MINIMIZING USE OF AQUACULTURE PONDS BY DOUBLE-CRESTED CORMORANTS *PHALACROCORAX AURITUS* AND OTHER FISH-EATING BIRDS

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Abstract: Methods used to minimize abundance of double-crested cormorant (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and great egrets (*Ardea alba*) at aquaculture facilities have limited success because of the birds' ability to habituate to the applied technique. The primary objectives of this study were to evaluate and quantify the effects of overhead lines on minimizing number of cormorants, egrets and herons. We measured the long-term (01 December 2000 to 14 April 2001) effectiveness of exclusion barriers positioned every 30 m at 8 aquaculture ponds in southeastern Arkansas and the post-removal of the barrier effects from 15 April to 31 May 2001. The exclusion barrier limited the number of cormorants landing on treatment ponds significantly ($P < 0.001$, by 10-fold), had a greater effect on herons ($P < 0.001$, by 19-fold), and completely excluded egrets. Over 200 hours of observations with the barriers installed and an additional 90 hours of post-treatment observation resulted in 23,200 cormorant observations at the site. Eight treatment ponds averaged 429 cormorant landings (1.9 birds per hour) compared to 4,240 cormorants landings (15.6 birds per hour) on 8 control ponds. Although the physical barrier did not exclude all cormorants and other fish-eating birds from a pond, this technique offers a nonlethal, cost-efficient, easy installation and removal, and low maintenance method to minimize depredation at aquaculture ponds.

Key words: aquaculture, *Ardea herodias, Ardea alba*, double-crested cormorant, great blue heron, great egret, net facilities, nonlethal, *Phalacrocorax auritus*, physical barrier, technique

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INTRODUCTION

Predation by piscivorous birds, especially double-crested cormorants (*Phalacrocorax auritus*), great blue herons (*Ardea herodias*), and great egrets (*Ardea alba*), referred to as cormorants, herons, and egrets from hereon, at aquaculture facilities is perceived as a substantial threat to the industry (Stickley et al. 1992, Glahn and Brugger 1995, Blackwell et al. 2000, Wires et al. 2001). To reduce the impact of avian depredation to fisheries, aquaculture, and vegetation, several techniques have been developed or proposed. These techniques include lethal and non-lethal measures. However, the effectiveness of these techniques is often difficult to assess because the impacts have been poorly quantified or not implemented at the aquaculture production scale (Lagler 1939, Andelt et al. 1997, Whisson and Takekawa 2000, Wires et al. 2001).

The direct and negative impacts of piscivorus avifauna at aquaculture facilities has created the need for improved or new methodologies to minimize depredation. Because cormorants, egrets and herons are opportunistic foragers, they readily exploit food resources that are abundant both spatially and temporally. Aquaculture ponds, specifically catfish production ponds, are shallow (1-2 m) and contain up to 150,000 fish/ha, thereby making these man-made aquatic sites attractive to these birds. Presently, Arkansas has 155 channel catfish (*Ictalurus punctatus*) producers encompassing 36,200 water-acres (NASS 2003) and 62 baitfish producers (NASS 1998). With already established bird night roosts within the aquaculture producing areas, these avian piscivores use this readily available food source during their winters in Arkansas and the southeastern U.S.

Managing cormorant, egret and heron populations, or the manipulation of their habitats to minimize aquaculture-related conflicts, is restrictive since their listing on the Migratory Bird Treaty Act in 1972. Cormorant numbers are of significant concern to aquaculturalists because their populations have significantly increased and their present day numbers are at historical highs within the catfish production regions of the southeastern United States (Jackson and Jackson 1995). Much of the growth occurred between the late 1970s to early 1990s. During that same time period, the aquaculture industry has expanded in Arkansas and the surrounding states. Concurrently, cormorant numbers increased on the wintering range, particularly in the Mississippi River Alluvize valley, an area of high human-cormorant conflict over catfish resources (Wires et al. 2001).

Currently, U.S. Fish and Wildlife Service permits are required within the U.S. to lethally control cormorants, egrets and herons, except at 13 mostly southern states, where there is a standing depredation order to allow shooting of DCCO on aquaculture facilities. Non-lethal harassment of birds depredating or about to depredate does not require permits. Mott and Boyd (1995) described lethal and nonlethal techniques to prevent cormorant depredations at aquaculture facilities and stated the critical points for these strategies were the timing of their application and the choice of the device employed. However, the authors concluded "none, by themselves or in combination with others, have been found sufficiently effective to resolve the conflict". Whether this conclusion was based on quantifiable data or perceptions held by the aquaculture community was not specified.

Two popular approaches to disperse concentrations of birds involve (1) habitat modifications (Booth 1994, Wires et al. 2001) and (2) the use of scare devices (Booth 1994, Andelt et al. 1997). Aquaculture industry infrastructure, environmental laws, and concerns from neighboring landowners within the delta of Arkansas have limited the ability to change habitat characteristics. Unfortunately, all scare device techniques thus far have failed to provide sufficient protection at the scale of a typical aquaculture production facility. The apparent failure for many of these techniques is because of the birds' innate ability to habituate to the applied technique.

Mott (1978), Salmon and Conte (1981), Booth (1994), and Mott and Boyd (1995) listed the currently available devices and discussed the techniques used to reduce avian depredation. These authors also provided limited information on the effectiveness of these methods. Recent developments of additional nonlethal devices, such as an inflatable effigy (Stickley et al. 1995), low-powered laser guns (Blackwell et al. 2002), floating ropes (Mott et al. 1995), and plastic molded alligators (Radomski unpubl. data), have been used successfully for temporary alleviation, but most birds habituated to the techniques over a short period of time (days to weeks). Inglis (1980) reported that the more frequently birds are exposed to a particular visual scare device, the faster the habituation.

The common practice invoked at Arkansas aquaculture facilities involves a hazing program. Hazing programs may involve aggressive and/or passive approaches, and may occur at the aquaculture facility or nearby roost sites (Mott et al. 1998, Glahn 2000, Tobin et al. 2002). The aggressive approach is labor intensive, potentially dangerous, and has the additional costs of hiring personnel, maintaining vehicles, and purchasing ammunition or pyrotechnics. This common practice involves personnel disturbing birds as they attempt to land on ponds, levees, or roost trees, often by shotguns, small caliber rifles, and/or pyrotechnics. The passive approach simply involves parking a vehicle on or near a levee or placing a boat in the pond.

Because many fish-eating birds adapt to these techniques and because these species have increased dramatically within the aquaculture production areas of Arkansas and other southeastern states (Wires et al. 2001), there is a need for conflict resolution and an efficient and cost-effective technique to assist aquaculture producers.

METHODS

Materials and Installation

We selected materials that minimized the cost while maximizing the availability, durability and ease of installation with minimal labor. The following items were used: (1) 1.8 m t-posts, (2) t-post driver, (3) number 36 tarred twine, (4) spooler; as used in barbed wire fencing, (5) spooler tool or adjustable wrench, (6) duct tape, (7) orange flagging tape, and (8) a measuring wheel.

A 3-person crew can manually install the 22 t-posts and attach the twine for a 6.8-ha pond in 3 hrs working from the pond levees. Alternatively, using a front-end loader tractor to position the t-post and all-terrain vehicles to transfer the twine from levee to t-post can reduce set-up time to 2 hrs. To optimize set-up efficiency, we tied 4 to 6 strings to an all-terrain vehicle or the bumper of a truck, then placed the rolls of twine onto a metal pole that one person positioned at one end of the levee while the driver slowly traversed the width of the pond. While the twine was on the levee, flagging tape was attached at 10-m intervals to make the twine more visible to target and nontarget species. We started at the t-post in the mid-section of each pond levee and worked toward the pond's outer levees. The twine was carried to the corresponding t-posts, attached using a knot at the post with duct tape to reduce friction and abrasion, and then we tightened the spooler using a wrench at the opposing t-post. The twine was tightened on a need-basis over the winter months. The twine was maintained at minimum distance of 1 m above the water's surface at the middle of the pond.

Removal Technique

To uninstall the twine and reuse for a later date, we cut the twine from the duct taped t-post. We collected the twine from the opposing levee by guiding it onto a 30-cm plastic (or pvc) tube with the cordless drill by attaching a bolt to tube's cap. The plastic tubes then can be coded in accordance to the pond and/or t-post position. At a later date, pending the need to gain access into the pond or for the following season, the twine can be unrolled and repositioned as described above.

As an option to minimize reinstallation of t-posts at the same ponds, a metal pipe of greater diameter may be placed into the ground and the surface opening covered with a readily visible cap. This allows for maintenance of levees or access to seining the pond while increasing the efficiency of re-establishing the barrier since the cap can be removed and the t-post placed at the same location.

Data Collection and Analysis

A standardized collection protocol was established and four observers were trained to collect data. Observations were made with the naked eye and binoculars from two permanent, 4.2-m towers juxtaposed against a utility pole along a graveled levee road. Observation times were randomly established between 0900-1700 hr and observers did not exceed 4 hrs per day. We attempted to have similar times of observations from both towers.

Observers collected data at a privately owned catfish farm in Arkansas (Figure 1) from one of two observation locations (Figure 2). It was situated within a block of 24 ponds (6.8 ha each) along the northern extent of the farm. The adjacent property was row cropped and separated by a drainage ditch. It was located 2 ponds (6.8 ha each) to the south, and these study ponds were 1.9 ha each. The southern boundary of these ponds was adjacent to a paved county road. The towers were established in September, prior to the influx of cormorants into the area, so the birds were allowed time to acclimate to the towers. However, to avoid the potential bias caused by the towers, the ponds adjacent to the tower were omitted from the study. The towers were only used for observations and no harassment was associated with them.

Hazing intensity was qualitatively described and quantitatively ranked based on encounters per hour. No differentiation was given between hazing techniques (i.e., aggressive vs. passive) during the ranking. A value of 1 was given for each 15 minute block of observation in which the hazing personnel were in the vicinity of the research ponds. Therefore, a maximum value of 4 was obtained during four hazing encounters per hour.

Data were analyzed using Proc Mixed, SAS V.8.2. We collected the following information at both sites: (1) total number of cormorants, egrets and herons flying overhead, (2) total number of cormorants, egrets and herons landing on ponds with the barrier ("treatment ponds"), (3) total number of cormorants, egrets and herons landing on ponds outside the barrier ("control ponds"), (4) duration birds stayed at a pond, (5) number of birds that were observed to avoid or be deterred by the barriers, and (6) other behaviors of birds, such as number of times the bird dove for fish, numbers of fish eaten, the activity of birds on water, duration birds stayed on treatment ponds compared to control ponds, differentiation in hazing techniques, types and numbers of birds present, and other interesting observations. We will discuss items 1-4 in this paper.

Figure 1. Study site of the privately owned catfish farm in Chicot County, Arkansas; star symbol indicates the study site location within the county.

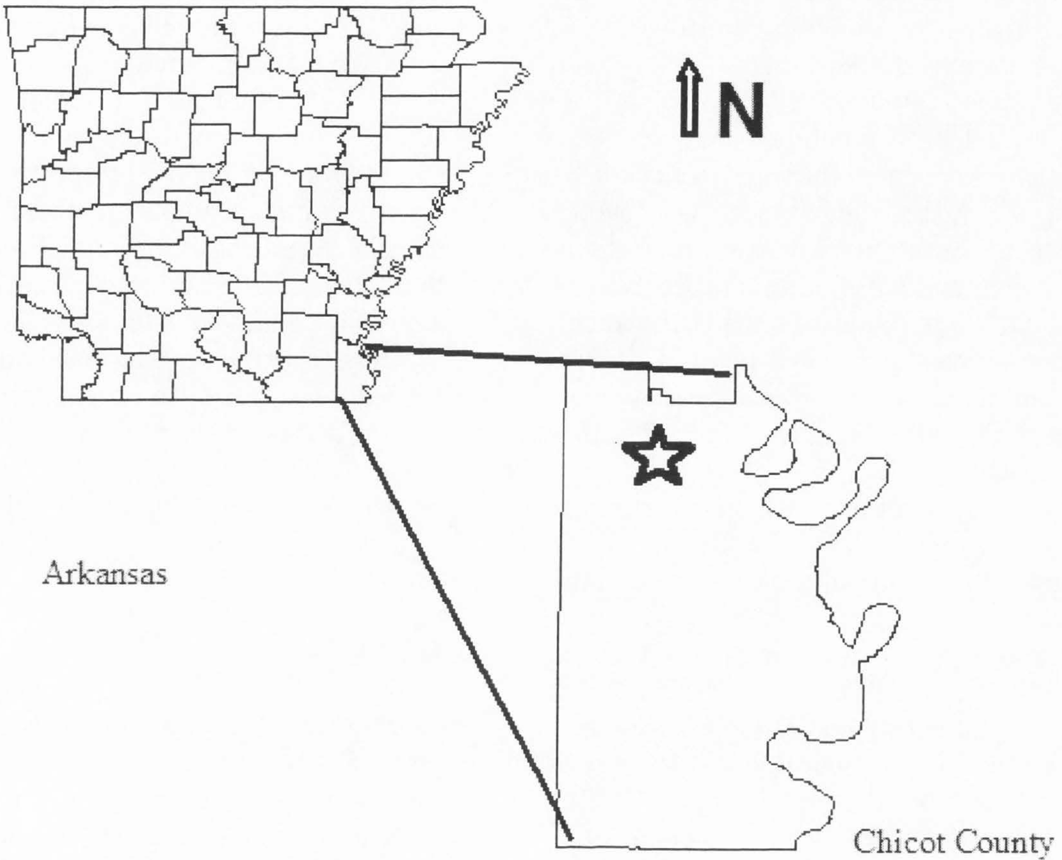
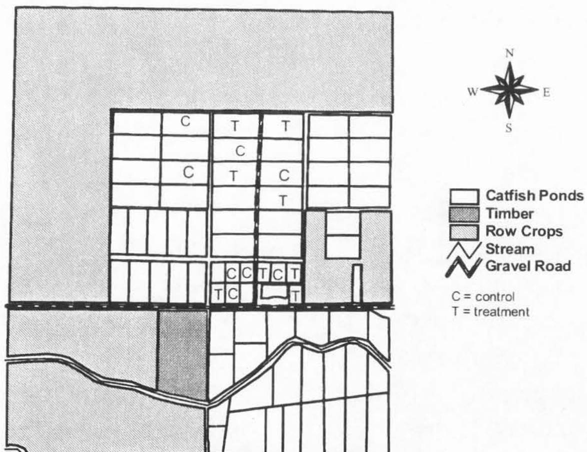


Figure 2. Digitized aerial photograph of the privately owned catfish farm with 80 ponds (8 treatment and control ponds) in Chicot County, Arkansas.



RESULTS

The twine remained tight and durable despite periods of icy, rainy and windy conditions. Ultraviolet rays appeared not to affect twine durability. However, on three occasions during the study, most of the twine was re-tightened to maintain the tension and proper height above the water surface. Anecdotal findings indicated that when the twine sagged near (< 1m) the water surface, cormorants were more apt to avoid them and have an unimpeded landing. Only one observation was made in which a cormorant made contact with the twine. The incident did not result in any apparent injury to the bird or affect the structural integrity of the barrier.

Number of observations between the two sites were similar (north and south, 132 and 96 hrs, respectively) during the duration the barriers were installed. However, observation numbers were skewed during the post-treatment period (north and south, 73.1 and 17.0 hrs, respectively) due to the limited bird use of these ponds. Between 01 December 2000 and 06 April 2001, 228.6 hrs of observations were compiled. The number of cormorants observed flying over the research ponds was 23,200 (101.5 birds per observation hour). Treatment ponds had significantly fewer cormorant encounters ($P < 0.001$, $n = 429$, 1.9 birds per observation hour) compared to 4,240 cormorant encounters (15.6 birds per observation hour) on control ponds. Great blue heron and great egret numbers were counted 48 and 0 times at treatment ponds compared to 437 and 19 encounters at control ponds.

An additional 90.2 hrs of observations were collected after the barriers were removed from 14 April to 30 May 2001. An additional 1809 cormorant observations (20.0 birds per observation hour) were made. Previously treated ponds had significantly greater number of cormorant encounters ($P < 0.001$, $n = 701$, 7.8 birds per observation hour) compared to the control ponds ($n = 128$, 1.4 birds per observation hour). Numbers of egrets and herons flying over research ponds were 163 and 205, respectively. Egrets avoided control ponds compared to 151 encounters at previously treated ponds. Herons frequented formerly treated ponds at a similar rate as at control ponds, 60 and 70 respectively.

The standard farm operations were not altered during the study. We classified the hazing program and intensity as an aggressive approach and it was quantified as 2.7 on a scale 0 to 4. The standard operating procedure of hazing on this site involved 2 pickup trucks traversing pond levees and a person discharging a shotgun, primarily as a nonlethal method of harassing. Pyrotechnics and the vehicle's horn were occasionally used.

DISCUSSION

Cormorants were prevented from landing on aquaculture ponds using the physical barrier system by a 10-fold difference when compared to control ponds. Although large variations in numbers of cormorant landings between ponds (0 – 438 birds/4 hrs) and pond sizes within farm (0 – 104 and 0 – 100 birds/4 hrs in large [6.8 ha] and small [1.8 ha] ponds, respectively) occurred during our observations, the overall trend was for fewer cormorants, egrets and herons landing on ponds with the exclusion barrier. Even though the 1.8- ha ponds were in close spatial proximity to the 6.8-ha ponds, the variation in bird use on these ponds could possibly be attributed to the pond size and the adjacent paved county road with vehicle traffic.

The physical barrier technique has some obvious benefits when compared to the other techniques. The most significant finding was the long-term effect it had on preventing cormorants, egrets and herons from landing in ponds. Techniques to minimize birds are usually reported as effective for a few days to a few weeks. Also, some more subtle effects included minimizing herons and egrets after the barrier was removed. One potential negative impact may occur if cormorants are in the vicinity after removing the barrier. Although the numbers of cormorants per hour was less than the control ponds during the treatment phase, they may have cued into the available resource. It is possible that the number of cormorants in the area have declined since this was during the time that most birds migrated to their northern breeding sites.

The use of flagging was incorporated initially to increase the visibility of the twine to cormorants as well as protect nontarget species, such as owls and hawks, from entanglement. We did not attempt to conduct an experiment to determine if the flagging was essential nor did we compare the colors of twine or flagging that are available. Of greater interest to this research, we plan to conduct research examining the effects of twine spacing as well as configuration across the pond in the future.

The social behavior of most fish-eating birds, such as the cormorant, adds to the dilemma of managing birds. Therefore, aside from preventing birds from landing on aquaculture ponds, the barrier also may be keeping additional cormorants and birds from landing. This confounding effect is difficult to quantify but poses an additional positive finding from this study. Although this technique is not a "silver bullet" to prevent all birds from landing on ponds, it does offer an additional procedure that may provide relief.

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