A comparative study on assessing rodent damage intensity in rice crop based on two different methods

Rachmawati* and N A Herawati
Balai Besar Penelitian Tanaman Padi (Indonesia Center for Rice Research), Subang, Indonesia

*Corresponding author: rachmawati_07@yahoo.co.id

Abstract. Rodent damage is commonly concentrated towards the center of rice fields. There are some approaches to assess the damage, two of them are the transect and the Malayan method. The transect technique is a well-known applicable practice employed among agricultural workers in Indonesia, while the Malayan method is generally performed in Malaysia. The objective of this study was to compare both methods in terms of determining the more representative technique for assessing rodent damage. The study was conducted in Karanggetas village, Bangodua subdistrict, Indramayu district, West Java (6°51'S, 108°29'E) in 2018. Two plots (0.35 ha and 0.56 ha) were selected as the study site which was planted with Inpari 32. Since the generative stage of the rice crop is the most preferable phase for rodents, therefore we solely observed the damage within this period. We recorded the damage intensity four times with weekly intervals by both methods in each plot. To confirm the rodent population and reproduction status, we installed a linear trap barrier system and dug some active burrows along the irrigation channel bank as their main habitat. The result showed that the damage intensity was significantly different between both methods. The damage intensity was higher when it was assessed by the transect method compared to the Malayan one. The result indicated that the transect method is a better technique representing the damage than the Malayan method. This due to the first method covered almost entirely the damaged spot. This finding suggested that the transect method is the representative technique for assessing rodent damage intensity.

1. Introduction

The top rice damage in Indonesia and almost in the rice culture countries has been by the rodent. About 5-10% of the loss has been recorded in Southeast Asia including Indonesia [1]. The attack has covered about 85,733 ha (average) per year during 2017-2019 [2], which equals 271 million kg of rice (national production: 5.1 ton GKG [3]; with ratio GKG to rice: 62%, [4]) for feeding about 2.8 million peoples (rice consumption per capita: 97 kg [4]) in a year. The wide rate attack suffers the rice bowl of Indonesia, i.e. North Sumatera, West Java, Central Java, Southeast Sulawesi, and East Java [2].

The highest rate of attack usually occurs in the highly intensive planting area, where the rice is planted continuously but not simultaneously (asynchronous). A continuous and asynchronous planting provides food availability all the time for the rodents especially on extending their breeding season [5]. Rodent eats all the rice stages, so that the damage may occur along the whole of the cropping season. These kinds of rice stage provide more nutritive value which gives them the best vigour e.g. body mass and more offspring [6]. The composition of the nutritive value of rice changes by the stage. The protein is high during the tillering stage, while carbohydrate is elevated during the booting and ripening stage [7]. The protein in the tiller triggers the onset of the main breeding season, leading to
the high rates of conception during the booting and ripening stage [5,8,9]. The carbohydrate in the booting and ripening stage provides sufficient nutrients to maintain pregnancy and lactation [8]. Rodent shows more preference to booting and milky stage where containing more sulphuric volatile compound [10].

Rodent moves locally for food and the home range is about 75 m [11]. During the breeding season, their movement, especially males, would be more expansive [12] and in food scarcity conditions the travel movement could be 700 m [13]. Males could move wider (2.64 ha) than females (0.5 ha) [14]. During fallow, they travel to the village and travel back to rice field starts from the vegetative stage [15]. The pattern of the movement is stay in the rice field during day light and inhabit the village during night. Home range for female is about 0.8 ha with a span of 184 m [16]. It could be even wider during pre harvest time. The range span was longer in the same time as the response to predation risk [17].

During movement and migration, rodent will attack the rice field and other alternative food. The rice damage by rodent is commonly concentrated towards the centre of rice fields. Rodent damage to rice is greater in the middle part due to a lower perceived predation risk, both avian and terrestrial predator [18]. Farm size is typically less than 1.5 ha in the Philippines and less than 1 ha in Java, Indonesia. It is also common to construct the secondary bunds for farmer access. In addition, farmer generally practices rodent pest management by clearing vegetation from field edges and bunds which recognized as sanitation method. Rodent pests tend to nest on rice field edges, on rice bunds and in surrounding habitats rather than within the rice field itself, especially during flooded conditions [19]. Therefore, there must be a perceived fitness or survival advantage with feeding in the centre of the rice field.

Rice damage by rodent usually is not obvious whether spread randomly or unevenly within a field. In term of assessing the damage, it is recommended to use stratified random sampling. The results of this sampling will always be equal to or better than the precision that we can get from random sampling with no stratification [20]. In the damage spot, there are some techniques of assessment which are applied in some countries i.e. the Philippine, the Malayan and transect in Indonesia [13]. The transect method is a well-known applicable practice employed among agricultural workers in Indonesia, while Malayan method is generally performed in Malaysia. The objective of this study was to compare both methods in terms of determining the more representative technique on assessing rodent damage.

2. Materials and methods

The assessment of rice damage by rodent was conducted in Ds. Karanggetas (village), Indramayu (district), West Java (6°51'S, 108°29'E) in dry season of 2018. The study site represented a large area of lowland irrigated agroecosystem. The damage assessment was recorded during generative stage and supported by rodent population information and female breeding status in the same time.

2.1. Damage assessment

Two plots (0.35 ha and 0.56 ha) were selected purposively where the rodent attack occurs. The plots were planted with Inpari 32 (rice variety). Both plots were assessed by transect and Malayan method for the rodent damage. The data were collected four times during generative stage, with weekly interval. The damage intensity was analysed by F test with probability of 0.05. At the harvest time, the yield was recorded as well.

2.1.1. Transect method. The transect lines were established at 10 m, 20 m, 30 m, 40 m, and 50 m from bund. Ten hills were assessed from each transect line perpendicularly (Figure 1) [20]. Cut tiller and total tiller in the hill were counted. The damage intensity was calculated by the formula below,

\[ I = \frac{a}{b} \times 100\% \]

Where I = damage intensity (%); a = cut tillers of hill; b = total tillers of hill

2.1.2. Malayan method. As the plots were consisted of 200-600 hills, then the plot was imaginatively splitted into two equal areas. From each area, we selected two lines as the sample. Twelve to thirteen hill pairs in line were assessed (Figure 1) [13]. The number of cut tiller and total tiller in the hill were counted. The damage intensity was calculated by the same formula.
2.2. Rodent population
The rodent population was assessed by using Linear Trap Barrier System (LTBS) as performed in some rodent population studies [15,20,21]. The LTBS was set along the irrigation channel bank and big paddy banks. The system consisted of 120 m plastic fence and six traps which were placed 20 m apart each other. The bottom part of fence was embedded to the ground prevented the rodent to pass the underneath. The fence was installed to direct the rat to get into the trap (Figure 2). A bamboo stick with 60-70 cm height was also inserted into the hole of the fence with 10 m distance to erect the plastic fence. The traps were made from metal wire with dimension of 40 x 40 x 60 cm. A wire cone was put in front of the trap as a way for the animals to get in but unable to escape. A small rectangular door (10 x 10 cm) was located on the back side of the trap functioning as an access to collect the rats. The traps were checked regularly every morning as soon as possible to avoid trap shyness and release the non target species. The number of trapped animals were collected and recorded daily.

2.3. Rodent breeding status
To assess rodent breeding status, we performed kill sampling by fumigating and digging some active burrows [20,22,23]. The active burrows were identified by the presence of soil crumb surrounding the entrance (Figure 3a). We fumigated the burrow with sulphuric smoke to get saturated (Figure 3b) and plugged the entrance by mud. After that, we dug out the burrows (Figure 3c) and collected the rodents from the chambers (Figure 3d). The adults and their litters were counted and recorded. The adult females were dissected to observe the pregnancy, uterus scars and the number of their embryos.
3. Results and discussion

Generally, the rice damage intensity by rodent from both plots was relatively low, ranged from the highest intensity in the first observation and becoming lower at the last record. The damage decreased consistently in accordance with the rice maturity by both methods (Table 1). However, if we compared the damage assessment by the two techniques, the intensity was recorded higher by the transect method. The damage intensity was significantly different within both methods (Table 2).

| Damage Intensity (%) | Transect 1 | Transect 2 | Malayan 1 | Malayan 2 |
|----------------------|------------|------------|-----------|-----------|
| 1                    | 3.07       | 1.31       | 0.77      | 0.29      |
| 2                    | 1.58       | 0.55       | 0.57      | 0.22      |
| 3                    | 0.26       | 0.42       | 0.08      | 0.00      |
| 4                    | 0.00       | 0.00       | 0.00      | 0.00      |

(*) weekly interval

| Table 2. F test of damage intensity to compare the differences between transect and Malayan method |
|-----------------------------------------------|---------------------|----------------------|---------------------|
| Mean                                          | 0.89875             | 0.24125              |
| Variance                                      | 1.103127            | 0.084441             |
| Observations                                  | 8                   | 8                    |
| df                                            | 7                   | 7                    |
| F                                             | 0.003099            |
| p                                             | 0.052               |

Both methods, actually, met some of the assumptions of transect method, i.e. (1) the object on the transect line was detected, (2) the object did not move in response to the observer before the detection was recorded, (3) the object was only counted once, (4) the object was recorded at the point of initial detection, (5) the distances were measured without errors [24]. The differences were (1) in the transect method we took 5 lines and in Malayan method we took 4 lines, (2) in transect method we took a single hill (with at least 20 tillers per hill) as a sample and in Malayan method we took a pair hill. It could be said that the lack of lines in Malayan method was compensated by more hill samples. However, practically Malayan method could miss the centre part of damage as described in Figure 1. Meanwhile, transect method was believed to be more efficient in time because of fewer samples [13]. This due to the Malayan method picks the pair hill samples, while transect method only picks a single hill with at least 20 tillers. Regarding the time consuming, it could be an important issue for field worker. In rice field, especially in Indonesia, farmers work in the morning until 10 am and back to the field at about 3 pm to sunset. Hence, it is essential (pick other word, as “important” already used in previous sentence) to choose a suitable method to their regular activity.

At that time, the transect method was believed to be more representative to the real condition. The method recorded well the centre part of the damage area which is usually called “stadium effect”. Transect method is also employed by colleagues from International Rice Research Institute (IRRI) in their study [18]. However, in rice field, the rodent damage does not appear to be random. It is required to calculate the relative proportion of each damage area within the total study area. The number of sampling points is then scaled to reflect these relative proportions [20].

Even though the damage intensity was relatively low, the rodent population was growing. From LTBS we caught on average three rats per day from the traps during generative stage (Figure 4). The rodent

![Figure 3. Active burrow excavation for assessing the rodent breeding status. An identified active burrow (a) was fumigated by sulphuric smoke (b), than it was dug out (c) to collect the rodent (d).](image-url)
density probably less than 100 rats per ha at emergence or less than 42 rats (on average) per ha from sowing to harvest as a model developed by Brown et al. [25]. Moreover, the breeding data confirmed that the population was growing. From burrow digging we identified 33 males and 38 females. We found about 58% of adult females were lactating for 11 litters. And about 86% of adult females were pregnant with 11 embryos in uterus (Table 3). It was confirmed that the population was growing.

![Graph showing number of rats captured by LTBS over days.](image)

**Figure 4.** Number of rat captured by linear trap barrier system (LTBS) during generative stage of rice.

**Table 3.** Summary of female reproduction status in study site

| Total of adult female | Ratio of breastfeed to adult female (%) | Average of litter per adult female | Ratio of pregnancy to adult female (%) | Average of embryo per adult female |
|-----------------------|----------------------------------------|-----------------------------------|----------------------------------------|-----------------------------------|
| 7                     | 57.1                                   | 11                                | 85.7                                   | 11                                |

4. Conclusion

It was concluded that the area was a rodent endemic, and the damage occur in every season. For sure, rodent management practices should be conducted in endemic area, so the damage could be prevented or diminished. The best assessment method should be applied consistently, so it could monitor and compare the damage all the time. The transect method was suggested to be the best method to assess the rice damage by rodent as it was a simpler technique to be executed and well represented the damage spot as well. As the damage is assessed for monitoring purpose, it is important to apply the same method within the period of monitoring.

Acknowledgments

We thank to students from Politeknik Negeri Lampung and our technicians, Tedi Purnawan and Oo Taofik, for their excellent work in the field, as well as the collaborative farmers in Karanggetas who supported this work.

5. References

[1] Singleton G R 2003 Impact of rodents on rice production in Asia *IRRI discussion paper series* **45** (Los Banõs: International Rice Research Institute) pp 30

[2] Pusdatin Pusat Data dan Sistem Informasi Pertanian 2019 *Statistik Iklim, Organisme Pengganggu Tanaman dan Dampak Perubahan Iklim 2016-2019* ed Subehi M, Abdulrachman A A, Hasanah L, Supriyatna M A, Gultom R, Surasa J, Uliyah, Sulistiyowati H, Martono H D, Heruwaty and Indah K (Jakarta: Pusdatin Sekretariat Jenderal Kementerian Pertanian) p 273

[3] Prasetyo O R, Amalia R R, Astuti K, Khasanah I N, Rahmadhani N and Poerwaningsih R 2020 *Ringkasan Eksekutif Luas Panen dan Produksi Padi di Indonesia 2019* ed Buana W P, Kadir, Drajat D and Suwarti (Jakarta: Badan Pusat Statistik) p 22
Sabarella 2019 *Buletin Konsumsi Pangan* 10 1 ed Sumantri A (Jakarta: Pusdatin Sekretariat Jenderal Kementerian Pertanian) p 96

Karyanto P 2005 Sumber belajar ekologi: pola konsumsi tikus sawah (*Rattus argentiventer* Rob. & Kloss) pada persawahan tanam tidak serempak *Bioedukasi* 2 24–48

Sudarmaji 2018 *Tikus Sawah Biokologi dan Pengendalian* (Jakarta: IAARD Press) p 120

Rahmini and Sudarmaji 1997 Penelitian variasi pakan tikus sawah pada berbagai stadia pertumbuhan tanaman padi *Prosiding III Seminar Nasional Biologi XV* (Lampung: Perhimpunan Biologi Indonesia) p 1525–28

Htwe N M and Singleton G R 2014 Is quantity or quality of food influencing the reproduction of rice-field rats in the Philippines? *Wildlife Research* 41 56–63

Rochman and Sudarmaji and S Swalan 2000 Hama tikus dan pengendaliannya *Monograf Organisme Penganggu Tanaman dan Pengendaliannya di Lahan Pasang Surut* Bogor Puslitbangtan pp 12–23

Mardiah Z and Sudarmaji 2012 Identifikasi komponen volatil tanaman padi fase bunting dan matang susu sebagai pakan alami yang disukai tikus sawah *Penelitian Pertanian Tanaman Pangan* 31 2 100–107

Brown P R, Singleton G R and Sudarmaji 2001 Habitat use and movement of the rice field rat *Rattus argentiventer* in west Java *Indonesia Mammalia* 65 2 151–166

Tristiani H, Murakami O and Watanabe H 2003 Ranging and nesting behavior of the rice field rat *Rattus argentiventer* (Rodentia: Muridae) in West Java *Indonesia Journal of Mammalogy* 84 4 1228–36

Priyambodo S 1995 *Pengendalian Hama Tikus Terpadu Seri PHT* (Jakarta: Penebar Swadaya) p 134

Sudarmaji and Rahmini 2000 Daya jelajah dan preferensi penggunaan habitat tikus sawah (*Rattus argentiventer*) di ekosistem padi sawah *Prosiding Seminar Nasional Biologi XVI* (Bandung: Kampus ITB) p 184–187

Sudarmaji, Rahmini and Singleton G R 2006 Habitat utilization and movement of rice-field rat to village habitats at various rice stages: implication for rodent management *Rice Industry, Culture and Environment Proc. of the Int. Rice Conf.* Book 1. (Sukamandi: Balai Besar Penelitian Tanaman Padi) pp. 307–312

Hadi S, Subagia J and Sudarmaji 2006 Perilaku spasio temporal tikus sawah (*Rattus argentiventer*) betina *Biota XI* 2 110–115

Jacob J, Nolte D, Hartono F, Subagia J and Sudarmaji 2002 Pre- and post-harvest movements of female rice field rats in West Javanese rice fields *Rats, Mice and People: Rodent Biology and Management* ed Singleton G R, Hinds L A, Krebs C J and Spratt D M (Canberra: ACIAR) pp 277–280

Jones C R, Lorica R P, Villegas J M, Ramal A F, Horgan F G, Singleton G R and Stuart A M 2017 The stadium effect: rodent damage patterns in rice fields explores using growing-up densities *Integrative Zoology* 12 438–445

Stuart A M, Prescott C V and Singleton G R 2012 Natal nest locations of the Asian house rat (*Rattus tanezumi*) in lowland rice-coconut cropping systems: A coconut penthouse or rice bunds with water frontage? *Wildlife Research* 39 496–502

Aplin K P, Brown P R, Jacob J, Krebs C J and Singleton G R 2003 *Field Methods for Rodent Studies in Asia and the Indo-Pacific* ACIAR Monograph no 100 (Canberra: Australian Center for International Agricultural Research) p 223

Sudarmaji and Herawati N A 2001 Metode sederhana pendugaan populasi tikus sebagai dasar pengendalian dini di ekosistem sawah irigasi *Penelitian Pertanian Tanaman Pangan* 20 2 27–32

Munadjat A and Sudarmaji 1998 Studi reproduksi dan cacah tikus (populasi) *Rattus argentiventer* R. & K. pada tingkatan stadium pertumbuhan tanaman padi *Jurnal Penelitian Pertanian “Agrin”* 3 5 32–39
[23] Nolte D L, Jacob J, Sudarmaji, Hartono R, Herawati N A and Anggara A W 2002 Demographics and burrow used of rice-field rats in Indonesia Proc. 20th Vertebr. Pest Conf. ed R M Timm and R H Schmidt (Davis: Univ. of Calif. Davis) pp 75–85.

[24] Navarro J and Diaz-Gamboa R 2015 Line Transect Sampling Introduction to Ecological Sampling ed Manly B J F and Alberto J A N (Florida: CRC Press) pp 47–61

[25] Brown P R, Huth N I, Banks P B and Singleton G R 2007 Relationship between abundance of rodents and damage to agricultural crops Agriculture, Ecosystems and Environment 120 405–415