



Unmanned aerial systems (UAS) for mitigating bird damage in wine grapes

Santosh Bhusal¹, Kapil Khanal¹, Manoj Karkee¹, Karen M. M. Steensma², and Matthew E. Taylor³

¹Department of Biological Systems Engineering, Center for Precision and Automated Agriculture Systems, Washington State University, Prosser, WA, ²Department of Biology and Environmental Studies, Trinity Western University, Canada, and Department of Animal Science, Washington State University, Pullman, WA, ³School of Electrical Engineering and Computer Science, Washington State University, Pullman, WA

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Abstract. *Bird predation is a significant problem in high-value fruit crops, such as apples, cherries, blueberries, and wine grapes. Conventional methods such as netting, falconry, auditory scaring devices, lethal shooting, and visual scare devices are reported to be ineffective, costly, and/or difficult to manage. Therefore, farmers are in need of more effective and affordable bird control methods. In this study, two UAS was used as a bird-detering agent in a commercial vineyard. The experimental design consisted of six days of UAS flights and eight days of control observation (no UAS flight) alternated in an interval of two days, for a total of a 14-day experiment. On each of the flight days, a Matrice M600 Pro was flown over the field for approximately five hours supported by Phantom 3 Standard during the battery swapping of Matrice M600 Pro. Birds flying in and out of the field along the edges of the field were recorded using two different GoPro Hero 5 cameras. It was found that there was a significantly lower number of birds during the UAS cycles compared to those during the control cycles.*

Keywords.

Bird deterrence, unmanned aerial systems (UASs), vineyards, bird count

Introduction

Pest bird predation is a significant problem in high-value specialty crops such as apples (Lindell et al. 2016), cherries (Lindell et al. 2012), blueberries, and wine grapes (Curtis et al. 1994). Bird damage to fruit crops compromises both fruit yield and fruit quality. Damaged fruits will attract insects, and contribute to spreading diseases (Bomford and Sinclair 2002). It is estimated that US fruit growers lose hundreds of millions of dollars every year due bird damage and also in expenditures to mitigate those damages (Anderson et al. 2013). As fruits ripen, a number of birds attracted to the fruits will rise exponentially. A number of bird management techniques are available for protecting fruits against bird damage (Tracey et al., 2007; Steensma et al. 2016). These conventional methods such as netting, falconry, and scare devices have failed to meet the growers expectations as they are ineffective or are too costly to implement (Elser et al. 2016). Growers are in a need of more reliable means for affordable pest bird control (Anderson et al. 2013).

Recently, UAS has also been investigated for bird deterrence in agricultural settings (Bhusal et al. 2017; Goel et al. 2017). The main objective of this study is to develop a UAS-based automated bird deterrence system for mitigating bird damage in vineyards. Results from the previous study by the authors showed that a UAS flown in a random pattern and accompanying distress call can significantly reduce the number of bird activities (Bhusal et al. (submitted manuscript) 2018). That study was conducted with a smaller UAS covering only a small portion of a vineyard (30m by 30 m). The current study assessed the effectiveness of the UAS-based bird deterrence system using a larger and noisier aerial platform covering a much larger area of the same vineyard so that practical adaptability of the system could be established.

Materials and Methods

Experimental Site:

The experiment was conducted in a commercial vineyard (*Cabernet Sauvignon* wine grapes) located in Prosser, WA. The vineyard plot was about 15,000 m² (~3.75 acres). There was a canyon right next to the plot in the west and southwest corners of the plot with a lot of trees providing shelter/perch for hundreds of birds like Starlings and Robins. Water was available for birds from a river and an irrigation channel located in the south of the field within ~300 m. No other bird management techniques were implemented in the field by the grower. Fig 1 shows the sample example of bird damage in one of the vine.



Fig 1. A sample vine showing berry damage caused by the pest birds in the experimental field.

UAS Platform and Experimental Design

Matrice M600 Pro (DJI Inc., China) (Fig 2) was the UAS platform used for the experiment. UAS flight was limited to 3-6m above the canopies. The experimental design consisted of six days of UAS flight (called “a UAS cycle”) and eight days of control observations (also called “a No-UAS cycle”), alternated at an interval of two days, for a total of a 14-day experiment. On a flight day, the UAS was flown for around five hours so as to keep the birds away from the field during the peak bird activity time in the morning and evening. When Matrice was down for battery swapping, Phantom 4 (DJI Inc., China), which is a much smaller UAS platform, was flown to continue patrolling the plot.



Fig 2. GoPro Hero 5 camera and Matrice M600 Pro UAS in the scene used during the experiment. Trees in the background provided shelter for the birds feeding to the vines in this plot.

Southwest corner of the field was used for video surveillance of the field because more damage was observed in this corner than any other parts of the field since last two years (Bhusal et al. 2018). Also, the previous study by the authors had shown that 75% of bird activities observed in the southwest corner enter and exit from the south and the west boundaries and perch in the trees nearby. Incoming activities of birds were recorded using two GoPro Hero 5 cameras (GoPro Inc., USA) at 1080 pixel resolution and 30 frames per second. Videos were recorded only in the evening time for three hours each day. These videos were analyzed automatically to estimate the number of incoming birds using a bird detection and tracking technique described in Bhusal et al. (2017). Continuously recorded videos were split into 4GB chunks. Each of these individual videos was treated as samples for counting incoming birds.

Results and discussion

All the incoming bird count obtained from each sample videos during the UAS cycle and No-UAS cycle were grouped separately. Statistical analysis was carried out to find if the number of bird count during the UAS cycle and No-UAS cycle was significantly different. Analysis of Variance (ANOVA) was used for comparing the number of incoming birds using Microsoft Excel. Since the distribution of bird count data did not follow the normal distribution and equal variance assumption, count data were transferred into the natural logarithm scale for statistical analysis (Ramsey and Schafer 2002).

Birds feed actively (up to 80%) during three hours in the morning and three hours in the evening. So, the number of birds estimated by the machine vision system was used to estimate the daily bird inflow activities assuming birds feed actively for 7 hours (assuming one additional hour from inactive feeding time). Figure 3 shows the number of incoming birds estimated by the machine vision system over the experimental duration on daily basis. From the plot, it is evident that the number of birds coming to the field when UAS was flying (UAS Cycle) was much smaller than those without UAS flights (Control Cycle). The number of birds during the UAS cycles (mean \pm SE = 45 ± 6.00) was significantly different than the mean over control cycles (mean \pm SE = 67 ± 6.09) (One-way ANOVA, $F_{1, 280} = 6.25$, P-value = 0.01).

As seen in Figure 3, the bird count dropped for every UAS cycle and it increased during the control cycle. More than 1,000 birds were found to be entering into the field during the control cycle while slightly more than 500 birds enter into the field daily when UAS was used, which is 50% reduction in a number of birds. Based on the estimated number of birds on the UAS days, the bird does not seem to get habituated with the UAS platform. However, the nature of this study is not sufficient to make any specific conclusion about bird behavior whether they will go easy with the UAS platform after being exposed for a longer duration or continuously perceive it as a threat.

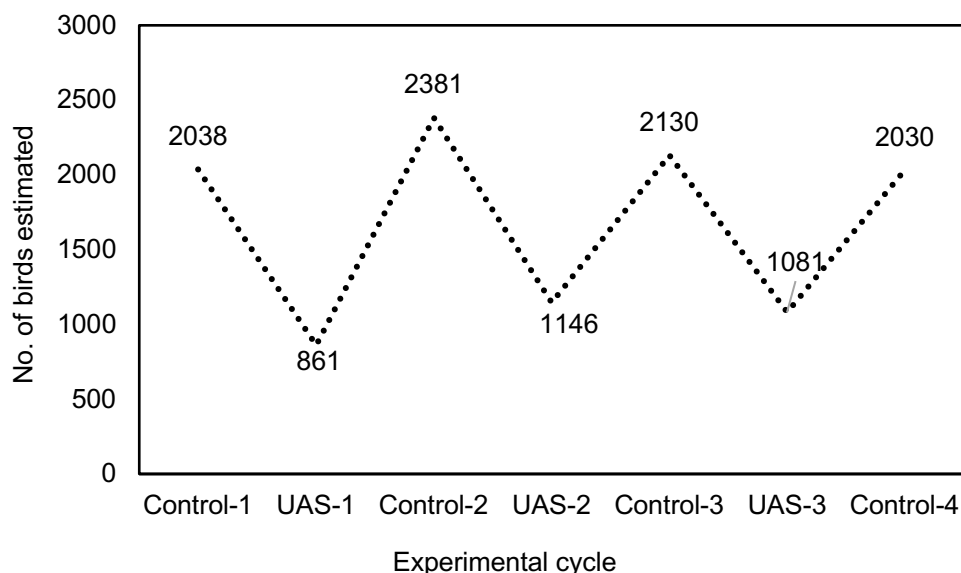


Figure 3: Bird count over the experimental duration. The plot shows, as expected, a clear effect of UAS flights on bird activity, when a UAS is flying (UAS Cycle) number of birds entering into the field is significantly lower compared to when the UAS is not flying (no-UAS Cycle or Control).

The experimental plot was observed on a daily basis for two weeks prior to the experiment. More birds were observed during the evening hours than the morning hours during that pre-experimental time. Thus, videos were only recorded during the evening hours and were used to estimate the total number of incoming birds for the entire experimental duration. This may mean that the actual number of birds might be slightly less than estimated in this article.

During the experiment, UASs were flown over the whole experimental field (~3.75 acres). As mentioned before, a nearly 50% reduction in bird count was observed when UAS was flown. In an earlier study by our team, 75% reduction was observed with a video surveillance carried out from all four sides of the same southwest corner (Bhusal et al. 2018). In this work, the reduction in a number of birds will be around 60% when only south and west corner are considered. The experiment in (Bhusal et al. 2018) was extremely confined in a narrow area (900 m²) using a small platform (Phantom 3 Standard, DJI Inc., China) equipped bird distress sound while current study covered a much larger area (~15,000 m²) using a larger platform (Matrice M600). Even though the reduction in bird count is slightly lower in this study compared to the same in a previous study by our team, this study demonstrated the capability to use UAS-based technology for bird deterrence at commercial scale. In the future, sensors and automated bird detection techniques can be integrated with UAS to locate incoming birds from a distance and divert those using autonomous flights. In addition to this, use of combining UAS and ground-based bird deterrents can also be carried out.

Conclusion

In this study, a large multi-rotor UAS platform accompanied by a small quad-copter was used as a technique for preventing activities of pest birds in wine grapes. No-flight and flight cycles were alternated for 14 days to evaluate the system performance in deterring birds. Our technique showed that the number of birds coming into the field was lowered by 50% when UAVs were used in the field. Such level of reduction in bird count is expected to lead to a significant reduction in fruit damage caused by these pest birds. The use of large platform can be suitable to pose threat against birds in larger vineyards. In the future, sensors and automated bird detection techniques will be integrated with UAS to locate incoming birds from a distance and divert those using autonomous flights.

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