COMPARISON OF HOST PLANT PREFERENCES, FECUNDITY AND LONGEVITY FOR DIET-REARED AND FIELD-COLLECTED FULLER'S ROSE WEEVIL

B.J. MAHER and D.P. LOGAN

HortResearch, 412 No. 1 Rd, Te Puke, New Zealand
Corresponding author: bmaher@hortresearch.co.nz

ABSTRACT

The New Zealand kiwifruit industry continues to face high fumigation costs when exporting fruit to Japan, mainly due to the presence of egg masses of Fuller's rose weevil *Naupactus cervinus* (Crotch) (Coleoptera: Curculionidae) on fruit. Experiments were carried out to ascertain whether adult FRW have feeding preferences for plants commonly found in the kiwifruit orchard ecosystem, and whether the behaviour of adults reared on artificial diet is different to that of field-reared FRW. In no-choice and choice tests, adults consumed more foliage of broadleaf dock *(Rumex obtusifolius*) and white clover *(Trifolium repens)* than other host plants. Diet-reared adults consumed less overall than field-collected adults. Fecundity and longevity of adult FRW caged in a shade house was determined. Adults laid more eggs when provided with broadleaf dock or white clover than with creeping buttercup (*Ranunculus repens*) or kiwifruit (*Actinidia chinensis*). Maximum longevity of caged adults was 12 months.
Keywords: Fuller's rose weevil, host plants, preference, artificial diet.

INTRODUCTION

Fuller's rose weevil, (FRW) *Naupactus cervinus* (Crotch) (= *Asynonycus cervinus* (Boheman)) has become a serious problem for the New Zealand kiwifruit industry in recent years, due to its status as a quarantine pest in Japan. There is one extended generation per year in New Zealand (May 1993) with peak adult numbers in the canopy of kiwifruit orchards occurring from mid-summer to mid-autumn (C. McKenna, unpubl. data). Adults lay their eggs in suitable crevices such as in bark, between newly emerging leaves, under the calyx of fruit or in the case of *Actinidia chinensis* Cv. Hort16A, inside the beak at the blossom end of the fruit. Larvae drop to the ground after hatching and burrow into the soil where they feed on plant roots for eight months or more (Chadwick 1965). Pupation occurs in the soil followed by emergence of adults in summer.

Adult FRW can be found both in the understorey and in the canopy of kiwifruit orchards. Leaves of some understorey plants are commonly notched as is typical of feeding by FRW, but little chewing damage is evident in the kiwifruit canopy. As adults need to feed to produce eggs (Morse et al. 1988), understorey plants may play a significant role in the population biology of FRW.

In this study, the feeding preference of adult FRW on three common understorey plants, citrus as a known host and kiwifruit was examined. A second objective was to examine whether the behaviour of laboratory-reared FRW differed to that of natural field populations. Recently, an artificial diet was developed to produce adults year round for experimental work (G. Clare, unpubl. data), since supply of insects can be a limiting factor. The fecundity, longevity and host preference of adults reared on artificial diet and adults from the field were compared.

MATERIALS AND METHODS

Laboratory feeding trials

Five host plants, kiwifruit (*Actinidia chinensis* Cv. Hort16A*),* white clover *(Trifolium*

repens), broad-leaf dock *(Rumex obtusifolius*), creeping buttercup (*Ranunculus repens*) and navel orange (*Citrus sinensis*), were used in no-choice and choice tests. Of these, all except citrus and kiwifruit are plants found in abundance in the understorey of kiwifruit blocks in the Bay of Plenty. Kiwifruit was included as it is part of the orchard ecosystem. Citrus was used as a standard as it is a known host of FRW (Chadwick 1965; Madge et al. 1992).

Adults were collected from the understorey of kiwifruit orchards early in their emergence period (January 2003), or were reared from larvae fed on artificial diet. Pupation of fully-grown larvae was slow to occur on the diet and some late instar larvae were transferred to pots containing soil with a potato as a food source, and pupation was improved. Adults from the field (referred to later as 'field-collected'), adults reared completely on diet ('diet-reared'), and adults reared on diet followed by pupation in soil ('soil-pupated') were treated as three separate FRW populations in no-choice and choice tests. Thus the preference of three FRW populations (factor 1) was tested for five different host plants (factor 2).

Leaf discs (20 mm diameter) of host plants were set up on filter paper moistened with water in 90 mm diameter plastic Petri dishes. In the no-choice test, a single leaf disc was placed in the centre of the Petri dish. In the choice tests, a leaf disc of each of the five hosts was placed equidistantly from the centre of the Petri dish. Foliage from host plants was collected from the field in the morning when leaves were at their most turgid. One adult was added to the centre of each dish and all adults were starved at 20°C for 48 h to encourage feeding during tests. There were ten replicates for each combination of factors, and all Petri dishes were held in an incubator at 20°C (±0.5°C) under natural photoperiod (ca 14:10 h light:dark). Additional drops of water were added to the filter paper after 48 h to prevent the leaf discs drying out. After 72 h dishes were removed from the incubator and the amount of each leaf disc consumed (mm^2) was measured using a template marked on a 1 mm^2 grid.

No choice cage trial–fecundity and longevity

Fecundity and longevity of FRW adults on each of four host plants (kiwifruit, broadleaf dock, white clover or creeping buttercup) was tested in a shade house. Citrus was omitted from this trial as it is not part of the kiwifruit ecosystem and previous work has confirmed citrus as a good host (Morse & Larkin 1987). Adults were either reared on artificial diet ('diet-reared') or in soil-filled containers planted with ryegrass ('ryegrass-reared'). Three newly-emerged adults were introduced to a mesh cage (480 mm wide x 480 mm long x 730 mm high) with a single host plant. Adults were assumed to act independently of each other. There were four and five cages per host plant for 'diet-reared' adults and 'ryegrass-reared' adults, respectively. Due to irregular emergence of the adults, cages were set up from mid March to late April 2003. Adults were allocated without conscious bias in groups of three per cage to one cage per host plant on the same day. All plants were between 100 and 200 mm high and were potted into PB3 bags. Host plants were watered regularly and trimmed periodically to maintain plant health and vigour.

Two wooden blocks (40 mm x 20 mm x 0.7 mm) with a piece of acetate stapled to one side were placed at either the plant base or pegged to the side of the cage as artificial oviposition sites. Cages were checked weekly, and the number of adults found and the number of egg batches laid on the blocks, on foliage or in the cage mesh were recorded. The number of eggs per batch was recorded when laid on the blocks, but eggs could not be removed and counted from the cage mesh and other sites. The survival time in weeks for each adult was recorded as the last week it was found alive.

Data analysis

In order to remove variance heterogeneity, data for area of leaf eaten (mm^2) in no-choice and choice tests and for the total number of egg-batches laid in cages were transformed by ln(x +0.5), and data for the average survival time (weeks) of adults in each cage were transformed by ln(x). Data were analysed as a two-way crossed ANOVA design using the GLM procedure in Statistica 6.1. The model used was: host plant + FRW population + host plant*FRW population. Where there was no significant interaction

between factors (P>0.05), means were separated by the Least Significant Difference test at P<0.05.

RESULTS

No choice feeding tests in the laboratory

Under no-choice conditions, there was a significant difference in the leaf area of the different host plants consumed (P=0.002). There was also a difference in area consumed by different FRW populations (P<0.001) (Fig. 1). A significant interaction between host and source population (P=0.003) was found so the means within factors were not investigated further (Zar 1996). Adults ate more dock and white clover than any other hosts.

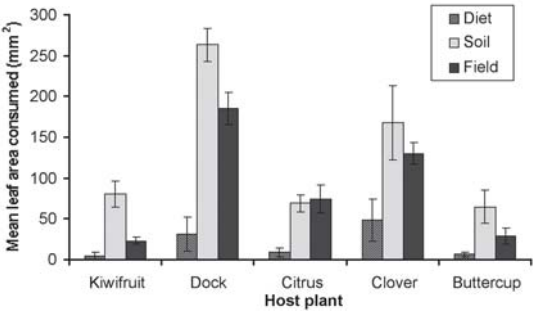

FIGURE 1: Mean leaf area consumed (mm^2) in 72 h in no-choice tests by diet-reared, soil-pupated and field-collected Fuller's rose weevil adults. Error bars are one SEM.

Choice feeding tests in the laboratory

When given a choice, adults differentiated between hosts (P<0.001). Differences occurred between populations (P<0.001), with soil-pupated adults eating more (53.0±66.3 mm^2) than diet-reared (28.6±64.4 mm^2) and field-collected adults (31.1±60.9 mm^2) (Fig. 2). There was no interaction between population and host (P>0.05). Adults consumed more white clover (back-transformed mean, 38.2 mm^2) than any other host plant, and more dock (8.0 mm^2) and citrus (6.7 mm^2) than buttercup (1.3 mm^2) and kiwifruit (0.4 mm^2).

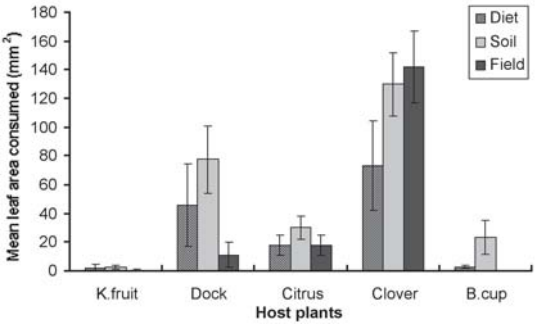

FIGURE 2: Mean leaf area consumed (mm^2) in 72 h in choice tests by diet-reared, soil-pupated and field-collected Fuller's rose weevil adults. Error bars are one SEM.

No-choice cage trial–fecundity and longevity

There was a difference in survival between diet-reared (back-transformed mean=15.7 weeks) and ryegrass-reared (20.9 weeks) adults (P=0.008) (Fig. 3), and between host plants (P<0.001). There was no interaction between population and host plant (P>0.05). All adults lived longer on dock, clover and buttercup than on kiwifruit plants (24.5, 25.6, 21.3 and 8.1 weeks respectively). The longest-lived adults were still alive at trial completion (54 weeks) on dock and on buttercup.

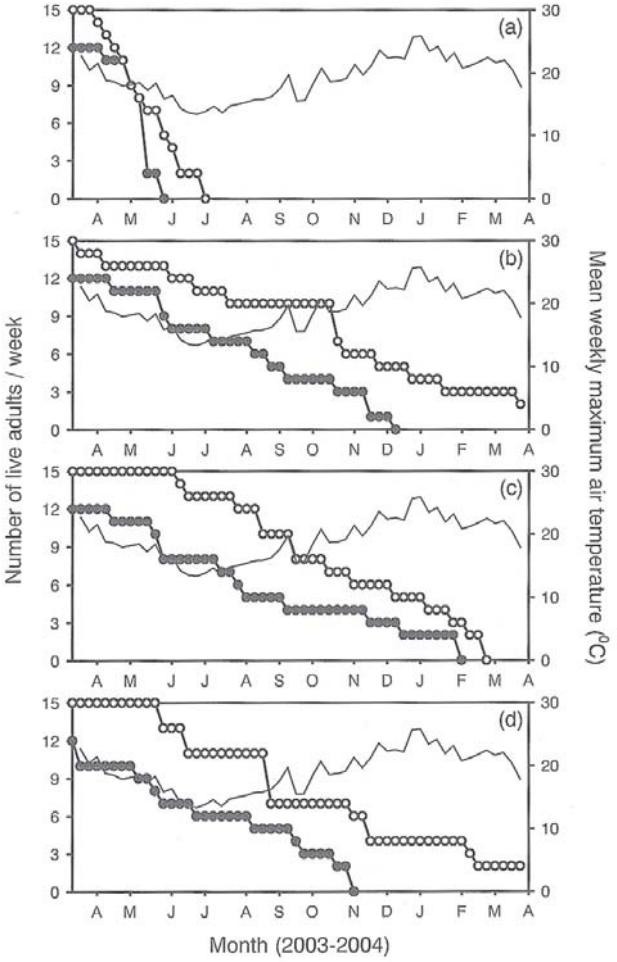

FIGURE 3: Longevity of diet-reared (solid symbols) and ryegrass-reared (open symbols) Fuller's rose weevil adults on (a) kiwifruit, *Actinidia chinensis*, (b) broadleaf dock, *Rumex obtusifolius*, (c) white clover, *Trifolium repens*, and (d) creeping buttercup, *Ranunculus repens*. Solid lines without symbols are the mean weekly maximum temperature to indicate seasonality.

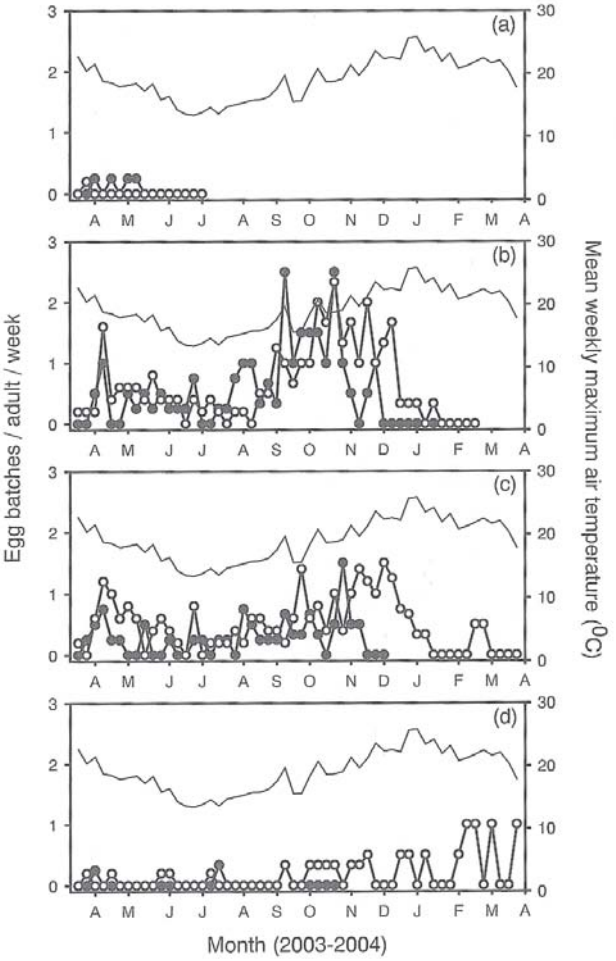

FIGURE 4: Fecundity of diet-reared (solid symbols) and ryegrass-reared (open symbols) Fuller's rose weevil adults on (a) kiwifruit, *Actinidia chinensis*, (b) broadleaf dock, *Rumex obtusifolius*, (c) white clover, *Trifolium repens*, and (d) creeping buttercup, *Ranunculus repens*. Solid lines without symbols are the mean weekly maximum temperature to indicate seasonality.

There was no difference in the number of egg batches laid by adults reared on ryegrass and those reared on diet (P>0.05), and no interaction of population with host plant (P>0.05) (Fig. 4). FRW adults of both populations laid more egg batches when caged with dock (back-transformed mean, 12.6) or clover (14.5) than with buttercup (1.0) or kiwifruit (0.4) (P<0.0001). While adults caged with buttercup laid some egg batches, very few of either population laid eggs when caged with kiwifruit (Table 1) (Fig. 4). Adults preferred the gauze netting of the cage (45%) or the oviposition blocks (41%) as egg laying sites compared to foliage (6.3%) or 'other' sites (8%). Number of eggs per batch laid in wooden blocks for all host plants varied from 11 to 71. Sufficient data were

available to compare egg numbers in batches for dock and white clover only. Egg batches laid by adults feeding on dock were larger than those laid by adults feeding on clover (two sample t-tests, $P<0.01$). Increased egg laying was evident between weeks 24 and 38, which coincided with spring leading into summer (Fig. 4).

TABLE 1: Number of egg batches per cage (Mean ± SD).

Host plant	Diet-reared	Ryegrass-reared
Kiwifruit	1.0 ± 0.82	0.2 ± 0.45
Dock	9.0 ± 6.38	24.4 ± 13.90
Clover	16.0 ± 12.36	23.0 ± 20.46
Buttercup	0.75 ± 0.96	4.4 ± 6.19

DISCUSSION

In no-choice and choice tests FRW adults consumed more white clover and broadleaf dock than the other three hosts plants tested. White clover and dock both have a thin relatively hairless leaf in comparison to kiwifruit and buttercup, which are more rough and hairy with larger veins. These physical characteristics may have contributed to the observed host plant preferences.

The feeding preferences found in no-choice and choice tests were consistent with the effect of host plants on the fecundity and longevity of adults in the shade house. Kiwifruit was not a preferred host in feeding tests and was also a relatively poor host in the longevity and fecundity trial. On the best host plants in the shadehouse (dock, white clover and buttercup), ryegrass-reared adults survived for 30 weeks on average. A few adults in cages with dock and buttercup were still alive at 54 weeks. Prior to this study it was thought that most adult FRW died off in winter, based on low or zero counts of adults from vine shakes in June (C. McKenna, unpubl. data). Adult FRW have been found all year round in orange groves in Australia (Madge et al. 1992). However, in Australia emergence occurs throughout the year whereas in New Zealand the emergence period begins in summer and ends in late autumn (C. McKenna, unpubl. data). This implies that adults could potentially persist for long periods in common understorey plants throughout the winter.

Adults laid more egg batches on average when caged with broad-leaf dock or white clover than with kiwifruit or buttercup, and there was a marked increase in the number of egg batches laid coinciding with the onset of spring. This suggests that in kiwifruit orchards a relatively small proportion of all eggs laid per adult are laid while the maturing fruit is on the vine (late summer–autumn). Egg batch size differed between adults caged with white clover and with dock and this may be explored in further work. The oviposition sites chosen by caged adults indicates that FRW are not very particular about where to lay their eggs which is not consistent with observations of egg laying on citrus plants (Coats & McCoy 1990). Gauze mesh and wooden blocks were equally inviting, but only those adults caged with white clover laid eggs on the plant foliage. This suggests there are many places in the orchard environment, other than the fruit, that are likely to be used for egg laying.

In all tests, adults reared on artificial diet did not perform as well as those collected from the field or those moved into soil to pupate. Similar to our situation of slow pupation on diet, Schroeder (1987) found that pupation of citrus root weevil, *Diaprepes abbreviatus*, was improved after moving fully-grown larvae into a soil mix. The two most noticeable differences were that survival of diet-reared adults in the shade house was inferior to the ryegrass-reared adults, and in the laboratory experiments the adults reared on diet alone consumed less food than the other two populations. It is possible that when development is completed on artificial diet, the adults have been exposed to a higher nutrient content for a longer time period than in the field and may not need to

feed as much in the days following emergence. Although no adult weights were taken in this study, other tests have shown that diet-reared FRW adults are larger in size and weigh more than those collected from the field (S. Dobson, unpubl. data). In future, use of diet-reared FRW may best be limited to short-term studies where reduced survival will not affect results.

This study shows that FRW adults have preferred hosts for feeding. Citrus was not preferred for feeding in choice tests and may not be preferred in orchard situations where other hosts are present. This is consistent with Masaki & Kadoi (1997) who tested five host plants and found that the number of eggs per adult on citrus was half the number laid on peanuts, *Rubus* sp. and strawberry, and that longevity was also reduced. However, caution is required when interpreting results from laboratory or shade house studies as they may not be directly applicable to field situations. For example, cages may provide some protection from environmental conditions and natural predation leading to increased survival.

In the orchard understorey, FRW may find and choose to feed on dock and white clover and these plants may contribute significantly to their fecundity. East (1977) and Ottens & Todd (1979) similarly observed an increased reproductive potential of white-fringed weevil (*Naupactus sp*.) when feeding on favourable foods. As a management strategy, altering the botanical composition of the understorey by removing dock and white clover may not affect survival of FRW, but it may have some impact on their fecundity. That is, adults may survive by feeding on some unfavourable plants but they may not lay eggs. In the shade house trial, adults fed on buttercup with some surviving for over 54 weeks but few eggs were laid. This suggests that buttercup may not provide adequate nutrition for egg development. The present study shows for the first time that FRW adults are potentially able to persist for long periods through winter on common understorey plants, which is consistent with grower observations of FRW adults in kiwifruit vines in winter and spring. The extended period that adults are present in kiwifruit orchards should be considered when developing novel tools for reducing FRW numbers.

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