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STUDY ON TRAP BARRIER SYSTEM TOWARDS RODENT POPULATION AND RICE PRODUCTION IN TIDAL AREA SOUTH SUMATERA INDONESIA

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ABSTRACT

Rice is a strategic food commodity in many countries used as staple food. In South Sumatera, rice was cultivated mostly in tidal area. One of the most important pests is rice field rats, *Rattus argentiventer*. The objectives of research were to study species and rat population, rat 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. Research were located in two hectares of rice field in which one hectare TBS and one hectare non-TBS. Observation of rat population was done 3 times, i.e. vegetative stage (30 days after planting/dap), vegetative stage (65 dap) and ripening stage (100 dap). Observation resulted two species of rats, namely *R. argentiventer* and *Suncus murinus.* In non-TBS, rat population was lower, however damage level was higher than thus in TBS. Number of *R. argentiventer* male captured was higher than female, whereas all *S. murinus* captured was female. Number of footprints did not represent number of rodent capture. 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.

KEY WORDS : Lowland, Pest, Paddy, Rats, Physical control

INTRODUCTION

Rice is a strategic food commodity in many countries used as staple food. In South Sumatera, rice was cultivated mostly in tidal area. Banyuasin district is one of the center 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 123,1803 tons in the year of 2015 or equivalent to 30% of rice production in South Sumatra. Rice productivity level was 4.8 tons/ha, slightly lower than provincial productivity of 5 tons/ha (BPS SS, 2015). In Banyuasin tidal areas, most rice cultivation 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/December and harvested in January/February. In general, farmers do not cultivate rice in the second seasons, as a result, the land is overgrown by weeds. There are some constraints affecting productivity, one of them is pest disturbance. In Malaysia, rodents species has caused yield losses of 6−11%. In Indonesia, an estimated 17% of the total planted area is estimated to be damaged annually (IRRI, 2016). In tidal area, the rice field rat *Rattus argentiventer* usually do not attack in the first season, because stock of water is available from rain and tide. In the other hand, during the second season, farmers in general do not cultivate thus land. The effort to plant in the second season is a very special business because farmers prefer to leave their land without any crop.

R. argentiventer live in paddy fields and its surrounding areas and have the ability to breed rapidly. They are more active at night finding food, looking for couples and covering the region as well. To avoid from unfavorable environments, rats usually make nests in humid areas, close to water and food sources such as the sidelines of stones, irrigation, embankments, and small hills. The damage caused by rodent pests can be recognized on the cut rice rods (form 45^{o}) 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, they destruct ability increases to 24-246 rice stalks per night (Aplin et al, 2003, Sharwar, 2015).
As a rodent, in fulfilling their life rats need to cut off the rice stem with a ratio of 5: 1, in which 5 rods are caught just to sharpen their teeth to keep it short, and 1 stalk of rice is eaten for the necessities of life. The attack on the rice plant shows 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 stage of paddy, since rice is planted until harvesting. The problem of rat must be solved in many techniques such as non-toxic rodent control method (Roomaney et al, 2012), cultural practices, burrow fumigation and poison baiting (Mulungu et al, 2016; Rani et al, 2014) and Ecological Based Rats Management (EBRM) (Jacob *et al*. 2010). Kabir and Hossain (2014) studied trap barrier system (TBS) with time-varying treatment which resulted in the conclusion that prior planting 30 days earlier would significantly lower attack rate compared with planting after 60 days. Singleton *et al* (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 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 one hectare allocation of TBS and one hectare of non-TBS. TBS installation was begun at planting time.

1. Preparation of rice cultivation

a. Rice grown by TBS system according to the rules determined by IRRI, that is by planting 3 varieties of rice in the form of Ciherang (V_1), Inpara 4*(V_2),* and Inpari 22 *(V_3)*. Area planting of 1 hectare was divided into 6 sub blocks where the treatment of varieties and direct stocking and seeding planting, as following: 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.

b. Farmer's practice (FP) (1 ha)

Farmer used Ciherang variety with broadcast seeding. TBS was uninstalled in this area.

2. Preparation and installation of TBS

In its application, TBS plot was surrounded by a 50 cm wide trench filled with water to prevent rat from digging or perforating plastic fences. In order to keep the plastic fence teak, a wooden then given buffer with a distance every 2 meters and immersed into the ground as deep as 50 cm. The land area of 1 ha was completely lined with plastic.

3. Observation of rat population was done 3 times, i.e. vegetative stage (30 days after planting/dap), vegetative stage (65 dap) and maturing stage (100 dap). In TBS, there were 10 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 after 24 hours installation. Trap mounting was done for 3 days in a row. The caught rodents were identified with gender, body weight and body length, number of nipples (Aplin *et al*., 2003; Chaval *et al*, 2011).

4. Observation of rat foot prints

The wooden bridge (5cm length and 10cm 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 foot prints was observed in the morning of the following day. Number of rat footprints present was calculated and well documented.

5. 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 (@ 20m x 100m). In each sub block was chosen 5 spots of observation with the size 1 m x 1m. Number of attacked and healthy tillers were counted. The percentage rate of rice damage was number of attacked tillers divided by total number of tillers multiplied by 100%. Rice production was calculated in the end of rice cultivation.

6. Data of rat captured footprint number and yield of rice were descriptively analyzed, while data

percentage of damage of was analyzed by t-test.

RESULTS AND DISCUSSION

1. **Species and rat population captured**

Observations was conducted in the second rice season (February - May 2016) and the second season (February - May 2017). We found 2 species of rats, namely rice-field rats *Rattus argentiventer* (Rodentia:Murinae) and Asian house Shrew *Suncus murinus* (Rodentia:Soricidae). The morphology characteristic of these species was identified using Aplin *et al*.(2003); Chaval *et al.* (2011).

2. **Species and rat population captured**

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Rice-field rats *R. argentiventer* was medium-sized rat, average of body weight was 128.5 g. Their fur was orange-brown dorsal flecked with black without spines. The belly varied from silvery-white to a dull grey in color. 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 present just forward of the ear. The hind foot was white-grey above and its mammal pattern was 1+2+3.

Asian house Shrew, *S. murinus*, In Indonesia was known as "tikus celurut". Body colored was uniform, gray bluish and brownish. The tail was flat, especially at the base, and shrinks to the tip, brown gray-black, with rare and rough hairs. Eventhough *S. murinus* belonged to Rodentia, they did not cut off plant. Their role was an insect eater. They have very unique behaviour. In a danger situation they released special bad smell, so their natural enemies will avoid them. The average weight of *S. murinus* was 42 g. Morphological characteristics of *R. argentiventer* and *S. murinus* were shown in Table 1. Number of rodents captured in February - May 2016 was higher than thus in February - May 2017 due to different situation of neighbourhood. In 2017, some of closer land neighbours were rice cultivation where as in 2016 no neighbour land was cultivated. It means when most rats need some foods for their life, they just found in the rice-cultivated area. Usually, farmer did not want to cultivate their land due to water limitation. In this conditions, in a very limited food source, rodents invaded the rice cultivation at all stages. It was similar to statement of Chaval (2011) that rats are smart animal to survive. In their live, rats divide their roles. Female were kept their burrow and children and male were looking for food. It was no doubt that number of *R. argentiventer* male was higher than female in both observation in the year 2016 and 2017, however *S. murinus* captured was all female. It might be different in their tasks. This phenomenon showed female has its tasks as a food collector and give it to her children (Table 2).

Observations on the number of rats caught on TBS and non-TBS for two years (2106 and 2017) showed that the number of mice caught on TBS was higher than in non-TBS (Table 3). This 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 to that place again. Such rat behavior indicated that they were smart animals and could save themselves by avoiding traps. It is also stated by IRRI (2016) that the behavior of rats was strongly influenced by the level of animal intelligence and instincts.

S. murinus found in non-TBS areas solely were small in number, i.e in found 7 and 2 individues in the year of 2016 and 2017, respectively. There were no *S. murinus* found in the TBS field. It is suspected that the rodents were not interested in the bridges made to fit into the traps laid in rice fields surrounded by TBS fences. It is in accordance with the behavior of S. murinus reported by Kawano (1992) that this species was not plant-eaters instead of insectivorous eaters. Thus, it was suspected that the presence of these rodents in non TBS rice was actually looking for food (insects) (Table 3.)

In capturing rats in the second season both in 2016 and 2017, it was clearly noticed in ripening stage, the number of rodents caught was the highest. Rats came to rice field to find food usually choose the most suitable rice stage to fulfill the needs. At ripening stages, the rice plants provided the rice grain that has begun to contain a lot of carbohydrate. In general, rodents prefer high carbohydrate content produced in ripening stage compared to vegetative and reproductive ones. Young grain of rice was thought to be one of the pullers for rodent to visit rice cultivation. This is in accordance with the opinion Aplin et al. (2003) which state on the grain of rice has a carbohydrate content favored by rats. In the ripening, the number of rats caught the highest both in 2016 and 2017, i.e 52 and 25 individues respectively. The lowest number of caught in the vegetative stages was 13 and 11 individues, respectively in 2016 and 2017. The results are presented in Figure 1.

3. Foot prints 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 at the day of installation trap was rain, it was expected no rat footprint found in the following day. As a result, the treatment should be repeated.

The existence of rat footprints was indicating the existence of an effort of rat to approach the rice plant. In the following figure (Fig.4), even though it was not so clear, the size footprints were visible and indicated the track of different age of rats visiting. This meant that the size or age of rats that enter the trap was not necessarily similar. The size of mouse footprints was also varies.

Number of footprints in TBS field showed at ripening stage the number of footprint was the highest compared with other rice stages. From this available data, it is shown although the number of footprints were abundant, it did not meant captured the highest number of rat. It is assumed that rats were walking toward the entrance of the trap, but they went backward. The difficulty in counting the number of foot prints was they were piled up in which the observations should be made more thoroughly. The same opinion about the footprints was expressed by Hasler *et a*l (2004), every footprints found must be interpreted by trained expert. Therefore, the number of mouse footprints does not merely describe the number of mice caught, but rather indicates the number of mice that are in place to get the food.

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) (Figure 4A). It was allegedly because their positions were closed to the embankment which served as a road. This was in line with the Aplin et al.(2003) that the trap position closed to the embankment usually resulting captured rodents, since rodent used this road across the fields to pass. The existence of a bridge connecting rice field with TBS and embankment became one of the way of rodents to enter the TBS area.

In Figure 4B, at the reproductive stage, number of rat footprints was the highest (122.3), however the rodent captured was 26 individues. On the contrary, at ripening stage number of the footprints was 108.5 but the captured rodents was the highest (52 individues) (Table 1). This indicated the number of footprints did not represent the number of rodent captured. Hasler et al (2014) also mentioned that footprints of rats might not indicate the number captured.

4. Symptom of Damage and Production of Rice

The damage of rice plants caused by rats was visible both in the vegetative and reproductive stages.It was showed in reproductive stage (Fig. 5A), after rats cutting the rice grain, the grain will fell down on the ground surrounding the rice plant. In the vegetative stage, rats cut off the rice stalk as consequences the plant will collapse. Although Aplin et al. (2003) said that one of the characteristics of a rat attack was by cutting with a 45-degree angle, but sometimes it was found the damage symptom of rice was totally collapse (Figure 5B).

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 (Figure 6). Comparing damage level in TBS and non TBS in the year 2016, it was found statistically different between vegetative, reproductive and ripening stages in TBS and non TBS. In non TBS area there was a tendency that level damage was higher than thus in TBS, because the area of non TBS did not install by plastic fence. As a result, rodents were freely entering non TBS area. Focusing on captured rodents, in TBS area was higher (59 individues) while in non TBS was captured 19 individues. This indicated rats attack in non TBS area was not all captured by live-captured trap.

Rice production during the second planting season of 2016 (February -May 2016) in TBS and non-TBS showed results of 2.720 ton/ha and 2.795 ton/ha, respectively. This different production was not only the presence of rodent attacks, but also another rice pest and diseases, whereas in 2017, rice production was higher in TBS than thus in non-TBS. This was probably due to the TBS system can reduce the attack of rats entering into the fields so the production remained high. However, this production was considered low because the Inpari 31 variety has production potential of 6 tons / ha (Balitpa, 2013).

Focusing in the use of TBS system for controlling rodents, interesting data was found. In the first season of 2016 yield data obtained was 5.625 ton/ha while in the second season was only 2.720 ton/ha. Likewise in 2017, the yield of first season reached 3.945 ton/ha while in the second season reached 2.842 ton/ha (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 was spreading evenly so the loss of production decreased. Thus was similar to rat pests case. The observations result showed there was no attack of rats. At that time the water was inundated high enough, leading on the impact of the absence of rat populations. It was also revealed by IRRI (2016) in the first season with the width of acreage opened for rice fields will cause no concentration of pest attack.

CONCLUSIONS AND SUGGESTION

Observatıon of rats by TBS in tidal area found two species of rodents namely *Rattus argentiventer* (Rodentia:Murinae) and *Suncus murinus* (Rodentia: Soricidae). Rodent population was higher in TBS however percentage of rice damage was lower. TBS integrated with monitoring was very useful to control rodent in tidal area. Number of footprints did not represent the number of rodent capture. Yield of rice in second season was lower than thus in first season. It was suggested to install TBS to reduce rat's attack.

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FIGURES AND TABLES

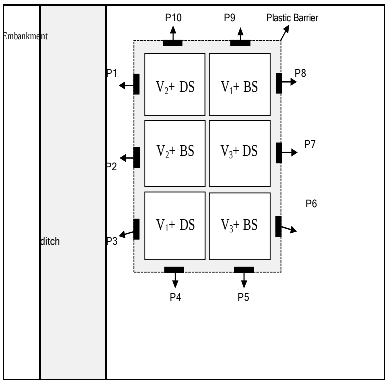

Figure 1. Layout of observation of rodent in TBS installed area (February-May 2016) in Banyuasin District South Sumatera

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)			*Suncus murinus* (n=4)		
	Average	Std. Dev	Range	Average	Std. Dev	Range
Total (cm)	31.1	3.2	25.2- 35.4	19.6	1.4	18.3 -19.2
Head and Body (cm)	15.8	1.8	12.6 -18.5	12.7	0.9	11.9 -12.6
Tail (cm)	15.4	1.5	12.6 -18.0	6.6	0.4	6.0 - 6.9
Foot (cm)	3.5	0.2	3.1 - 4.0	2.0	0.1	1.8 - 2.1
Ear (cm)	2.1	1.0	1.6 - 2.2	1.1	0.2	1.0 -1.9
Head (cm)	4.6	0.5	3.8 - 5.8	3.6	0.2	3.3-3.8
Weight (g)	128.5	40.2	60 - 210	42.0	8.1	40 - 50

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

Species	February - May 2016			February-May 2017		
	Sex		Total	Sex		Total
	Male	Female		Male	Female	
Rattus argentiventer	76	65	141	47	21	68
Suncus murinus	0	7	7	0	2	2
TOTAL	76	72	148	47	23	70

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

Species	February - May 2016			February-May 2017		
	TBS	Non TBS	Total	TBS	Non TBS	Total
Rattus argentiventer	91	50	141	59	19	68
Suncus murinus	0	7	7	0	2	2
TOTAL	91	57	148	59	21	70

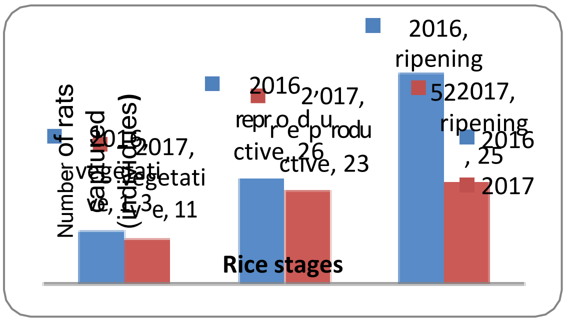

Figure 2.Number of rats captured in rice field installed-TBS in second season (February-May) 2016 and 2017 in tidal area Muara Telang, Banyu Asin district South Sumatera

Figure 3. Footprints of rat on wooden bridge smeared with thin mud

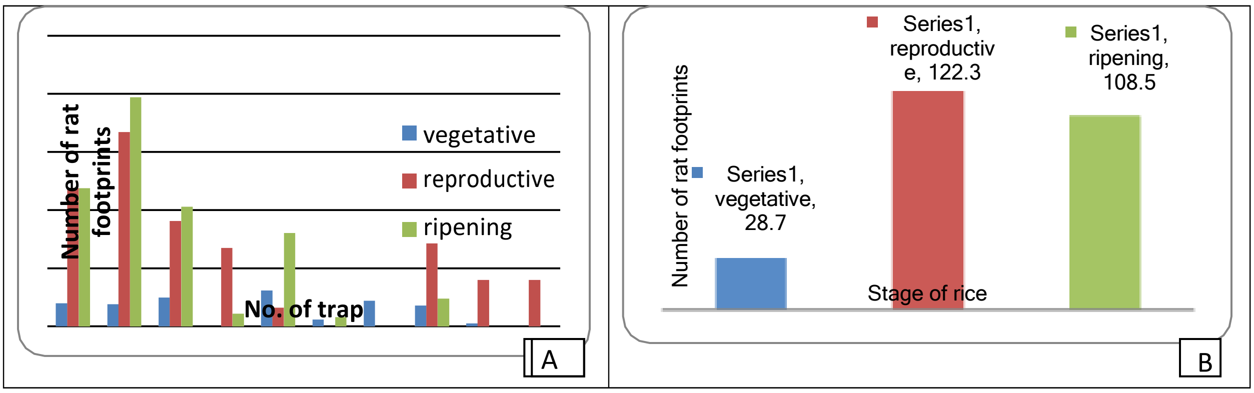

Figure 4. Number of rat footprints in rice field installed-TBS in second season (February-May 2016) in tidal area Muara Telang, Banyuasin district, South Sumatera

A : footprints found in a single trap

B : footprints accumulated in every stage of rice

A B

Figure 5. Damage symptom of rice consumed by rodents in vegetative stage (A) and reproductive stage (B)

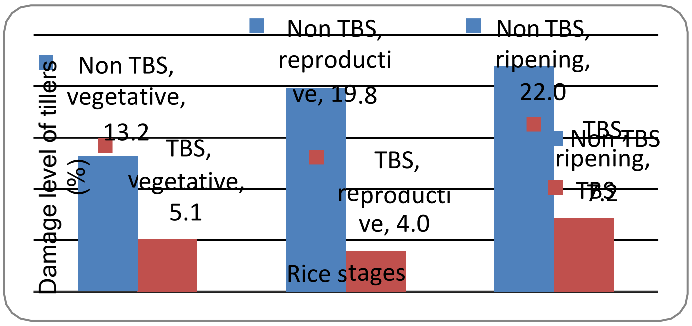

Figure 6. Level of rice tillers damaged by rodents in various rice stages observed in TBS and Non TBS area rice cultivation in Tidal Area Banyuasin District South Sumatera in second season (year 2017)

Table 4. Yield of rice in the year 2016 and 2017 at TBS and non TBS-installed rice cultivation in tidal area in Muara Telang, Banyuasin District, South Sumatera

Year (Second season)	Yield (ton/ha)	
	TBS	Non-TBS
2016	2.720	2.795
2017	2.842	2.016

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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.

Keywords: control; footprints; *Rattus argentiventer*; Trap Barrier System

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.

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 45^{o}) 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).

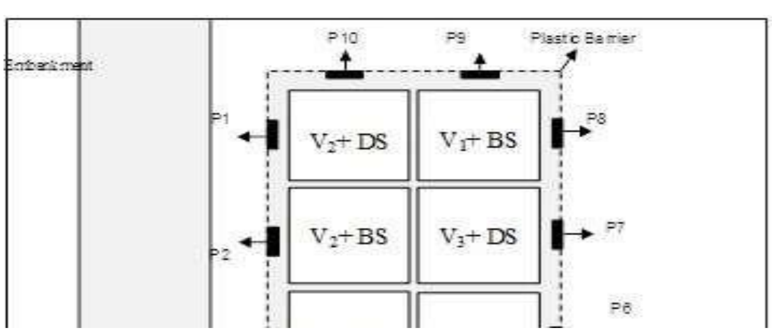

Fig. 1. The layout of observation of rodent in TBS installed area (February-May 2016) in Banyuasin District South Sumatera **(Bu mohon untuk mengirimkan semua figure berukuran 4MB ke email agrivita@ub.ac.id, agar tulisan di dalam gambar terbaca dengan jelas, tidak terlalu kecil)**

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.

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 *R. 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)

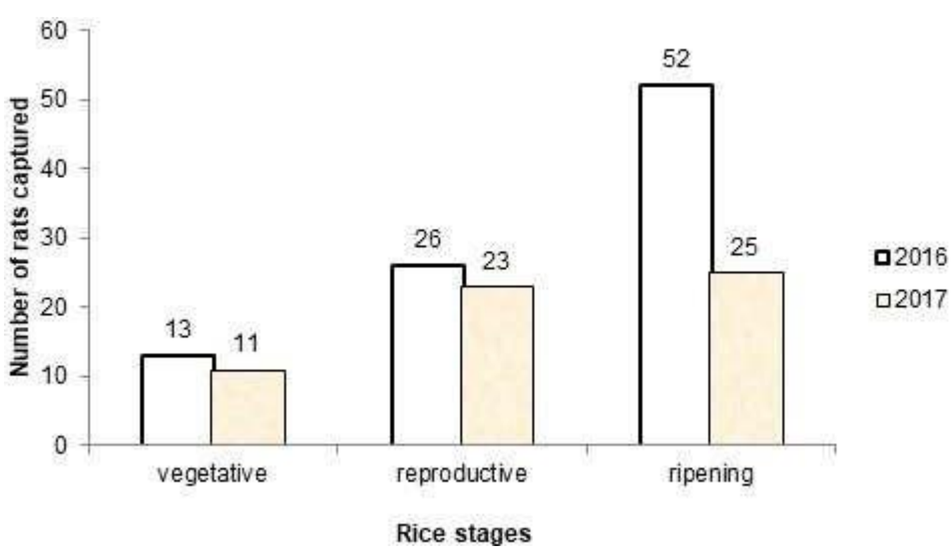

Fig. 2. Number of rats captured in rice field installed-TBS in the second season (February-May) 2016 and 2017 in tidal area Muara Telang, Banyu Asin district South Sumatera.

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. 3. Footprints of rat on wooden bridge smeared with thin mud **(Bu mohon untuk menyebutkan fig. 3 di dalam teks, jika tidak mohon dihapus saja)**

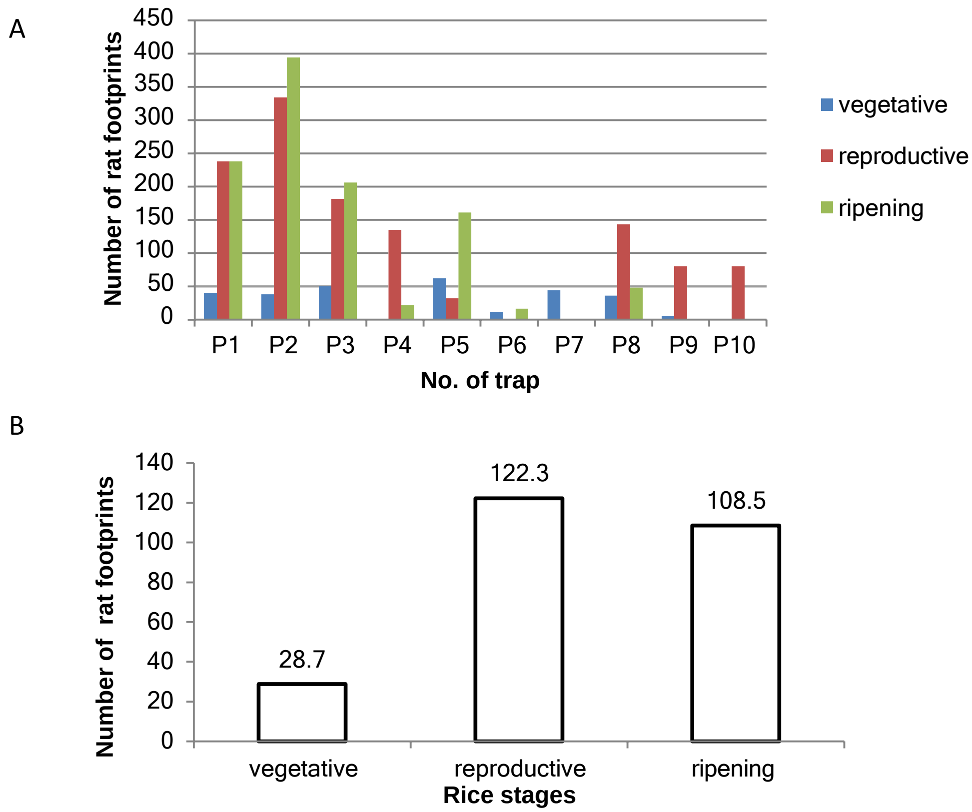

Fig. 4. Number of rat footprints in rice field installed-TBS at second season (February-May 2016) in tidal area Muara Telang, Banyuasin district, South Sumatera (A: footprints found in a single trap; B: footprints accumulated in every stage of rice.)

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. In Fig. 4, 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. 4B) 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. 4A). 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. 4B, 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.

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 (Fig. 5A), 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 (Fig. 5B).

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. 6). 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. 5. Damage symptom of rice consumed by rodents in the vegetative stage (A) and reproductive stage (B) **(Bu ini gambarnya kekecilan sekali, nanti pecah kalau di-layout, mohon mengirimkan foto berukuran min. 4MB agar jelas tidak kekecilan)**

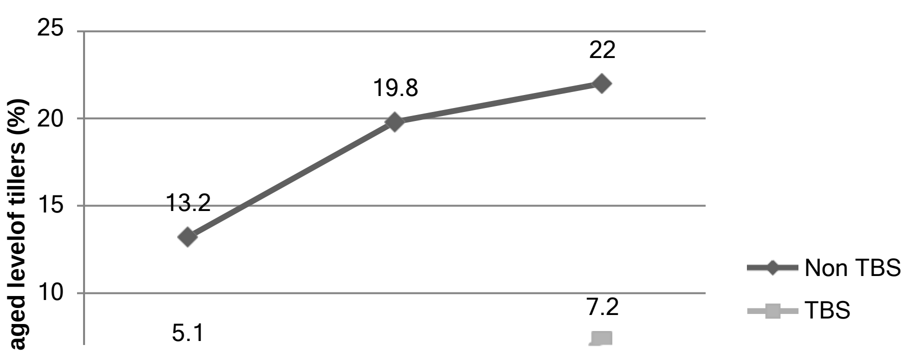

Fig. 6. Level of rice tillers damaged by rodents in various rice stages observed at TBS and Non TBS area rice cultivation in Tidal Area Banyuasin District South Sumatera in the second season (year 2017)

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. The yield of rice in the year 2016 and 2017 at TBS and non-TBS installed rice cultivation in a 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

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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BUKTI NOMOR : 4

Yulia Pujiastuti <ypujiastuti@unsri.ac.id>   24 Agu 2018 11.28
kepada agrivita

Yth. Editor Agrivita,
kami kirimkan fileyang sudah saya revisi, dengan perubahan sebagai berikut:
1. Figure 1, dilampilkan sketsa asli dalam format word
2. Figure 3 dihapus, karena kami tidak memiliki gambar dengan kapasitas 4MB
3. Figure 5 dihilangkan karena tidak ada stok foto dengan kapasitas 4B

Jadi, setelah menghapus Fig 3 dan Fig 5, lalu dilakukan perubahan urutan nomer figure.
Demikian revisi yang telah saya lakukan, mohon diproses untuk tahap berikutnya.

Salam,

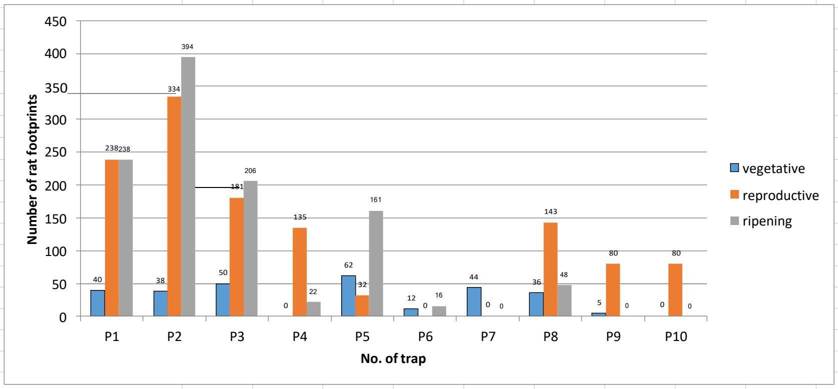
Yulia

Dr Ir Yulia Pujiastuti, MS
Entomologist
Plant Protection Department
Agricultural Faculty, Sriwijaya University
PALEMBANG-INDONESIA

Data 1. Untuk Fig. 4 A.

Lahan TBS th 2016

Rice stages	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	jumlah	rata-rata
vegetative	40	38	50	0	62	12	44	36	5	0	287	28.7
reproductive	238	334	181	135	32	0	0	143	80	80	1223	122.3
ripening	238	394	206	22	161	16	0	48	0	0	1085	108.5



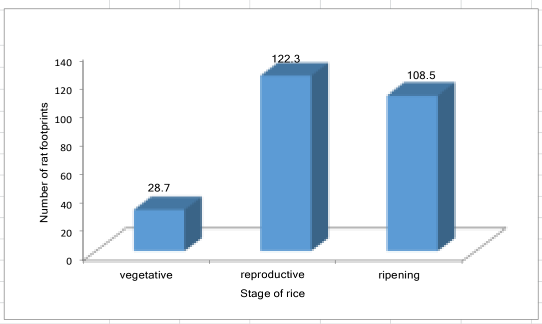
vegetative	28.7
reproductive	122.3
ripening	108.5

Fig. 4. 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.)

Data 2. Untuk Fig 4 B.

F

Rice stages	Number of footprints found
vegetative	28.7
reproductive	122.3
ripening	108.5



	TBS	Non TBS
Vegetative	5.1	13.2
Reproductive	4	19.8
Ripening	7.2	22

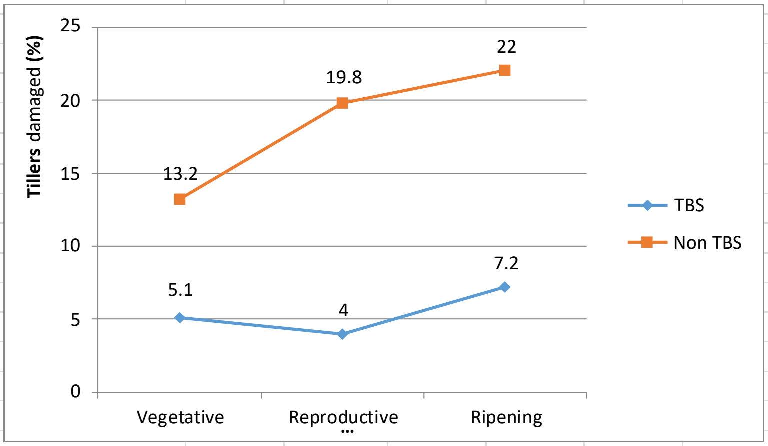


Figure 6. Level of rice tillers damaged by rodents in various rice stages observed at TBS and Non TBS area rice cultivation in Tidal Area Banyuasin District South Sumatera in second season of 2017)

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Agrivita . <agrivita@ub.ac.id>
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Sen, 3 Sep 2018 08.32

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Dear mbak Lala,
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Untuk running title, kami pilih sebagai berikut :
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AGRIVITA
Journal of Agricultural Science

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.

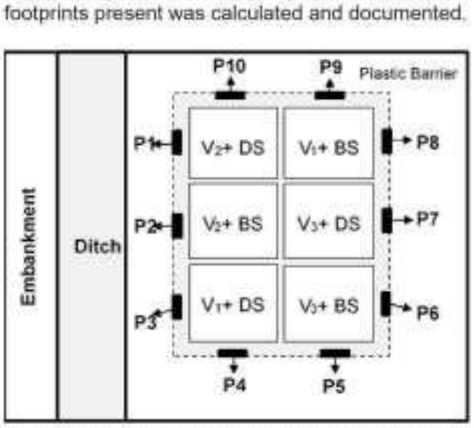

Fig. 1. The layout of observation of rodent in TBS installed area (February-May 2016) in Banyuasin District South Sumatera

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.

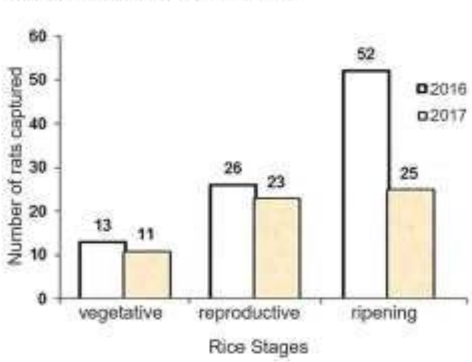

Fig. 2. Number of rats captured in rice field installed-TBS in the second season (February-May) 2016 and 2017 in tidal area Muara Telang, Banyu Asin district South Sumatera

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.

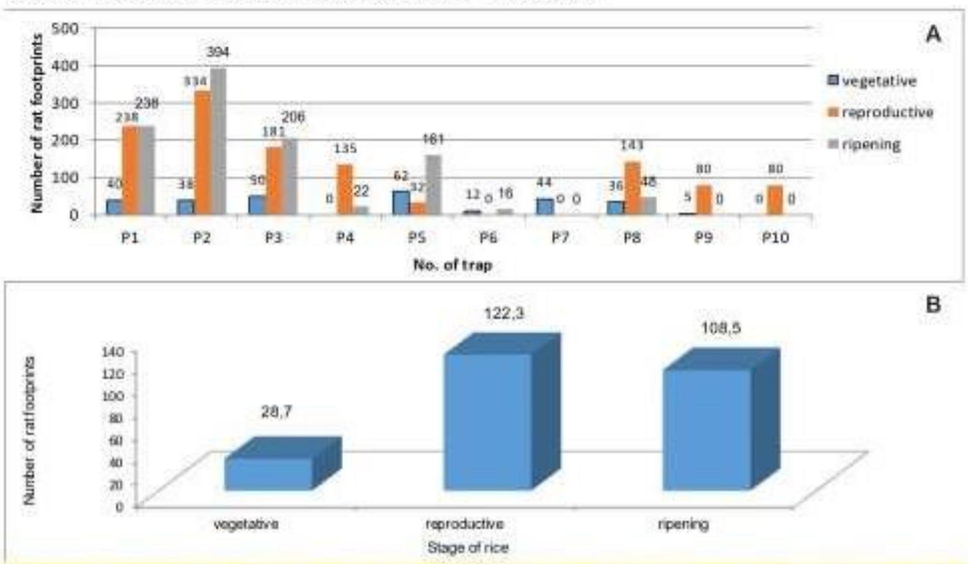

Fig. 3. Number of rat footprints in rice field installed-TBS at second season (February-May 2016) in tidal area Muara Telang, Banyuasin district, South Sumatera (A: footprints found in a single trap; B: footprints accumulated in every stage of rice)

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.

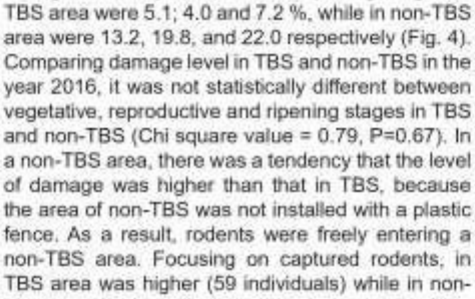

Fig. 4. Level of rice tillers damaged by rodents in various rice stages observed at TBS and Non TBS area rice cultivation in Tidal Area Banyuasin District South Sumatera in the second season (year 2017).

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 3. 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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On Tuesday, September 25, 2018, 9:19:32 AM GMT+7, Agrivita . <agrivita@ub.ac.id> wrote:

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Atas perhatian dan kerjasama yang Ibu berikan kami sampaikan terima kasih.

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Re: Form Competing Interest

Kotak Masuk

Yulia Pujiastuti **<yulunsri@yahoo.com>**

2 Okt 2018 13.31

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Untuk selanjutnya akan kami hubungi lagi kedua co author tsb.

Terimakasih..

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