# COMPARING ARMOURED SCALE INSECT (*HEMIBERLESIA* SPP.) POPULATIONS ON MALE AND FEMALE *ACTINIDIA CHINENSIS* VINES

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## ABSTRACT

The wood and leaves of *Actinidia chinensis* 'Hort16A' and two male pollinisers, *A. chinensis* 'Meteor' and *A. chinensis* 'Sparkler', from commercial kiwifruit orchards were sampled for the presence of armoured scale insects during winter 2007 and summer 2008/09. The numbers and species of scale insect were recorded. 'Meteor' had high armoured scale insect populations on its wood, with approximately 10 times more armoured scale insects than 'Sparkler' or 'Hort16A'. The leaves of 'Hort16A' vines adjacent to 'Meteor' vines had 44% more armoured scale insects and were 30% more likely to be infested by scale insects than the leaves of 'Hort16A' vines adjacent to 'Sparkler' vines. The implications of these findings for armoured scale insect control on 'Hort16A' fruit are discussed.
**Keywords:** armoured scale insects, kiwifruit, sampling, latania scale, greedy scale, host plant resistance.

## INTRODUCTION

The kiwifruit IPM system KiwiGreen® has been used as the industry standard for insecticide spray decisions since 1997. Spraying of vines during the period between fruit set and harvest is based upon an assessment of the proportion of leaves with live armoured scale insects. This system was developed in the early 1990s on *Actinidia deliciosa* (A Chev.) C.F.Liang et A.R. Ferguson 'Hayward', the only commercial kiwifruit cultivar at the time. The system was adopted for use on *Actinidia chinensis* Planch 'Hort16A' when that species was first commercialised in 1997 and has been used since then without further validation.

A recent survey of armoured scale insect incidence on kiwifruit leaves and fruit (Edwards et al. 2008) showed that latania scale (*Hemiberlesia lataniae* Signoret) had displaced greedy scale as the dominant species on 'Hayward' vines since the last survey published 20 years ago (Berry et al. 1989),. However, greedy scale (*Hemiberlesia rapax* Comstock) remained the dominant armoured scale insect species on 'Hort16A' vines and was the only armoured scale insect species found on 'Hort16A' fruit.

Experimental studies of the susceptibility of 'Hort16A' and 'Hayward' to both armoured scale insect species has shown that latania scale cannot develop on 'Hort16A' bark (Hill et al. 2007) and therefore cannot maintain a population on vines during the dormant period. The discovery that about 30% of armoured scale insects on 'Hort16A' leaves were latania scale (Edwards et al. 2008) led to speculation that this species was migrating onto 'Hort16A' leaves from a source external to the vine. The two possible candidate sources were adjacent male vines or orchard shelter trees. 'Hort16A' orchards have two main pollinisers, 'Meteor' and 'Sparkler'. They differ in flowering phenology as 'Meteor' is earlier than 'Sparkler' by approximately 1-2 weeks. A new late flowering variety, 'Bruce', was released 3 years ago to replace 'Sparkler'.

This paper (1) compares the susceptibility to scale insect attack of the two main common commercial *A. chinensis* pollinisers ('Meteor' and 'Sparkler') with 'Hort16A', (2) measures the influence of male vines upon the scale insect numbers present on leaves of adjacent 'Hort16A' vines, and (3) examines the possible impact of differential genotype susceptibility to infestation by scale insects on the accuracy of the KiwiGreen® scale monitoring system.

## METHODS

### Sampling *A. chinensis* male wood

During August 2007, samples of pruning wood from *A. chinensis* 'Hort16A', 'Meteor' and 'Sparkler' vines were taken from six commercial 'Hort16A' orchards in Te Puke and Opotiki. In the laboratory, the wood was cut into sections according to age, determined by evidence of yearly budbreak, and examined for the presence of scale insects under a binocular microscope (10×–25× magnification). Armoured scale insects were recorded as live or dead, adult or immature. Adults were identified to species using the morphological characters in Morales (1988). Base plates (the remains of detached scales) were also recorded. The area of the wood sampled in each annual age category was estimated by measuring its length (± 1 mm) and diameter (± 0.1 mm) at either end using Vernier callipers.

### Sampling *A. chinensis* male and adjacent 'Hort16A' leaves

Ten orchards, with 'Hort16A' pergola blocks, between Te Puke and Opotiki were selected. At each orchard, five 'Meteor' and five 'Sparkler' vines were chosen at random from the middle of the block. Leaf sampling was carried out between 11 March and 2 April 2008. Fifty mature leaves were picked without bias from each male and from the immediately adjacent 'Hort16A' vines in the adjacent rows. Three of the orchards had 'strip males' (alternate rows of male and female vines). The remaining seven orchards grew males arranged in a matrix pattern throughout the blocks such that every 'Hort16A' vine had one neighbouring male vine.

The data from the male wood samples were analysed to compare the density of scale insects on the three *A. chinensis* cultivars over five annual age classes of wood (current year to 4 years old). The leaf data were analysed to compare the infestation rate of each of the two armoured scale insect species on male leaves and on the leaves of adjacent 'Hort16A' vines. Paired t-tests comparing data from the two male polliniser samples from each of the 10 orchards were carried out using Minitab (Release 15.1).

## RESULTS

### Scale insects on *A. chinensis* wood

The total area of bark sampled varied from 237 $cm^2$ (4-year-old wood) to 618 $cm^2$ (current season's wood). There was no difference in the results from orchards with strip males or matrix males. One-year-old bark had higher armoured scale insect densities than the current season's bark, and scale insect density declined as bark aged from 1-year-old to 4-year-old. Densities of scale insects on 'Meteor' were an order of magnitude higher than those on either 'Sparkler' or 'Hort16A' (Fig. 1). The high armoured scale insect incidence on 'Meteor' bark was made up predominantly (87%; n=1584) of latania scale. Most armoured scale insects found on 'Sparkler' bark were also latania scale (74%; n=155), whereas those on 'Hort16A' bark were predominantly greedy scale (93%; n=256).

### Sampling 'Hort16A' and male vine leaves

The leaves from 'Meteor' vines held over five times more scale insects than leaves from 'Sparkler' vines (Table 1). Greedy scale was the dominant adult scale insect on 'Sparkler' (87%), but there were approximately equal numbers of adult greedy and latania scale on 'Meteor' (55% greedy). The leaves of 'Hort16A' vines adjacent to 'Meteor' vines held 44% more scale insects and were 30% more likely to be infested than 'Hort16A' vines adjacent to 'Sparkler' vines (Table 1). There were approximately four times more adult greedy scale than adult latania scale on the 'Hort16A' leaves and there was 42% more adult greedy scale on the leaves of 'Hort16A' vines adjacent to 'Meteor' vines than on 'Hort16A' vines adjacent to 'Sparkler' vines (Table 1).

**TABLE 1: Armoured scale insect incidence on five male vines and their adjacent female vines. Values are total numbers for 250 leaves from male vines or 500 leaves from female vines, which were sampled at each orchard. These are presented as means ± standard errors for the 10 orchards. The results of paired t-tests (9 d.f.) are in the last column.**

| | 'Meteor' | 'Sparkler' | P-value |
|---|---|---|---|
| **Scale insects on male vines** | | | |
| Total scale insects on male vines | 206.9±61.8 | 37.0±12.5 | P=0.02 |
| % of adult scale insects that were greedy scale | 55% | 87% | P=0.06 |
| **Scale insects on adjacent 'Hort16A' vines** | | | |
| No. infested leaves on adjacent 'Hort16A' vines | 115.7±16.2 | 89.0±14.7 | P=0.01 |
| Total insects | 203.5±34.1 | 141.1±32.5 | P=0.03 |
| Adult latania scale | 7.6±2.3 | 5.6±1.9 | P=0.23 |
| Adult greedy scale | 35.0±7.5 | 24.5±6.6 | P=0.05 |
| % of adult scale insects that were greedy scale | 82% | 81% | P=0.79 |

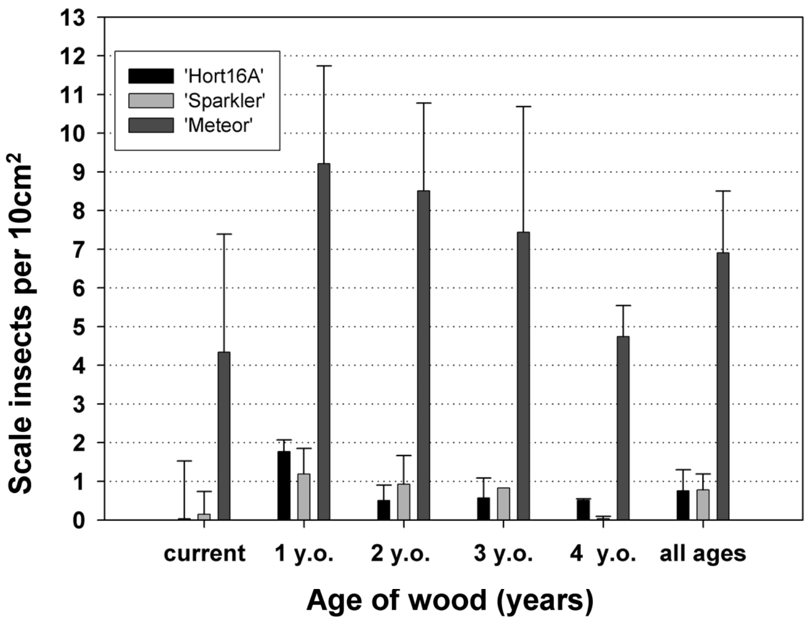


**FIGURE 1: Mean (±SE) density of scale insects (numbers/10 cm$^2$ of bark) from wood aged less than one year (current) to 4-year-old (4 y.o.) from female 'Hort16A', and male ('Sparkler' and 'Meteor') kiwifruit vines. Values are the mean of six orchards.**

## DISCUSSION

This is the first study to compare the susceptibility of male and female kiwifruit varieties to attack by armoured scale insects. The kiwifruit male 'Meteor' had much larger resident scale insect populations on bark than did the other male, 'Sparkler', or the female 'Hort16A'. 'Hort16A' vines adjacent to 'Meteor' vines had larger scale insect populations on their leaves in March than those adjacent to 'Sparkler' vines. This is probably attributable to the migration of scale insect crawlers from the large populations on adjacent 'Meteor' vines. Latania scale is a recent coloniser of kiwifruit orchards in the Bay of Plenty and appears still to be increasing in population size and dominance, displacing greedy scale from established 'Hayward' vines (Berry et al. 1989; Edwards et al. 2008). Most of the scale insects on 'Meteor' bark were latania scale (87%) , but over half of those on 'Meteor' leaves (55%, Table 1) were greedy scale. This is probably because of different species population mixtures between the vines, but as different vines were sampled for bark and leaves, further sampling is required to verify this.

The much greater susceptibility of 'Meteor' bark to scale insect infestation suggests that it may be necessary to adopt special scale insect control measures for this cultivar. For example, selective hand-gun applications of insecticide to these males during the dormant period may be warranted. In addition, the removal of as much 'Meteor' wood as possible immediately following fruit-set, when male pruning is routinely carried out, would minimise the risk of armoured scale insect transfer from 'Meteor' to 'Hort16A'. Removal of 'Meteor' vines from orchards is not an option because of its earlier flowering compared with 'Sparkler'. However, priority should be given to finding alternative pollinisers to 'Meteor' with the same flowering phenology.

The implications of these findings for KiwiGreen sampling are complex, as the significance of the migration of armoured scale insects from the highly susceptible 'Meteor' vines onto 'Hort16A' vines depends upon which species is involved. Although latania scale and greedy scale are both highly polyphagous and closely related taxonomically (Miller & Davidson 2005), they have been shown to respond very differently when settled on different cultivars of kiwifruit (Hill et al. 2007). Latania scale cannot develop on 'Hort16A' bark or fruit, but is prevalent on leaves (Edwards et al. 2008; M.G. Hill, unpubl. data), whereas greedy scale grows readily on any above-ground part of 'Hort16A'. Thus, if 'Meteor' vines harbour large populations of greedy scale, these can move to adjacent 'Hort16A' vines and infest the fruit. If, however, the 'Meteor' armoured scale populations are predominantly latania scale, as was the case for the bark sampling in this study (87% latania scale), the fruit will not be at risk of increased infestation. However, in this case, the leaves of adjacent 'Hort16A' will become infested with latania scale, thereby overstating the likely risk of armoured scale pressure on fruit during KiwiGreen® monitoring, and leading to unnecessary spraying.

This situation cannot be easily amended by instructing pest monitoring centre staff to identify the two scale insect species during KiwiGreen® monitoring, as accurate identification is only possible in the adult stage. When KiwiGreen® leaf monitoring takes place from January to March, a high proportion of the scale insects on kiwifruit leaves will be immature. Fortunately, armoured scale insect populations change relatively slowly, and the proportion of the two species in the population on any vine will not change radically from one year to the next. Thus, the best way of assessing the risk of armoured scale insect populations on 'Meteor' vines is to determine the species composition by taking a late season sample of leaves or a dormant season sample of wood. Once the proportions of the two scale insect species on the male vines are known, the risk to the following season's crop posed by the actual numbers of insects can be assessed.

Over the last 20 years, latania scale has spread throughout the kiwifruit growing regions of the North Island and has substantially displaced greedy scale (Berry et al. 1989; Edwards et al. 2008). The exact mechanism for this competitive displacement is unknown. Ecological studies of armoured scale insect species competition in hemlock (*Tsuga canadensi* Carriere) attribute the displacement of *Tsugaspidiotus tsugae* (Marlatt) by *Fiorinia externa* Ferris to competitive exclusion resulting from its ability to occupy the limited number of preferred settlement sites on hemlock needles earlier in the season (McClure 1980). Thus, one strategy for coping with high levels of greedy scale on 'Meteor' vines could be to seed populations of latania scale artificially onto the bark to enhance the displacement process. While contributing to a solution for the fruit infestation problem, this would not prevent latania scale from building up on 'Hort16A' leaves, leading to false KiwiGreen® monitoring results, as the numbers of scale on leaves are meant to reflect the risk of scale attacking the fruit (Anon. 2001).

To overcome the problem of erroneous KiwiGreen® monitoring results caused by scale insects moving from 'Meteor' to 'Hort16A', a greater level of understanding of the distribution of fruit and leaf infestation within both male and female vines is needed, and improved sampling methods developed. Further work is under way to achieve this. Future potential pollinisers should be screened for scale insect susceptibility before their release.

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