Winter bird feeding and localized predation on simulated bark-dwelling arthropods

Tammie J. Martinson and David J. Flaspohler

Abstract Recreational bird feeding is an extremely popular activity that influences winter bird distribution and demography and may influence other organisms near feeders. In the United States, an estimated 60 million people, or 43% of households, currently feed wild birds. For this reason, it has been suggested that public bird feeding currently is the largest wildlife management activity in northern temperate regions. We used a replicated experiment utilizing mealworms (Tenebrio molitor) as surrogate overwintering arthropods to examine whether supplemental winter bird feeding influences kill rate on nearby alternative foods (i.e., mealworms). After 6 weeks of exposure during winter 2000–2001, more mealworms were consumed in feeder plots than in control plots. Predation intensity on mealworms did not decline at distances up to 20 m from feeders. Our findings support the hypothesis that the aggregation of birds near a feeder results in increased predation on nearby bark-dwelling arthropods. Use of winter bird feeders as a potential alternative form of arthropod pest control deserves further study.

Key words arthropods, bird feeders, foraging, overwintering, pest control, supplemental feeding

Recreational winter bird feeding has grown dramatically in the last 50 years (United States Department of the Interior and United States Department of Commerce 1997). In the United States, an estimated 60 million people, or 43% of households, currently feed wild birds, mostly during the winter months. For this reason, it has been suggested that bird feeding is currently the largest wildlife management activity in northern temperate regions (Brittingham and Temple 1992). Numerous studies have explored how experimental food supplementation during winter influences the biology of birds. Supplemental winter feeding has been shown to increase body mass (Brittingham and Temple 1988), nutritional condition (Grubb and Cimprich 1990), winter survival rates (Brittingham and Temple 1988, Desrochers et al. 1988), clutch size and fledgling numbers (Arcese and Smith 1988), and to advance egg-laying dates (Källander 1974, Smith et al. 1980). Such research has focused on direct effects of supplemental feeding on bird biology. Researchers have paid little attention to potential indirect effects of supplemental feeding on other ecosystem components. Because of the enormous scale of recreational bird feeding in many temperate areas, even subtle local effects may have impacts at larger scales. For example, supplemental winter bird feeding may alter local arthropod abundance in the short term, and change relative abundance of bird species frequenting forested habitats near feeders. In this study we used an experimental approach to investigate the short-term effects of recreational bird feeding on overwintering arthropods.

One of the most obvious results of provisioning winter birds with supplemental food is the creation of foraging aggregations around a feeding station. Most insectivorous winter resident birds are opportunistic foragers (McFarlane 1976) and will incorporate insects, seeds, and carrion into their diet.
(Howitz 1981, Smith 1991). Many birds utilize overwintering arthropods as a major food source (Bent 1939, 1947). Black-capped chickadees (*Poecile atricapillus*), with access to supplemental food in southern Wisconsin, relied on feeders for 21% of their daily requirements, with the remaining 79% coming from natural food items (Brittingham and Temple 1992). Thus, feeders create temporally and spatially dynamic bird aggregations (Desrochers and Hannon 1989) that may influence other nearby prey resources. In this way, winter feeders may have an influence on nearby diapausing arthropod populations that is similar to the influence that nest sites have been shown to have on arthropods active during the breeding season. For example, two species of European titmice (family Paridae) greatly reduced arthropod resources near (<20 m) their nests (Naef-Daenzer 2000), and bark-foraging Eurasian treecreepers (*Certhia familiaris*) depleted bark-dwelling arthropods within 10 m of their nests (Jantti et al. 2001). Like nests, winter bird feeders create areas of concentrated foraging, with a difference being that an entire community does the foraging for many months during the temperate winter.

The objective of our study was to determine whether winter bird feeding influenced kill rate on experimentally placed bark-inhabiting arthropods near feeders. We proposed two competing hypotheses describing the potential influence of feeders on arthropods overwintering near (<20 m) feeders: 1) presence of a feeder will increase kill rate on overwintering bark-dwelling arthropods because birds concentrated near a feeder will also spend time foraging on trees in the vicinity of the feeder, or 2) the presence of a feeder will decrease kill rate on overwintering bark-dwelling arthropods because the feeder provides a low-cost, high-energy foraging option relative to foraging on nearby trees.

**Materials and methods**

**Study area**

This study was conducted in the Upper Peninsula of Michigan in two study areas in Houghton County (Figure 1): Tech Ski Trails (TT)

![Figure 1. Location of study areas in the Upper Peninsula of Michigan, layout of plots at Tech trails (TT) in 2000–2001, and approximate locations of sample trees within each plot. Plot layout at Maasjo Hihto (MH) was similar, with feeder and control plots placed along a trail system according to the same conditions (randomized with the restriction that no more than 3 feeder plots be adjacent).](image-url)
(47°06'N, 88°33'W) and Maasto Hiihto Ski Trails (MH) (47°08'N, 88°36'W). Since these two study areas are approximately 6 km apart and the winter range of mixed-species flocks of passerines was between 6 and 39 ha (Brewer 1978), we assumed our study areas contained two discrete bird communities. Study plots (0.13 ha) were set up within a 50-ha area at TT and a 65-ha area at MH. All study plots were in continuous second-growth northern hardwood or mixed northern hardwood forests composed primarily of sugar maple (Acer saccharum), red maple (Acer rubrum), white ash (Fraxinus americana), aspen (Populus spp.), paper birch (Betula papyrifera), and balsam fir (Abies balsamea). Average yearly snowfall measured at the Houghton County airport was 5.46 m, and the average winter temperature was −9°C (National Weather Service 2001). Because of deep snow cover from December through April, resident birds in the study area were unable to forage on the ground during the winter months and relied on seeds, overwintering arthropods, carrion, or supplemental food.

**Methods**

We used a treatment-control study design with replication. During the winter of 2000–2001, we conducted an experiment to test for differences in kill rates on overwintering arthropods between plots with feeders and control plots. Conventional arthropod sampling techniques rely on arthropod mobility and therefore are ineffective during winter. Direct observation of overwintering arthropods is difficult because they are highly cryptic (Cooper and Whitmore 1990). Sampling bark-inhabiting arthropods in their natural overwintering habitat would require observers to remove bark, which would destroy arthropod overwintering habitat at the study’s onset. To avoid these difficulties, we used mealworms (Tenebrio molitor) as surrogates for natural overwintering bark-dwelling arthropods.

During the winter of 2000–2001, we inserted mealworms into holes drilled in the bark of trees to simulate bark-dwelling arthropods. We placed mealworms within the bark of trees in feeder and control plots at the two study areas, TT and MH (Figure 1), along cross-country ski trails for ease of access. Fifteen feeder plots and 17 control plots were established at TT, and 15 feeder plots and 15 control plots at MH. Plots were separated by 100 m and were randomly assigned as either a feeder or control plot, with a constraint that no more than three feeder plots be adjacent. In the middle of each circular plot we identified a center tree on which we hung either a flag (control plot) or a feeding station (feeder plot). Feeding stations consisted of one tube feeder with black sunflower seeds (Helianthus spp.) and one suet cage with a block of suet. We then walked 20-m transects in the four cardinal directions from the center tree and identified the trees closest to the 5, 10, 15, and 20 m mark of each transect for a total of 16 trees/plot. In early January 2001, we drilled four 2.5-cm-deep holes at breast height using a cordless handheld drill (0.48-cm drill bit) on the four cardinal sides of each of 16 sample trees in feeder and control plots (Figure 1). This allowed us to know precisely the number of mealworms (64 in each plot) available before feeders were installed.

In each hole we placed one 2.5-cm mealworm, which had been frozen for at least 36 hr prior to insertion to ensure that it was dead. After the mealworms were in place, we placed feeders on
all feeder plots and maintained them for 7 weeks from mid-January to early March. During this time, we checked and refilled feeders every 2-3 days and recorded the amount of seed and suet added to each feeder plot. After 6 weeks we sampled all plots through direct counts of mealworms. A mealworm was considered eaten if there was any evidence of consumption or if it was completely missing.

In February 2000 and February 2001, we performed point counts to compare winter bird communities in TT and MH and between feeder plots and control plots. We used 3-minute point counts at 5 randomly selected (with the constraint that they had to be at least 250 m apart) feeder plots and 5 randomly selected control plots at each study area (Ralph et al. 1995) and did not include birds that flew overhead in the analyses. To control for daily variation in weather conditions that might affect bird activity (Grubb 1978), we conducted point counts between 0800-1100 hr twice during the study at both study areas on the same mostly sunny days with calm winds.

**Statistical analyses**

Probability plots indicated that our data did not meet the assumption of normality. Therefore, we used nonparametric Mann-Whitney tests (Zar 1999) to test for differences in the number of mealworms eaten in feeder and control plots. We reported mean values for combined feeder and control plots for each study area, although Mann-Whitney tests were done using individual plot data. To allow for the possibility of differences between TT and MH, we conducted this test separately for the 2 study areas. We used two-factor ANOVA to test for differences in relative abundance between study areas and between feeder and control plots for all bird species detected and to test for differences in the relative abundance of bark-gleaning bird species between the two study areas. Simple linear regression was used to examine the relationship between predation rate on mealworms and distance from feeders. We use a significance level of $\alpha=0.05$.

**Results**

Significantly more mealworms were consumed in feeder plots ($\pm$SE) (MH: 63.3±0.3, TT: 57.2±3.4) than in control plots (MH: 57.4±2.8, TT: 44.1±6.0) after 6 weeks in the MH study area ($U=161.5, n=15, 15, P=0.017$) and in the TT study area ($U=190.5, n=15, 17, P=0.009$). Kill rate did not change with increasing distance from the feeder at TT ($F_{1,2} =0.99, P=0.424 (R^2_{adj}=0.003)$ or MH ($F_{1,2}=0.63, P=0.512 (R^2_{adj}=0.14)$).

The amount of seed added to a feeder showed a positive, significant correlation with the number of mealworms consumed at TT ($r_s=0.64, P=0.009$) but not at MH ($r_s=0.16, P=0.571$). It was not practical to perform a correlation between the amount of suet consumed and the number of depredatecd mealworms consumed because the amount of suet consumed was only approximated to the nearest whole block and varied little between plots.

Species richness of bark-foraging birds based on point counts at TT and MH was similar (4 and 5 species, respectively; Table 1), although point counts often missed sparsely distributed species known to use both study areas (e.g., hairy woodpecker [*Picoides villosus*], pilate woodpecker [*Dryocopus pileatus*] [Flaspohler, unpublished data]). The relative abundance of all bird species was significantly different between study areas ($F=6.37, df=1$ and $16, P=0.023$), although there was no significant difference in the relative abundance of bark-foragers ($F=3.86, df=1$ and $16, P=0.067$) between study areas (Table 1). As expected, significantly more birds were detected at feeder plots than at control plots (all species: $F=10.53, df=1$ and $16, P=0.005$; bark-foragers: $F=5.08, df=1$ and $16$).

<table>
<thead>
<tr>
<th>Species</th>
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<td>2.5</td>
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* Species considered bark-gleaners (Ehrlich et al. 1988).
with feeder plots having an average of 2.9 times more birds than control plots (Table 1).

**Discussion**

In our study, the presence of a bird feeder (with sunflower seeds and suet) caused increased predation on experimentally placed mealworms near (≤20 m) the feeder. This suggested that bark-inhabiting arthropods in trees near bird feeders are subject to increased predation pressure compared to similar arthropods far from bird feeders. Bark-foraging birds consumed a large number of arthropods during winter (Solomon et al. 1976, Norberg 1978). Given the widespread occurrence of backyard bird feeding, local reductions of overwintering arthropods near a single feeder may be greatly magnified in areas with many feeders. These results have a number of potential implications for arthropod and bird populations and the human motivation for bird feeding, each of which is considered.

Overwintering arthropods are immobile for many months and therefore must rely on cryptic coloration or concealment below tree bark or in bark crevices to avoid predation. Bark-foraging predatory birds search for, excavate, and glean arthropods from tree surfaces throughout the winter. In our study, bird feeders influenced density of the bark-foraging and excavating bird community and are therefore likely to influence local predation intensities. Two characteristics of avian foraging behavior support this contention: 1) birds tend to respond to concentrated food sources by adopting area-restricted searches (Smith 1974, Zach and Falls 1977), and 2) predation rates on true arthropods have been shown to be positively related to search rate (Gendron and Staddon 1983) and insectivorous bird density (Otvs 1979). Moreover, our findings suggested that overwintering insectivorous birds reduce arthropod populations in spatially predictable ways. Breeding European titmice collected 90% of their prey items within 25 m of their nests (Naef-Daenzer 2000), while breeding Eurasian treecreepers depleted bark-dwelling arthropod populations near (10–35 m) their nests at a higher rate (38% greater) than farther (90–115 m) from their nests (Jäntti et al. 2001). In our study, bird feeders increased the predation intensity on experimentally placed arthropods within 20 m of the feeder. If this pattern holds for naturally occurring overwintering arthropods, local areas with winter feeders may contain fewer bark-dwelling arthropods by the end of the winter compared to areas without feeders. An as yet unexplored implication of this pattern is the possibility that such localized depletion of arthropods could influence the foraging success and flocking behavior of bark-foraging bird species, such as the brown creeper (Certhia americana), that do not frequent feeders.

Kill rate on mealworms did not decline with increasing distance from the feeder. It may be that our 20-m plot was too small to detect the distance of the feeder effect on our experimentally placed mealworms, suggesting that feeders might create relatively large “halos” of intensified predation.

A large proportion of mealworms was consumed at both feeder and control plots. Factors that might have influenced patterns of predation on surrogate arthropods include direct learning through the formation of search images for drilled holes (Tinbergen 1960, Pietrewicz and Kamil 1979) and observational learning from the behavior of other flock members (Alcock 1969). Mealworms may offer a visual cue that was repeated, and thus they may have been more obvious than were natural overwintering arthropods. This may have made it easier for birds to develop search images for these objects. If this were so, we would expect the influence of feeders on natural overwintering arthropods to be more subtle.

High numbers of American goldfinches (Carduelis tristis) in the winter of 2000–2001 confound interpretation of seed-consumption data. Although they utilized the feeders, American goldfinches are not bark gleaners and do not typically consume arthropods in the winter. Therefore, we would not expect them to be important consumers of mealworms. The National Audubon
Society Christmas Bird Count data for Houghton County, Michigan indicates that the number of American goldfinches detected per party hour increased from 0.41 in 1999-2000 to 9.53 in 2000-2001 (Sauer et al. 1996).

The use of any experimental substitute for actual overwintering arthropods raises one methodological and inferential question: to what extent do mealworms inserted into holes resemble actual overwintering arthropods? Although the mealworms were fairly difficult for us to see, they may be less cryptic than most arthropod eggs, pupae, or adults, and certainly do not approach the concealment achieved by an arthropod beneath the bark. However, our study was designed to measure the relative intensity of predation exerted by a community of bark-foraging birds with and without a nearby feeder. For this we needed only to array a number of food items that approximated overwintering arthropods in size and general location within replicated forest plots.

Management Implications

Millions of people feed birds for aesthetic and educational reasons or to increase overwinter survival. Our results suggest that bird feeding may also reduce overwinter survival of local populations of arthropods. Studies focusing on whether bird predation near feeders affects particular arthropod species or taxa (such as nonnative forest pests or potentially beneficial predatory spiders) are needed to identify which groups of arthropods are most influenced by winter foraging. Birds may increase tree health by consuming leaf-chewing arthropods (Altegrim 1989, Marquis and Whelan 1994). Takekawa et al. (1982) provide a review of avian predation on destructive forest insects and the role of biological control. They discuss management approaches to increase densities of insectivorous birds (e.g., providing nestboxes, leaving snags, or implementing silvicultural practices) as an alternative to pesticides in areas with forest pests. The use of winter bird feeders as an alternative form of arthropod pest control warrants further investigation.

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Literature cited


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