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Brian E. Washburn
United States Department of Agriculture, brian.e.washburn@aphis.usda.gov

Glen E. Bernhardt
USDA APHIS Wildlife Services, National Wildlife Research Center

Lisa A. Kutschbach-Brohl
USDA-NWRC, Sandusky, OH

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Commentary

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BRIAN E. WASHBURN, USDA/APHIS, Wildlife Services' National Wildlife Research Center, 6100 Columbus Avenue, Sandusky, OH 44870, USA *brian.e.washburn@aphis.usda.gov*
GLEN E. BERNHARDT, USDA/APHIS, Wildlife Services' National Wildlife Research Center, 6100 Columbus Avenue, Sandusky, OH 44870, USA
LISA A. KUTSCHBACH-BROHL, USDA/APHIS, Wildlife Services' National Wildlife Research Center, 6100 Columbus Avenue, Sandusky, OH 44870, USA

WILDLIFE–AIRCRAFT COLLISIONS (wildlife strikes) pose a serious safety risk to aircraft and cost civil aviation >$614 million annually in the United States (Dale 2009, Dolbeer et al. 2009). Over 89,700 wildlife strikes with civil aircraft were reported to the U.S. Federal Aviation Administration (FAA) during 1990 to 2008 (Dolbeer et al. 2009). Aircraft collisions with birds accounted for 97% of the reported strikes (Dolbeer et al. 2009). Gulls (*Larus* spp.), waterfowl, such as Canada geese (*Branta canadensis*), raptors (hawks and owls), blackbirds, and European starlings (*Sturnus vulgaris*) are the species of most concern at airports (Dolbeer et al. 2000, Dolbeer and Wright 2009). Analyzing information from the FAA's National Wildlife Strike Database regarding wildlife strikes with civil aircraft, Dolbeer (2006) found that 74% of all wildlife strikes were at altitudes of ≤125 m above ground level (AGL) and suggested that most wildlife strikes occur within the airport environment. Sound management techniques that reduce bird numbers in and around airports are therefore critical for safe airport operations.

Large-scale killing of birds to solve conflicts often is undesirable or impractical (Dolbeer 1986, Dolbeer et al. 1997). Nonlethal frightening techniques to keep birds away from airports are available (Marsh et al. 1991, Cleary 1994), but they can be cost-prohibitive or only temporarily effective (Dolbeer et al. 1995, Washburn et al. 2006, Baxter and Allan 2008). Habitat management within airport environments is the most important long-term component of an integrated approach to reduce the use of airfields by birds and mammals that pose hazards to aviation (Transport Canada 1994, Washburn and Seamans 2004, Cleary and Dolbeer 2005, Washburn et al. 2007).

Habitat management efforts, such as alteration of plant communities, are an integral part of wildlife hazard management programs conducted on airports and airfields to reduce the risk of wildlife strikes. These habitat management activities are often conducted to reduce foraging opportunities for hazardous wildlife within the airport environment. However, for such management actions to be most effective, the specific foods and resources that are being used by wildlife that pose a hazard to safe aircraft operations must be identified and addressed.

Our objectives are to: (1) demonstrate the use of dietary analyses for directing effective airfield wildlife management and (2) provide case studies of wildlife management within airport environments.

Wildlife foraging on airfields

Airports and military airfields represent a unique land use, particularly in suburban or urban environments (Kutschbach-Brohl et al. 2010). Consequently, grasslands and other habitats on or near airfields often provide foraging opportunities for wildlife that are hazardous to aviation.

Dietary plasticity (i.e., variation in foods consumed) is an important factor to consider when evaluating the feeding habits and patterns of resource selection by wildlife. Many factors, including time of year, species, sex, and age influence foraging in birds (Rotenberry 1980, Yard et al. 2004). For example, many birds shift their feeding patterns from insectivory during the breeding season to frugivory during autumn migration or winter (Parrish 1997). Plasticity in avian diets can occur within a species, across

the range for a given species, across time, and among closely related species within the same general area. Localized studies are necessary to identify the particular forage resources being used by those species at specific airports, thus, allowing managers to reduce airport-specific attractants. Also, some issues with bird species (and strike issues) might be localized to only certain places.

Sources of foraging information

Dietary information regarding the feeding habits of hazardous wildlife is available through the scientific literature, direct observation of wildlife foraging on or near airports, and by collecting representative individuals and using methods of dietary analysis. Direct observation of foraging birds is 1 method of identifying the specific foods and forage resources used by hazardous birds (Duffy and Jackson 1986, Rosenberg and Cooper 1990). Optics (e.g., binoculars, spotting scopes) and the ability to quickly and accurately identify prey items are essential. This method has biases and disadvantages, as proper identification of prey items and the overall proportion of observed prey items in the diet might be difficult to obtain (Duffy and Jackson 1986, Rosenberg and Cooper 1990).

Many forms of dietary analysis have been utilized to quantify the feeding habits of various wildlife species, including the analysis of stomach contents (Duffy and Jackson 1986, Rosenberg and Cooper 1990). Birds that collide with aircraft, birds killed during wildlife control operations to increase air safety, and potentially hazardous birds collected specifically for dietary analyses are sources of appropriate samples. Irrespective of the source of specimens, it is very important that the specimens collected are representative of the situation in question.

Detailed methods and techniques of sample preservation (e.g., use of ethanol), prey-item identification, and other stomach content analysis techniques are available in the scientific literature (see Duffy and Jackson 1986, Rosenberg and Cooper 1990). Differential digestibility of consumed prey items has been documented during studies of a variety of birds, and this important factor should be considered when assessing the food habits of birds collected in airport environments (Custer and Pitelka 1975, Williams and Jackson 1981, Briggs et al. 1985).

Directing management actions

Information gained from dietary analysis of hazardous wildlife can be very useful to direct management actions and ensure such efforts are targeted to the appropriate forage species and are timed properly to reduce or remove wildlife attractants on airports. Consequently, the selection of products (e.g., insecticides, rodenticides, herbicides) with high efficacy and the timing of pesticide applications can be made to maximize the impact on appropriate targets to reduce forage availability.

Once forage resources are identified (using information derived from dietary analyses), airport managers and wildlife biologists must examine the availability of those forage resources and determine if they can be controlled or eliminated from airport property. Seasonal trends in forage availability are also important, and an understanding of these patterns is essential for directing effective management. For example, fruits and berries might be seasonally available on an airport; during that time period, bird use and the risk of bird strikes might be particularly high. Periods of increased bird presence on airports, for example, during times of high fruit or insect abundance, can be anticipated and mitigated through planned wildlife control activities.

Managing plant communities

Landscaping and airport vegetation management provides an opportunity to reduce wildlife hazards (Washburn and Seamans 2004, Washburn et al. 2007). For example, removal of fruit-bearing landscaping trees and shrubs might reduce hazardous wildlife use of airport environment. Tree swallows (*Tachycineta bicolor*) have been identified as a wildlife strike hazard at John F. Kennedy International Airport (JFKIA; Bernhardt et al. 2009) in New York. Using stomach content analysis techniques, Bernhardt et al. (2009) identified bayberry (*Myrica* spp.) fruits as the predominant forage used by tree swallows at the airport during the fall migration period. Following removal of bayberry bushes from the airport, wildlife strikes involving tree swallows were reduced by 75% (Bernhardt et al. 2009).

Managing insect communities

Grassland habitats on airfields often contain abundant and diverse arthropod communities (Kutschbach-Brohl et al. 2010). Management of insect populations at airports (e.g., grasshoppers [*Orthoptera* spp.], turf-damaging insects, and beetles; Figure 1) identified as a food source and, therefore, an attractant to hazardous wildlife, provides an opportunity to reduce the risk of wildlife strikes (Caccamise et al. 1994). Spatial and temporal patterns of insect abundance clearly demonstrate the need for effective, targeted pesticide applications to control insect pests or reduce food resources on airports (Bernhardt et al. 2010, Kutschbach-Brohl et al. 2010).

Managing small mammal communities

Airport grasslands often provide habitat for small mammals that could attract mammalian and avian predators to airport environments. Assessing food habits of birds (e.g., red-tailed hawks [*Buteo jamaicensis*]) that use airports allows management efforts to be directed toward the specific prey species of concern. Reductions in small mammal populations on airfields can be accomplished by implementing an integrated pest management program, which might include the use of targeted pesticide applications, habitat management actions, or other tools. Toxic baiting applications with rodenticides, such as zinc phosphide, might be effective in reducing use of airfield environments by avian predators (Witmer and Fantinato 2003, Witmer et al. 2007). Also, vegetation management activities (i.e., mowing) have resulted in reduced small mammal presence within grassland habitats (Seamans et al. 2007, Washburn and Seamans 2007).

Case studies

We provide some case studies where dietary analysis has been applied to airport situations to reduce hazards posed by birds.

Gulls

Collisions between gulls and aircraft represent a significant issue at many airports, in particular those located within coastal areas. Caccamise et al. (1994) examined the food habits of laughing gulls (*Larus atricilla*) at the Atlantic City International Airport in New Jersey and found that insects, in particular Coleoptera: *Scarabaeideae* (scarab beetles), were the most important prey items used by laughing gulls at the airport. Consequently, management efforts to reduce beetle populations on the airfield were used to effectively reduce laughing gull abundance at that airport.

European starlings

European starlings (*Sturnus vulgaris*) are food generalists (Williams and Jackson 1981, Feare 1984, Fischl and Caccamise 1987, Cabe 1993). During 2007 to 2009, we conducted dietary analyses on European starlings collected

Figure 1. Grasshoppers (left) have been found to be a food source and attractant to American kestrels (*Falco sparvarius*). Dietary items, such as these junebugs (*Phyllophaga* spp.; right) found in the stomach of a laughing gull (*Larus atricilla*), can provide important information for directing management actions to reducing wildlife hazards to aviation.

during wildlife control operations at Langley Air Force Base (AFB) in Virginia and at JFKIA to quantify foraging habits of European starlings at airports.

European starlings collected during late summer and early fall (2007 and 2008) at Langley AFB were primarily insectivorous. A diversity of Coleoptera (beetles) was consumed by starlings, including representatives from ≥9 families, but broad-nosed weevils (Curculionidae: Entiminae) accounted for the majority of beetles identified during dietary analyses. Consequently, management efforts should be focused on reducing the abundance of vegetation-dwelling insects within the grassland habitats on the airfield.

European starlings collected at JFKIA during late summer and fall of 2009 were found to be diverse in their use of foraging habitats and types of foods consumed. Terrestrial insects (in particular beetles and ants [Hymenoptera: Formicidae]) were frequently consumed by starlings, in addition to fruits and berries that were frequently consumed. Thus, efforts to reduce insect populations on the airfield and to remove fruit-bearing trees and shrubs from the airport would be appropriate management actions to reduce starling use of the airport.

Raptors

Raptors frequently use grassland habitats within airport environments for foraging. Variation in raptor food habits occurs among species across seasons due to prey availability and other factors. Stucker and Dunlop (2002) conducted stomach content analysis on raptors (mostly red-tailed hawks) collected at an airport in Kentucky. They found that 77% of the prey items consumed by raptors were small mammals (e.g., *Microtus* spp. and *Peromyscus* spp.). Similarly, meadow voles (*Microtus pennsylvanicus*) were the primary prey of raptors at Toronto International Airport (Baker and Brooks 1981). These studies suggest that an integrated wildlife damage management effort focused on the reduction of small mammal populations within airfield grassland habitats would likely reduce the use of those airports by raptors, thus, reducing the risk of raptor–aircraft collisions.

We conducted stomach content analyses on 11 American kestrels (*Falco sparverious*) collected during wildlife control operations at Laughlin Air Force Base (Laughlin, Tex.) in September of 2009. We found that all 11 kestrels had consumed short-horned grasshoppers (Orthoptera: Acrididae) and 46% had fed on beetles (Order Coleoptera). Similarly, Garland et al. (2009) observed that grasshoppers were a food resource used by American kestrels (presumably) struck by aircraft at Montreal-Trudeau International Airport. These findings suggest that integrated pest control programs, specifically targeting grasshoppers, could be an effective management action to reduce the use of airfields by American kestrels.

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BRIAN E. WASHBURN is a research biologist for the USDA, Wildlife Services' National Wildlife Research Center field station in Sandusky, Ohio, and is an adjunct assistant professor with Michigan State University, North Carolina State University, and the University of Missouri. He earned his M.S. degree from The Pennsylvania State University (wildlife science) and a Ph.D. degree from the University of Kentucky (Animal Sciences). His research involves finding science-based solutions to wildlife–aviation conflicts, stress and reproductive physiology of wildlife, and habitat management of grassland ecosystems.

GLEN E. BERNHARDT has worked part-time as a biological technician for the USDA, Wildlife Services' National Wildlife Research Center field station in Sandusky, Ohio, since the early 1980s. He has been involved with projects ranging from bird-damage to corn, woodchuck-control methods, and determining the physical density of birds. He has written numerous articles about northern Ohio flora and fauna. He is a graduate of Ohio State University with a B.S. degree in comprehensive science education. He and his wife Marje run a store specializing in selling toy marbles and teach children how to play marbles and other vintage games.

LISA A. KUTSCHBACH-BROHL has a B.S. degree in natural resources management and an M.S. degree in environmental science, with emphasis on wetland ecology, from Ohio State University. Her research interests include wetlands, birds, and insects. She works as a part-time biological technician for the USDA, Wildlife Services' National Wildlife Research Center field station in Sandusky, Ohio. She teaches courses in local flora at Ohio State University Stone Laboratory and is active with the Lake Erie Islands chapter of Black Swamp Conservancy. She also operates a summer nature camp for children. She and her husband live year-round on a small island in Lake Erie.