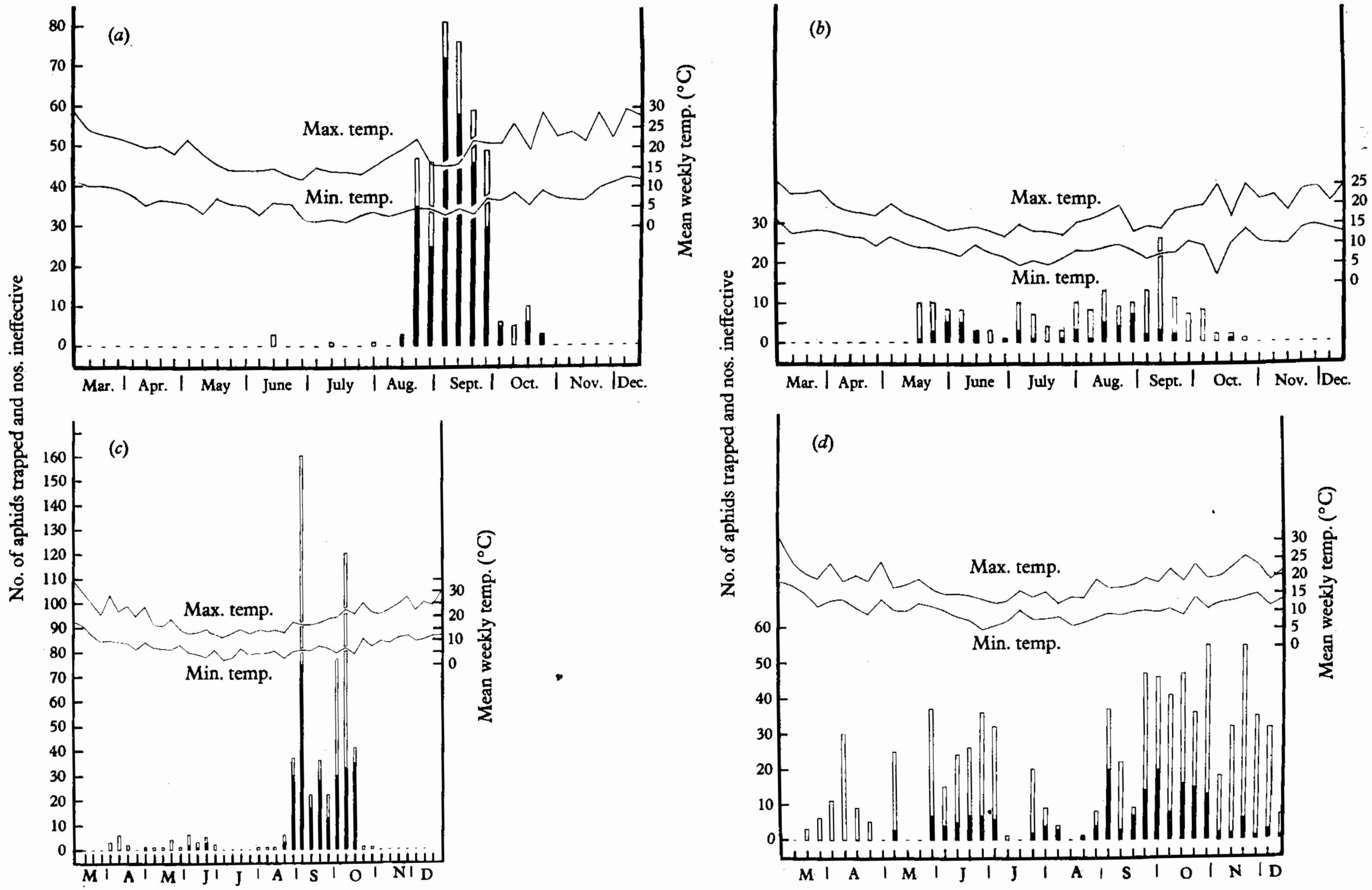

Fig. 1. Total weekly catches of *Rhopalosiphum padi* (open histogram) and the number infective with BYDV (shaded histogram), and the mean weekly maximum and minimum temperatures. (*a*) Horsham 1977. (*b*) Burnley 1977. (*c*) Horsham 1978. (*d*) Burnley 1978.

Table 2. BYDV incidence and alate aphids detected in wheat and oat plots sown adjacent to aphid suction traps at Burnley in 1978

Sowing date	Date of assessment	Aphid species	Aphids detected per metre of row Oats	Wheat	BYDV in oats (%)
20 March	26 May	*R. padi*	14·4	2·4	27·7
		M. miscanthi avenae	3·7	1·5	
		R. maidis	0·5	2·4	
20 April	12 June	*R. padi*	1·0	4·9	1·8
		M. miscanthi avenae	4·1	1·4	
		R. maidis	0·1	2·6	
20 June	1 August	*R. padi*	0·9	1·2	35·4
		M. miscanthi avenae	0·1	0·6	
		R. maidis	0·1	0·1	
1 August	24 October	*R. padi*	0·7	0·9	45·5
		M. miscanthi avenae	2·0	1·1	
		R. maidis	0	0	

Table 3. Condition and reproduction, at the end of infection feeding period, of aphids caught in suction traps at Burnley and Horsham in 1978

Percentages do not add up to 100, as some categories overlap and many aphids were not recovered and so were not recorded

Aphids		Burnley	Horsham
	(a) All		
% reproducing	*R. padi*	56	46
	M. miscanthi avenae	65	16
	R. maidis	13	—
% dead	*R. padi*	17	14
	M. miscanthi avenae	14	18
	R. maidis	24	—
% alive	*R. padi*	53	65
	M. miscanthi avenae	58	85
	R. maidis	37	—
	(b) Infective Aphids		
% reproducing	*R. padi*	68	31
	M. miscanthi avenae	31	10
	R. maidis	33	—
% dead	*R. padi*	19	1
	M. miscanthi avenae	38	3
	R. maidis	—	—
% alive	*R. padi*	59	53
	M. miscanthi avenae	15	22
	R. maidis	67	—
	(c) Not Reproducing		
% alive	*R. padi*	72	99
	M. miscanthi avenae	80	90
	R. maidis	—	—
% dead	*R. padi*	28	1
	M. miscanthi avenae	20	9
	R. maidis	—	—

At Horsham the number of infective *R. padi* generally followed the same pattern as the total catch of *R. padi*, but at Burnley, where it was more difficult to identify a period of maximum aphid activity, the numbers that carried BYDV varied throughout the year and did not always follow the same pattern as the total number caught.

Few aphids were trapped when the weekly mean minimum temperature was below 6°C or the maximum above 25°C; most were trapped when the weekly mean maximum was between 15 and 20°C.

Except at Burnley in 1977 there was an interval of approximately 2 months between the capture of the first aphid, which was always *R. padi*, and the first infective *R. padi* (Table 1). In both 1977 and 1978 the first aphid was caught a month earlier at Burnley than at Horsham. There was also a month interval in 1978 between the dates of catching the first infective aphids at the two sites, but in 1977 the first infective aphid was caught at Burnley three months earlier than at Horsham.

At Horsham in 1978 few Algerian oat plants showed symptoms of BYDV in the plots sown adjacent to the aphid traps in March and April, and there were few alate *R. padi* in either the wheat or oat plots during August and September.

In contrast, aphids and BYDV were common in the cereal plots sown at Burnley (Table 2), and infection with BYDV was widespread in oats sown in March, June and August; there was little infection in the plot sown in April. The numbers of aphids in the oat and wheat plots were similar, except in the March sown plots, where there were many more *R. padi* on the oats.

The survival and fecundity of trapped aphids on test plants is shown in Table 3. Both *R. padi* and *M. miscanthi avenae* survived better on oats at Horsham than at Burnley, although fewer reproduced. *R. maidis* survived less well than the other two species, and few produced nymphs (Table 3(*a*)). Of those aphids that transmitted BYDV, a greater proportion of all species reproduced at Burnley than at Horsham, but also more died during the feeding period. Of the infective aphids, more *R. padi* survived and reproduced than did *M. miscanthi avenae* (Table 3(*b*)).

Discussion

The trapping results were similar to those for New Zealand (Lowe 1966, 1968), but differed from those obtained by Plumb (1976) in England where, in 1969–73, less than half the alate cereal aphids trapped were *R. padi*. The results also confirmed *R. padi* as the most common cereal aphid in Victoria (O'Loughlin 1963), and as the most numerous infective aphid at Burnley and Horsham. The percentage of infective *R. padi* was two to five times that recorded in eastern England (Plumb 1976). Although the percentage infective was greater in other regions of Britain (A'Brook 1974; Smith *et al.* 1977), it never equalled the percentage infective in Victoria.

The dominant strain of BYDV in Victorian cereals and grasses is RPV (Rochow 1969; Price, unpubl. data; P. R. Smith, unpubl. data), which is specifically transmitted by *R. padi*, whereas in Britain, although there seem to be differences in the geographical distribution of virus strains, no single strain is dominant and most strains are transmitted by most aphid species (Plumb 1974). Different clones of *R. padi* from different regions of the U.S.A. differed in their ability to transmit BYDV (Rochow and Eastop 1966). However, climate probably has the most influence on the importance of *R. padi* as a vector of BYDV (Plumb 1977), and the climates of Victoria and Britain do differ greatly.

The present study has shown that infective *R. padi* survived and reproduced better after trapping than did other cereal aphids and are thus well adapted to colonizing cereals and thus spreading BYDV in Victoria. At Burnley the flights of aphids throughout the cereal-growing season and the large proportion carrying BYDV were reflected in the large incidence of BYDV recorded in the plots of oats sown adjacent to the suction trap. However, it is difficult to explain why so much of the plot sown in March 1978 was infected when there was so little infection in the April sowing, and no infective aphids were trapped until May. It is apparent that the prolonged presence of alate *R. padi* in southern Victoria could account for the large incidence of BYDV seen in this area in most years (Price 1970). By contrast, the flights of infective aphids at Horsham were too late to infect many plants, because these were too old to be easily infected (Watson and Mulligan 1957, 1960; Jenkins 1966; Doodson and Saunders 1970; Smith *et al.* 1977).

The only previous information for Victoria on flights of *R. padi* (O'Loughlin 1963) showed a different pattern from that reported here. In 1977 and 1978 aphid flights at Burnley occurred throughout the winter, not only in autumn and spring, as was indicated by yellow water trap and sticky trap catches in earlier years (O'Loughlin 1963). While this may reflect seasonal differences, it is more likely to result from differences in trapping efficiency, yellow water traps catching aphids only when many are present.

At Horsham almost all the aphids were trapped during a 9–11 week period in spring. This pattern distinguishes this site from others in New Zealand (Lowe 1966, 1968, 1974) and England (Plumb 1976), where two distinct periods of flight activity occur.

A number of factors could explain the difference in the abundance of *R. padi* and its times of flight at Horsham and Burnley. The mean minimum temperature at Horsham, especially in winter, is generally less, whereas the mean maximum temperature, especially in summer, is usually greater than at Burnley. These temperatures, coupled with declining rainfall to the north and west of Victoria, result in a shorter period when conditions are suitable for aphid multiplication and flight. These conditions are met when there is, or has been, sufficient rainfall to promote grass and cereal growth and when minimum temperatures are above the minimum for flight but not above the maximum for aphid activity. Although no studies have been made of the effect of temperature on the flight of *R. padi*, by analogy with *Aphis fabae* (Taylor 1957), flight activity might be expected to be restricted at temperatures much below 15°C. Dean (1974) has also shown that reproduction of *R. padi* almost ceases at 10°C and below. The warmer minimum temperatures in winter, the greater rainfall, a larger area of perennial grasses and earlier sowing of cereals in southern Victoria, than in the Wimmera, obviously favour *R. padi* and increase the likelihood of BYDV infection. In the Wimmera the brief period of aphid activity seems generally to be too late in relation to growth stage of the crop for BYDV to cause much damage.

Suction trapping in England proved a more sensitive method of detecting alate aphids than yellow traps or surveying oats and wheat (Taylor 1974). At Burnley, however, aphid numbers were similar in wheat and oats. Consequently, the incidence of obvious symptoms of BYDV in oats may be a better indication of natural virus incidence in adjacent wheat plants, as late infections of wheat rarely shows symptoms.

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