Research reports

Seasonal abundance and distribution of Fuller's rose weevil, *Asynanychus cervinus* (Boheman) (Coleoptera: Curculionidae) in Sunraysia citrus groves.

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Summary

Fuller's rose weevil (FRW), *Asynonychus cervinus* (Boheman), also referred to as Fuller rose beetle, *Asynonychus godmani* Crotch in the United States, was recognized as a quarantine pest in 1987 when live eggs were found on citrus imported into Japan. Citrus groves in the Sunraysia region (centred on Mildura, Victoria) were surveyed to determine the distribution and infestation levels of FRW, and seasonal abundance was monitored during 1988–1990 in one grove. Infested groves were found throughout Sunraysia, with high levels of infestation strongly associated with older plantings. Adult FRW were found on citrus trees throughout the year, with a population peak occurring from March to May, and a definite trough in November-December. A rapid climb in FRW numbers began each year in late December-early January, with high rates of emergence occurring soon after rainfall. An egg parasitoid (*Fidiobia citri*) was found to be active throughout the period that eggs were sampled (mid April to late November).

Introduction

Fuller's rose weevil (FRW), *Asynonychus cervinus* (Boheman), also referred to as Fuller rose beetle, *Asynonychus godmani* Crotch in the United States, is a widespread pest of a range of crops including citrus, on which it is usually considered a minor problem. Adult FRW, of which only females have been recorded, feed on the foliage of citrus trees and tend not to move between trees unless they are in close contact (Morse and Lakin 1987). Newly emerged adults feed for one to two weeks before oviposition commences (Morse *et al.* 1988). FRW lay eggs on all parts of the tree, with a strong preference for fruit (Coats and McCoy 1989). Egg development is temperature dependent and may take several weeks to over three months. The newly hatched larvae drop to the ground and burrow into the soil where they feed on roots of the citrus trees for up to ten months. Pupation occurs in the soil and takes one to two months, after which the adult FRW emerge and begin to feed on weeds or citrus foliage (Morse *et al.* 1988). FRW are flightless and so must enter the trees by climbing the trunk or tall weeds.

In 1987, FRW was recognized as a quarantine pest in relation to citrus exports to Japan. This was a result of the detection of live FRW eggs on citrus fruit imported from Australia. It is possible that prior to this, FRW eggs on citrus had been killed by routine fumigation with ethylene dibromide (EDB) for fruit fly, a treatment disallowed by Japan in 1987. From that year, EDB fumigation was replaced by cold disinfestation, a treatment known to be ineffective against FRW eggs (Edwards *et al.*, unpublished data).

A research program began in 1987 to reduce infestation of citrus fruits with eggs of FRW, and to detect and treat infested fruit prior to export. This paper reports on aspects of the program dealing with field surveys to determine infestation levels, and a study of the seasonal abundance of FRW in citrus.

Materials and methods

Sampling for FRW

Adults of FRW were sampled from citrus trees using a beating method. Two branches per tree were hit sharply five times with a rubber mallet, over a 0.28 m^2 tray. The number of FRW collected in the tray was recorded and the weevils replaced at the base of the tree being sampled.

The infestation of citrus fruits by eggs of FRW was determined by sampling 20 fruit randomly from the grove being surveyed. The fruit were taken to a laboratory for examination. Care was taken to ensure that the calyx on each fruit remained intact. For each fruit, the calyx was carefully removed and the underside of the calyx and stem-end of the fruit was examined under a microscope for the presence of FRW egg masses. Any egg masses present were recorded as containing live, dead, hatched or parasitized eggs, with the criteria being:

live – full, pale yellow colour, exude pale creamy fluid when punctured, or containing a pale yellow larva.

dead – unbroken, but dry and possibly shrivelled, regardless of colour. No fluid exuded when punctured.

hatched – empty with no indication that the egg was parasitized (i.e., no parasite pupal case within the FRW egg case).

parasitized – containing a darker coloured pupa of a parasitic wasp, or empty with a darker coloured pupal case within the FRW egg case.

Population monitoring

The site used for long-term monitoring of a FRW population was a commercial orange grove (cv Lane's late navel) at Nangiloc, 40 km south-east of Mildura, Victoria. The trees were 15–18 years old and were double planted (2.3 × 7.3 m), growing together as a hedgerow allowing free movement of FRW between trees. Soil type was a red sandy loam, and soil management involved slashing of a mixture of legume cover crops, grasses and broadleaf weeds. The grove was under trickle irrigation.

From April 1988 to December 1990, 21 untreated trees were sampled weekly for adult FRW, using the method described above. During the same period, 21 sticky-banded trees were sampled weekly for the numbers of adult FRW caught in the band. These counts gave an indication of the timing of FRW emergence from the soil. The sticky band was a 10 cm wide barrier of Rentokil® bird repellent completely encircling the trunk. In both cases the trees were chosen such that any particular tree was sampled once every three weeks.

In addition, fortnightly surveys of citrus fruit for FRW egg masses were carried out at the same site from mid April to late November 1990.

The sampling methods described above generally follow those used in FRW research in the United States, as outlined by Morse and Lakin (1987). One variation was the use of a 0.28 m^2 tray on two sites per tree to collect adult FRW during the beating sampling (effective sample area 0.56 m^2 per tree), compared to the American method which uses a 0.92 m^2 catch cloth on one site per tree giving an effective sample area of 0.92 m^2 per tree.

Also, the measurement of FRW emergence from the soil was made using cages in the American work, while for this current research the numbers of adult FRW

trapped in sticky trunk bands were used as an indication of emergence. The latter technique takes into account the entire soil area from which emergence can occur, but may result in a delay in observed emergence patterns if newly emerged FRW wander around or feed on weeds for a time before climbing citrus trees.

Grove surveys

Detailed surveys were carried out to determine the relative infestation levels of FRW in commercial citrus groves in Sunraysia. For each grove, 20 trees and/or 20 fruit were sampled as described above, for FRW adults and eggs respectively. The trees and fruit were selected randomly from throughout each grove. Soil and irrigation type, and tree age were also recorded for each grove.

In 1988, 27 blocks of navel orange trees were surveyed for adult FRW. In 1989, 88 blocks of Valencia orange trees were surveyed for FRW eggs, with 42 of those also surveyed for adult FRW. In 1990, 69 Valencia blocks were surveyed for FRW eggs only. Inspection of the fruit for the 1990 survey was carried out largely by a contract entomologist, and in some cases by the growers using instructions provided by the Department of Agriculture.

Over the two years, a total of 104 separate blocks were surveyed, covering nine districts located between Palinyewah, 60 km north-west of Mildura, and Kenley, 135 km south-east of Mildura. The blocks were nominated by growers for inclusion in the surveys partly on the basis of apparent freedom from FRW. For this reason the infestation levels observed are very likely under-estimates of levels in the Sunraysia district generally.

Results and discussion

Seasonal abundance

Although adult FRW were present on the trees throughout the year, a population peak occurred from February to May, and a definite trough around November-December (Figure 1a). The rapid increase in the FRW population each year began in late December-early January. Similar population trends for FRW have been reported from Yanco, NSW (James, personal communication). Reports from California (Anon 1989, Morse *et al.* 1987) also indicate a peak in FRW populations during the same relative period (mid Summer-mid Autumn). In Florida the situation appears different with the peak occurring during late Spring-early Summer (Lye, personal communication).

FRW emergence

Weekly counts of adult FRW trapped in the sticky trunk bands indicated that some emergence of FRW from the soil occurred throughout the year, with a peak around March-May (Figure 1b). During a one-year period (1989) only one month recorded a very low level of emergence, less than 2% of the total for the year. This contrasts with the experience in California and Florida where up to six months of very low levels of emergence have been recorded each year (Anon 1989, Lye, personal communication). This difference may be due to the use of sticky bands in the current work as opposed to emergence traps in America. As the bands trap any FRW climbing the tree trunks and are not selective for recently emerged adults, they may have trapped a small but continual supply of FRW which were wandering between trees or had spent some time feeding on weeds, regardless of when they had emerged. However, it is considered that FRW tend to climb into the citrus trees soon after emergence and remain in the trees for their lifetime, so sticky trunk bands are likely to be a reasonable indicator of emergence patterns, if not absolute levels.

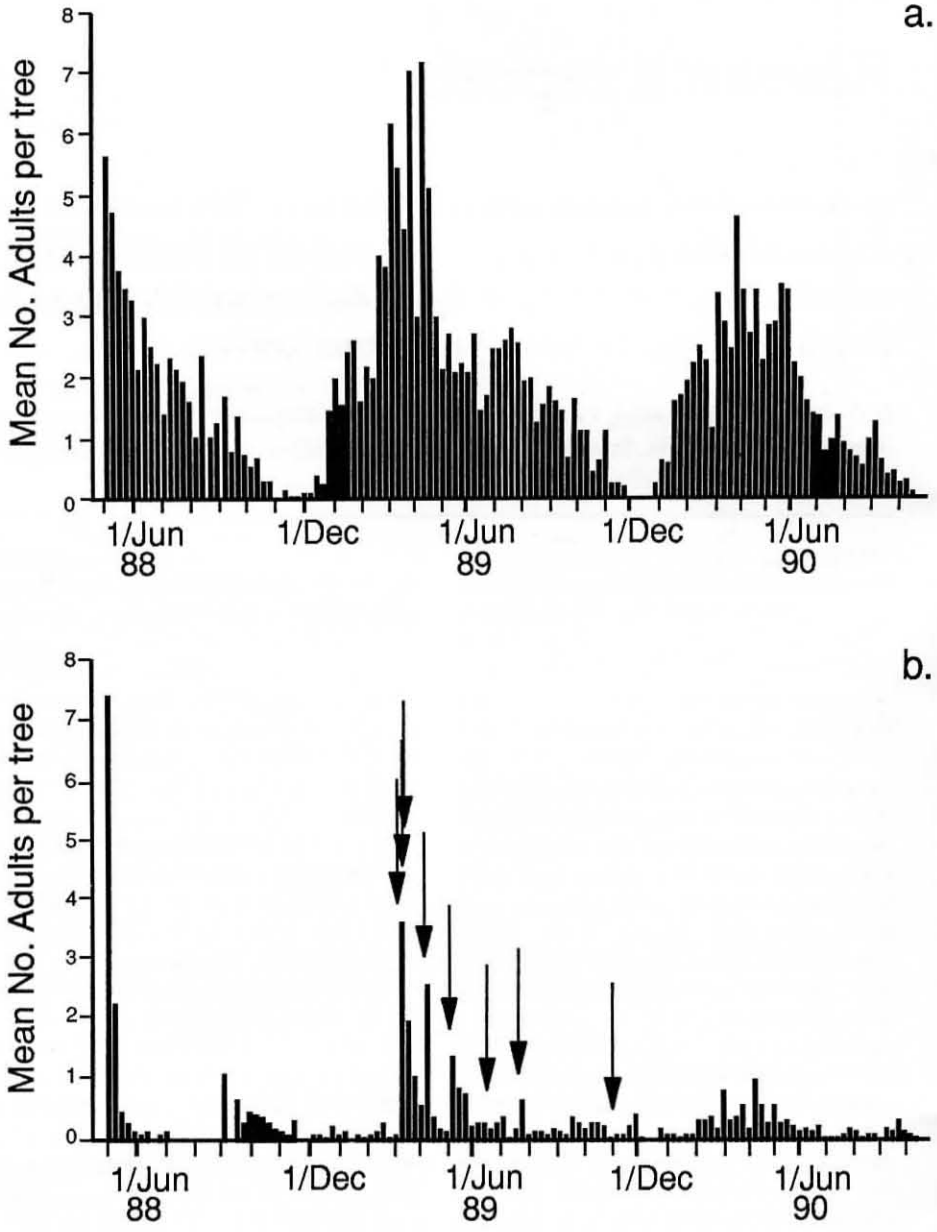

Figure 1. Weekly counts of adult FRW in a commercial orange grove in Sunraysia. (a) Numbers of weevils beaten from canopies of untreated trees, and (b) numbers trapped in sticky bands encircling the trunks. Days on which more than 10 mm of rain fell in 1989 are arrowed.

Control strategies for FRW are likely to be based on exclusion of the adult weevils from trees during their entire active period, or exclusion only over the period necessary to ensure that fruit are free of viable eggs at harvest. Because adult FRW appear to be present throughout the year, the former approach would involve year-long control with its associated maintenance costs. The latter time-specific approach may be more desirable, and could be based on a predictive model relating the required control period to FRW devel-

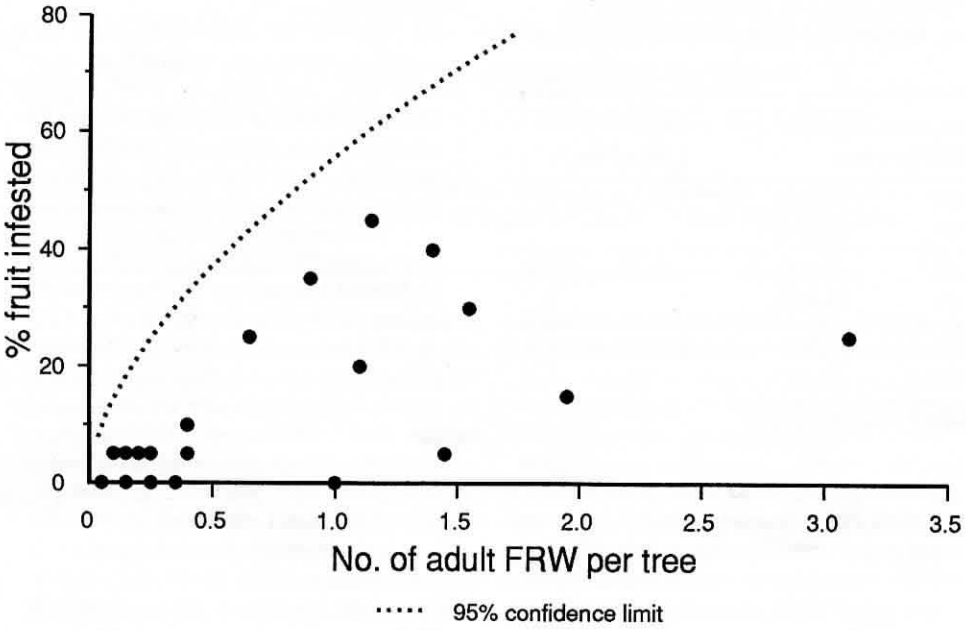

Figure 2. Percent of fruit infested with live FRW eggs in relation to the numbers of adult FRW found in tree canopies.

opmental rates and expected harvest dates (Lakin and Morse 1989).

Trunk treatments to control FRW in citrus are preferable to foliar applications of insecticides which have greater potential to disrupt successful integrated pest management systems. A range of materials have been evaluated for use as trunk treatments (Magarey *et al.* 1991).

The relatively low levels of emergence recorded in the current trial after the initial peak may have been due to the population being suppressed by the trunk barriers which prevented adult weevils from entering the trees to feed. Some weeds are known to be alternative hosts for FRW, but without a suitable food source the weevils die within two to three weeks (Morse and Lakin 1987). In Sunraysia citrus groves, adult FRW have only been observed feeding on leaves of two species other than citrus. These are pistachio (*Pistachia vera* L.) and blackberry nightshade (*Solanum nigrum* L.). A preliminary trial showed that adult FRW on *S. nigrum* fed and laid viable eggs for 25 weeks. In the citrus grove being monitored, *S. nigrum* was relatively scarce, and may have been insufficient to support a large population of FRW denied access to citrus trees.

FRW emergence, as indicated by numbers trapped in sticky bands, appears to be stimulated by rainfall (Figure 1b), a phenomenon also observed in the United States (Morse *et al.* 1987). This was despite daily trickle irrigation which kept the soil moist. No consistent effect of rain on numbers of FRW adults in the foliage of trees was noted during the population monitoring.

Distribution of FRW

Of the 104 Valencia blocks surveyed in 1989 and 1990, 22% were infested by FRW. The survey results are summarized in Table 1. Infested blocks were found in all nine districts covered by the surveys. As the blocks were chosen for survey partly on the basis of apparent freedom from FRW, the infestation levels observed may be taken as conservative estimates of levels in the Sunraysia district generally.

The preliminary survey of 27 navel orange blocks in 1988 gave similar results. Adult FRW were found in 81% of blocks, with a mean of 1.1 FRW per tree in the infested blocks (range 0–11 per tree).

It is clear that level of infestation varies widely between blocks. However, even those with low numbers of fruit carrying live eggs (1 per 20 fruit sample) could be considered very heavily infested. Morse *et al.* (1987) considered that to have a reasonable chance of passing the Japanese quarantine inspection, a citrus load should contain less than 0.1% of fruit with live FRW eggs. This indicates that although adult FRW numbers were relatively very low in late Autumn-early Summer (Figure 1a), there may be only a marginal advantage, in relation to quarantine risk, in concentrating on varieties harvested at that time, as levels of infestation by FRW eggs appeared to always be in excess of the theoretically acceptable level for export fruit. Inspection of fruit for live eggs was performed by Departmental staff in 1989 and by growers and a contract entomologist in 1990. This may account for some of the difference in results between the two years.

The relationship between the percentage of fruit infested with FRW eggs and the numbers of adult FRW was investigated for the May 1989 survey data (Figure 2). It appears from the data that there may be an upper limit to the proportion of fruit infested, in relation to the level of infestation by adults. To indicate this an upper 95% tolerance limit was calculated. The tolerance limit is based on the model $y = Bx^c$ (y = percent of fruit carrying FRW eggs, x = number of adult FRW per tree). The model was fitted using simple linear regression of $\log(y)$ on $\log(x)$, with the tolerance limit calculated on the log scale prior to back-transformation to the original scale for presentation.

The nature of this relationship suggests that for quarantine purposes, grove surveys should be more reliable when based on sampling of fruit for eggs, rather than on presence of adults in canopies. Surveys for adults would be more suitable for the initial selection of groves with low FRW infestation levels. In practice, sampling and examination of fruits for FRW eggs is quicker and easier than beating techniques to collect the adults.

Characteristics of infested groves

Data from the 1989 survey for adult FRW were analysed to clarify relationships between weevil numbers and tree age, irrigation type and soil type. The regression analyses used a generalized linear model based on an overdispersed Poisson distribution (Table 2).

The FRW counts were strongly associated with tree age regardless of the other

Table 1. Percent of surveyed Valencia blocks infested with FRW and mean numbers of adult FRW, live FRW egg masses and percent infested fruit found in infested blocks. Means are followed by ranges (in brackets).

	May 1989 42 blocks	Sep 1989 88 blocks	Aug. 1990 69 blocks
Percent of blocks on which FRW adults and/or eggs were detected	47.6	26.1	27.5
Mean no. of adult FRW per tree	0.83	–	–
(20 tree sample per block)	(0.05 – 3.1)	–	–
Mean no. of live egg masses per fruit	0.20	0.19	–
(20 fruit sample per block)	(0 – 4)	(0 – 3)	–
Mean percent of fruit with live eggs,	13.75	13.5	5.0
(20 fruit sample per block)	(0 – 45)	(0 – 50)	(0 – 20)

Table 2. Mean numbers of adult FRW found in each Valencia block in 1989, in relation to grove characteristics. Means are followed by standard errors (in brackets).

Grove characteristic		Mean no. of adult FRW per tree		LSD $t_{45}\sqrt{(se_1^2+se_2^2)}$
Age of trees	< 19 years	0.07	(0.033)	0.46 (P=0.005)
	>= 19 years	0.98	(0.168)	
Irrigation type	overhead	0.26	(0.078)	0.53 (P=0.05)
	undertree	0.95	(0.305)	
Soil type	sandy loam	0.35	(0.097)	0.47 (P=0.05)
	sand	0.59	(0.261)	

* characteristics were considered independently of each other.

factors. Three possible explanations for this association are:

1. Nursery material used to establish the older plantings may have been infested with FRW to a greater degree than the material available in recent years;
2. Nursery material may generally have been infested but populations have had more time to increase and spread in older plantings, or
3. Nursery material may generally have been 'clean', with groves being infested by introduction of FRW, and populations having more time to increase and spread in older plantings.

The association between FRW counts and irrigation type was significant only when considered independently of tree age. The data were insufficient to clarify whether irrigation type had a real effect. The level of infestation by FRW was not significantly related to either of the soil types for which there was sufficient data for analysis.

Parasitoid activity

Results from grove surveys and continuous monitoring indicate that an egg parasitoid of FRW, *Fidiobia citri* (Nixon), was active throughout the monitoring period (mid April to late November). This appears to be the first record of *F. citri* in Australia, although it has subsequently been reported from FRW populations at Yanco, NSW (James, personal communication). *F. citri* has been reported from FRW populations in California (Morse and Lakin 1987), where it is also noted that the FRW egg masses are rarely 100% parasitized by the wasp (Morse *et al.* 1988). The situation in Sunraysia appears similar. Parasitized eggs were present in up to 48% of egg masses, and although some egg masses contained only parasitized eggs, in most cases parasitized eggs were accompanied by live or hatched eggs. Based on these observations, *F. citri* alone is unlikely to provide the level of control of FRW needed to satisfy the stringent quarantine requirements of markets such as Japan.

Acknowledgments

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