

EFFECT OF TEBUFENOZIDE ON *ENCARSIA CITRINA*, AN ARMoured SCALE PARASITOID

A.R. TOMKINS, C. THOMSON and D.J. WILSON

*The Horticultural & Food Research Institute of New Zealand Ltd
Ruakura Research Centre, Private Bag 3123, Hamilton*

ABSTRACT

Laboratory bioassays determined the effect of tebufenozide on pre-imaginal stages of *Encarsia citrina* a key parasitoid of the armoured scale insects infesting kiwifruit. Bioassays were conducted by dipping potatoes which were infested with second instar greedy scale (*Hemiberlesia rapax*) parasitised by *E. citrina* in insecticide solutions. Tebufenozide had no effect on greedy scale whereas parasitism generally prevented its further development past the second instar. No adverse effect of tebufenozide was found on the parasitoid. The potential for inclusion of tebufenozide in the kiwifruit Integrated Pest Management system (Kiwigreen) is discussed.

Keywords: kiwifruit, greedy scale, *Hemiberlesia rapax*, parasitoid, *Encarsia citrina*, tebufenozide

INTRODUCTION

Armoured scale insects (greedy scale (*Hemiberlesia rapax*), latania scale (*Hemiberlesia lataniae*) and oleander scale (*Aspidiotus nerii*)) are key pests of kiwifruit grown in New Zealand. Until recently, controlling these and the other pests of kiwifruit relied solely on calendar spray programmes involving regular application of insecticides, mainly organophosphates or synthetic pyrethroids. However, since the 1991/92 season a rapidly increasing proportion of the national crop has used a first stage Integrated Pest Management (IPM) system commonly called Kiwigreen. At present, Kiwigreen still depends solely on insecticides, and the timing of them, to achieve pest management. In the next stage of development of Kiwigreen, the range of control techniques used to manage pests will be broadened with greater use of biological control.

Armoured scale insects are attacked by a range of parasitoids (Tomkins 1994), with a common species being the endoparasitoid *Encarsia citrina* (J. Charles pers. comm.). However, these parasitoids are absent or only present at very low levels on kiwifruit vines which have been regularly sprayed with broadspectrum insecticides (Tomkins 1992a, b, 1994). Some insect growth regulators are now available which provide good activity against scale insects (Tomkins *et al.* 1994) and other kiwifruit pests (Stevens and Steven 1994) and field trials indicate that scale insect parasitoids may be able to survive where some of these insecticides are used (Tomkins 1992a, b, 1994).

Tebufenozide is a new insect growth regulator which interferes with the activity of ecdysone, thereby adversely affecting insects during moulting. Previous studies have found a high level of activity against Lepidoptera (Walker *et al.* 1991; Stevens and Steven 1994) and low toxicity to pest natural enemies (Brown 1994) including predatory mites (Heller *et al.* 1992).

This paper reports on laboratory trials investigating the effect of tebufenozide on the parasitoid *E. citrina*.

METHODS

A laboratory bioassay was conducted to determine the effect of tebufenozide on *E. citrina* parasitising second instar greedy scale (*H. rapax*). Parasitised and unparasitised

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greedy scale were treated with four rates of tebufenozide (RH5992 20FLO) including an untreated control (Table 1), with the basic unit being a potato infested with approximately 50 greedy scale. The recommended use rate of tebufenozide is 6 g/100 litres.

Potatoes were infested with greedy scale crawlers which were allowed to settle and were then left to develop under controlled environment conditions (20°C, 55-75% RH and 16:8 photoperiod) until they reached the second instar. The potatoes were then individually placed in plastic pottles, fitted with gauze lids. In the parasitised treatments, 10 adult parasitoids were added to each pottle which was left for 2 days before they were removed. During this period, the adult parasitoids were provided with cotton wicks saturated with honey dissolved in water to help prolong their longevity.

Treatments were then applied by dipping potatoes into agitated solutions for 5 seconds, before air drying. Water was used as the control, with the spreader Multifilm (0.25 ml/litre) added to all treatments. The potatoes were returned to the pottles which were placed back under the same controlled environment conditions used prior to parasitism.

The scale insects were examined 35-39 days after tebufenozide treatment, when most greedy scale should have reached the third instar. Scale stage and mortality (and probable cause of mortality), parasitism, parasitoid stage (larvae, pupae, adult) and whether the adult parasitoid had emerged were recorded. Because emerged parasitoid adults immediately begin parasitising scale, the assessment was not left until all the adults emerged, as this may have resulted in an overlap of parasitoid generations.

All of the parasitised greedy scale from one replicate of all four treatments were destructively examined using a slightly modified version of Sandlant's (1978) technique. Scale insect bodies were cleared by placing them in Essig's fluid for at least 1 week prior to heating at 60°C for 3 h which also stained any parasitoid stages present. Specimens were slide-mounted and the host body contents ruptured with a dissecting pin before microscopic examination. The detailed examination served as a check for a simpler examination conducted visually for the remaining replicates, 39 days after tebufenozide treatment.

Some of the parasitised greedy scale had reached the older immature third instar stage and these insects were left for a further 27 days to see whether they would continue their development and produce crawlers.

Analyses were made with the treatments that were, or were not, exposed to parasitoids pooled, or compared separately using generalised linear models with a logit link and errors proportional to those for a binomial model. Staining and the associated preparation of greedy scale confirmed that simpler visual examination could detect parasitism and so data from the mounted and visually examined scale insects were pooled.

RESULTS AND DISCUSSION

At the time of the first assessment, 35-39 days after tebufenozide treatment, the majority of the greedy scale from the control which had not been exposed to parasitism, had reached the older immature third instar stage (Table 1).

Tebufenozide used alone at the rates tested had no effect on greedy scale. This was shown by the similar age structure and mortality (Table 1) of the greedy scale on the unparasitised control and tebufenozide treatments. A higher proportion of the greedy scale on treatments which had been exposed to parasitism were still in the second instar 35-39 days after tebufenozide treatment (Table 1). Although the level of mortality in parasitised and unparasitised treatments were similar for the young immature third instar greedy scale, a distinct difference was found between the two sets of treatments for the second instars. Namely, whilst most second instars on treatments which had not been exposed to parasitism were dead, 58-78% were still alive on the parasitised treatments. No significant differences were found in the level of greedy scale mortality between those treatments which had been exposed to parasitism for both stages of greedy scale.

The proportion of greedy scale that developed through to the older immature third instar stage was significantly higher ($P < 0.01$) on the unparasitised than parasitised treatments (Table 1). This was due to the parasitoid preventing or delaying the development of the scale in the second instar, with only a few parasitised scale reaching the third instar. None of these parasitised, older immature third instar scale reached maturity and produced crawlers.

TABLE 1: Percentage (\pm SE) of total greedy scale in different instars 35-39 days after treatment with tebufenozide.

Treatment (g ai/litre)	Scale insect stage (instar)					
	Second		Young immature third		Older immature third	
	Live	Dead	Live	Dead	Live	Dead
Not exposed to parasitism						
0	0	4.3	7.0	13.5	75.0	0
0.03	0	7.8	3.2	17.4	61.3	9.3
0.06	0	10.6	8.9	18.1	62.5	0
0.12	0.5	5.0	4.9	15.8	73.9	0
Exposed to parasitism						
0	52.3	17.2	2.7	5.4	22.4	0
0.03	25.9	18.9	7.0	11.0	37.2	0
0.06	41.0	11.6	3.8	10.0	33.6	0
0.12	54.9	17.3	2.8	3.0	22.0	0

When greedy scale were exposed to *E. citrina* some scale insects were not parasitised. Of those greedy scale which were parasitised, the majority were still in the second instar 35-39 days after treatment with tebufenozide, with a single parasitised young immature greedy scale found on a control replicate. No adverse effect of tebufenozide treatments was found on the proportion of second and older immature third instar greedy scale parasitised by *E. citrina* (Table 2). Older immature third instars from the potatoes treated with the middle rate of tebufenozide had a significantly higher rate of parasitism than the other treatments. The proportion of parasitised greedy scale which reached the older immature third instar stage was higher on all tebufenozide treatments (ie. 8, 23 and 5% respectively for the 0.03, 0.06 and 0.12 g/litre treatments) than the control (3%), but this difference was not significant.

TABLE 2: Percentage (\pm SE) parasitism of greedy scale instars, 35-39 days after treatment with tebufenozide.

Treatment (g ai/litre)	Scale insect stage (instar)	
	Second	Older immature third
0	72.9 (5.8)	8.0 (5.7)
0.03	52.8 (8.2)	5.5 (3.7)
0.06	74.0 (6.6)	34.7 (8.2)
0.12	70.5 (6.0)	11.6 (6.9)
Significance ¹	NS	*

¹ NS = not significant, * = $P < 0.01$.

At the time of the assessment, most of the *E. citrina* were pupating although some had reached the adult stage and had chewed through the scale cap and emerged (Table 3). No significant differences were found between treatments in the proportions of the *E. citrina* found in different stages of the parasitoid.

No evidence was found to suggest that tebufenozide treatments adversely affected parasitism by *E. citrina* as would have been shown by a reduced rate of parasitism or delays or death of the parasitoid in one of its own stages of development. Tebufenozide used to manage leafrollers, does therefore appear to be compatible with the use of *E. citrina* to help manage greedy scale, which may assist the further development of the kiwifruit IPM system.

TABLE 3: Percentage (\pm SE) of *Encarsia citrina* in different stages found in second instar greedy scale 35-39 days after treatment with tebufenozide following exposure to parasitism.

Treatment (g ai/litre)	Third instar	Parasitoid stage Pupae	Emerged
0	3.5 (2.3)	69.5 (6.6)	27.0 (7.9)
0.03	10.5 (5.7)	48.6 (10.6)	41.0 (12.9)
0.06	11.5 (4.6)	52.3 (8.2)	36.2 (9.8)
0.12	3.6 (2.4)	47.7 (7.3)	48.6 (9.1)
Significance ¹	NS	NS	NS

¹ NS = not significant.

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