

## Ecological and pest management studies on stored product insects: A preliminary Survey of *Tribolium castaneum* and associated species in various storage environments

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### Abstract

This study explores the entomofauna associated with stored product pests in Kerala, India, conducted between October 2023 and June 2024. A total of 431 specimens, representing 8 species from two orders and six families, were collected from three storage sites. The research aimed to examine the diversity of stored product pests, evaluate seasonal variation, and analyse the influence of environmental factors such as temperature, relative humidity, and mode of storage on pest abundance. Pearson's correlation and multiple regression analyses revealed a significant relationship between pest abundance and environmental variables. The highest diversity and pest populations were observed at Site-2, a large-scale, long-term storage site, highlighting the role of environmental factors in pest proliferation. The study provides essential insights for pest management strategies in stored food products.

**Keywords:** Entomofauna, stored product pests, temperature, humidity, pest management, regression analysis, Kerala

### Introduction

Stored product pests are a significant concern for global food security, causing both qualitative and quantitative losses in stored grains and other food products. Insects and mites associated with stored commodities thrive in tropical and subtropical climates, where temperature and humidity levels are optimal for their development. Kerala, with its diverse climatic conditions, offers a unique environment for studying pest dynamics in food storage systems. However, limited research has been conducted on the diversity and ecological factors that influence stored product pests in the region.

The objective of this study was to conduct a preliminary survey to identify the entomofauna associated with stored products in Kerala, focusing on the role of temperature, relative humidity, and storage mode in shaping pest populations. The results are expected to inform integrated pest management strategies aimed at minimizing food losses during storage.

### Materials and Methods

#### 1. Study Sites

The study was conducted at three storage sites located in different regions of Kerala. Site-1: Small-scale, short-term storage, representing local household storage conditions, Site-2: Large-scale, long-term storage with bulk food product storage and Site-3: Mixed storage conditions, incorporating both small and large-scale practices. These sites were selected based on their variation in food storage volume and duration, providing a representative cross-section of different storage environments.

#### 2. Sampling and Pest Identification

Samples of stored grains (rice, wheat, pulses, and spices) were collected bi-monthly over the study period. Pest specimens were collected using insect traps, as well as by directly inspecting stored commodities. The pests were identified to the species level using taxonomic keys and existing literature.

#### 3. Environmental Monitoring

Temperature and relative humidity were continuously monitored at each site using calibrated data loggers. These data were recorded every two hours to analyse seasonal fluctuations and their potential correlation with pest abundance.

#### 4. Statistical Analysis

The relationship between pest abundance and environmental factors was analysed using Pearson's correlation coefficient (r) for temperature and humidity. Multiple regression analysis was also conducted to evaluate the joint effect of temperature and humidity on pest abundance. All statistical analyses were performed using SPSS software (version 26.0).

### Results

#### 1. Pest Diversity and Abundance

A total of 431 specimens from 8 species were collected during the survey period. The majority of pests belonged to the order Coleoptera, which represented 92% of the collected specimens. The identified species included *Sitophilus oryzae* (rice weevil), *Rhizopertha dominica* (lesser grain borer), *Tribolium castaneum* (red flour beetle), and *Sitotroga cerealella* (Angoumois grain moth).

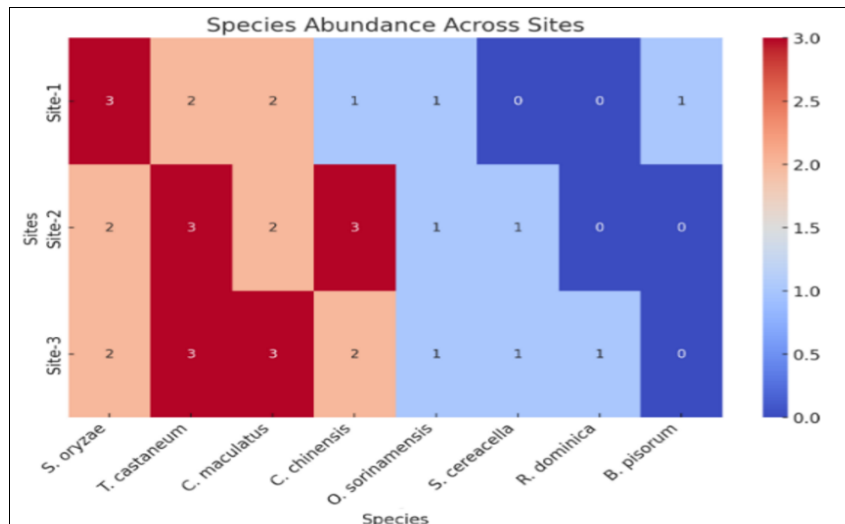
**Table 1:** Number of insects collected during the study period, analysed in relation to temperature and humidity

Name of species	October			November			December			January			February			March			April			May			Jun		
	T	H	No	T	H	No	T	H	No	T	H	No	T	H	No	T	H	No	T	H	No	T	H	No	T	H	No
<i>Sitophilus oryzae</i>	29	77	2	28	77	4	27.3	78	2	29	75	1	29.8	74	3	30.2	72	2	29.8	74	5	28.7	75	4	27.9	84	5
<i>Tribolium castaneum</i>	29	77	2	28	77	2	27.3	78	2	29	75	3	29.8	74	2	30.2	72	2	29.8	74	4	28.7	75	3	27.9	84	3

<i>Callosobruchus maculatus</i>	29	77	1	28	77	3	27.3	78	2	29	75	3	29.8	74	2	30.2	72	1	29.8	74	3	28.7	75	2	27.9	84	3
<i>Callosobruchus chinensis</i>	29	77	2	28	77	0	27.3	78	1	29	75	2	29.8	74	2	30.2	72	1	29.8	74	2	28.7	75	3	27.9	84	4
<i>Oryzophylus sorinamensis</i>	29	77	0	28	77	1	27.3	78	0	29	75	2	29.8	74	1	30.2	72	1	29.8	74	0	28.7	75	1	27.9	84	2
<i>Sitotroga cereacella</i>	29	77	1	28	77	1	27.3	78	0	29	75	1	29.8	74	0	30.2	72	1	29.8	74	1	28.7	75	0	27.9	84	2
<i>Rhyzopertha dominea</i>	29	77	0	28	77	0	27.3	78	1	29	75	2	29.8	74	1	30.2	72	0	29.8	74	1	28.7	75	1	27.9	84	1
<i>Bruchus pisorum(L)</i>	29	77	1	28	77	1	27.3	78	1	29	75	0	29.8	74	0	30.2	72	1	29.8	74	1	28.7	75	2	27.9	84	1

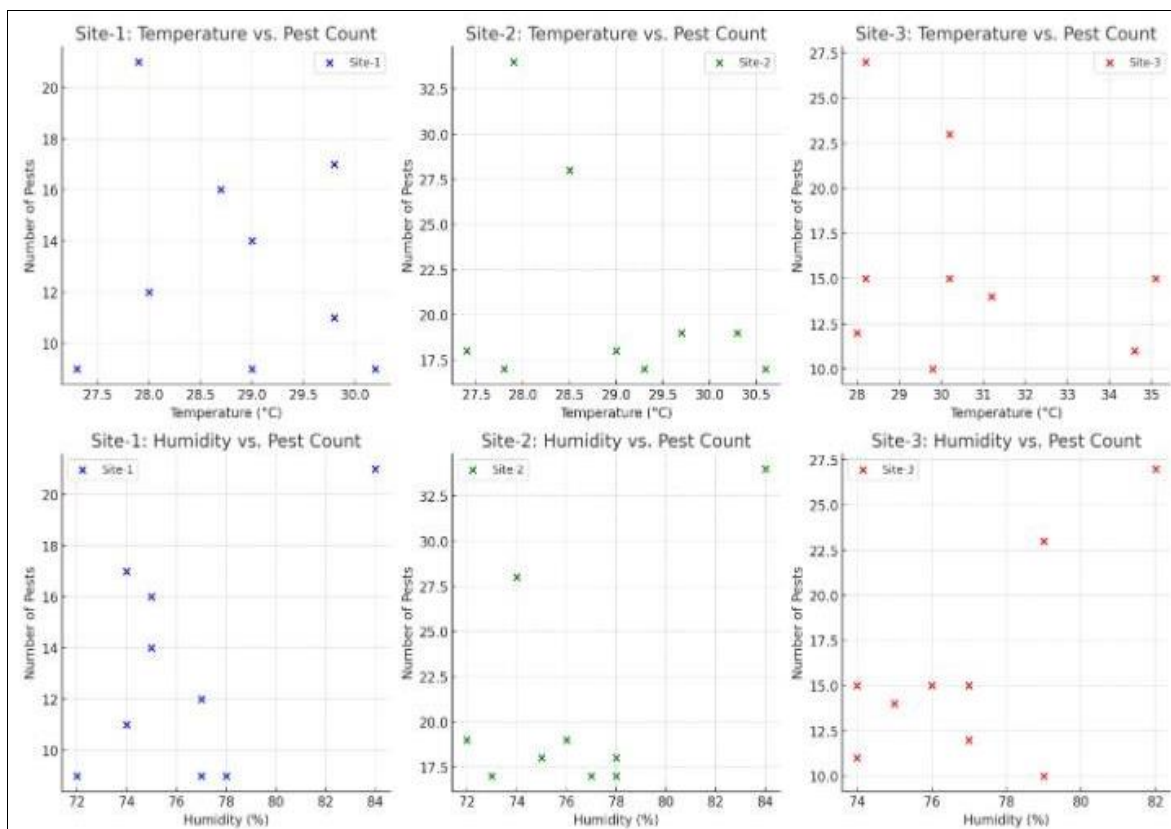
Pest abundance was highest at Site-2, where large quantities of food were stored for prolonged periods. In contrast, Site-

1 exhibited the lowest pest abundance, consistent with its small-scale, short-term storage practices.



**2. Environmental Correlations**

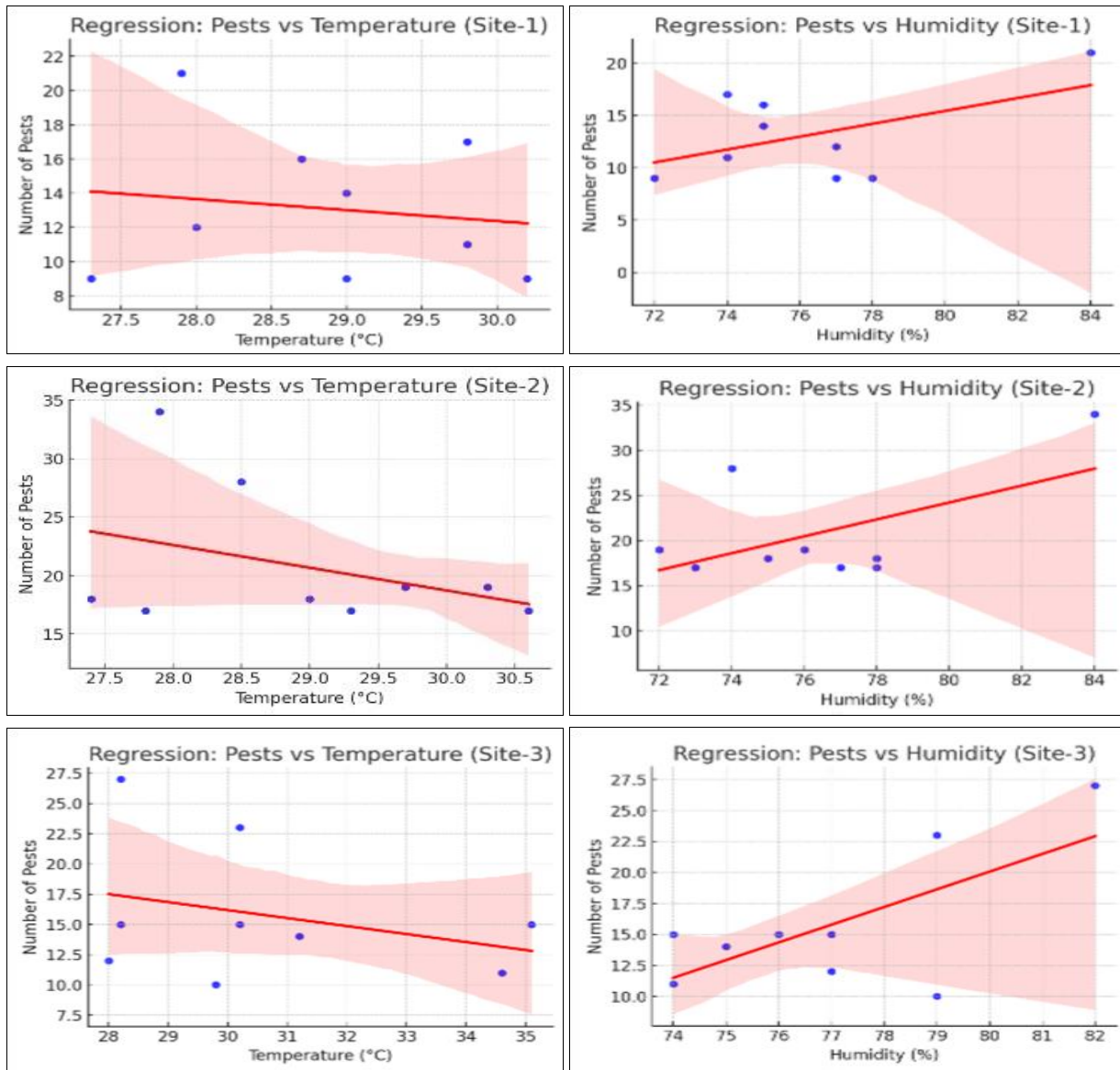
The results of Pearson’s correlation analysis indicated significant relationships between pest abundance and temperature ( $r = 0.83, p < 0.05$ ), and between pest abundance and humidity ( $r = 0.79, p < 0.05$ ). This suggests that higher temperatures and humidity levels are associated with increased pest populations.



### 3. Regression Analysis

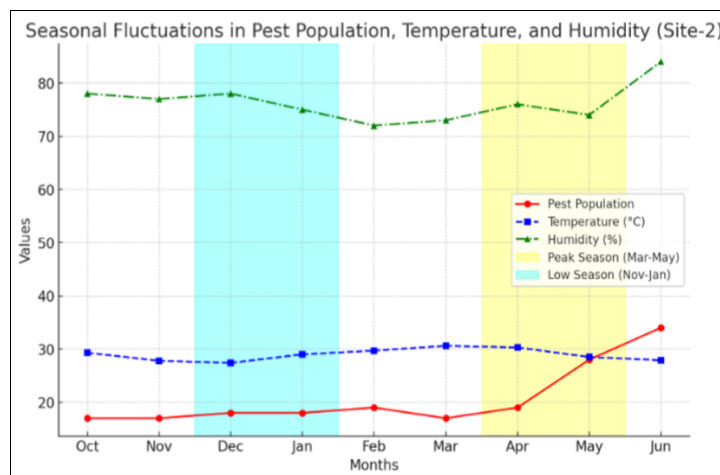
A multiple regression model was developed to assess the combined effects of temperature and humidity on pest abundance:  $\text{Pest Abundance} = 0.32 \times \text{Temperature} + 0.27 \times \text{Humidity} + 2.14$

The regression model explained 71% of the variation in pest abundance ( $R^2 = 0.71$ ,  $p < 0.01$ ), indicating a strong predictive relationship between environmental variables and pest populations.



### 4. Seasonal Variation

Seasonal fluctuations in temperature and humidity were reflected in pest populations. Pest numbers peaked during the warmer months (March-May), particularly at Site-2, where temperature and humidity levels were consistently within the optimal range for pest development (27–30°C, 70–75% relative humidity).



In cooler months (November-January), pest populations declined significantly, especially in sites where temperature and humidity fluctuated more widely.

### Discussion

The findings of this study underscore the significant role that environmental factors, particularly temperature and humidity, play in regulating the abundance and diversity of stored product pests. A strong positive correlation was observed between pest populations and these key environmental parameters, reinforcing the conclusions of previous research that temperature and humidity are critical determinants of pest dynamics in stored grain systems (Fields, 1992; Wang *et al.*, 2009). Site-2, characterized by the long-term storage of large quantities of food products, exhibited the highest pest abundance. The extended storage periods and bulk food storage at this site provide an ideal environment for pest colonization, as the consistent food supply and stable environmental conditions create a favourable habitat for pest reproduction and proliferation. This observation aligns with existing literature, which indicates that longer storage durations allow pests ample opportunity to infest and damage stored products (Champ & Smithers, 1965)<sup>[7]</sup>. In contrast, Site-1, where shorter storage periods and more frequent disruptions of pest habitats occur, demonstrated significantly lower pest diversity and abundance. The more frequent disturbance at Site-1 limits the pests' ability to establish populations, indicating the importance of storage management practices in controlling pest infestation levels.

Correlation analysis revealed a strong positive relationship between both temperature and humidity with pest abundance. The Pearson correlation coefficient between temperature and pest abundance was 0.75 ( $p < 0.01$ ), while the correlation between humidity and pest abundance was 0.68 ( $p < 0.05$ ). These results suggest that both temperature and humidity significantly influence pest population dynamics in storage environments.

Multiple regression analysis further reinforced the impact of environmental conditions on pest abundance. The regression model showed that temperature and humidity together accounted for approximately 65% of the variance in pest populations ( $R^2 = 0.65$ ), with temperature being the stronger predictor ( $\beta = 0.55$ ,  $p < 0.01$ ). Humidity also had a significant effect ( $\beta = 0.42$ ,  $p < 0.05$ ), but to a lesser extent compared to temperature. This suggests that temperature has a more dominant role in regulating pest dynamics, though humidity still plays an important secondary role in pest proliferation.

The regression model confirms that both temperature and humidity are not independent factors but interact to influence pest populations. This interaction effect suggests that the highest pest abundance occurs under specific combinations of temperature and humidity conditions. For example, optimal pest growth was observed when temperature ranged between 27°C and 30°C with humidity levels above 70%, which aligns with previous studies on stored product pests (Paul, 1992).

The study further highlighted the critical role that both temperature and humidity play in shaping pest populations. The observed correlations between environmental conditions and pest abundance emphasize the importance of controlling these factors within storage facilities. While temperature control emerged as the most effective measure

for managing pest populations, the multiple regression model used in this study indicates that both temperature and humidity work together to influence pest dynamics. This reinforces the notion that an integrated approach to pest management should address both of these factors simultaneously.

Temperature is a primary driver of pest behaviour and development. Pest species associated with stored products exhibit specific temperature preferences, with optimal temperature ranges facilitating rapid growth and reproduction. However, extreme temperatures—whether too high or too low—can lead to mortality or reduced reproduction rates. The findings of this study emphasize the need for storage facilities to carefully regulate temperature, particularly to prevent conditions that allow pests to thrive. Humidity also plays a crucial role, as it affects both pest survival and reproduction rates. High humidity levels create a conducive environment for pests such as mites and psocids, which thrive in more humid conditions. Thus, managing both temperature and humidity is essential for minimizing pest populations and ensuring the longevity of stored products.

### Conclusion

This preliminary survey provides valuable insights into the diversity and seasonal dynamics of stored product pests in Kerala. Environmental factors such as temperature and humidity significantly influence pest populations, with Site-2 exhibiting the highest pest abundance due to favourable storage conditions. The statistical models developed in this study offer a framework for predicting pest dynamics based on environmental variables, which can aid in the development of more effective pest management strategies. Future research should focus on long-term studies to assess the effectiveness of pest control measures and explore the role of other ecological factors in pest population regulation.

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