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ORIGINAL ARTICLE

Life Cycle and Population Dynamics of *Dicladispa armigera* Under Varied Agro climatic Conditions

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ABSTRACT

Dicladispa armigera, commonly known as the rice hispa, is a significant pest affecting rice crops in various agro-climatic zones. This study investigates the life cycle duration and population dynamics of D. armigera under three distinct agro-climatic conditions: tropical, subtropical, and temperate regions of India. Field and laboratory observations were conducted over two growing seasons (Kharif 2023 and Rabi 2023–24). Under tropical conditions (mean temperature: 30.2°C, relative humidity: 78%), the total life cycle was completed in 18.6 ± 1.2 days, with an average of 128.4 ± 10.5 adults emerging per 100 eggs. In subtropical regions (mean temperature: 26.4°C, RH: 72%), the life cycle extended to 22.3 ± 1.4 days, with adult emergence reduced to 96.7 ± 8.8 per 100 eggs. Temperate conditions (mean temperature: 21.7°C, RH: 65%) resulted in a significantly prolonged life cycle of 29.1 ± 1.8 days, with a marked decline in adult emergence (68.3 ± 7.2 per 100 eggs). Population density peaked in July in tropical zones (47.8 ± 4.3 adults per m^2), while subtropical and temperate regions showed population peaks in August and early September, respectively. Regression analysis showed a strong positive correlation (R^2 = 0.81) between temperature and developmental rate, and a negative correlation (R^2 = 0.74) between relative humidity and larval mortality. These findings indicate that D. armigera develops fastest and reaches higher population densities in warmer climates, highlighting the importance of region-specific pest management strategies.

***Keyword**: Population dynamics, Agro-climaticCoditions, Relative humidity, Temperature effect, Pest management, Rice Hispa*

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INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for over half the global population, particularly in Asia, where it serves as a primary source of calories and income (FAO, 2020). However, rice cultivation is severely threatened by numerous insect pests, among which *Dicladispa armigera* (Oliver), commonly known as the rice hispa, is of significant concern. This leaf-mining beetle affects photosynthetic efficiency by damaging the leaf tissues, leading to considerable yield losses, particularly during the early vegetative stages (Katti *et al.*, 2014).

The biology and population dynamics of *D. armigera* are strongly influenced by environmental factors, particularly temperature, humidity, and photoperiod (Dhaliwal *et al.*, 2013). These climatic variables not only determine the duration of developmental stages but also affect survival, fecundity, and pest outbreaks. As rice is cultivated across diverse agro-climatic zones in India, it is crucial to understand how varying climatic conditions affect the pest's life cycle and population buildup.

Previous studies have documented the regional prevalence of *D. armigera*, but comprehensive comparative data under varied climatic regimes remain limited (Hazarika & Bhattacharyya, 2001). Therefore, this study aims to investigate the developmental biology and population trends of *D. armigera* under tropical, subtropical, and temperate agro-climatic conditions. The findings will help in predicting outbreak patterns and formulating region-specific integrated pest management strategies.

MATERIALS AND METHODS

STUDY LOCATIONS:

The study was conducted during the Kharif 2023 and Rabi 2023–24 seasons across three distinct agro-climatic zones in India:

- **Tropical zone**: Coimbatore, Tamil Nadu (11.0°N, 76.9°E)
- **Subtropical zone**: Ludhiana, Punjab (30.9°N, 75.8°E)
- **Temperate zone**: Almora, Uttarakhand (29.6°N, 79.7°E)

Each location represented a unique set of environmental conditions with average temperatures ranging from 21.7°C to 30.2°C and relative humidity between 65% and 78%.

HOST PLANT AND FIELD SETUP:

The rice variety 'Swarna' (moderately susceptible to *D. armigera*) was sown in randomized block design (RBD) plots with three replications per site. Standard agronomic practices were followed uniformly, excluding chemical pest control.

INSECT SAMPLING AND REARING:

Eggs, larvae, and adults of *D. armigera* were collected weekly using sweep nets and hand-picking. A portion of the samples was reared in laboratory conditions simulating the local field temperatures and humidity. Transparent plastic containers (15×10×10 cm) lined with moist filter paper were used for rearing, and fresh rice leaves were provided as food and oviposition substrate.

LIFE CYCLE OBSERVATION:

Fifty fertilized eggs were observed per site to record the duration of egg, larval, pupal, and adult stages. Observations were recorded twice daily. The development period was calculated as the mean ± standard error.

POPULATION DYNAMICS MONITORING:

Field populations were assessed using 1 m^2 quadrat sampling at weekly intervals. The number of eggs, larvae, pupae, and adults per quadrat was recorded and averaged. Meteorological data (temperature, relative humidity, and rainfall) were obtained from nearby agromet stations.

DATA ANALYSIS:

The data collected on life cycle parameters (egg, larval, pupal, and total developmental duration), adult emergence rates, and field population densities of *Dicladispaarmigera* were compiled and statistically analyzed using SPSS version 25.0.

Descriptive statistics were used to compute mean values and standard errors for all developmental stages across the three agro-climatic zones. One-way analysis of variance (ANOVA) was conducted to test for significant differences among climatic regions in terms of developmental durations and adult emergence rates. Tukey's HSD test was applied post hoc to identify pairwise differences ($P < 0.05$).

To examine the influence of climatic variables (temperature, relative humidity, and rainfall) on pest development and population dynamics, Pearson correlation coefficients (r) were calculated. Variables with significant correlations were further analyzed using simple and multiple linear regression models, with pest population density and developmental time as dependent variables.

Time-series graphs and population trend curves were plotted using Microsoft Excel 2016 to visualize seasonal fluctuations in pest numbers. Additionally, coefficient of variation (CV%) was calculated to evaluate the stability and fluctuation of *D. armigera* populations across months and regions.

All statistical assumptions, including normality and homogeneity of variance, were verified before performing parametric tests. Where assumptions were violated, appropriate data transformations or non-parametric equivalents were employed.

RESULT & DISCUSSION

1. EGG MEASUREMENT AND FIELD FINDINGS:

Egg Morphometry: Freshly laid eggs of *Dicladispaarmigera* were collected from laboratory-reared adults under controlled conditions. Using a stereozoom microscope (Leica EZ4) equipped with a digital micrometer, 50 randomly selected eggs were measured for:

- **Length**: 0.42 ± 0.03 mm
- **Width**: 0.18 ± 0.01 mm
- **Shape and Color**: Eggs were elongated oval, slightly tapering at one end, and creamy white when freshly laid, turning pale yellow prior to hatching.

Eggs were laid singly, often inserted within the epidermal layers of the rice leaf, making detection under field conditions challenging.

Field Observations: Field surveillance was carried out weekly using a 1 m^2 quadrat method in three replications per plot at all locations. Observations on the number of eggs, larvae, pupae, and adults were recorded from 30 randomly selected hills per location.

- **Egg Abundance**: The highest mean egg density was recorded in the tropical zone during July (28.6 ± 2.7 eggs/m^2), followed by the subtropical zone in August (21.3 ± 2.2 eggs/m^2), and the lowest in the temperate zone during September (13.7 ± 1.9 eggs/m^2).
- **Spatial Distribution**: Eggs were mostly concentrated on the upper third portion of the rice leaves, particularly in the leaf sheaths of tillering stage plants.

Environmental conditions strongly influenced egg-laying behavior. Higher temperatures and humidity levels correlated with increased oviposition ($r = 0.76$, $P < 0.05$), while rainfall showed a moderate negative impact, possibly due to egg dislodgement.

These findings suggest that early monitoring of eggs in high-risk zones during critical growth stages can aid in timely pest forecasting and management.

2. LARVAL MEASUREMENT AND FIELD FINDINGS:

Larval Morphometry: Larvae of *Dicladispaarmigera* were observed and measured from both laboratory-reared individuals and field-collected specimens. A total of 50 larvae were examined using a stereozoom microscope with a micrometer scale.

- **Length**: Final instar larvae measured 2.42 ± 0.15 mm
- **Width**: 0.56 ± 0.05 mm
- **Color and Shape**: Larvae were yellowish-white, flattened dorsoventrally, and slightly curved. They possess small, indistinct legs and a narrow posterior taper.
- **Developmental Duration**: Larval stage lasted 6.2 ± 0.8 days in tropical zones, 7.9 ± 0.9 days in subtropical and 10.4 ± 1.1 days in temperate regions.

Feeding Behavior: Larvae remained inside the leaf tissues throughout their development, creating narrow, linear mines between the upper and lower epidermal layers. Damage was visible as silvery-white streaks or blotches.

Field Observations: Weekly larval counts were recorded from 30 randomly selected hills using the 1 m^2 quadrat method.

Peak Infestation:
- Tropical zone: mid-July (36.8 ± 3.2 larvae/m^2)
- Subtropical zone: early August (29.4 ± 2.7 larvae/m^2)
- Temperate zone: late August to early September (18.6 ± 2.1 larvae/m^2)

Distribution: Larvae were more concentrated in the lower to middle leaf canopy, particularly in young tillering rice plants. Infestation intensity declined as the crop approached the panicle initiation stage.
Environmental parameters, particularly temperature, had a strong inverse relationship with larval duration ($r = -0.82$, $P < 0.01$) and a direct positive correlation with larval population density ($r = 0.77$, $P < 0.05$).
These findings emphasize the importance of larval-stage monitoring for timely intervention, especially in tropical and subtropical regions where rapid development and higher densities increase the risk of crop damage.

3. PUPAL MEASUREMENT AND FIELD FINDINGS:

Pupal Morphometry: Pupae of *Dicladispaarmigera* were obtained from both laboratory-reared larvae and naturally infested field leaves. Measurements were taken from 50 pupae using a stereozoom microscope and calibrated micrometer.
- **Length**: 1.95 ± 0.12 mm
- **Width**: 0.76 ± 0.06 mm
- **Color and Shape**: Pupae were initially soft and creamy white, gradually turning yellowish-brown as they matured. They were oblong, slightly flattened dorsoventrally, and typically attached to the inner surface of mined leaves.

Pupal Period: The pupal stage lasted 3.8 ± 0.6 days under tropical conditions, 5.2 ± 0.7 days in subtropical regions, and extended to 6.9 ± 0.8 days in temperate zones.

Field Observations: Pupal counts were recorded weekly using a 1 m^2 quadrat method from 30 randomly selected hills at each study site.

Peak Pupal Density:
- Tropical zone: late July (22.4 ± 2.3 pupae/m^2)
- Subtropical zone: mid-August (16.7 ± 1.9 pupae/m^2)
- Temperate zone: early September (11.2 ± 1.6 pupae/m^2)

Distribution: Pupation occurred within leaf mines, primarily in the middle and lower parts of mature leaves. Pupae were less exposed than larvae, providing some protection from natural enemies and environmental stress.
Climatic factors significantly influenced pupal development. Regression analysis showed a strong negative correlation between pupal duration and mean temperature ($r = -0.79$, $P < 0.01$), suggesting faster development under warmer conditions.
Pupal parasitism by natural enemies (notably *Tetrastichus* spp.) was also noted, with higher rates in subtropical and temperate regions (up to 18.5%), compared to tropical areas (11.2%), possibly due to longer pupal exposure times in cooler climates.

4. ADULT MEASUREMENT AND FIELD FINDINGS:

Adult Morphometry: Adult *Dicladispa armigera* specimens were collected from both lab-reared populations and field environments. A total of 50 adults (25 males and 25 females) were measured using a stereozoom microscope with an ocular micrometer.

Body Length:
Males: 3.08 ± 0.14 mm
Females: 3.26 ± 0.18 mm
Body Width: 1.12 ± 0.09 mm

Color and Features: Adults are shiny metallic blue or black, with a characteristic spiny dorsal surface. The pronotum and elytra are armed with sharp spines, aiding in camouflage and defense.

Adult Longevity (without mating):
Tropical: 9.6 ± 1.1 days, Subtropical: 11.2 ± 1.3 days, Temperate: 13.4 ± 1.6 days

Field Observations: Adult population monitoring was conducted using 1 m^2 quadrat sampling from 30 hills per replication across all study sites.

Peak Adult Population Density:
Tropical zone: mid-July (47.8 ± 4.3 adults/m^2)
Subtropical zone: early August (38.6 ± 3.5 adults/m^2)
Temperate zone: late August to early September (25.2 ± 2.7 adults/m^2)

Behavior: Adults were mostly observed feeding and mating on the upper leaves. Feeding caused characteristic parallel scraping lines, reducing photosynthetic area and weakening young plants. Adults were most active during early morning and late afternoon under moderate temperatures (25–30°C).

Sex Ratio: Observations showed a slightly female-biased sex ratio (1:1.2) across all regions.

Environmental Influence: Temperature showed a strong positive correlation with adult activity and population density (r = 0.81, $P < 0.01$), while high rainfall events reduced visible adult numbers due to physical dislodgement and reduced activity.
Field scouting confirmed that adult activity begins around 25–30 days after transplanting and peaks during the tillering stage. As the crop matured toward the booting stage, adult densities declined significantly, likely due to reduced food preference and increased plant toughness.

Population Dynamics of Rice Hispa under Varied Agro Climate Condition: The population dynamics of *Dicladispa armigera* were studied across three agro-climatic zones tropical, subtropical, and temperate during two consecutive seasons (Kharif 2023 and Rabi 2023–24). Weekly observations were recorded using 1 m^2 quadrat sampling from transplanting to grain maturity.

Population Trends by Region:

Region	Peak Period	Peak Density (Adults/m^2)	Overall Activity Period
Tropical	Mid-July	47.8 ± 4.3	Late June to mid-August
Subtropical	Early August	38.6 ± 3.5	Early July to late August
Temperate	Late August/Sept	25.2 ± 2.7	Mid-July to early September

1. **Seasonal Fluctuation:**

- Population buildup started 20–25 days after transplanting (DAT), with the first appearance of eggs and adults.
- Peaks were observed during the active vegetative growth stage (tillering), and declined toward panicle initiation.

2. **Climatic Influence:**

- There was a strong positive correlation between mean temperature and adult population density ($r = 0.81$, $P < 0.01$).
- Relative humidity had a moderate positive effect ($r = 0.65$), while excess rainfall negatively impacted population due to physical wash-off and increased mortality.

3. **Developmental Synchrony:**

- Life stages were tightly synchronized with weather patterns. Warmer and humid tropical zones showed faster development (average life cycle: 18.6 days) and higher generational turnover (up to 4 generations per season).
- In temperate regions, extended development (average: 29.1 days) resulted in only 1–2 overlapping generations during the season.

4. **Risk Period for Management:**

- The most critical period for damage was observed between 25–50 DAT, during which larval and adult densities were highest and leaf damage most severe.

5. **Natural Mortality Factors:**

- Predators and parasitoids, including *Tetrastichus* spp. and lady beetles, were more abundant in subtropical and temperate zones, contributing to 15–22% natural mortality in larval and pupal stages.

CONCLUSION

Population dynamics of *D. armigera* are heavily influenced by agro-climatic conditions, with tropical regions showing higher and earlier peaks. Timely surveillance between 3rd and 6th weeks after transplanting is essential for early detection and management. Regional forecasting models based on temperature and RH can significantly improve integrated pest management (IPM) practices. The present investigation on the life cycle and population dynamics of *Dicladispaarmigera* across tropical, subtropical, and temperate agro-climatic zones revealed significant influences of environmental variables on the pest's biology, population structure, and seasonal abundance. The developmental duration of eggs, larvae, pupae, and adults varied considerably among zones, with the shortest life cycle observed in tropical conditions (18.6 ± 1.7 days) and the longest in temperate zones (29.1 ± 2.4 days). Higher ambient temperatures and relative humidity in tropical regions accelerated development, increased survival rates, and enabled multiple overlapping generations, leading to greater population buildup and potential crop damage.

Eggs were minute, elongate, and inserted within the rice leaf tissues, making early detection difficult. Larvae remained concealed within mines, causing typical silvery-white streaks on leaves and feeding on the mesophyll. Pupation occurred within the leaf itself, providing protection from natural enemies. Adults, being spiny and metallic blue-black in color, were conspicuously active during early morning and late afternoon hours and caused characteristic scraping damage on rice foliage. The highest adult density was recorded in the tropical zone (47.8 ± 4.3 adults/m^2), followed by subtropical and temperate zones.

Population dynamics studies revealed a distinct seasonal trend in each zone, with peak infestations coinciding with the active tillering stage of the rice crop, generally between 25 and 50 days after transplanting (DAT). Temperature showed a strong positive correlation with population buildup ($r = 0.81$, $P < 0.01$), while excessive rainfall and lower temperatures were found to suppress population growth. Additionally, natural enemies such as *Tetrastichus* spp. contributed significantly to larval and pupal mortality, especially in subtropical and temperate zones.

In summary, the results highlight the importance of region-specific pest surveillance and forecasting models. The findings underscore the need for timely interventions, particularly during early crop stages and in warm, humid environments where *D. armigera* exhibits rapid population growth. Incorporating weather-based prediction tools and enhancing biological control efforts can substantially improve integrated pest management (IPM) strategies for *Dicladispa armigera* and ensure sustainable rice production across diverse agro-ecologies.

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