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ABSTRACT--Estimates of nontarget animal mortality due to the effects of agricultural pesticides may be biased by the removal of carcasses by scavengers. We placed intact songbird carcasses in ripening sunflower fields in late-summer, and in harvested corn fields and woodlots in early spring to assess carcass removal by scavengers. Removal curves differed among the three habitats ($P < 0.001$). One day after placement, 58% of carcasses persisted in the sunflower fields, whereas 82% and 90% remained in the corn fields and woodlots, respectively. Our results suggest that survival times for carcasses are variable and dependent on habitat and, perhaps seasonal factors. In most cases, searches for carcasses should be conducted within one day of the pesticide application.

Key words: carcass survival, estimating bird mortality, pesticides, scavengers.

Insects and blackbirds cause extensive damage to crops in the northern Great Plains (Lamey et al. 1993). Insecticides, including some that may be toxic to birds, are often used to reduce insect damage (Tome et al. 1991), and sunflower growers are requesting the development of avicides to reduce blackbird populations during spring and late-summer migrations (North Dakota Agricultural Statistics Service 1995). During the spring, avicides are spread in harvested cornfields and in ripening sunflowers in late-summer (Linz and Bergman 1995). Nontarget animal mortalities associated with agricultural pesticide applications are a concern (Balcomb 1986, Tobin and Dolbeer 1990, Linz et al. 1991, Tome et al. 1991). Therefore, reliable estimates of mortality must be obtained to evaluate the effects of pesticide applications.

The number of carcasses removed by scavengers is a factor that may affect the accuracy of mortality estimates (Balcomb 1986, Fite et al. 1988, Heisterberg et al. 1990, Linz et al. 1991). Researchers have placed carcasses in wetlands (Avery 1974, Avery et al. 1978, Faanes 1987, Linz et al. 1991), newly planted corn fields (Balcomb 1986), and fruit orchards (Tobin and Dolbeer 1990) to estimate the level of scavenging activity. However, to our knowledge, no systematic studies of scavenging of bird carcasses in ripening sunflower fields, harvested corn fields, and woodlots in the northern Great Plains have been conducted.

During August and September 1993, we placed intact blackbird (Icterinae) and house sparrow (*Passer domesticus*) carcasses in ripening sunflower fields in North Dakota. Similarly, in March and April 1995, we placed bird carcasses in woodlots and harvested corn fields in South Dakota. Our objective was to estimate bird carcass longevity in these habitats.

STUDY AREA AND METHODS

Our study was conducted in Grand Forks and Nelson counties in North Dakota and Miner and Brookings counties in South Dakota. These counties are located in an area known as the Prairie Pothole Region, which is characterized by numerous wetlands surrounded by farm land (Stewart and Kantrud 1974).

In August and September 1993, five ripening sunflower fields were divided into three strata, each containing an equal number of rows. One lane (about 1.5 m wide) was randomly created in each stratum by knocking over a row of sunflower with an all-terrain vehicle. To determine the number of carcasses per lane, we divided the number of carcasses to be placed in a field ($n = 20$ to 28) by the total length of all three lanes. The interval between carcasses was determined by dividing the total length of the lane by the number of carcasses assigned to that lane. The location of the first carcass in each lane was a randomly selected distance between zero (the edge of the field) and the carcass interval. The remaining carcasses were placed systematically along the lane. The status of each carcass was checked daily for four days.

In March and April 1995, we placed 10 bird carcasses along each of two randomly selected lanes in one 0.81-ha plot within each of four harvested, but not tilled, corn fields. Additionally, 10 carcasses were placed along each of two randomly selected transects in each of four woodlots located within 1 km of harvested corn fields. Placement and monitoring of carcasses within these habitats were the same as for those placed in the sunflower fields. Carcasses were recorded as intact, partially scavenged, or removed without a trace. A carcass was recorded as 'partially scavenged' if any part of the body remained

at the site. A small colored ribbon placed about 1 m from each carcass facilitated relocation.

We defined removal time as the time to disappearance of the carcass. Removal time is important in assessing potential secondary hazards of a pesticide treatment (Balcomb 1983) and must be considered when estimating mortality of target and nontarget species (Fite et al. 1988). Using the LIFETEST procedure in the SAS program package (SAS Institute, Inc. 1990), we analyzed removal time by the product-limit life table method (Kaplan and Meier 1958). Using a Wilcoxon test modified for censoring (Breslow 1970), we compared the percentage of removed carcasses among habitats. A censored carcass was any carcass still present at the last check (Linz et al. 1991).

A one-way analysis of variance (Cody and Smith 1991) was used to test the hypothesis that the average percentage of partially scavenged carcasses was equal among habitats on the last day the carcasses were checked, that is, day four. The number of partially scavenged carcasses is an important variable in assessing potential secondary hazards from a pesticide treatment (Balcomb 1983).

RESULTS

Removal curves differed among the three habitats ($X^2 = 51.07$, df 2, $P < 0.001$), with carcass longevity significantly shorter in sunflower fields ($\bar{x} = 2.0$, SE = 0.12 days) than in corn fields ($\bar{x} = 2.5$, SE = 0.13 days), and woodlots ($\bar{x} = 2.7$, SE = 0.11 days). One day after placement, 58% of the carcasses persisted in the sunflower fields, whereas 82% and 90% of the carcasses remained in the corn fields and woodlots, respectively (Fig. 1). By the end of four days, 12% (SE = 5%) of the carcasses persisted in the sunflower fields, 62% (SE = 19%) of the carcasses remained in the corn fields, and 75% (SE = 12%) lasted in the woodlots. The total number of partially scavenged carcasses differed slightly among habitats ($P = 0.080$), with more partially consumed carcasses in the woodlots ($\bar{x} = 36\%$, SE = 12%) than in the sunflower fields ($\bar{x} = 6\%$, SE = 6%).

DISCUSSION

Variability in carcass removal may have been confounded by seasonal differences between the sunflower fields checked in late summer and the corn fields and woodlots assessed in the spring. For example, during the fall, scavenger abundance is probably greater due to young-of-the-year birds and mammals. Also, the dense canopy provided by the ripening sunflowers may have afforded protection to scavenging mammals. On the other hand, the sunflower canopy could obscure the vision of raptors as they forage over the

fields. As evidenced by tracks, various mammals common to the northern Great Plains, for example red fox (*Vulpes vulpes*), raccoon (*Procyon lotor*), and coyote (*Canis latrans*), fed on the carcasses in the spring and fall. Avian predators (Accipitridae) may have found some carcasses, but are more likely to find debilitated birds that are often associated with pesticide poisoning (Bruggers et al. 1989). The high percentage of partially scavenged carcasses in the woodlots probably was the result of feeding by small mammals (Muridae and Soricidae) that were unable to remove the carcasses. Regardless of the reasons, scavenging was substantial in ripening sunflower fields compared to harvested corn fields and woodlots.

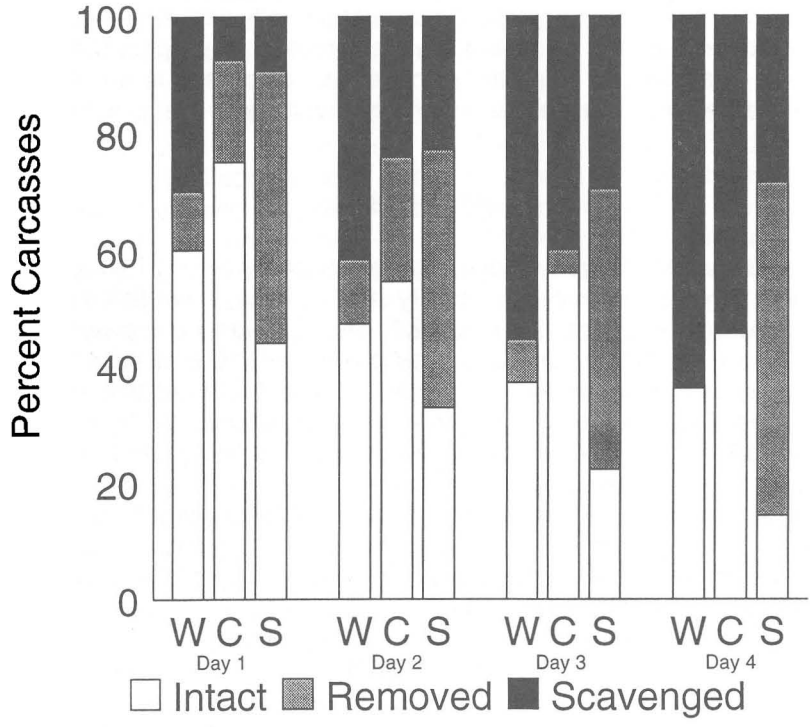

Figure 1. Percentages of song bird carcasses remaining (fully intact), partially scavenged, and removed without a trace in ripening sunflower fields (S) in North Dakota, and harvested corn fields (C) and woodlots (W) in South Dakota.

Other studies indicate that habitat characteristics are an important factor affecting the success of scavengers. In New York, Tobin and Dolbeer (1990) found that 31% and 62% of brown-headed cowbird (*Molothrus ater*) and house sparrow carcasses placed in cherry and apple orchards, respectively, survived four days. Additionally, scavengers removed significantly fewer carcasses from weedy orchards (60%) than from clean orchards (90%). Woronecki et al. (1979) recovered 66% of house sparrow carcasses two days after placement in ripening corn fields in Ohio. Balcomb (1986), however, found that only 14% and 9% of passerine carcasses remained intact two and four days after placement, respectively, in newly planted corn fields in Maryland.

We recognize that mammals may have followed our trail to the carcasses placed in the various habitats. On the other hand, trap-shy scavengers experienced with humans may avoid a carcass tainted with human scent (pers. observ.). This problem is an inherent part of carcass disappearance studies, especially where the same areas must be searched repeatedly; thus, investigators should wear rubber footwear and gloves when handling carcasses to reduce human scent.

Because scavenging differs among habitats, an index of scavenging activity should be obtained for each treated field. We suggest that, immediately before the pesticide is applied, a small number of carcasses be marked and placed in the habitat. The number of carcasses used to determine rate of scavenging should be relatively small so that scavengers do not become satiated, which could result in a low estimate of scavenging activity. The searches need to be conducted within one day of the pesticide application to ensure reliable estimates of mortality.

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