(ISSN: 0973-7049(P))

The Bioscan AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 21(4): S.I (4),855-862, 2026 www.thebioscan.com

Effect of Seasonal Variations and Weather Factors on Population Dynamics of Mealybugs (*Hemiptera: Pseudococcidae)* in the Kalakad Region, Tirunelveli District, Tamil Nadu, India

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DOI: https://doi.org/10.63001/tbs.2026.v21.i04.S.I(4).pp855-862

KEYWORDS
mealybugs; Pseudococcidae; seasonal abundance; temperature; rainfall; population dynamics; Kalakad; integrated pest management

Article Info
Received : 09/08 /2026
Accepted : 20 /09/2026
Published: 31/10/2026

Abstract

Mealybugs (*Hemiptera: Pseudococcidae*) are sap-feeding insects associated with a wide range of agricultural and horticultural plants. This study describes weekly variation in recorded mealybug colony abundance and its association with temperature in the Kalakad region of Tirunelveli District, Tamil Nadu, using 30 observations spanning 1 December 2023 to 2 July 2024. Recorded counts ranged from 0 to 42 colonies (mean = 18.17; sample standard deviation = 13.55). Counts increased from zero in the initial observations to a maximum of 42 in late May/early June and then declined to 26 in the final observation. Pearson correlation analysis showed positive associations with maximum temperature ($r = 0.180$, $p = 0.3408$), minimum temperature ($r = 0.388$, $p = 0.0340$), and average temperature ($r = 0.313$, $p = 0.0920$). Only the minimum-temperature association reached $p < 0.05$. A simple regression using average temperature produced $Y = -47.02 + 2.07X$ ($R^2 = 0.098$; $p = 0.0920$), indicating limited explanatory power. The supplied analysis also reported differences among monthly and seasonal groups, but these results require verification against the raw data and model assumptions. Rainfall was recorded qualitatively for selected weeks only; therefore, a numerical rainfall relationship could not be tested. These observations provide preliminary local evidence of temporal variation and demonstrate the need for standardized sampling and complete meteorological records.

1. Introduction

Mealybugs (Hemiptera: Pseudococcidae) are sap-feeding insects associated with many agricultural, horticultural and ornamental host plants. Feeding may weaken plants, while honeydew excretion can promote sooty mould growth and reduce plant quality. Their abundance may vary with host-plant condition, weather, crop management and natural-enemy activity. Mealybug biology and management have been reviewed by Mani and Shivaraju

(2016), and integrated management approaches are discussed by Franco *et al.* (2009) and Reddy (2014).

Monitoring pest abundance together with weather observations can help describe seasonal patterns and plan field scouting. However, correlation does not establish causation, and reliable inference depends on clearly defined sampling units, complete weather records and suitable statistical methods.

The supplied study concerns the Kalakad region of Tirunelveli District, Tamil Nadu. The original manuscript mentions gardens and agro-ecological sites with fruit and ornamental plants, including guava, papaya, sapota and hibiscus. Ferrisia virgata and Maconellicoccus hirsutus are listed among the observed mealybugs; these identifications should be confirmed from diagnostic records or voucher specimens before publication.

The objectives were to describe weekly variation in recorded colony abundance; assess associations with maximum, minimum and average temperature; summarize the supplied monthly and seasonal comparisons; and describe rainfall observations without making unsupported quantitative claims.

2. Materials and Methods

2.1 Study area and study period: The study was reported from the Kalakad region of Tirunelveli District, Tamil Nadu, India, within the Western Ghats landscape. The observation table spans 1 December 2023 to 2 July 2024 and contains 30 weekly records. This table-based period is used because the source Methods section describes the study as six months, whereas the observation dates extend into July.

2.2 Field sampling and identification: The supplied manuscript states that five fixed locations representing different cropping patterns and microclimates were selected and that ten plants of each crop species were randomly chosen at each location. Leaves, stems, fruits and roots were inspected when infestation was present. Specimens were collected with camel-hair brushes and preserved in 70% alcohol. Identification reportedly used a stereo-zoom microscope and taxonomic keys including Williams and Granara de Willink (1992) and Mani and Shivaraju (2016). The original files do not clearly specify whether each weekly colony count represents an individual plant, a site total or an average across plants. They also describe monthly sampling in one place while presenting weekly records. These details must be confirmed by the authors; they have not been inferred here.



Figure 1. Field photographs of mealybug-like insects on plant stems and leaves at Keela Pathai, Tirunelveli District, Tamil Nadu, India. (a–d) Representative field observations recorded in March and June 2024.

2.3 Weather data: Weekly maximum, minimum and average temperatures were supplied and attributed to the Regional Meteorological Centre in Tirunelveli. Rainfall was recorded qualitatively in selected weeks as "Rain" or "H. Rain". Complete numerical rainfall and relative-humidity series were not supplied; therefore, no quantitative analysis of rainfall or humidity was conducted.

2.4 Statistical analysis: Descriptive statistics, Pearson correlations, lagged correlations, simple linear regression and one-way ANOVA summaries are reported from the supplied corrected statistical analysis. Lag 0 denotes temperature and abundance in the same week; lag 1 denotes temperature in the preceding week; lag 2 denotes temperature two weeks earlier. Regression used average temperature as predictor and colony count as response. The significance threshold was $p < 0.05$. Because the files do not include a complete auditable raw-data sheet or model diagnostics, the inferential statistics should be independently recalculated before submission.

3. Results

3.1 Weekly variation in colony abundance: Across 30 observations, recorded colony counts ranged from 0 to 42 (mean = 18.17; sample SD = 13.55). Counts were zero in the first six observations, increased to 4 in the seventh observation and generally rose over the following months. The maximum recorded count was 42 during 28 May–4 June 2024. Counts then declined to 36, 32, 29 and 26 in the final four observations.

3.2 Correlation with temperature: The corrected same-week analysis showed positive correlations between colony abundance and each temperature variable (Table 2). Minimum temperature had the strongest same-week association ($r = 0.388$, $p = 0.0340$), which met the $p < 0.05$ threshold. Maximum temperature ($r = 0.180$, $p = 0.3408$) and average temperature ($r = 0.313$, $p = 0.0920$) were not statistically significant. These are associations and do not establish a causal effect.

3.3 Lagged correlations: The corrected analysis reported higher correlations when current-week colony abundance was compared with temperature from one or two weeks earlier (Table 3). At lag 2, coefficients were 0.381 for maximum temperature, 0.537 for minimum temperature and 0.497 for average temperature. Because adjacent weekly observations may share temporal trends, these coefficients should be treated as exploratory rather than proof of a biological delay.

3.4 Regression analysis: The supplied regression using average temperature was $Y = -47.02 + 2.07X$, where Y is recorded colony abundance and X is average temperature in °C. R^2 was 0.098 and the slope p-value was 0.0920 (Table 4). Average temperature therefore

explained approximately 9.8% of the observed variation in this model; the slope was not statistically significant at $p < 0.05$.

3.5 Monthly and seasonal variation: The supplied corrected analysis reported differences among monthly groups ($F(6,23) = 100.66$, $p = 2.444 \times 10^{-15}$) and seasonal groups ($F(2,27) = 27.32$, $p = 3.255 \times 10^{-7}$). The largest monthly mean was reported for May (38.25), and the lowest for December (0.00). Seasonal means were reported as 1.89 for winter, 23.82 for summer and 30.75 for early monsoon (Tables 5 and 6).

3.6 Rainfall observations: Some observations marked as rainy coincided with declining mealybug counts; however, rainfall values were not measured numerically for every week. Therefore, a rainfall correlation or quantified rainfall effect could not be determined. Relative humidity was considered as an environmental factor in the study rationale; however, a complete numerical dataset for relative humidity was not available for the observation period.

Table 1. Weekly colony counts and temperature observations

Obs.	Date/period	Colonies	Rain note	Max °C	Min °C	Avg °C
1	1–7 Dec 2023	0	Rain	32	27	29.5
2	8–14 Dec 2023	0	—	33	28	30.5
3	15–22 Dec 2023	0	Heavy rain	27	24	25.5
4	23–29 Dec 2023	0	Rain	33	26	29.5
5	30 Dec–5 Jan	0	Rain	32	27	29.5
6	6–13 Jan 2024	0	—	33	29	31
7	14–20 Jan	4	—	33	32	32.5
8	21–27 Jan	5	—	32	31	31.5
9	28 Jan–3 Feb	8	—	33	32	32
10	4–10 Feb	9	—	34	32	33
11	11–17 Feb	13	—	33	31	32

12	18–24 Feb	14	—	34	30	32
13	25 Feb–2 Mar	16	—	34	32	33
14	3–9 Mar	16	—	34	33	33.5
15	10–16 Mar	17	—	33	31	32
16	17–23 Mar	17	—	35	34	34.5
17	24–30 Mar	18	—	32	30	31
18	31 Mar–6 Apr	22	—	31	29	30
19	7–13 Apr	25	—	35	32	33.5
20	14–21 Apr	28	—	35	31	33
21	22–28 Apr	28	—	34	32	33
22	29 Apr–5 May	29	—	35	33	34
23	6–12 May	33	—	34	32	33
24	13–19 May	37	—	33	30	31.5
25	20–27 May	41	—	34	32	33
26	28 May–4 Jun	42	—	35	33	34
27	5–11 Jun	36	Rain	30	27	28.5
28	12–18 Jun	32	—	31	29	30
29	19–25 Jun	29	—	30	29	29.5
30	26 Jun–2 Jul	26	Rain	29	28	28.5

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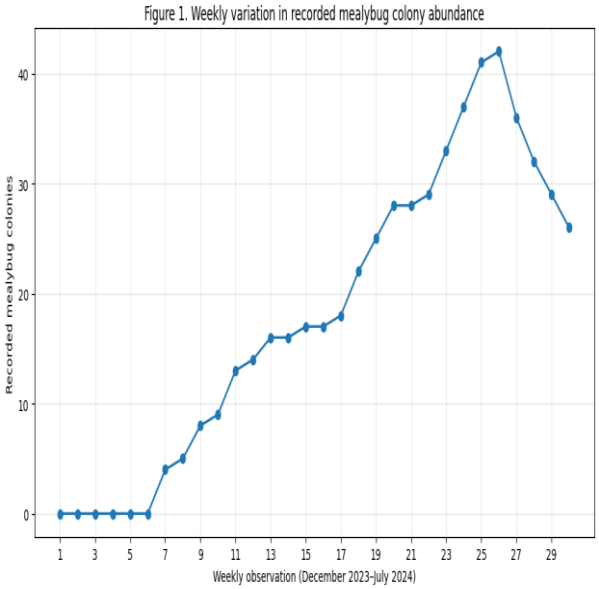


Figure 2. Weekly variation in recorded mealybug colony abundance in the Kalakad region, Tirunelveli District, Tamil Nadu, from December 2023 to July 2024.

Table 2. Same-week correlation with Temperature

Temperature variable	Pearson r	p-value	Interpretation
Maximum temperature	0.180	0.3408	Weak positive; not significant
Minimum temperature	0.388	0.0340	Moderate positive; significant
Average temperature	0.313	0.0920	Weak-to-moderate positive; not significant

Table 3. Lagged correlation coefficients

Temperature variable	Lag 0	Lag 1	Lag 2
Maximum temperature	0.180	0.295	0.381
Minimum temperature	0.388	0.470	0.537
Average temperature	0.313	0.417	0.497

Table 4. Average-temperature regression

Statistic	Corrected value
Equation	$Y = -47.02 + 2.07X$
Slope	2.071
Intercept	−47.024
R^2	0.098
p-value for slope	0.0920

Table 5. Monthly grouping and ANOVA summary

Month group	n	Mean colonies	Range / test
December	5	0.00	0–0
January	4	4.25	0–8
February	4	13.00	9–16
March	5	18.00	16–22
April	4	27.50	25–29
May	4	38.25	33–42
June–July	4	30.75	26–36
ANOVA	30	—	$F(6,23)=100.66$; $p=2.444\times10^{-15}$

Table 6. Seasonal grouping and ANOVA summary

Season	n	Mean colonies	Range / test
Winter (Dec–Jan)	9	1.89	0–8
Summer (Feb–May)	17	23.82	9–42
Early	4	30.75	26–36

monsoon (Jun–Jul)			
ANOVA	30	—	$F(2,27)=27.32$; $p=3.255\times10^{-7}$

4. Discussion

The records show an increase in recorded mealybug colonies from an initial zero-count period to a peak of 42, followed by a decline. This indicates temporal variation during the observed period, but one monitoring period cannot establish a recurring seasonal pattern across years.

Minimum temperature showed a moderate positive same-week correlation with abundance ($r = 0.388$, $p = 0.0340$), whereas the correlations with maximum and average temperature were not statistically significant. The average-temperature regression had low explanatory power ($R^2 = 0.098$). These findings do not support a strong claim that temperature alone explains colony growth. Host plant condition, humidity, rainfall, natural enemies and local management may also contribute, but their independent effects cannot be assessed from the supplied records.

Lagged correlations were stronger than same-week correlations, but lagged associations can arise from temporal autocorrelation or shared trends in short time series. Future studies should test serial dependence and use methods appropriate for repeated count data. The supplied ANOVA summaries indicate group differences, but unequal group sizes and undocumented diagnostic checks limit interpretation.

The rainfall notes are insufficient for quantitative testing. Complete weekly rainfall and relative-humidity data matched to sampling dates would be required to evaluate their association with abundance. Clear reporting of the sampling unit is also essential for reproducibility. Integrated management approaches are discussed in the literature (Franco et al., 2009; Reddy, 2014; Mani & Shivaraju, 2016), but this study did not test any management intervention and cannot establish treatment efficacy.

5. Limitations

Only 30 observations from one study period were supplied, so interannual variability cannot be assessed.

The colony-count sampling unit and aggregation method are not clearly defined in the source files.

The Methods section refers to monthly surveys, whereas the data table contains weekly observations.

Rainfall is qualitative and incomplete; complete numerical rainfall and relative-humidity records were not supplied.

The corrected statistical summaries require independent verification against raw data and documented model diagnostics.

Species identifications should be confirmed from taxonomic records and, where available, voucher specimens.

6. Conclusion

The present study revealed that mealybug colony abundance in the Kalakad region increased from zero during the initial observations, reached a maximum abundance of 42, and subsequently declined to 26 by the final observation. The observations indicated a clear seasonal pattern, with higher mealybug growth and colony abundance during the summer season, whereas comparatively lower growth and abundance were observed during the winter season. Minimum temperature showed a moderate positive association with mealybug abundance during the same week, while maximum and average temperature did not show statistically significant correlations. Regression analysis using average temperature explained only a small proportion of the variation in mealybug abundance.

Monthly and seasonal variations were observed in the study period; however, these patterns should be further validated using complete and standardized datasets. The available qualitative rainfall information was insufficient to establish a reliable numerical relationship between rainfall and mealybug abundance. Standardized sampling methods, complete meteorological records and multi-year monitoring are recommended to confirm seasonal trends and develop reliable forecasting models. The findings indicate that mealybug growth and abundance were higher during the summer season and lower during the winter season, highlighting the importance of seasonal conditions in understanding mealybug population dynamics.

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Author checks before submission

Confirm the colony-count sampling unit and resolve the monthly-versus-weekly sampling description.

Recalculate all statistics from a verified raw-data spreadsheet and check assumptions, including temporal dependence.