Frey, J.E., Guillén, L., Frey, B., Samietz, J., Rull, J., Aluja, M., 2013. Developing diagnostic SNP panels for the identification of true fruit flies (Diptera: Tephritidae) within the limits of COI-based species delimitation. BMC Evolutionary Biology 13, 106.

Virgilio, M., Daneel, J.H., Manrakhan, A., Delatte, H., Meganck, K., De Meyer, M., 2019. An integrated diagnostic setup for the morphological and molecular identification of the *Ceratitis* FAR complex (*C. anonae, C. fasciventris, C. rosa, C. quilicii,* Diptera, Tephritidae). Bulletin of Entomological Research 109, 376-382.

Virgilio, M., Manrakhan, A., Delatte, H., Daneel, J.-H., Mwatawala, M.W., Meganck, K., Barr, N.B., De Meyer, M., 2017. The complex case of *Ceratitis cosyra* (Diptera: Tephritidae) and relatives. A DNA barcoding perspective. Journal of Applied Entomology 141, 788-797.

White, I.M., Elson-Harris, M.M., 1994. Fruit flies of economic significance: Their identification and bionomics. CAB International, U.K.

Case 3 - Aphytis:

Pina, T, Verdú, MJ, Urbaneja, A and Sabater-Muñoz, B. 2012. The use of integrative taxonomy in determining species limits in the convergent pupa coloration pattern of *Aphytis* species. *Biological Control*, 61: 64-70.

Case 4 - False codling moth:

Bierman, A., Karsten, M., Terblanche, J.S. 2022. Genome assembly of *Thaumatotibia leucotreta*, a polyphagous pest of agriculture in sub-Saharan Africa. G3 Genes|Genomes|Genetics jkac328. https://doi.org/10.1093/g3journal/jkac328

Timm, A.E., Geertsema, H., Warnich. L. 2010. Population genetic structure of economically important Tortricidae (Lepidoptera) in South Africa: a comparative analysis. Bulletin of Entomological Research 100, 421–431.

3.4.5 FINAL REPORT: Monitoring and control techniques for Australian bug

Project 1314 (April 2021 – March 2023) by Leani Serfontein, Aruna Manrakhan and Evans Mauda (CRI)

Summary

Icerya purchasi Maskell (Hemiptera: Monophlebidae) (Australian bug) is a polyphagous and cosmopolitan pest of plants that includes citrus. Dense populations of Australian bug cause plant stress, leading to defoliation, fruit drop and a decrease in plant vitality. Australian bug excretes honeydew, which supports the growth of sooty mould, disfiguring the plant. *Novius cardinalis* (Mulsant) and *Novius iceryae* (Jenson) (Coleoptera: Coccinellidae) (Vedalia beetles) are natural enemies of the Australian bug that are generally successful in controlling their populations. Vedalia beetles are, however, susceptible to a number of insecticides used to control other insect pests in citrus orchards. High incidences of Australian bug were recently recorded in mandarin orchards in some citrus growing regions in South Africa. In order to better understand the causative factors leading to an increase in incidence of Australian bug, populations of Australian bug and Vedalia beetles were monitored on a monthly basis over two years (May 2021 – May 2023) in four mandarin orchards on four different farms in Mpumalanga Province, South Africa. Chemical application programmes for the selected orchards were obtained and correlated with Australian bug and Vedalia beetle populations. High populations of Australian bug (>60% trees infested) were recorded between May and July 2021. After July 2021, there was a rapid decline in both Australian bug and Vedalia beetle populations. This decline was attributed to the use of chemical insecticides targeting spring pests. Populations of Australian bug returned the following year (2022) but remained low. Vedalia beetles were only recorded on two of the farms in 2022 as compared to all four farms in the first year of the study. In the second part of the study *N. iceryae* were released into four selected orchards with little to no chemical application histories. *Novius iceryae* was able to control *I. purchasi* populations in two of the orchards where there were no chemical interventions. It was evident from the study that insecticidal applications disrupted the biological control of Australian bug in mandarin orchards.

Opsomming

Icerya purchasi Maskell (Hemiptera: Monophlebidae) (Australiese witluis) is 'n polifagiese en kosmopolitiese plaag van plante wat sitrus insluit. Digte bevolkings van Australiese witluis veroorsaak plantstres, wat lei tot ontblaring, vrugval en 'n afname in plantvitaliteit. Australiese witluis skei heuningdou uit, wat die groei van roetskimmel ondersteun, wat die plant ontsier. *Novius cardinalis* (Mulsant) en *Novius iceryae* (Jenson) (Coleoptera: Coccinellidae) (Vedalia-kewers) is natuurlike vyande van die Australiese witluis wat oor die algemeen suksesvol is om hul bevolkings te beheer. Vedalia-kewers is egter vatbaar vir 'n aantal insekdoders wat gebruik word om ander insekplae in sitrusboorde te beheer. Hoë voorkoms van Australiese witluis is onlangs in mandarynboorde in sommige sitrusgroeistreke in Suid-Afrika aangeteken. Ten einde die veroorsakende faktore wat lei tot 'n toename in voorkoms van Australiese witluis beter te verstaan, is populasies van Australiese witluis- en Vedalia-kewers op 'n maandelikse basis oor twee jaar (Mei 2021 – Mei 2023) in vier mandarynboorde op vier verskillende plase in Mpumalanga Provinsie, Suid-Afrika gemoniteer. Chemiese toedieningsprogramme vir die geselekteerde boorde is verkry en gekorreleer met Australiese witluis- en Vedalia-kewerpopulasies. Hoë bevolkings van Australiese witluis (>60% bome wat besmet is) is tussen Mei en Julie 2021 aangeteken. Na Julie 2021 was daar 'n vinnige afname in beide Australiese witluis- en Vedalia-kewerpopulasies. Hierdie afname is toegeskryf aan die gebruik van chemiese insekdoders wat lenteplae teiken. Populasies van Australiese witluis het die volgende jaar (2022) teruggekeer, maar het laag gebly. Vedalia-kewers is slegs in 2022 op twee van die plase aangeteken in vergelyking met al vier plase in die eerste jaar van die studie. In die tweede deel van die studie is *N. iceryae* in vier geselekteerde boorde vrygelaat met min of geen chemiese toedieningsgeskiedenis nie. *Novius iceryae* was in staat om *I. purchasi*-bevolkings in twee van die boorde te beheer waar daar geen chemiese ingrypings was nie. Dit was duidelik uit die studie dat insekdodende toedienings die biologiese beheer van Australiese witluis in mandarynboorde ontwrig het.

Introduction

Icerya purchasi Maskell (Hemiptera: Coccoidea: Monophlebidae: Iceryin), commonly known as the Australian bug, is a polyphagous and cosmopolitan pest that also affects citrus. Dense populations of the Australian bug cause citrus plants to show signs of stress through defoliation, fruit drop and a decrease in vitality (Grout and Moore, 2015). The Australian bug excretes honeydew which facilitates the growth of sooty mould on the stems, leaves and fruit, disfiguring the plant (Kim et al., 2011; Ján et al., 2016; Norwin et al., 2019). Damage can occur quickly due to the ability of *I. purchasi* to increase substantially within a short period of time and their ability to disperse rapidly (Kim et al., 2011).

A number of citrus farms in Mpumalanga have recently recorded high incidences of Australian bug, particularly in mandarin orchards. Outbreaks of Australian bug in South Africa and other citrus-producing countries are usually associated with the use of particular insecticides which disrupt biological control of this pest (Hattingh and Cilliers, 1998; Grafton-Cardwell and Gu, 2003; Grafton-Cardwell et al., 2005). In a recent report from California, interestingly, outbreaks of Australian bug were found to be higher in mandarin orchards compared to sweet orange orchards (Cass et al., 2020). Higher suitability of mandarin for the Australian bug and breakdown of the successful biological control of the pest in mandarin orchards due to canopy structure were suggested as the possible reasons for the higher outbreaks of Australian bug in those environments compared to the orange orchards (Cass et al., 2020). With growing mandarin cultivation in South Africa, an optimal way to manage this pest should be sought.

Novius cardinalis (Mulsant) and *Novius Iceryae* (Janson) (Coleoptera: Coccinellidae) (Vedalia beetles) are natural enemies of the Australian bug that are especially successful in controlling their populations. *Novius cardinalis* originates from Australia and *N. iceryae* is indigenous to South Africa (Mendel and Bloomberg, 1991; Hounkpati et al., 2019). The control of Australian bug by *N. cardinalis* is known as an example of successful classical bio-control in many different countries (Hoddel et al., 2013; Mangoud, 2010; Grafton-Cardwell and Gu, 2003, Hoddel, 2002; Hattingh and Cilliers, 1998). This can be attributed to the Vedalia's high reproduction rate, rapid development, and host specificity. It has been demonstrated by Grafton-Cardwell and Gu (2003) that Vedalia beetles are susceptible to a number of pesticides such as imidacloprid, cyfluthrin, fenpropathrin, buprofezin and pyriproxyfen to name a few. In South Africa, it was noted that insect growth regulators (IGRs) cause a decline in Vedalia populations (Hattingh and Tate, 1995; Grafton-Cardwell et al., 2005). In California, the use of insecticides such as pyrethroids, IGRs and neonicotinoids are important for the control of other important citrus pests such as citrus thrips, *Scirtothrips citri* (Moulton), and California red scale, *Aonidiella aurantii* (Maskell). Therefore, with the continued use of these insecticides, outbreaks of the Australian bug will continue to persist (Grafton-Cardwell et al., 2005).

Females of the Australian bug may be difficult to control due to the thick integument that develops on their dorsum as they grow. As a result, chemical applications will only be effective if done at the crawler stage (Kim et al., 2011). It is therefore important to conserve natural enemies in the orchards (Grafton-Cardwell et al., 2005). If populations of the biological control agents are affected by the insecticides used, then they are unable to increase in sufficient numbers in order to control the Australian bug populations, especially in the period before harvest when insecticidal applications no longer occur to comply with residue regulations. A solution would be to mass rear *N. cardinalis* for mass releases in the affected areas in the period where fewer insecticides and those with short residuals are applied before harvest.

The aim of the project was to determine if Vedalia beetles were still able to provide adequate control over Australian bug within mandarin orchards. Objectives for the study were: (I) Monitor the incidence of *Icerya* species: *I. purchasi* in selected mandarin orchards (those with recent outbreaks and those with no history of outbreaks) and correlate with spray programmes and ant control programmes; (II) Develop monitoring systems for the Australian bug and their natural enemies in citrus orchards; (III) Explore mass rearing options for Vedalia beetle, and (IV) Determine the impact of short residual insecticides on Vedalia beetle.

Stated objectives

I. Monitor the incidence of *Icerya* species: *I. purchasi* and in selected mandarin orchards (those with recent outbreaks and those with no history of outbreaks) and correlate with spray programmes and ant control programmes
II. Develop monitoring systems for the Australian bug and their natural enemies in citrus orchards.
III. Explore mass rearing options for Vedalia beetle.
IV. Determine the impact of short residual insecticides on Vedalia beetle.

Objective IV could not be achieved due to complications in rearing Vedalia beetle

Materials and methods

I. <u>Monitoring of *Icerya* species in mandarin orchards</u>

Four mandarin orchards with a history of high *Icerya* outbreaks and four mandarin orchards with low outbreak history were selected in Nelspruit, Mpumalanga. Infestation rates of *Icerya* spp. (*I. purchasi* and *I. seychellarum*) was determined by sampling ten branches of 25 randomly selected trees in each selected orchard monthly for two years. The presence and absence of *Icerya* species was first recorded to determine the infestation rate (i.e. number of infested trees over a total number of trees monitored in each orchard). *Icerya* species found were identified to species level based on morphological features. On five selected trees infested by *Icerya* species in an orchard, the number of individuals of different stages (i.e. nymphal stages and adult females) of the pest were counted on ten branches (of at least 50 cm in length from the trunk). The branches were tagged so that the development of the pests can be recorded. These branches included twigs and leaves. Adult beetles, pupae and larvae of *Novius* species found were counted on each selected branch. The pest control programmes from these farms were obtained to correlate the use of individual products with infestation level of *Icerya* spp.

II. <u>Rearing of Vedalia beetle</u>

Novius cardinalis was collected from orchards in 2022 for development of cultures at Citrus Research Centre, Citrus Research International, Nelspruit, South Africa. Unfortunately, the *N. cardinalis* individuals did not lay any eggs and the *I. purchasi* numbers on which they were reared were not high enough to sustain the *N. cardinalis* beetles' appetites.

A culture of *I. purchasi* was established onto young grapefruit trees under 20% shade net. In January 2023, a population of *Novius iceryae* had established on the *I. purchasi* colony. These were collected and used for the mass release trials (Objective III).

III. <u>Mass release of Vedalia beetle into selected orchards</u>

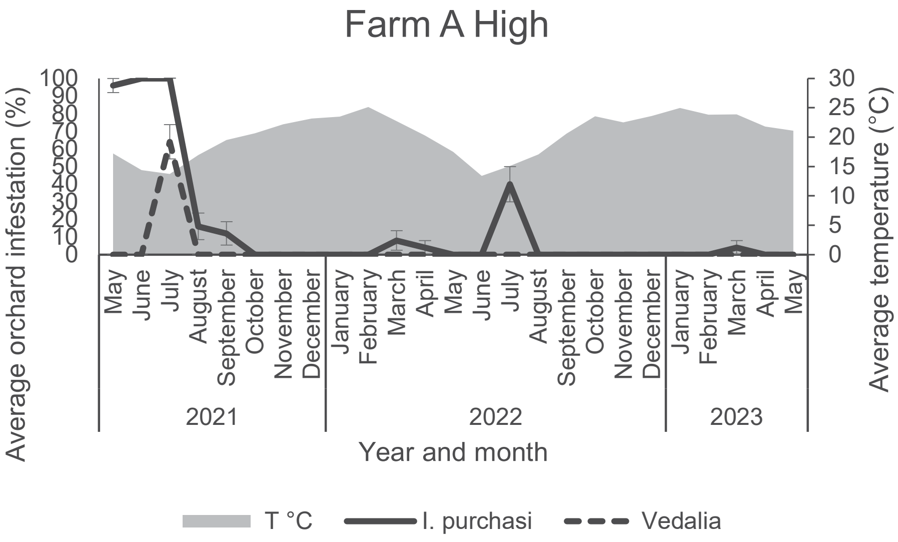
Four farms with high prevalence of *I. purchasi* were selected in Nelspruit, Mpumalanga. Releases of Vedalia beetle were carried out in January 2023 on orchards which were 2 years of age with little to no chemical application histories. Thirty pupae per hectare were released. Before release, populations of the *I. purchasi* and its natural enemy, *Novius* spp., were monitored in each orchard. Monitoring was carried out on a monthly basis until harvest. Monitoring of the *I. purchasi* and Vedalia was carried out as described under (I).

Results and discussion

I. Monitoring of *Icerya* species in mandarin orchards

Peaks in populations of *I. purchasi* generally occurred in May and July (Figs. 3.4.5.1 - 3.4.5.4). Vedalia beetles were not able to control *I. purchasi* populations on all of the farms. Peaks in the Vedalia beetle population generally coincided with peaks in *I. purchasi* populations (Fig. 3.4.5.1). Spearmans's rank-order correlations were run to examine the relationship between the *I. purchasi* and Vedalia populations. There was a significant and positive correlation, although not strong ($r_s = 0.315$, $p = <0.0001$). During the peak period of *I. purchasi* numbers, which occurs right before harvest, fewer insecticidal sprays are administered on the citrus to reduce the MRL residues occurring on the fruits. Harvest occurs between July and August. After harvest, insecticides such as Acetamiprid, Imidacloprid and Pyriproxifen were used for control of insect pests. These applications also possibly impacted on *I. purchasi* numbers. Very few or no Vedalia beetles could be observed in the orchards after these chemical applications. *Icerya purchasi* were however again recorded in the same orchards where chemical applications were applied. Monitoring the *I. purchasi* population after a chemical application is important for follow up pesticide applications when the crawlers emerge from the egg sacs and are susceptible to chemical control. In most orchards, buprofezin was applied from August to November (Table 3.4.5.1).

A logistic regression model was used to evaluate the impact of environmental factors on the *I. purchasi* populations. Temperature, relative humidity, rain and time of the year had significant influences on the *I. purchasi* populations (Temperature: $\chi^2 = 43.12$, df = 1.11, $p = <0.0001$; relative humidity: $\chi^2 = 67.97$, df = 1.11, $p = <0.0001$; rain: $\chi^2 = 23.85$, df = 1.11, $p = <0.0001$; time of year (month): $\chi^2 = 153.47$, df = 1.11, $p = <0.0001$).



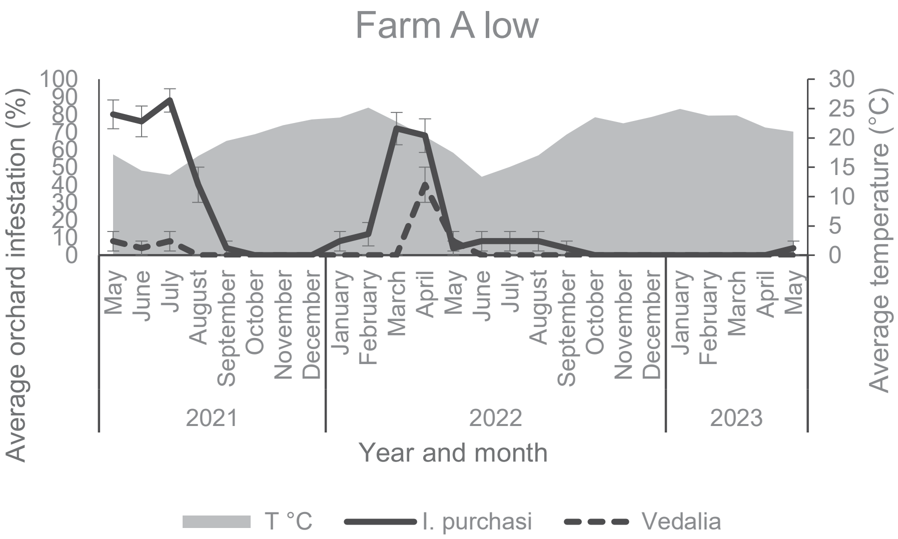


Figure 3.4.5.1. Farm A: Average number (±SE) of trees infested with *Icerya purchasi* and *Novius spp.* for Infested (high *I. purchasi* prevalence) and control (low *I. purchasi* prevalence) orchards.

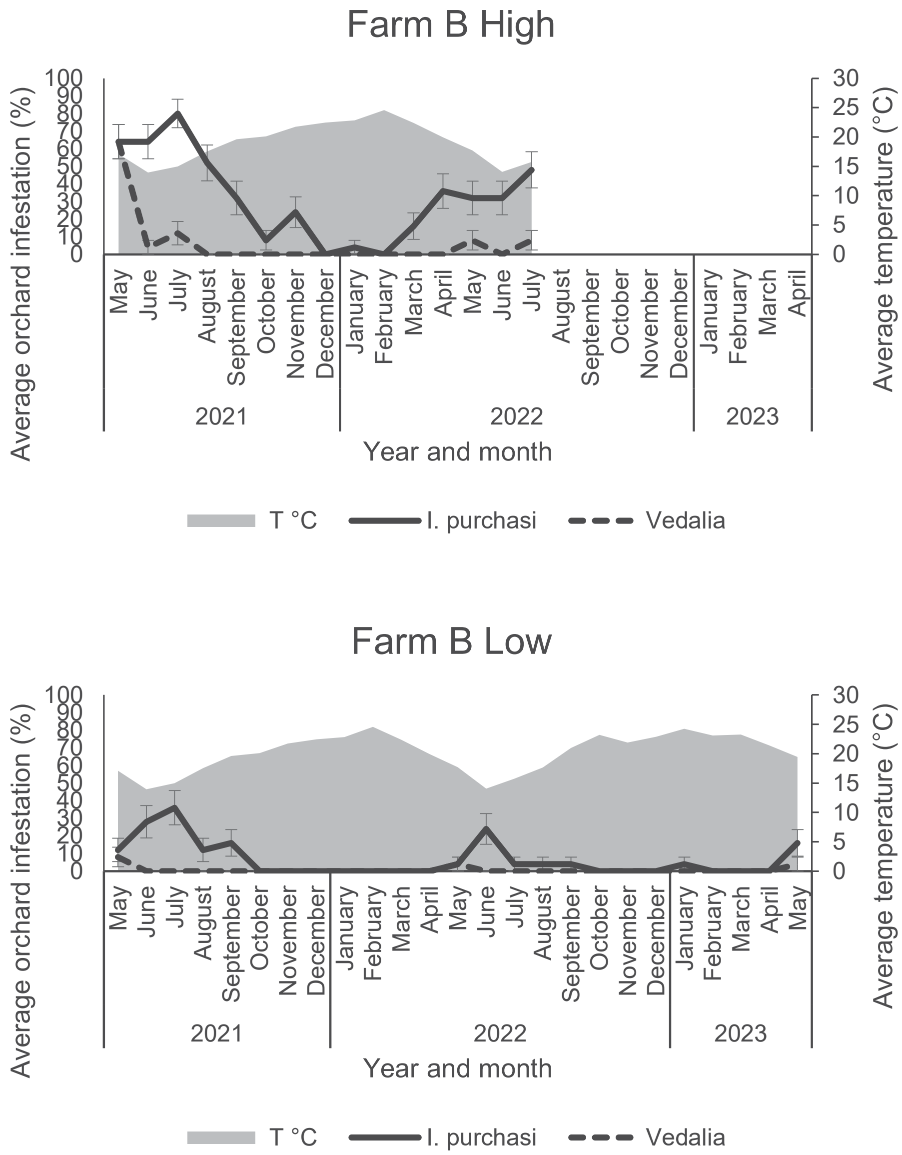


Figure 3.4.5.2. Farm B: Average number (±SE) of trees infested with *Icerya purchasi* and *Novius spp.* for Infested (high *I. purchasi* prevalence) and control (low *I. purchasi* prevalence) orchards.
*Orchard of high Australian bug prevalence was removed in August 2022.

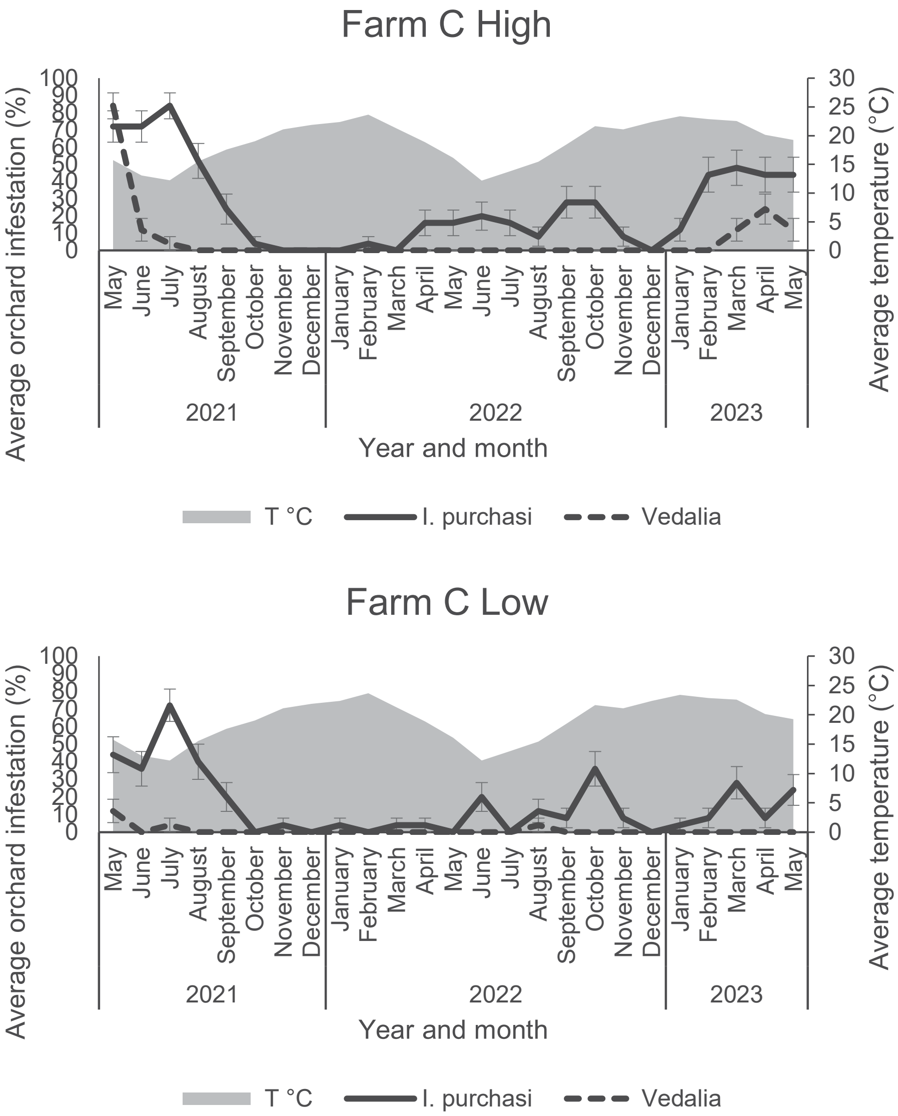
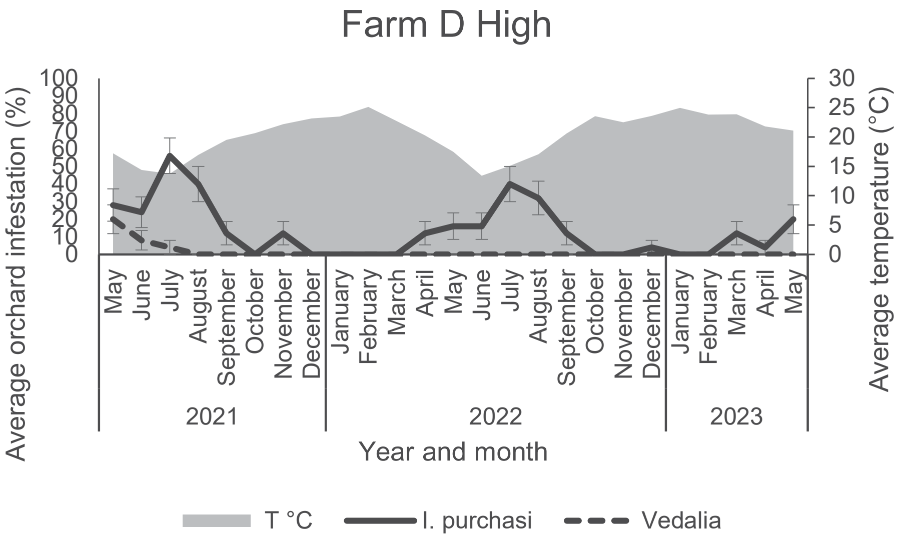


Figure 3.4.5.3. Farm C: Average number (±SE) of trees infested with *Icerya purchasi* and *Novius spp.* for Infested (high *I. purchasi* prevalence) and control (low *I. purchasi* prevalence) orchards.



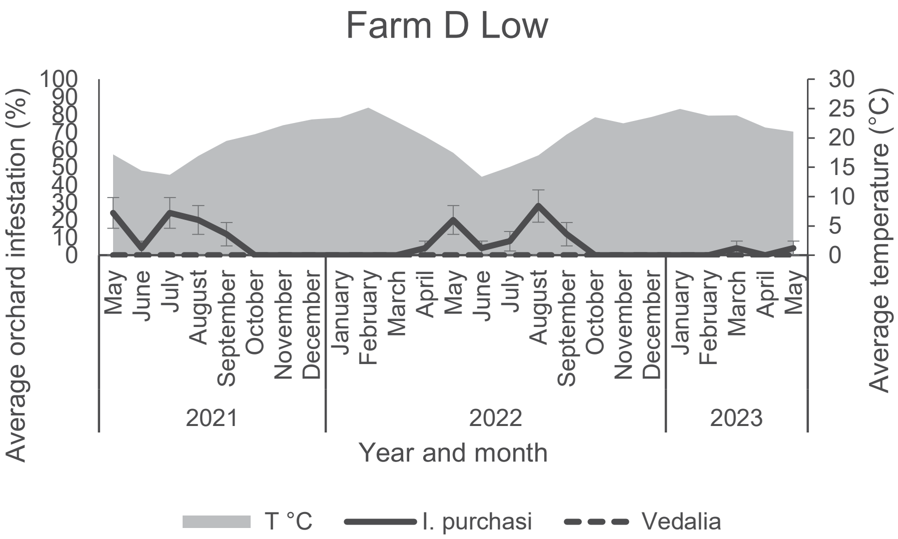


Figure 3.4.5.4. Farm D: Average number (±SE) of trees infested with *Icerya purchasi* and *Novius spp.* for Infested (high *I. purchasi* prevalence) and control (low *I. purchasi* prevalence) orchards.

Table 3.4.5.1. Insecticidal applications used in the orchards over time

Year	Month	Active	Farm A High	Farm A Low	Farm B High	Farm B Low	Farm C High	Farm C Low	Farm D High	Farm D Low
2021	January	Abamectin					X			
		Methamidophos	X	X						
	February	Spinetoram					X			
		Spinosad					X		X	X
	March	Methomyl					X			
		Spinosad							X	X
	April	Methomyl	X	X						
		Spinosad							X	X
	May	Methoxyfenozide					X		X	X
	June	Spinosad							X	X
	July	Spinosad							X	X
	August	Abamectin			X	X	X	X		
		Acetamiprid	X	X					X	X
		Bromopropylate			X	X				
		Buprofezin	X	X			X		X	X
		Imidacloprid				X	X	X	X	X
		Methomyl					X			
		Pyriproxifen	X	X						
		Spinosad							X	
	September	Buprofezin			X	X			X	X
		Fenproprathrin			X	X				
		Methomyl	X	X						
		Spineteram	X	X	X	X				

	October	Abamectin			X	X			X	X
		Acetamiprid	X	X			X			
		Buprofezin			X	X	X		X	X
		Imidacloprid						X		
		Methomyl						X		
		Spinetoram	X	X						X
		Spirotetramat			X	X			X	
	November	Abamectin					X	X		
		Methomyl						X		
		Spinetoram			X	X	X		X	X
	December	Abamectin	X	X	X	X	X	X	X	X
		Spinetoram							X	
2022	January	Abamectin			X	X		X	X	X
		Methoxyfenozide	X	X						
		Spinetoram								X
	February	Methoxyfenozide			X					
		Permethrin			X	X				
		Spinosad			X	X			X	X
	March	Methoxyfenozide			X	X				
		Permethrin			X	X				
		Spinosad			X	X				
	April	Methoxyfenozide	X	X				X		
		Permethrin			X	X				
		Spinosad			X	X				
	May	Methoxyfenozide			X	X		X	X	X
		Permethrin								

		Spinosad			X	X				
	June	Methoxyfenozide				X				
		Permethrin			X	X				
		Spinosad			X	X				
	July	Permethrin				X				
		Spinosad			X	X				
	August	Abamectin				X	X	X		
		Acetamiprid	X	X						
		Buprofezin				X				
		Fenpyroximate				X				
		Imidacloprid				X				
		Pyriproxifen	X	X						
		Spinosad								X
	September	Abamectin							X	X
		Buprofezin							X	X
		Spinatoram						X		
		Spinosad							X	X
	October	Abamectin						X	X	X
		Buprofezin							X	X
		Methomyl	X	X						
		Spinatoram	X	X		X	X			X
		Spinosad							X	
	November	Abamectin	X	X		X			X	X
		Buprofezin					X			
		Spinetoram						X	X	X
	December	Abamectin				X			X	X
		Buprofezin						X		

		Spinetoram					X			
2023	January	Abamectin				X	X			
		Buprofezin						X		
		Permethrin				X				
		Spinatoram								
		Spinosad				X				
	February	Spinosad				X			X	X
	March	Abamectin					X			
		Methoxyfenozide				X				
		Permethrin				X				
		Spinosad				X			X	X
	April	Methoxyfenozide	X	X		X		X	X	X
		Permethrin				X				
		Spinosad				X			X	X
	May	Methoxyfenozide					X	X	X	X
		Spinosad				X			X	X

II. Mass release of Vedalia beetle into selected orchards

All of the orchards in this part of the study were young trees (2-3 years) with no, or relatively low chemical application histories. As a result, the Vedalia were able to control *I. purchasi* populations in all of the orchards with no chemical interventions (Fig. 3.4.5.5 & Fig. 3.4.5.6). Farm G received one application of Abamectin and Methomyl in March 2023, and this coincided in a reduction in Vedalia population (Figure 3.4.5.7). However, Vedalia beetle could still be recorded and possibly assisted in limiting *I. purchasi* population (Figure 3.4.5.7). Farm H received regular applications of Buprofezin and Methomyl, resulting in Vedalia failing to establish in the orchard after release (Figure 3.4.5.8). This study showed that it is possible to release Vedalia into orchards to control *I. purchasi*, bearing in mind that once released; growers should carefully consider the chemical applications they administer.

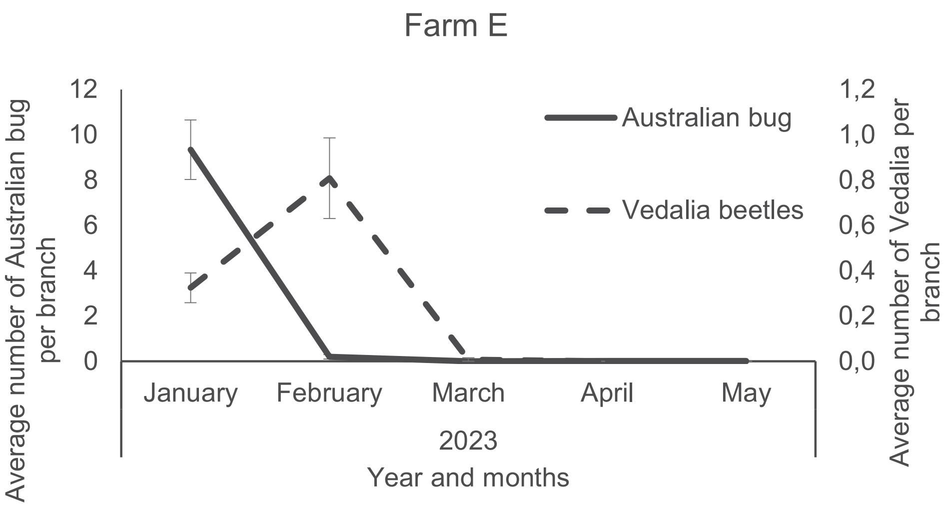


Figure 3.4.5.5. The average numbers of *Icerya purchasi* and *Novius iceryae* individuals (±SE) per branch for farm E. *No chemical applications were applied.

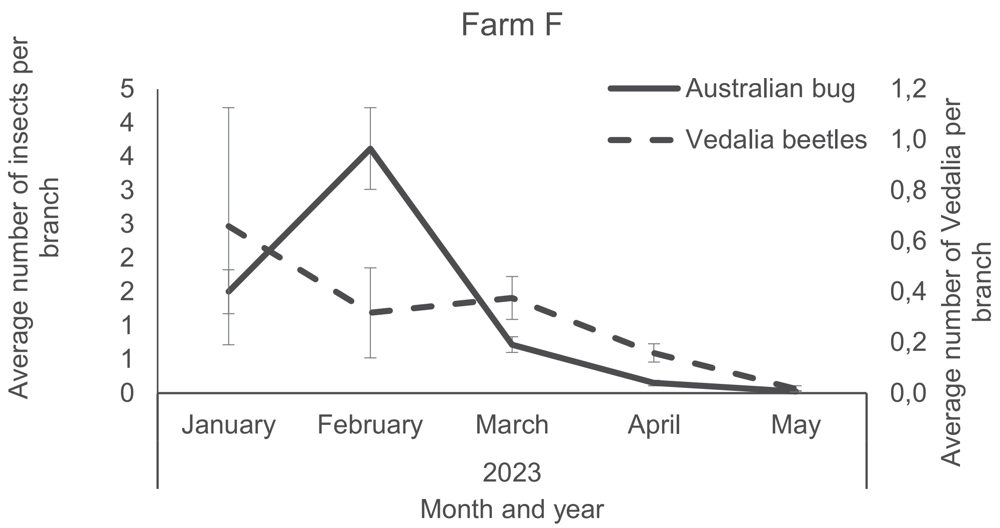


Figure 3.4.5.6. The average numbers of *Icerya purchasi* and *Novius iceryae* individuals (±SE) per branch for farm E. *One application of Methomyl was applied in September 2022.

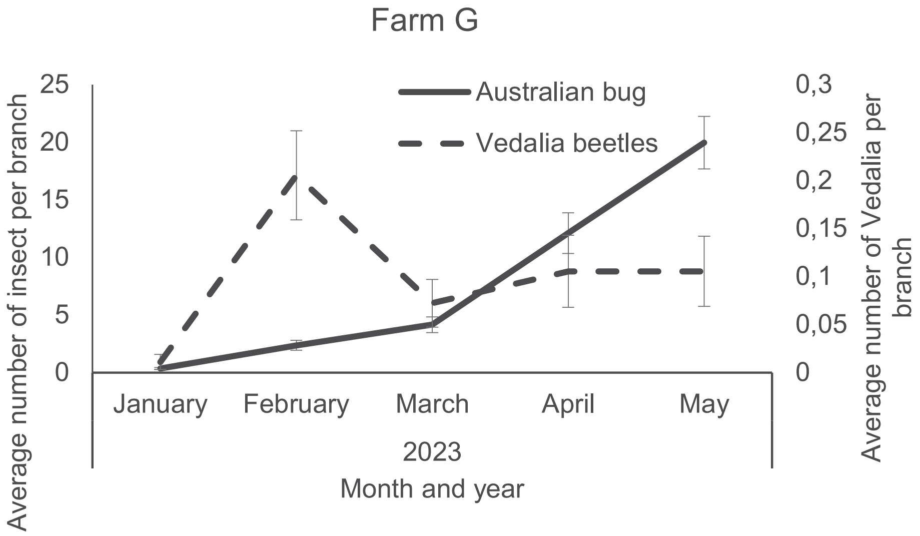


Figure 3.4.5.7. The average numbers of *Icerya purchasi* and *Novius iceryae* individuals (±SE) per branch for farm E. *Applications of Abamectin and Methomyl were applied in March 2023.

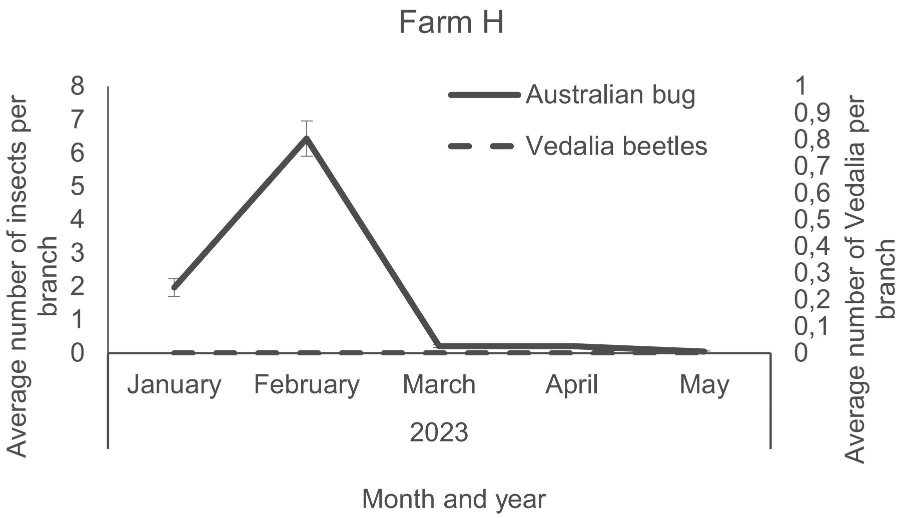


Figure 3.4.5.8. The average numbers of *Icerya purchasi* and *Novius iceryae* individuals (±SE) per branch for farm E. *Applications of Abamectin were applied in January, February and March 2023. Methomyl was applied in March 2023.

Conclusion

Vedalia beetle do occur naturally within mandarin orchards in South Africa. These biological control agents are able to control Australian bug only when minimal chemical interventions are implemented. However, Vedalia beetles are very sensitive to pesticides further hindering/reducing their establishments in farms with maximum chemical applications. It is recommended to collect Vedalia from neighbouring farms that might have a low chemical application and beetles have established healthy populations to augment the populations in orchards that might not have establishment. This study showed that biological control for certain pest species (for example, *I. purchasi*) is possible to achieve in a much better IPM programme in farms (i.e. less harsh chemical use for pests and timing of chemical sprays and Vedalia releases in the farms). It stands to reason that the more Vedalia there are, the greater their control over the Australian bug populations.

Future research

If colonies of Vedalia can be established, Objective IV can be carried out. Trials can also be conducted to determine how many Vedalia beetle should be released into an orchard based off of their Australian bug population density.

Technology transfer

SAFJ. FEB/MAR 2022 pg. 97-100. Australian Bug and the Vedalia Beetle.

Citrus Symposium 2022: Poster: Seasonal phenology of Australian bug in mandarin orchards in South Africa.

ESSA 2023: Presentation: The bug and the beetle: Are Vedalia beetles losing the battle in controlling Australian bug in mandarin orchards in South Africa?

References cited

Bernardo, U., and Viggiani, G. (2002). Effects of Oikos (ai Azadirachtin A) on the Vedalia ladybeetle *Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae). *IOBC WPRS BULLETIN*, *25*(11), 81-88.

Cass, B. N., Hack, L. M., Mueller, T. G., Buckman, D., Grafton-Cardwell, E. E., and Rosenheim, J. A. (2020). Arthropod Infestation Levels on Mandarins in California. *Journal of Economic Entomology* 113, 2335-2342. https://doi.org/10.1093/jee/toaa141

Grafton-Cardwell, E. E., and Gu, P. (2003). Conserving Vedalia beetle, *Rodolia cardinalis* (Mulsant)(Coleoptera: Coccinellidae), in citrus: a continuing challenge as new insecticides gain registration. *Journal of Economic Entomology*, *96*(5), 1388-1398.

Grafton-Cardwell, E. E., Gu, P., and Montez, G. H. (2005). Effects of temperature on development of Vedalia beetle, *Rodolia cardinalis* (Mulsant). *Biological Control*, *32*(3), 473-478.

Grout, T. G., and Moore, S. D. (2015). Citrus. *Insects of cultivated plants and natural pastures in Southern Africa*, 447-501.

Hattingh, V., and Cilliers, C.J. (1998). Australian bug: Icerya purchasi Maskell. *Citrus Pests in the Republic of South Africa. 2nd ed. Nelspruit: Institute for Tropical and Subtropical Crops*,108-112.

Hattingh, V., & Tate, B. (1995). Effects of field-weathered residues of insect growth regulators on some Coccinellidae (Coleoptera) of economic importance as biocontrol agents. *Bulletin of Entomological Research*, *85*(4), 489-493.

Hoddle, M.S., Ramírez, C.C., Hoddle, C.D., Loayza, J., Lincango, M.P., Van Driesche, R.G. and Causton, C.E. (2013). Post release evaluation of *Rodolia cardinalis* (Coleoptera: Coccinellidae) for control of *Icerya purchasi* (Hemiptera: Monophlebidae) in the Galapagos Islands. *Biological control*, 67(2), 262-274.

Hounkpati, K., Forrester, J. A., and McHugh, J. V. (2019). Neotype designation for *Rodolia iceryae* Janson in Ormerod, 1887 (Coleoptera: Coccinellidae). *Zootaxa*, *4563*(2), 396-400.

Ján, K., Ladislav, B. and Michal, P. 2016. First record of the cottony cushion scale *Icerya purchasi* (Hemiptera, Monophlebidae) in Slovakia–short communication. *Plant Protection Science*, 52(3), 217-219.

Kim, D. H., Yang, J. Y., Jang, Y. S., San Choi, K., Hyun, H. N., and Kim, D. S. (2011). Stage-specific population dynamics of cottony cushion scale, *Icerya purchasi* (Hemiptera: Monophlebidae), in citrus orchards in Jeju, Korea. *Journal of Asia-Pacific Entomology*, *14*(3), 305-309.

Mangoud, A.A.H. (2010). The efficiency of the vedalia beetle, *Rodolia cardinalis* (Mulsant)(Coleoptera: Coccinellidae) in suppressing populations of *Icerya seychellarum* (Westwood)(Homoptera: Monophlebidae) on grape vines in Egypt. *Proceedings of the XII International Symposium on Scale Insect Studies.* 63.

Mendel, Z., and Blumberg, D. (1991). Colonization trials with *Cryptochetum iceryae* and *Rodolia iceryae* for improved biological control of *Icerya purchasi* in Israel. *Biological Control*, *1*(1), 68-74.

Nowrin, S., Begum, M., Khatun, M. and Howlader, M.A. 2019. The abundance and mechanical control of *Icerya purchasi* (Maskell, 1878) (Hemiptera: Monophlebidae) on *Mangifera indica* in Dhaka, Bangladesh. *Bangladesh Journal of Zoology*, 47(1), pp.89-96.