The Efficacy of Visual and Auditory Bird Scaring Techniques using Drone at Paddy Fields

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Abstract. Birds can cause damages to crop and financial losses to farmers and able to spread exotic diseases such as Avian influenza and Newcastle disease to human. Numerous methods have been used in controlling birds, e.g. chemical, auditory, visual and lethal. In this research, visual and auditory methods were applied, where reflective boards and speaker were installed on a drone and were flown at different altitudes and intervals. The scaring approach were divided into five (5) categories; reflective board only, ultrasonic sound, predator sound, combination of reflective board and ultrasonic sound and combination of reflective board and predator sound. The test was conducted at a paddy field plot, Botanical Park, Shah Alam. The findings indicate that combination of visual and auditory techniques scared the highest number of birds. However, the effectiveness gradually decreases as altitude increases. The interval of flight does not show any correlation with the number of birds that flew away. It is recommended to conduct future research far from residential area due the sound from the drone and auditory devices which cause disturbances to residents. Future experiments should be conducted in a control environment, free from human and ground vehicles interruption in order to have better observations on the efficacy of the chosen methods.

1. Introduction

Damages to crops cause by birds can cause substantial losses to agriculture industry. Farmers perceived the losses are more than the estimates made by surveys of crop damage bird food requirements [1], [2]. In the USA, it was estimated a loss of $50-$200 per acre for apple crops and from $1000-$5000 per acre for seasonal crops like blueberries [3]. The estimated losses were based on consumption, product losses which include partially eaten, crops felt on ground, or contaminated by fecal droppings.

Besides that, birds also consume fish in aquaculture ponds, bees from hives, livestock food from feed lots, and pose risk to aircraft strike. They also can spread exotic diseases to human such as Avian influenza and Newcastle disease [4]. Birds are able to spread disease to other animals who consumed the infected fruits. Starlings and other pest birds are implicated of transferring disease to cattle [5]. These issues cause concern not only to farmers but also consumers, because the disease could be transmitted through the consumption of contaminated food products.

There are several methods that have been used in bird management control either to reduce the population, deter or scare them from eating and damage the crops. These methods can be categorised...
into; lethal control, habitat modification, physical exclusion, chemical deterrents, auditory deterrent, and visual deterrents [6].

Lethal control methods permitted are by shooting, a cage trap, and/or net (hand-propelled). Shooting are divided into two different approaches; shooting to kill and shooting to scare. Shooting efficacy depends on a number of factors; the target species, site characteristics and shooting regime. It is more effective at smaller site, and the number of consecutive days and shooting parties have an effect on the reduction of bird numbers [6]. However, the reduction in numbers is limited, because birds able to evade shooters, and this technique is expensive, and time-consuming [7]. Live trapping is not cost effective either. Trapping birds to help in reducing the population but not significantly able to reduce the damages to crop [4].

Habitat modification involves removal and/or alteration of habitat features. Typical actions include trimming or cutting trees, removal of puddles or ponds, revegetation of barren areas and allowing grass to grow taller especially near airports. Brough and Brigman [8], reported that longer grass was found to be successful at reducing the number of birds [8]. This technique is expensive, especially in grass maintenance. It is effective in reducing the number of birds rather than elimination of birds [6].

As for physical exclusion methods, netting is commonly use in vineyards. It is also used to prevent birds eating the fishes from aquaculture farm. However, it is not suitable if the covered area is large because the cost of netting will be expensive. Another disadvantage of nets is that they are easily damaged by wind or bad weather and if there are any rips or tears, it will allow birds or other small animals to exploit the crops. Netting also requires frequent maintenance. Overall, netting is an effective method in preventing birds damaging the crops but it is dependent on proper installation and maintenance, thus it is only practical for small scale agricultural area [6].

Chemical deterrent can be categorized as tactile, behavioral and taste repellents. Tactile repellents are sticky substance which repel birds from sitting on perches, ledges, antennas or signboards. To apply the sticky substances on the identified ledges and perches are laborious, and the stickiness is not long lasting [9]. Behavioural repellents such as Avitrol can be classified as toxicants which cause disorientation and erratic behaviour to birds. They are usually added to bait and upon consumption, the birds will emit distress call and exhibit erratic behavior which frighten other birds. It can be lethal if too high dose was ingested. Permits are required and agent must be administered by the authority [9]. As for taste repellents, they are divided into primary and secondary repellents. Primary repellents smell or taste offensive, and secondary repellents can cause illness after ingestion. Primary repellants are derived from natural products while secondary repellents are from synthetic agrochemical pesticides. Secondary repellents are considered more effective form of deterrent [6].

Auditory deterrent methods are scaring stimulus such as loud noises detonated from guns, cannons, modified rockets, firecrackers, or high intensity sound transmitted from sonic devices such as recorded bird alarm, distress calls, ultrasonic and predator sounds. The auditory methods found to be effective due to loud noises which provoke fear response from birds [10] and birds’ instinct to avoid danger. However, these methods are labour intensive and noise transmitted from explosions and audible bird scare devices are considered as nuisance to residents and also birds can become habituated to them unless they are varied regularly [11].

The common visual deterrent methods used are scarecrows, reflectors and reflecting tapes, predator model, gull model, kites and balloons. Based on the literature compilation of stationary visual deterrents by Transport Canada [9], their effectiveness are short term. Introduction of falconry, where trained falcons and hawks are used to chase birds from specific areas was found successful and effective [12] but must be conducted by well-trained dedicated falconers, and not suitable during high winds or heavy rains and at night [9].

Based on the research findings by Bishop et.al. [9], in terms of effectiveness of different categories mentioned above, habitat modification, lethal techniques and exclusion appeared to be more consistently effective than auditory, visual and chemical methods. However, since only one investigation was conducted on habitat modification and five experiments on exclusion, therefore it required further investigation to conclude the efficacy of these methods. As for cost effectiveness, exclusion method was rated to be most expensive followed by chemical techniques. Visual and auditory methods are less costly. It was also highlighted that combinations of techniques, used in
integrated control strategy are considered more effective than techniques apply using single method [6], but lack of references to back up the scientific evaluation.

The latest technology used in deterrent and scaring strategies is the utilisation of unmanned aerial vehicles (UAVs) or drones. The experiments using UAVs or drones in bird management are becoming popular among researchers, industries and farmers. UAVs have been used to replicate natural predation. Falconry as mentioned above was found effective but expensive control method since it requires professional falconers and multiple predatory birds, making it becomes uneconomical to utilize this method to manage large area. Whereas, UAVs now are becoming more affordable to own and the cost of operators can be reduced with autonomous technologies. UAVs can easily be programmed and has the advantage of covering large vineyards or agriculture land in within a short duration compared to ground vehicles. Biomimetic design was incorporated on UAVs such as appearance mimicking, replicating wing flaming motion, broadcasting predatory cries and imitating predatory behavior [13].

Wandrie et. al [14] experimented with fixed-wing and rotary-wing UAVs at different altitude flown over captive and free-ranging blackbirds. Fixed-wing results show that the birds were not afraid of fixed-wing but responded to approaches by rotary-wing at low altitudes [14]. A hexacopter multirotor drone equipped with horn tweeter and crow taxidermy was used to scare the birds psychologically as though a crow was caught by the UAV and emits distress call. The drone was flown manually, and the effectiveness was evaluated based on the number of birds before and after the flights in relation to radius covered and duration of influence. The findings indicate that there was significant reduction of silvereye birds after the UAV was flown but it could not completely chase away all the birds after each flight [15].

The aim of this research is to conduct an experiment on birds’ activity at the paddy fields in Malaysia, and evaluate the efficacy of drone equipped with speaker to broadcast the predator and ultrasonic sound, and reflective tape in chasing the birds away after flight. The important parameters to be determined are the effectiveness of the scaring methods, the influence of flight intervals and altitude.

2. Methods
The bird scaring experiments were performed in 2018 at paddy field plot, Botanical Park, Shah Alam, Malaysia. The size of each plot is about 65 x 45 meters (refer Figure 1). Paddy field is a place of interest of sparrows since rice is the main crop eaten by sparrows. Sparrows are categorised as major pest birds due to their ability to cause localised damage to the grain fields as they feed in large numbers over a small area. Sparrows are host of some parasites and diseases, like Chlamydiosis, Salmonellosis, Mycoplasma diseases, protozoal diseases and internal parasites like roundworms and tapeworms [16].

![Figure 1. Selected study area: Paddy field at Botanical Park, Shah Alam](image-url)
the captured images. The auditory and visual deterrents devices were selected for this study. Ultrasonic and predator sound were used as the auditory deterrents and for the visual deterrent, a reflective board of a size 0m x 0.1m with a thickness of 2mm was used. The JBL Go speaker which is light (130 grams) and small was found suitable to be used as the medium to broadcast the ultrasonic and predator sound and attached on the drone.

The experiments were divided into five (5) categories, and Figure 2 shows the attachment of the reflective boards and speaker on the drone:

i. Reflective boards only - The drone was attached with reflective boards at each end of the drone landing gear. They were suspended freely using paper rope.

ii. Ultrasonic sound only - The speaker was connected with MP3 player using 3.5mm audio jack cable and playing ultrasonic sound for a period of time. It was suspended using a double-sided tape glued on the drone.

iii. Predator sound only - The cried predator sound was broadcasted from the speaker.

iv. Reflective boards and ultrasonic sound - Both reflective board and speaker were attached to the drone. The speaker broadcasted the ultrasonic sound and the board reflected the sunlight.

v. Reflective boards and predator sound - Same as in iv, except the speaker was broadcasting predator sound.

Figure 2. The application of drone with, (a) reflective board only, (b) reflective board and speaker, (c) speaker only

2.1. Experiment design
The initial experiment was conducted for six (6) consecutive days in late April 2018 between 9.00 am -12.00 pm. These hours were chosen because from earlier observations and advice from the wildlife authority, the birds were most active during those hours. No baits or feed were used to attract the birds to the testing site.

The preparation of the drone equipped with the scaring devices was done early in the morning before the birds became active at the paddy field. Once the drone was ready to fly, the investigator measured and recorded the surrounding ambient sound level using the digital meter and the initial number of birds around the paddy fields were also recorded.

There are three (3) flight time intervals of flying the drone; every four (4) minutes, 10 minutes and random. The drone was flown at the height of five meters (m) and 10 m. For the case of four (4) minutes interval, the first time the drone flown in the air, it is recorded as 0 time, and the number of birds flown away were recorded. The investigators observed and recorded the number of birds at the paddy field for the next four (4) minutes. The drone was deployed again after four (4) minutes and the number of birds was flown recorded again. As the for 10 minutes interval, the first time the drone flown was set as 0 minute and the number of birds flew away are were counted. The investigator
recorded the number of birds observed at the paddy field. The drone was flown again after the next 10 minutes and the number of bird flown were recorded again. As for random intervals, the drone was flown randomly and the number of birds flew away were recorded every time the drone was flown. Figure 3 shows the process flow involved in the experiment. The same process flow was repeated again at 10 m height. The difference between the number of birds before and after flights provided an indication of the effectiveness of these methods.

![Flowchart](image)

**Figure 3.** The process flow of the experiment

The number of birds flew away caused by other disturbances were also recorded during the 10 minutes observation. As the paddy field is situated in a public park, it was not possible to stop public from passing through the test area. However, it was interesting to see whether ground disruptions have greater impact in chasing the birds away.

### 3. Results

It was difficult to have the same number of birds to begin with as the reference since it was free-ranging study. As the initial number of birds observed were not the same for each type of experiments, therefore observed number of birds flown away were tabulated in percentage. Figure 4(a) shows the percentage of bird that flew away at the height of 5m, whereas Figure 4(b) is the result for the altitude of 10m. It is quite apparent that at higher altitude the effectiveness of scaring the bird for all the methods has decreased.

The results shown indicated that random flights for both altitudes seem to record lower percentage of birds flew away. This could be the factor that the birds are becoming immune to the drone flying around the paddy fields, and learnt that it would not harm them. Among all the five (5) devices used in this experiment, combination of reflective boards and ultrasonic/predator sound showed a slightly consistent result on the percentage of birds flown away except for the random flight at 10m height.

As the paddy fields are accessible to public, therefore other interferences on the ground such as movement of human, wind, and vehicles e.g. lorry, car, motorcycle, van or bicycle affect the number of initial birds during observation period.
*RB = Reflective Boards
*Ultra. S = Ultrasonic Sound
*Pred. S = Predator Sound
*RB+Ultra S = Reflective Boards and Ultrasonic Sound
*RB+Pred. S = Reflective Boards and Predator Sound

**Figure 4.** The percentage of bird flew away at different flight interval at the height of (a) 5m (b) 10m

The percentage of birds flew away for 5m and 10m heights were combined and the average was calculated to reflect which methods is most effective in scaring the birds away. Figure 5 shows the average percentage of the number of birds flew away compared to the percentage of birds flew away caused by ground disturbances.

*RB = Reflective Boards
*Ultra. S = Ultrasonic Sound
*Pred. S = Predator Sound
*RB+Ultra S = Reflective Boards and Ultrasonic Sound
*RB+Pred. S = Reflective Boards and Predator Sound

**Figure 5.** The mean percentage of birds flew away (a) for different methods b) different types of ground disturbances

Figure 5(a) shows the highest percentage of bird flown away are from the combination of reflection boards and auditory sound (ultrasonic and predator) with 22%, and followed by ultrasonic sound (21%). The predator sound seems to score the lowest (16%), but the result cannot be conclusive to state that this method is not effective because predator sound recorded the highest percentage during...
the testing of four (4) minutes interval (refer Figure 4a). Figure 5(b) shows that ground disturbances seem to have almost equal percentage among the sources. This probably mean that scaring the birds from the ground is more effective due to the sound emitted by large ground vehicle such as lorry is louder compared from the air, thus it is able to scare more birds.

3.1. Sound Level Measurement Analysis

The sound level measurement is usually used to limit the noise level from harming human. However, in this research, the sound level is measured to classify its subjective effect and community respond toward the sound produced from bird scaring methods. In order to measure the sound level difference between ambient sound and noise source, the following formula (1) is used [17].

\[
L_{\text{diff}} = 10 \log \left[ \frac{10^{L_{p1}/10} - 10^{L_{p2}/10}}{10^{L_{p1}/10} - 10^{L_{p2}/10}} \right]
\]

\((1)\)

L\(_{\text{diff}}\) is calculated by subtracting the sound level recorded with noise source and ambient sound. L\(_{p1}\) is the noise source produced by each method, while the L\(_{p2}\) is the ambient sound level. Once the value of sound level difference has been obtained, the subjective effects are referred to Table 1 [18].

| Change in level of dBA | Subjective Effect |
|------------------------|-------------------|
| 3                      | Just perceptible  |
| 5                      | Clearly perceptible |
| 10                     | Twice as loud     |
| 20                     | Much louder       |

Referring to Table 2, at the height of 5 m, the sound produces to scare the bird can be considered as very loud, but at the height of 10m, the sound level has been slightly reduced. Thus, it shows that the effectiveness of scaring techniques have been reduced as the drone’s flying height increased.

| Noise Source with Drone Application | \(L_{\text{diff1}}\) (dBA) | \(L_{\text{diff2}}\) (dBA) | \(L_{\text{diff3}}\) (dBA) | Subjective Effect |
|-----------------------------------|--------------------------|--------------------------|--------------------------|-------------------|
| h = 5m                            |                          |                          |                          |                   |
| Reflective Board                  | 12.9*                    | 12.8*                    | 9.7                      |                   |
| Ultrasonic Sound                  | 11.5*                    | 13.6*                    | 19.9*                    | *twice as         |
| Predator Sound                    | 16.5*                    | 12.1*                    | 10.3*                    | loud              |
| Reflective Board and Ultrasonic Sound | 16.8*                    | 9.6                      | 10.4*                    | (≥10 dBA)         |
| Reflective Board and Predator Sound | 13.8*                    | 15.4*                    | 11.3*                    |                   |
| h = 10m                           |                          |                          |                          |                   |
| Reflective Board                  | 11.7                     | 8.2*                     | 6.9*                     | *clearly          |
| Ultrasonic Sound                  | 9.2*                     | 8.2*                     | 3.2*                     | perceptible      |
| Predator Sound                    | 6.3*                     | 3.7*                     | 7.1*                     | (≥ 5dBA)         |
| Reflective Board and Ultrasonic Sound | 9.1*                     | 10.8                     | 4.8*                     | but               |
| Reflective Board and Predator Sound | 8.7*                     | 13.4                     | 5.5*                     | <10dBA            |

\*\(L_{\text{diff1}}\) = Change in level of dB(A) between ambient sound and noise source when drone flying every 4 minutes
\*\(L_{\text{diff2}}\) = Change in level of dB(A) between ambient sound and noise source when drone flying every 10 minutes
\*\(L_{\text{diff3}}\) = Change in level of dB(A) between ambient sound and noise source when drone flying every random minutes
4. Conclusion and Future Research

This study proposes a low-cost and non-lethal bird scaring methods to scare the birds away at the paddy fields. In conclusion, incorporating visual and auditory devices on a drone create a new dynamic approach for bird control method. The short-term responses from the birds indicate that the drone can potentially be used to scare birds away, but it must be carried out continuously. It was found that ground vehicles interferences have immediate effect in scaring the birds at the paddy fields, thus combination of air and ground methods should be looked further in the future.

For the percentage analysis, results indicated that combination technique of reflective board and ultrasonic/predator sound are more effective compared to single device. However, with increased of flight altitude to 10m, the effectiveness showed reduction. For the drone’s flight time interval, it was found that the flight times have no significant difference to the number of bird that had been chased away. This is perhaps due to uncontrolled environment, where the number of initial birds during the experiment for each technique was different. The weather such as wind and rain also have an effect on the number of birds, where certain days during the investigation have less number of birds and some days have more birds.

The ground vehicles or human that passed through the park, chased away birds during the observation periods, thus affect the number of birds counted. Finally, sound level measurement showed that the noise emitted by the drone and the auditory devices can cause noise disturbance and annoyance to humans.

Therefore, the bird scaring method using drone are recommended to be implemented far from residential areas. For future studies, it is recommended that the bird scaring method to be carried out in a controlled environment where the initial number of birds can be assumed constant, and no interferences from ground vehicles or human. It is recommended that future research employed ground and air methods simultaneously equipped with several other visual and auditory scaring devices.

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