Using Unmanned Aerial Vehicles for Bird Harassment on Fish Ponds

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ABSTRACT: The effects of aquaculture decline on piscivorous birds in the Mississippi Delta concern catfish farmers, with possible increases in fish loss and disease transmission. Piscivorous birds quickly habituate to most current methods of harassment (loud noises and visual disturbances) leading to increased depredation and disease. Our study was designed to test the efficacy of using unmanned aerial vehicles (UAVs) to effectively control piscivorous birds at fish farms. We hypothesized that a UAV would be more efficient at reducing the number of fish-eating birds on fish ponds than current forms of harassment. We conducted pre-treatment bird surveys, harassment observations, and post-treatment surveys at each experimental unit before and after each treatment on the same treatment days on 6 study sites in the Mississippi Alluvial Valley. The results of this study indicate that UAV harassment did not reduce piscivorous bird abundance more than human harassment in a 2-year field experiment.

KEY WORDS: aquaculture, harassment, piscivorous birds

Proceedings of the 18th Wildlife Damage Management Conference.

(J.B. Armstrong, G.R. Gallagher, Eds.). 2019. Pp. 13-23

INTRODUCTION

Commercial production of channel catfish (Ictalurus punctatus) was first established in Mississippi (MS) in 1965 (Wellborn 1983, Mott and Brunson 1995). The Mississippi alluvial valley (hereafter referred to as the Mississippi Delta) provides a well-suited area for pond culture of channel catfish. At the industry's peak in 2002, there were approximately 50,000 ha in production in Mississippi (Hanson and Sites 2014).

With the increase in production, farmers started to experience problems with avian depredation (Schram et al. 1984;

Stickley and Andrews 1989; Mott and Brunson 1995; Price and Nickum 1995). The shallow depth and high stocking rates of catfish ponds created ideal foraging environments for piscivorous birds (Tucker 1996, King 1997, Glahn and King 2004), while natural wetlands in the Mississippi Delta provided loafing, roosting, and/or breeding habitats for fish-eating birds involved with aquaculture conflicts (e.g., double-crested cormorants (Phalacrocorax auritus), great egrets (Ardea albus), great blue herons (Ardea herodias), and American white pelicans (Pelecanus erythrorhynchos); hereafter cormorants, egrets, herons, and pelicans, respectively; Mott and Brunson 1995, King and Werner 2001; Glahn and King 2004). These birds can depredate and spread diseases to commercial fish, causing significant financial losses (Mott and Brunson 1995, Griffin et al. 2012). Estimates showed annual economic losses to aquaculture industries caused by cormorants alone approached $25 million in Mississippi (Glahn and King 2004). Thus, developing cost-effective, efficient methods for controlling fish-eating birds has become a critically important research topic for resolving human-wildlife conflicts. Since 2008, aquaculture hectares in production in the Southeast decreased by approximately 50%, with about 16,000 ha remaining in production in Mississippi as a result of rising feed and fuel costs and increasing amounts of imported catfish (Hanson and Sites 2015, Hanson and Sites 2014). Farmers are concerned with how to keep these piscivorous birds off the remaining ponds in the region.

Cormorants and pelicans cause more harm than direct consumption of catfish through the spread of disease. The ease by which these birds can spread diseases that may cripple or destroy commercial fish populations suggests more efficacious scaring tactics are essential to prevent avian depredation and disease spread on catfish farms.

Littauer (1990) and Glahn and King (2004) described scaring tactics commonly used for fish-eating birds on catfish ponds in the Mississippi Delta. There are three major types of scaring techniques: audio frightening devices, visual devices, and supplemental killing. Catfish farmers are currently using all three techniques to prevent bird depredation on catfish.

Audio frightening devices include pyrotechnics, automatic exploders, recorded distress calls, and live ammunition. Pyrotechnics are firework devices used for scaring wildlife, including bird bangers, screamer sirens, and screamer bangers. These pyrotechnics are 15 mm cartridges fired from handheld .22 caliber modified starter pistols (Gorenzel and Salmon 2008). Automatic exploders are devices that use propane gas or acetylene to make loud explosions at controllable intervals on an automatic timer. Live ammunition is for scaring birds by firing shotgun and/or rifle rounds near birds to scare the flock. Birds become habituated to these noises when the sounds occur frequently at regular intervals and intensities (Curtis et al. 1996).

Visual frightening devices include scarecrows, radio-controlled aircraft, reflective Mylar ribbon, hawk silhouette kites, helium balloons, and flashing lights (Littauer 1990). Visual frightening devices can be useful if moved often and reinforced with audio frightening devices. Birds habituate to frightening techniques, so Littauer (1990) suggested it would be beneficial to the farmer to kill a limited number of birds to reinforce fear in the remaining birds after obtaining depredation permits.

Existing scaring tactics are often ineffective against birds depredating catfish on aquaculture ponds. With the costs of depredation, spread of disease, and costs of harassment, catfish farmers need better and more cost-effective ways of scaring piscivorous birds off their ponds than the commonly used tactic of human harassment. There are few experimental studies of human harassment effectiveness on piscivorous birds in the Mississippi Delta (Mott and Boyd 1995).

Newly developed scare tactics need to minimize bird habituation to the harassment technique. Unmanned aerial vehicles include either fixed-wing or rotary type models, both of which are controlled by external remote devices. There are UAVs capable of autonomous flight, wherein the flight path consists of input GPS coordinates for the device to fly and perform a variety of tasks on its own without remote assistance (Fabiani et al. 2007). UAVs have become increasingly popular for research in the wildlife field. Recent advances in UAV technology have reduced the cost of production as well as simplified the training and licensing processes, which enables people to use the UAV with far less training than in the past. Regarding wildlife, UAVs have proven to be a low-cost and efficient tool for surveys or high-resolution photography (Grenzdörffer 2013). Unmanned aerial vehicles may potentially produce audible, visual, and motion disturbances to piscivorous birds. For catfish farmers, this method could be useful for scaring piscivorous birds off their facilities since these birds have not yet habituated to the motion and noise produced by a UAV. Currently, most farmers have multiple bird chasers on patrol night and day during peak season for fish-eating birds. With a switch to UAV bird harassment, the number of people needed to do the job could range anywhere from 2 pilots to none (using autonomous flight). Using UAVs could require less labor, and with today's rapid advances in technology, it could be less costly than human harassment in the future. However, no studies have assessed the efficacy of UAVs as avian scaring devices.

Our objective was to determine the efficacy of using UAV harassment in reducing the abundance of piscivorous birds at fish farms to mitigate predation and disease transmission. We hypothesized that the UAV would be more efficient at reducing the number of fish-eating birds on fish ponds than human harassment.

STUDY AREA

This study was conducted in the Mississippi Delta region, comprising approximately 16,000 km2 of the flood plain of the Mississippi River and its tributaries, the Yazoo, Sunflower, and Tallahatchie Rivers (35.0°N – 32.3°N, -91.2°W – -90.1°W). Most of the Mississippi Delta lost wetlands due to draining for agriculture with approximately 10% of the original wetland area such as cypress swamps, oxbow lakes, and bayous remaining (Glahn et al. 1996). Our research included 6 study sites in the Mississippi Delta region including Sunflower, Washington, Sharkey, and Yazoo counties (Figure 1).

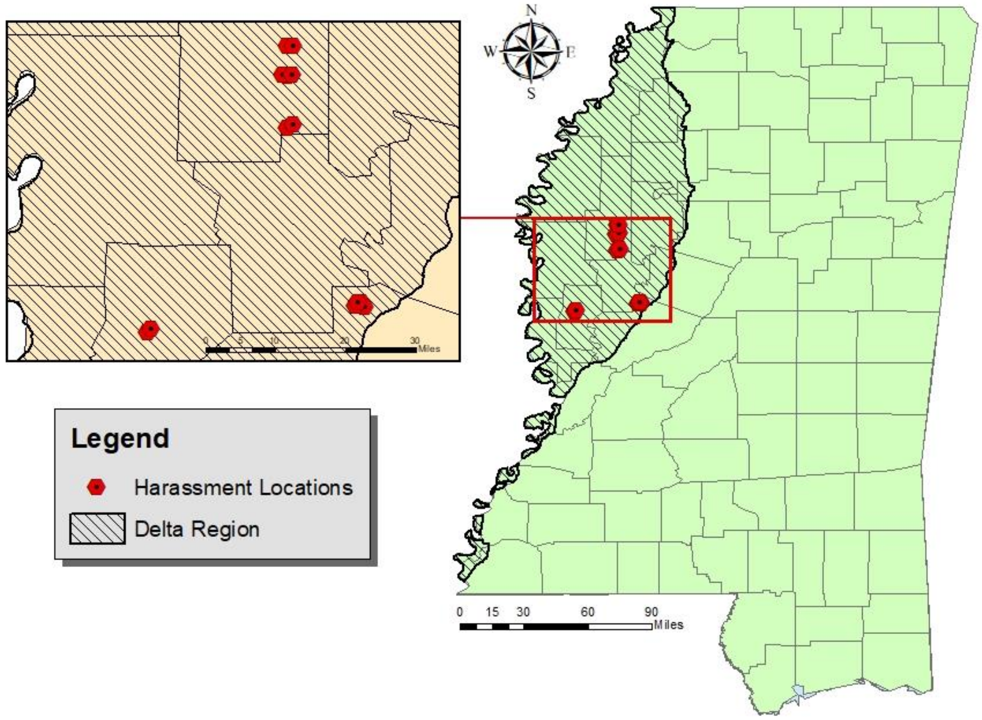

Figure 1: **Mississippi Delta study region.**
The shaded region shows the region referred to as the Mississippi Delta. The Mississippi Delta is the flood plain of the Mississippi River and its tributaries, the Yazoo, Sunflower, and Tallahatchie Rivers. Harassment locations are the catfish farms highlighted in red showing the 2 experimental units on each farm.

METHODS

Scaring regimes and experimental design

We defined human harassment as a combination of lethal and audio frightening categories. The bird chasers used live ammunition to harass birds while driving around the complex in a vehicle. Additionally, we used UAVs to frighten birds away from catfish ponds. USDA APHIS, National Wildlife Research Center, Institutional Animal Care and Use Committee (IACUC; protocol number: QA-2586) approved all the procedures. Our collaborators, Mississippi State University Geosystems Research Institute, provided UAVs and skilled pilots for this study and licensing required to fly UAV missions. To prevent the birds from linking humans with the UAV, the pilots and an observer operated from a pop-up ground blind at the intersection of each experimental unit for the duration of each trial. The UAV was placed directly outside the blind to take off and land after harassment. The UAV pilots remotely flew the quadcopter (Phantom II Vision Plus, DJI, Shenzhen, China) around the perimeters of an experimental unit (ponds), and then flew over the water to focus on any birds still left in the area. The UAV was flown at an approximately 7 m above ground level to avoid power lines and other farm equipment at a speed of 4 to 14 km/h. The UAV pilots harassed birds for a total of 20 minutes at each experimental unit.

Each farm received the same treatment twice in one year with a period between treatments to allow for bird behavior restabilization. We replicated the experiment the following year but in earlier months. We used human harassment as a positive control and the UAV flying was the treatment. Two plots ≥700 m apart were chosen as experimental units on each of the 6 study sites (n = 12; Figure 2). Each experimental unit consisted of 4 fish ponds, as close in size and catfish size class as possible, arranged in a 2 by 2 array. Each of the 12 plots received 2 reverse sequences of treatments (i.e., UAV-human harassment and human-UAV harassment) with a 1-week washout period between the two sequences. We conducted the treatments and observations on an experimental unit either in the morning or afternoon peak hours of fish eating bird activity (06:00 to 11:00 and 14:00 to 18:00; King and Werner 2001). We repeated treatments and bird surveys from March to April in 2015-2016 (n = 72) and January to February in 2017 (n = 57).

Figure 2: Example of two random points (red dot) on a catfish farm facility. Four ponds surrounded each point representing my experimental unit (blue outline).

Bird survey methods

We conducted pre-treatment bird surveys, harassment observations, and post-treatment surveys at each experimental unit before and after each treatment on the same treatment days. We used the intersection of 4 neighboring fish ponds on an experimental unit as my observation location. To obtain a pre-treatment count of birds at observational locations, we approached the intersection by vehicle and counted the birds when they flushed. Any birds that did not flush when we arrived at the observation location were added to the total. After obtaining the pre-treatment count, the vehicle stopped at the observation location, and we set up a camouflage ground blind (2 m x 2 m x 1.8 m). The pilots and observer positioned themselves in the blind to prevent the birds from associating people with any harassment technique. Once personnel were inside the blind, the vehicle drove to a distant observational point and waited until the trial was over before returning to our observation location to load the blind and move to the next experimental unit.

Next, we waited a minimum of 30 minutes for birds to habituate to the ground blind presence. We recorded harassment activities (types of harassment techniques and their start and end times), the number and species of birds on the ponds during the harassment, direction of departing birds, number of birds leaving the experimental unit, and the number and species of birds that returned within one hour after each harassment treatment.

Post-treatment observations took place after each harassment event at each observation location. Two different observers conducted these counts at 10-minute intervals for one hour after harassment. Post-harassment counts were conducted in two parts: Post 1 and Post 2. Post 1 comprised the counts during the first 30 minutes after harassment, while Post 2 included the counts during the last 30 minutes post-harassment. We averaged the abundance of double-crested cormorants, American white pelicans, great egrets, and great blue herons every 10 minutes between post 1 and post 2 periods for post-harassment averages.

Data Analysis

We fit linear models to compare the mean abundance of fish-eating birds between UAV and human harassments. We took square root transformation of the bird abundance to normalize the abundance data. Explanatory variables of fixed effects included harassment and survey-time interaction, year (2016 and 2017), treatment sequence, time of day (morning or afternoon peak hours), and treatment sequence nested within farm ID.

We checked the assumption of normality using quantile-quantile (QQ) plots. Statistical tests at the significance level of 0.05 were conducted in the R environment (R Version 3.3.1, www.r-project.org, accessed 21 June 2016).

RESULTS

Residuals of the full model, including all covariates, met the normality assumption ($n = 129$). The model showed neither significant differences in the transformed abundance between the treatments ($P = 0.32$) nor significant treatment and survey-time interaction ($P = 0.58$). Despite being insignificant, average bird abundances tended to decrease, by approximately 50%, in both treatments in 2017. However, the trends were not observed in 2016, (Figure 3).

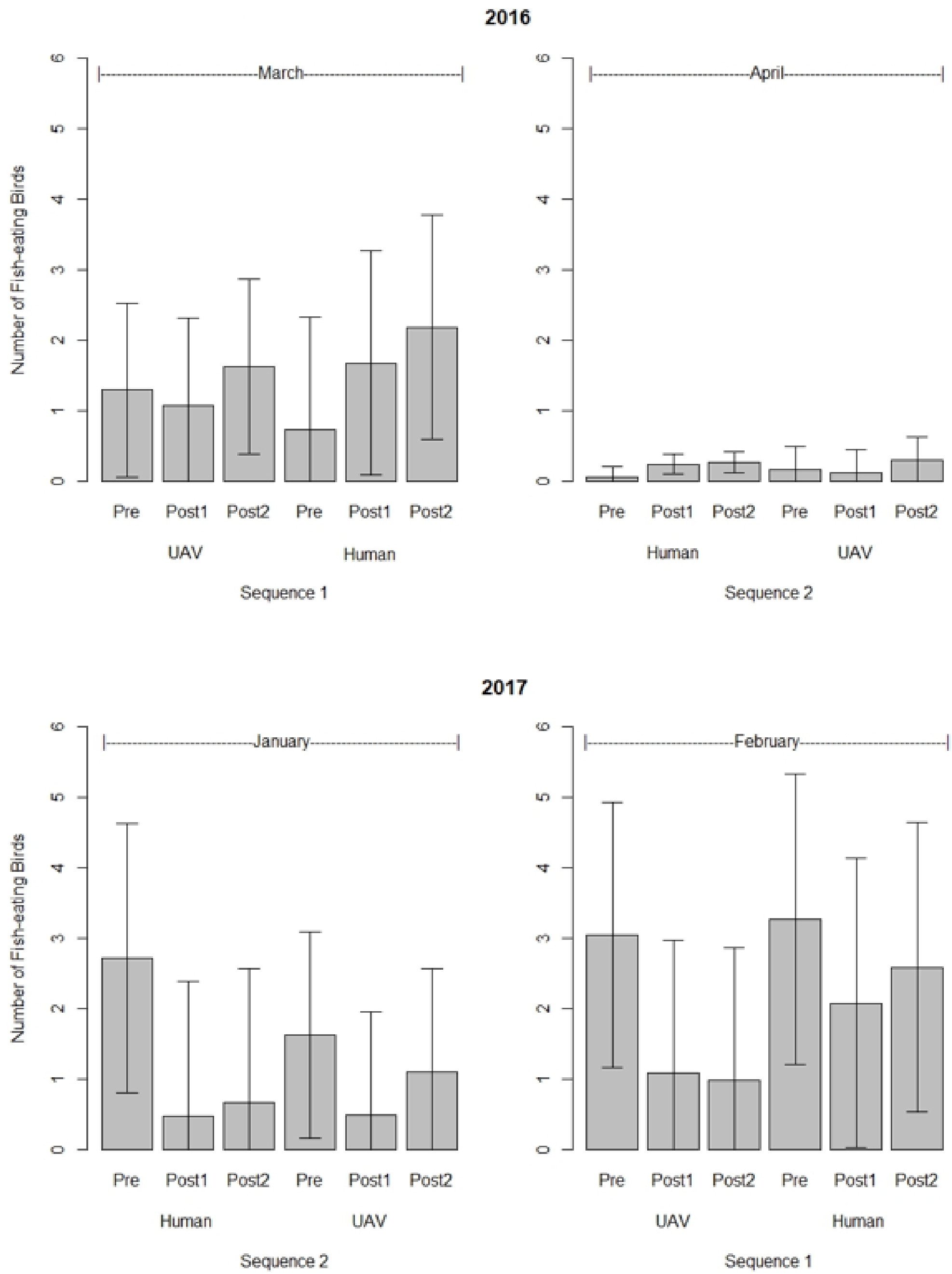

Figure 3: Results (mean ± SE) of post-treatment abundance at the square root scale of fish-eating birds for both UAV and human harassment in 2016 and 2017.

DISCUSSION

This study demonstrated that with current technological limitations, UAV harassment is not more efficient at harassing piscivorous birds than human harassment. Different trends of bird abundance during the pre- and post-treatment surveys between 2016 and 2017 may be caused by differences in the time of year during conducted studies. In 2016, we conducted field experiments in March and April, in contrast to January and February in 2017. Changing Federal Aviation Administration (FAA) regulations on UAVs in 2016 delayed study initiation. By March and April, a large majority of migratory piscivorous birds had already migrated north. In 2017, the study was conducted earlier in January and February when peak numbers of piscivorous birds were in the Mississippi Delta (Glahn et al. 1996, King and Michot 2002). The different trends of the two years may suggest that non-migratory individuals become habituated to all scaring tactics in March and April (Lowney 1993). In 2016, the birds did not appear scared by either harassment method in later months when there were fewer migratory birds present implying that migratory birds may habituate less to harassment methods than non-migratory birds.

Several factors might have confounded the effects of our harassment treatments in addition to time of year. We did not quantify and could not standardize the frequency and intensity of human harassment among all six sites. Frequencies and intensities of human harassment occurred at different levels between farms. In future studies, using a dose-response relationship to quantify disturbance intensity would greatly enhance our understanding of how much harassment effort is needed to be effective (Belant and Martin 2011, Tombre et al. 2013, Simonsen et al. 2015). Recording how many times the bird chaser and other farm equipment came by, and how many times the bird chaser fired his/her weapon could be broken into different intensity classes for analysis. Additionally, incidental human harassment (bird chasers driving by study sites) often took place during UAV harassment. Despite higher frequencies of human harassment than UAV harassment during each experiment, human harassment did not result in greater decline in the bird abundance than UAV harassment, suggesting the latter is labor efficient.

Although our results were not significant, this study is still useful to catfish farmers as the first step towards developing the usefulness of UAVs with avian harassment. Finding more efficient ways to harass these piscivorous birds warrants more research. Future research should determine if maximum effort by the UAs can prevent piscivorous birds from landing on a pond. We recommend future studies use >1 UAV over entire catfish farms, several pilots and observers, as well as many batteries (and/or wireless charging stations) to see if birds can be kept off entire farms during daylight hours. In addition, we suggest future studies combine UAV and human harassments. For instance, initial UAV harassment in combination with occasional human harassment using lethal methods may make piscivorous birds less likely to habituate, therefore making the combined harassment method more effective (Littauer 1990). In addition, incorporating noise and/or flash tape to the UAVs may enhance efficacy. Noises mimicking shotguns, pyrotechnics, and distress calls could add an additional element to prevent habituation to scaring tactics (Littauer 1990, Littauer et al.1997, Belant and Martin 2011).

In summary, we do not think the extant technology for UAVs can outcompete human harassment based on the results within our study parameters. Short battery lifetime and restricted weather operating condition limited practical applications of

UAVs to control piscivorous birds at aquaculture facilities. We observed that maximum battery time of the Phantom II Vision Plus was approximately 20 minutes depending on weather conditions. However, with the rapid advancement in UAV technology, we believe that UAVs will become a useful tool for catfish farmers in the near future.

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