



Survey and abundance of mealybug species (Hemiptera: Pseudococcidae) infesting cassava in Kerala

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Received on 04 October 2024; received in revised form 15 January 2025, accepted 18 February 2025.

Abstract

Cassava (*Manihot esculenta*) is an important crop in Kerala, yet it is highly susceptible to infestations by various mealybug species that significantly impact yield. This study aimed to survey and assess the abundance of mealybug species infesting cassava in key growing regions of Kerala. Field surveys were conducted from 2023 to 2024 across multiple locations, identifying *Phenacoccus manihoti* Matile-Ferrero, 1977 and *Paracoccus marginatus* Williams and Granara de Willink, 1992 as dominant species. This study assesses the distribution and abundance of mealybug species affecting cassava in Kerala. *Ph. manihoti* was most abundant in Vellanikkara, Kaprassery, and Krishnapuram, while *P. marginatus* was dominant in Ponniam, Elanthoor, and Idukki, with particularly high infestations in Idukki (95.34%) and Kasargod (90.90%). *Pseudococcus jackbeardsleyi* Gimpel & Miller, 1996 and *Ferrisia virgata* Cockerell, 1893 were found at lower levels, with minimal impact on cassava. *Phenacoccus solenopsis* Tinsley, 1898 was detected only in Thrissur. The findings highlight *Ph. manihoti* and *P. marginatus* as the primary pests, necessitating focused pest management in affected regions. The results emphasize the need for effective monitoring and management strategies to mitigate mealybug damage and ensure sustainable cassava yields in the region.

Keywords: Abundance, Cassava, Field study, Kerala, Mealybug species, Pest distribution, *Phenacoccus manihoti*, *Paracoccus marginatus*, Survey

Introduction

Cassava (*Manihot esculenta* Crantz), a resilient root crop, is a vital staple food for millions across the world (Scaria et al., 2024). In India, cassava is grown across 13 states, with the majority of cultivation concentrated in Kerala and Tamil Nadu (Edison, 2001; Prakash et al., 2021; Scaria et al., 2024). While these states lead the nation in cassava processing, with numerous starch factories (Srinivas & Anantharaman, 2005), the industry faces increasing threats from potential invasive pests and diseases, despite modern production techniques. Mealybugs are significant pests infesting cassava and can severely impact its yield and quality. These pests weaken cassava plants by feeding on sap, causing stunted growth, yellowing of leaves, and overall reduced productivity. Additionally, the honeydew produced by mealybugs fosters the growth of sooty mold, further damaging the plants and affecting photosynthesis. Managing mealybug is crucial in maintaining cassava productivity, especially in tropical and subtropical regions where these pests thrive (Calatayud and Le, 2006). Globally, 24 mealy bug species have been

identified attacking cassava (García Morales, 2016), with 10 species documented in India (Joshi et al., 2021). *Phenacoccus manihoti* and *Ph. herreni* cause substantial yield loss in cassava, with infestations reported up to 80% on farms in Brazil. In Africa also, these pests have led to crop loss upto 80%, while in Colombia, yield reductions ranges from 68% to 88%, depending on the susceptibility of cultivars used for planting (Bellotti et al. 1999; Vargas and Bellotti 1984; Herren and Neuenschwander 1991). Based on the significant negative impact of mealybugs on cassava, this study aims to conduct a survey to assess their abundance and distribution in Kerala.

Materials and methods

A survey was conducted across unsprayed cassava fields in Kerala (2023-2024) to assess the presence and severity of mealybug infestations across different regions. The survey focused specifically on fields not treated with pesticides to gauge natural infestation levels accurately. Mealybug colonies were documented from 15 randomly selected

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cassava plants at each survey location to estimate mealybug populations. This sampling approach allowed for an unbiased assessment of mealybug presence across varying environmental conditions. The GPS coordinates of each surveyed location were recorded and subsequently mapped on a geographical representation of Kerala (see Fig. 1), enabling a spatial analysis of infestation distribution. To evaluate species dominance within the mealybug populations, the Balogh formula (Adly et al., 2016) was employed, as follows:

$$D = \frac{a_1}{\sum a_i} \times 100$$

where:

- D = Dominance percentage,
- a_1 = number of identified specimens of one species,
- $\sum a_i$ = total number of all collected specimens.

This formula calculates the per cent dominates by comparing the number of individuals of a specific species to the total number of mealybugs collected, thereby determining the prevalence of each species within the ecosystem. After estimating species dominance using the Balogh formula, the collected mealybugs were further identified based on their morphological and taxonomic characteristics. The *Ph. manihoti* was identified as per Murthy et al. (2024) and the remaining mealybugs were identified by using detailed keys and descriptions developed by Williams and Williams (1992) and further refined by Joshi et al. (2021), which are

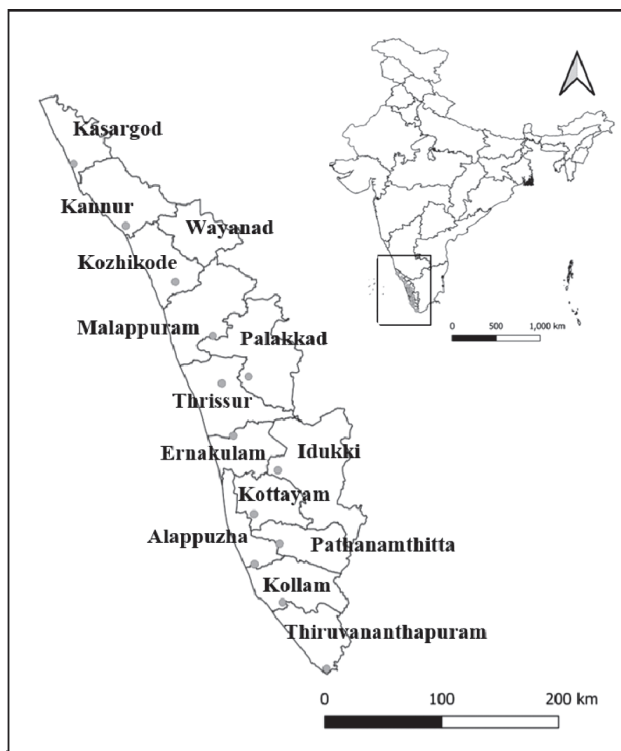


Figure 1. GPS Coordinates of Surveyed Locations in the Study Area

recognized as authoritative references for distinguishing mealybug species. These identification protocols ensured accurate classification of mealybug specimens, facilitating a deeper understanding of the diversity and spread of mealybug species within the surveyed regions.

Results and discussions

The survey revealed the presence of several mealybug species infesting cassava in Kerala. The identified species include *Phenacoccus manihoti*, *Paracoccus marginatus*, *Ferrisia virgata*, *Pseudococcus jackbeardsleyi*, and *Phenacoccus solenopsis*. Each of these species, presented in Fig. 2, was observed at varying mean infestation levels across the surveyed fields. The mean population of different mealybug species colonies per plant and the standard error (Mean $\pm$ S.em) for various mealybug species across different districts in Kerala is presented in Table 1. *P. manihoti* was present in all surveyed locations except Kasargod (Padanakkad) and Idukki (Karimkunnam), with its population ranging from 0.00 ± 0.00 to 4.13 ± 0.75 (Vellanikkara, Thrissur district). It was also significant in Kaprassery (Ernakulam district) with 3.2 ± 0.48 and Krishnapuram (Alappuzha district) with 3.06 ± 0.62 . *P. marginatus* was observed in all locations, with its population ranging from 0.66 ± 0.23 (Krishnapuram and Padanakkad) to 3.13 ± 0.37 (Ponniam, Kannur district). *P. jackbeardsleyi* was recorded at very low levels across most locations, with the highest population found in Vellanikkara (0.33 ± 0.15) and minor populations in Palakkad (0.26 ± 0.11) and Kozhikode (0.06 ± 0.06). It was absent in locations like Kaprassery, Ponniam, Kalluvathukkal, Padanakkad and Elanthoor. *F. virgata* exhibited the highest population in Ernakulam (0.53 ± 0.13) and Kozhikode (0.26 ± 0.11), with the lowest observed in Idukki (0.06 ± 0.006) and Kasargod (0.07 ± 0.06). It was absent in many surveyed locations such as Vadakkencherry, Chelakkad, Kalluvathukkal, Krishnapuram, and Chingavanam. *P. solenopsis* was detected only in Thrissur (0.4 ± 0.19), with all other districts showing no presence of this species.

Table 2 illustrates the distribution and dominance of mealybug species across different locations in Kerala, highlighting the variability in population dynamics of these pests affecting cassava. *P. manihoti* demonstrates significant dominance in several districts, particularly in Alappuzha (Krishnapuram), where it accounts for 80.70% of the mealybug population. Other districts with notable dominance include Thrissur (Vellanikkara) at 60.78%, Palakkad (Vadakkencherry) at 57.62%, Ernakulam (Kaprassery) at 50% and Kozhikode (Erannikoth) at 47.36%. *P. marginatus* exhibits notable dominance in several districts, particularly



Figure 2. Mealybug species complex in cassava A. *Phenacoccus manihoti*, B. *Paracoccus marginatus*, C. *Ferrisia virgata*, D. *Pseudococcus jackbeardsleyi*, E. *Phenacoccus solenopsis*

Table 1. Mean Population of Mealybug Species Colonies in Cassava

District	Location	Latitude	Longitude	Mean population of mealybug colonies per plant (Mean $\pm$ S.em)				
				<i>Phenacoccus manihoti</i>	<i>Paracoccus marginatus</i>	<i>Pseudococcus jackbeardsleyi</i>	<i>Ferrisia virgata</i>	<i>Phenacoccus solenopsis</i>
Ernakulam	Kaprassery	10.142389	76.371629	3.2 $\pm$ 0.48	2.67 $\pm$ 0.44	0.00 $\pm$ 0.00	0.53 $\pm$ 0.13	0.00 $\pm$ 0.00
Idukki	Karimkunnam	9.874462	76.717055	0.00 $\pm$ 0.00	2.73 $\pm$ 0.45	0.06 $\pm$ 0.06	0.06 $\pm$ 0.006	0.00 $\pm$ 0.00
Thrissur	Vellanikkara	10.549386	76.2832418	4.13 $\pm$ 0.75	1.8 $\pm$ 0.31	0.33 $\pm$ 0.15	0.13 $\pm$ 0.09	0.4 $\pm$ 0.19
Kannur	Ponniam	11.77111111	75.5377778	1.93 $\pm$ 0.51	3.13 $\pm$ 0.37	0.00 $\pm$ 0.0	0.2 $\pm$ 0.10	0.00 $\pm$ 0.00
Palakkad	Vadakkencherry	10.601113	76.489999	2.26 $\pm$ 0.52	1.4 $\pm$ 0.28	0.26 $\pm$ 0.11	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Malappuram	Chelakkad	10.91886111	76.2131667	0.66 $\pm$ 0.25	0.86 $\pm$ 0.27	0.06 $\pm$ 0.06	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Kozhikode	Eranhikoth	11.338205	75.922936	1.8 $\pm$ 0.40	1.66 $\pm$ 0.25	0.06 $\pm$ 0.06	0.26 $\pm$ 0.11	0.00 $\pm$ 0.00
Kollam	Kalluvathukkal	8.850345	76.752956	1.26 $\pm$ 0.34	1.53 $\pm$ 0.21	0.00 $\pm$ 0.0	0 $\pm$ 0.00	0.00 $\pm$ 0.00
Trivandrum	Kulathoor	8.334488	77.094309	1.46 $\pm$ 0.36	2.86 $\pm$ 0.35	0.13 $\pm$ 0.09	0.27 $\pm$ 0.10	0.00 $\pm$ 0.00
Pathanamtittha	Elanthoor	9.304222	76.73044	0.93 $\pm$ 0.33	3 $\pm$ 0.45	0.00 $\pm$ 0.00	0.2 $\pm$ 0.10	0.00 $\pm$ 0.00
Alappuzha	Krishnapuram	9.145715	76.536704	3.06 $\pm$ 0.62	0.66 $\pm$ 0.18	0.07 $\pm$ 0.06	0.00 $\pm$ 0.00	0.00 $\pm$ 0.00
Kottayam	Chingavanam	9.534239	76.532112	2.86 $\pm$ 0.64	1.2 $\pm$ 0.24	0.13 $\pm$ 0.09	0.00 $\pm$	0.00 $\pm$ 0.00
Kasargod	Padanakkad	12.250346	75.133795	0.00 $\pm$ 0.00	0.66 $\pm$ 0.23	0 $\pm$ 0.00	0.07 $\pm$ 0.06	0.00 $\pm$ 0.00

in Idukki (Olamottam), where it reaches an exceptional 95.34% of the mealybug population. This high prevalence indicates a severe infestation in that area, necessitating urgent pest management interventions. Similarly, in Kasargod (Padakkanad), it representing 90.90%, highlighting another area of critical concern. The species also shows notable presence in Kannur (Ponniam) at 56.62%. The other mealybug species, including *F. virgata*, *P. jackbeardsleyi* and *P. solenopsis*, exhibited lower dominance across the surveyed districts, indicating they are less of a concern in cassava cultivation compared to *P. manihoti* and *P. marginatus*.

Globally, cassava is known to host a total of 24 recorded mealybug species (Garcia Morales et al., 2016). Calatayud et al. (2006) identified nineteen mealybug species infesting cassava. Among these, four species viz., *P. manihoti*, *P. marginatus*, *F. virgata*, and *P. jackbeardsleyi* are the species causing significant economic impact on cassava production. Our study corroborates these findings, as we also documented the presence and abundance of these prevalent mealybug species in surveyed area. In a field survey conducted by Fanani et al. (2019) in Indonesia, four mealybug species were documented on cassava *P. marginatus*, *P.*

Table 2. Percentage of dominance of mealybug colonies in various districts

District	Location	Month and Year of collection	% Dominance of mealybug colonies				
			<i>Phenacoccus manihoti</i>	<i>Paracoccus marginatus</i>	<i>Ferrisia virgata</i>	<i>Pseudococcus jackbeardsleyi</i>	<i>Phenacoccus solenopsis</i>
Ernakulam	Kaprassery	January, 2024	50	41.67	8.33	0	0
Idukki	Olamottam	January, 2024	0	95.34	2.32	2.32	0
Thrissur	Vellanikkara	February, 2023	60.78	26.47	1.96	4.90	5.88
Kannur	Ponniam	April, 2023	34.93	56.62	3.61	4.81	0
Palakkad	Vadakkencherry	June, 2023	57.62	35.59	0	6.77	0
Malappuram	Chelakkad	August, 2023	41.66	54.16	0	4.16	0
Kozhikode	Eranhikoth	February, 2024	47.36	43.85	7.01	1.75	0
Kollam	Kalluvathukkal	February, 2024	45.23	54.76	0	0	0
Trivandrum	Kulathoor	February, 2024	30.98	60.56	5.63	2.81	0
Pathanamtittha	Elanthoor	February, 2024	22.58	72.58	4.83	0	0
Alappuzha	Krishnapuram	February, 2024	80.70	17.54	0	1.75	0
Kottayam	Chingavanam	February, 2024	68.25	28.57	0	3.17	0
Kasargod	Padakkanad	October, 2024	0	90.90	9.09	0	0

jackbeardsleyi, *F. virgata*, and *P. manihoti*. Among these species, *P. manihoti* was the most dominant, followed by *P. marginatus*, *F. virgata* and *P. jackbeardsleyi*. In India, Joshi et al. (2021) identified a broader diversity, recording ten mealybug species on cassava: *P. manihoti*, *P. marginatus*, *F. virgata*, *P. jackbeardsleyi*, *P. longispinus*, *P. solenopsis*, *P. madeirensis*, *M. hirsutus*, *Pl. citri*, and *N. viridis*. In the state of Kerala, however, only two species (*P. manihoti* and *P. marginatus*) are abundant, while the remaining species (*F. virgata*, *P. jackbeardsleyi*, *P. solenopsis*, and *P. madeirensis*) occur less frequently. More recently, Premalatha et al. (2023) conducted a comparative study on the morphological traits of *Ph. manihoti*, *F. virgata*, and *P. jackbeardsleyi* on cassava and the results were in line with the findings of our study. Our findings corroborate those of Sarvanan et al. (2023), who conducted field studies at TCRS, Yethapur, and surveys in Salem and Namakkal districts (2021–23), identifying *P. manihoti* and *P. marginatus* as dominant cassava pests, with peak infestations occurring in June–September, causing severe damage in hotspot blocks.

The reported mealybugs were invasive and polyphagous pests. The mealybugs *P. marginatus*, *P. solenopsis*, *F. virgata*, and *P. jackbeardsleyi* are highly polyphagous pests, feeding on various plant species across multiple families. Among these, *P. marginatus* is particularly abundant in cassava, infesting 95 host plants from 39 families, with Euphorbiaceae being the most prominent. This preference makes cassava a primary host for *P. marginatus* in Kerala (Chellappan et al., 2013). Globally, it feeds on plants from 50 families and 158 taxa, highlighting its adaptability (García Morales, 2016). *P. solenopsis* feeds on numerous hosts approximately 204 plant species, including field crops, ornamentals, trees, vegetables, and weeds (García Morales, 2016). Joshi et al. (2021) reported that cassava is a less preferred host of *P. solenopsis*. *F. virgata* is among the most polyphagous mealybugs, infesting plant species from approximately 203 genera across 77 families (McCorquodale and Hodges, 2017). These mealybugs are significant pests of cassava, compromising plant health by feeding on phloem sap, which triggers a cascade of symptoms such as stunted growth, leaf chlorosis, and, in severe infestations, plant mortality (Calatayud et al., 2006). Their population dynamics are particularly alarming during warmer weather, which accelerates their reproduction and dispersal. Addressing the complexity of mealybug infestations requires an integrated pest management (IPM) approach, as single-method interventions are insufficient. The comprehensive strategy encompasses biological control through periodic releases of specific parasitoids: *Anagyrus lopezi* De Santis for managing *P. manihoti*, and a complex of parasitoids including *Anagyrus loecki* Noyes & Menezes, *Acerophagus papayae* Noyes &

Schauff, and *Pseudleptomastix mexicana* Noyes & Schauff for controlling *P. marginatus* (Jayaprakas et al., 2022). These biological control agents have demonstrated significant efficacy in regulating mealybug populations across various regions. For long-term sustainability, the development and adoption of resistant cassava varieties offers a promising avenue for reducing crop vulnerability to mealybug infestations.

Acknowledgements

The authors express their heartfelt gratitude to the Head, Department of Entomology and AINPVP, College of Agriculture, Kerala Agricultural University, Vellanikkara, for providing essential facilities and timely support throughout this study. The author, Jasti Sri Vishnu Murthy, would like to extend his sincere thanks to the Kerala State Biodiversity Board (KSBB), Thiruvananthapuram for the financial grant during his PhD research under reference number 612/A11/2022/KSBB. Additionally, I would like to convey his sincere thanks to Dr. Sunil Joshi from the National Bureau of Agriculturally Insect Resources (NBAIR) for the valuable guidance regarding mealybugs identification during the course of the study.

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