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Research Article

Daily Captured Pattern of Rice Field Rat Using Trap Barrier System Application in Fallow Land

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ABSTRACT

Rice (*Oryza sativa*) is an important staple crop for more than half of the world's population to fulfill required nutrients. The most important pest in rice crops is the field rat (*Rattus argentiventer*), which causes damage and significant yield losses during almost every growing season. One method of rat control is the Trap Barrier System (TBS) which consists of fences, mass/multiple live traps, and trap crops and was able to continuously catch rats during the growing season. The objectives of this study were to count rat captured in TBS during one planting season in fallow lands, identify attack source, and calculate rat damage intensity. The study was conducted on one hectare of rice field and number of rat caught were observed daily. Results showed that 4,580 rats were caught, consisting of 57% males and 43% females, with 94% adults and 6% juveniles. Average rat damage intensity was 15% and the highest number of rats caught were in trap 8, 9, and 10 which were located on the north side and had many suitable shelters for rats.

Keywords: fence system; management of rat; multiple live traps; trap crop

INTRODUCTION

Rice (*Oryza sativa* L.) is a important food crop consumed as the main food for more than half of the world's population. It contains nutrients needed for the human body (Pratiwi, 2016). Harvested area of rice in Indonesia during 2020 was estimated to be 10.79 million hectares, an increase of 108.93 thousand hectares or 1.02% from the 2019 which was 10.68 million hectares. Furthermore, on the same year rice production was estimated at 55.16 million tons of milled dry grain, an 556.51 thousand tons increase from 54.60 million tons of milled dry grains (*Badan Pusat Statistik*, 2020). Rice is an important cereal crop and its derivatives are consumed as the main food of the Indonesian people. Thus, increasing its productivity becomes a priority. Rice production is influenced by many factors, such as variety selection, application of fertilizers, crop cultivation techniques, and disturbance by plant pest organisms. Pest i.e., vertebrate/invertebrate pests, diseases, and weeds cause low rice productivity per hectare and may even lead to crop failure (Wati, 2017). There are three main pests in rice plants, namely rice stem borer (*Scirpophaga* sp.), brown plant hopper (*Nilaparvata lugens*), and rice field rat (*Rattus argentiventer*).

During almost every growing season, rice fields across Indonesia are almost always infested by rats that causes damage and yield losses. *Pusat Data dan Sistem Informasi Pertanian* noted that rice field rats was the primary rice pests with the highest crop failure rate (*Pusat Data dan Sistem Informasi Pertanian*, 2022). Rat infested areas in Indonesia reached 66,087 ha/year with 1,852 ha experiencing harvest failure (*puso*). This is a detrimental condition for farmers due to crop damage and economic losses (Marbawati & Ismanto, 2011; Siregar *et al.*, 2020). Rats only require feed about 10–15% of their body weight, but they have incisors that grow continuously throughout their life. To avoid interferences with the eating process and daily activities, their incisors must be sharpened and reduced, which can be done by biting hard objects in their environments (Marbawati & Ismanto, 2011).

Damage caused by the rice field rats can start from the nursery and continue until harvest, even in post-harvest in the storage. On average, rats can damage 79 stalks during early growth or during the vegetative phase, 12 stems per night during the panicle formation, and 103 stems during the ripening stage. Rice field rats prefer to attack mature rice plants causing the highest damage within all rice growth stages. Several methods can be used to control rat damage in the rice field ecosystem, such as applying rodenticides, mass hunting (*gropyokan*), fumigation, regulating cropping systems, maintaining field sanitation, and conserving natural predators (Brown *et al.*, 2003). In addition, Trap Barrier System (TBS) can also be established by using a combination of fences, multiple live traps, and trap crops (Nurhawati *et al.*, 2020). Hereafter, the Trap Barrier System is abbreviated as TBS.

The TBS is a rat control technique that can be implemented throughout the growing season. TBS is recommended to be used in heavily infested areas with consistent high rat populations. According to The Indonesian Agency for Agricultural Research and Development [*Badan Penelitian dan Pengembangan Pertanian*] (*Badan Penelitian dan Pengembangan Pertanian*, 2019), TBS is effective in capturing large numbers of rats continuously from the beginning of planting to harvesting, in rat endemic areas with high population levels (Brown *et al.*, 2003; Wang *et al.*, 2017; Pujiastuti *et al.*, 2018; Herawati & Purnawan, 2019).

Various experiments regarding TBS in rice cultivation have been done, but no TBS trials have been done in fallow land. Studies on this TBS application in fallow areas can inform rice field rat control in areas that can significantly reduce rat population for the following season. TBS installation focus to the six physical abilities of rats, including digging, climbing, jumping, gnawing, swimming, and diving (Husein, 2017). TBS is made from plastic fences with an adjustable size depending on the land. Multiple live traps ("*bubu*" traps) with dimension of 60 cm (length) × 25 cm (width) × 25 cm (height) are installed on each side of the plastic fence with holes facing out. A 25 cm deep trench is made outside of the plastic fence. The bottom of the fence is flooded so rats cannot pass through the trap (Sepe & Suhardi, 2021).

The objectives of the study were to identify and count rats captured in TBS, identify sources the rice field rats attack, calculate the attack intensity, and measure the economic value of TBS. This research is expected to provide a method for controlling rice field rats, reduce the attack intensity, and increase the farmers awareness on ecological approach for controlling rice field rats.

MATERIALS AND METHODS

The study was conducted from October 24, 2021 to January 8, 2022 at one hectare of rice field in Kiarasari Village, Compreng District, Subang Regency, West Java Province (6° 43' 55.97" South and 107° 88' 73.75" East). A set of TBS with multiple live traps, bamboo stakes, wire rope, electronic scales, plastic with a thickness of 0.2 mm, camera, ruler, calculator, and glutinous rice varieties namely Ketan Grendel Putih were used in this study.

This research was conducted at a one hectare rat endemic area. The glutinous rice variety was transplanted (October 17, 2021) for trap crop on a plot of 151.8 × 62 m which was divided in six equal size subplots. The TBS was installed (Sudarmaji & Anggara, 2006) for one growing season (October 24, 2021), since the beginning of planting until harvesting. A plastic fence of 90 cm in height and 428 m long was installed around the edge of the plot, with bamboo stakes distanced 1 m apart on the inside of the fence, and 20 cm deep ditches were made surrounding the plastic fence. A total of 16 *bubu* rat traps were installed on the TBS with arrangement shown in Figure 1. Ten traps were installed during the initial installation due to consideration on size suitability for the TBS area. Then traps were added according to the direction and number of rats captured on each TBS side. On the 11th day, 1 to 11 traps were added; on the 30th day, 4 to 15 traps were added. Then on the 38th day, 1 trap was added to make 16 traps; while on the 57th day, trap 14 was removed leaving only 15 traps. Traps without captured rat were removed. Distance between traps were 20–30 m. In general, the location was specifically used for rice cultivation.

Resources for rice field rat attacks were observed at areas approximately 1,000 m outside of TBS.

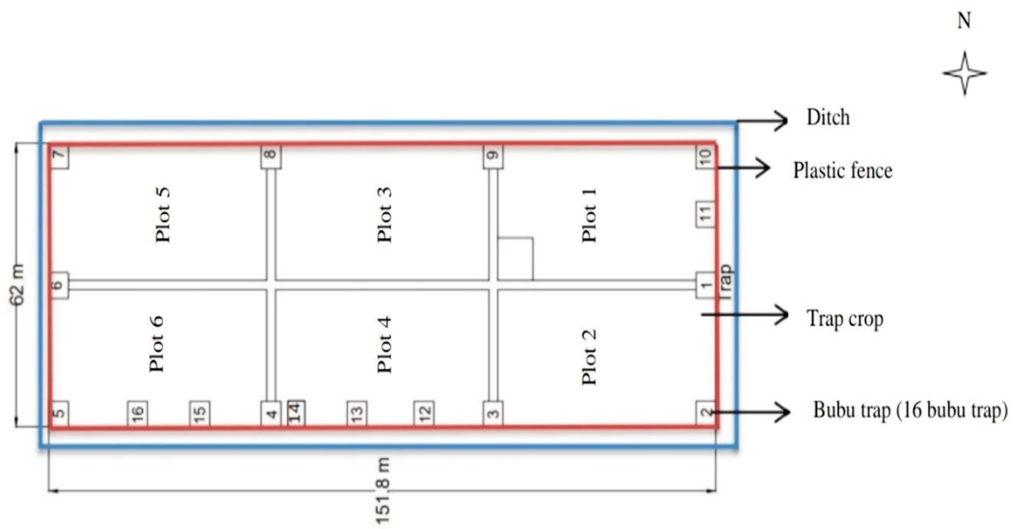

Figure 1. Trap barrier system installation with position of the 16 "*bubu*" traps and six plots of rice field with 5 sub-plots inside each plot

Distance from the TBS was calculated using the *Avenza Maps* application. Rat presence signs at a radius of 1,000 m from the TBS was indicated by the attack rat path, and rat burrow.

Rat captured was recorded daily at 05.30 in the morning throughout the planting season.Captured animals were counted and sex was determined to calculate sex ratio. In addition, adultand immature rats were also distinguished by observing their genital characteristics. According to Sudarmaji, mature male rats have enlarged testes in the testicle sacs and protrudes called scrotal testes, meanwhile testes located in the abdominal cavity for immature rats. Mature female rats were identified from the characteristics of their nipples and vaginas, which indicate their pregnancies (Sudarmaji, 2018).

Rat attacks in rice plots within TBS were observed. Sampling units were rice clumps. A total of four rice clumps were observed at five points within a diagonal line in the center of sub plots (Figure 1). Clumps of rice plants were taken purposively when clumps showed signs of damage by rats. Hence, out of the six plots there were 30 sub plot or sampling points and 120 rice clumps. Dead rice plants were assumed as losses, hence, the percentage of the attacked plants indicated the losses. Daily rat capture fluctuation was depicted in graphs based on rats sex, age, and rats caught in each of "*bubu*" trap.

RESULTS AND DISCUSSION

Total Daily Catch

Total daily rats captured from the initial installation of TBS to harvest was 4,580 individuals. During the observation, the number of rats trapped daily varied. As seen in Figure 2, the pattern of rats capture fluctuated daily. It showed a convex curve with the peak population of rats caught at the age of 66 days after planting (DAP) maybe caused due to rice plants entering their generative phase. The rice field rat population will increase when rice plants enter the generative phase and female rats captured showed signs of having to give birth (Sudarmaji, 2004). This indicate that female rice field rats reach maturity reproductive stage at when rice plants reach generative stages.

During the vegetative stages, the number of rats captured daily was 1,782 individuals (38.91% of total caught), with the highest number 148 rats and the lowest 7 rats. The highest number of rat captured was obtained on the 40th day of observation (59 DAP), because the condition of the land around the TBS was free from any plants or shrubs. In addition, on the 23rd to 30th observation day, several lands around the TBS were in the land cultivation. The lowest catch was obtained on the 13th day of observation (32 DAP), because the condition of the land around the TBS have not been cultivated re-

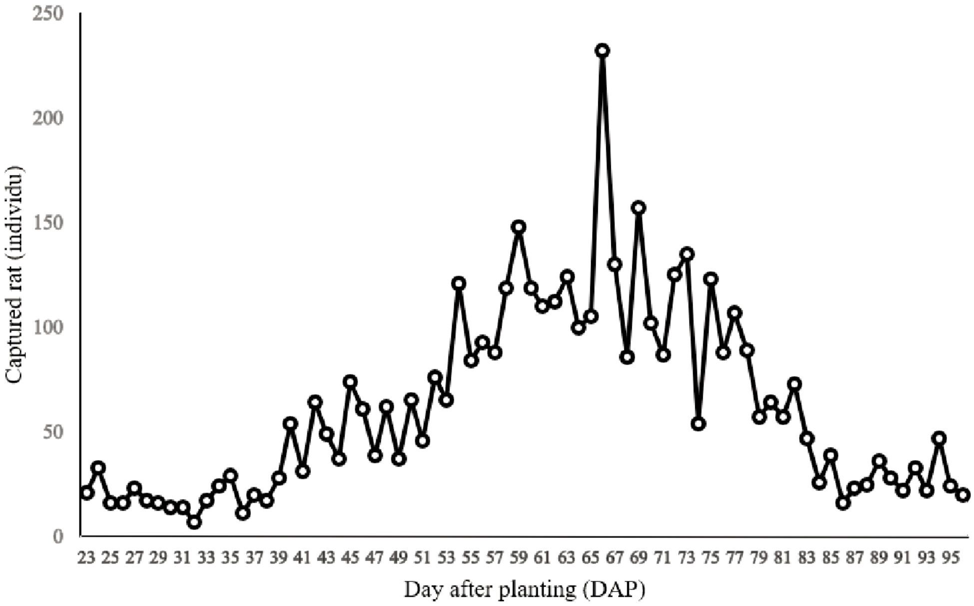

Figure 2. Daily rats captured for 74 consecutive days (DAP = day after planting) from 16 *bubu* traps

ducing food sources availability for rats around the TBS fields. In addition, tillage was carried out on the 23rd day of observation (42 DAP) causing low rats capture numbers.

In the generative phase of rice plants, 2,844 rats (62.10%) were captured. The highest number of animal caught was 232 rats on the 47th day of observation (66 DAP), when the land outside around TBS started to prepare for second planting season. During that time, the land around TBS were clean and no food sources for rats. The lowest number of rat captured was 16 rats on the 67th day of observation (86 DAP), rice fields around the TBS began to grow and food was abundantly available and might reduce rats to attack rice crop trap in the TBS. During the rice generative stage, few rats left fields to villages because available and abundant rice for feed. Lush rice crops are also good shelters for rats (Sudarmaji & Anggara, 2006). Eighty four percent of days male and female rat captures during early to late tillering were in banks, whereas 59% of days captures were located within rice field when the crop became denser, during the early reproductive stage (Brown *et al.*, 2001).

Number of Rats Caught in Each Trap

Highest number of captures were in trap 9 (800 rats = 17.47%) followed by trap 8 (746 rats), 10 (403 rats) and 1 (397 rats) (Figure 3). In average, traps in the northern part of TBS obtained higher captures, namely trap No. 8, 9, and 10. This was related to the direction of the rats and conditions around the TBS. North side of TBS was a water hyacinth swamp and dam. In addition, according to farmers, the rice fields on the northern location have experienced crop failure due to the attack of rats. Distance between TBS to the water hyacinth swamp was 1,304 m and 1,513 m to the artificial river. Rat habitats in irrigated rice fields were identified and the most inhabited were habitats on the out skirts of villages and irrigation embankments (Sudarmaji *et al.*, 2006).

The second highest catch was on the east side of the TBS field, with trap 1, 2, 10, and 11. The eastern part contained several habitats for rice field rats, namely mango and banana plantation, shrubs, waterways, and Cipunagara River embankments. The distance between TBS and these habitats was approximately 97 m, while the distance between TBS and the river embankment was 418 m.

Furthermore, the third highest number of catches was on the west side of the TBS from 7, 6, and 5. The west side of TBS had a highway and rice fields. The distance between TBS and the highway was 418 m. Thus, not many rats were caught. In addition, there were few shrubs on the land towards the highway making it unfavorable for rats to live.

The south side of the TBS had the lowest rat capture. The southern part of the land only had

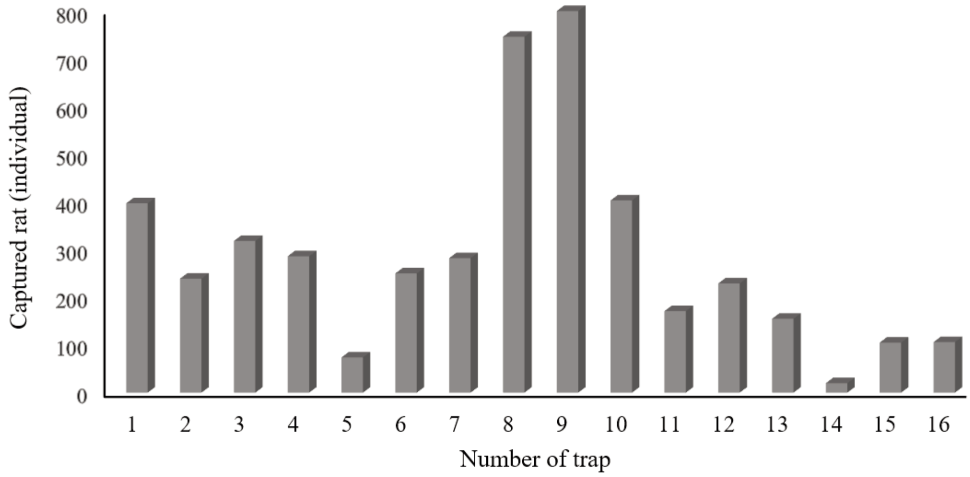

Figure 3. Rat captured from 16 *bubu* traps for 74 consecutive days

a small irrigation channel with a distance of 435 m. In addition, there were three chicken coops, with the closest distance of 628 m and the furthest 917 m. Rice field rats are omnivorous animals that eat various types of food available in their environment (plants, animals, fungi, and others). Rice field rats consume food from plants and animals live in the rice field with varying diets (Rahmini & Sudarmaji, 1997). It is possible that the rice field rats on the south side had enough food around the nest and not moving too far to find food.

Some sources of rat attack had distances <1,000 m from the TBS. The furthest distance from the source of the rat attack was an man-made river (1,513 m) and the closest distance was a mango plantation (97 m). The space for rats to move when sufficient food and protection is usually ≤ 100 m (Brown *et al.*, 2001), and rats attack rice plantation starting from the middle of rice fields. When there is not enough food, rats will migrate in large numbers and can reach food sources that as far as 3–5 km away in one night (Putra & Arjunet, 2019). This causes differences in the number of catches in each trap, the southern and western sides of which had sufficient food and also conditions that was not suitable for rat habitat. On the northern and eastern sides which were the source of suitable rat habitat, so on this side many rats was caught.

Rat Caught Patterns by Age

The number of adult rats caught was 4,313 (94.17%) while the number of immature rats caught was 267 (5.83%). Adult female rats will reach sexual maturity at a body weight of at least 60 g or more than 40 days old. After the body weight reached 90 g, male rat was estimated to be equivalent to the age of 59 days. The number of adult rats always increased according to the development of the rice plant age, the increase in adult rats occurred significantly at the age of 58–77 DAP. This is related to rice plants entering the generative phase. In the rice–rice–fallow cropping pattern, it has been reported that at the beginning of the generative stage, almost 100% of captured female rats had given birth (Sudarmaji, 2018). This proves that the female rice field rats present at the time the rice crops enter the generative stage have matured and reproduced.

In addition, male rats gradually increased following the growth of rice plants. The peak of male rats sexual maturity occurred when rice planting reach maximum budding stage to the panicle stage (late vegetative stage to early generative). During maximum germination stage to milk maturity, almost 100% of male rats have reached sexual maturity. This indicates that during the generative phase, the number of rats captured was dominated by adult rats. There was no visible difference of immature rats captured between vegetative and generative stages based on observations. At the end of the generative rice stage or fallow period to beginning of the vegetative stage of the next growing season, female rats capture was dominated by the pre-adult generation. Young male rats increased in population during the mature stage, fallow period, and early vegetative stage (Sudarmaji, 2004). This indicated that the number of catches of immature rats at the

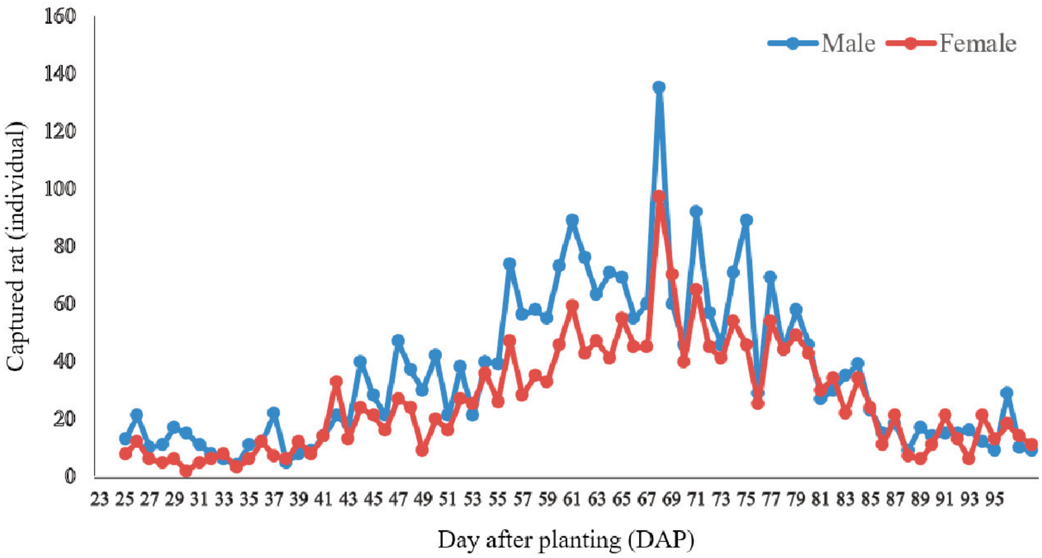

Figure 4. Daily rat captured by sex (male and female) for 74 consecutive days

Table 1. Damage intensity of tiller of rice crop

Plot	Mean of damage intensity (%)					Mean/plot
	Subplot 1	Subplot 2	Subplot 3	Subplot 4	Subplot 5	
1	16.37	42.29	14.81	37.09	21.53	26.42
2	29.85	9.28	7.29	23.32	3.44	14.64
3	15.84	9.85	6.72	7.71	10.26	10.08
4	10.53	12.62	29.26	41.29	5.57	19.85
5	9.83	15.28	2.38	3.09	5.90	7.30
6	15.83	13.35	10.23	13.57	2.70	11.14
Mean	16.375	17.11	11.78	21.01	8.23	**14.90**

beginning of rice plant vegetative phase should have been higher.

Rat Caught Patterns by Sex

Based on the sex ratio, the number of rats caught from the beginning of planting to harvesting was 2,623 males (57.27%) and 1,957 females (42.73%) (Figure 4). Male rats were more cooperative than female, because they are leaders in groups, so male rats have the task of looking for food and have a longer home range than female. Male rats are more active in foraging and looking for partners (Rusdy & Fatmal, 2008). The number of captured female rats was higher than that of males when the age of rice plants was more than 70 DAP, besides that time the difference between males and females were not more than 10 individuals/day. This happened because at the age of 70 DAP, rice crops have entered the generative phase. In the late generative rice stage, rat populations were dominated by females. Female rats are more active in looking for food, especially during breeding season and pregnancy (Herlina, 2016).

Damage Intensity of Rats Attack

The average damage intensity in all plots was 14.90% (Table 1) because the sample clumps taken as samples were done purposively on plants showing symptoms of rat attack. The highest intensity was in the 1st plot (26.42%), followed by the 4th plot (19.85%). The lowest attack intensity was in the 5th plot (7.30%).

In plot 1 the highest number of rats were captured per trap. In addition, plot 1 is on the north side that has the most suitable habitat for rats. Then plot 4 has the second highest attack intensity due 4 more traps placed near the plot. This allows more rats to enter the TBS field, compared to the sides that has a small number of traps. This makes it easier for rats to damage the plastic that is near the trap as more traps are installed causing higher damage intensity. Damage intensity is strongly influenced by the abundance of the rat population. Higher the rat population correlated with higher damage intensity.

CONCLUSION

As much as 4,5800 rats were capture in one planting season and consisted of 57.27% males and 42.73% females, 94.17% adults and 5.83% immatures. The highest attack intensity and number of daily catches were in the plot one (26.41%) and trap 9 (17.47%), 8, and 10, which were on the north and east sides of installed TBS. The north side consisted of water hyacinth swamps and a dam, and in this area there was history of crop failure due to rat attack. The east side consisted of several habitats (mango and banana plantation, shrubs, waterways, and Cipunagara River embankments). Average intensity of rat attacks was 14.90%.

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