Study on Trap Barrier System Towards Rodent Population and Rice Production in Tidal-Area of South Sumatera Indonesia

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Study on Trap Barrier System Towards Rodent Population and Rice Production in Tidal-Area of South Sumatera Indonesia

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ABSTRACT

Rice cultivation in tidal area faces many obstacles. Rodent is one of important pests attacking rice both in vegetative and generative phases. The objectives of this research were to study the rat species and population, footprints, symptoms and level of rice damage and rice production by Trap Barrier System (TBS). The study was conducted in Jalur 6 of Muara Telang Banyuasin district, South Sumatera, 2016-2017. The research was carried out in two hectares of rice field with one hectare TBS and one-hectare non-TBS. Observation of rat population was done three times, during vegetative stage (30 days after planting/dap), reproductive stage (65 daps) and ripening stage (100 daps). One species of rats had been found namely *Rattus argentiventer*. In non-TBS, rat population was lower. However, in the damage level, the rat population was higher than in TBS. The number of *R. argentiventer* male captured was more extensive than the female. The number of footprints did not represent the number of rodents caught. The existence of rat footprints was indicating the existence of rat effort to approach the rice plant. The yield of rice was higher in TBS area.

INTRODUCTION

Rice is a strategic food commodity in many countries used as staple food. In South Sumatera, rice is cultivated mostly in a tidal area. Banyuasin district is one of the centers of rice production of South Sumatra with tidal area width is 266,674 ha, and this represents 34.28 % of all agricultural land in South Sumatera. Production of rice was 840.9 t in the year of 2016 or equivalent to 30 % of rice production in South Sumatra. Rice productivity level was 4.8 t ha^{-1}, slightly lower than the provincial productivity of 5 t ha^{-1} (Adam, Marwa, Husni Thamrin, & Bashir, 2017; Nisma, Sriati, Najib, & Maryadi, 2017). Based on the observations, in Banyuasin tidal areas, most rice cultivations are planted once a year due to limited water supply, where during the second growing season (February-May) water supplies usually begin to decline. Planting in the first season is started in November or December and harvested in January or February. In general, farmers do not cultivate rice in the second season. As a result, the land is overgrown by weeds.

Beside the degradation of the water supply, there are some constraints affecting productivity, one of them is pest disturbance. In Malaysia, rodents have caused yield losses of 5 %, while in Indonesia, 15-17% of the total planted area is estimated to be damaged annually (Singleton, 2003). In a tidal area, the rice field rat *Rattus argentiventer* usually do not attack in the first season, because the stock of water is available from rain and tide. On the other hand, during the second season, farmers, in general, do not cultivate the land. The effort to plant in the second season is an extraordinary business because farmers prefer to leave their land without any crop.

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R. argentiventer lives in paddy fields and its surrounding areas and can breed rapidly. They are more active at night for finding food, looking for mates and covering the region as well. To avoid hostile environments, rats usually make nests in humid areas, close to water and food sources such as the sidelines of stones, irrigation, dams, and small hills. The damage caused by rodent pests can be recognized on the cut rice rods (form 45o) and have the remaining trunk parts that are not cut off. In the vegetative phase of paddy, rats can damage 11-176 stems per night. While at pregnancy, their destruction ability increases to 24-246 rice stalks per night (Aplin, Brown, Jacob, Krebs, & Singleton, 2003; Sarwar, 2015).

Like a rodent, in fulfilling their life, rats need to cut off the rice stem with a ratio of 5:1, in which 5 rods of rice are caught only to sharpen their teeth to keep it short, and 1 rod is eaten for the necessities of life. The attack on the rice plant is found on the trunk of tillers which is cut off. The magnitude of losses caused by rats is determined by the number of tillers failing to produce panicles at harvest time. Rodents attack rice plants in all period of paddy, from the beginning stage of rice until harvesting. The problem of rat must be solved in many techniques such as non-toxic rodent control method (Roomaney, Ehrlich, & Rother, 2012), cultural practices, burrow fumigation and poison baiting (Mulungu S, Lopa, & Mdangi, 2016; Rani, Rao, & Suryanaryana, 2014) and Ecological Based Rats Management (EBRM) (Jacob et al., 2010). Kabir & Hossain (2014) studied the trap barrier system (TBS) with time-varying treatment which resulted in the conclusion that treatment 30 days before planting would significantly lower attack rate compared with planting after 60 days. Singleton, Belmain, Brown, Aplin, & Htwe (2010) reported integrated management system actions in irrigated lowland areas including monitoring of rice crop damage, sanitation, plastic fencing in nurseries, bait traps, and trap barrier systems (TBS) installations. However, observation of rat footprint as a marker of the population is rarely conducted. The objectives of this research were studying rat species and populations with the installation of TBS, footprint rodent as an indicator of rat presence, damage symptoms and rice production

MATERIALS AND METHODS

The study was conducted at Jalur 6 of Sumber Mulya Village, Muara Telang Subdistrict Banyuasin South Sumatera (02°34′30″S, 104°53′16″E), from February 2016 until May 2017. The study area was laid on two hectares of rice field in which the one-hectare allocation of TBS and one hectare of non-TBS. TBS installation was begun at planting time.

Preparation of Rice Cultivation

Three varieties of rice namely Ciherang (V_1), Inpara 4 (V_2), and Inpari 22 (V_3) were chosen. Planting area of 1 hectare was divided into 6 sub-blocks where the treatment of varieties and direct stocking and seeding planting were as following: Integrated Crop Management (ICM) + drum seeding (DS) + variety 1 (V_1), ICM + drum seeding (DS) + variety 2 (V_2), ICM + drum seeding (DS) + variety 3 (V_3), ICM + broadcast seeding (BS) + variety 1 (V_1), ICM + broadcast seeding (BS) + variety 2 (V_2), ICM + broadcast seeding (BS) + variety 3 (V_3). This area was covered by TBS. Another 1 hectar of Ciherang variety was cultivated as farmer's practice. TBS was uninstalled in this area.

Preparation and Installation of TBS

In its application, TBS plot was surrounded by a 50 cm wide trench filled with water to prevent the rat from digging or perforating plastic fences. To keep the plastic thoroughly stand, bamboo was staked to support the fence and string or wire to erect the barrier. Plastic was buried 10 cm into the ground, and have fence 50 cm above ground. An encircling moat was constructed by digging or widened existing channels. Earth mounds were constructed partway across the moat leading to multiple capture traps. This trap was installed along the inside of the fence to catch the rats.

Observation of Rat Population

Observation of rat population was done three times, i.e. vegetative stage (30 days after planting/dap), reproductive stage (65 dap) and maturing stage (100 dap). In TBS, there were ten units of doors, and in each door, a live captured trap was installed inside of the rice field (Fig. 1.). Observation of the caught rodent was conducted 24 hours after installation. Trap mounting was done for three days in a row. The caught rodents were identified with sex, body weight and body length, the number of nipples (Aplin, Brown, Jacob, Krebs, & Singleton, 2003; Chaval, 2011).

Observation of Rat Footprints

The wooden bridge (5 cm length and 10 cm width) was installed between the land across the paddy field and the TBS paddock at the trap door. The bridge was a way in which the rat entering the trap located in the paddy field. The wood was smeared with thin mud as a marker when the rat passed through. The installation was done in the afternoon, and the rat footprints were observed in the morning of the following day. The number of rat footprints present was calculated and documented.

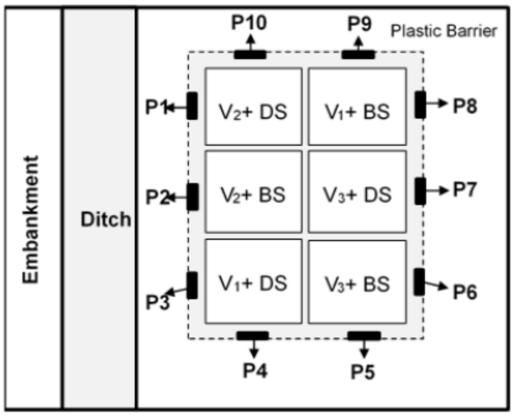

Fig. 1. The layout of observation of rodent in TBS installed area (February-May 2016) in Banyuasin District South Sumatera

Observation of Damage to Paddy Crops and Production of Rice

Symptoms of rat attack in the base of truncated rice stems were observed in three stages of rice. One ha of rice field was divided into 5 sub-blocks (@ 20 m x 100 m). In each sub-block was chosen 5 spots of observation with the size 1 m x 1 m. The number of attacked and healthy tillers were counted. The percentage rate of rice damage was the number of attacked tillers divided by total number of tillers multiplied by 100 %. Rice production was calculated in the end of rice cultivation.

Data Analysis

Data of, footprint number and yield of rice were descriptively analyzed, while data rat captured and percentage of damage was analyzed by Chi square-test.

RESULTS AND DISCUSSION

Rat Species and Population Captured

Observations were conducted in the second rice season (February–May) of 2016 and 2017. We found one species of rat, namely rice-field rats *Rattus argentiventer* (Rodentia: Murinae). The morphological characteristic of that species was identified using Aplin, Brown, Jacob, Krebs, & Singleton (2003) and Chaval (2011).

Table 1. Characteristic morphology of rodents captured during observation in second rice season (February-May 2016) and (February-May 2017) in TBS and non-TBS rice cultivation in tidal area Banyuasin District South Sumatera

Characteristic	Rattus argentiventer (n=24)		
	Average	Std. Dev	Range
Total (cm)	31.1	3.2	25.2 - 35.4
Head and Body (cm)	15.8	1.8	12.6 -18.5
Tail (cm)	15.4	1.5	12.6 -18.0
Foot (cm)	3.5	0.2	3.1 - 4.0
Ear (cm)	2.1	1.0	1.6 - 2.2
Head (cm)	4.6	0.5	3.8 - 5.8
Weight (g)	128.5	40.2	60 - 210

Rice-field rat *R. argentiventer* was a medium-sized, average of body weight in this study is 128.5 g. Their fur was orange-brown dorsal flecked with black without spines. The belly varied from silvery-white to a dull grey. Their tail was dark brown, mono-color equal to or slightly shorter than the length of head and body. Their ears were large with a distinct orange fringe of fur usually presents just forward of the ear. The hind foot was white-grey above, and its mammal pattern was 1+2+3 (Aplin, Brown, Jacob, Krebs, & Singleton, 2003; Chaval, 2011).

Morphological characteristics of *Rattus argentiventer* was shown in Table 1. The gender of rodents captured in February-May 2016 showed male was higher than that in February-May 2017 (Table 2) due to the different situation of the neighbourhood. It had a significant difference according to statistical analysis (Chi-square value: 4.03, P value: 0.04). In 2017, some of closer land neighbours were rice cultivation whereas in 2016 no neighbour land was cultivated. It means when most rats need some foods for life, they just found themselves in the rice-cultivated area. Usually, in this period of a year, farmers do not want to cultivate their land due to water limitation. In this conditions, in an insufficient food source, rodents invaded the rice cultivation at all stages. It was similar to the statement of Chaval (2011) that rats are smart survivor animals. In their live, rats divide their roles. Females are in their burrow with their offspring and males look for food. There was no doubt that number of *R. argentiventer* male was larger than the number of female in 2016 and 2017. This phenomenon showed female has its tasks as a food collector and give it to her offspring.

Table 2. Species and number of rodents captured in tidal area in rice cultivation in Muara Telang, Banyuasin District, South Sumatera

Duration	Number of *R. argentiventer* captured		Total
	Male	Female	
February - May 2016	76	65	141
February - May 2017	47	21	68
Total	123 a	86 b	

Remarks: Number in the same raw followed by different character was significant different (Chi-square value = 4.03, P value = 0.04)

Table 3. Species and number of rodents captured TBS and non-TBS rice cultivation tidal area in Muara Telang, Banyuasin District, South Sumatera

Duration	Number of *R. argentiventer* captured		Total
	TBS	Non-TBS	
February - May 2016	91	50	141a
February - May 2017	59	19	68 b

Remarks: Number in the same column followed by different character was significant different (Chi-square value: 2.87, P value: 0.09)

Observations on the number of rats caught on TBS and non-TBS for two years (2016 and 2017) showed that the number of mice caught on TBS was higher than in non-TBS. Statistical analyses showed that there was a significant difference between the year of observation (Chi-square value: 2.87, P value: 0.09) (Table 3). It happens because the TBS mounting traps are followed by the installation of wooden bridges smeared with mud, causing rats such as getting a path to enter into the door or hole created and finally stuck into the trap. While in the trap installation on non-TBS method, it was estimated that rats enter randomly and when they realized that there was a trap, the other rats will feel deterrent and did not visit that place again. Such rat behaviour indicated that they were smart animals and could save themselves by avoiding traps. It is also stated by IRRI (2016) that the behaviour of rats was strongly influenced by the level of animal intelligence and instincts.

In capturing rats in the second season both in 2016 and 2017, it was noticed in the ripening stage, the number of rodents caught was the highest. Rats came to the rice field to find food usually choose the most suitable rice stage to fulfil the needs. At ripening stages, the rice plants provided the rice grain that has begun to contain much carbohydrate. In general, rodents prefer high carbohydrate content produced in the ripening stage compared to vegetative and reproductive ones. Young grain of rice was thought to be one of the pullers for the rodent to visit rice cultivation. It is in line with the opinion of Aplin, Brown, Jacob, Krebs, & Singleton (2003) which state on the grain of rice has a carbohydrate content favoured by rats. In the ripening, the number of rats caught the highest both in 2016 and 2017, i.e. 52 and 25 individuals respectively. The lowest number of catch in the vegetative stages was 13 and 11 individuals, in 2016 and 2017, respectively. The results were presented in Fig. 2.

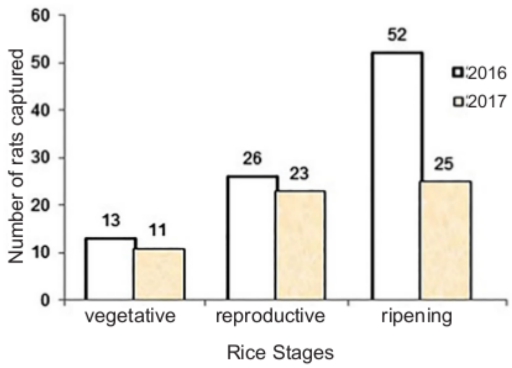

Fig. 2. Number of rats captured in rice field installed-TBS in the second season (February-May) 2016 and 2017 in tidal area Muara Telang, Banyu Asin district South Sumatera

Footprints of Rats

Footprints of rats were observed on wooden bridge smeared with thin mud. Rat footprints were observed in mud deliberately spread over bridges stretching from embankment to the trap door. In the following day, the footprints were carefully observed. Supposed that on the day of trap installation was raining, it was expected no rat footprint was found on the following day. As a result, the treatment should be repeated.

The existence of rat footprints was indicating the existence of rat effort to approach the rice plant. Even though it was not so clear, the size of footprints was visible and indicated the track of different age of rats visiting. It meant that the size or age of rats that enter the trap was not necessarily similar. The size of rat *R. argentiventer* footprint was also varied.

The number of footprints in TBS field showed at the reproductive stage, the number of footprints was the highest compared with other rice stages. From this available data (Fig. 3B) it is shown although footprints were abundant, it did not mean the highest number of captured rat. It is assumed that rats were walking toward the entrance of the trap, but they went backwards. The difficulty in counting the number of footprints comes from the fact that they were piled up. Therefore the observations should be made more thoroughly. The number of rat footprints does not merely describe the number of rats caught, but rather indicates the number of rats that are in place to get the food. Every footprint found must be interpreted by trained expert (Yuan, Russell, Klette, Rosenhahn, & Stones-Havas, 2005). Sometimes, rats walked around TBS fence to ensure whether the situation is safe or not. Brown, Leung, Sudarmaji, & Singleton (2003) also explained no rats would enter the trap after one rat has been captured.

The rodents footprints obtained on each trap varied and were highly dependent on the location. Most footprints were found in traps number two (P2), especially during reproductive and ripening stages, followed by trap number 1 (P1) and number 3 (P3) (Fig. 3A). It was allegedly because their positions were close to the embankment which served as a road. It was in line with the Aplin, Brown, Jacob, Krebs, & Singleton (2003) that the trap position close to the embankment usually result in capturing rodents, since rodent use this road across the fields to pass. The existence of a bridge connecting rice field with TBS and embankment became one of the ways of rodents to enter the TBS area.

In Fig. 3B, at the reproductive stage, the number of rat footprints was the largest (122.3), but the rodent captured was only 26 individuals. On the contrary, at the ripening stage number of the footprints was 108.5, but the captured rodents were the most abundant (52 individuals) (Table 1). It indicated the number of footprints did not represent the number of rodents captured. Hasler, Klette, Rosenhahn, and & Agnew (2004) also mentioned that footprints of rats might not indicate the number of captures.

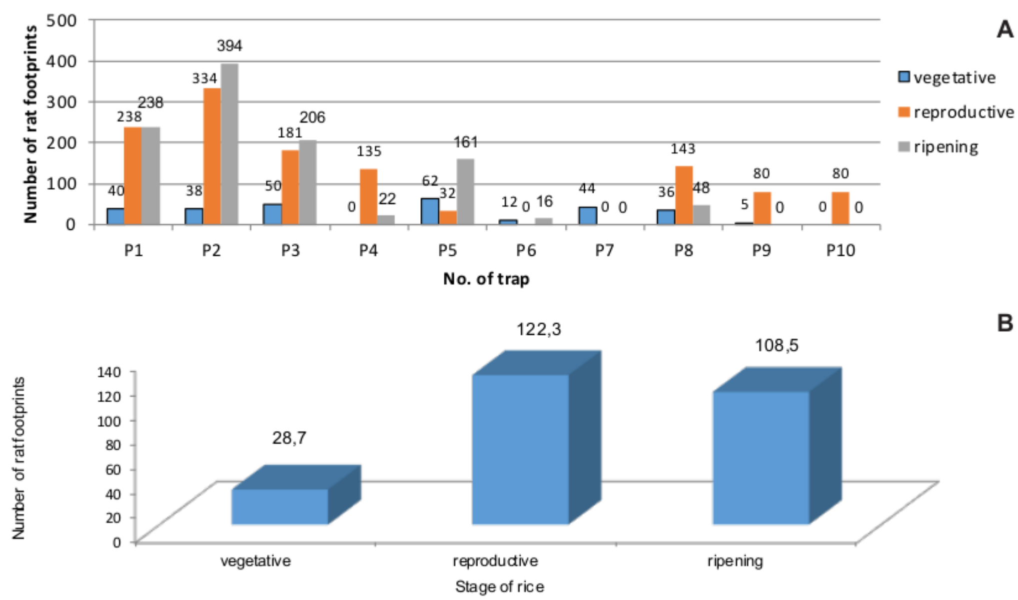

Fig. 3. Number of rat footprints in rice field installed-TBS at second season (February-May 2016) in tidal area Muara Telang, Banyuasin district, South Sumatera (A: footprints found in a single trap; B: footprints accumulated in every stage of rice)

The Symptom of Damage and Production of Rice

The damage of rice plants caused by rats was visible both in the vegetative and the reproductive stages. It was shown in the reproductive stage, after rats cutting the rice grain, the grain will fell on the ground surrounding the rice plant. In the vegetative stage, rats cut off the rice stalk. As a consequence the plant will collapse. Although Aplin, Brown, Jacob, Krebs, & Singleton (2003) said that one of the characteristics of a rat attack was by cutting with a 45-degree angle, sometimes it was found the damage symptom of rice was totally collapse.

Damaged level of rice was observed in the year 2017. All stages of rice both in TBS and non-TBS area indicated rat attack. The levels of damage in vegetative, reproductive and ripening stages in TBS area were 5.1; 4.0 and 7.2 %, while in non-TBS area were 13.2, 19.8, and 22.0 respectively (Fig. 4). Comparing damage level in TBS and non-TBS in the year 2016, it was not statistically different between vegetative, reproductive and ripening stages in TBS and non-TBS (Chi square value = 0.79, P=0.67). In a non-TBS area, there was a tendency that the level of damage was higher than that in TBS, because the area of non-TBS was not installed with a plastic fence. As a result, rodents were freely entering a non-TBS area. Focusing on captured rodents, in TBS area was higher (59 individuals) while in non-TBS was 19 individual. It indicated rats attack in the non-TBS area was not all captured by the live-captured trap.

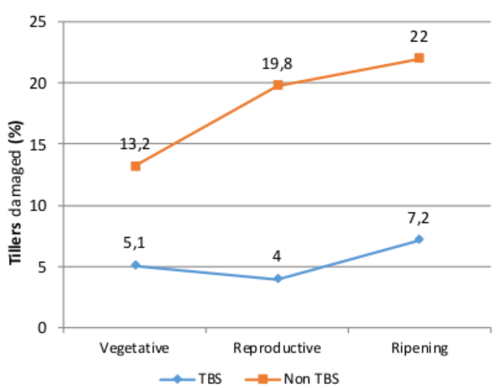

Fig. 4. Level of rice tillers damaged by rodents in various rice stages observed at TBS and Non TBS area rice cultivation in Tidal Area Banyuasin District South Sumatera in the second season (year 2017)

Rice production during the second planting season of 2016 (February-May 2016) in TBS and non-TBS showed results of 2.720 t ha^{-1} and 2.795 t ha^{-1}, respectively. This different production was not due only to the presence of rodent attacks, but also another rice pest and diseases, whereas, in 2017 rice production was higher in TBS than that in non-TBS. It was probably due to that TBS system can reduce the attack of rats entering into the fields so the production remained high. However, this production was considered to be low because the Inpari 31 variety has production potential of 6 t ha^{-1} (Ngurah Arya, Mahaputra, & Suharyanto, 2017).

Focusing on the use of TBS for controlling rodents, interesting data was found. In the first season of 2016 yield data obtained was 5.625 t ha^{-1} while in the second season was only 2.720 t ha^{-1}. Likewise in 2017, the yield of the first season reached 3.945 t ha^{-1} while in the second season reached 2.842 t ha^{-1} (Table 4). In the first season, the tidal fields were mostly planted, because it was the beginning of the rainy season and water stock was abundant from the tidal river. At that time because of the extent of rice cultivation, the pest population is melting or spreading across a wide area. The damage of rice caused by the pest and diseases were spreading evenly, so the loss of production decreased. It was similar to the rat pests' case. The observations result showed there was no attack of rats. At that time the water was inundated high enough and leading to the impact of the absence of rat populations. It was also revealed in the first season with the width of acreage opened for rice fields will cause no concentration of pest attack

Table 4. Species and number of rodents captured TBS and non-TBS rice cultivation tidal area in Muara Telang, Banyuasin District, South Sumatera

Year (Second season)	Yield (t ha^{-1}) TBS	Non-TBS
2016	2.720	2.795
2017	2.842	2.016

Remarks: Number in the same column followed by different character was significant different (Chi-square value: 2.87, P value: 0.09)

CONCLUSION AND SUGGESTION

Observation of rats by TBS in tidal area found one species of rodents namely *Rattus argentiventer* (Rodentia:Murinae). The number of rodent population was more significant in TBS, but the percentage of rice damage was lower. TBS integrated with monitoring was very useful to control rodent in tidal area. The number of footprints did not represent the number of rodents captured. The yield of rice in the second season was lower than that in the first season. It was suggested that installing TBS reduces rat's attack.

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