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Effects of visual obstruction, prey resources, and satiety on bird use of simulated airport grasslands

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ABSTRACT

Grasslands represent 39%–50% of U.S. airport properties, and a recent management framework recommended exploiting both antipredator behaviours and food resources in airport grasslands to curb use by birds considered hazardous to aviation safety. We evaluated framework predictions empirically by exposing unsated and sated brown-headed cowbirds (*Molothrus ater*) to visually obstructive (~13-cm vegetation height; tall), higher-risk plots versus unobstructive (<8 cm vegetation height; short) plots, and relative to prey resources. We predicted that 1) unsated birds (unfed since the previous day) would be present in greater numbers and forage more in short than tall vegetation plots 24 h post-mowing because of invertebrate flush resulting from mowing; 2) unsated birds would show increasing numbers and foraging in tall plots >24 h post-mowing because of decreasing food abundance and availability in short plots; and 3) sated birds would be present in greater numbers and forage more in short vegetation overall, because vigilance needs would exceed that of food needs. We evaluated effects of visual obstruction (a metric correlated with both vegetation height and insect density) on behaviours within plots via generalized linear mixed models. Unsated cowbirds showed nearly equal numbers in tall and short plots ($\bar{X}$ [SE] individuals using tall plots: 9.5 [5.1]; short plots: 9.8 [5.1], $P = 1.00$, Wilcoxon Signed Ranks Test), and foraged nearly equally in both plots 24 h post-mowing (tall plots: 6.9 [4.7] individuals; short plots: 6.6 [4.1] individuals, $P = 0.94$). Prey availability was likely enhanced within short plots within 24 h of mowing, but possibly in adjacent tall plots as well. Over the course of the experiments (8–9 days) unsated cowbirds showed no difference in numbers between plots (tall plots: 8.2 [4.9] individuals; short plots: 11.4 [4.9] individuals, $P = 0.13$), but foraged more in short plots (tall plots: 4.4 [3.8] individuals; short plots: 7.8 [4.2] individuals, $P = 0.01$); visual obstruction was significantly and negatively correlated with foraging in tall plots. Sated cowbirds selected for short plots (use of tall plots: 5.9 [4.2] individuals; short plots: 11.7 [4.6] individuals, $P < 0.01$; foraging in tall plots: 4.1 [3.3] individuals; short plots: 8.2 [4.6] individuals, $P < 0.01$). Our findings support recommendations for use of visually obstructive vegetation in combination with proactive control of food resources to reduce use of airport grasslands by birds that select against visually obstructive cover.

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1. Introduction

Wildlife collisions with aircraft (strikes) represent a substantial safety and economic burden to civil aviation worldwide (Allan, 2002; DeVault et al., 2013; Anderson et al., 2015). Bird strikes composed 97% of strikes reported to the U.S. Federal Aviation Administration (FAA) from 1990-2014 (Dolbeer et al., 2015). Further, approximately 72% of all bird strikes reported to the FAA occurred ≤152 m above ground level (AGL), thus within the airport environment; these strikes represented approximately U.S. $640 million annually in direct and indirect costs to the civil aviation industry operating within the USA (Dolbeer et al., 2015; see also Anderson et al., 2015).

Given the predominance of strikes within the airport environment, management of wildlife and habitats that serve as resources to birds is a critical component of strike reduction (Blackwell et al., 2009a, 2013; Dolbeer, 2011; DeVault and Washburn, 2013). Grasslands, for example, represent 39% to 50% of U.S. airport properties (DeVault et al., 2012). Management of grasslands at U.S. airports,

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particularly, has focused more on vegetation height than a comprehensive examination of species use and associated foraging and antipredator behaviours (e.g., Blackwell et al., 2013 Supporting information 2, including citations therein; Washburn and Seamans, 2013). A recent management framework suggested exploiting both antipredator behaviours (via management of vegetation height) and food resources (via mowing and chemical controls) in airport grasslands to curb use by birds considered hazardous to aviation safety (Blackwell et al., 2013).

Specifically, Blackwell et al. (2013) theorized that with fluctuations over time in prey availability within an airport's vegetation community, habitat structure likely plays a key role in avian use of airport habitats by affecting not only prey availability, but perceived predation risk (e.g., Devereux et al., 2004; Whittingham and Devereux, 2008). Our purpose was to evaluate the framework predictions empirically by exposing brown-headed cowbirds (*Molothrus ater*) to visually obstructive (~13-cm vegetation height; tall), presumably higher-risk plots (e.g., Beauchamp, 2015), versus un-obstructive (<8 cm vegetation height; short) plots. Brown-headed cowbirds (hereafter, cowbirds) are omnivorous species known to selectively forage in less visually obstructive environments (Morris and Thompson, 1998; Shaffer et al., 2003; Seamans et al., 2007). However, cowbirds will also use visually obstructive habitats based on prey availability (e.g., Morris and Thompson, 1998). This adaptability to grassland structure and food resources makes this species useful to testing hypotheses directed toward ecologically based management of airport grasslands to deter use by obligate and facultative grassland bird species. In addition, within our study area cowbirds are easily captured during spring migration, fare well in captivity, and have served as a surrogate species in behavioural studies examining a variety of issues associated with small, flocking birds (e.g., Icteridae) involved in bird strikes (Seamans et al., 2007; Blackwell et al., 2009b; Doppler et al., 2015; DeVault et al., 2015). Also, cowbirds were involved in 1973 a strike that resulted in seven fatalties (Thorpe, 2003). Further, there have been 185 reports to the FAA (1990–2014) involving cowbirds struck by aircraft; 51 instances which involved multiple birds (Dolbeer et al., 2015).

We predicted that 1) food-deprived (hereafter unsated) birds would be present in greater numbers and forage more in mown vegetation plots 24 h post-mowing than in tall, visually-obstructive plots because of effects of invertebrate flush from recent mowing (see Blackwell et al., 2013); 2) unsated birds would show increasing numbers and foraging in tall plots >24-h post-mowing because of decreasing food abundance and availability in short plots (Blackwell et al., 2013 Supporting information 2; see also Peggie et al., 2011), indicative of more risk-prone behaviour; and 3) fed (hereafter sated) birds would be present in greater numbers and forage more in short vegetation as vigilance needs take on a greater importance over food needs through time. Our ultimate objective was to use our findings to better inform management of airport grasslands relative to deterring use by birds that select against visually obstructive vegetation.

2. Methods

2.1. Ethics statement

The study was conducted following approved National Wildlife Research Center Protocol, 2068.

2.2. Study area

We conducted our study on the 2200-ha National Aeronautics and Space Administration's (NASA) Plum Brook Station (PBS; Erie County, OH, USA; 41° 22′ N, 82° 41′ W; see Bowles and Arrighi, 2004 for detailed description of PBS). Our experimental site consisted of approximately 900 m^2 of mixed turf grass and forbs. Approximately 25% of the area had been mown regularly during spring and summer for over two decades. We recovered the remainder from grass and shrub habitat during 2012, tilled the soil and sowed a mixture of cool-season grasses (e.g., *Poa pratensis*, *Festuca arundinacea*). The entire site was fertilized in 2012 and 2013 in preparation for our 2014 experiments.

2.3. Cowbird capture and maintenance

We captured 250 male cowbirds using decoy traps on PBS (April–May 2014). Captured birds were held in six 2.4- × 2.4- × 1.8-m cages containing ≥ 13.7 m of perch space/cage (maximum of 50 birds/cage) in an enclosed aviary with a concrete floor on PBS where they received a maintenance diet, and water ad libitum (National Wildlife Research Center, NWRC, Protocol 2068). Aviary windows were of wire mesh with only an awning enclosure, which was always open. Each end of the aviary was fitted with sliding doors that opened to approximately 90% of the width of the building; these doors were opened each day at approximately 0800 h and closed by 1600 h. Thus, all birds were exposed to the prevailing light-dark cycle and ambient temperature conditions. The birds were released upon completion of the study.

2.4. Experimental protocol

Behavioural research conducted using captive birds inherently imposes restrictions on inference to factors affecting particular behaviours (e.g., responses to predation risk). However, these caveats can be balanced, via sound experimental design, against the increased logistics and potentially inadequate data collection in natural settings where controls are minimal or nonexistent. With regard to avian foraging and antipredator behaviours, previous behavioural research was conducted primarily using relatively small (0.5 m^3) enclosures (e.g., Devereux et al., 2004, 2006a,b,c, 2008). These smaller cages inhibit natural behaviours (e.g., flight), but are useful in testing questions requiring controls with regard to bird interactions, vegetation composition, and influence of specific predator stimuli. Here, however, we chose to allow our experimental groups (see Experimental protocol, below) to select vegetation conditions and respond to other group members, as well as visual and auditory stimuli from free-ranging wildlife near our study site.

We established ten 3.6- × 8.0-m flight cage locations (not separate flight cages) within our study site that were arranged in three columns, one comprising five locations, another with four locations, and a third with a single location based on levelness of the ground (Fig. 1). Each location consisted of two, 2.4- × 2.4-m vegetation plots, with 0.61-m buffers of vegetation that were maintained in the same manner as the respective plot. Flight cage locations within a column were separated by approximately 2.0 m.

We used a single flight cage (4.8- × 4.8- × 3.6 m or ~83 m^3), designed such that each half could be moved to a new location independently, positioned over the plots and in contact with the other cage half. This design allowed us to expose each cowbird group to a unique location (Fig. 1). In addition, we positioned two closed-circuit digital cameras (Illustra Flex 800, American Dynamics, 6600 Congress Avenue, Boca Raton, Florida, USA 33487) mounted on tripods outside of the cage and at 90° to the opposing camera (Fig. 1). We used pre-measured lines that were secured to cage corners to position each camera at the same elevation and distance from each cage and the respective plots (i.e., insuring the same area of video coverage after the cage was repositioned in a new location). All lines were removed prior to data collection. Cabling for each camera ran to an observation trailer approximately 60 m from