Universal Journal of Agricultural Research 12(2): 342-346, 2024 http://www.hrpub.org
DOI: 10.13189/ujar.2024.120213

A Low-Cost Detector and Eviction Module for Agricultural Bird Pest Design

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Received December 22, 2022; Revised March 8, 2023; Accepted April 7, 2023

Cite This Paper in the Following Citation Styles

(a): *[1] Mustaqimah, Ramayanty Bulan, Zulfikri, Indera Sakti Nasution, Muhammad Idkham , "A Low-Cost Detector and Eviction Module for Agricultural Bird Pest Design," Universal Journal of Agricultural Research, Vol. 12, No. 2, pp. 342 - 346, 2024. DOI: 10.13189/ujar.2024.120213.*

(b): *Mustaqimah, Ramayanty Bulan, Zulfikri, Indera Sakti Nasution, Muhammad Idkham (2024). A Low-Cost Detector and Eviction Module for Agricultural Bird Pest Design. Universal Journal of Agricultural Research, 12(2), 342 - 346. DOI: 10.13189/ujar.2024.120213.*

Abstract Agricultural bird pest is generally regarded as the main problem farmers face due to their existence which can cause a decrease in the quality and quantity of agricultural products such as paddy. Most studies on agricultural bird pest control have neglected the design of the prototype without considering the economic aspect. This study aims to develop a low-cost detector and eviction module for agricultural bird pests using artificial sound from the predator of this bird pest. The method used in this research is to conduct experimental design, testing performance, and techno-economic analysis. The results show that the PIR sensor system is accurate enough to find bird pests and that integrated with speakers with artificial sound from its predator makes a big difference in evicting agricultural bird pests. The results showed that the developed module could work in 50 to 150 cm with a satisfactory success rate (maximum about 66.67 ±10.21%). In addition, technology development with components used in this study is less than the US$ 50 per module. This makes it possible to use this technology for paddy farmers in Indonesia because the cost per module of this technology is meager.

Keywords Appropriate Technology, Bird Pests, Farmer, Low-Cost, Paddy Field

1. Introduction

There are a lot of natural resources in Indonesia. Indonesia is an agrarian country because a lot of people there make their living from farming and agriculture. The majority of people in a country known as an agrarian country, especially rice farmers, make their living as farmers. When the rice plants are properly cared for, there will be a lot of what they produce. When farmers want to keep the crop's quality and quantity, they have to deal with a problem: birds that eat their crops [1, 2]. Birds eat plants that are about to be ready to harvest rice. Birds will eat rice grains that have already turned yellow, which will cause a direct loss of yield. Birds are also responsible for broken rice panicles. Birds do a lot of damage if the planting time is more than three weeks different from the other rice fields surrounding it. Sparrows from the Lonchura leucogastroides species (Figure 1) are the birds that usually cause the most damage [3]. They usually attack in groups of tens to thousands. Because of this, we need a device that can prevent birds from eating plants and keep an eye on the conditions near plants that birds eat.

There have been several studies on how to remove bird pests. Since the studies were done in closed rooms with objects that did not fly, the pests in the studies did not leave [4, 5]. Pests can be scared off by making noise, which can be shown to work. But getting rid of pests can only be used when the robot is in the problem area. It cannot be used on a large scale. In the same way, specific frequencies are used to scare away birds [6]. But the research went well because the trials were in the room and the birds did not make any noise. Whereas, if you want to use it in a paddy field (outdoors), it does not rule out the possibility that it will not work right if it disturbs birds often [1]. So, building

a wireless sensor network can be used in a rice field to keep an eye on birds that are a problem and eliminate them by making enough noise with a buzzer.

Figure 1. Agricultural bird pests (*Lonchura leucogastroides*) [7]

One urgent problem underlying research on detecting and evicting agricultural bird pests is the need to find effective, sustainable, and non-toxic methods for controlling pest populations. This is important to protect crops and prevent economic losses for farmers. Integrating artificial sounds from the pests' predators into this research can be a promising approach, as it can help to repel pests without the use of chemicals or other harmful methods [8, 9]. However, there are several challenges that need to be addressed in order to make this approach effective, such as determining the most effective sounds to use and how to deliver them in a way that will be most effective in repelling pests. Additionally, research is needed to understand the potential long-term effects of using artificial sounds in this way on both the pests and the ecosystem as a whole.

The problem in this research is how to develop a low-cost portable system for detecting and evicting agricultural bird pests integrated with artificial sound from its predators, which can then be used in paddy fields. Unfortunately, until now, no one has reported developing a portable low-cost system for detecting and evicting agricultural bird pests integrated with artificial sound from its predators. Some articles only focus on developing detectors and actuators without considering the economic aspects [10-12]. The novelty of this article is the development of detectors and actuators considering the economics of killing agricultural bird pests integrated with artificial sound from its predators. Therefore, this paper provides research on developing a portable low-cost system for detecting and evicting agricultural bird pests integrated with artificial sound from its predators. This study explores, for the first time, using artificial sound from its predators and considering the economic aspects of the module that was developed so that it can be affordable if it is applied by rice farmers, especially in Indonesia.

2. Materials and Methods

Bird repellent tools use several important steps in the manufacturing process; the first step is to prepare tools and materials. In assembling the tool, the primary step that must be considered is initializing the microcontroller on the electronic components. Then, the jumper cable is connected between the arduino and the PCB board as the media for the connecting course. The df player module is used as a medium for storing artificial sound from its predator (in this study using from eagle bird) in the form of MP3, which then becomes the speaker's sound output [12, 13]. The Passive InfraRed PIR sensor is connected to the Arduino as an object reading. After everything is done, the next step is assembly.

The tool performance test procedure is carried out to ensure that each component used in this study is expected to work well. This test is carried out by testing the hardware, namely, the circuit on the board connected to the Arduino UNO and the Passive InfraRed (PIR) sensor where this test concludes whether the sound output of the eagle can repel sparrows properly and observe the results of the flight distance of birds.

The test design of the developed module is presented in Figure 2. In this study, three spacings (50, 100, and 150 cm) with four caged agricultural bird pests (species *Lonchura Leucogastroides*) caged in cages were used. The test is carried out in a conditioned room so that external factors that cause the bird to be disturbed or the sensor to be disturbed can be ignored. The bird movements recorded by the sensor are then recorded as data to be analyzed to determine the success rate of the developed module. The test was repeated six times for each treatment. Furthermore, the cost of each component that composes the module is calculated to catch the total cost of the developed design module.

Statistical analysis was performed in a randomized factorial design using one-way analysis of variance (ANOVA) to determine the effects of modules of different ranges on success rate. Data testing was presented in means ± standard deviations. Tukey's test determined significant differences in the data at an alpha of 5%. Meanwhile, significant differences in the ranges module method data were determined by the independent sample t-test at an alpha of 5%.

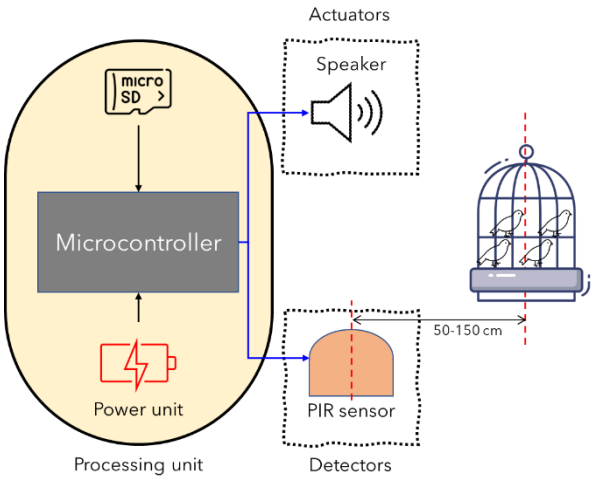

Figure 2. Schematics of testing module

3. Result and Discussions

3.1. Performance and Evaluation of Devices

Arduino Integrated Development Environment (IDE) is open-source software that develops programming sketches according to the expected program flow and has been widely used in previous studies [14, 15]. In this software design, a library stores the programming to be executed by a detector in the form of a PIR sensor and an actuator in the form of a speaker that emits artificial sound from the predator agricultural bird pest. The software programmed through the Arduino IDE application aims to provide instructions to be able to operate the hardware that will be designed. According to Paper [16], arduino is the go-to platform for interactive hardware and software projects. Arduino code may operate an Arduino board linked to a breadboard with inputs, sensors, lights, and displays.

The PIR sensor performs a continuous detection process until there is a movement of agricultural bird pests in the range of 50 to 150 meters. The Passive Infrared sensor (PIR) is employed to measure the detection of incursion in fields and has been widely used in previous studies [17, 18]. The suggested system utilizes the HC-SR501 PIR sensor. This sensor requires a minimum of 5v and a maximum of 20v in order to operate. It has three pins and is compatible with the Arduino board. VCC is intended for voltage control. GND PIN and OUT PIN are used to ground the sensor and receive output from the sensor, respectively [19]. As a microcontroller that obtains information from the PIR sensor, Arduino UNO will forward it to the actuator unit. The speaker will output artificial sound from the agricultural bird pest. Furthermore, if the PIR sensor detects bird movements, it will send data to the Arduino, which is then processed on the microcontroller so that it outputs artificial sound from the agricultural bird pest predator through the speaker that the agricultural bird pest fears.

The detector and eviction module test using artificial sounds from agricultural bird pests is presented in Figure 3. It can be seen that the developed low-cost module can work well in the range of 50 to 150 cm with a success rate range of 45.83±20.41% to 66.67±10.21%. The results of the ANOVA test ($p<0.05$) also found that there was no significant effect between the success rate and the distance from the sensor applied in this study. The best range is that the distance between the module and the agricultural bird pest is 50 cm. This shows that the PIR sensor capabilities in this module suggest that the distance between the object and the module must be 50 cm to achieve its effectiveness. This is different from that performed by Ramadhan, et al. [1] placing the PIR sensor at a distance of 12 m, so it is necessary to generate a buzzer with a frequency of 1500 Hz. A detector and eviction module test using artificial sounds from agricultural bird pests involves simulating the calls and vocalizations of these pests in a controlled environment and monitoring the response of the module. The purpose of the test is to evaluate the effectiveness of the detector in identifying and locating the simulated pests, as well as the ability of the eviction module to deter or remove them. This type of testing can provide valuable information for farmers and other agricultural professionals looking to protect their crops and property from damage caused by bird pests.

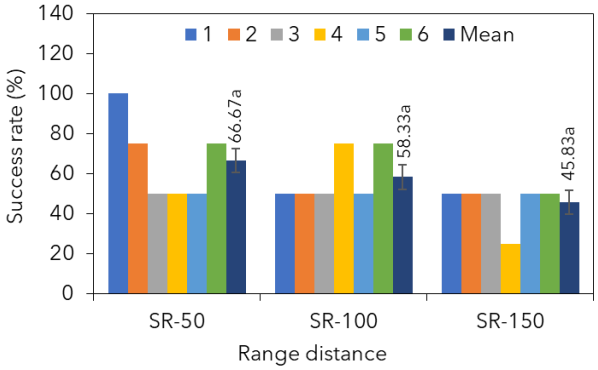

Figure 3. Performance test detector and eviction module using artificial sound from the predator agricultural bird pest

3.2. Techno-economic analysis of device

New research, innovations, and applications for low-cost technology have already been reported in several studies that have evaluated this sort of technology for agricultural monitoring [20-22]. These technologies are easy to use and, in the majority, provide quantitative information about agriculture that can support success in increasing productivity. The list of components used in the design of the portable system to detect and evict agricultural bird pests integrated with artificial sound from its predator unit is shown in Table 1. The capital cost for the construction and installation of this system is less than US$ 50 per module. This cost is lower than that of other low-cost systems, such as that by Putra [23] and Pramono, et al. [24], which is a portable sensing system for US$ 130 and US$ 130.7, respectively.

Table 1. Pricelist and components (as of June 2022)

#	Component	Quantity	Price unit (US$)	Remark
1	Arduino	1	22.81	IDE UNO, 5V, 40mA
2	Sensor passive infrared receiver (PIR)	1	2.85	
3	Mini speaker	1	2.85	5V DC, 350–4500 Hz
4	Toggle switch	1	2.00	
5	Battery	2	3.42	1100mAH
6	Sensor cable	1	1.43	
7	Connector	1	0.71	
8	PCB	1	1.43	
9	Terminal baterai	1	1.43	
10	Micro SD card	1	5.07	DFR0229
11	Memory card	1	4.56	1 GB
Total			48.55	US Dollars

4. Conclusions

This paper has shown a new portable and low-cost system for detecting and evicting agricultural bird pests integrated with artificial sound from its predator. The developed module has been tested with a success rate range of 45.83 ±20.41% to 66.67 ±10.21% in the field of 50 to 150 cm. Although there is a difference in the success rate due to the range of sensor distancing from agricultural bird pests, the ANOVA test (p<0.05) found no difference in these parameters. However, to get the maximum success rate, the use of a distance of 50 cm is highly recommended from the results of this study. The development of this portable system costs less than US$ 50 per module. The most important limitation is that it is important to test this system directly on the field of paddy to see the performance in the field. Therefore, future research should consider the possible effects on the environment so that this module is tested before it can be widely used by rice farmers, especially in Indonesia.

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