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Population Distribution of Rats (*Rattus argentiventer*) and the Damage Intensity on Rice and Other Crops in Pleret, Yogyakarta, Indonesia

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Abstract

Rice field rats is one of the main pests of rice in Indonesia and other Asian countries that can cause a crop failure. The availability food sources might affect the rat foraging in the field. The research aimed to determine the distribution of rat population and their nests in the field with different crop and to examine the level of crop damage caused by rats. The research was conducted from January to April 2023 in Pleret district, Yogyakarta, Indonesia. The 1000 m^2 TBS (Trap Barrier System) was installed in the middle of the 225 ha observation area to trap rats. Crop damage inside TBS was observed using a diagonal sampling method. Crop damage outside TBS was observed using the line transect method in the 4 cardinal directions with a distance of 250m, 500m, and 750m from TBS. Rat nest's locations were mapped using GPS. The results showed that the number of rats trapped was low in the early and late stage of rice growth and peaked when the rice aged 12 weeks after planting (WAP). Rice crop damage inside TBS occurred when rice entered 12 WAP. There was no damage on rice crops around the TBS. Rats also attacked corn and sugarcane which caused heavy damage to these crops. There were 157 active holes found in 225ha observation area and they mostly were found in rice field bunds, irrigation embankments, and vacant land. This study implied that understanding the distribution of rat's population and their nest will support the rat control.

Keyword: Crop damage, nest, rodent, trap barrier system

Introduction

Rice is a staple food in Indonesia and other Asian countries. Rice is frequently planted continuously throughout the year without crop rotation in well-irrigated areas. Planting rice continuously throughout the year could increase pests' population that decrease rice productivity and can cause crop failure (Sudarmaji et al., 2017). Ricefield rat (*Rattus argentiventer* (Robinson and Kloss, 1916) is a major rice pest.

Rat attacks can cause crop failure or damage rice plants planted every season. It was reported that between January and June 2021, 58,443 ha of rice fields suffered from rat attacks, which resulted in crop failure of approximately

1,842 ha. Lampung, Central Java, East Java, West Java, and South Sulawesi were the five provinces with the highest percentage of rat infestation. (Direktorat Perlindungan Tanaman Pangan, 2021). In Malaysia, rice yield losses due to rat attacks ranged from 5% to 10% (Brown et al., 2017). Rat attacks are usually high during the early generative stage of rice growth (Hamdan et al., 2020)

Ricefield rats travel daily to find food, mate, and form a group. The distance traveled by rats is affected by the distance from the food source to the nest. If sufficient food sources are available, rats will travel less than 200 m and attack the middle of the rice fields. If the food source is insufficient, rats can also travel until 700 m, even more. The distance rats travel in one night when looking for food sources is 3-5 km (Priyambodo, 2009; Sudarmaji et al., 2010). Female rats prefer to forage food where the male rat is present in the food location than where food is current with other females (Zhou et al., 2023).

The ecosystem surrounding rice fields also affects the level of attack by ricefield rats. The field with dirty irrigation and less clean land would experience highest damage caused by ricefield rats. Rats like dirty places with many tall bushes where rats can hide, breed, and nest (Putra et al., 2019). Ricefield rats mostly live in the burrows in the ground. Holes inhabited by rats are called "active holes." Active holes generally contain female rats and their children and food for their living needs. Field rats are also highly adaptable to various places (Samadi, 2018).

Controlling rats is more difficult because of their complex bio-ecological (Garfansa et al., 2023). Trap Barrier System (TBS) is a physical and technical culture control technique that can be used to control rats (Nurhawati et al., 2020). The TBS can be implemented throughout the growing season. TBS is recommended in heavily infested areas with consistently high rat populations (Saputra et al., 2023).

The population dynamic of rodent species varies across the globe. In the northern hemisphere, the small rodent population tends to fluctuate regularly, whereas in the southern hemisphere, the rodent population has an irregular dynamic with a large amplitude of outbreak (Andreassen et al., 2020). Food availability and quality would affect ricefield rats' breeding and, thus, their subsequent population. Rice panicles and rice seeds that contain high protein are rats' main food, leading to high rates of conception (Htwe & Singleton, 2018). Irrigation systems also affect the intensity of ricefield rat attacks on rice in Wajo, Indonesia. The highest rat attack occurred during the generative 1 stage of rice in fields with rainfed irrigation systems (29,39%) in comparison to other fields with irrigation (8.88%) and dryland (8.73%) (Haddina et al., 2023). Considering that the agroecosystem condition could affect the population of field rats, it is imperative to understand the dynamics of the rats' population in rice and other crops available in the field. Therefore. This study aimed to examine the population dynamic of rats, the level of damage to rice and secondary crops caused by ricefield rats, and the distribution of ricefield rat nests.

Methods

This research was carried out in February until Mei 2023 in Pleret District, Yogyakarta. The coordinates of this research field are 7°52'31°S 110°23'03°E. This research was conducted on a rice field covering an area of 225 ha and in the middle of the research area a TBS of 1000 m^2 (100m x 10m) was installed to trap rats. The rice (Inpari 32) within TBS was planted 3 weeks earlier than the surrounding plots.

Installing Trap Barrier System (TBS)

When rice reached three weeks after planting, TBS was installed. TBS was fitted with UV plastic spread around a rice field of 1000m2. TBS was installed with 30 cm of the bottom part buried in the ground so rats could not enter the field and 90 cm above the ground. The bamboo stake was planted every 5 m on the west and east sides while on the north and south sides every 10 m. The bottom of the TBS was punched into a rat trap. Ten units of rat traps with the size 40cm x 20cm x 20cm were installed on the north and south sides with the distance between traps being 20 m, and on the west and east sides, four rat trap units were installed with the distance between traps is 4 m (Figure 1). There was irrigation around the TBS with a width of 20cm, and a bridge made of wood was given as a rat road to the trap.

Figure 1. Installation of a trap barrier system in the field: a. Trap ilustration, b. Trap barrier System (TBS) instalation, c. Rat's trap.

Parameter Observed

Damage intensity of rice plants

The diagonal sampling method was used to observe the damage intensity in TBS. Observations were made when the rice in the TBS reached four weeks after planting until harvest. The TBS area of 1000 m2 will be divided into four parts with the same area of 250 m2. Several sampling plants have seven rice clumps (Kementerian Pertanian, 2018). The formula used to calculate damage intensity is:

$I = \frac{a}{a+b}$ x 100% .... (1)

Description: I = damage Intensity (%), a = number of affected tillers, b = number of the healthy tillers

Damage intensity on crops outside TBS

Following the four cardinal directions, the line transect method was used to examine the crop damage intensity outside TBS with distances between sampling points were 250m, 500m, and 750m from TBS. The damage intensity on rice crops outside TBS was observed with a radius of 20 m from TBS. The number sampled was 30 clumps. Damage levels outside TBS were observed once a week. Observations were made when the rice in the TBS was four weeks after planting until harvest. The damage intensity outside TBS was calculated by taking samples of 30 plants. Sampling is carried out using the diagnostic method to form the letter "X." According to Kementerian Pertanian (2018), the formula used is:

$I = \frac{n}{N}$ x 100% .... (2)

Description: I = damage Intensity (%), a = number of sample (shoots, panicles, grain, panicle necks, stems, cobs, pods, clumps/plant parts) that are absolutely damaged, b = number of samples were observed.

Number of rats caught in TBS

Observations were conducted when rice was four weeks after planting until harvest. Observations were made daily in the morning during the growing season.

Number and location of active holes

The number of rat active holes was examined using line transect method in four cardinal directions. The number of active holes was observed once during the growing season. The locations of the active holes were mapped using the software ArcGIS 10.2, 365 GPS, Google Earth, and Avenza maps, and the number of active holes was counted. The results of observations of active rat holes were displayed in the form of a map.

Data Analysis

The data was processed using a quantitative descriptive analysis method. Correlation analysis was subjected between the number of rats caught and the number of active rat holes with the damage intensity inside TBS

Result

Damage Intensity of Rice Plants

There was a damage on the rice crops inside TBS, while the rice plants around the TBS with a radius of 20 m did not show any damage. The highest crop damage occurred at 14 weeks after planting, then continued to decline (Figure 2). Rat attacks caused stems to break obliquely, many panicles fell around (Figure 3).

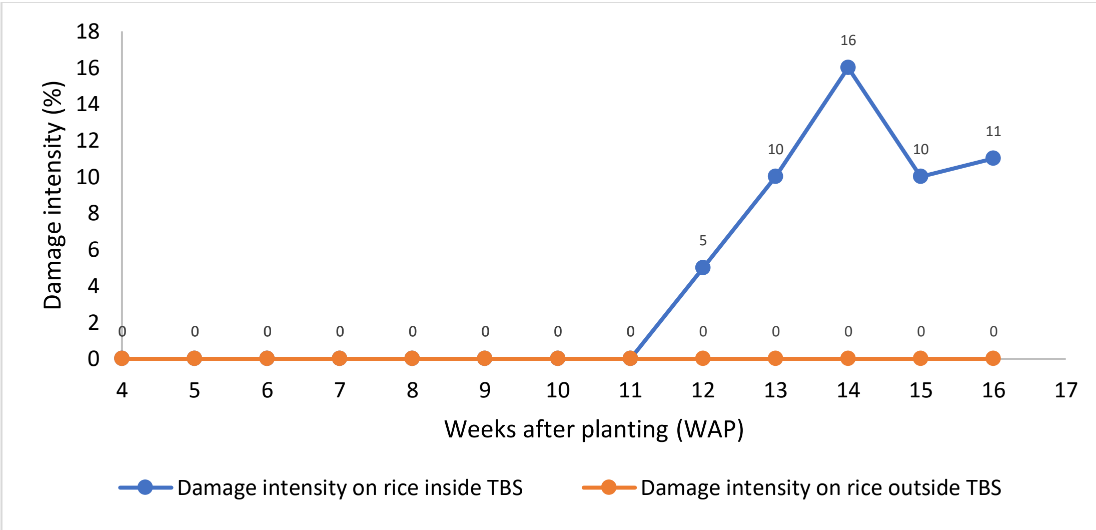

Figure 2. Damage intensity of rice plants inside and outside TBS

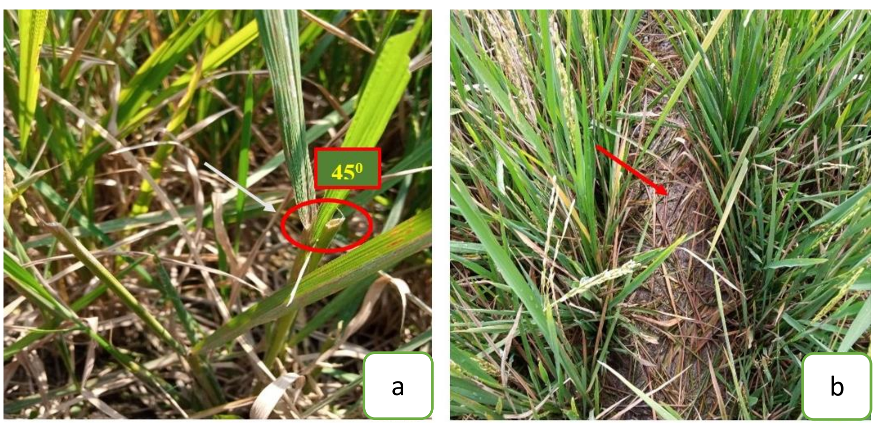

Figure 3. Characteristics of rat attacks on rice plants: a. broken rice stalks, b. panicles fall

Damage Intensity on Other Crops Outside TBS

Sugarcane located 500 m to south of TBS

There was a sugarcane plantation 500 m to the south of TBS. There was no damage by rats observed earlier until finally occurred at the age of 32 weeks after planting. Observation results showed that the damage intensity to sugarcane plants increased weekly (Figure 4).

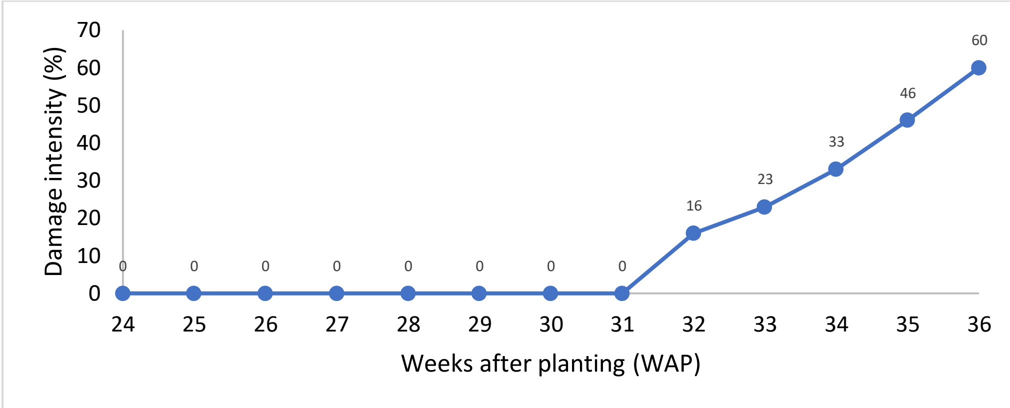

Figure 4. Damage intensity of sugarcane located 500 m to south of TBS

Cornfield of 250 m and 500 m to the north

Cornfields are located as far as 250 m and 500 m to north of the TBS. The observations showed that there was damage to the corn plants. Damage to corn plants continues to increase from 8 weeks after planting (Figure 5a). Corn plants are an alternative food for rats besides rice. The characteristic of corn plants that attacked by rats is the corn cobs eaten by rats. Rats ate bite marks on the corn are signs that corn plants are attacked by rats on damaged corn crops (Figure 5b).

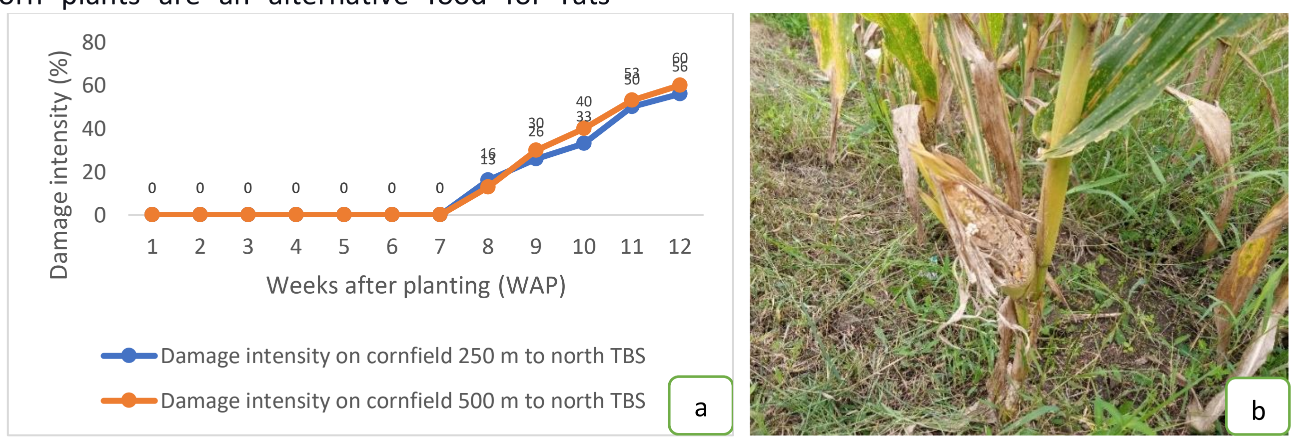

Figure 5. Rat attack on corn crops: a Damage intensity; b. Rat attack on corn cob

Number of Rat Caught in TBS

From 4 weeks until 16 weeks after planting, the number of rats caught fluctuated, and more female rats were trapped than male rats (Figure 9). The number of rats caught was related to the growth phase of the rice plant, where more rats were trapped when rice entered the initial productive phase. The highest catch was when the rice plant age was nine weeks after planting. More rats were caught in traps that were set on the north side of TBS compared to other directions (Figure 6).

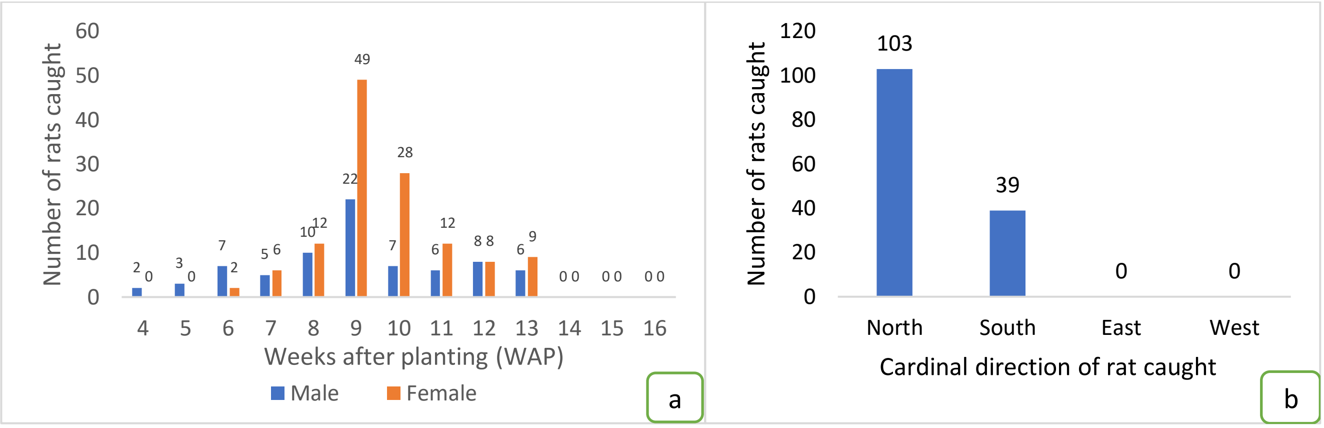

Figure 6. The number of rats caught inside TBS: a. based on sex of rat, b. based on cardinal direction

Number and Location of Active Holes

Based on observation, the number of active rat holes increased weekly (Figure 7a). The most active rat holes were found south of the TBS (Figure 7b).

Active rat holes were often found around irrigation embankments and areas with tall bushes. In the study site in Pleret, several other plants were planted besides rice. Crops has not been planted yet on plots outside the TBS area because the TBS was planted three weeks earlier than the surrounding fields, the rats could be lured into the TBS. It was found that rats often make nests near their food sources. Ricefield rats also make nests around irrigation or bushes. In distances of 250m, 500m, and 750m to the north of TBS, there was a corn field, corn field, and village, respectively. In the distance 250, 500, and 750 m to the south of TBS, there was a motor cross area, sugarcane field, and barren land. In the distance 250, 500, and 750 m to the east of TBS, there was barren land after harvest and village, respectively. In the distance 250, 500, and 750 m to the west of TBS, there was a football stadium and village, respectively, where the number of active holes was the lowest (Figure 8).

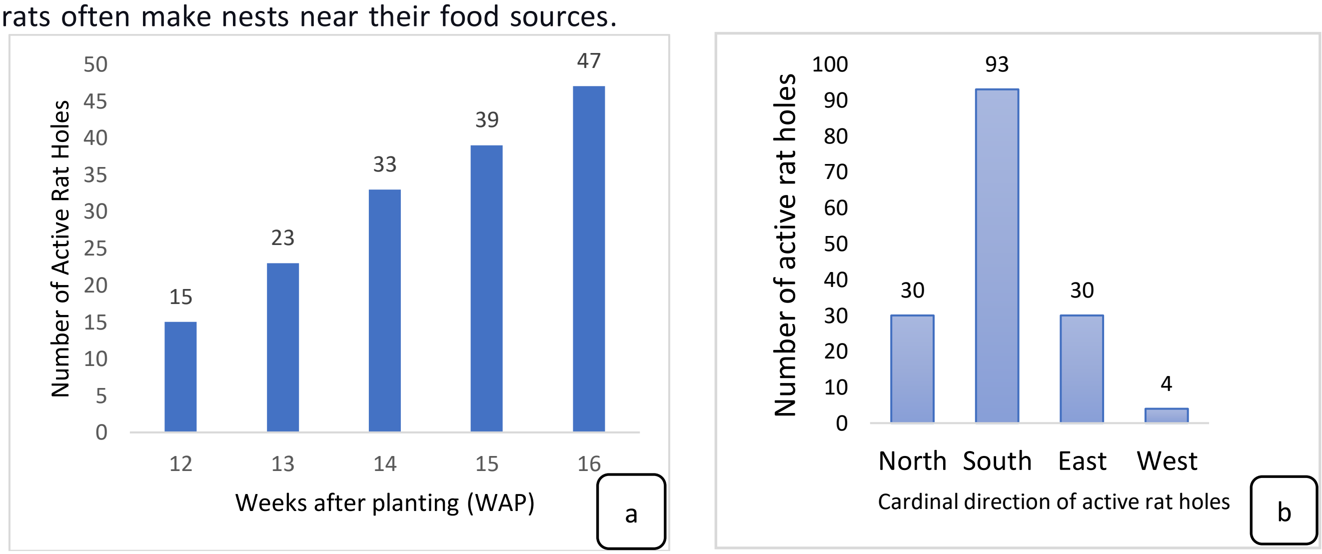

Figure 7. Cumulative number of active rat holes within 225ha: a. based on rice age; b. based on cardinal direction

Figure 8. Distribution of active rat holes within 225ha in Pleret, Yogyakarta, Indonesia

Correlation Analysis

Data analysis showed one quadratic correlation between the number of active rat holes and the damage intensity. Correlation analysis between the damage intensity of rice crops and the number of active rat holes showed a sufficient relationship with R = 0,54. Regression analysis showed a positive relationship between the number of active holes and the damage intensity inside the TBS (Figure 9). There was a negative relationship between the damage intensity within TBS and the number of rats caught within TBS. The number of rats caught decreases as the damage intensity increases (Figure 10).

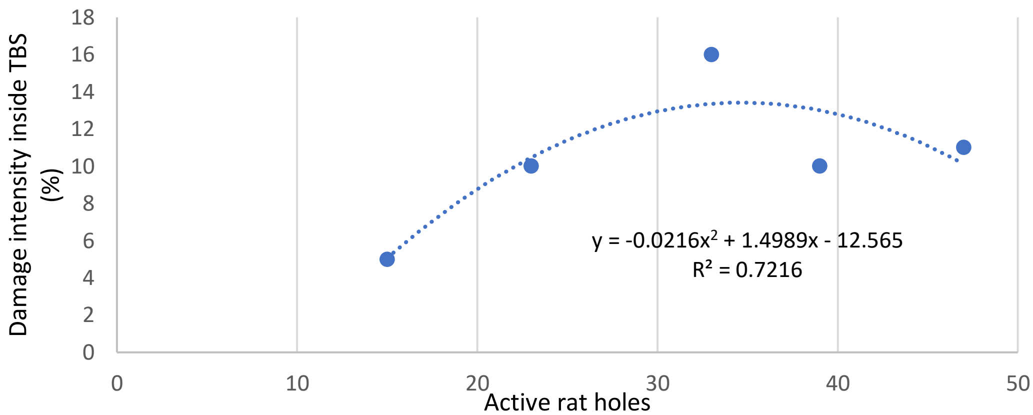

Figure 9. Relationship between the number of active rat holes and damage intensity of rice plant

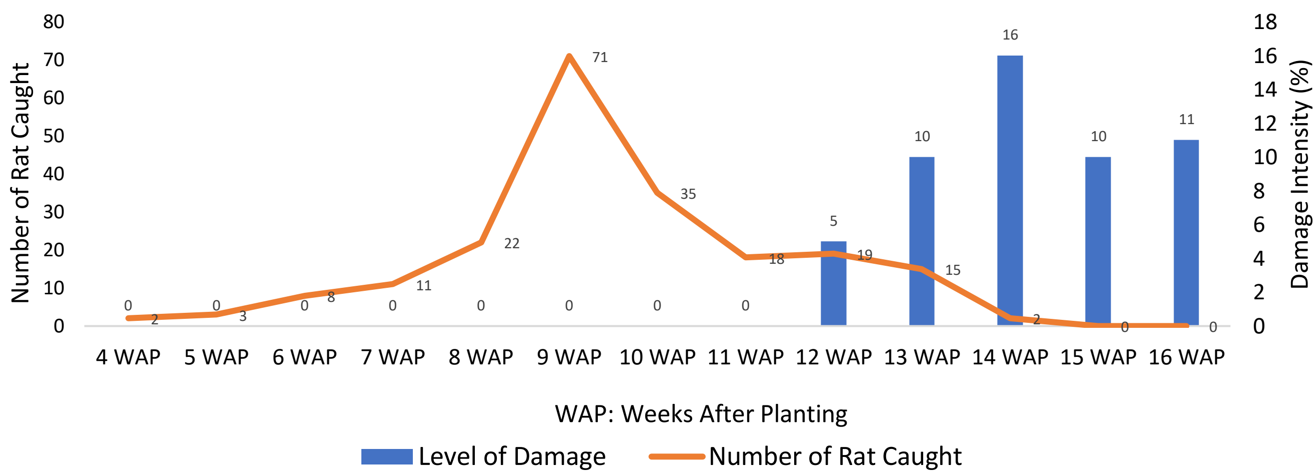

Figure 10. Damage intensity to rice plants in relation to the number of rats caught inside TBS

Discussion

There was a rat attack inside TBS because rats managed to burrow and make holes in TBS to enter the plot inside TBS and damage the crops. In the early rice growth until 11 weeks after planting (WAP), many rats entered traps, so they didn't attack rice outside TBS. After 11 WAP rats avoid the bridge/path to enter the traps and make their path/holes, the number of trapped rats decreases (Figure 2, 3).

Rats are clever animals that can learn and become trap deterrents. Rats attacked rice crops inside TBS because the surrounding environment had not been planted with rice.The TBS caught many rats since the rice was planted three weeks earlier than the surrounding area. As many rats attracted the rice crops, many became ensnared in the traps. Field rats are drawn to crops planted 2-3 weeks earlier; field rats will be drawn to them and become trap crops (Brown et al., 2003; Singleton et al., 1998; Siregar et al., 2020). According to Wang et al. (2017), rats are drawn to trap crops at all stages of growth. Several rats trapped in earlier times were quite low, but it increased along the change of rice growth stage (Sekarweni et al., 2019). Several rats trapped and damaged were high in the early generative stage of rice and decreased when rice reached its maturity (Rachmawati & Herawati, 2021).

The high number of rats attacking TBS was because there were still no crops around the TBS. Rats attack rice plants because rice is one of their primary foods. Most rats were collected when they were in the early stages of development. Ricefield rats prefer rice crops as they reach the initial reproductive phase (Siregar et al., 2021).

As rats could dig holes in the TBS, they damaged rice crops. This occurred when the rice was 12 weeks old after planting (Figure 3). The broken stems caused by rat bites could be distinguished from other causes. Many panicle stems around the attacked crops have fallen to the ground. Aside from that, rice crops attacked by rats will stop developing because the rats assault the rice crop's growing point (Figure 3). This is consistent with Pitojo et al.'s (1997), and Siregar et al.'s (2022) that broken panicle can identify rice attacked by field rat. As stated by Samadi (2018), rats attack rice by eating the rice stalks at an angle so that they form a 45° angle.

Based on the observations, the high number of rats attacking TBS was because there were still no crops around the TBS. Rats attack rice plants because rice is one of their primary foods. Most rats were collected when they were in the early stages of development. Ricefield rats prefer rice crops as they reach the initial reproductive phase (Siregar et al., 2021).

Rats also attack sugarcane (Figure 4), corn (Figure 5), and rice plants. As a result, the rat has a food source other than rice. Rats attack sugar cane and corn by biting the stem or roots of the plant. The damage intensity reached 60% when sugarcane was 36 WAP (Figure 4). At 36 WAP, the sugarcane has reached maturity, so the sugar content in the crop is higher and preferred by rats than when the cane is younger. The sugar content is higher in mature than immature tissue (Mason et al., 2020).

Corn crop damage started when it entered late vegetative development and reached the highest damage intensity when corn had already developed cob (12 WAP) (Figure 5a). Corn (RM2) hybrid enters the reproductive stage (R1) at 69-76 days after planting. (Nleya et al., 2019). Bisi corn enters the reproductive stage (R1) 51-60 days after planting. Kernels Pasty (R4) develops 75-88 days after planting (Agrikan, 2019). Corn crops attacked by rats had a characteristic, showing bite marks on the cobs (Figures 5b).

In addition, the high damage to sugar cane and corn crops is due to the large number of active rat holes in these crops. Rats make nests around the sugar cane and corn crops because these plants are the primary food source for rats. This is similar to Sudarmaji et al. (2007) that rats often build their nests near their food source.

More female rats were trapped during the early generative stage (Figure 6). This result is similar to Siregar et al. (2022). This is because female rats forage for food in preparation for breeding. Female rats need high-protein food for conception (Htwe & Singleton, 2018).

The position of rat nests/active holes affected the number of rats trapped in the north and south. There are numerous rat nests on the north and south sides of TBS. Based on observations made from 12 WAP until 16 WAP, the number of active rat holes/nests increased weekly (Figures 7). As a result, innumerable rats become caught on that side. Several factors impact where rats build their nests, including proximity to food and water sources and protection from predator assaults (Sudarmaji et al., 2007). The unplanted sides of TBS and the plant age difference caused more rats to be trapped in that direction. The vast population of field rats, the rodents' behavior, and the environment all impact the quantity of field rats trapped (Siregar et al., 2020).

The environment is very influential for ricefield rats to determine their nests. Field rats like dirty or bushy land because field rats can hide and make nests in that place. Rat nests were found at a distance of 250 m to the south of TBS, a motor cross area. Approximately 500 m to the south of TBS, fields were planted with sugarcane in this area. Active rat holes were found around the irrigation embankment (Figure 8). The motor cross area has lots of bushes and is rarely passed by humans. Field rats prefer to make nests on grassy land or land with bushes (Harrison, 1995). Furthermore, rice field rats prefer irrigation embankment because their nests are not submerged by water in a flood (Sudarmaji et al., 2007).

The fewest active holes were found 250, 500, and 750 m west of TBS, where the village and football stadium are located (Figure 8). This result indicates that rats prefer to avoid making nests where human activities are frequent, such as in the village and football stadium. Many rat holes were discovered as far north as 250 m from TBS. Corn plants can be found in this area (Figure 8). Rat holes are frequently discovered near rice field bunds and in areas with tall bushes. This is because rats build their nests in places that are hidden. Rats will build nests in areas safe from predators and close to food sources (Sudarmaji et al., 2007).

The data revealed a relationship (R= 0,54) between damage intensity inside the TBS and the number of active rat holes. A high point between the number of active rat holes and the damage intensity to rice plants in TBS (R^2= 0.7216). The number of rats caught negatively correlates with the damage intensity in TBS (R^2= 0,1652) (Figure 9). The greater the number of active holes, the greater the plant damage. This is related to environmental conditions that are suitable for rat to survive. Sudarmaji (2007) states that field rats will build nests near food sources.

The number of rats caught has no strong relationship with damage severity in TBS. When many rats are trapped, the plant damage is minimal. When the number of rats caught decreased, the damage intensity began to increase when the plants entered the productive phase, which occurred 12 WAP and reached its peak 14 WAP. After that, the number of rats caught decreased gradually (Figure 10). Rats can adapt to traps, making them difficult to trap (Gumay et al., 2020). Rats can learn from experience because they have good senses of smell and hearing (Priyambodo, 2006).

Conclusion

This research concluded that ricefield rats can cause damage to rice plants, corn, and sugarcane. The highest rice crop damage (16%) occurred at 14 weeks after planting (WAP), whereas the highest damage on corn (60%) and sugarcane (60%) occurred at 12 WAP and 36 WAP, respectively. The highest rat population was trapped during the early generative growth of rice nine weeks after planting. Besides that, field rats also like to build nests around their food sources, irrigation embankments, barren fields, and rice field bunds.

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Declaration

Author contribution

R.R. Rukmowati Brotodjojo is the main contributor of this paper, R.R. Rukmowati

Brotodjojo is the corresponding author, and Ikhsan Lazuardi and Antik Suprihanti are co-authors. All authors read and approved the final paper.

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Competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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