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Female Blackbirds' Responses to Stress during Breeding: Possible Implications for Future Management

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ABSTRACT: Blackbirds are reported to cause between 1-2% crop damage per year, but the distribution of damage is not uniform, with some fields this number can be as high as 20%. With many consumers in today's market concerned with animal welfare, nonlethal management techniques have become more important. Many of these techniques exploit natural predator-prey systems. One area of research that has not been previously addressed is the physiological response of birds to visual and auditory scare devices designed to imitate predators. The current project is part of a series of studies that aim to develop knowledge of both physiological and behavioral trade-offs of female red-winged blackbirds when exposed to predation risk as a chronic stressor. Breeding colonies were exposed to an avian predator, avian nest parasite, or a non-threatening avian effigy with corresponding bird call at the beginning of the breeding season. Behavioral responses were monitored across the season, including general response to the predators and reproductive trade-offs. We predicted that female response to perceived predation risk would be greater than response to parasites or control treatments, and that females would make a greater reproductive trade-off in favor of future breeding seasons when presented with the perceived risk and stress of predation. Results suggest that red-winged blackbirds do have a greater response to the perceived risk of predation than to the parasites or control treatments. In terms of nest success and lay date, females do not seem to have different reproductive behavioral trade-offs under different treatments. However, there is a trend for larger clutches in nests found within the predator treatment, suggesting that females may actually be making a trade-off for the current rather than future seasons. Future work will focus on analyzing the physiological trade-offs that females make during the breeding season, especially while under chronic stress of predation risk. Results will help provide a basis for applied research aimed at improving bird damage management.

KEY WORDS: *Agelaius phoeniceus*, nest parasite, predator, red-winged blackbird, reproduction, stress

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INTRODUCTION

The primary diet of the red-winged blackbird (*Agelaius phoeniceus*) during the breeding season is high-protein invertebrate prey that fuel reproduction and offspring growth. Diets shift across the season to grains that fuel migratory and overwintering physiology (Hintz and Dyer 1970, Hintz 2000). Crop grain maturation often occurs simultaneously with shifts in the foraging and diets of the blackbirds (Dolbeer 1990). The usual amount of regional crop damage averages 1-2% but can be over 20% in some fields (Peer et al. 2003, Klosterman 2011).

Current management practices aimed at reducing damage to crops have had some success, but new approaches are needed to better manage crop damage (Linz et al. 2011). Predation is a common occurrence for wild bird populations and can come in the form of adult (and fledgling) predation or nest predation (Lima 2009). Nonlethal management techniques aimed at exploiting a prey species' (e.g., red-winged blackbird) fear of predators (e.g., raptors) is an area of research accepted by consumers concerned about animal welfare (Zachary B. Hermstadt, unpubl. report, Dept. of Community Sustainability, Michigan State Univ.). Thus, scientists are attempting to increase knowledge of predator-prey interactions to develop improved nonlethal approaches to protect crops.

The fitness costs of reproduction include trade-offs between current and future reproduction that must be

addressed each breeding season by the parental generation. A female must consider not only the current risks of mating and her current season's reproductive output, but she must also consider her future reproductive output (Searcy 1979). Within a current mating season, risks include decreased survival through predation (Lima 2009) or self-maintenance (Drent and Daan 1980), and decreased survival of offspring through predation (Lima 2009) or brood parasitism (Payne 1977). Although a few studies have evaluated these risks separately, showing that females can respond and react differently to the risk of parasitism and predation (Neudorf and Sealy 1992), there has not been a comprehensive study of how females balance multiple risks when making reproductive decisions, which has important implications for the numbers of birds recruited to the blackbird population.

When assessing the risk of predation during the breeding season, the female red-winged blackbird has to assess both the survival risk for herself and the survival risk for her offspring, which can also be thought of in terms of her reproductive success. Because nest predation is one of the leading causes of reproductive failure in avian species, most studies focus on how females assess and react specifically to nest predators (Lima 2009). Numerous studies have shown that breeding birds have the ability to respond proactively to the presence of nest predators by selecting nest sites that

are of lower quality, but that may reduce the ability of predators to access the nest (Milks and Picman 1994, Forstmeier and Weiss 2004, Eggers et al. 2006). However, a few studies have focused on adult predation risk and have shown that females can select territories that are located further from a predator's nest (Suhonen et al. 1994, Norrdahl and Korpimäki 1998) or respond with changes in normal behavior such as call rate or intensity (Beletsky 1991).

Brood parasitism is also of concern to many species of songbirds such as the red-winged blackbird. When a parasitic bird species lays its eggs in the host nest, the host often does not seem to notice and raises the parasite as its own, depleting its own energy and reproductive success (Payne 1977). The most common brood parasite of the central United States is the brown-headed cowbird (*Molothrus ater*) (Friedmann et al. 1971, Mayfield 1965). The female lays its egg in the nest of its host after first removing one of the host-bird eggs. Through the removal of an egg, the brown-headed cowbird further lowers the reproductive success of the host (Clotfelter and Yasukawa 1999).

As breeding seasons are usually limited to a short period of time during the year, time constraints can become an issue that a female must consider (Verhulst and Nilsson 2008). She must be able to weigh the costs and benefits to determine the "perfect" time to start breeding (Drent and Daan 1980). If she does not wait until she has enough stored energy before mating, she decreases her own and her offspring's chances of survival. However, if she waits too long before mating, both offspring fitness and her own decrease because of the lack of time available to prepare for winter. The presence of an extra risk like a predator or nest parasite may cause a female to delay egg-laying (Morosinotto et al. 2010), creating a shorter period of time for her to raise her offspring and prepare for migration.

This is the first of a series of studies with the purpose of integrating and improving the effects of visual and auditory scare devices for protecting fruit and grain crops. Although the overall intent is to develop knowledge of physiological responses of birds when exposed to predators, this first study focuses on examining how red-winged blackbirds respond behaviorally to the perceived risk of predation and parasitism during the breeding season using avian effigies and calls. In addition, this study will begin to examine some of the potential reproductive trade-offs such as egg-laying date, clutch size, and nest success.

We predicted that females will show a greater behavioral response to the predator effigy than the other effigies. In addition, females will make a greater reproductive trade-off in favor of future breeding seasons when presented with the perceived risk and stress of predation.

METHODS

Study Organism

The red-winged blackbird is a polygynous species that nests in large breeding colonies in wetlands found in most of North and Central America. Clutches range in size between two and four eggs. The incubation and

nesting period is between 22 and 27 days long. Females are known to raise one or two clutches through the breeding season; however, we monitored nests closely to ensure that our results were from first nesting attempts only.

At our field site, males are known to arrive on the breeding grounds well in advance of the females at the beginning of May. After arriving females have been known to wait several weeks before selecting a mate (Beletsky and Orians 1997). The breeding season lasts through July.

Field Site

Our field site is located in a coulee system, which is part of the Sheyenne River watershed in Mapleton, ND, located in Cass County. The surrounding area is mainly used for agricultural purposes, with the prominent crops including corn, soybean, and wheat. The coulee itself is ephemeral, and is stagnant due the overgrowth of cattail. Other avian species found in the area include brown-headed cowbirds, marsh wrens (*Cistothorus palustris*), and yellow-headed blackbirds (*Xanthocephalus xanthocephalus*). Waterfowl and other wetland species common to the area can also be found at our field site.

Behavioral Study Protocol

At the start of the blackbird breeding seasons of 2013 through 2015, breeding colonies were identified in the coulee system in Mapleton by locating adult male red-winged blackbirds defending territories. The breeding colonies were separated into three treatment groups (or four in 2013): control (no effigy in 2013), avian control (purple martin, *Progne subis*), nest parasite (brown-headed cowbird), and predator (great horned owl, *Bubo virginianus*). Each treatment group had a total of 12 sites (three in 2013 and 2014; six in 2015). All sites were at least 30 meters long and separated by at least 60 meters. In addition, sites were confirmed as active if a male was spotted on the site. Sites were assumed to be physically similar; however, to control for any possible dissimilarities between sites, sites were randomly assigned to a treatment.

Once females were observed on territories, the groups were presented with their corresponding effigy and avian call for one hour per day, for four days in no more than a 2-week period. To control for the fact that great-horned owls are a crepuscular species, we presented to each treatment group twice at sunrise, and twice two hours before sunset.

In the 2013 field season, an observation protocol designed specifically for common red-winged blackbird behaviors (i.e., attacking the effigy, alarm calling, non-interactive behavior, and approaching the effigy) was used to observe individual male territories during the effigy and avian call presentation. A similar protocol has been used successfully with other bird species (Coslovsky and Richner 2011).

For the remainder of the breeding season all three years, sites were monitored for active nests. Nests were marked using neon orange flagging tape. In addition, nests were also marked in a Garmin GPSMAP62sc (Garmin International Inc., Olathe, KS) for ease in

relocating the nests as the season progressed. Active nests were monitored for reproductive data (i.e., lay date, clutch size, and nest fate). Due to the high levels of brown-headed cowbird brood parasitism in the area, we also monitored parasitism activity by counting the number of brown-headed cowbird eggs in each nest. In addition, the third laid egg was removed, when possible, for future hormone analysis.

In the 2015 field season, individual nests from each treatment were monitored using a Drift Ghost-S action video camera (Drift Innovation, London, UK). Nests were monitored during effigy exposure to evaluate incubation behavior. Cameras were mounted by the nests 30 minutes before sites were exposed to the effigy to ensure that females could acclimate to the camera and all behaviors observed during the effigy exposure were due to the effigy. Nests were also monitored when nestlings were five to eight days old to examine if feeding rates of the parents differed across treatments. Nestling age was selected to control for differences in feeding rates based on age and yet still young enough so that they would be less likely to fledge too early due to human disturbance.

Data Analysis

Analyses were performed using JMP® version 11 (SAS Institute Inc., Cary, NC). An ANOVA with a Tukey post-hoc analysis was used to determine differences in behaviors between treatment groups. Nest success was determined using the Mayfield method and a 27-day incubation period (Mayfield 1975). An ANOVA with a Tukey post-hoc analysis was then used to determine differences in nest success between treatments.

RESULTS

The behavioral response of red-winged blackbirds to the treatments differed significantly. In the presence of the predator effigy, blackbirds spent more time attacking the effigy per minute than any of the other treatments (Figure 1). However, nest parasite, avian control, and control treatments did not differ between each other ($F_{3,20} = 10.79$, $p = 0.0002$). Blackbirds also spent on average significantly more time per observation interval alarm calling to other blackbirds when in the presence of the predator effigy than any of the other treatments (Figure 2). None of the other treatments differed significantly from each other in alarm calls ($F_{3,20} = 11.00$, $p = 0.0002$).

Only one of the reproductive trade-off measurements that were monitored showed significant differences across treatments. Nest success and lay date did not differ across treatments ($F_{2,88} = 0.6885$, $p = 0.5051$; $F_{2,74} = 1.36$, $p = 0.2632$). However, clutch size differed significantly across treatments (Figure 3), with a trend towards larger clutches in the predator and nest parasite treatments compared to the avian control treatment ($F_{2,89} = 3.1714$, $p = 0.0468$). Feeding rates and time incubating also did not differ significantly across treatments ($F_{2,12} = 1.2651$, $p = 0.3237$; $F_{2,12} = 0.2384$, $p = 0.7922$).

DISCUSSION

Results suggest that the red-winged blackbird does show a greater response to the presence of the great horned owl effigy and call than in the presence of the

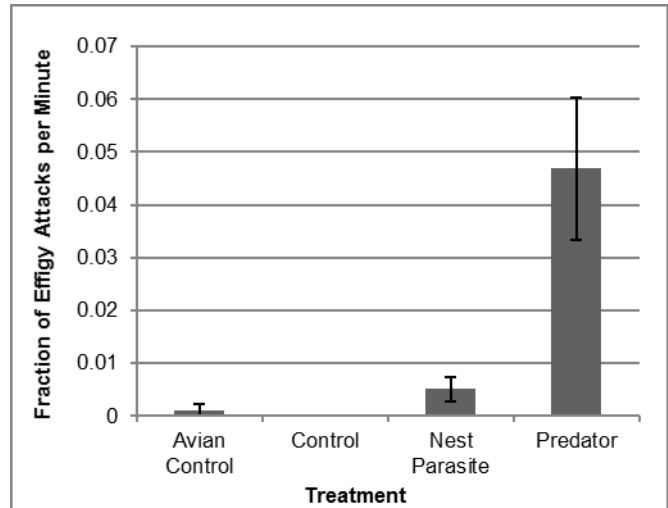


Figure 1. Average effigy attacks per minute. Fraction of effigy attacks was defined as the total number of effigy observations per total time observing.

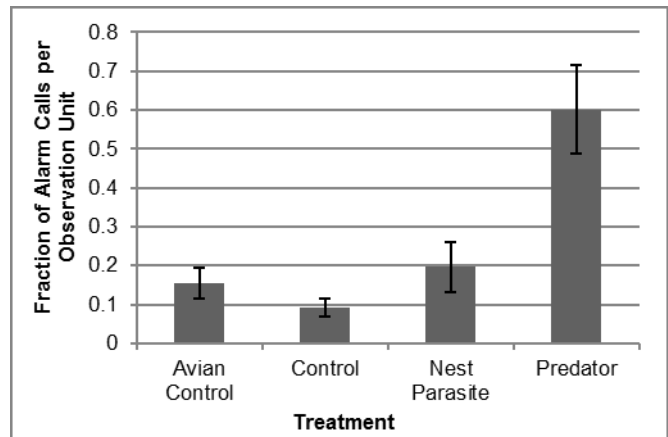


Figure 2. Average amount of alarm calling per observational unit. Fraction of alarm calling was defined as the number of observational units (5 minutes) with alarm calls observed divided by the total number of observational units.

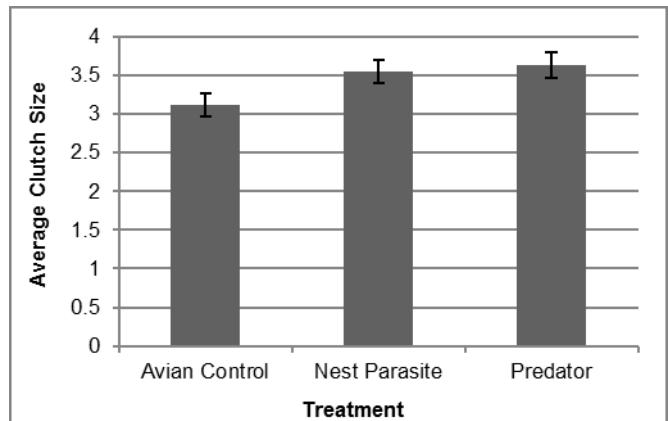


Figure 3. Average clutch size of nests in treatment groups for the 2014 and 2015 breeding season.

purple martin or female brown-headed cowbird effigies and calls. In particular, blackbirds participated in mobbing and alarm calling behavior more frequently.

Mobbing is a particularly interesting behavior, because it is potentially dangerous for the attacker. In fact, the risk of mobbing has been confirmed in other species, where the mobbing bird was killed by the predator (Denson 1979). However, it has also been suggested that there must be some benefit for such a risky behavior to continue. For example, in the American robin (*Turdus migratorius*), most mobbing behavior happens only during the breeding season, suggesting that individuals may be more likely to risk injury for the reward of being able to remain on their current territory (Shedd 1982). As effigies were presented to the blackbirds after territories had mostly been selected, and in some cases nest building had begun, it would make sense that female red-winged blackbirds would make a similar trade-off.

In the presence of a predator, alarm calling may give away prey location; however, it may also help individuals signal information about the risk to others within the colony (Miller 2005). It has been suggested that female brown-headed cowbirds use host vocalizations to locate host nests (Clotfelter 1998). Thus, it would make sense that red-winged blackbirds may reduce vocalizations within their territory when a female brown-headed cowbird is present.

Although egg-laying date and nest success did not differ significantly across treatments, clutch size did show a significant trend of larger clutches for predator and nest-parasite treatments. This suggests that females are making a trade-off in favor of the current breeding season. In the case of both treatments, increasing clutch size may be a way to ensure that at least one offspring survives the breeding season, ensuring that the female's genetic material is passed on to the next generation. This is in contrast to other studies that have demonstrated a reduction in clutch size while in the presence of predators (Eggers et al. 2006, Morosinotto et al. 2010).

Female behavioral response to predator and nest parasite effigies does not give us a clear idea of how these tools can be used for blackbird management. In fact, our results may suggest the opposite of what was intended, and presenting blackbirds with additional stressors during the breeding season may have the unintended consequence of increasing recruitment to fall blackbird populations. Because many of the risks discussed in the paper may induce a certain amount of stress, it is important to not only examine the behavioral response to risk but also the physiological response, as high levels of stress hormones have been correlated with increased immunodeficiency (Maier et al. 1994) and decreased survival. Future work will focus on examining other potential trade-offs, specifically the physiological trade-offs connected to the behavioral trade-offs. A comprehensive approach is important to create a more realistic breeding season scenario that can be studied, because no single risk is going to be solely responsible for shaping how a breeding community functions behaviorally and physiologically.

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