



Original Article

## Field evaluation of the olfactory response of *Leptocorisa* spp. to shrimp and invasive apple snail carcass baits

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### ARTICLE INFORMATION



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### ABSTRACT

Rice bugs (*Leptocorisa* spp.) are destructive agricultural pests that inflict severe damage on paddy crops from the flowering stage through the milk ripening stage. Heavy infestations often result in devastating crop failure, compromised grain quality, and reduced overall agricultural yield. To mitigate these economic losses, developing environmentally sustainable management strategies that suppress pest populations without disrupting the surrounding ecosystem is crucial. This study evaluated the field efficacy of olfaction-based traps baited with decaying animal carcasses to actively lure and capture rice bugs. The field experiment was conducted on a 30 × 15 m rice field plot cultivated with the Ciliwung Super cultivar. The custom traps were fabricated from 1,500 mL plastic bottles, each loaded with 150 g of bait consisting of either decaying shrimp or invasive apple snail (*Pomacea canaliculata*) carcasses, with ten experimental replications per treatment. Capture rates were recorded at three-day intervals, whereas damage intensity was assessed at seven-day intervals. The experimental results demonstrated that both shrimp and invasive apple snail carcass baits effectively attracted *Leptocorisa* spp. adults. Although the difference was not statistically significant, shrimp carcass bait showed a numerically higher attraction rate than invasive apple snail bait, suggesting its potential as an organic attractant for rice bugs monitoring and management.

**Keywords:** Attraction rate; Damage intensity; Organic attractant; *Pomacea canaliculata*; Rice bugs; Sustainable management strategies

### 1. Introduction

Rice (*Oryza sativa* L.) serves as the primary staple food for nearly half of the global population. To satisfy the consumption demands of an expanding global population, worldwide rice production must scale up significantly over the coming decades. Projections indicate that the global demand for rice will rise from 439 million tons in 2010 to 553 million tons by 2035 (Jena et al., 2018; Shrestha et al., 2020). Beyond its primary macroeconomic value, rice represents a crucial foundational source of human nutrition, contributing approximately 77.1% carbohydrates, 8.1% protein, and an array of essential minerals to daily dietary intake. However, rice crops are highly vulnerable to destructive insect pests complexes. Major economic pests, including the yellow stem borer (*Scirpophaga incertulas*),

brown planthopper (*Nilaparvata lugens*), and the rice bugs (*Leptocorisa* spp.), collectively cause substantial damage that can reduce annual yields by up to 30% (Bisen et al., 2019).

Among these destructive hemipteran pests, rice bugs (*Leptocorisa* spp.) specifically target rice plants during their most vulnerable reproductive growth phases, spanning from pre-flowering through the critical hard dough stage. Field observations indicate that the insect's seasonal incidence peaks significantly during these generative stages, closely interacting with microclimate parameters (Yadav et al., 2025). By piercing and sucking the sap of developing grains, these insect pests stunt grain development and concurrently inoculate the endosperm with opportunistic fungal and bacterial pathogens. This feeding mechanism results in severe yield degradation via

the formation of empty or unfilled grains, as well as permanent kernel discoloration that drastically devalues the quality and marketability of the final milled product (Jahn et al., 2004). In severe infestations, species such as *L. acuta* have been documented to trigger devastating crop losses reaching nearly 50% of the total rice harvest (Gunawardena & Ranatunga, 1989).

Historically, the management of *Leptocorisa* populations has relied heavily on chemical intervention. However, conventional control measures like synthetic and broad-spectrum chemical pesticides are increasingly restricted worldwide. These chemical methods have proven ecologically unsustainable due to their severe negative environmental impact, the rapid evolution of insecticide resistance within target pest populations, and the secondary resurgence of minor pests due to the elimination of natural predators (Ileke, 2014). Despite these documented systemic drawbacks, many current regional strategies implemented to minimize field crop losses still depend almost entirely on commercial chemical pesticides (Estruch et al., 1997). This operational paradox highlights an urgent need for eco-friendly, accessible, and economically viable alternatives within integrated pest management networks.

Developing sustainable, non-chemical alternatives requires the creative utilization of local agricultural waste streams and co-occurring invasive bio-resources. One such widespread biological threat is the apple snail (*Pomacea* spp.), which has caused massive economic damage to global rice production, particularly across Southeast Asia. In addition to devastating rice seedlings, these highly adaptable snails cause widespread ecological and financial damage to various aquatic crops, including taro, water spinach, water chestnut, and lotus (Arfan et al., 2015).

Historically, the common name "golden apple snail" has been widely used in Asia to describe introduced *Pomacea* species, under the false assumption that it represented a single biological entity (Cowie et al., 2017; Joshi & Sebastian, 2006). However, molecular and morphological data have confirmed that "golden apple snail" is an ambiguous designation that actually encompasses an ill-defined group of multiple species and their hybrids, most prominently *P. canaliculata* and *P. maculata* (Cowie et al., 2006; Hayes et al., 2012). Because using the name "golden apple snail" creates significant scientific confusion regarding which exact species is being studied, this manuscript deliberately rejects that ambiguous common term in favour of the more accurate designation invasive apple snail to ensure taxonomic clarity, comparability, and precise species reference (*P. canaliculata*).

Concurrently, fish and aquaculture processing generates substantial volumes of organic by-products, with processing waste ranging from 20% to 80% depending on the processing level and type of fish. Farmed shrimp represent the most important group of farmed crustaceans globally, contributing 64.0% of world farmed crustacean production in 2018 (Ghaly, 2013; Miao & Wang, 2020; Peñarubia et al., 2020). Although international production dynamics and commercial trade volumes vary considerably across different shrimp species, the processing of these commodities invariably generates substantial organic

byproducts and processing waste. This abundant waste stream represents a valuable source of bioactive polymers like chitin and chitosan, which have demonstrated substantial efficacy in agricultural applications and eco-friendly plant protection (Abirami et al., 2021).

To mitigate the ecological drawbacks of synthetic chemicals while utilizing these abundant organic resources, trapping techniques that deploy decaying animal tissues have emerged as a highly viable behavioral management alternative. Olfactory baits composed of materials such as fish entrails, snail meat, or dried sardines successfully exploit the innate evolutionary tendency of specific phytophagous and omnivorous insects to aggregate around sources of organic decomposition. The underlying behavioral efficacy of these organic baits rests on the volatilization of specific biochemical compounds, most notably the biogenic amines putrescine and cadaverine, which are synthesized during microbial protein catabolism. These compounds belong to the broader class of volatile organic substances that readily vaporize under normal atmospheric temperature and pressure (Pei et al., 2025). These volatile compounds generate a sharp, highly distinctive pungent odor that serves as a powerful long-range chemical cue (Giogios et al., 2013; Kumar et al., 2021). When deployed in field environments, these natural semiochemicals mimic critical biological aggregation signals, luring target insect pests into physical traps where they can be contained and eradicated with minimal environmental disruption (Taek, 2023).

Utilizing organic attractants derived from pest or aquaculture waste represents a highly sustainable, circular approach to controlling *Leptocorisa* populations. This methodology capitalizes on the natural olfactory attraction of rice bugs to the pungent gases emitted by decaying animal protein. When integrated into standardized field traps, these decomposing materials provide a powerful, chemical-free primary lure that simplifies the mass capture and subsequent removal of the insects from the crop canopy. The proven field efficacy of rudimentary organic baits underscores their potential to serve as low-cost, highly effective, and eco-friendly components of modern integrated pest management systems (Gunawardena & Ranatunga, 1989).

Building upon these ecological principles, this study aims to evaluate and compare the preference efficiency of field traps baited with shrimp and invasive apple snail carcasses in attracting *Leptocorisa* spp. males and females. The experimental traps evaluated in this research were strategically deployed along the perimeter edges of active rice paddies to intercept invading populations. By establishing the relative attractiveness of these two distinct, locally abundant animal tissue substrates, this study introduces a validated, environmentally sound rice bug control strategy that minimizes smallholder reliance on hazardous chemical pesticides and advances sustainable tropical plant protection.

## 2. Materials and Methods

### 2.1. Study Site

This study was conducted in March 2023 in Hamlet 1 of Tompo Padalle, Parangluara Village, North Polongbangkeng Subdistrict, Takalar Regency, South

Sulawesi Province. The field experiment was carried out from February to March 2023, coinciding with the critical reproductive phases of the crop, specifically spanning from the initial flowering stage to the late milky grain development stage, when the plants are highly vulnerable to pest infestations, for a total duration of 20 days.

## 2.2. Materials and Equipment

The biological materials utilized in this research consisted of healthy rice plants, fresh shrimp carcasses, and invasive apple snails (*P. canaliculata*) selected as experimental bait substrates. The chemical components included standard tap water and commercial fragrance-free liquid detergent used as a surfactant. The mechanical equipment and tools deployed for trap construction and field establishment consisted of 1,500 mL clear polyethylene terephthalate (PET) plastic bottles, structural bamboo stakes, digital scales, nylon strings, hammers, and standardized measuring tapes.

## 2.3. Experimental Design and Field Procedures

### 2.3.1. Trap Construction and Field Assembly

The physical traps were fabricated using 1,500 mL clear plastic bottles according to modified semiochemical trap designs (Ikhwan & Siregar, 2024), measuring 32 cm in height and 8 cm in base diameter. Two secondary bottles were cut and inverted to form bilateral funnel-shaped entry cones, which were then fitted tightly into opposing pre-cut lateral slots on the main central bottle housing. This structural arrangement created a secure, one-way entry point designed specifically to facilitate the ingress and prevent the escape of rice bugs (*Leptocorisa* spp.).

Each central trap housing was filled with a killing and retention solution consisting of 400 mL of water mixed thoroughly with 4 mL of fragrance-free liquid detergent to eliminate surface tension and rapidly drown captured insects (Murchie, 2023). For field deployment, each trap assembly was secured with nylon strings to a 100 cm tall vertical bamboo stake, aligning the trap height precisely with the natural vegetative canopy of the rice plants. The designated organic bait was suspended via a string directly inside the upper chamber of the central bottle, remaining elevated immediately above the liquid layer.

### 2.3.2. Bait Preparation and Spatial Installation

The experimental treatments compared two distinct organic bait types: shrimp carcasses and invasive apple snail carcasses. To prepare the snail treatments, whole *P. canaliculata* specimens were mechanically crushed using a hammer to expose the soft internal tissues. Both the shrimp and snail substrates were portioned and weighed to a uniform mass of 150 g per trap using a digital scale. To optimize the volatilization of target semiochemicals, the prepared baits were skewered and allowed to undergo natural microbial decomposition in a controlled environment for 24 hours prior to field placement, maximizing the emission of characteristic attractant odors (Eger et al., 2015; Fisher et al., 1998).

The experiment was laid out in a randomized complete block design (RCBD) based on trap positions around the rice field, with a single factor (bait type) consisting of two treatments: shrimp carcasses and

invasive apple snail carcasses. A total of 20 experimental trap units (10 replicate units for the shrimp bait and 10 replicate units for the invasive apple snail bait, with no unbaited controls) were deployed within a 30 × 15 m rice field plot cultivated with the Ciliwung Super cultivar using a direct-seeding system. The traps were installed systematically along the plot perimeter boundaries in an alternating cross-grid arrangement to eliminate edge-effect biases, with a fixed spacing of 5 m along the 30 m sides and 3.75 m along the 15 m sides. Additionally, five 1 × 1 m subplots were positioned according to the diagonal sampling technique for agronomic and pest density assessments. No unbaited trap was included for evaluating trap attraction. However, a separate untreated rice plot without bait traps was used as a control for assessing crop damage intensity.

## 2.4. Data Collection and Observation Variables

The primary agronomic and entomological parameters monitored during the study were the captured population dynamics of *Leptocorisa* spp. and the corresponding pest damage intensity across the rice crop. Entomological populations were quantified by collecting, sorting, and counting the absolute number of captured adult males and females inside each individual trap. Captured rice bugs were then sorted by sex and identified to species level based on external morphological characters, including body coloration, body shape, and abdominal markings (Barrion & Litsinger, 1981; Mandanayake et al., 2014). Population sampling and data recording were conducted at rigid three-day intervals during the early morning hours, which represented the period of peak insect inactivity. Immediately following each population count, the old trapping solutions and decomposed baits were completely removed and replaced with freshly prepared materials to maintain consistent attractant volatilization rates.

Concurrently, the crop damage intensity was evaluated visually at seven-day intervals utilizing a standardized diagonal sampling technique across the plot (Siregar et al., 2025). A total of 100 individual rice hills were thoroughly inspected at each designated sampling station along the field diagonals during the generative phase. The percentage of crop damage intensity was calculated using the following formula (1):

$$I = \frac{n}{N} \times 100 \quad (1)$$

Where I represents the calculated damage intensity expressed as a percentage, n is the number of individual rice hills displaying active symptoms of infestation, and N represents the total number of observed rice hills (N = 100) per sampling zone. A rice hill was categorized as systematically infested if the developing panicles or stems exhibited the characteristic necrotic punctures, spotting, or empty grains indicative of *Leptocorisa* spp. feeding activity.

## 2.5. Statistical Analysis

The collected datasets regarding the total population of captured insects (subdivided by developmental stage and sex) and the observed field damage intensities were subjected to statistical verification. The data were analyzed using an independent samples *t*-test were used to compare capture numbers between bait types. One-way analysis of

variance (ANOVA) was used to compare *Leptocorisa* spp. captures among rice growth stages. Infestation intensity data were analyzed using ANOVA followed by a Tukey's honestly significant difference (HSD) test at the 5% significance level. All mathematical computations and hypothesis testing were performed at a 5% significance level ( $P < 0.05$ ). Data were compiled using Microsoft® Excel version 14.0.4760.1000, while all statistical computations and analyses were performed using IBM® SPSS® Statistics version 25.

### 3. Results

#### 3.1. Field Capture Dynamics and Sex Distribution of *Leptocorisa* spp.

Field observations showed that both shrimp carcass and invasive apple snail carcass baits attracted adult rice bugs (*Leptocorisa* spp.), with captures dominated by male individuals (Table 1). Overall, the combined population of *L. oratorius* and *L. acuta* was higher in traps baited with

shrimp carcasses than in those baited with invasive apple snail carcasses. Shrimp carcass bait captured an average of  $4.00 \pm 0.86$  males and  $0.22 \pm 0.22$  females, resulting in a total mean capture of  $4.22 \pm 0.92$  individuals. In contrast, invasive apple snail carcass bait captured  $2.00 \pm 0.47$  males and no females, resulting in a total mean capture of  $2.00 \pm 0.47$  individuals.

Statistical analysis indicated that the total number of *Leptocorisa* spp. captured was significantly higher in shrimp carcass bait than in invasive apple snail carcass bait, as shown by different lowercase letters in the total column. However, when males and females were analyzed separately, the number of captured males and females did not differ significantly between bait types. Within each bait treatment, male captures were significantly higher than female captures, as indicated by different uppercase letters within the same row. This result suggests a strong male-biased attraction of *Leptocorisa* spp. to carcass-based baits.

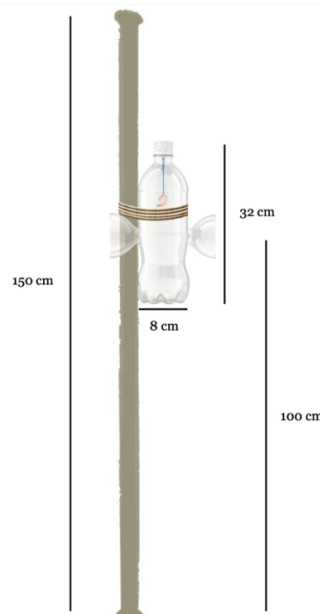


Figure 1. Illustration of the organic carcass-baited trap setup.

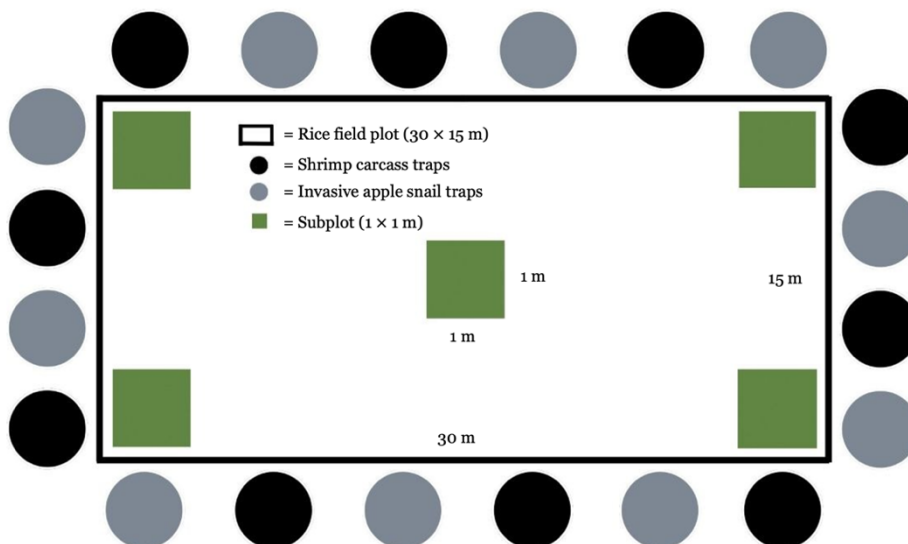


Figure 2. Illustration of the experimental layout of the rice field plot.

**Table 1.** Population of male and female *Leptocorisa* spp. attracted to shrimp and invasive apple snail carcass baits.

Types of bait	Male (Individuals)	Female (Individuals)	Male + Female (Individuals)
<i>L. oratorius</i>			
Shrimp carcass	3.22 ± 0.83 aA	0.00 ± 0.00 aB	3.22 ± 0.83 a
Invasive apple snail carcass	1.22 ± 0.32 bA	0.00 ± 0.00 aB	1.22 ± 0.32 b
<i>L. acuta</i>			
Shrimp carcass	0.78 ± 0.27 aA	0.22 ± 0.22 aA	1.00 ± 0.37 a
Invasive apple snail carcass	0.78 ± 0.22 aA	0.00 ± 0.00 aB	0.78 ± 0.22 a
<i>L. oratorius</i> + <i>L. acuta</i>			
Shrimp carcass	4.00 ± 0.86 aA	0.22 ± 0.22 aB	4.22 ± 0.92 a
Invasive apple snail carcass	2.00 ± 0.47 aA	0.00 ± 0.00 aB	2.00 ± 0.47 b

Values represent mean ± standard error. Different lowercase letters within the same column indicate significant differences between bait types within each species or species combination based on an independent samples *t*-test at the 5% significance level. Different uppercase letters within the same row indicate significant differences only between male and female captures within the same bait treatment

### 3.2. Species-Specific Selection and Interaction with Trapping Substrates

The captured rice bugs consisted of two species, *L. oratorius* and *L. acuta*. The response to bait type differed between species (Table 1). For *L. oratorius*, shrimp carcass bait captured significantly more males than invasive apple snail carcass bait, with mean captures of 3.22 ± 0.83 and 1.22 ± 0.32 individuals, respectively. No female *L. oratorius* individuals were captured in either bait treatment. Consequently, the total capture of *L. oratorius* was significantly higher in shrimp carcass bait than in invasive apple snail carcass bait.

For *L. acuta*, the number of captured males was similar between shrimp and invasive apple snail carcass baits, with both treatments capturing 0.78 individuals on average. Female *L. acuta* were captured only in shrimp carcass bait, although the difference between bait types was not statistically significant. The total number of *L. acuta* captured also did not differ significantly between the two bait treatments.

Comparatively, *L. oratorius* contributed more to the total rice bug captures than *L. acuta*, particularly in shrimp carcass bait. This indicates that the higher overall attractiveness of shrimp carcass bait was mainly driven by the stronger response of male *L. oratorius*. In contrast, *L. acuta* showed a relatively weak and statistically similar response to both bait types.

### 3.3. Influence of Phenological Rice Growth Stages on Trapping Efficiency

The monitoring data recorded during the field study demonstrated that the overall population size and capture frequency of *Leptocorisa* spp. fluctuated dynamically based on the specific reproductive and ripening phases of the surrounding rice crop. The distribution of captured pests across the three main phenological stages, namely the flowering phase, the milky grain phase, and the ripening phase is comprehensive detailed in Table 2.

During the initial flowering phase, pest presence inside the traps was minimal. The highest early capture was recorded in the shrimp baited traps by the species *L. oratorius*, yielding a mean of 1.66 individuals, while the corresponding invasive apple snail bait captured only 0.33 individuals. The sister species *L. acuta* exhibited negligible activity during this opening crop phase, with a low mean capture of 0.33 individuals in the shrimp traps and an identical 0.33 individuals in the snail traps.

As the rice crop entered the milk-ripening phase, a major increase in the volume of trapped insects was observed across the field. The absolute peak capture of the study was recorded during this phase within the shrimp baited traps, driven heavily by *L. oratorius* which reached an average of 6.25 individuals per trap. During this same peak crop phase, *L. acuta* individuals also showed increased movement, averaging 1.50 individuals in the shrimp treatments. Conversely, the invasive apple snail

**Table 2.** Population of *Leptocorisa* spp. attracted to treatments across the reproductive growth phases of the rice plant.

Types of bait	Species	Flowering phase <sup>ns</sup>	Milky grain phase <sup>ns</sup>	Ripening phase <sup>ns</sup>
Shrimp carcass	<i>L. oratorius</i>	1.66 ± 1.33	6.25 ± 1.54	2.00 ± 0.50
	<i>L. acuta</i>	0.33 ± 0.33	1.50 ± 0.25	0.50 ± 0.50
Invasive apple snail carcass	<i>L. oratorius</i>	0.33 ± 0.33	1.00 ± 0.47	0.50 ± 0.50
	<i>L. acuta</i>	0.33 ± 0.33	0.25 ± 0.28	0.50 ± 0.50

Values represent mean ± standard error. “ns” within the same column indicates no significant differences among trap–species combinations within the same rice growth phase based on one-way ANOVA at the 5% significance level.

**Table 3.** Damage intensity (%) of *Leptocorisa* spp. infestations across different phenological growth stages of rice.

Treatment	Flowering stage (60–70 DAT) (%)	Milky grain stage (70–90 DAT) (%)	Ripening stage (90–100 DAT) (%)
Control (no unbaited trap)	15.80 ± 2.15 aB	48.00 ± 6.08 aA	27.60 ± 1.50 aAB
Bait trap	6.20 ± 1.01 bB	30.80 ± 2.93 bA	17.80 ± 3.15 bAB

Values represent mean ± standard error. DAT: days after transplanting. Different lowercase letters within the same column indicate significant differences between treatments (control vs. bait trap) at the 5% significance level. Different uppercase letters within the same row indicate significant differences among rice growth stages within the same treatment at the 5% significance level based on a Tukey's HSD test.

bait traps exhibited much lower efficiency during this high-infestation window, recording a mean capture of 1.00 individuals for *L. oratorius* and a minimal 0.25 individuals for *L. acuta*.

When the crop progressed into the final ripening phase, the overall population numbers caught inside the traps declined noticeably across all experimental units. Despite this general drop-off, the highest remaining population average was sustained within the shrimp carcass traps for the *L. oratorius* species, maintaining a mean capture of 2.00 individuals. In comparison, the traps containing invasive apple snail bait caught a maximum average of only 0.50 individuals for both *L. oratorius* and *L. acuta*, while *L. acuta* individuals were no longer found trapped in any significant numbers within the snail treatments.

While the data showed a clear pattern where pest numbers peaked during the milky grain phase and declined as the crop matured, these observed differences in population levels across the three phenological stages were not statistically significant. This indicates that, despite visible fluctuations in capture frequency, the attraction and activity of *Leptocorisa* spp. did not differ significantly between the flowering, milky grain, and ripening phases, meaning the effectiveness of the traps remained relatively consistent throughout the crop's reproductive development.

### 3.4. Intensity of *Leptocorisa* spp. Infestations

Field monitoring demonstrated that the deployment of organic carcass traps significantly mitigated the feeding damage caused by *Leptocorisa* spp. across the successive reproductive and ripening growth stages of the rice crop. The comparative analysis of damage levels between the untreated control plots and the trapped plots is summarized in Table 3.

In the untreated control plots, the baseline infestation intensity was recorded at 15.80% during the initial flowering stage (60–70 DAT). This damage surged sharply to a peak of 48.00% during the milky grain phase (70–90 DAT) before declining to 27.60% at the full ripening stage (90–100 DAT).

In contrast, the rice plots protected by the organic carcass traps exhibited a significantly lower infestation

intensity of 6.20% during the initial flowering phase. Although the damage within the trapped plots increased to 30.80% during the milky grain phase, it remained substantially lower than the control. This temporary increase across both treatments during the mid-generative phase corresponds directly with peak food availability, as the developing rice grains are soft, fluid-filled, and highly optimal for the piercing-sucking feeding mechanisms of the bugs. As the crop progressed to the full ripening stage, the infestation intensity in the trapped plots dropped to 17.80%. This general late-season decline is primarily attributed to the mechanical hardening of the rice endosperm, which renders the mature grains less suitable as a food source and prompts the remaining *Leptocorisa* populations to disperse toward alternative hosts or wild grassy borders.

Statistical evaluations confirmed the definitive efficacy of the trapping strategy. As indicated by the lowercase superscript letters in Table 3, the infestation intensities in the bait trap plots were significantly lower than those in the control plots across all evaluated growth stages ( $P < 0.05$ ). Furthermore, the uppercase superscript letters denote that within both treatments, the variations in damage across the three phenological stages were statistically significant ( $P < 0.05$ ), with the milky grain phase representing the period of peak vulnerability.

### 3.5. Non-Target Entomofauna Captured in Organic Baits

Throughout the nine systematic field observation sessions, several non-target insect species were attracted to the volatile organic compounds emitted by the decomposing shrimp and invasive apple snail substrates. The taxonomic distribution and absolute abundance of these co-attracted non-target insects are detailed in Table 4.

An aggregate total of 31 rice green grasshoppers (*Oxya chinensis*) and 98 green blowflies (*Lucilia sericata*) were recorded within the trap housings over the course of the study. The incidental capture of *O. chinensis* is primarily a function of its high population density and ubiquitous distribution within local rice agroecosystems, where it functions as a common defoliator that actively (individuals) is a direct consequence of their specialized necrophagous life history. These dipterans rely entirely on

**Table 4.** Taxonomic classification and absolute abundance of non-target entomofauna captured in organic carcass traps.

Common name	Scientific name	Order	Family	Number of insect (Individuals)
Rice green grasshopper	<i>Oxya chinensis</i> (Thunberg)	Orthoptera	Acrididae	31
Green blowfly	<i>Lucilia sericata</i> (Meigen)	Diptera	Calliphoridae	98

consumes leaf and stem tissues from the vegetative through the generative crop phases.

Conversely, the high capture rate of *L. sericata* was directly mediated by chemical attraction. As a highly specialized necrophagous family, these dipterans are evolutionarily adapted to seek out proteinaceous decay, using specialized olfactory receptors to trace the volatile biogenic amines putrescine and cadaverine released by the decomposing shrimp and snail tissues. Because these non-target insects fell outside the primary scope of the plant protection evaluation, their capture metrics were excluded from formal inferential statistical analysis.

#### 4. Discussion

The findings indicate that both shrimp and invasive apple snail carcass baits attracted *Leptocorisa* spp. adults. Shrimp carcass bait showed higher numerical capture than invasive apple snail bait, although the difference was not statistically significant. This behavioral response is mediated by the long-range volatilization of highly pungent olfactory cues from decomposing animal tissues. However, comparative analysis reveals that shrimp carcass traps possess a higher descriptive attraction potential for managing adult male *Leptocorisa* spp. on rice crops relative to invasive apple snail baits, although the difference is not statistically significant. This trend indicates that utilizing crustacean processing waste within specialized trapping arrays offers a viable alternative for suppressing field populations of target hemipteran pests.

The underlying mechanisms governing insect attraction to organic decay rests upon innate behavioral aggregation responses to specialized volatile chemical profiles. The distinct, putrid odor generated by decomposing animal matter is driven by the structural breakdown of tissue proteins. Specifically, bacterial amino acid catabolism converts ornithine and lysine into the biogenic diamines putrescine (1,4-diaminobutane or tetramethyl enamine) and cadaverine (1,5-pentanediamine or pentamethylenediamine), respectively (Taek, 2023). These specific volatile compounds generate an intense, sharp, and highly distinctive aroma that functions as a powerful semiochemical mimic (Giogios et al., 2013). The abundance of these nitrogen-containing volatile compounds and amino acid derivatives is highly characteristic of degrading shrimp (*Acetes* sp.) tissues (Ali et al., 2020). Phytophagous and omnivorous insects, including *Leptocorisa* spp., possess specialized antennal olfactory receptors finely tuned to trace these chemical plumes over long distances, drawing them directly into physical traps (Ikhwan & Siregar, 2024).

The higher capture numbers observed in the shrimp carcass bait can be attributed to its rapid decomposition rate compared to that of the invasive apple snail. Crustacean tissues lack the dense calcareous skeletal defenses of gastropods and possess a high concentration of readily accessible moisture and soluble nitrogenous proteins, facilitating accelerated microbial colonization. Pristine marine and freshwater baits release a substantial pulse of volatile attractant compounds during the initial 24 to 48 hours of tissue autolysis and bacterial breakdown (Løkkeborg, 1990). This rapid degradation is highly driven by the strong activity of endogenous hydrolytic enzymes

and spontaneous microbial breakdown inherent in *Acetes* sp. biomass, which rapidly cleaves complex proteins into simpler volatile fractions directly after tissue death (Ali et al., 2020). This initial emission peak creates a steep concentration gradient in the field canopy. Because a higher rate of material decomposition increases the volume and velocity of semiochemicals released into the surrounding air column, it enhances the insect's ability to navigate along wind-borne odor plumes via their highly sensitive olfactory system, thereby exponentially increasing the number of flying insects successfully intercepted by the traps (Fisher et al., 1998; Mweresa et al., 2020). Conversely, the invasive apple snail bait, despite bacterial decay, retains structural matrices that slow bacterial decay, resulting in a lower emission rate that limits its competitive efficiency in the field.

A striking feature of the collection data is the extreme male-biased sex ratio observed among the captured *Leptocorisa* spp. across both bait treatments. This strong male preference for nitrogen-rich decaying carcasses is intricately linked to species-specific metabolic demands and reproductive physiology. Male hemipterans require substantial reserves of protein, amino acids, and essential lipids to synthesize complex spermatophores and accessory fluids, which are entirely depleted during the mating process. To replenish these vital nutrient reserves, males actively forage for hyper-concentrated external sources of nitrogen and amino acids. This physiological drive is heavily supported by previous entomological surveys. For instance, field traps baited with decomposing shrimp and fish tissue successfully intercepted 1,712 heteropteran specimens across 91 distinct species, with a massive imbalance of 1,356 male individuals compared to a minimal 356 female individuals within the closely related family Scutelleridae (Eger et al., 2015). Similarly, marine protein baits, such as squid carcasses, consistently attract a vast majority of male insects due to this evolutionary pressure to offset reproductive metabolic exhaustion (Baz et al., 2010).

The field data further confirmed distinct interspecific variations, with *L. oratorius* captured in significantly greater abundance than *L. acuta* across all trapping intervals. This distribution pattern is closely tied to the microclimate preferences and ecological niches characteristic of each species. *L. oratorius* is an obligate occupant of high-humidity agroecosystems, reaching its highest population densities within well-irrigated, wet lowland rice paddies (Litsinger et al., 2015; Rillon, 2010). In contrast, *L. acuta* exhibits a strong physiological preference for drier habitats, predominantly colonizing upland rice fields, uncultivated peripheral grasslands, or wild weeds along forest margins. Morphologically, these two sympatric species are easily distinguished under field conditions; *L. oratorius* exhibits a clear diagnostic row of dark spots on the lateral margins of its abdomen, whereas *L. acuta* completely lacks these lateral abdominal pigmentations.

The incidental capture of non-target entomofauna, namely the green blowfly (*L. sericata*) and the rice green grasshopper (*O. chinensis*), provides further context regarding the ecological interactions inside the rice ecosystem. The massive ingress of *L. sericata* (98

putrescine and cadaverine signals to locate decaying protein substrates required for adult nutrition and subsequent oviposition. On the other hand, the presence of *O. chinensis* (31 individuals) represents a series of random, non-olfactory mechanical collisions. Because orthopterans are highly abundant folivores that move continuously through the upper vegetative canopy from the vegetative to the generative phases, their entry into the traps is a function of high baseline field densities rather than a targeted chemical attraction to the carcass volatiles.

While this study establishes the clear potential of shrimp carcass traps as a viable, low-cost component of integrated pest management (IPM), certain structural limitations must be addressed. The rapid decomposition rate that gives shrimp its high initial capture efficiency also results in a brief operational lifespan, requiring total bait replacement every three days to maintain optimal suppression. Additionally, the labor required to prepare, install, and continuously service these traps may present challenges for large-scale agricultural operations. Future research should focus on optimizing long-term performance by evaluating chemical stabilizers or slow-release matrices that prolong the lifespan of the bait. Investigating optimal spatial trap placement densities per hectare and evaluating the exact economic thresholds of crop damage mitigation will provide smallholders with a highly standardized, chemical-free tool for sustainable tropical plant protection.

## 5. Conclusion

Based on the field results, shrimp carcass bait showed a numerically higher capture rate of adult rice bugs (*Leptocorisa* spp.) than invasive apple snail (*P. canaliculata*) bait, although the difference between bait types was not statistically significant. This finding suggests that shrimp carcass bait has potential as an organic attractant for rice bug monitoring and management. The higher numerical capture of shrimp bait may be associated with the rapid decomposition of shrimp tissues and the release of pungent volatile compounds, but further chemical analysis is needed to identify the specific attractant compounds involved.

In addition, rice plots equipped with carcass-baited traps showed lower infestation intensity than untreated control plots across the observed rice growth stages, indicating that perimeter trap deployment may contribute to reducing rice bug damage during the generative phase. However, further studies using larger replicated plots, clearly separated untreated controls, and different trap densities are required to confirm the effectiveness and practical applicability of this trapping system. Overall, carcass-baited traps may serve as a low-cost and ecologically sound supporting component of integrated pest management for rice bugs in tropical rice agroecosystems.

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**Ravindra Chandra Joshi:** Validation, Writing – review & editing.  
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