IJPP

International Journal of Food Safety and Public Health
Vol. 12 (2), pp. 01-09, July-December, 2025
ISSN: 2756-3693

Full Length Article

Diversity And Seasonal Population Dynamics Of Insect Pests In Rice Cropping Systems Of Durg District

Pooja Singh[1], Dr. Munshi Lal Patel[2]
Research Scholar, Department of Zoology, Bharti University, Durg (Chhattisgarh)[1]
Supervisor, Department of Zoology, Bharti University, Durg (Chhattisgarh)[2]

Accepted 09 December 2025
Author retains the copyrights of this article

Abstract
Rice in central India supports a complex insect community whose composition changes with crop phenology, weather, and management. This empirical-style paper assesses insect-pest diversity and seasonal population fluctuations in the rice-cropping system of Durg District, Chhattisgarh, using a synthetic dataset because primary observations were unavailable. The simulated design represents 18 transplanted-rice fields across Durg, Dhamdha, and Patan blocks, monitored weekly from July to November. Visual hill counts, sweep-net samples, light-trap catches, and damage assessments were integrated with crop stage and weather. Twelve pest species and 4,750 pest individuals were represented. Yellow stem borer, Scirpophaga incertulas, was most abundant (17.68%), followed by rice leaf folder, Cnaphalocrocis medinalis (14.84%), and brown planthopper, Nilaparvata lugens (12.84%). Community diversity increased from establishment to booting, peaked at booting (Shannon H'=2.34), and declined toward maturity. Dominant pests rose sharply during September–October; rice bug peaked later, during grain filling. Relative humidity and crop age were more consistently associated with pest build-up than maximum temperature. Fields classified as low-insecticide/high-habitat had a lower pest:defender ratio, less composite damage, and higher yield than high-insecticide/low-habitat fields, although the observational structure cannot establish causality. The analysis supports stage-specific surveillance: stem borer and leaf-folder monitoring from tillering, planthopper inspection at the plant base during humid reproductive stages, and rice-bug monitoring from flowering onward. Conserving natural enemies and avoiding calendar insecticide sprays are implications. Results establish a reproducible template linking diversity, phenology, weather, damage, and management, while requiring validation with georeferenced field data from Durg.

Keywords: *rice ecosystem; insect-pest diversity; seasonal abundance; yellow stem borer; brown planthopper; integrated pest management; Durg District.*

1. Introduction

1.1 Rice production context and pest risk

Rice (Oryza sativa L.) is simultaneously a food-security crop and a managed wetland habitat. More than one hundred insect species may use rice fields, although only a smaller group regularly causes economic damage [1], [2]. In India, the recurring complex includes yellow stem borer, leaf folder, gall midge, brown and white-backed planthoppers, green leafhopper, rice hispa, whorl maggot, caseworm, and rice bug [3], [4]. Their importance is not constant: stem-borer larvae generate dead hearts during vegetative growth and white earheads during reproduction, defoliators remove photosynthetic tissue, hoppers extract phloem and can transmit viruses, and rice bugs feed directly on developing grain. Crop-loss relationships are therefore conditioned by pest identity, density, timing, crop compensation, and the duration of attack. National and regional IPM packages accordingly emphasize diagnosis and economic thresholds rather than treating every insect observation as an instruction to spray [4], [5].

Durg lies within the rice-growing landscape of central Chhattisgarh, where monsoon rainfall, warm temperatures, transplanted crop structure, irrigation continuity, and asynchronous planting can create a sequence of resources for pest populations. Yellow stem borer is particularly relevant in Chhattisgarh and central India [6]. Yet district-level decisions require more than a list of pests. Extension personnel and growers need to know when dominant species appear, how rapidly populations change, whether diversity is concentrated in one or several species, and whether natural enemies remain sufficiently abundant to restrain outbreaks. Such information can improve the timing of scouting, distinguish routine presence from damaging population growth, and reduce expenditure on poorly timed control. It can also identify periods when field demonstrations, pest advisories, and community-level planting coordination are most useful. Without a seasonal baseline, outbreak reports remain difficult to compare among blocks, varieties, and years, and post hoc spray records can be mistaken for evidence of effective prevention. A repeatable district

protocol is therefore both an ecological and an extension requirement.

1.2 Diversity, seasonality, and ecological regulation

A rice field is a temporally assembled food web. Detritivores and aquatic organisms can support generalist predators early in the season; spiders, mirid bugs, coccinellids, odonates, staphylinids, parasitoids, and other defenders may then suppress herbivores [7], [8]. Diversity is consequently not equivalent to crop loss. A species-rich community with high predator representation may be more stable than a species-poor community dominated by a single outbreak pest. Shannon diversity, Simpson dominance, richness, and evenness provide complementary descriptions, but they must be interpreted beside absolute abundance, feeding guild, and damage. Insecticides can simplify this web, remove predators and parasitoids, and sometimes promote planthopper resurgence [8]–[10]. Habitat diversification and flowering bunds can strengthen biological-control services in rice landscapes [11], [12].

Seasonal fluctuation arises from interacting drivers. Crop growth changes food quality and canopy architecture; rainfall and humidity influence survival and movement; temperature affects development; and planting date determines whether vulnerable stages coincide with pest immigration [13], [14]. A peak in light-trap catch indicates flight activity and relative abundance, not a direct field density over a known area, while sweep and hill counts sample different canopy strata [15]. Sound monitoring therefore combines methods and treats weather correlations as associations rather than proof of mechanism.

1.3 Research gap, objectives, and hypotheses

Published work describes rice-pest biology and seasonal incidence across India and Asia, but locality-specific, multi-method analyses for Durg are not readily consolidated. This paper responds with an empirical-style framework that can later receive genuine field observations. Its objectives are to: (i) characterize pest species composition and dominance; (ii) quantify population change across months and crop stages; (iii) examine associations with weather and crop age; and (iv) relate management intensity, defender abundance, crop damage, and yield. The demonstration hypotheses are that pest abundance and diversity peak during booting to flowering, humidity and crop age positively track major pests, and fields retaining habitat and natural enemies show lower damage. The abstract states these relationships prospectively, and the conclusion returns to them after evaluating the tabulated evidence. Because the dataset is synthetic, the hypotheses illustrate analysis and are not claims about sampled farms.

2. Survey Of Literature

Foundational rice-entomology texts distinguish key pests by feeding niche and diagnostic injury [1]–[3]. Stem borers are concealed feeders, making direct larval counts difficult; dead-heart and white-earhead percentages are therefore common field indicators. Muralidharan and Pasalu demonstrated that the timing and form of stem-borer injury matter for estimating yield loss [16]. Leaf folder incidence is usually represented by damaged leaves or folded leaves, whereas planthoppers require counts near the basal tillers. Rice bug is most consequential around milky grain. These differences justify a phenology-stratified survey rather than one undifferentiated seasonal mean.

Community studies show that sampling method changes the observed assemblage. Visual counts represent sedentary pests and damage, sweep nets capture mobile canopy insects, sticky traps intercept flying taxa, and light traps are effective for nocturnal activity but are influenced by bulb type, moonlight, competing lights, and weather [15], [17]. A recent organic-rice assessment combined visual counts, quadrats, sweeps, sticky traps, pan traps, and aquatic sampling and then calculated Shannon, Margalef, and Pielou indices [18]. A lowland-rice study in Nepal recovered 414 insects from 11 families and eight orders, with grasshoppers and brown planthopper prominent [19]. Such results are informative but not directly transferable because collection effort, taxonomic resolution, season, and production system differ.

Seasonal-incidence research generally reports strong crop-stage signals. Stem borer and leaf folder often build from tillering into the reproductive phase, while rice bugs become conspicuous near heading and milk stage. The relationship with weather varies among locations and years: humidity, rainfall, and temperature can be positive, negative, or non-significant depending on lag structure, pest generation, crop stage, and sampling method [6], [13], [20]. Recent climate-suitability work identifies warm, moist conditions and rice availability as important for yellow stem borer distribution, including high suitability in Chhattisgarh [21]. These studies caution against converting a single contemporaneous correlation into a forecast rule.

The ecological-regulation literature broadens assessment beyond pests. Way and Heong argued that biodiversity, host-plant resistance, habitat continuity, and natural enemies underlie stability in tropical irrigated rice [7]. Settle et al. showed that alternative prey can give generalist predators an early-season ‘head start,’ whereas disrupting predators can permit later pest resurgence [8]. Subsequent work linked unnecessary insecticide use with reduced beneficial organisms and no dependable yield advantage [9], [10]. Multi-country ecological-engineering experiments found that crop and bund diversification can enhance biological

control and reduce pesticide dependence [11]. More recent rice-field studies likewise report higher natural-enemy abundance under ecological-engineering practices [12].

Crop establishment and agronomy also shape incidence. Multi-location Indian evidence indicates that System of Rice Intensification management may reduce stem borer, planthoppers, and gall midge while some other pests can increase, underlining that no establishment method suppresses every guild [22]. Direct-seeded and transplanted systems may differ in canopy, water, and pest timing [23]. Nitrogen management, variety, planting synchrony, water regime, weed hosts, and prophylactic sprays can confound apparent seasonal effects. Accordingly, analytical designs should record these covariates and, ideally, use repeated-measures or mixed models.

The practical synthesis is IPM: monitor, identify, conserve defenders, and intervene only when validated thresholds and crop stage justify action [4], [5], [24]. Diversity indices can reveal community structure; time-series counts locate risk windows; weather models can support warnings; and pest:defender ratios can inform planthopper decisions. However, each metric addresses a different question. The present framework combines them in five linked tables so that species dominance, seasonal peaks, diversity, environmental associations, and management outcomes can be interpreted together rather than in isolation.

A remaining gap concerns scale and reproducibility. Many incidence papers summarize one research plot or one season, whereas farmer fields vary in planting date, cultivar, fertilizer, water, and control history. Block-level pooling can conceal localized outbreaks, while repeated weekly values from the same field are not independent replicates. Transparent metadata, consistent denominators, and models that preserve field identity are therefore essential. Likewise, a statistically significant weather coefficient has limited extension value unless it predicts an actionable density or damage threshold in a later season. The proposed Durg framework addresses these weaknesses by specifying field-week records, multiple observation methods, explicit crop stages, and linked ecological and yield outcomes; its synthetic implementation also makes clear which claims cannot be made until authentic local data are collected.

3. Methodology

The demonstration study was structured as a stratified, repeated-observation survey of transplanted kharif rice. Eighteen hypothetical farmer fields were allocated equally among Durg, Dhamdha, and Patan blocks (six fields per block), with two villages represented in each block and fields separated sufficiently to reduce duplicate sampling of the same local population. Monitoring extended for 20 weeks from July through November and covered establishment, tillering, booting, flowering/milk, and maturity. In each field, five fixed diagonal sampling points were defined. At each visit, observers would examine ten hills per point for basal hoppers, egg masses, larvae, and diagnostic damage; take ten standardized 180-degree sweep-net strokes; and record one overnight light-trap count at a representative village site. Species identity would be verified with rice-pest field keys [1], [3], [4]. Defenders would be recorded separately as spiders, coccinellids, mirid bugs, odonates, staphylinids, and parasitoids. Temperature, relative humidity, and rainfall would be matched to the nearest validated meteorological record. In an actual study, sampling should occur at a consistent morning time, voucher specimens should be deposited, GPS coordinates anonymized, and insecticide, variety, planting date, nitrogen, and irrigation histories recorded.

All numbers used here were generated as a biologically plausible synthetic demonstration and then constrained so that species totals equal monthly and crop-stage totals. Abundance is expressed as pooled individuals unless a table specifies individuals per ten sweeps. Relative abundance was calculated as $p_i=n_i/N$. Species richness was the number of taxa detected; Shannon diversity was $H'=-\Sigma p_i \ln(p_i)$; Simpson diversity was $1-\Sigma p_i^2$; and Pielou evenness was $J'=H'/\ln(S)$ [25]–[27]. Damage combined standardized percentages of dead hearts/white earheads, folded leaves, hopper-burn area, and bug-injured panicles. Management classes were defined before comparison: low-insecticide/high-habitat (zero or one need-based spray plus vegetated bund), moderate (two sprays and partially vegetated bund), and high-insecticide/low-habitat (three or more sprays and simplified bund). These labels describe a synthetic gradient, not audited farmer behavior. Yield was represented by crop-cut equivalent tonnes per hectare at 14% grain moisture.

Analysis was planned at field-week level to avoid treating pooled insects as independent replicates. Count responses would be fitted with negative-binomial generalized linear mixed models, with crop stage, block, management class, and weather as fixed effects and field as a random intercept; an observation-level term or zero-inflated model would be considered when diagnostics required it. For transparent tabulation, Pearson correlations across 20 weekly means summarize contemporaneous association; in a real dataset, Spearman coefficients, one- and two-week weather lags, autocorrelation checks, and false-discovery-rate adjustment should be reported. Management-class means would be compared by one-way ANOVA only after residual checks, otherwise by Kruskal–Wallis tests. Effect sizes and 95% confidence intervals should accompany P values. Relationships between damage

and yield, and between insecticide intensity and defenders, would be estimated with field-level correlations and multivariable regression. Statistical significance was set at $\alpha=0.05$, but ecological magnitude and sampling uncertainty were prioritized over dichotomous significance [28].

4. Data Collection And Analysis

The following five tables are the analytical core of the paper. They are deliberately cross-linked: Table 1 identifies dominant taxa, Table 2 places those taxa in time, Table 3 describes whole-community structure by crop stage, Table 4 evaluates potential environmental and phenological drivers, and Table 5 relates pest pressure to defenders, damage, and yield. Values are synthetic and serve only as a model for analysis.

Table 1: Synthetic Species Composition And Relative Abundance Across The Crop Season

Common name	Scientific name	Order	Individuals (n)	Relative abundance (%)
Yellow stem borer	Scirpophaga incertulas	Lepidoptera	840	17.68
Rice leaf folder	Cnaphalocrocis medinalis	Lepidoptera	705	14.84
Brown planthopper	Nilaparvata lugens	Hemiptera	610	12.84
Green leafhopper	Nephotettix virescens	Hemiptera	520	10.95
White-backed planthopper	Sogatella furcifera	Hemiptera	410	8.63
Rice bug (gundhi bug)	Leptocorisa spp.	Hemiptera	360	7.58
Short-horned grasshopper	Oxya spp.	Orthoptera	300	6.32
Asian rice gall midge	Orseolia oryzae	Diptera	285	6.00
Rice hispa	Dicladispa armigera	Coleoptera	240	5.05
Rice whorl maggot	Hydrellia spp.	Diptera	190	4.00
Rice caseworm	Nymphula depunctalis	Lepidoptera	170	3.58
Rice swarming caterpillar	Spodoptera mauritia	Lepidoptera	120	2.53
Total			4,750	100.00

Table 1 shows a community dominated by stem borer, leaf folder, and planthoppers rather than by one overwhelmingly dominant species. Yellow stem borer contributed 17.68% of all individuals, and the three most abundant taxa together contributed 45.36%. Hemipterans accounted for four of the six leading taxa, indicating substantial sap-feeder and grain-feeder pressure, while Lepidoptera included both concealed stem feeders and defoliators. The pooled Shannon index calculated from the 12 species was approximately 2.37 and Simpson diversity approximately 0.90, consistent with a relatively even multi-pest assemblage. These indices do not mean that all taxa caused equivalent loss: 100 stem-borer larvae, for example, cannot be equated mechanically with 100 leafhoppers. The result supports parallel diagnostic monitoring rather than a single-pest program.

Table 2: Monthly Population Fluctuation Of Five Dominant Or Phenologically Important Pests

Month / principal stage	YSB	Leaf folder	BPH	GLH	Rice bug	Five-pest total
July / establishment	30	20	15	40	0	105
August / tillering	110	95	60	105	0	370
September / booting	230	220	180	160	20	810
October / flowering–milk	310	275	260	155	145	1,145
November / maturity	160	95	95	60	195	605
Season total	840	705	610	520	360	3,035

The five focal pests increased from 105 individuals in July to 1,145 in October, an almost eleven-fold rise, before declining in November. Yellow stem borer, leaf folder, and brown planthopper peaked in October, when the canopy was dense and much of the crop was reproductive. Green leafhopper peaked earlier, in September, whereas rice bug exhibited the clearest late-season signature: it was absent from July–August counts, appeared in September, and reached 195 individuals in November. Thus, a district calendar based only on early vegetative scouting would miss the principal risk windows. The table also demonstrates why pooled seasonal totals are insufficient: equal totals could conceal very different timing and management implications.

International Journal of Food Safety and Public Health
Vol. 12 (2), pp. 01-09, July-December, 2025
ISSN: 2756-3693

Table 3: Synthetic Pest-Community Diversity By Rice Growth Stage

Crop stage	Richness (S)	Individuals (N)	Shannon H′	Simpson 1−D	Pielou J′
Establishment	8	410	1.86	0.79	0.89
Tillering	11	1,120	2.21	0.86	0.92
Booting	12	1,395	2.34	0.89	0.94
Flowering–milk	12	1,250	2.29	0.88	0.92
Maturity	9	575	1.95	0.82	0.89
Whole season	12	4,750	2.37	0.90	0.95

Richness and diversity rose as the crop developed, with the maximum number of taxa and highest stage-specific Shannon diversity at booting (S=12; H′=2.34). Flowering–milk retained all 12 taxa but showed a small decline in evenness, reflecting concentration in stem borer, leaf folder, planthoppers, and the emerging rice-bug population. Maturity had fewer individuals and taxa, partly because defoliators and some hoppers declined as leaves senesced, while grain feeders remained. The whole-season H′ is higher than any single-stage value because temporal pooling combines taxa whose peaks do not coincide. This is a reminder that gamma-like seasonal diversity and within-stage diversity answer different questions.

Table 4: Pearson Correlations (R) Between Weekly Mean Pest Abundance, Weather, And Crop Age (N=20 Weeks)

Pest	Max temp.	Min temp.	Mean RH	Rainfall	Crop age
Yellow stem borer	0.31	0.44	0.62*	0.48	0.71**
Rice leaf folder	0.26	0.39	0.58*	0.53*	0.65**
Brown planthopper	0.18	0.42	0.70**	0.46	0.74**
Green leafhopper	0.22	0.33	0.49	0.41	0.36
Rice bug	0.10	0.05	0.22	−0.12	0.79**

Relative humidity was the strongest weather correlate for brown planthopper (r=0.70) and yellow stem borer (r=0.62). Leaf folder was positively associated with both humidity and rainfall. Crop age had larger coefficients than any weather variable for four of five pests, especially rice bug (r=0.79), confirming that phenological resource availability is essential to interpretation. Maximum temperature had only weak positive relationships. These are contemporaneous bivariate coefficients: crop age, humidity, and seasonal time co-vary, and serially correlated weekly means violate the simplest correlation assumptions. A verified dataset should therefore use lagged mixed models before issuing a weather-based forecast.

Table 5: Management Gradient, Pests, Defenders, Damage, And Yield (Field Mean ± Sd)

Management class	Fields	Pests / 10 sweeps	Defenders / 10 sweeps	P:D ratio	Composite damage (%)	Yield (t ha^{-1})
Low insecticide / high habitat	6	18.4 ± 2.1	8.7 ± 1.0	2.11	6.8 ± 1.2	4.72 ± 0.24
Moderate input / partial habitat	6	23.9 ± 2.8	6.2 ± 0.8	3.85	9.7 ± 1.6	4.31 ± 0.29
High insecticide / low habitat	6	31.6 ± 3.5	3.4 ± 0.6	9.29	14.8 ± 2.0	3.75 ± 0.34
ANOVA P value		0.004	<0.001		<0.001	0.002

The synthetic management gradient links ecological condition with agronomic outcome. Low-insecticide/high-habitat fields had 42% fewer pests per ten sweeps and 2.6 times as many defenders as high-insecticide/low-habitat fields. Their pest:defender ratio was 2.11 rather than 9.29, composite damage was less than half, and mean yield was 0.97 t ha^{-1} higher. At field level, the demonstration data produced r=−0.76 between damage and yield and r=−0.71 between spray frequency and defender abundance. These patterns are compatible with ecological regulation, but management class also bundles habitat, spray frequency, and potentially farmer resources, variety, nitrogen, planting date, and water control. Consequently, Table 5 supports a testable relationship not a causal estimate of insecticide harm or habitat benefit.

5. Discussion

The integrated results support the paper's central proposition that pest risk in Durg rice should be understood as a changing community rather than a fixed list. The 12-species assemblage was relatively diverse, yet three species represented nearly half of all synthetic captures. This combination high

community diversity with concentration in a few economically important taxa means that diversity indices and targeted damage indicators should be reported together. Shannon H′ peaked at booting, while abundance of several dominant pests peaked during October. Diversity and abundance therefore did not reach their maxima at exactly the same point, which is ecologically plausible: new taxa entered as crop niches expanded, after which dominant species accumulated disproportionately.

The seasonal sequence also differentiates interventions. Stem borer and leaf folder require surveillance from tillering onward, with attention to egg masses, dead hearts, damaged leaves, and later white earheads. Planthopper counts should be taken at the base of hills, particularly under humid, dense canopies; sweep samples alone can underrepresent them. Rice bug monitoring should intensify at flowering and milk stage. Light traps can provide an early-warning signal for moth flights, but trap catches should not be interpreted as a known density per hectare [15]. The practical objective is not eradication but detection of a trajectory likely to exceed a validated economic threshold.

Humidity and crop age were more informative than maximum temperature in the synthetic correlation matrix. The large crop-age coefficients show why simplistic claims such as 'rain causes an outbreak' are unsafe. Crop age is a proxy for canopy size, tissue quality, panicle availability, elapsed calendar time, and cumulative exposure. Humidity also co-varies with rainfall and canopy closure. A mechanistic model would separate these variables using field-week data, lagged weather, and random effects. It should test non-linearity because heavy rainfall can sometimes remove small insects even when moderate moisture favors survival.

The management table is consistent with conservation-biological-control theory. Fields with habitat and fewer need-based sprays retained more defenders, had a lower pest:defender ratio, and showed less damage. However, reverse causation is possible: farmers may spray more because pest pressure is already high. Unmeasured agronomy could also influence both spraying and yield. A stronger design would match fields on planting date and variety, record pre-spray populations, and use a randomized ecological-engineering or threshold-based intervention. Even without causal proof, the pattern argues against calendar spraying and for defender counts in routine surveillance.

From a decision perspective, the five tables should be read sequentially rather than as independent findings. A common species is prioritized only when its population is rising in a susceptible crop stage and corresponding injury is increasing; a weather signal matters only if it improves that judgment; and a control action is justified only after defenders and threshold status are considered. This sequence reduces the risk of treating trap catches, diversity, or correlation as direct substitutes for economic injury. It also provides a practical structure for weekly district advisories: report the monitored stage, dominant taxa, direction of change, observed damage, defender condition, and recommended next observation before naming an intervention.

6. Critical Analysis And Comparison With Past Work

The dominance of yellow stem borer in Table 1 agrees with descriptions of the species as a major Chhattisgarh and Asian rice pest [1], [6], [21]. The simulated October maximum also corresponds broadly with studies locating substantial stem-borer activity from late vegetative through reproductive growth [6], [13], [20]. Muralidharan and Pasalu's loss assessment [16] is especially relevant because it warns that visible injury and yield loss are not interchangeable: rice can compensate for some early dead hearts, whereas white earheads directly remove productive panicles. The present framework improves interpretation by separating crop stages, but its pooled insect count still cannot estimate loss without stage-specific damage and crop-cut data.

The booting-stage diversity peak is comparable to surveys that find pest richness increasing as rice develops and structural niches expand [17]–[19]. Nevertheless, numerical comparison of H′ values among studies is risky. Regmi et al. sampled with sweep nets and light traps and reported an assemblage structured strongly by grasshoppers and brown planthopper [19], while the current synthetic community is led by stem borer and leaf folder. Differences may arise from geography, taxonomy, effort, trap selectivity, and whether individuals or damage symptoms were counted. Recent multi-trap work demonstrates that sticky, light, sweep, pan, and aquatic methods recover different richness and guild composition [18]. A robust Durg survey should therefore report diversity separately by method before combining standardized observations.

The positive humidity associations for stem borer, leaf folder, and brown planthopper are directionally compatible with several seasonal studies, yet the wider literature is not uniform [6], [13], [20], [21]. Weather effects depend on the pest's life stage and on delayed responses: rainfall may improve host growth and field humidity, but storms may reduce exposed adults or nymphs. Temperature responses are usually curved rather than linear, and weekly averages conceal extremes. The present correlations omit wind, sunshine, lunar phase for light traps, and lagged rainfall. Their apparent significance is additionally inflated by testing multiple pests and predictors. Consequently, Table 4 is best read as a hypothesis generator. A preregistered Durg analysis should compare distributed-lag models, control false discovery, and validate predictions in a second season.

Table 5 aligns with the ecological interpretation developed by Way and Heong [7] and Settle et al. [8]: diverse rice habitats and alternative prey can maintain early natural enemies that later suppress herbivores. It also resembles experimental and multi-country evidence that ecological engineering increases beneficial arthropods and can suppress pests without yield penalties [11], [12]. Ali et al. found that ecological-engineering plots supported more natural enemies and that prophylactic insecticide treatments did not reliably increase yield [12]. The synthetic Durg gradient shows the same direction, but it is observational and bundles two exposures spray intensity and habitat. It cannot identify whether predators reduced pests, whether low pests reduced spray demand, or whether a third variable caused both.

Past work on SRI and crop establishment provides another caution. Multi-location Indian analysis reported lower incidence of several major pests under SRI, but some pests were more abundant [22]. Direct seeding can alter the timing and magnitude of planthoppers and stem borers relative to transplanting [23]. The current design is restricted to transplanted kharif rice to reduce heterogeneity, which improves internal comparability but limits generalization to direct-seeded, summer, or irrigated dry-season crops. A district surveillance program should stratify establishment method rather than average them.

The synthetic values are internally consistent but not empirically identifiable. No confidence interval can repair the absence of real random sampling. There is also a measurement problem in combining counts from hills, sweeps, and light traps: each has a different effective sampling area and detection probability. Direct summation, used only for demonstration in Tables 1–3, should be replaced by method-specific standardized indices or a hierarchical model with observation process. Species identification also needs quality control because closely related hoppers, stem borers, and rice bugs can be confused, and cryptic species may require expert or molecular confirmation.

A stronger follow-up would monitor at least 30–45 fields over two or more kharif seasons, preserve the field-week structure, and collect pre- and post-intervention observations. Sampling effort should be calibrated through accumulation curves; light-trap hardware and operating nights should be fixed; missing weather should be documented; and raw data, code, and a data dictionary should be archived. Models should include block, field, crop stage, variety, planting date, nitrogen, irrigation, and spray timing, with zero inflation and non-linearity tested. Multivariate ordination could compare community composition, while occupancy or N-mixture approaches could address imperfect detection where assumptions are supportable [29], [30].

Despite these limitations, the analytical relationships form a coherent chain. Phenology creates changing resources; weather modifies survival and activity; pest communities build and shift; defenders can moderate that build-up; realized damage then influences yield. The abstract summarized this chain, and the data tables demonstrate how each link would be evaluated. The framework's value lies not in the synthetic point estimates but in making assumptions explicit and preventing a local empirical claim from being constructed without local evidence.

7. Conclusion

This empirical-style assessment developed a transparent data-analysis framework for insect-pest diversity and seasonal population fluctuation in the rice-cropping system of Durg District. In the synthetic demonstration, 12 pests formed a moderately even assemblage dominated by yellow stem borer, rice leaf folder, and brown planthopper. Diversity peaked at booting, dominant-pest abundance rose most strongly during September–October, and rice bug shifted the risk window toward flowering and grain filling. Relative humidity tracked several major pests, but crop age produced stronger and more consistent associations, showing that weather cannot be interpreted independently of crop phenology. The low-insecticide/high-habitat class retained more defenders, had a lower pest:defender ratio, less damage, and higher yield; nevertheless, observational confounding and reverse causation prevent a causal claim.

The evidence chain returns to the relationships proposed in the abstract: diversity, seasonal timing, weather, ecological regulation, damage, and yield must be analyzed jointly. For Durg, the operational implication is stage-specific surveillance stem borer and leaf folder from tillering, basal planthoppers during humid reproductive growth, and rice bugs from flowering onward combined with defender conservation and threshold-based intervention. Calendar insecticide applications should be avoided where field diagnosis and validated thresholds do not justify them. Most importantly, the numerical findings are synthetic, not observations from Durg farms. Before scientific or policy use, the five tables must be replaced with quality-controlled, georeferenced, multi-season field data and reanalyzed using field-level repeated-measures models. Used in that way, the framework can support a defensible district pest calendar, targeted extension advisories, and ecologically informed rice IPM.

References

[1] M. D. Pathak and Z. R. Khan, Insect Pests of Rice. Manila, Philippines: International Rice Research Institute, 1994.

[2] E. A. Heinrichs, Ed., Biology and Management of Rice Insects. New Delhi, India: Wiley Eastern Ltd. and International Rice Research Institute, 1994.

[3] B. M. Shepard, A. T. Barrion, and J. A. Litsinger, Helpful Insects, Spiders, and Pathogens: Friends of the Rice Farmer. Manila, Philippines: International Rice Research Institute, 1987.

[4] National Institute of Plant Health Management, Integrated Pest Management Package for Rice. Hyderabad, India: NIPHM, Ministry of Agriculture and Farmers Welfare, Government of India, 2014.

[5] International Rice Research Institute, Standard Evaluation System for Rice, 5th ed. Manila, Philippines: IRRI, 2013.

[6] R. K. M. Baskaran, J. Sridhar, K. C. Sharma, and S. Senthil-Nathan, "Influence of summer weather on prevalence of rice yellow stem-borer in central India: Monitoring and biocontrol strategy," Biocatalysis and Agricultural Biotechnology, vol. 21, Art. no. 101340, 2019.

[7] M. J. Way and K. L. Heong, "The role of biodiversity in the dynamics and management of insect pests of tropical irrigated rice A review," Bulletin of Entomological Research, vol. 84, no. 4, pp. 567–587, 1994.

[8] W. H. Settle et al., "Managing tropical rice pests through conservation of generalist natural enemies and alternative prey," Ecology, vol. 77, no. 7, pp. 1975–1988, 1996.

[9] K. L. Heong and K. G. Schoenly, "Impact of insecticides on herbivore-natural enemy communities in tropical rice ecosystems," in Ecotoxicology: Pesticides and Beneficial Organisms, P. T. Haskell and P. McEwen, Eds. London, U.K.: Chapman & Hall, 1998, pp. 381–403.

[10] W. H. Reissig, E. A. Heinrichs, J. A. Litsinger, K. Moody, L. Fiedler, T. W. Mew, and A. T. Barrion, Illustrated Guide to Integrated Pest Management in Rice in Tropical Asia. Manila, Philippines: International Rice Research Institute, 1986.

[11] G. M. Gurr et al., "Multi-country evidence that crop diversification promotes ecological intensification of agriculture," Nature Plants, vol. 2, Art. no. 16014, 2016.

[12] M. P. Ali et al., "Establishing next-generation pest control services in rice fields: Eco-agriculture," Scientific Reports, vol. 9, Art. no. 10180, 2019.

[13] P. Jasrotia, A. Khippal, J. Yadav, P. L. Kashyap, S. Kumar, and G. P. Singh, "Effect of weather variables on the incidence of yellow stem borer (Scirpophaga incertulas W.) and leaf folder (Cnaphalocrocis medinalis G.) in rice," Journal of Cereal Research, vol. 11, no. 3, pp. 247–251, 2019.

[14] S. Savary, P. S. Teng, L. Willocquet, and F. W. Nutter Jr., "Quantification and modeling of crop losses: A review of purposes," Annual Review of Phytopathology, vol. 44, pp. 89–112, 2006.

[15] Philippine Rice Research Institute, Field Guide: Sampling Insect Pests, Damaged and Diseased Plants, and Beneficial Organisms in the Rice Field Devices and Techniques. Muñoz, Philippines: PhilRice, 2023.

[16] K. Muralidharan and I. C. Pasalu, "Assessments of crop losses in rice ecosystems due to stem borer damage (Lepidoptera: Pyralidae)," Crop Protection, vol. 25, no. 5, pp. 409–417, 2006.

[17] M. Nasiruddin and R. C. Roy, "Rice field insect pests during the rice growing seasons in two areas of Hathazari, Chittagong," Bangladesh Journal of Zoology, vol. 40, no. 1, pp. 89–100, 2012.

[18] S. Chaitanya et al., "Diversity and relative abundance of insect pests and natural enemies in organic rice," Uttar Pradesh Journal of Zoology, vol. 45, no. 15, pp. 573–580, 2024.

[19] B. Regmi, "Diversity and abundance of insect pest of low land rice field in Lamahi, Dang district of Nepal," Journal of Agriculture and Natural Resources, vol. 2, no. 1, pp. 137–145, 2019.

[20] M. N. Morshed, M. A. Al Mamun, S. A. I. Nihad, M. M. Rahman, N. Sultana, and M. M. Rahman, "Effect of weather variables on seasonal abundance of rice insects in southeast coastal region of Bangladesh," Journal of Agriculture and Food Research, vol. 11, Art. no. 100513, 2023.

[21] P. Jasrotia et al., "The global invasion risk of rice yellow stem borer, Scirpophaga incertulas, under current and future climates," PLOS ONE, vol. 20, no. 3, Art. no. e0310234, 2025.

[22] P. Chintalapati, S. Rathod, N. Repalle, N. R. G. Varma, K. Karthikeyan, S. Sharma, R. M. Kumar, and G. Katti, "Insect pest incidence with the System of Rice Intensification: Results of a multi-location study and a meta-analysis," Agronomy, vol. 13, no. 4, Art. no. 1100, 2023.

[23] A. K. Singh, S. P. Singh, and R. K. Naresh, "Impact of crop establishment methods on rice insect-pest incidence," Indian Journal of Agricultural Sciences, vol. 89, no. 3, pp. 480–485, 2019.

[24] R. F. Denno and T. J. Perfect, Eds., Planthoppers: Their Ecology and Management. New York, NY, USA: Chapman & Hall, 1994.

[25] C. E. Shannon, "A mathematical theory of communication," Bell System Technical Journal, vol. 27, pp. 379–423 and 623–656, 1948.

[26] E. H. Simpson, "Measurement of diversity," Nature, vol. 163, p. 688, 1949.

[27] E. C. Pielou, Ecological Diversity. New York, NY, USA: Wiley, 1975.
[28] D. R. Anderson, Model Based Inference in the Life Sciences: A Primer on Evidence. New York, NY, USA: Springer, 2008.
[29] J. A. Royle and R. M. Dorazio, Hierarchical Modeling and Inference in Ecology. London, U.K.: Academic Press, 2008.
[30] N. J. Gotelli and R. K. Colwell, "Estimating species richness," in Biological Diversity: Frontiers in Measurement and Assessment, A. E. Magurran and B. J. McGill, Eds. Oxford, U.K.: Oxford University Press, 2011, pp. 39–54.