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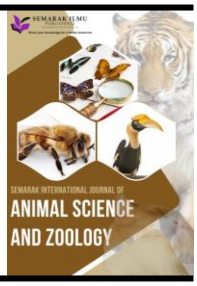

Spatial Distribution of Green Stink Bug, *Rhynchocoris Humeralis* (Hemiptera: Pentatomidae) Before and After Chemical Control on Calamansi Trees at the Bangi Botanic Garden, UKM

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ABSTRACT

The green stink bug, *Rhynchocoris humeralis* is a dominant pest in calamansi plantations. The impact of the stink bug causes damage to calamansi fruits and leaves. Monitoring the abundance and distribution of pest insects is crucial for systematic pest control, but it is often neglected until the crop area is severely infested. Therefore, the objective of this study was to examine the spatial distribution of *R. humeralis* in calamansi trees and to compare its abundance before and after chemical control. Sampling was conducted in February and March 2024 using sweep nets, with data collected before and after chemical treatment. Insect sampling was done once before chemical treatment and twice after, one and two weeks post-treatment. Initial data recorded 71 insects before chemical control, which decreased to 45 one week after treatment but increased to 86 after two weeks. Data were analyzed using QGIS 3.36.2, and the results showed spatial distribution maps and density maps of *R. humeralis*, helping to identify changes in pest abundance before and after chemical treatment. Paired t-tests were conducted using RStudio to compare the distribution before and after treatment. The first comparison showed a statistically significant difference ($p = 0.02268$), while the second comparison was not significant ($p = 0.3450$). A deeper understanding of the spatial distribution of *R. humeralis* will help identify areas with higher insects, allowing for more effective control methods.

1. Introduction

Calamansi (*Citrus microcarpa*) is an important product at the Bangi Botanic Garden in Universiti Kebangsaan Malaysia (UKM). The fruit is popular among local consumers due to its high quality and the minimal use of insecticides, which helps maintain the sustainability of the Bangi Botanic Garden

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UKM. Despite its benefits for health and the economy, calamansi production has recently declined due to pest infestations. To control these pests, the chemical pesticide Albarol was used, but its effectiveness varies based on location and time.

Calamansi is an important crop in tropical and subtropical regions, valued for its taste and health benefits. The *Citrus* species, including calamansi, are crucial in the pharmaceutical and medical industries because of their nutrients. These plants have antioxidants that protect against diseases like diabetes, cancer and heart problems.

One major pest affecting calamansi is the green stink bug (*Rhynchocoris humeralis*). Stink bugs belong to the Pentatomidae family, which includes many economically significant pests [1]. Most stink bugs are plant-feeders and can damage crops by feeding on them and spreading plant diseases [1]. The green stink bug specifically harms the fruit and leaves of calamansi, affecting the plant's growth and quality. The insect uses a needle-like mouthpart to suck the juice from the fruit, damaging the skin and potentially transmitting diseases [2].

Although calamansi is important, there's still much to learn about how *R. humeralis* affects these plants. Research has shown that factors like weather and soil impact the presence and activity of pests on calamansi [3]. This pest is known to cause significant economic losses to various crops [4], and while adult bugs can fly between trees, the younger ones (nymphs) can only walk. Chemical control is one method to reduce their population [5], but better management and monitoring systems are needed to reduce the reliance on insecticides [6].

Without systematic monitoring, controlling pests becomes more expensive and challenging. Inadequate monitoring can lead to late detection, requiring more insecticides, which raises costs and harms the environment and human health. Regular and systematic monitoring helps control pests early, reducing the need for excessive chemical use and overall costs. Understanding where and how pests like *R. humeralis* spread can help develop better ecological pest management practices [7]. Monitoring of this pest is crucial in order to understand its abundance and distribution in the orchards.

Thus, this study aims to monitor how the pest population changes before and after chemical control at UKM's calamansi plantations and to identify which areas are most affected by this pest in the plot of calamansi trees at the Bangi Botanic Garden UKM.

2. Methodology

2.1 Study Location

The study was conducted at the plot of calamansi trees in the Bangi Botanic Garden, UKM (N 2.9196176658388135, E 101.7845076308724). The total area of the calamansi plot was 0.25 acre, and the trees were six years old, having been planted in 2018. There were 81 calamansi trees in total (Figure 1). Insect samplings were performed three times which are once before chemical control and twice after chemical control.

2.2 Study Sampling

2.2.1 Sampling of Rhynchocoris humeralis

Active sampling of *R. humeralis* was conducted using insect sweeping nets inside the plot of calamansi trees (Figure 2). The insect sampling started in the morning and ended at midday (8:30 AM - 12:00 PM). The first sampling was done before chemical control (Arbarol, White Oil 72 %) was applied. The second and the third samplings were done after 1 week and 2 weeks after chemical treatment. The total number and locations of the collected insects were geo-tagged with the coordinate location of the calamansi trees.

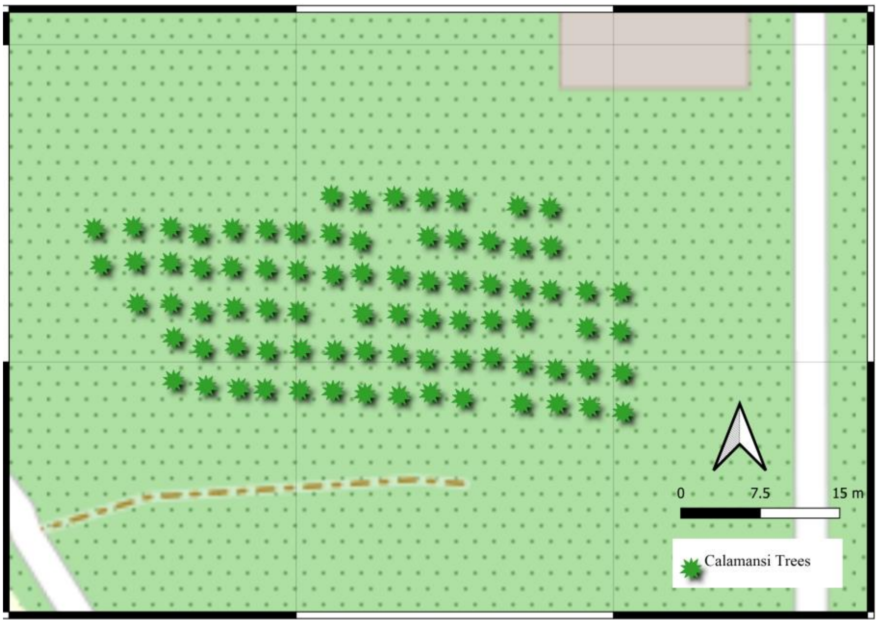

Fig. 1. Plot of Calamansi trees at the Bangi Botanic Garden, UKM

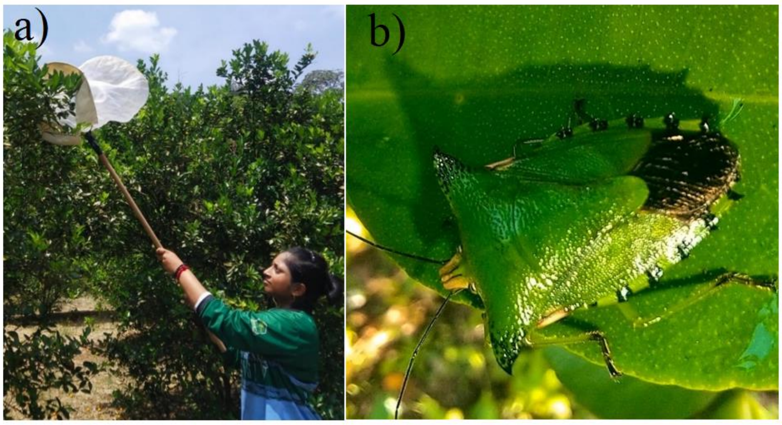

Fig. 2. Samplings of *R. humeralis*. a) Active sampling using sweep net and b) *R. humeralis*

2.3 Data Analysis
2.3.1 Spatial distribution analysis using QGIS

The data collected during the sampling were analyzed using QGIS 3.36.2 to create spatial distribution maps of *R. humeralis*. This software helped visualize the density and distribution of the pest before and after chemical control. Heatmaps were generated using Kernel Density Estimation (KDE) to represent the spatial distribution of *R. humeralis* population. The heatmaps for the three sampling periods were compared to assess the effect of chemical control.

2.3.2 Statistical analysis using T-Test

Paired t-tests were conducted using RStudio to compare the distribution of *R. humeralis* before and after chemical treatment.

3. Results and Discussion

This study successfully monitored the abundance of *R. humeralis* in the plot of calamansi trees. The spatial distribution of *R. humeralis* was visualized using KDE methods in QGIS spatial analysis (Figure 3).

3.1 Spatial Distribution of R. humeralis Before and After Chemical Control

The map for the spatial distribution of *R. humeralis* before and after chemical control was compared (Figure 3). A map created with QGIS depicts the spatial distribution of insects on calamansi trees in the plot. This map used a heat map to show the total number of insects, the gradient color scale is from light to dark, which represents an increase in the number of insects present. The lightest color represents the lowest insect density of 0.65 while the darkest color is associated with the highest insect density of five. The spatial distribution pattern of *R. humeralis* is random throughout the area of the calamansi trees at the Bangi Botanic Garden, UKM.

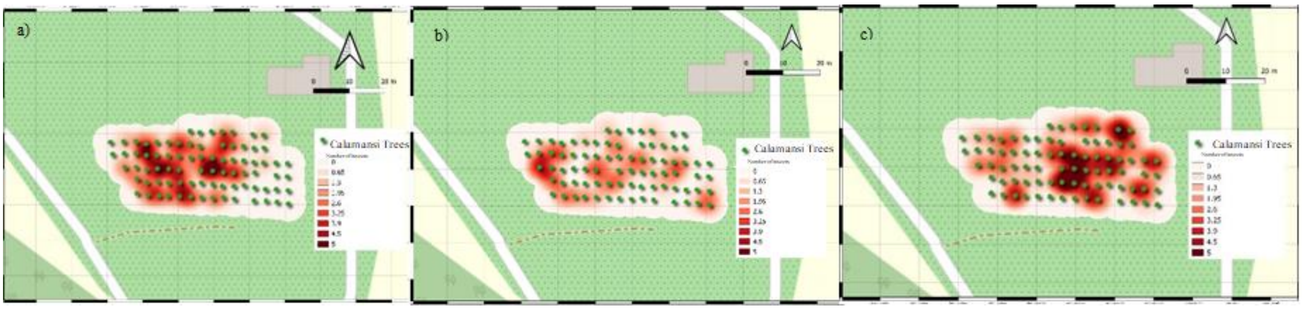

Fig. 3. Heat map of the spatial distribution of *R. humeralis* using KDE method. a) Spatial distribution of *R. humeralis before treatment*, b) Spatial distribution of *R. humeralis* after 1 week of the chemical control and c) Spatial distribution of *R. humeralis* after 2 weeks of the chemical control

Differences in color intensity on the heat map indicate high and low insect density areas. This makes it easier to identify spatial direction and potential hotspots for insect activity [8,9]. These color differences helped this study identify the areas of high and low insect density around calamansi trees. Dark red indicates high insect density, while lighter colors indicate areas with lower insect density. This information can assist future studies in investigating factors that drive high insect density in specific areas. In this study, the kernel density estimation technique used a range from zero to five. This unit is based on insect density, where zero represents the absence of insects, and five represents the highest insect density.

The insecticide used by UKM orchard managers to control the abundance of the insect *R. humeralis* is albarol. This study shows that this insecticide was ineffective in reducing *R. humeralis* (Figure 4). The linear regression showed a positive relationship before and after treatments. The study proves that albarol treatment is only effective for one week. From the insect sampling data, it is clear that insect abundance increased during sampling after two weeks of control. Therefore, the treatment used by orchard managers, which is albarol, needs to be repeated after seven days.

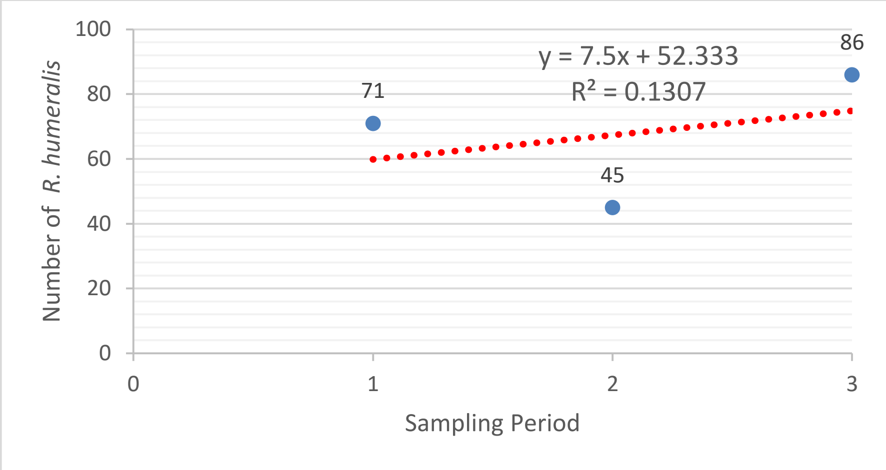

Fig. 4. Scatter plot with linear regression for all three insect samplings. The red dotted line represents the linear regression trend line. ***Note:*** 1 = before control, 2 = one week after control and 3 = two weeks after control

This insect has become a major challenge to the pest management system known as Integrated Pest Management (IPM). This is because control options are limited to the use of broad-spectrum insecticides such as organophosphates, carbamates and pyrethroidsn [10]. In previous studies, albarol has been tested for its effectiveness against rice stem borers and was found to be effective in controlling the population of the black-headed stem borer, *Chilo polychrysus*, with high efficacy and lethal index recorded [11]. According to a study [12], albarol is effective in controlling aphid populations. Albarol works by blocking the respiratory pores of insects, causing suffocation and death [12].

3.2 The Abundance of R. humeralis Before and After Chemical Control

A paired t-test analysis was conducted to compare the number of *R. humeralis* individuals before and after one week of chemical control (Figure 5). The results indicated a statistically significant difference in the number of individuals, confirming that the pest population decreased after 1 week of chemical control. The results showed a significant difference in the first comparison (p = 0.02268) (Table 1).

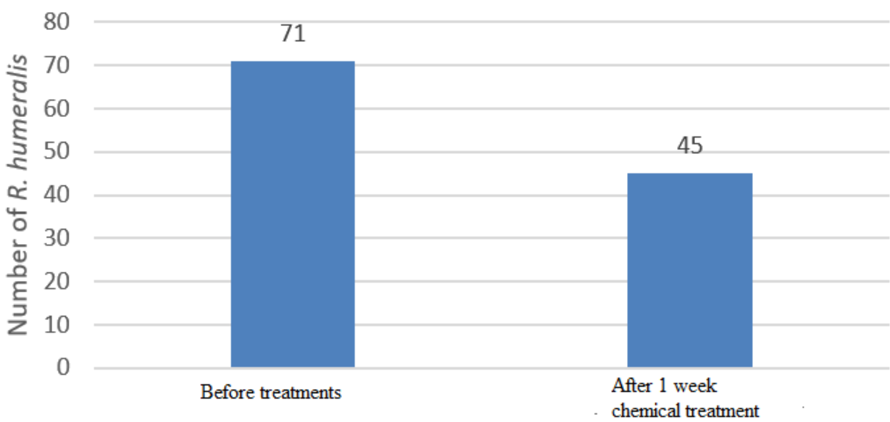

Fig. 5. Bar graph of the number of insects at the first and second sampling

Table 1
Paired t-test analysis for the first and second sampling data

Mean different	T value	Degree of freedom	*p* value	95 % Confidence interval
0.3210	2.3237	80	0.02268	0.046,0.596

A paired t-test was aslo performed to compare the data before and after two weeks of chemical control (Figure 6). Unlike the one-week data, this analysis showed no statistically significant difference (p = 0.3450) (Table 2), suggesting that the pest population remained stable two weeks after the chemical application.

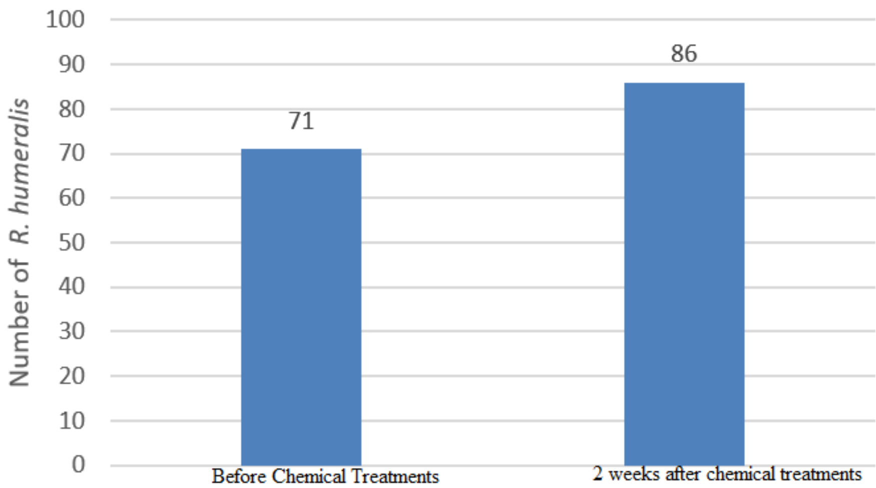

Fig. 6. Bar graph of the number of insects at the first and third sampling

Table 2
Paired t-test analysis for the first and third sampling data

Mean difference	T value	Degree of freedom	*p* value	95 % Confidence interval
-0.1852	-0.9500	80	0.3450	-0.573,0.203

According to the previous study [10], it was found that neonicotinoids are effective chemical pesticides for controlling the pest *R. humeralis* and may not have negative effects on natural enemies. There are also studies conducted on the chemical management of Pentatomidae species in soybean crops. These studies have proven that neonicotinoid, organophosphate and pyrethroid insecticides are effective controls. These chemical pesticides are often mixed together to enhance control efficacy and prevent resistance development [13]. The repeated use of the same insecticide can lead to resistance in stink bug populations [14]. This necessitates the development of new control strategies or the use of insecticide mixtures to maintain effectiveness.

This study will contribute to developing more effective pest management strategies that do not rely on chemical insecticides. Additionally, the study on the spatial distribution of *R. humeralis* will optimize control methods by targeting areas with higher pest populations. The IPM program combines various control methods, including biological control, cultural practices and insecticides. By understanding the spatial distribution of pest insects, the IPM program can be tailored for the sustainable cultivation of calamansi [15]. A deeper understanding of the spatial distribution of *R. humeralis* will help orcard managers with effective and environmentally friendly pest management techniques.

4. Conclusions

This study can assist in implementing an IPM program in the calamansi orchard at the Bangi Botanic Garden, UKM. This study has successfully evaluated the spatial distribution of *R. humeralis* before and after chemical control in calamansi trees. The results of this study can be used to help identify areas with higher numbers of insects so that control methods can be more effective. In conclusion, this study provides a better understanding to develop control strategies for orchard managers.

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References
[1] McPherson, J. E., C. Scott Bundy, and Alfred G. Wheeler. "Overview of the Superfamily Pentatomoidea 1, 2." In *Invasive Stink Bugs and Related Species (Pentatomoidea)*, pp. 3-22. CRC Press, 2018. https://doi.org/10.1201/9781315371221
[2] Panizzi, ANTÔNIO R., J. E. McPherson, David G. James, M. Javahery, and Robert M. McPherson. "Stink bugs (Pentatomidae)." *Heteroptera of economic importance* 828 (2000). https://doi.org/10.1201/9781420041859
[3] Ceballo, Flor A., Gimme H. Walter, and Wayne Rochester. "The impact of climate on the biological control of citrus mealybug Planococcus citri (Risso) by the parasitoid Coccidoxenoides perminutus Girault as predicted by the climate-matching program CLIMEX." *Philippine Agricultural Scientist* 93, no. 3 (2010): 317. https://doi.org/10.1093/jee/toy103
[4] Grabarczyk, Erin E., Ted E. Cottrell, and Glynn Tillman. "Characterizing the spatiotemporal distribution of three native stink bugs (Hemiptera: Pentatomidae) across an agricultural landscape." *Insects* 12, no. 10 (2021): 854. https://doi.org/10.3390/insects12100854
[5] Sosa-Gómez, Daniel R., Beatriz S. Corrêa-Ferreira, Beatriz Kraemer, Amarildo Pasini, Patrícia E. Husch, Carlos E. Delfino Vieira, Claudia B. Reis Martinez, and Ivani O. Negrao Lopes. "Prevalence, damage, management and insecticide resistance of stink bug populations (Hemiptera: Pentatomidae) in commodity crops." *Agricultural and Forest Entomology* 22, no. 2 (2020): 99-118. https://doi.org/10.1111/afe.12366
[6] Horowitz, A. Rami, Peter C. Ellsworth, and Isaac Ishaaya. "Biorational pest control–an overview." *Biorational control of arthropod pests: Application and resistance management* (2009): 1-20. http://dx.doi.org/10.1007/978-90-481-2316-2_1
[7] Park, Yong-Lak, and Jon J. Tollefson. "Spatio-temporal dynamics of corn rootworm, *Diabrotica* spp., adults and their spatial association with environment." *Entomologia experimentalis et applicata* 120, no. 2 (2006): 105-112. https://doi.org/10.1111/j.1570-7458.2006.00428.x
[8] Yu, Chang, and Zhao-Cheng He. "Analysing the spatial-temporal characteristics of bus travel demand using the heat map." *Journal of Transport Geography* 58 (2017): 247-255. https://doi.org/10.1016/j.jtrangeo.2016.11.009
[9] Zakaria, A., Rafie, M. B. S. A., Hussain, M. H., Johari Jalinas, J. and Ghani, I.A. "Effectiveness of several insecticides on red palm weevil, *Rhynchophorus ferrugineus* on coconut palm. *SERANGGA* 29(2):189-199. https://doi.org/10.17576/serangga-2024-2902-14
[10] Kamminga, K., Koppel, A.L., Herbert D.A. Jr., and Kuhar, T.P. "Biology and management of the green stink bug." (2012). http://dx.doi.org/10.1603/IPM12006
[11] Khari, N. A. M., and Hamid, S. A. "Efficacy of insecticides on black-headed stem borer, *Chilo polychrysus* Walker (Lepidoptera: Pyralidae) in glasshouse condition." (2021): 255-270. https://ejournal.ukm.my/serangga/issue/view/1406/showToc
[12] Pinese, B., Lisle, A.T. Ramsey, M.D., Halfpapp, K. H., and DeFaveri, S. "Control of aphid-borne papaya ringspot potyvirus in zucchini marrow (*Cucurbita pepo*) with reflective mulches and mineral oil-insecticide sprays." *International Journal of Pest Management* 40, no. 1 (1994): 81-87. https://doi.org/10.1080/09670879409371859
[13] Marques, Rafael P., Adriano A. Melo, Jerson VC Guedes, Cristiano De Carli, Alberto Rohrig, Henrique Pozebon, Clérison R. Perini et al. "Managing stink bugs on soybean fields: insights on chemical management." *Journal of Agricultural Science* 11, no. 6 (2019): 225. https://doi.org/10.5539/jas.v11n6p225

[14] Du, Yuzhe, Shane Scheibener, Yu-Cheng Zhu, K. Clint Allen, and Gadi VP Reddy. "Insecticide Susceptibilities and Enzyme Activities of Four Stink Bug Populations in Mississippi, USA." *Insects* 15, no. 4 (2024): 265. https://doi.org/10.3390/insects15040265
[15] Lampert, C.. Integrated pest management in citrus. *California Agriculture* 64, no. 5 (2010): 228-234. https://doi.org/10.3733/ca.v064n05p228