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The Comparative Efficacy of Two Traps for Monitoring Parasitoids of the Vine Mealybug *Planococcus ficus* Signoret (*Hemiptera*: *Pseudococcidae*) in the Western Cape Province, South Africa

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Abstract

Three parasitoids (*Anagyrus pseudococci, Leptomastix dactylopii* and *Coccidoxenoides perminutus*) of the vine mealybug, *Planococcus ficus*, were monitored using both yellow sticky traps and yellow delta traps, the latter baited with lures containing the female pheromone of *P. ficus*. The yellow sticky trap is usually used to monitor parasitoids and predators whilst the yellow delta trap is used to monitor male *Planococcus ficus*. All three parasitoid species showed positive phototaxis to the traps. There was no significant difference in the total number of parasitoids caught on the yellow sticky traps and yellow delta traps between the areas except at Morgenster at P=0.05. The yellow delta traps and yellow sticky traps showed different peak reflectances of 42.96% and 30.58%, respectively. The yellow delta traps (12.5 kWh/m^2) were more efficient than yellow sticky traps (4.2 kWh/m^2) in attracting parasitoids at low sunlight radiation. Generally, the results showed that the yellow delta trap with the pheromone lure used to monitor male mealybugs could also be used to monitor the natural enemies of the female *P. ficus*.

Keywords: Yellow sticky trap; Yellow delta trap; Parasitoids; Wavelength

Introduction

The methods used by entomologists to monitor insect numbers are often impractical and unsuitable for insects of economic importance on farms where the time and expertise for this is limited. Therefore, the easiest and most efficient method must be found to sample a given species or life stage of species [1,2]. In this regard, the various kinds of traps available can be very useful [3,4] used yellow sticky traps to monitor populations of the citrus thrips, *Scirtothrips citri* (Moulton) (Thysanoptera: Thripidae) which hitherto had been done by visual inspection [5,6] found that the whitefly, *Trialeurodes vaporariorum* (Westwood) and the coccinellid *Harmonia axyridis* (Pallas) are respectively more attracted to yellow sticky traps than sticky traps with a blue hue [7] also used yellow sticky traps to monitor the grape berry moth *Endopiza viteana* Clemens [8] found yellow delta traps superior to white delta traps and yellow square traps in assessing the numbers of the male Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), (*Diptera*: *Tephritidae*). Some natural enemies of California red scale, *Aonidiella aurantii* (Maskell), (*Hemiptera*: *Diaspididae*) [3,9-11] are positively phototactic to yellow-coloured surfaces. The propensity of parasitoids to orientate towards yellow-coloured surfaces could be used in studying aspects of their population dynamics, such as population levels at specific times, that would improve pest management practices. In this regard yellow sticky traps that attract and catch them can be very useful.

Planococcus ficus (Signoret) (*Hemiptera*: *Pseudococcidae*) is a mealybug of tropical and sub-tropical regions of the world which became established in vineyards of the Western Cape Province in South Africa and became an important phytosanitary pest [12-14]. It has caused considerable economic losses in California, the Middle East, South America, Pakistan, South Africa and the Mediterranean [15]. The mealybug produces wax secretions, egg sacs and honeydew, which render the grapes unmarketable [13] Furthermore, at very high infestation levels it can cause the grapes to wither, attain both poor taste and an unflattering colour [12,13,16]. Yellowing of the leaves and premature leaf drop may occur [13,14]. The vine may become weakened, plant vigour could decline and as a result its lifespan shortened [12-15].

In South African vineyards, *P. ficus* is mostly parasitized by *Anagyrus pseudococci* (Girault), (*Hymenoptera: Encyrtidae*), *Leptomastix dactylopii* (Howard) (*Hymenoptera: Encyrtidae*) and *Coccidoxenoides perminutus* (Timberlake) (*Hymenoptera: Encyrtidae*) [17-21]. The aim of this work was to establish whether yellow delta traps with male mealybug lure presently used by farmers to monitor male mealybug numbers (referred to as yellow delta traps in this study), could also be used to assess parasitoid numbers by comparing the numbers of parasitoids caught on yellow sticky traps and yellow delta traps.

Materials and Methods

Four vineyards (± 3 ha each) with a history of parasitoid presence (Mgocheki & Addison 2009) were selected as trial sites: Nietvoorbij, Stellenbosch (33° 91´S; 18° 85´E; altitude 149 m), Groot Constantia, Constantia (34° 03´S; 18° 42´E; altitude 100 m), Backsberg, Paarl (33° 83´S; 18° 91´E; altitude 242 m), and Morgenster, Durbanville (33° 83 ´S; 18° 61´E; altitude 248 m). Parasitoid numbers were assessed by placing one yellow sticky trap Agribiol® (200 mm × 100 mm) without pheromone lure per hectare in each of the trial sites at a height of 1.0 m from the soil surface. A second assessment of the parasitoid numbers was made by using Chempac™ yellow delta traps™ (110 mm × 200 mm × 280 mm) containing a removable white sticky pad with female *P. ficus* Chempac™ pheromone lures, also at a density of one per hectare.

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The yellow delta traps were also placed at a height of 1.0 m. The yellow delta traps and yellow sticky traps were placed 30 m apart in the same row in the centre of each hectare. All traps were placed in the centre of the vineyard to avoid potential edge effects [7]. The traps were inspected fortnightly for parasitoids from September 2005 to August 2008. At every inspection the yellow sticky traps and removable sticky insert of the delta traps were removed and replaced with new ones. The lures were replaced every four weeks. Traps were taken to the laboratory and, aided by a microscope; the species were identified and counted [22].

To obtain an estimate of similarity in the colour of the traps, the spectral reflectance over the UV-to-visible spectrum range (300-700 nm) was determined, using an Ocean Optics (Dunedin, Florida, USA) S2000 spectrometer and Ocean Optics DT-mini deuterium tungsten halogen light source (200-1100 nm). Readings were taken through a fibre-optic reflection probe (UV/VIS 400 µm). The probe was held at 45 and about 5 mm from a cut-out portion of each trap with a surface area of 1 cm^2 [23]. Only new traps were used.

Data Analysis

A randomized experimental layout with a split plot design, with treatment and season as main factors, was used in the trials and species as sub-plot factor. The data were analysed using SAS version 9.2 [24]. Data for the four different sites were combined and the logit transformed data were subjected to an Analysis of Variance (ANOVA) to determine effects of area (A), treatment (T), season (S), species (Sp) and the interactions between these factors on the trap catch numbers. Student's t-Least Significance Difference was calculated at the 5% significance level to compare treatment means [25].

Results

There was no significant difference in the total number of parasitoids trapped between the four areas and the two treatments (sticky traps and delta traps) (Table 1). There were, however, significant differences in trap catch numbers between seasons and also species of parasitoids (Table 1).

At Morgenster and Groot Constantia more parasitoids were trapped in autumn than in summer (Figure 1).

The yellow delta traps and yellow sticky traps placed at the same heights showed no significance differences in the trap catch numbers of the parasitoids (Figure 2). There was no significant difference in the total number of parasitoids (all species) trapped at the different areas (P=0.05), except at Morgenster where there were significantly more parasitoids (all species) 18.1 trapped by yellow sticky traps than 14.2 yellow delta traps (Figure 2).

The combined number of parasitoids trapped in the four trial sites showed a progressive decrease as the seasons changed and showed significant differences at P=0.05 (Figure 3). The yellow delta trap was more efficient than the yellow sticky trap in attracting parasitoids at low sun radiation (Figure 3).

The parasitoids *C. perminutus* and *L. dactylopii* appear to have equal inclination for yellow delta traps and yellow sticky traps as there was no significant difference between them in numbers captured (P>0.05) (Figure 4). The parasitoid *A. pseudococci*, however, had predilection for the yellow delta traps as trap catch numbers were significantly higher than for sticky traps at P=05 (Figure 4). The predominant parasitoid species trapped was *C. perminutus*, followed by *A. pseudococci* and *L. dactylopii*, with their numbers showing significant differences at P=0.05 (Figure 4).

Factor	Df	Mean Square	P. level
Area (A)	3	0.1271	0.9326
Rep (Area)	8	0.901	-
Treatment (T)	1	0.0017	0.9277
A*T	3	0.6887	0.0672
Rep (A*T)	8	0.1937	-
Seas on (S)	3	13.7064	<0.0001
A*S	9	0.2822	0.0107
T*S	3	0.7737	0.0003
A*T*S	9	0.2201	0.0417
Rep(A*T*S)	48	0.1018	-
Species (sp.)	2	226.0815	<0.0001
A* sp.	6	10.0893	<0.0001
Sp*T	2	8.4229	<0.0001
Sp*A*T	6	4.0721	<0.0001
Sp*S	6	14.0355	<0.0001
Sp*S*A	18	3.5805	<0.0001
Sp*S*T	6	2.8492	0.0021
Sp*S*A*T	18	1.8798	0.0016
Error	2720	0.8253	-
Corrected Total	2879	-	-

Table 1: Analysis of variance for the interaction of area (A) treatment (T), season (S) and species (Sp) for four areas (main sites) for the survey period from September 2005 to August 2008.

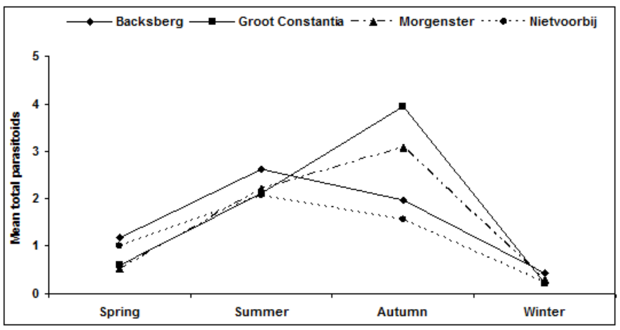

Figure 1: Mean of the combined trap catch numbers for *Coccidoxenoides perminutes, Anagyrus pseudococci* and *Leptomastix dactylopii* trapped per trial site per season from September 2005 to August 2008.

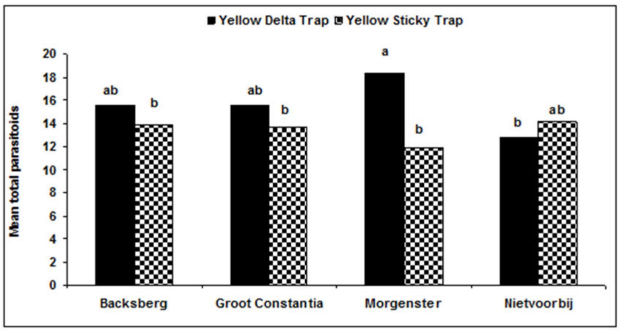

Figure 2: Mean of the combined trap catch numbers for *Coccidoxenoides perminutes, Anagyrus pseudococci* and *Leptomastix dactylopii* trapped per treatment per trial site from September 2005 to August 2008. Means with the same letters are not significantly different at P=0.05.

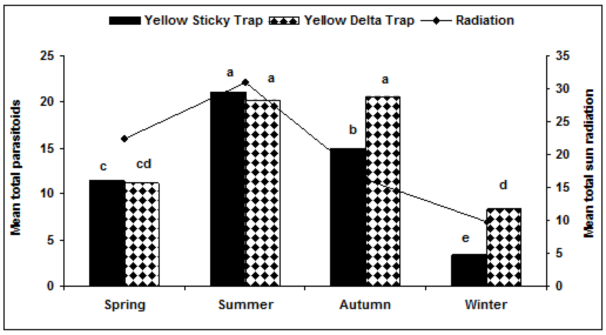

Figure 3: Mean of the combined trap catch numbers for *Coccidoxenoides perminutes, Anagyrus pseudococci* and *Leptomastix dactylopii* trapped per trial site per season from September 2005 to August 2008. (Sun radiation = kW/m^2).

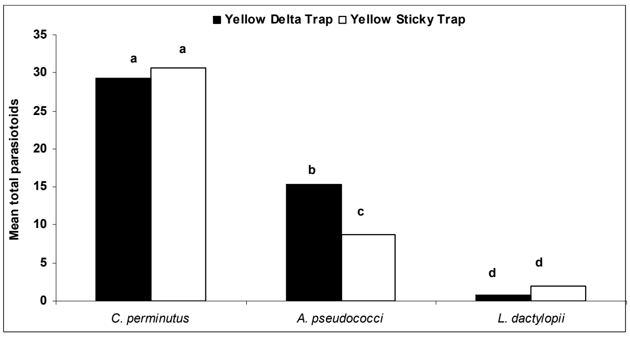

Figure 4: Mean total parasitoids captured with different traps from September 2005 to August 2008. Means with the same letters are not significantly different at P=0.05.

The reflection spectrum of the traps showed a peak wavelength at 560.58 nm and 524.91 nm and percentage reflectance of 42.96 and 30.58 for yellow sticky traps and yellow delta traps respectively (Figure 5). The two traps seem to have similarity in the purity/saturation (hue) of yellow colour with the yellow delta trap having slightly more purity than the yellow sticky trap. Furthermore, the percentage reflectance (which depicts the brightness or brilliance of the traps) showed that the yellow delta trap was brighter than the sticky trap (Figure 5). There was little reflection lower than 480 nm but rose in a sigmoid curve, tapering off as the wavelength approached the 600 nm (Figure 5).

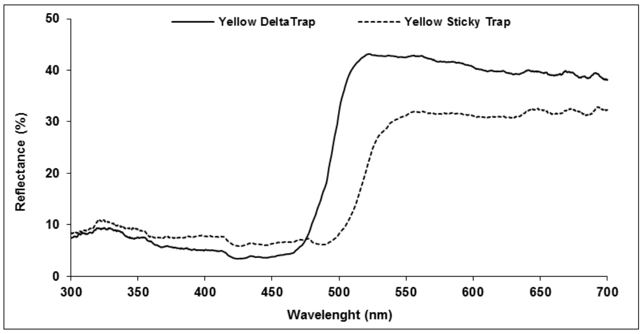

Figure 5: Spectral reflectance of yellow delta trap and yellow sticky trap.

Discussion

The finding that there was no significant difference with traps placed at the same height was in agreement with [3,26] who found that the mean number of the California red scale *A. aurantii parasitoids* trapped in yellow delta traps at the same heights were similar. Since the delta trap with the female mealybug lure did not attract significantly more parasitoids than the trap without the lure, it appears that the parasitoids might not use the female mealybug pheromone to locate the female mealybug. In this study, the parasitoid numbers peaked between summer and autumn, as was also observed by Ref. [21] who found the parasitoid numbers peaking mostly in March.

The higher number of parasitoids caught by the yellow delta traps during the low radiation months of autumn and winter (Figure 3) might be due to the low wavelength and high quality of the reflected light from the delta traps compared to the sticky trap. The latter had high wavelength but low peak reflectance (brightness) [27] attributed stronger thrips response to white traps relative to blue traps to the low peak reflectance (brightness) of blue light. The parasitoids *C. perminutus* and *L. dactylopii* appear not to be affected by the differences in the wavelength of the two traps in contrast to *A. pseudococci* which had a more positive response to the yellow delta trap (Figures 4 and 5). The observation that the three parasitoids appear to be enticed towards the yellow traps with peak reflectance between 500 nm and 600 nm is in agreement with [5,25,28-30] who found that yellow, being in the range of 500-600 nm, elicits positive responses from adult *Anthonomus grandis, Trialeurodes vaporariorum, Frankliniella occidentalis, F. occidentalisi* and *Thrips tabaci*, respectively.

Conclusion

The results show that a yellow pigment with a low wavelength of 525 nm and a high reflectance of 43% will be ideal for sampling the three parasitoids, *A. pseudococci, C. perminutus* and *L. dactylopii*. Furthermore, yellow delta trap with female mealybug baited lure used by researchers, farmers and extension workers to monitor the pest status of the vine mealybug could simultaneously be used to monitor how well the parasitoids are represented in the field.

A model for the number of parasitoids per yellow delta trap that could provide adequate biological control of specific mealybug numbers should be developed. However, this requires census data for several successive seasons.

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