Predation of apple leafcurling midge, *Dasineura mali*, by *Sejanus albisignata*

P.W. Shaw and D.R. Wallis

The New Zealand Institute for Plant & Food Research Limited, Old Mill Road, RD3, 7198, Motueka, New Zealand

Corresponding author: peter.shaw@plantandfood.co.nz

Abstract The predatory mirid bug, *Sejanus albisignata*, has been observed feeding on apple leafcurling midge (ALCM) eggs, but quantitative data on its potential as a predator of ALCM are lacking. Two methods were trialled to assess predation of ALCM by *S. albisignata*. In a laboratory experiment, apple shoots infested with freshly laid ALCM eggs were contained with and without a *S. albisignata* adult and, in a field experiment, paper bags were secured over shoots with ALCM eggs and individual *S. albisignata* nymphs were introduced into half of these. There were significant reductions of surviving midge larvae on shoots confined with adult predators, and reduced numbers of midge-infested leaves and larvae on bagged shoots with *S. albisignata* nymphs. Results from these non-choice trials indicate that *S. albisignata* can be an effective predator of ALCM. More detailed feeding studies would determine if adult and immature *S. albisignata* have a preference for midge eggs or larvae.

Keywords apple leafcurling midge, *Dasineura mali*, predation, *Sejanus albisignata*, feeding study.

INTRODUCTION

The mirid bug, *Sejanus albisignata* (Knight), is both a plant feeder and a predator. The bug was accidentally introduced to New Zealand (Charles 1998) and was first recorded in 1930 (Dumbleton 1938). There are usually two generations per year, with the possibility of a partial third generation during warm seasons (Wearing & Attfield 2002). It is common in most commercial apple orchards, and adults and nymphs feed on a variety of mite and insect pests including European red mite and *Bryobia* sp. (Collyer 1964), codling moth eggs and young larvae (Wearing & Charles 1989), two-spotted mite, Froggatt's apple leafhopper, and the eggs of the noctuid *Graphania mutans* (Wearing & Attfield 2002). A.R. Gibb (HortResearch, personal

communication, 1998) reported *S. albisignata* feeding on the eggs of apple leafcurling midge (ALCM) in Canterbury and it has also been observed feeding on ALCM eggs in Nelson. It is often found in rolled ALCM-infested leaves, but it is unclear whether it feeds on ALCM larvae or is merely seeking refuge within the rolled leaves.

Controlling ALCM in commercial orchards is important because it is a quarantine pest for export markets such as California, Taiwan and Australia. The presence of mature midge larvae or pupal cocoons on apples is unacceptable in these sensitive markets.

The use of more selective pesticides in integrated fruit production (Walker et al. 1997)

has increased the potential for natural enemies to contribute to pest management in commercial apple orchards (Charles 2008). Shaw et al. (1997) reported higher trap catches of *S. albisignata* in apple blocks treated with the selective insecticide buprofezin than in blocks that received the broad-spectrum insecticide chlorpyrifos. Predation of ALCM egg batches and reduced numbers of ALCM-infested shoots were associated with large numbers of *S. albisignata* in an apple block treated with selective pesticides compared with one treated with chlorpyrifos (Shaw et al. 2003).

This polyphagous predatory bug could have economic importance for the management of a number of insect pests of pipfruit, including ALCM. However, quantitative information on its potential as a biocontrol agent of ALCM is lacking. This paper presents the results of feeding studies to investigate predation of ALCM by *S. albisignata*.

MATERIALS AND METHODS

Laboratory trial

Twenty apple shoots, infested with ALCM eggs and free of potential predators, were collected on 29 November 2011 from an orchard block at the Plant & Food Research site near Motueka and individually placed in small sealed plastic pottles containing sugar solution (10 g/litre). These were confined within larger 1.6 litre plastic containers covered with fine mesh curtain material for ventilation. A single adult *S. albisignata* was placed onto each shoot in ten of the containers and the remainder served as controls. The containers were maintained in the laboratory at 20°C with natural light from windows. The shoots were removed from the containers after 7 days, any rolled (infested) leaves were dissected and examined under a binocular microscope, and the number of midge larvae inside was counted.

Field trial

Thirty apple shoots infested with ALCM eggs and free of potential predators were tagged on 19 January 2012 in an orchard block at the Plant & Food Research site near Motueka. All shoots were covered with paper bags and a single

S. albisignata nymph was placed inside half of these. The bags were then securely tied around the shoots to prevent escape or entry of *S. albisignata* and other natural enemies. The bags were removed after 2 weeks and the shoot tips removed for examination in the laboratory. The number of leaves infested with ALCM larvae on each shoot tip and the number of larvae inside rolled leaves were counted.

Monitoring ALCM and *Sejanus albisignata*

ALCM males were monitored approximately fortnightly from September 2010 to April 2011 by recording the numbers caught on sticky bases (180 × 190 mm) placed inside Desire® pheromone traps containing 3 µg of synthetic ALCM sex pheromone in a rubber septum lure. *Sejanus albisignata* were monitored at the same frequency over the same period by recording numbers trapped in yellow sticky traps (180 × 190 mm) hung vertically on apple trees. Trapping results were obtained from one ALCM pheromone trap and one yellow sticky trap each at two orchards on the Waimea plains near Richmond and three orchards near Motueka. Results are presented for the 2010-11 fruit season to illustrate the relationship between the seasonal abundance of ALCM and *S. albisignata*.

Statistics

The numbers of infested leaves in the field trial were analysed using a generalised linear model with residuals following a Poisson distribution and a log link, and with treatment fitted as a factor (i.e. *S. albisignata* introduced or not). The numbers of larvae in each treatment in both studies were analysed using analysis of variance on square root transformed data. The number of larvae per rolled leaf in each treatment was derived by dividing the number of larvae by the number of rolled leaves, unless there were no rolled leaves, in which case this variate was taken as zero.

All analyses were undertaken in R 2.14.0 (2011). Back-transformed values are presented in Table 1. Residual plots were checked for the presence of outliers and to confirm the validity of the analysis assumptions.

Table 1 Mean numbers of ALCM-infested apple leaves per shoot, ALCM larvae and larvae per rolled leaf from the field study, and mean number of larvae from the laboratory study, for the treatment (*S. albisignata*) and control. The 95% confidence intervals are shown in parentheses.

	Field trial			Laboratory trial
	Rolled leaves	Larvae	Larvae/rolled leaf	Larvae
Control	2.07 (1.53-2.8)	22 (13-33.3)	11.6 (6.7-17.9)	17.3 (6.1-34.3)
<i>S. albisignata</i>	0.87 (0.54-1.38)	2.3 (0.2-6.8)	1.6 (0.2-4.4)	5.0 (0.3-15.6)

RESULTS

Laboratory trial

Although, on average, there were fewer ALCM larvae in the ten pottles with *S. albisignata*, there was considerable variation between pottles and the difference was not statistically significant ($P=0.129$) (Table 1). Midge predation occurred within 3 days of the predator introductions. After this time, all the predators had died and the shoots were beginning to wilt despite being in a nutrient solution. Because the shoots wilted so quickly, this may have precluded infestation by ALCM larvae so numbers of infested leaves were not assessed.

Field trial

Adding *S. albisignata* nymphs to bags significantly reduced the number of rolled leaves ($P=0.004$), the total number of ALCM larvae ($P<0.001$) and the number of ALCM larvae per leaf ($P=0.001$) (Table 1). Predator survival in the bagged shoots in the field was better than that of adults in the pottles in the laboratory.

Monitoring ALCM and *S. albisignata*

Trap counts of ALCM males and *S. albisignata* followed a similar seasonal pattern, with peaks occurring in December and February (Figure 1).

Figure 1 Numbers of apple leafcurling midge (ALCM) males caught (catch per trap per day) in pheromone traps averaged over five orchard sites, and the numbers of *Sejanus albisignata* caught on sticky traps at the same five sites during the 2010-11 fruit season in Nelson.

Large numbers of ALCM males were captured in the pheromone traps. Yellow sticky traps captured low numbers of *S. albisignata* but provided an indication of seasonal peaks that are consistent with previous observations of *S. albisignata* abundance on apple shoots (P.W. Shaw, unpublished data).

DISCUSSION

In both feeding trials, there were fewer midge larvae on shoots where *S. albisignata* adults and immature stages were present. However, the laboratory results were compromised by early mortality of *S. albisignata* adults and wilting of shoots, and the numbers of larvae would probably have been reduced further if predator survival and shoot quality had been maintained. The field trial, which had no obvious problems with shoot quality and *S. albisignata* survival, provided more robust data and clearly indicated the potential for predation by *S. albisignata* to reduce larval numbers and leaf infestations. It is likely that egg predation also contributed to the reduction in the numbers of infested shoots and midge larvae, although more detailed feeding studies are required to determine the predator's preferences for ALCM eggs and larvae.

Generalist predators can concentrate their feeding activity on a temporarily abundant prey species, potentially stabilizing prey populations (Murdoch 1969). This might occur with ALCM, as observations over several seasons (illustrated with data from the 2010-11 season, see Figure 1) indicate that seasonal peaks of ALCM male flight activity, which immediately precedes mating and egg laying, broadly coincided with peak numbers of *S. albisignata*, so potentially providing the predator with abundant food. However, the present studies were non-choice tests because the predator was confined with one prey species, and its functional response might differ when additional prey species are present. Nevertheless, the present results support previous anecdotal observations by demonstrating the potential for predation of ALCM by *S. albisignata*.

Sejanus albisignata is commonly found in commercial apple orchards in New Zealand

and the present data suggest it probably makes an important contribution to biological control of ALCM, along with other natural enemies, such as the egg parasitoid *Platygaster demades* (Hymenoptera: Platygasteridae).

ACKNOWLEDGEMENTS

We wish to thank Peter Alspach for his help with statistical analyses. The Ministry of Science and Innovation provided funding for this research (Contract CO6X0301).

REFERENCES

- Charles JG 1998. The settlement of fruit crop arthropod pests and their natural enemies in New Zealand: an historical guide to the future. *Biocontrol News and Information* 19: 47N-58N.
- Charles JG 2008. Insect pest control by natural enemies – an integral part of horticulture's future. In: Butcher MR, Walker JTS, Zydenbos SM ed. *Future challenges in crop protection: repositioning New Zealand's primary industries for the future*. New Zealand Plant Protection Society Inc., Hastings, New Zealand. Pp. 117-127.
- Collyer E 1964. Phytophagous mites and their predators in New Zealand orchards. *New Zealand Journal of Agricultural Research* 7: 551-568.
- Dumbleton LJ 1938. Notes on a new mired bug. *New Zealand Journal of Science and Technology* XX: 58B-60B.
- Murdoch WW 1969. Switching in General Predators: Experiments on Predator Specificity and Stability of Prey Populations. *Ecological Monographs* 39: 335-354.
- R Development Core Team 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>.
- Schenk D, Bacher S 2002. Functional response of a generalist insect predator to one of its prey species in the field. *Journal of Animal Ecology* 71: 524-531.

- Shaw PW, Bradley SJ, Walker JTS 1997. The impact of early season insecticides in an integrated fruit production programme on apple. Proceedings of the 50th New Zealand Plant Protection Conference: 283-287.
- Shaw PW, Wallis DR, Rogers DJ 2003. The impact of early season insecticides on biological control of apple leafcurling midge (*Dasineura mali*). New Zealand Plant Protection 56: 164-167.
- Walker JTS, Hodson AJ, Wearing CH, Bradley SJ, Shaw PW, Steifel HE, Batchelor TA 1997. Integrated fruit production for New Zealand pipfruit: Evaluation of pest management in a pilot programme. Proceedings of the 50th New Zealand Plant Protection Conference: 258-263.
- Wearing CH, Attfield B 2002. Phenology of the predatory bugs (Heteroptera: Anthocoridae) and *Sejanus albisignata* (Heteroptera: Miridae) in Otago, New Zealand, apple orchards. Biocontrol Science and Technology 12 (4): 481-492.
- Wearing CH, Charles JG 1989. *Cydia pomonella* (L.), codling moth (Lepidoptera: Tortricidae). In: Cameron PJ, Hill RL, Bain J, Thomas WP ed. A Review of Biological Control of Invertebrate Pests and Weeds in New Zealand 1874 to 1987. Technical communication, CAB International Institute of Biological Control 10. CAB International, Wallingford, UK. Pp. 161-169.