The Occupancy of Barn Owl in The Artificial Nest Box to Control Rice Field Rats in Yogyakarta Indonesia

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ABSTRACT

One component of integrated rat management in rice fields is barn owl as biological control. The study was conducted to evaluate the occupancy rate of barn owl nest boxes, the local rat population, and rat damage to rice crops. It was conducted in three locations in Yogyakarta by observing 10 nest boxes per site. Assessment of their occupancy was monitored by barn owl presence in nest box (egg, chick, and adult) and natural nests in villages nearby. In comparison with control village, the local rat population was observed by the active burrow count method and linear trap barrier systems. Rat damage intensity is estimated by sampling 150 tillers using a stratified sampling approach. The result indicated that 1-4 nest boxes were occupied per location. The owls also nested within buildings nearby. Active burrows ranged from 4 to 25 burrows per 150 m. The rat damage area ranged from 33.33% - 48.57% with 6.33% - 14.86% damage intensity was significantly lower than the control site. Artificial nest box installation for owls in rice fields were only occupied for breeding. The use of barn owls for biological control of rice field rats should be combined with other methods in an integrated approach.

Keywords: *barn owl, a rice field rat, rodent management, biological control*

ABSTRAK

Salah satu komponen pengendalian tikus sawah secara terpadu adalah penggunaan burung hantu sebagai pengendali biologi. Penelitian dilakukan untuk menguji tingkat huni burung hantu di dalam rubuha, populasi tikus sawah, serta kerusakan tanaman padi akibat serangan tikus. Penelitian dilaksanakan di tiga lokasi di Yogyakarta, dengan cara mengamati 10 rubuha per lokasi. Pengamatan tingkat huni burung hantu dilakukan berdasarkan keberadaan burung hantu di dalam rubuha (telur, anak, dewasa) dan di sarang alaminya di perkampungan dekat sawah. Untuk membandingkan dengan desa kontrol, populasi tikus dihitung dari jumlah lubang aktif dan pemasangan ***Linear Trap Barrier System***. Intensitas kerusakan padi akibat tikus dihitung menggunakan metode transek pada 150 rumpun. Hasil penelitian menunjukkan bahwa terdapat 1-4 rubuha per lokasi yang dihuni oleh burung hantu. Selain itu, burung hantu juga bersarang di bangunan-bangunan perkampungan sekitar sawah. Terdapat 4 – 25 lubang aktif per 150 m. Luas kerusakan akibat tikus 33.33% - 48.57% dengan intensitas kerusakan tanaman 6.33% - 14.86%, nilai ini nyata lebih rendah dibandingkan desa kontrol. Rubuha yang dipasang di tengah sawah hanya dihuni saat perkembangbiakan burung hantu. Penggunaan burung hantu sebagai pengendali biologi tikus sawah harus dikombinasikan dengan metode pengendalian lain dengan pendekatan yang terintegrasi.

Kata kunci: burung hantu, tikus sawah, pengendalian tikus, pengendalian biologi.

INTRODUCTION

Rice field rat *Rattus argentiventer* is the main pest causing serious damage to the rice field in Indonesia. Rice field rat attacks occur on all growing stages of rice plants from seedlings to harvest, even causing postharvest damage in the storage (Sudarmaji, 2018; Sudarmaji and Herawati, 2017; Sudarmaji and Pustika, 2018; Brown et al, 2017; Sudarmaji et al, 2010 -a). In Indonesia, the damaged area caused by rice field rats was averaged as 161,372 ha per year during 2010-2014, equivalent to a loss of 620,000 tons of rice (Sudarmaji 2018; Pusat Data dan Sistem Informasi Pertanian, 2015), without considering losses due to nursery and storage damage. In 2019 Yogyakarta farmers control rice field rats in 19,525 ha area using the various method. Farmers conducted lethal mass activity, fumigation of the active net, rodenticide, mechanical control, and artificial net installation the barn owl. On the other side, the damaged area in Yogyakarta during 2019 was 6,105 ha (Yogyakarta Agricultural Plant Protection Institute, 2020), estimated to cause 36,020 tons losses when the rice productivity in Yogyakarta was averaged 5.9 tons per hectare (Dinas Pertanian dan Ketahanan Pangan DIY, 2019). Losses of 36,020 tons of rice are equivalent to losses of 2,304 tons of milled rice. If Yogyakarta's rice consumption is 88.3 kg/capita/year (Statistics of DIY, 2020), then 2,304 tons can feed 26 thousand people in a year. Besides lead to serious damage in rice production, rice field rats are also known as a reservoir of dangerous diseases in humans and livestock (Sudarmaji, 2018; Ristiyanto et al, 2014; Sudarmaji et al, 2010-b).

The integrated control of rice field rat (PHTT) concept has been recommended to control rice field rats (Sudarmaji, 2018; Sudarmaji and Harawati, 2008, Sudarmaji, 2007). One of the PHTT components is the utilization of barn owls (*Tito alba javanica*) as rat predators in the biological control system (Supriyana, 2014; Sudarmaji, 2004; Priyambodo, 1995). The barn owl is one of the nocturnal birds as effective predators which prey on rodents and other small mammals (Munoz-Pedreros et al., 2016). Barn owls are the most effective natural predators to control rice field rats (Kuswardani, 2006, Andres et al, 2016; Hafidzi, 2003). It was chosen as control agent because it performs better potential than other predators such as eagles, snakes, cats, dogs, and others (Priyambodo, 1995). It search and prey at night (nocturnal) in a more active way with rats as the main prey and some alternative prey such as bats, birds, insects, frogs, snakes, fish, lizards, geckos, and others. The ability to prey on adult *serak putih* owls ranges from 3-5 rats per day (Kuswardani, 2016). The prey is whole swallowed and then digested, then the body parts of the prey that cannot be digested such as the skull, hair, and relatively large bones will be vomited back as regurgitation called pellet or bolus, approximately 7-8 hours after being swallowed by an owl (Sipayung et al. 1990)

Generally, nocturnal birds of prey can be potent predators of some species of the order Rodentia. Some raptor species and barn owls can perform as the regulator for rodent numbers in an ecological role (Munoz–Pedreros *et al.* 2016). Although constraints are found to demonstrate this top-down control empirically, several authors reported the impact of certain raptors on the population of rodents (Ostfeld and Holt, 2004; Salo et al, 2010; Norrdahl and Korpimaki 1993; Korpimaki and Norrdahl, 1998; Korpimaki et al, 2002; Hanski et al, 2001; Gilg et al, 2003). In addition to certain predators, they present to have a role in suppressing rodent's population and keep their densities low (Ostfeld and Holt, 2004). The use of barn owls as rat predators has been developed and is reported to provide quite good hope in oil palm plantations (Heru, et al. 2000). Hafidzi (2003) reported that owls are effective for controlling rats in the wetland ecosystem in Malaysia. In Indonesia efforts to control rats with the release of barn owls in rice fields have been carried out in several areas in Central Java, East Java, and Yogyakarta (DIY), but there are no reports regarding they are successful (Kuswardani, 2006). Monitoring of natural owl nests and occupancy rates of owl houses in Sleman Yogyakarta was carried out by Supriyana (2014), but there were no reports of rat populations and the extent of damage to rice plants in the field. The effectiveness of barn owl release and the installation of its shelter (rubuha) in rice fields in DIY has never been evaluated. Therefore, a study was conducted to determine the occupancy rate of barn owls in the rice fields and their relationship to the level of rats population and the level of rice plants damage around the rubuha installation.

MATERIALS AND METHODS

The study was conducted in the dry season of 2016 (DS) and rainy season of 2018 (RS) in rat endemic area of irrigated rice ecosystem which was installed with rubuha. It was conducted in 26 hectares area of Godean sub-district ricefield (-7045'36 '', 110015'58 ''), 25 hectares area of Sedayu (-7049'14 '', 110015'23 ''), 29 hectares area of Kalibawang (-7042'2 '', 110013'49 ''), and 35 hectares area of Minggir (-7043'31 ' ', 110015'25' '). Three locations (Godean, Sedayu, and Kalibawang) were installed with rubuha. Each location was installed with 10 rubuha with 60 x 60 x 50 cm dimensions. Rubuha are supported by bamboo with 5 m in height. The rubuha installation was conducted by farmer groups 5 - 10 years ago. Meanwhile, Minggir is a location of control area without rubuha.

The record of the barn owl's occupancy rate in rubuha was conducted with direct observation by climbing the rubuha and verifying the internal condition of rubuha. Observations were made by recording the existence of barn owls using positive inhabited criteria (adult owls, nestling, or eggs was found inside rubuha), rubuha once inhabited (there is dirt or nest in the rubuha), and uninhabited rubuha (empty/clean inside). Observation of barn owl natural nest was carried out on each natural nest that was expected to be inhabited by barn owls and at the site of the settlement around the study sites by a collaboration with residents.

Observation of rice field rat population was carried out with the active nest method (Sudarmaji and Herawati, 2001). The active nest method means covering all rat nests with mud in the afternoon and making observations the next morning. Open rat nests are an indication that the nest is actively inhabited by rats. Active nest observation is carried out in the main habitat along 150 m. Observation of the rat population was also carried out by the linear trap barrier system (LTBS) method (Sudarmaji et al, 2005). LTBS is a plastic fence with 60 cm height and 100 m length equipped with 6 traps. LTBS was installed for 3 nights and the numbers of trapped rats in each location were recorded.

Rice plant damage was recorded by conducting structured transect methods (Sudarmaji and Anggara, 2006; Singleton et al., 2005; Aplin et al., 2003) with 150 rice clumps sample that was observed in each location. Damage assessment was measured based on the percentage of damage area and percentage of damage intensity. Measuring the percentage of damage area is done by calculating the total number of clumps and the number of damaged clumps. While the percentage of damage intensity was measured based on the calculation of the number of damaged tillers and the total number of undamaged tillers.

RESULTS AND DISSCUSSION

Predators of *R. argentiventer* in irrigated rice agroecosystems in Java, particularly Yogyakarta have not been much studied, however snakes, especially cobras (Naja), are deemed the most important. Snakes, particularly spitting cobra (*N. sputatrix*) often trapped during the study conducted in south Indonesia by Murakami *et al.* (1990). Several avian predators (*Bubo bengalensis*, *Buteo rufinus, Elanus axillaris*, *Falco tinnunculus*, *Falco cenchroides*, and *Tyto alba*) were commonly mentioned in the biological control for rodents, especially barn owls (*T. alba*) are the most exposed species (86% of studies). Researchers found some provision that avian predators resulted positive, suggested definable effects that the increased presence of avian predators provided lower population of rodent, lead to lower crop damage (Labuschagne, *et al.* 2016). However, related research of artificial shelter (rubuha) on avian predation to rodent pests was limited. The observation of barn owl's occupancy rate in the rubuha showed that the occupancy rates of positive inhabited barn owls were only 5-6 (17% - 20%) from a total of 30 rubuha installations (Table 1). Most of rubuha (50 - 60%) had been once

Table 1. Occupancy Rate of Barn Owls at Rice Field Installed Rubuha

Location/ Village	Area (hectares)	August 2016 (DS 2016)				April 2018 (RS 2018)		
		Rubuha installed	Positive inhabited *)	Once inhabited **)	Un-inhabited ***)	Positive inhabited *)	Once inhabited **)	Un-inhabited ***)
Godean	26	10	4	4	2	3	5	2
Sedayu	25	10	1	6	3	1	6	3
Kalibawang	29	10	1	5	4	1	7	2
Total	30	30	6 (20%)	15 (50%)	9 (30%)	5 (17%)	18 (60%)	7 (23%)

Description: *) Presence of eggs, nestlings and adult incubating female; **) Presence of dirt or nests inside; ***) Empty/clean inside

Table 2. Population of Barn Owls Natural Nest in The Village Closed to Rice Fields Installed with Rubuha

Location/village	Agustus 2016 (DS 2016)		April 2018 (RS 2018)	
	natural nest inside the building *)	nest in big tree/others	natural nest inside the building *)	natural nest inside the building *)
Godean (26 ha)	5	0	5	0
Sedayu (25 ha)	2	0	3	0
Kalibawang (29 ha)	4	0	4	0
Minggir (35 ha as control)	3	0	4	0

Remarks: *) Buildings used for barn owls natural nesting are residential houses, schools, mosques, churches, village offices and warehouses

inhabited, while 23% - 30% rubuha had never been inhabited. Positive inhabited rubuha was indicated by the presence of egg, nestling, or female adult barn owl which incubated its eggs. During observation, barn owls that inhabited without breeding activities were not found. In other words, all inhabited rubuha was occupied by breeding barn owls. The highest occupancy rate occurred in Godean, 4 positive inhabited rubuha (40%) were found in DS 2016 and 3 positive inhabited rubuha (30%) were found in RS 2018. Whereas in Sedayu and Kalibawang, only one positive inhabited rubuha (10 %) was found both in DS 2016 and RS 2018. Rubuha that was once inhabited in the previous season can be identified by the presence of dirt or nests inside. While un-inhabited rubuha was looking clean inside.

Barn owl's natural nest has been identified in the settlements around the rice fields where rubuha was installed. Natural nests of active (inhabited) were all found in buildings, such as residential buildings, mosques, churches, schools, offices, and warehouses. There were no barn owls found in large trees or other places of the village. Barn owls are not able to build their nests then only inhabited places that are thought to be safe and suitable as nesting sites. The number of natural nests ranged from 2-5 nests from all observation sites (Table 2). The highest number of natural nests was found in Godean, which is in line with highest occupancy rate of barn owls. Occupancy rates and numbers of identified natural nests in each study sites indicate the presence of barn owls with an estimated population of less than 10 in each site. The existence of this barn owl is expected to be a biological control agent of rice field rats.

Observation result on rice field rat populations that was relatively measured based on active nests showed that the number of active nests in all locations ranged from 4 to 25 nests per 150 m along habitat. There was less than 50% of rat nest which was inhabited, while the rest was an empty

Table 3. Active Rat Nest Populations in Various Main Habitats (Irrigation Dikes, Rice Field Paths and Rice Bunds) Along 150 M at Rubuha Installation Site

Location/village	Agustus 2016 (DS 2016)			April 2018 (RS 2018)		
	Nest	Active nest	% Active nest	Nest	Active nest	% Active nest
Godean	27	12	44,4	34	15	44,1
Sedayu	21	9	42,8	60	25	41,7
Kalibawang	22	8	36,4	12	4	33,3
Minggir (control)	24	12	50,0	47	16	34,0

nest (Table 3). The empty rat nest is thought to be caused by preyed rats, leaving rats, or other unknown reasons. Rat population was categorized as moderate (> 10 ≤ 30 active nests) per 100 m along with habitat (Sudarmaji and Herawati, 2001). Other research conducted by Burhanudin and Noor (2019) reported that activity levels and population density of rats are resembled the number of an active nest, whereas the proportion of 30% active nests designated that level of invasion to rice crops remains considerable.

Regarding Munoz-Pedreros *et al* (2010), the natural density of *Tyto alba* at certain enlargement habitat at RN Lago Penuelas was 2.13 individuals per km^2. With regard *Tyto alba* diet, it consumes 1-3 mice (50-150 g) daily, it was suggested that rodent consumption is 2,332 individuals annually per km^2. Another study conducted by Alvarez-Castaneda *et al* (2004) showed that sub-adult rodents were extant pellets as 61.9% while rural rodents comprised 83.3% of the prey. The daily biomass of food consumed was expected at 55.7±33.5 g (12–152) on average. It is proposed that *Tyto alba* is a resourceful species that prey mostly on small rodents of 7–24 g and feed on only the necessary quantity of rodents to cover biomass requirements. Although there is still lack of information on rodent density the Yogyakarta area, rodent studies alongside any gradient of altitude were conducted in Italy by Milana *et al* (2019) regarding estimating the dissimilarities in taxonomical structure and the metric of community. The results showed that the number of rodent species declined significantly with the gradient of elevation. A little significant negative correlation was found concerning the number of species and altitude. It was presumed that the decline of rodent species number with altitude is possibly predisposed by the higher proportion of existing agricultural acreage at lower altitudes in Italy. According to Yogyakarta Agricultural Plant Protection Institute (2020), approximately 400 - 500 owls were found in Moyudan, Seyegan, Tempel and Godean, which each of them potentially eat 4 - 7 rats per night. However, the rat population in Yogyakarta can rise rapidly due to the excessive breeding of rice field rats in one season (Sudarmaji and Herawati, 2018; Sudarmaji et al, 2007). Another study suggested the breeding season of rats in the rice field is generally closely associated with crops maturity. Moreover, breeding in the village habitat might be occur along the year where sufficient food and shelter are available. However, when plenty of grain was accessible in the village grain stores, the breeding rate of adult females might be highest. As the consequence of breeding that occurs in the village along the year, village habitat corresponds to a latent source of rats that might reinvade the nearby rice fields when environments became appropriate (Leung *et al.*, 1999; Jacob *et al.*, 2003). Additionally, *R. rattus* performs a life strategy similar to *Mus musculus* alive in commensal farm situations (Pocock *et al.*, 2004). The excessive breeding of rice field rats could not be followed by the breed rate and the maximum ability to prey from the barn owls. Therefore, the control of rice field rats that rely on barn owls is estimated ineffective. Rice field rat control should adopt the concept of integrated rat control, which means the barn owls are only one component of some other components of the integrated control concept. Other experiments resulted that predation has assumed the most support in the cycle of rat population (Hanski and Korpimaki 1995, Hanski *et al.* (2001), Krebs 1996, Gilg *et al.* 2003), however, it appears not to be a sufficient factor, for instance, cycles were not manipulated by the replacement of a main individual predator (Graham 2001, Graham and Lambin 2002, Oli 2003). Likewise, a particular factor, such as predation, is possibly insufficient to create the distinctive manifestation of the inhabitant's cycles in little mammals (Lidicker 1988). Radchuk *et al.* (2016) reported that only the relation between intrinsic (sociality and distribution) and extrinsic (predation) reasons affects the cyclic character of vole inhabitants in the field. Rainfall and drought as climate factors are associated with capturability, the numbers of the population, and rates of survival, in addition to life histories (Rocha *et al.* 2017). These results pointed out that the effective control of rat populations ought to emphasize on decreasing rat population and possible crop damage over habitat management, thorough trapping, and village grain store protection during harvest season. When the abundance of rats in rice fields possibly be suppressed before the beginning of the highest breeding season, it could minimize the level of crop damage.

Sampling results of rice field rat populations using the linear trap barrier system (LTBS) method show that the rat population was relatively low, ranging between 3-9 captured rats (Table 4). The highest population of rice field rats was in Godean (9 captured rats). The captured rats were all identified as *Rattus argentiventer*. LTBS method also captures non-target organisms as snakes, particularly cobra (*Naja naja*) as 1-3 snakes in each location. This also proves that besides barn owls, there were other predators which played role in the dynamics system of the rice field rats population. This result and other studies showed that there is a diet disparity of barn owls reliant on the accessibility of food substances and the area. Munoz-Pedreros *et al* (2010) reported that the greatest consume prey of *Tyto alba* in Chile is *Oligoryzomys longicaudatus*, *Phyllotis darwini, and Abrothrix olivaceus*. This is inlined with other studies which suggest that *T. alba* is a potentially promising agent to control rodents biologically. Another study by Ajitha K.V. *et al* (2013) in Calicut India suggested that *Suncus murimus* is the favorite food of barn owls. A study in Tunisia resulted from the diet of *Tyto alba* lies dominantly (more than 50% of total prey biomass) of rodents and the three-toed Jerboa (*Jaculus jaculus*). It was also suggested that barn owls indicate a nonrandom propensity concerning rodents species predominantly little and early individuals (Leonardi and Dell'Arte, 2006). The predation rate of barn owls and other predators seemed also affected by the dense canopy of trees in the agroecosystem. Tobin *et al.* (1996) submitted that the chance of exposure of rice field rats to some potential predators such as

Table 4. Indications of Captured Rice Field Rats Population Using 100 M of 3 Nights Installed Linear Trap Barrier System (Ltbs) in Irrigation Rat Habitat of Rice Field Installed with Rubuha

Location/village	Numbers of captured rats *)	Numbers of captured snakes **)
Godean	9	3
Sedayu	3	2
Kalibawang	3	1
Minggir (control)	5	2

Remarks: *) The captured rat species is rice field rats (Rattus argentiventer), **) The captured snake species is rat predators (*Naja naja*) barn owl (*Tyto alba*), mongoose (*Herpestes javanicus*), and domestic cat (*Felis catus*) seemed reduced by canopy density of macadamia nut trees (*Macadamia integrifolia*).

There are no significant differences in the damage percentage between rice fields installed with rubuha (Godean, Sedayu, Kalibawang) and rice fields without rubuha (Minggir) as 33.33 – 48.67% (Table 5). This indicates that the installation of rubuha in the rice fields did not significantly reduce the level of rats attack.

Damage intensity of rice field ranged from 6.33% - 14. 89% show no significant difference between rice fields installed with rubuha and control, with an exception in Kalibawang site. Synchronous planting has been implemented in Kalibawang resulted from the reduction of excessive rat breeding compared with other sites. The lowest indications of rat relative population at this site were in line with the lowest percentage of crop damage intensity. Therefore, controlling rats with rubuha installation should be combined with other components of technology. On the other side, the highest percentage of crop damage intensity has occurred in Godean which is closely related to the results of the high rat relative population. The damage of rice crops may be affected by the availability of rice crop in unsynchronous planting pattern, that resulting rodent diet order. Eva ***et al.*** (2016) reported that the quantity and quality of rodent diets greatly affect their population. Varied landscapes with diverging cultural crops (maize, wheat, barley, alfalfa, rape, and sunflower) as well as in unplanted habitats (old orchard and herbs set-aside) influenced their order in food intake.

Table 5. Percentage of Damaged Area and Damaged Intensity of Rice Fields with Installed Rubuha

Location/village	Numbers of captured rats *)	Numbers of captured snakes **)
Godean	48.67 a	14.89 c
Sedayu	38.67 a	8.72 ab
Kalibawang	33.33 a	6.33 a
Minggir (control)	42.00 a	10.08 b

Remarks: Numbers followed by the same letters do not differ in the Duncan Multiple Range Test (DMRT) test of 0.05%

Effects of habitat, individual factors (age, sex, breeding, and body length), and kin plenty the quality of intake of food were also discovered. Under situations of higher rodent population density, they consumed food more affluent in nitrogen. Similar results were reported by Jacob *et al* (2003) and Brown et al (2005) regarding the move of rats in response to the change of food resources available in the rice farming system. Rats moved after harvest in a year from rice field into the village due to food accessibility, resulted less adult female rats that could be found in the field during the period of fallow. According to Tristiani ***et al*** (2003), male rats had larger ranges of home (3.20–3.24 ha) than females (2.51–2.34 ha) during the breeding season. These differences were not found in the nonbreeding period. Rats seemed nomadic and nests appeared dispersed randomly within ranges during the nonbreeding season. It was discovered that sharing nests between males and females were never found during the nonbreeding period. Based on the occupancy of habitat, rice fields were probably used for nest construction, feeding, as well as protection from predation.

For controlling determinations, it is essential to comprehend the factors that affect the commencing and termination of breeding, female breeding percentage, and fluctuations in abundance. It leads to the appropriate control actions, despite waiting for damage occurrence. In Yogyakarta, as well as other sites of Indonesia irrigated rice area, the main rodent pest species, *Rattus argentiventer* is affected by main crops (rice) growth and development (Leung *et al.*, 1999; Brown *et al.*, 2005; Douangboupha *et al.*, 2009). This research provides information on factors that control or regulate rice field rat populations and predation mechanisms that indicate population outbreaks. This information will support the improvement of rat-control practices, cheaper and less dependent on rodenticide. In some rat endemic damage areas of Yogyakarta, it is the main problem for smallholder farmers who have only 1-2 hectares or less, even 0.5 hectares in average. The patchy nature of rat damage on crops affected much to loss. If they conduct individually rat control on their land, it increases their cultivation cost. Regarding large home ranges of rice field rats (3 ha on average), the cooperative control of farmer groups on large areas (at least 50 hectares) is recommended.

CONCLUSION

The installation of rubuha in rice fields did not reduce the percentage of crop damage, however, the intensity of crop damage was significantly lower at rice fields installed with rubuha and implements synchronous planting (Kalibawang Village). The average of barn owls occupancy is low (≤20%). Rubuha was occupied with barn owls breeding. They make natural nests in several buildings in the villages around rice fields. Control rice field rats using one technology is not effective. The use of barn owls as rat predators should be combined with other control technologies according to the concept of integrated rat control (PHTT).

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