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Metallic light-based bird-repellent prototype to reduce paddy yield loss in Jatinangor, Sumedang Regency

Abstract. Munia birds (*Lonchura* spp.) are pests that attack paddy plants during the reproductive phase. The traditional methods of controlling birds are considered less effective because birds can adapt to the tools used. This study aimed to determine the effectiveness of a metallic light-based bird-repellent prototype to reduce paddy yield loss. The experiment was conducted in Cileles Village paddy fields, Jatinangor Subdistrict, Sumedang Regency, West Java Province, Indonesia. The effectivity of the prototype was tested by measuring the effective distance (m^2), counting the frequency of bird visits (number of visits), bird populations, and the level of paddy damage (%), and paddy yield (kg/64 m^2). The result of the experiment showed that 3 m was an effectual deterrent factor for the prototype, thus the tool can protect paddy plants with an area of 28.26 m^2. The frequency of bird arrivals in the treatment was 22.25 times, compared to 61.25 times in the control; the bird population in the treatment was 48.25 birds, while the control was 108.75 birds; the level of damage to paddy panicles in the treatment was 10.11%, compared to 37.79% in the control; and the production of paddy yield with the repellent was higher (33.37 kg/64 m^2) than the control (23.09 kg/64 m^2). This innovative prototype was potentially able to deter bird pests in the paddy fields.

Keywords: Antipredator · Bird deterrent · Paddy protection · Reflectors

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Introduction

Paddy (*Oryza sativa* L.) is an essential commodity for Indonesians. Statistics Indonesia (2022) states that the population in Indonesia currently reaches 278 million people and most of them use paddy as a staple food. Indonesia's population will increase over time, resulting in a greater demand for paddy (Nuriliana, 2021). However, efforts to increase paddy production in Indonesia have been hampered by several factors, including Plant-Disrupting Organisms (PESTs). According to Sumayanti (2021), birds are one of the pests that can cause direct damage to paddy plants during the generative phase.

Munia birds (*Lonchura* spp.) are grain-eating animals that can cause damage to paddy plants. According to Bari et al. (2021), munia birds that attack paddy plants consist of Javan Munia (*Lonchura leucogastroides*), Spotted Munia (*L. punctulata*), and White-headed Munia (*L.maja*) with an average body size of around 10-11 cm (Joshi, 2019). Munia birds show daily feeding activities by 16.9-44.69% and moving and resting activities by 35.9-65.2% (Dwijayanti et al., 2021). As a result of their feeding activities, munia birds can reduce paddy production by 50% and cause losses of Rp. 2,500,325/ha in Bogor City (Ziyadah, 2011; Ardjansyah et al., 2017).

Munia bird control in paddy crops can be applied using various techniques. In general, farmers use scarecrows or cans filled with gravel at an indeterminate distance and guarded for a full day (Ejiogu & Okoli, 2012). These methods are decreasing in effectiveness due to frequent use, and birds adapt to scarecrows or cans filled with gravel. Birds have antipredator traits that will be active when disturbed by shadows or sounds they are not used to hearing (Beauchamp, 2015).

Reflectors are one of the tools that can induce antipredator traits in birds. The reflector will reflect light and affect bird vision (Emerson et al., 2022). The use of reflectors will be more effective if combined with predator shapes and the addition of sound (Bishop et al., 2003). Currently, no studies evaluate the effectiveness of predator-shaped reflectors combined with additional sound in paddy fields to deter birds. Therefore, this study aims to evaluate the effectiveness of a metallic light-based bird-repellent prototype to reduce paddy yield loss.

Materials and Methods

Research site. The experiment was conducted from February to May 2020 in a farmer-owned paddy field in Cileles Village, Jatinangor District, Sumedang Regency, at 6°54'35.4 "S, 107°46'31.5 "E with an altitude of 750 m above sea level. The experiment was conducted during the dry season with an average wind speed of 10 km/h from the west direction. The area used for testing was a paddy field with paddy plants that had entered the generative phase (age ≥ 70 days) and had a high level of bird infestation. Each research plot measured 64 m² with a distance of 2 m between the plots.

Bird repellent preparation. The research uses an experimental method of comparing two means (Independent Samples t-test) consisting of two treatments, with the installation of repellent devices and without repellent devices (control). Each treatment is repeated seven times.

The repellent preparation was initiated by throwing away the top and bottom lids of milk cans. The outside of the can is covered with gold-colored foil paper 25 x 10 cm. A 2 m x 1 m metallic curtain was divided into two parts (1 m x 1 m) and attached to the inside of the can. The device is then attached with rattles and eye-shaped accessories to the top of the can. Five rattles (⌀: 1.8 cm) first be inserted into the u-shape wire with the hooked two ends to the top of the can to form the lip of the device.

The bird repellent was placed in the center of the paddy field by hanging it with a 2.5 m high pole (Figure 1a). A stake was placed per meter from the repellent device to mark the distance or radius from the center (Figure 1b). Sampling was carried out using the diagonal line method to represent each area of each radius.

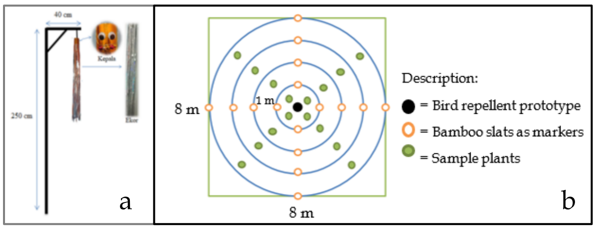

Figure 1. The shape of the bird repellent tool and its placement pattern. The shape of the bird-repellent tool. (a), the pattern of repellent placement, and paddy sampling (b).

Bird species identification. Bird species observation was conducted by directly observing birds attacking paddy plants and documented using an observation camera (yi outdoor camera 1080p). Bird identificationuses bird guidebooks (Field Guide Series of Birds in Sumatra, Java, Bali, and Kalimantan by MacKinnon et al. 2010).

Effective distance of bird-repellent devices. Observations were made using an observation camera and direct observation. The observation camera was kept in the corner of the research field to show all areas of the research field from 6:00 am to 06:00 pm. Observations of the effective distance of the repellent prototype were made by determining the distance at which birds visited paddy plants in the research plot and by counting the number of birds at each repellent radius. Observations of the effective distance of the repellent prototype were made by determining the distance at which birds visited paddy plants in the research plot and by counting the number of birds at each repellent radius.

Visit frequency and bird population. The frequency of bird visits was calculated by summing the number of bird groups visiting the research plots. Meanwhile, the bird population was calculated by summing up the total number of birds that came to the research plot area through a camera that had been installed every day for 12-hour observations.

Percentage of paddy damage. According to Ardjansyah et al. (2017), the level of damage to paddy caused by birds can be done by direct observers to the clumps marked as samples and then counting the number of intact and non-intact panicles. This calculation uses the following formula:

$$\% \text{ panicle damage} = = \frac{y}{x}\, x\ 100\%$$

Note:
y= Number of panicles attacked
x= Total number of panicles

Paddy yield. Paddy yield data was obtained at the end of the experiment. Paddy yield loss is determined using the following formula: Potential yield of the IR36 variety (kg/64 m^2 - production yield in the field (kg/64 m^2). Loss of harvest yield and harvest yield per plot are then compared between the treatment and control.

Data analysis. Data were analyzed using the Independent Sample T-Test method, an average difference test with two independent data that were repeated seven times. Subsequently, the data were statistically analyzed using Statistical Package for the Social Sciences (SPSS) software version 21.

Results and Discussion

Bird Species Identification. The type of bird that attacks paddy plants is generally the munia bird group (*Lonchura* spp.). Bari et al. (2021) report that Javan Munia (*L. leucogastroides*), Spotted Munia (*L. punctulata*), and White-headed Munia attack paddy plants (L. maja). The paddy planted in the research field is the IR36 variety. Based on observations, only Javan Munia was found attacking paddy plants in the research paddy fields (Table 1).

During the observation, birds flying in the study area were characterized by dark brown heads and tails, white bellies, and chests. These characteristics refer to the Javan Munia (*L. leucogastroides*) described in the Field Guide to Birds of Sumatra, Java, Bali, and Kalimantan by MacKinnon et al. (2010). Javan Munia can adapt to various habitats and has a rapid reproductive rate, allowing it to dominate the study area (MacKinnon et al., 2010). Other types of munia birds were not found. In addition, there were sparrows found in the yard area of residents' houses or perched on electric cables on the edge of paddy fields.

Table 1. Results of Bird Species Identification in the Study Area

Bird Species	Characteristics according to MacKinnon et al. (2010)	Observation Results
Javan Munia (*L. leucogastroides*)	The feathers are dark brown from the head to the tail, and the belly is white.	Found
Spotted Munia (*L. punctulata*)	The feathers are brown on the upper part of the body and white on the lower part, with spotted patterns on the chest and sides.	Not found
White-headed Munia (*L. maja*)	The feathers are dark brown from the neck to the tail, while the head to the neck has white feathers.	Nor found

The Javan Munia feeds primarily on grains such as paddy or grass seeds and uses large trees as nesting sites. Javan Munia is common in Java, Sumatra, NTT, NTB, and Bali (Coates & Bishop, 2000; Sulistyadi, 2010). This bird's feeding habits form groups in large and small numbers (MacKinnon, 1990). According to Hidayatullah (2015), the nesting characteristics of the Javan Munia are in trees with a height between 3.5-8 m, a nesting height of 1.5-4.5 m, and a canopy area of 2.5-109.7 m^2. Javan Munia utilizes soursop trees (*Polyalthia muricata*), mango trees (*Mangifera indica*), and water guava trees as nesting sites (*Eugenia aquea*).

Effective Spacing of Bird Repellent Prototypes. The bird-repellent prototype was placed at the center of the research field, and every one-meter distance was marked using a stake. Based on the observations, there were differences in the number of individual birds that attacked at each radius (Table 2).

Table 2. Javan Munia Population in the Treatment Field

Observation Time	Bird Population at Radius to... (birds)				Total (birds)
	0-1 m	1-2 m	2-3 m	3-4 m	
11 WAP	-	-	-	24	24
12 WAP	1	2	4	38	45
13 WAP	2	3	9	35	49
14 WAP	4	7	20	44	75

*WAP: Week After Planting

Table 2 shows that on the 11th WAP, the visitation of munia birds was minimal due to abundant food sources in the research area, leading the birds to evenly distribute their visits to other fields not designated for research. Additionally, the number of birds at each radius within the repellent treatment area varies. The number of individual birds at a distance of 3-4 m from the repellent had the highest value than at closer distances. This phenomenon happened because, at a radius of 1-3 m, flashes of light from the metallic curtain and the sound of rattles and strands of the metallic curtain can protected the paddy from bird attacks. These sounds and flashes activate the adrenal cortex, causing bird fear (Davis et al., 2008).

In addition, the presence of trees that served as bird perches around the research area caused birds to attack paddy on the side of the field closest to them (3-4 m from the repellent device). These results align with the research of Muslihun (2010), which states that the highest intensity of bird attacks occurred at the edge of the plantation at 62.23%, compared to the middle part at 29.54% and the middle part at 24.07%.

Arrival Frequency and Bird Population. Bird arrival frequency was lower in the treated plots compared to the untreated plots when using the bird-repellent prototype. Around the observation area, there are no various other types of plants that could influence bird behavior such as cassava plantation. It was observed that the birds did not cause any damage to the cassava crops. This could be associated with Milolo et al. (2023), that the birds able to not to eat crops due to the absence of food preference. Due to the paddy cultivation in the observation area, which is the primary preference of the Javan Munia, it will refrain from consuming other crops.

The total average arrivals frequency in the treatment plot was 22.25 times, while in the control plot was 61.25 times (Figure 2a). The average Javan Munia bird population in the treatment plot was 48.25 birds, while in the control plot reached 108.75 birds during the period (Figure 2b).

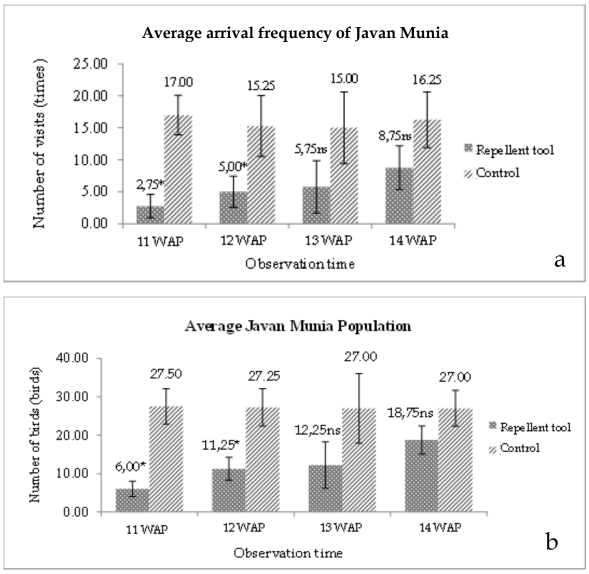

Figure 2. Arrival frequency and bird populations. Frequency of arrival of Javan Munia birds (a) and the average number of Javan Munia individuals (b) in paddy fields with treatment (prototype repellent) and without treatment (control).
Notes: (*) Significantly different. (ns) Not significantly different.

The lower arrival frequency and bird populations in the treatment field is thought to be because the repellent can trigger antipredator traits in birds. This trait can emerge when birds see artificial predators or sound generated from an object in the center of a field (Storms et al., 2022; Kasmawan et al., 2018). The prototype repellent used is thought to look like a predator, creating light reflections from the metallic paper like a reflector, affecting the birds' vision. This is consistent with the findings of Khan's (2014) study, which demonstrated that the number of crows visiting the wheat nursery decreased to zero after being treated with reflector tape. In contrast, the number of crows, parakeets, and mynah birds decreased in corn entering the milk maturity phase after applying reflector tape (Khan, 2014).

Paddy Panicle Damages. Based on the study's results, damage to paddy panicles in control plots fluctuated over time (Figure 3). Damage to paddy panicles at 11 WAP reached 28.95%, which was thought to be due to the paddy grains entering the milk ripening phase. This phase is the preferred phase of Munia birds, where the juvenile grain of paddy is chopped using their beaks, then the birds will suck the thick white liquid and then remove the empty seed coat (Bari et al., 2021). Panicles damage at 12 WAP decreased because due to the transition from the milk stage to the ripe stage. This makes it difficult for birds to eat the paddy.

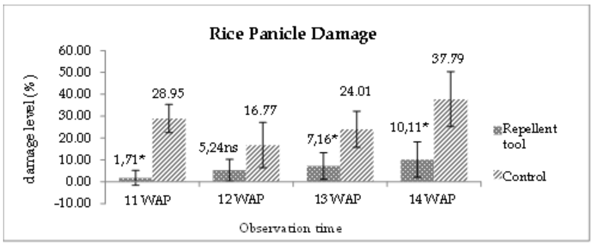

Figure 3. The average level of panicles damage by the Javan Munia bird.
Notes: (*) Significantly different. (ns) Not significantly different.

The use of the repellent prototype showed lower levels of panicle damage compared to the control. This is thought to be the effect of the combination of flashes of light, the sound of curtains blowing in the wind, and the sound of rattles that drove birds away from the study field. According to Bishop et al. (2003), adding sound in reflector-based repellents will be more effective in controlling birds. The panicle damage caused by birds in the prototype repellent treatment increased over time. This is thought to be due to the adaptation process of Munia birds to the repellent used. Javan Munia can adapt to various kinds of habitats and reproduce at a rapid rate, resulting in a gradual increase in paddy plant damage (MacKinnon et al., 2010).

Average Yield of Paddy. Using the repellent prototype affected the level of damage to paddy panicles, which correlated with the average of yield production. Paddy fields treated with the repellent prototype showed a significantly higher average yield than the control (Table 3). This phenomenon happened because the paddy plants in the control field were eaten by Javan Munia birds.

Table 3. Effect of using the repellent prototype on the average yield of paddy plant production

Treatment	Potential yield (t/ha)	Potential yield (kg/64 m^2)	Loss of yield (kg/64 m^2)	Paddy Yield (kg/64 m^2)
Prototype of repellent tool	5.8	37.12	3.75*	33.37*
Control	5.8	37.12	14.03	23.09

Description: (*) Significantly different.

The yield potential of the IR36 variety is 5.8 t/ha (Suprihatno et al., 2009) and converted to 37.12 kg/64 m^2. On 64 m^2 of research land, yield loss due to bird infestation in the prototype repellent treatment plots was lower than the control, which correlated with the number of yield productions. This is in line with research by Hardiansyah et al. (2023), which showed that the average yield of paddy can increase by up to 89% when using repellent compared to without repellent.

Conclusion

An innovative prototype repellent made from metallic curtains and rattles effectively controls birds that attack paddy plants. It could suppress bird visits up to 3 m. In addition, the repellent prototype reduced the frequency of visits and bird population in the study area. As a result, the panicle damage caused by the prototype repellent treatment plots was significantly lower than that of the control. In addition, the use of the repellent was able to produce higher average yields than the control in paddy plants.

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