BIODIVERSITAS
Volume 25, Number 7, July 2024
Pages: 2993-2998

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d250720

Effectiveness of using the trap barrier system to control rats in palm oil plantations

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Manuscript received: 17 May 2024. Revision accepted: 9 July 2024.

Abstract. *Efriansyah, Priyambodo S, Hindayana D. 2024. Effectiveness of using the trap barrier system to control rats in palm oil plantations. Biodiversitas 25: 2993-2998.* Oil palm is one of the plantation crops that is the largest contributor to the country's income; increased market demand affects palm oil production, which continues to increase. Rats are among the most important pests in oil palm plantations because of their diverse habitats, large populations, and easy breeding. One of the mechanical control concepts that can be implemented is the Trap Barrier System (TBS) technique. This research method was implemented by installing a trap barrier between oil palm trees. This TBS research is divided into two methods. The first method used three treatments with three replications in the main plot, and there were three main plots. The second method used nine treatment sub-plots with three replications. The Ciliwung variety of rice was planted inside the TBS in a 3 m x 3 m plot. Field observations included the number of rats caught and the percentage of damage done at the trial's beginning and end. Species of rats found in oil palm plantations are Malaysian field rat (*Rattus tiomanicus* Miller, 1900), oriental house rat (*Rattus tanezumi* Temminck, 1845), and dan müller's giant sunda rat (*Sundamys muelleri* Jentink, 1879). The *S. muelleri* was the most frequently caught species in each block and method. TBS placement does not need to pay attention to the initial severity of the block. Providing additional bait in traps can increase the attraction of rats to TBS. The extent and intensity of attacks and yield losses in each block with TBS treatment showed a greater reduction than in blocks without TBS.

Keywords: Decreased damage, number of rats caught, *Sundamys muelleri*

Abbreviations: BPS: Central Bureau of Statistics, LPDP: Indonesia Endowment Funds for Education, TBS: Trap Barrier System

INTRODUCTION

Oil palm is one of the plantation crops that is the largest contributor to the country's foreign exchange and is useful as a cooking, industrial, and fuel oil producer. Oil palm, mostly used for commercial agriculture, consists of two species, *Elaeis guineensis* Jacq. and *E. oleifera* (Kunth) Cortés (Siswati et al. 2020). Bangka Belitung Islands are one of the palm fruit-producing provinces in Indonesia. Oil palm plantations in the Bangka Belitung Islands can produce palm fruit production of 800,400 tons from 46,223,300 tons (Indonesia), comprose of 1.73% of the total production in Indonesia in 2021 (BPS 2022). The high productivity of oil palms causes many problems in the field, decreasing the quantity and quality of oil palm fruit products, which will be processed into Crude Palm Oil (CPO).

Oil palms experience many obstacles in their production activities in the field. Obstacles in oil palm plantations include land suitability for oil palm, choice of commodities or varieties planted, access to fertilizer, labor management, management processes and techniques, production and marketing, capital, accessibility to palm plantation, and environmental and societal impacts (Khairil 2023). According to Murphy et al. (2021), oil palm production faces challenges in the structure of the oil palm industry, the environmental context, pests and diseases, breeding, and biotechnology to improve oil palm as a crop, global supply chains, and consumer perceptions, production, and sustainability and environmental challenges. Paterson (2019) states that climate has a big influence on oil palm because it hinders and becomes a challenge for oil palm farmers in their development and management. Problems that evolved from the community include border areas and the welfare of the surrounding area; several of those problems can be overcome by creating clear borders and improving the welfare of the surrounding community (Lee et al. 2014). Aditionally, another problem faced in oil palm plantation management is pests, including rats.

Rats are cosmopolitan mammals found in primary and secondary forests, plantation areas, and rice fields to human settlements (Rizwar et al. 2018). Rats are a very important pest in oil palm plantations because they live easily in various habitats, have high population levels, and breed easily (Ikhsan et al. 2020). Rats that are often found in oil palm plantations are Malaysian field rats (*Rattus tiomanicus* Miller, 1900), ricefield rats (*R. argentiventer* Robinson & Kloss, 1916), and oriental house rats (*R. tanezumi* Temminck, 1845) (Puan et al. 2011a). The *R. tiomanicus* is a species found as a major pest in oil palm plantations in most locations, and these rats mostly live in scrub vegetation, secondary forests, and plantations (Paramasvaran et al. 2013). The *R. argentiventer* is mostly found in forest ecosystems, rice fields, and plantations, creating habitat niches that allow rats to be able for food storage and breed well (Harper and Bunbury 2015), while *R. tanezumi* is a commensal pest seen near human habitats (Buckle and Smith 2015). According to Puan et al. (2011b), rats can consume as much as 10% of their body weight and carry four to five times as much food into their nests or hiding places daily. This is the importance of controlling rats in oil palm plantations, called the principles of Integrated Pest Management (IPM). Rat control was conducted using mechanical, chemical, and biological techniques (Tipawan and Jarun 2016). One of the mechanical control concepts implemented was using the Trap Barrier System (TBS) technique, which can control rats significantly in Banyuasin District, South Sumatra (Sekarweni 2019). TBS is a rat trap system using bait plants to attract rats (Kabir and Hossain 2014). Based on research conducted by Kanwal et al. (2015), TBS has a range of attracting rats up to 200 m. Installation of TBS must be aware of aspects including the ability of rats to dig holes, climb, jump, burrow, swim, and dive (Husein et al. 2017). This research aims to determine the effectiveness of TBS in managing rat problems in oil palm plantations.

MATERIALS AND METHODS

Time and place of research

This research was carried out from July 2023 to January 2024. The research location was sector PM 16, Gunung Nayo, Kebun Timur, PT Steelindo Wahana Perkasa (SWP), East Belitung, Bangka Belitung Islands, Indonesia.

Procedures

The TBS consisted of a plastic barrier with holes where multiple live traps were installed. We used 27 TBS with two different methods; the first method used three replications of three subplot treatments consisting of three blocks or main plots. The second method used nine treatments in each block (three blocks). The first and second methods were carried out in stages and sequentially.

Rice maintenance

Rice maintenance is carried out from the beginning of sowing until the rice is ready to be transplanted into polybags. The rice used in this research was the Ciliwung variety which was planted in polybags measuring 30 cm x 30 cm containing one clump of three to four rice seeds. The number of polybags used is 25 polybags per TBS, so the total polybags prepared are 675 polybags or 2,025 – 2,700 rice seeds for 27 TBS.

Preparation of trap barrier system

Preparation of TBS begins with preparing the tools and materials needed. This preparation begins with cutting wildwood to install medium-sized TBS ± 120 cm long. A 50 cm long woodcut can also be used as a barrier or prop for multiple live traps (*bubu*). The transplanting process is carried out after the rice is 25 days old. Polybags are filled three-quarters with soil; the soil is saturated with water for three days before planting rice. Another preparation is cleaning the TBS laying location using heavy equipment.

Installation of trap barrier system

The installation of TBS is carried out after rice maintenance and preparation. TBS was installed in three blocks, subdivided into three treatments with three replications. TBS is placed in the middle of 10 x 10 plants, each TBS measuring 3 m x 3 m, as shown in Figure 1.

The rice variety used in the treatment plot was Ciliwung, chosen because it has a short planting period and high tillering. TBS method 1 uses three treatments, namely rice crops, and *bubu* without additional bait (P1), rice crops plus salted fish bait in *bubu* (P2), and rice crops plus roasted coconut bait in *bubu* (P3). Furthermore, TBS method 2 uses 9 treatments, namely rice crops only (P1), grain bait only (P2), no bait (empty) (P3), grain bait with salted fish (P4), grain bait with roasted coconut (P5), grain bait with oil palm fruit (P6), salted fish bait only (P7), roasted coconut bait only (P8), and oil palm fruit only (P9). TBS was installed by inserting stakes to install the plastic which becomes a barrier. After that, polybags containing prepared rice crops are arranged in the middle areas. Then, holes are made in the plastic for placing *bubu*. The trap that has been installed must be equipped with stakes at the back so that the trapped rats cannot push it. There are 54 traps installed from two traps per TBS. The trap barrier system installation considers rat's five physical abilities: trapping, diving, swimming, climbing, and jumping. Observations of the TBS treatment, including the number of rats entering the trap, were carried out for 10 weeks in TBS method 1 and 8 weeks in TBS method 2. Observations of the number of catches were carried out every day.

Field observations and damage caused by rats

Field observations were carried out in line with observations at TBS. Observations were made by observing sections of the TBS treatment plots with plots not treated with TBS following the census point route in the observation block. This was done to evaluate the TBS effect on rat attacks on oil palm plantations compared to rat attacks without TBS. This observation was carried out at the beginning and end of the TBS research to evaluate the differences between those periods. The observation data was used to determine the intensity and extent of attacks.

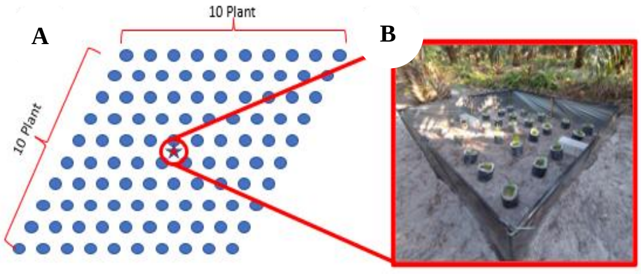

Figure 1. TBS installation map: A. Plot TBS, B. Trap barrier system

Observation of the area of attack is carried out by dividing the number of attacked plants by the total number of plants observed. The attack's intensity was observed by counting the attacked bunches from the total bunches per plant and then determining the damage score based on the attacked bunches (Table 1). Yield loss on oil palm fruit is obtained by multiplying the area of attack by the intensity of the attack and then multiplying by 100%.

The intensity of rat attacks uses the formula (Townsend and Heuberger 1948):

$$I = \frac{\sum_{i=1}^{k}(n_i \, X \, v_i)}{N \, X \, Z} \, x100\%$$

Where:
n_i: the number of bunches that fall into an attack category;
v_i: score in each attack category;
N: number of bunches observed;
Z: score for the heaviest attack category
Area of rat infestation using the formula:

$$L = \frac{n}{N} \, x \, 100\%$$

Where:
L: Extent of attack
n: Number of plants showing signs of being attacked by a rat
N: Total number of plants observed

Data analysis

Observation data were tabulated using microsoft excel 365 software. Then, they were analyzed using R-studio software with analysis of variance in a completely randomized split-plot design for TBS method 1, a randomized block design for TBS method 2, a comparison between species in both methods of TBS, and a completely randomized design for extent and intensity of infestation and yield loss. The results showed real differences, followed by the tukey test at a significance level of 5 %.

RESULTS AND DISCUSSION

Trap barrier system method 1

TBS research in method 1 was carried out with 27 plots, divided into three main plots categorized as low (A06), medium (A08), and high (A07), and the observations were carried out for 10 weeks. The catch ratio in TBS method 1 is 2.47 rats daily. The catch ratio is obtained from the number of rats caught divided by the number of days the trap was carried out.

The observations show the highest catch was in block A08 (68 individuals), followed by block A06 (56 individuals), and the lowest was in block A07 (49 individuals). Data analysis shows no real differences in catches in each block (A06, A07, and A08); this shows that TBS placement does not need to be aware of the severity level of the main plot. The analysis also showed no significant differences between added-up treatments from the three blocks. These data show a tendency for higher catches in replications one and three; this could occur due to the locations of the locations of the replications of the replications being in the north and south, which have a high potential for mobilization of rats outside the nine treatment plots into the treatment plot area. Comparisons between main plots and treatments tested using a completely randomized split-plot design analysis showed no significant differences, too.

Number of catches between main plots and treatments

TBS catch data for method 1 in each main plot and treatment varied greatly (Table 2).

Number of catches between species in TBS method 1

There were three different species of rat caught in this study. These species are *Sundamys muelleri* (Jentink, 1879) (95 individuals), *R. tanezumi* (52 individuals), and *R. tiomanicus* (24 individuals) (Table 3). The analysis of variance carried out showed that there were significant differences between *S. muelleri* and *R. tiomanicus* but not significantly different from *R. tanezumi*. This data shows that the species *S. muelleri* was the dominant species caught in TBS method 1. Two rats escaped when taken from the bubu, so the species could not be analyzed.

Table 1. The value of the plant damage score is based on the affected bunches

Attack category	Scale of attack (oil palm fruit)	Score
No attack	0	0
Light	1 – 5	1
Medium	5 – 15	2
Heavy	> 15	3

Table 2. Number of rats caught in TBS method 1 for 10 weeks with 2 *bubu* per TBS

Block	Treatment	Repetition 1	Repetition 2	Repetition 3	Average
	P1	12	3	7	7.33 a
A06	P2	8	3	13	8.00 a
	P3	4	5	1	3.33 a
	P1	3	3	12	6.00 a
A07	P2	4	6	15	8.33 a
	P3	3	2	1	2.00 a
	P1	23	4	6	11.00 a
A08	P2	6	7	8	7.00 a
	P3	4	10	0	4.67 a
Average		7.44	4.78	7.00	6.41

Note: P1 (were rice crops without additional bait in *bubu*), P2 (rice crops plus salted fish bait in *bubu*), and P3 (rice crops plus roasted coconut ait in *bubu*). Numbers followed by the same letter indicate they are not significantly different based on the honest significant difference test (Tukey's) at the α=5% level

The number of rats (total from 9 TBS) caught between species in block A06 was 38 rats (*S. muelleri*), 11 rats (*R. Tanezumi*), and 6 rats (*R. tiomanicus*), respectively. The data was then analyzed for variance using a randomized block design, showing a real difference to meet the tukey test requirements at the α=5% level. The dominant species in block 6 is *S. muelleri*, significantly different from the other two species. Tukey's test also showed no differences between *R. tanezumi* and *R. tiomanicus* species. Observations in block A07 found 27 *S. muelleri*, 11 *R. tiomanicus*, and 11 *R. tanezumi*. Based on the number of rats caught in block A07, the *S. muelleri* is the rat that has the highest number of catches. However, variance analysis showed no real differences between the species caught, so the tukey test could not be continued. Based on data obtained from block A08, it was found that the highest number of rats caught was in the rat species *R. tanezumi* (30 individuals) and *S. muelleri* (30 individuals); the lowest was *R. tiomanicus* (seven individuals). Based on the randomized block design analysis, ANOVA results showed no significant differences between species. Testing was only carried out up to the ANOVA that did not meet the advanced requirements (Tukey Test). Due to the dominant and endemic species in that location, the *S. muelleri* species in the three blocks showed more catches than others. This is supported by the statement by Cranbrook et al. (2014) that *S. muelleri* is the dominant rat in Borneo and Sumatra.

Trap barrier system method 2

The second method of TBS was carried out after observing the first method's results. The second method used nine treatments with three replications (blocks A06, A07, and A08). Observations on TBS method 2 were carried out for eight weeks, and the catch ratio for TBS method 2 is 1.05 rats per day. The catch ratio is obtained from the number of rats caught divided by the number of days the trap was carried out.

Comparison of the number of catches between blocks and treatments

Rat catches in TBS method 2 in each treatment showed varying results (Table 4). The highest total catch was in treatment 3, with 12 rats. The data was then analyzed for variance using a randomized block design. The results of the analysis showed that there were no real differences in each treatment. The non-significant differences in catches for each treatment indicate that the rats entered the TBS not based on the bait in the bubu but randomly.

Number of catches between species in TBS method 2

There were four different species of rats caught in this study, namely *S. muelleri* (35), *R. tanezumi* (20), *R. tiomanicus* (three), and one shrew (*Suncus murinus*) (Table 5).

Table 3. Average of rats caught from 9 treatments between species in the three observation blocks of TBS method 1

Species	Block A06	Block A07	Block A08	Average
Sundamys muelleri	4.22 a	3.00 a	3.33 a	3.52 a
Rattus tanezumi	1.22 b	1.22 a	3.33 a	1.93 ab
Rattus tiomanicus	0.67 b	1.22 a	0.78 a	0.89 b
Average	2.04	1.81	2.48	2.11

Note: Numbers (in the same column) followed by the same letter indicate that they are not significantly different based on the tukey test at the α=5% level

Table 4. Number of rats caught in TBS method 2 for 8 weeks with 2 traps per TBS

Block	P1	P2	P3	P4	P5	P6	P7	P8	P9	Average
A06	1	4	5	3	1	1	1	4	0	2.22
A07	0	3	4	1	0	5	3	2	4	2.44
A08	0	0	3	3	6	0	3	1	1	1.89
Average	0.33 a	2.33 a	4 a	2.33 a	2.33 a	2 a	2.33 a	2.33 a	1.67 a	2.19

Note: P1 (rice crops only), P2 (grain bait only), P3 (no bait/empty), P4 (grain bait + salted fish bait), P5 (grain bait + roasted coconut bait), P6 (grain bait + oil palm fruit), P7 (salted fish bait only), P8 (roasted coconut bait only), dan P9 (oil palm fruit bait only). Numbers followed by the same letter indicate they are not significantly different based on the tukey test at the α=5% level

Table 5. Number of rats caught from 9 treatments between species in the three observation blocks of TBS method 2

Species	Block A06	Block A07	Block A08	Average
Sundamys muelleri	1.56 a	1.89 a	0.44 a	1.30 a
Rattus tiomanicus	0.11 b	0.11 b	0.11 a	0.11 b
Rattus tanezumi	0.56 ab	0.44 b	1.22 a	0.74 ab
Suncus murinus	0 b	0 b	0.11 a	0.08 b
Average	0.74	0.81	0.47	0.74

Note: Numbers (in the same column) followed by the same letter indicate that they are not significantly different from based on the tukey test at the α=5% level

The number of rats (total from 9 treatments) caught by species in block A06 was dominated by the *S. muelleri* species (14 individuals), then there was *R. tanezumi* (five individuals) and *R. tiomanicus* (one individual). The ANOVA results show a significant difference so that it meets the requirements for the Tukey test at the α=5% level. The number of *S. muelleri* rats caught showed a significant difference from the *R. tiomanicus* species but was not significantly different from *R. tanezumi*. The same species as block A06 were found in block A07, namely *S. muelleri* (17 individuals), *R. tiomanicus* (1 individuals), and *R. tanezumi* (4 individuals). The analysis shows significant differences in the *S. muelleri* species against the *R. tiomanicus* and *R. tanezumi* species, but the two last species were not significantly different. Based on the number of catches in block A08, it shows that the highest number of rat caught was *R. tanezumi* (11 individuals), then *S. muelleri* (four individuals), *R. tiomanicus* (one individual), and *S. murinus* (one individual of shrew). Analysis of variance showed that there were no significant differences between species caught. The test was only carried out until Anova because it did not meet the requirements for continuation (tukey test). These data show that the number of catches of the *S. muelleri* species is the highest compared to other species. This proves that *S. muelleri* is the dominant species in that place.

The extent and intensity of attacks, as well as yield losses due to rat attacks

Observations of the area and intensity of attacks, as well as yield losses due to rat attacks on oil palm plantations, were carried out by observing five diagonal rows in each block (Table 6). Oil palm plantations that fall in the observation row and plants that do not have fruit are not counted in the calculation. This happens because the plants do not represent the observed attacks from rats.

The average attack area increased in block A05 (without TBS treatment) and block A07, namely 3,78% in blok A05 and 5,68% in block A07, while in block A06 and block A08, it decreased drastically, namely 49.77% in block A06and 36.01% in block A08. This is due to the smaller number of catches in block A07 compared to other treatment blocks. Thus, the rat population attacking oil palm fruits in the field is higher in blocks without TBS treatment. The highest increase in attack area observed in blok A05 proves that blocks without TBS treatment can potentially cause an increase in the attack area.

The average attack intensity in the initial observation census showed no significant differences. However, the final observation census indicated a significant difference between Block A06 (0.66%) and Block A07 (2.22%), while the other two blocks showed no significant differences. The average attack intensity in each block with TBS treatment decreased from the initial to final census by 54.16% in block A06, 3.05 % in block A07, and 42.78% in block A08, while in block A05 (without TBS treatment), it showed an increase of 7,51% (Table 7). This shows that TBS effectively controls the intensity of attacks from rats in the field, as the block with TBS treatment experienced a decrease in the attack intensity on oil palm fruit bunches.

Based on the data on the area and intensity of the attack above, yield loss on oil palm fruit is obtained by multiplying the area of attack by the intensity of the attack and then multiplying by 100%. Based on the obtained data, the average yield loss in block A06 and block A08 decreased in percentage from the initial to the final census by 78.12% in block A06 and 64.93% in block A08. An increase in yield loss was observed in block A05 (without TBS treatment) and block A07, with an increase of 9.75% in block A05 and 1.51% in block A07. This shows that TBS treatment can reduce yield losses caused by rats in oil palm plantations (Table 8).

Table 6. Area of attack (%) of oil palm plants due to rat attacks

Census point	Initial				Final			
	Block A05	Block A06	Block A07	Block A08	Block A05	Block A06	Block A07	Block A08
1	38.2	24.3	4.76	29.7	23.5	10.3	22.5	23.7
2	13.9	23.1	9.62	9.8	35.1	5.88	34	29.8
3	15.8	23.1	46.2	34.8	17.1	10.2	16	15.9
4	22.2	21.3	46	50	20	14.3	35.4	10
5	24.2	18.8	34.6	-	23.3	14.6	41.7	-
Average	22.9 a	22.1 a	28.2 a	31.1 a	23.8 xy	11.1 y	29.9 x	19.9 xy

Note: Numbers (initial and final rows) followed by the same letter are not significantly different based on the tukey test at the α=5% level

Table 7. Intensity of attacks (%) on oil palm plants due to rat attacks

Census point	Initial				Final			
	Block A05	Block A06	Block A07	Block A08	Block A05	Block A06	Block A07	Block A08
1	2.87	1.29	0.20	1.40	1.82	0.76	1.53	1.09
2	0.59	1.81	0.59	0.52	2.00	0.30	2.55	2.07
3	0.62	1.32	3.49	3.01	1.03	0.44	0.96	0.89
4	1.21	1.64	4.19	3.09	1.83	1.02	2.43	0.54
5	2.71	1.13	2.96	-	1.96	0.78	3.63	-
Average	1.60 a	1.44 a	2.29 a	2.01 a	1.73 xy	0.66 y	2.22 x	1.15 xy

Note: Numbers (initial and final rows) followed by the same letter are not significantly different based on the tukey test at the α=5% level

Table 8. Yield loss (%) of oil palm plants due to rat attacks

Census point	Initial				Final			
	Block A05	Block A06	Block A07	Block A08	Block A05	Block A06	Block A07	Block A08
1	1.10	0.31	0.01	0.42	0.43	0.08	0.34	0.26
2	0.08	0.42	0.06	0.05	0.70	0.02	0.87	0.62
3	0.10	0.30	1.61	1.05	0.18	0.04	0.15	0.14
4	0.27	0.35	1.93	1.55	0.37	0.15	0.86	0.05
5	0.66	0.21	1.02	-	0.46	0.11	1.51	-
Average	0.37 a	0.32 a	0.65 a	0.77 a	0.41 xy	0.07 y	0.66 x	0.27 xy

Note: Numbers (initial and final rows) followed by the same letter are not significantly different based on the tukey test at the α=5% level

Conclusively, rat capture in TBS method 1 showed no significant differences. TBS on the edge had a higher catch due to rats' migration from outside the treatment plot areas; the number of catches in TBS method 1 was 2.47 rats per day. The rat caught in TBS method 2 showed no significant differences in each treatment, so it is assumed that the rat entered the TBS not based on the bait in the *bubu* but more randomly. The number of TBS method 2 catches was 1.05 rats per day. In both methods of TBS, the species *S. muelleri*, *R. tanezumi*, *R. tiomanicus*, and *S. murinus* were found. The species *S. muelleri* dominates in both methods of TBS. The low catch in block A07 causes a higher attack area than in other blocks. The intensity of attacks decreased in all treatment blocks, indicating that TBS effectively controlled rats. Therefore, TBS treatment can reduce yield losses caused by rats in oil palm plantations.

ACKNOWLEDGEMENTS

This project is part of the first author's master's thesis research, supported by the Indonesia Endowment Funds for Education (LPDP). The Authors would like to thank PT SWP (Steelindo Wahana Perkasa) and PT AARI (Applied Agricultural Resources Indonesia) for helping and providing needs during the research.

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