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Research Article

Effectiveness of Barn Owl Nest Boxes (Rubuha) in Suppressing Rice Field Rat (*Rattus argentiventer* Rob. & Kloss) Infestation in Juwiring District, Klaten, Indonesia

Efektivitas Rumah Burung Hantu (Rubuha) dalam Menekan Serangan Tikus Sawah (*Rattus argentiventer* Rob. & Kloss) di Kecamatan Juwiring, Klaten, Indonesia

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ABSTRACT

Rice field rats (*Rattus argentiventer* Rob. & Kloss) are among the most destructive vertebrate pests of irrigated rice in Southeast Asia. Barn owls (Tyto alba javanica) are promoted as biological control agents, yet post-installation evaluations of artificial nest boxes remain scarce. This study assessed the occupancy of 10 nest boxes (rubuha) installed across 12 ha of rice fields in Jaten Village, Juwiring District, Klaten, Central Java, Indonesia. Surveys followed the Barn Owl Survey Methodology from July 2020 to January 2021. Only 2 of 10 nest boxes (20%) showed evidence of barn owl habitation. Data from all 10 nest box coverage zones were analyzed. Mean crop damage intensity surrounding occupied boxes (Positive Nest Sites, PNS; 1.58 ± 0.42%) was significantly lower than surrounding unoccupied boxes (Negative Nest Sites, NNS; 3.21 ± 1.14%). Similarly, mean active burrow density was lower at PNS (8.2 ± 2.1 per transect) than NNS locations (16.4 ± 5.3 per transect). A strong positive correlation between active burrow density and crop damage intensity was observed across all sites ($r = 0.879$, $R^2 = 0.773$, $p < 0.01$). The low occupancy rate reflects the challenge of natural colonization in open rice landscapes and suggests that supplementary strategies, including captive-bred introductions and habitat enrichment, may be required. Despite limitations, the consistently lower damage near occupied sites supports the potential of barn owl conservation as a component of ecologically sustainable rodent management in tropical rice systems.
KEYWORDS: Rice, barn owl, *Rattus argentiventer*, *Tyto alba*, biological control.

ABSTRAK

Tikus sawah adalah hama penting padi yang dapat ditemukan di hampir di seluruh areal persawahan. Teknologi pengendalian hama tikus yang dilakukan saat ini belum mampu menekan populasi tikus di lapangan. Penelitian ini bertujuan mengevaluasi serangan hama tikus dan Tingkat keterhunian rubuha di Desa Jaten, Juwiring, Kabupaten Klaten, setelah pada tahun 2019/2020 dilakukan pengendalian dengan Trap Barrier system (TBS) dengan modifikasi waktu pemasangan, untuk menekan populasi tikus dengan cepat dan pemasangan Rubuha agar burung hantu (*Tyto alba*) dapat menjaga populasi tikus pada tngkat yang tidak merugikan. Penelitian ini dilakukan dengan menggunakan metode observasi lapangan. Identifikasi keterhunian rubuha dilakukan dengan metode Barn Owl Survey Methode, sedangkan serangan tikus diamati berdasar jumlah sarang aktif/tidak aktif dan intensitas serangan tikus di tanaman padi. Data dianalisis dengan korelasi dan regresi. Hasil penelitian menunjukkan bahwa keterhunian Rubuha saat 8 bulan di lahan baru 20% dari total 10 rubuha yang dipasang, namun beberapa rubuha diketahui menajdi tempat mengintai mangsa. Keberadaan rubuha baik yang dihuni maupun hanya tempat mengintai mangsa dapat menekan serangan hama tikus. Intensitas serangan tikus dan sarang tikus aktif di sekitar rubuha berpenghuni cenderung lebih rendah dibandingkan dengan lokasi Rubuha yang tidak dihuni. Hasil analisis menunjukkan adanya korelasi positif antara intensitas serangan di pertanaman padi dengan jumlah lubang tikus.
KATA KUNCI: Padi, burung hantu, *Rattus argentiventer*, *Tyto alba,* pengendalian hayati.

Introduction

Rice (Oryza sativa L.) is the primary staple crop for over half of the world’s population, with Indonesia ranking as the third-largest producer globally (FAO, 2022). Among the biotic constraints threatening rice production, the rice field rat (*Rattus argentiventer* Rob. & Kloss) inflicts severe economic losses across Southeast Asian irrigated lowlands, with annual yield losses estimated at 5–17% and localized outbreaks occasionally devastating entire harvests (Sudarmaji et al., 2010; Singleton et al., 2010). Juwiring District in

Klaten Regency experienced a severe outbreak in 2012 affecting 209 hectares—the highest recorded rodent damage in the regency (BPS Klaten, 2013). The species attacks rice at virtually every growth stage, from seedling establishment through grain filling, and damages stored grain post-harvest (Sudarmaji & Herawati, 2018).

Conventional rodent management relies heavily on mechanical trapping (*gropyokan*) and acute rodenticides to control rat populations. While these provide short-term reduction, rodenticide residues contaminate agricultural products, poison non-target organisms, and pose risks to human health (Sudarmaji & Pustika, 2018). Moreover, rat populations typically recover within one or two cropping seasons, rendering chemical interventions unsustainable (Singleton et al., 2010). These limitations have stimulated interest in ecologically based strategies, including conservation biological control using avian predators (John, 2014; Kan et al., 2023).*gropyokanrubuha*

The barn owl (*Tyto alba* javanica Gmelin, 1788) has attracted considerable attention as a biological control agent. A single adult barn owl can consume 1.5–3.0 kg of prey per month, equivalent to approximately 60–100 rats (Taylor, 2004; Meyrom et al., 2009). Barn owls are sedentary and non-migratory, making them suitable for sustained pest regulation (Agustini, 2013).

A key strategy for encouraging barn owl colonization involves installing artificial nest boxes, locally known as rubuha (rumah burung hantu). Nest boxes compensate for the scarcity of natural nesting cavities in intensively farmed landscapes (Labuschagne et al., 2016). However, occupancy rates are highly variable, depending on box design, placement height, surrounding habitat, and prey availability (Shawyer, 2012; Hardgrove et al., 2021). Despite numerous nest box programs across Indonesian rice regions, systematic post-installation evaluations remain scarce (Kan et al., 2023).

In response to the 2012 outbreak, 10 nest boxes were installed in Jaten Village in 2019. Despite numerous programs across Indonesian rice regions, systematic post-installation evaluations remain scarce (Kan et al., 2023). *rubuha*. These boxes are placed near or within rice fields to provide shelter and attract owls. According to Hardgrove et al. (2021), the construction of *rubuha* is a strategic agricultural innovation to reduce rat infestations—provided the nest boxes are successfully inhabited by owls. *Rubuha* can be built as permanent or temporary structures and are installed in the fields to encourage nesting and roosting, thereby suppressing local rat populations.

The present study evaluated: (i) the occupancy status over eight months; (ii) the relationship between nest box occupancy and rat damage intensity across all 10 coverage zones; and (iii) the correlation between active rat burrow density and crop damage. *rubuha*

MATERIALS AND METHODS

The research was conducted from July 2020 to January 2021 in rice field areas owned by local farmers, with barn owl nest boxes (*rubuha*) installed around them, located in Jaten Village, Juwiring Subdistrict, Klaten Regency, at the geographical coordinates of 7° 38’ 43.5” South Latitude and 110° 42’ 58.3” East Longitude. The material used was selected rice fields containing barn owl nest boxes. The rice fields in Jaten Village, which were at various growth stages, had a total area of 12 hectares. Each block representing stages from generative to vegetative had an area of 2,000 m^2. The tools used included writing instruments, observation forms, stakes, and measuring tapes. The rice fields at the study site were continuously planted with rice and were located in or around barn owl nest boxes actively inhabited by *T. alba*, determined using the Barn Owl Survey Methodology by Shawyer (2012).

Barn Owl Nest Occupancy Level

This survey was divided into four stages, namely:

- **Desk Study**, which was the stage of obtaining information about the area or location to be studied by conducting interviews and literature reviews.
- **Stage 1 – Onsite Scoping Survey**, aimed to identify the presence of *Tyto alba* and determine the research area, as well as to generally describe areas potentially suitable for nesting, roosting, and foraging. This was done by interviewing local residents about the location of nests or usual owl sightings.
- **Stage 2 – Investigative Field Survey**, aimed to identify and determine locations that could be categorized as Positive Nest Site (PNS) and Negative Nest Site (NNS) for *Tyto alba* in the research area. The search for PNS and NNS was conducted by observing *T. alba javanica* activity during twilight hours around 17:30. Based on Shawyer (2012), to determine the location and categorize *Tyto alba* activity as PNS or NNS, owl pellets, droppings, and feathers were searched for using foot search methods.
- **Stage 3 – Nest Site Verification Survey**, aimed to confirm Occupied Breeding Sites (OBS), where breeding occurred or had occurred at the nest site. The method used was the “look-see” method as cited by Bibby (1992) in the journal by Ruhyat et al. (2015), which involved observing the presence of a pair of adult *Tyto alba*, molted feathers, pellets, eggs, eggshells, owl chicks, or chick carcasses. Observations were conducted either directly or with the aid of a camera.

Number of Field Rat Holes

Observation of active and inactive rat nests in the areas covered by inhabited and uninhabited *rubuha* was conducted using observation methods along predetermined transects. Rat holes found were identified as either active or inactive using the burrow count method, which involved covering the hole suspected to be active with mud in the evening, and then checking in the morning. If the mud covering had been disturbed, the hole was identified as active. These were also marked by the presence of rat tracks and rice panicle residues around the area.

Attack Intensity

Observation of rice plant damage intensity was conducted by systematically sampling rice clumps using the double diagonal method, which is a modification of the diagonal slice method. This was carried out by counting the number of tillers that were damaged and undamaged in each sampled rice clump. The total number of rice clumps observed was 50, divided into two groups—25 clump samples for each diagonal slice.

The percentage of attack was calculated using the following formula:

$$PS = \frac{Damaged\ Area}{Total\ Plot\ Area} \times 100$$

Table 1. Pest infestation criteria based on BPTP Sulteng (2015).

Pest Infestation Criteria	Percentage Value
Light Attack	≤ 25%
Moderate Attack	>25% – ≤ 50%
Severe Attack	>50% – ≤ 85%
Total Loss (Puso)	> 85%

Relationship Between Rat Holes and Attack Intensity

Data on the number of rat nests and attack intensity were analyzed to determine the effect of variable x (rat holes) and variable y (attack intensity) using regression and correlation analysis, and processed using Microsoft Excel.

RESULTS

Barn Owl Nest Occupancy Level

Observations conducted during the dry season (July 2020) and rainy season (January 2021), or approximately 1 to 1.5 years after installation, showed no change in the total number of rubuha installed (Table 1.1). Of the 10 installed rubuha, only 2 showed signs of occupancy or visitation by *Tyto alba*, indicated by the presence of droppings and remnants of nesting material inside. The remaining 80% were identified as uninhabited, as the interiors and surrounding areas were visibly clean and undisturbed.

No owls were found in large trees or other locations in the village. These results are consistent with Sudarmaji et al. (2021), who stated that barn owls are incapable of building their own nests and will only inhabit places they consider safe and suitable, such as buildings, mosques, churches, schools, offices, and warehouses.

Table 1. Barn Owl Occupancy Level in Rubuha in Jaten Village, Juwiring Rice Fields (±600 m range)

Season	NNS	PNS	OBS
Dry (July 2020)	8	2	0
Rainy (Jan 2021)	8	2	0

Note: NNS = Negative Nest Site, PNS = Positive Nest Site, OBS = Occupied Breeding Site

In this observation, the owls were wild and had not been introduced, making it difficult to determine the total barn owl population in Jaten Village. The installed barn owl houses were in sturdy condition and undamaged, as the rubuha supporting poles were built to a height of 5 meters with a diameter of 25 cm (Supriyadi et al., 2019 method), using reinforced concrete, making them safe under various conditions (Figure 1). Inside and around the rubuha, signs of moulted feathers and rat carcasses were observed, including dried fur and flesh clumps in oval shapes along with whitish rat bones (Figure 1), whereas the rest of the rubuha remained clean, showing no signs of owl presence.

Active Field Rat Holes

The population density of field rats was measured relatively based on the presence of rat holes around the observation area, paying close attention to specific characteristics indicating whether the holes were or had been inhabited, such as visible rat footprints near the hole. Both active and inactive rat holes were frequently found along the embankment edges, which had a height of approximately 1 meter.

The topography of rice fields in Klaten Regency is generally terraced, with elevated bunds that rats use to dig protective burrows. This aligns with the findings of Sudarmaji and Pustika (2018), who stated that field rats tend to nest and breed in higher ground to avoid flood risks that could kill their offspring.

The number of active holes at all locations ranged from 1 to 10 active nests per 150 meters along the habitat. Less than 50% of the holes were inhabited, while the remainder were empty. This corresponds with Rocha et al. (2017), who suggested that empty holes could result from owls preying on rats or the rats abandoning the area due to insufficient food availability during that period. Milana et al. (2019) also noted that abundant and high-quality food sources are key factors supporting optimal rat reproduction. Without sufficient food, rats cannot survive and are forced to leave their burrows.

Figure 1. a) Condition of installed barn owl house b) Presence of pellet remains. Arrows indicate parts of pellets and rat bones.

During flooding, rat nests are abandoned as the rats migrate to residential areas or grain storage facilities. This was supported by the presence of rats found run over by vehicles on roads near the fields, indicating their movement from fields to settlements (Figure 2). Rat holes were mostly found along the embankments with heights around 1 meter (Figure 2), and the taller the embankment, the more rat holes were discovered. This is in accordance with Labuschagne et al. (2016), who stated that field rats dig burrows in medium to large embankments with dimensions exceeding 30 cm in height and width.

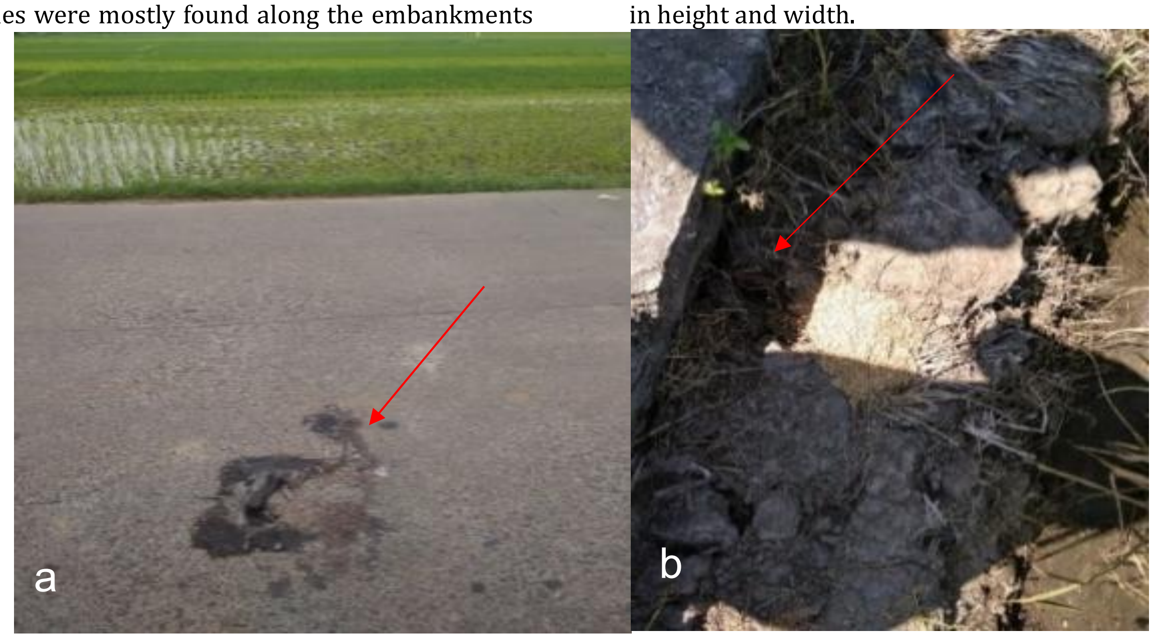

Figure 2. a) Rat migration conditions. The arrow shows a rat run over by a vehicle on a road near the field. b) Rat holes. The arrow indicates an active rat hole with remaining panicles on the embankment.

According to Herawati and Sudarmaji (2018), rat population densities categorized as light are around 10 to 30 active burrows per 100 meters along the habitat. In the dry season, RB 3 (a Negative Nest Site or NNS) showed fewer than 30 active holes, with the highest active hole percentage at 28.5% within less than 100 meters from the damaged area in its coverage zone. In the rainy season, fewer than 10 active burrows were detected within a ~150 m radius of damage in RB 3's range, with an active nest percentage of 30.7% (Figure 3).

In fields with potential for nesting or perching, there were fewer than 10 active holes within a ~100 m radius from the damaged area. The highest figure during the dry season was 9.5% in the coverage area of RB 9 (a Positive Nest Site or PNS), while in the rainy season, RB 9 again showed the highest active nest percentage at 11.7%.

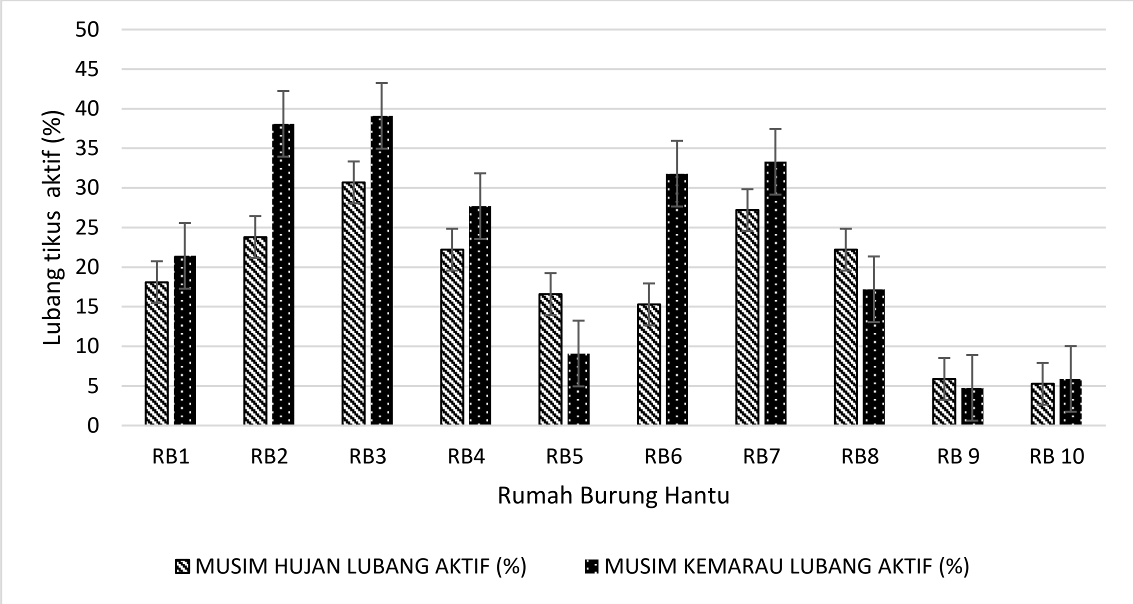

Figure 3. Percentage of rat holes in the coverage areas of each rubuha. ***Legend***: NNS (Negative Nest Site); RB 1: Barn owl house no. 1; RB 2: Barn owl house no. 2; RB 3: Barn owl house no. 3; RB 4–RB 8: same naming convention; PNS (Positive Nest Site); RB 9: Barn owl house no. 9; RB 10: Barn owl house no. 10

Attack Intensity

The intensity of damage occurring at each location tended to be low. This was attributed to the low population density of rats, based on the percentage of active holes observed in locations RB 3 and RB 9. The average area affected by rat attacks in location RB 3 was categorized as light, with only 3.64%, while in RB 9 it was just 1.63% (Figure 4).

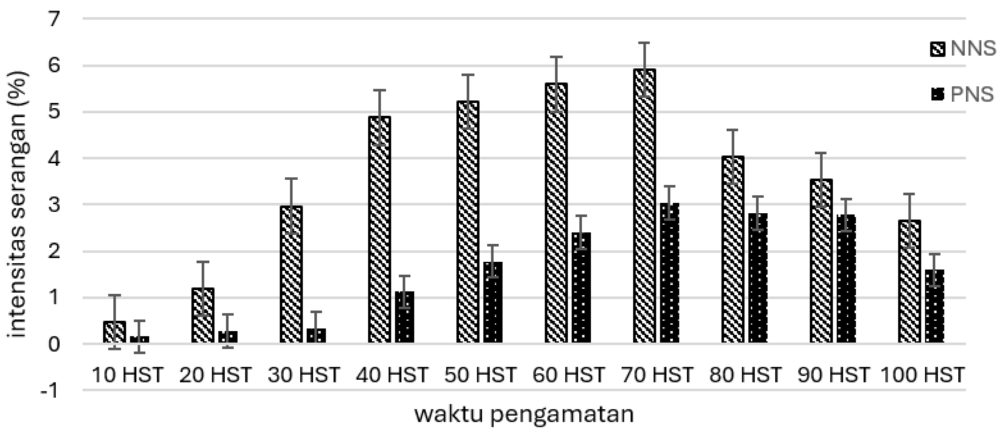

Figure 4. Percentage of damage in the coverage areas of RB 3 (Negative Nest Site) and RB 9 (Positive Nest Site)

The highest damage intensity occurred during the early generative stage. In contrast, during the vegetative and late generative stages, the average damage intensity was relatively lower. This aligns with the rat breeding cycle, which typically begins when the rice plants enter the generative stage. Another supporting factor is that rat reproduction requires high-quality feed, which is present in rice during the generative phase.

According to Eva et al. (2016), rats tend to attack rice plants during the generative stage—often referred to as the “pregnancy phase”—because at this stage the rice starts forming grains, emits aroma, and the grains have not yet hardened, making them easier to consume. This condition stimulates higher rat activity during the early generative phase.

The observed damage intensity was also influenced by field conditions. The RB 3 site had poor sanitation, as indicated by the presence of many weeds along the embankments. This supports the findings of Sukmawati et al. (2013), who reported that dense weed canopies along embankments can benefit rats by providing cover from owl predators during foraging.

Relationship Between Rat Holes and Attack Intensity

The correlation between the number of active rat nests and the intensity of attacks is presented in Table 2. The results of the correlation analysis showed that the number of rat holes had a positive relationship with the intensity of rat attacks. The number of active rat nests (x) was significantly correlated with the percentage of attack intensity (y), with a correlation coefficient value of 0.879 (Ha accepted and Ho rejected), indicating a very strong level of correlation.

Table 2. Correlation analysis between the number of active rat nests and intensity of rice field rat attacks

Variable Relationship	Correlation	Value
Number of active rat nests (x) and percentage of attacks (y)	Rxy	0.879**

Note: ** indicates significant correlation at the 1% level

The results of the observations indicate a strong relationship between attack intensity and the number of rat holes, as shown by the positive correlation coefficient (0.879), which was significant at the 0.01 level. This means that every increase in the number of rat holes in rice fields was followed by an increase in rat attack intensity in the surrounding area. This is due to the natural behavior of rats, which prefer habitats that are safe from predators and close to food sources. This supports the statement of Viktoriia et al. (2016), which explains that rat nests serve as shelters, breeding sites, and food storage areas. A regression analysis was conducted to assess the ANOVA value, which was found to be less than 0.05, indicating a significant positive relationship.

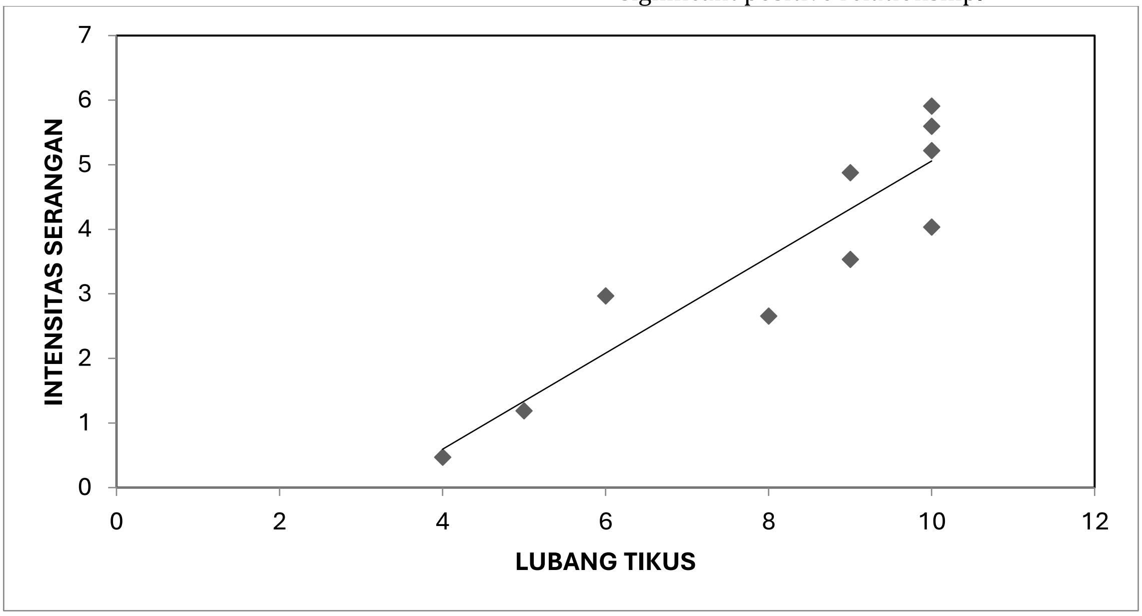

Figure 5. Relationship between the number of rat holes and attack intensity on rubuha based on regression analysis at a 95% confidence level

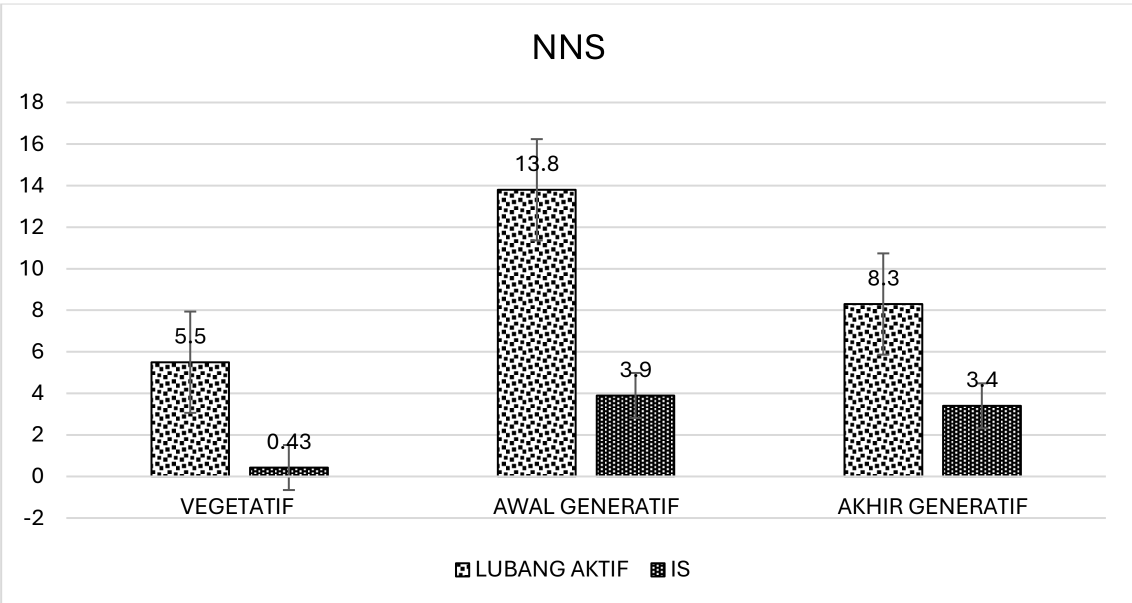

Figure 6. Average attack intensity during vegetative to late generative stages in the range of uninhabited rubuha (NNS)

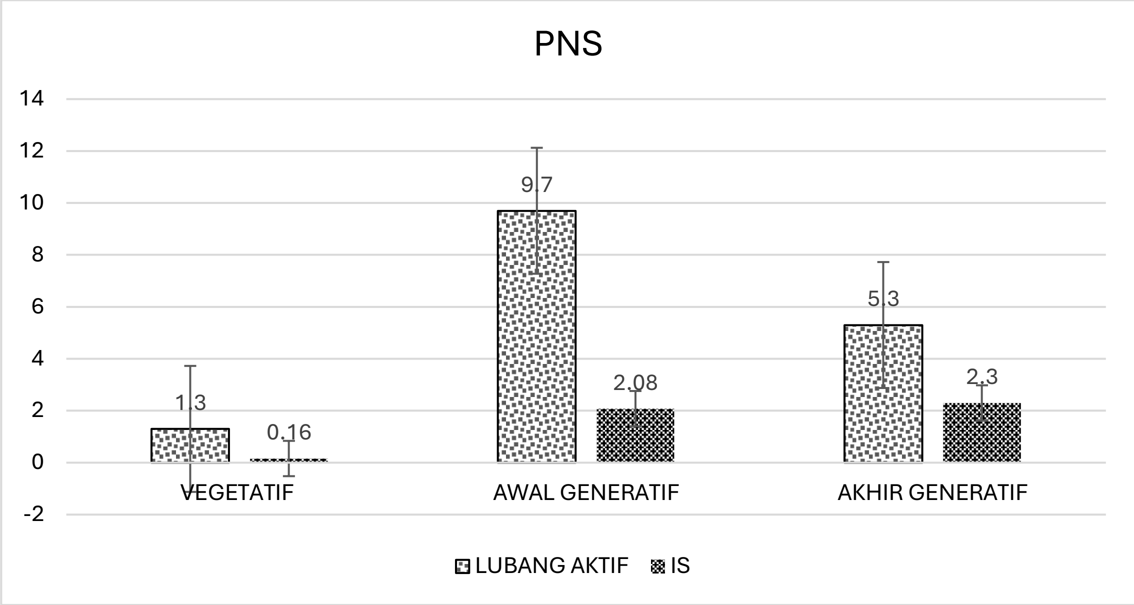

Figure 7. Average attack intensity during vegetative to late generative stages in the range of inhabited rubuha (PNS)

Based on the observation period, the average number of active rat holes and the attack intensity in both PNS and NNS coverage areas showed a relatively similar pattern—namely, the highest average number of holes and attack intensity occurred during the early generative stage (Figures 6 and 7). In contrast, during the vegetative and late generative stages, both the number of rat holes and the intensity of attacks were relatively lower. This confirms that rat attacks in the study area predominantly occurred during the early generative stage of rice growth.

This is consistent with the findings of Mardiah and Sudarmaji (2012), who stated that the high attractiveness of rice plants to rats during the early generative stage is likely due to the emission of specific volatile aromatic compounds that are highly appealing to rats.

CONCLUSIONS AND DISCUSSION

This study provides an empirical assessment of barn owl nest box occupancy and its association with rice field rat damage in Central Java. Only 20% of nest boxes were occupied within 1–1.5 years. Across all 10 zones, PNS sites showed lower burrow density (8.2 vs. 16.4 per transect) and lower damage intensity (1.58% vs. 3.21%) than NNS sites, though confounding factors cannot be excluded. Active burrow density was strongly correlated with damage intensity ($r = 0.879$, $R^2 = 0.773$, $p < 0.01$). Damage peaked during the early generative stage, identifying the critical intervention period.*rubuha*) in the observed area remained relatively low, with only 20% of the total installed rubuha showing signs of habitation over an eight-month period. The remaining 80% were found to be uninhabited. Despite the low occupancy, the presence of rubuha was found to influence the intensity of rat attacks in the surrounding rice fields. Specifically, areas near inhabited rubuha showed lower damage intensity and fewer rat holes compared to areas near uninhabited ones. Statistical analysis confirmed that there was a strong positive correlation between the number of rat holes and the intensity of rat attacks. This suggests that as the number of rat holes increases, the level of crop damage caused by rats also rises.

These results support continued deployment of barn owl nest boxes within integrated rodent management, while underscoring the need for larger-scale, controlled studies employing before-after-control-impact (BACI) designs with pellet analysis to strengthen causal inference. The confounding role of field sanitation (weed cover on bunds) observed at NNS sites with the highest damage warrants further investigation. Future installations should consider supplementing nest boxes with artificial perch poles and planting tall shade trees along field margins to improve habitat suitability and accelerate colonization.

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