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Entomology, Ornithology & Herpetology: Current Research

Research Article

Using Synthetic Pheromone and Degree-Days to Determine the Bio-Fix of the Grapevine Mealybug *Planococcus ficus* (Sig.) (*Hemiptera: Pseudococcidae*)

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ABSTRACT

Four vineyards in South Africa, two from the Coastal region and two inland, with mealybug infestation, were chosen for studies to determine a bio-fix for the vine mealybug *Planococcus ficus* (Sig.). Male mealybug numbers were monitored using delta traps baited with sex pheromone lures in each treatment plot. Old sticky pads and lures were removed and replaced with new ones every week in Spring and Summer and four weeks in Autumn and Winter, respectively. This was done for three seasons (2005, 2006 and 2007), from June to October. However, to determine the bio-fix, the males were counted every week from 08-08-2007 to 26-08-2007. The cumulative degree days (°D) obtained were lowest at Farm D farm and also the mealybugs had only three generations as compared to five on the other three farms. The males had higher cumulative numbers than the females throughout the census and therefore appear to be a better indicator as a warning tool. The work done showed that the bio-fix for male P. ficus at the four farms A, B, C, D and their surrounding areas was mid-September (i.e. 13th). However, since the female *P. ficus* lags behind two days to the male in their development to adult, the bio-fix should subsequently be on the 15th of September in relation to the area the data was collected.

Keywords: Delta trap; Vineyards; Warning tool; Sustained male flight.

ABBREVIATIONS:

COXI: Cytochrome Oxidase Subunit 1; GLRD: Grapevine Leafroll Disease ;QOL: Quality of Life

INTRODUCTION

The vine mealybug, *Planococcus ficus* (Sig.) (*Hemiptera: Pseudococcidae*), can cause great economic damage as it feeds on bunches, leaves, shoots, stems and roots of the plant. If the attack is severe, it could cause stunted growth or death to the vine if not managed [1]. Since the vines are grown in the same field for successive years, they are readily accessible to the mealybug. Mealybug infestation is one of the most serious problems for vine growers in South Africa [2-3], the Mediterranean Basin [4] and California.

[5]. Mealybug is considered the major vector of grapevine leafroll virus [6-7] and corky-bark diseases [8]. Mealybugs also affect crop quality and yield by excreting honeydew that promotes the growth of sooty mould fungi and reduces photosynthetic activity in leaves [9]. Furthermore, the presence of mealybug on export table grapes may lead to rejection of consignments [10].

Planoccocus ficus could have as many as three to five generations annually per season in the South African wine growing regions [11-12]. Detection of *P.ficus* male is best achieved with a sensitive monitoring tool such as sex pheromone-baited traps [12]. Forecasts based on adult capture in pheromone-baited traps are beneficial not only for *P. ficus* management but also for a number of pest species in various managed field crop systems. Adult trap capture in pheromone-baited traps is an early predictor of outbreaks of bertha armyworm, Mamestra configurata (Wlk.) (*Lepidoptera: Noctuidae*), in canola (*Brassica napus L.*) [13] and larvae damage of the potato tuberworm, Phthorimaea operculella (Zeller) (*Lepidoptera: Gelechiidae*) [14]. Pheromone-based monitoring of the European corn borer, Ostrinia nubilalis (Hübner) (*Lepidoptera: Pyralidae*), predicts oviposition and initiates monitoring for other life stages in corn

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Received: March 10,2021;**Accepted**: March 24,2021; **Published**: March 31,2021

Citation: Achiano KA (2021) Using Synthetic Pheromone and Degree-Days to Determine the Bio-Fix of the Grapevine Mealybug *Planococcus ficus* (Sig.) (*Hemiptera: Pseudococcidae*). Entomol Ornithol Herpetol. 10:241.

(*Zea mays L. (Poaceae)*) [15], while the method is also used to predict larval infestations in corn [16]. The predictive capacity of pheromone-baited traps that target the diamondback moth, Plutella xylostella (*Lepidoptera: Plutellidae*) has been tested in cabbage (*Brassica oleracea var. capitata*) [17-18].

The inclusion of temperature-based phenology model data into decision-making processes should greatly enhance the grower's ability to time chemical or biological intervention more efficiently [19]. It could also lead to considerable savings in money, labour, time, and in damage reduction by insects [19]. The ability to precisely identify optimum treatment times for *P. ficus* could also enable growers to use "softer", short-residual pesticides and thus avoid adverse effects on beneficial insects [20].

A bio-fix based on male capture in pheromone-baited traps has not been developed for *P. ficus* infesting vines in South African wine growing regions. The bio-fix for *P. ficus* was arbitrarily set by grape growers in South Africa as the 15th of August. The purpose of this study was to determine whether the capture of *P. ficus* male in synthetic sex pheromone-baited traps could be used to determine its bio-fix as the female is virtually sessile and first instars are difficult to observe on the vines.

MATERIALS AND METHODS

Four wine grape vineyards (± 3 ha each), with pine tree windbreaks on at least one side and with a history of mealybug infestation were chosen for studies. Each trial vineyard was divided into three blocks of approximately 1 ha each. A pheromone-baited trap was placed in the centre of each 1 ha subplot. The GPS coordinates for the farms were A (Chardonnay) (S 33° 49, 684 ′ E 18° 54, 917), B (Pinotage) (S 34° 01' 37,03" E 18° 25' 28,84") C (Chardonnay Blanc) (S 34° 5' 2.32" E 18° 53' 7.23,78") and D (Chardonnay) (S 26°43'43.16", E 27°04'47.71"). Chemicals to control or suppress mealybug numbers were applied at Farms A and D between August - September and January - February, respectively. A dormant treatment of chlorpyrifos, Dursban EC, 100-200 ml/100 L was applied one to two weeks before bud break at Farm D, while Farm A had a seasonal treatment of mevinphos, Phosdrin EC, 150 ml/100 L applied one month before harvest. At Farms B and C, augmentative releases of the parasitoid Coccidoxenoides perminutus Girault (Hymenoptera: Encyrtidae) and predator Cryptolaemus montrouzieri Mulsant (*Coleoptera: Coccinellidae*) were applied in October and September, respectively.

Male mealybug numbers were monitored using delta traps baited with sex pheromone lures in each treatment plot. Old sticky pads and lures were removed and replaced with new ones every week during Spring and Summer and every four weeks in Autumn and Winter. This was done for three seasons (2005, 2006 and 2007), from June to October. The male mealybugs were recorded weekly from each trap in a month in order to calculate the mean value of male mealybugs per trap per month. However, to determine the bio-fix, the males were counted every week from 08-08-2007 to 26-08-2007 under a microscope of 10X, 50X magnification. The female mealybugs were assessed physically every four weeks from 20 evenly distributed plots of five vines each at each site. The degree-day estimations were made from temperature values obtained from data loggers at each site.

Mean value of male mealybugs per trap per month and the mean temperature per month were plotted against time. The cumulative degree days for each site was calculated from mid-September (Achiano per. observ.) as the bio-fix and based on 16.59°C as the estimated minimum threshold for development of *P. ficus* as was determined by [21] and 235°D as one generation [22]. The regression analysis of percentage males on cumulative degree days at P<0.05 was also done.

RESULTS

The temperatures increased gradually from September at the beginning of the season, peaking between January-February and tapering off thereafter, for all four farms (Figure.1). The percentage for the males also followed a similar trend, increasing with increase in temperature, peaking in January and February at the Farm B and C, respectively, but not at Farm A and C, which appear to have their peaks at the end of the season between March and April, respectively. The apparent peak in March- April was because no intervention was taken against the mealybug grape population after grapes were harvested by the end of February on all farms. At the beginning of the season, in September, the male numbers were very low or absent at all four farms. Farm D had the lowest mealybug infestation.

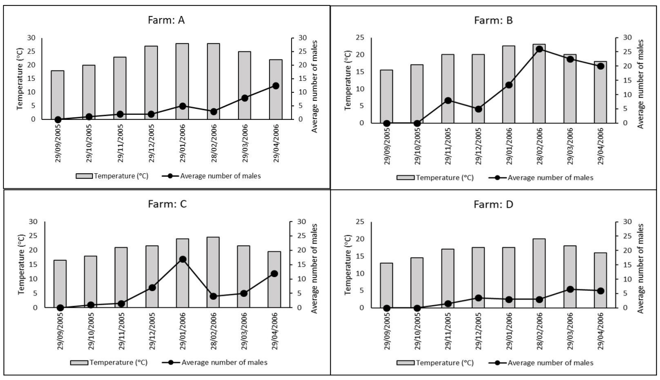

Figure 1: Mean Temperature and Average number of males/trap/month vs. time (months) at four farms at different sites.

Degree Days and Cumulative Degree Days

The accumulation of degree-days (°D) for mealybug accrued rapidly from December to April in all areas due to high temperatures recorded during that period (Figure 1 and 2). However, the cumulative °D attained after April was gradual as the temperature gained was minimal on all farms. The cumulative °D obtained was lowest at Farm D and the mealybug also had only three generations as compared to five on the other three farms.

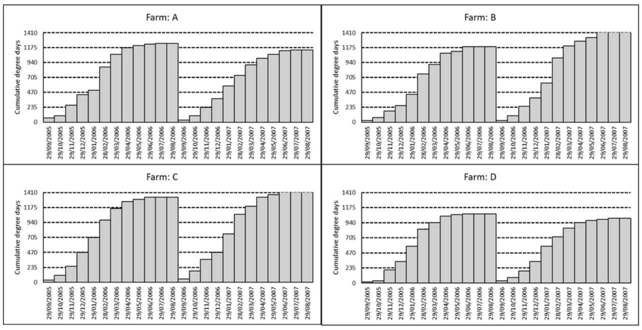

Figure 2: Cumulative degree days for vine mealybug with 235°D as the generation time for four areas for two seasons 2005/2006 and 2006/2007.

The males had higher cumulative numbers than the females throughout the census and therefore appear to be a better indicator as a warning tool (Figure 3). There was a positive and significant relationship ($P<0.05$) between male numbers and cumulative °D on all the farms and throughout the seasons at except at Farms C and D ($P=0.07$ and $P=0.09$), respectively, during the second season, from September 2006 to August 2007.

Figure 3: Percentage cumulative mealybug infestation levels in relation to cumulative degree-days for September 2005-August 2006 and September 2006-August 2007 seasons at four farms.

Figure 4. The regression of average number of male mealybugs on cumulative degree-days for two seasons. Y1= September 2005 - August 2006 and Y2=September 2006-August 2007.

The male numbers at all four farms showed a decrease from June, with the lowest count occurring in August and increasing as from September (Figure 5) as the temperature also increased (Figure 1). The data also showed that at all four farms no male flights occurred for two weeks (06-9-2007 and 13-9-2007) (Figure 6). A continuous flight of the males only occurred after 13-9-2007. Furthermore, the calculated monthly average numbers seem to mask the actual activities or occurrence of the male flights during the week.

Figure 5: Average number of males per plot at different farms collected from June – October in 2005, 2006 and 2007.

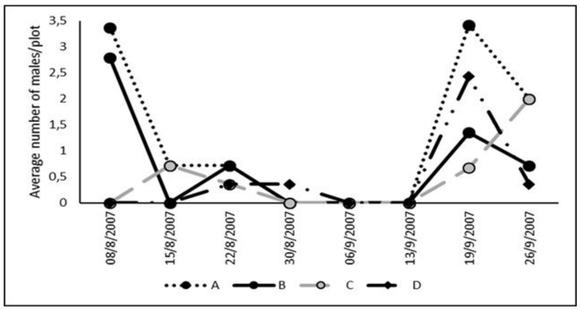

Figure 6: Average number of males per plot at different farms (A, B, C and D) collected from August–September in 2007. Average number of males/plot for three seasons 2005, 2006 and 2007 from June to October at four farms.

DISCUSSION

The seasonal month ideal for the *P. ficus* population to start increasing was October [23-25]. in their studies in the Western Cape province of South Africa, also determined that increase in rapid development of *P. ficus* occurred from October as a result of increase in temperature. The number of vine male mealybug generations of between three and five is in agreement with the work done by [26] in Italy and [27] in South Africa who also recorded three and five generations in the female *P. ficus*, respectively. The correlation coefficients between cumulative °D and number of *P. ficus* males was mostly positive, suggesting that the two parameters were dependent [28-29].

The observation made in this study conformed to the apt definition of bio-fix: e.g. the first male moth or moths trapped with no significant interruption in trap catches [30], first consistent catch without a break [31], first sustained capture of male moths in pheromone traps [32] and [33],[34] stated that for Oriental Fruit Moth, the bio-fix is the first date of consistent, sustained adult moth catches using pheromone traps in the orchard or vineyard. The work done here shows that the bio-fix for male *P. ficus* at the four Farms A, B, C and D and their surrounding areas was mid-September (i.e. 13th). In this case, however, the female *P. ficus*, which sustains itself by sucking on the vine sap, and as such does more damage to the vines, developed to adults two days after the male had matured [35], which renders the bio-fix to be 15th September. This is the date at which to begin calculating the °D accumulation of P. ficus, which was determined by [36] to be 235 °D and [37] determined the bio-fix for lygus bug, Lygus lineolaris (Palisot) (*Heteroptera: Miridae*), which attacks sunflower, Helianthus annuus L., as 1st April, [38], in South Africa, alluded the bio-fix for Cydia pomonella (*Lepidoptera: Tortricidae*), as mostly occurring on the 10th of October after recording constant catches from that date. The prior knowledge of the bio-fix will allow farmers to decide on the type of insecticides and/or augmentative biological control procedure to apply. In South Africa, vine growers tend to use insecticides or biological control agents such as C. *perminutus* in order to subdue the build-up of mealybug in the early part of the season. In future, should the calculated accumulated °D be validated, a model could be developed, which could be used as a tool to accurately schedule control actions and reduce the number of insecticide sprays and/or biological control interventions against mealybugs on vines. For example, Nietvoorbij may actually require only one insecticidal spray throughout the season apart from the initial bio-fix (15th September) as the second 470 °D occurs in late February at which time most farmers would have harvested their grapes. This would not only have decreased the cost and time required of the mealybug control programmes, but would also have led to the minimum exposure of beneficial insects and the vineyard environment to an unnecessary insecticide treatment. The primary limiting factor in using °D is obtaining accurate temperature readings. If a thermometer or weather station location is not representative of the environment in which the target insect occurs, the resultant °D will not mirror the actual insect development. This is because temperatures at one site may not be reflective of conditions at another site due to different microclimates. However, this could be obviated by placing temperature data loggers at the site where °D are needed. *Planococcus ficus* control in the future could be based on the precise information to achieve maximum control with minimum insecticide and/or biological control interventions. The importance of the prevention of oral frailty is clear from a previous report that oral frailty affects disability and mortality [9]. However, by which we enlighten the importance (such as "being able to eat well and enjoy meals for as long as possible") to the nation from the perspective of QOL improvement, it may be possible to prevent oral frailty at an earlier stage, even for the elderly who are currently healthy [11,12].

ACKNOWLEDGEMENTS

I would like to thank Drs. K. L. Pringle and J. H. Giliomee of Stellenbosch University for their inputs. My sincere thanks also go to WINETECH and the ARC for making this work possible.

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