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Does Removal of Duck Nest Predators Affect the Temporal Patterns of Predation for Simulated Nests of Grassland Songbirds?

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We tested whether the temporal patterns of songbird nest predation changed following removal of predators of duck nests in North Dakota, USA, 1995-1996. Overall, 2286 simulated nests were deployed of which 951 were equipped with depredation timing devices that recorded the time of day of nest destruction. Predators destroyed 242 timer nests, and 155 depredation events were recorded. Temporal distribution of predation events was uniform over a 24-h period. However, predator groups, identified by using marks left on modeling clay eggs, depredated nests at different times. Mean times of depredation were 07h41, 12h57, 17h50, and 22h47 for small mammals, ground squirrels, birds, and medium-sized mammals, respectively. Daily depredation events occurred earlier on removal versus non-removal sites. However, within each predator group, there was no difference in depredation times between removal and non-removal sites. We suggest that the difference in time of depredation is caused by the differential importance of each predator group on removal versus removal sites, and thus conclude that removing duck nest predators does not affect temporal foraging patterns of smaller predators.

Key Words: grasslands, nest predation, predator control, songbirds, timing devices, waterfowl.

In North American grasslands, agricultural expansion and resultant habitat fragmentation have led to increased nest predation rates and have caused declines in numerous populations of ground-nesting birds (Ricklefs 1969; Klett et al. 1988). Consequently, much effort is devoted to mitigate predation of bird nests. Management practices typically involve restoration or conservation of nesting habitats (McKinnon and Duncan 1999), or more intensive methods of predator management such as predator control (Garretson et al. 1996). Most often, predator control is implemented to enhance nest success of economically important avian groups such as waterfowl (Sargeant et al. 1995), or upland game birds (Chessness et al. 1968).

The impact of removing carnivores on the abundance of smaller predators is unknown. In some areas, removing larger predators led to trophic effects and the increased abundance of smaller predators (Palomares et al. 1995). During short-term (one season) predator control, nest success of grassland songbirds was not affected by removal of larger predators (Dion et al. 1999), possibly because of compensatory predation on songbird nests by smaller predators such as ground squirrels (*Spermophilus*) or smaller mammals (Dion et al. 2000). The compensatory response was suggested because both groups of small predators depredate nests in more open habitats on sites where predators were removed, possibly because they perceived reduced predation risk (Lima and Dill 1990) or because vulnerable animals occupying more open habitats experienced improved survival and consequently could depredated more nests. Herein, we compare the daily patterns of depredation of simulated songbird nests between sites with and without removal of predators to test whether predators of songbird nests displayed different temporal foraging patterns.

Study Area and Methods

We conducted this study during the breeding seasons of 1995 and 1996 as part of a larger study on the .effects of predator removal on the nesting success of songbirds in the grasslands of eastern (48° N, 98° W) North Dakota, USA. This region has little relief and is dominated by small grain agriculture. Wetlands and fields enrolled under the Conservation Reserve Program and Water Bank Program, as well as Waterfowl Production Areas occur throughout the area (Garretson et al. 1996). Each year, we chose eight sites (all sites > 6 km apart) that possessed numerous potholes and with 10-30% of their surface as perennial grasslands. Each site was 41 km² in size, and was randomly assigned as "removal" or "non-removal". Removal sites were subjected to intensive predator trapping while nonremoval sites were left untreated (Garrettson et al. 1996). Predator removal was performed from March through July, using similar removal methods (boxtraps, snares, leghold traps, and shooting) on all removal sites. Red Fox (*Vulpes vulpes*), Striped Skunk (*Mephitis mephitis*), Raccoon (*Procyon lotor*), and America Badger (*Taxidea taxus*) were targeted for removal.

Within each site, we established three 500-m transects for the placement of simulated nests. All transects were in contiguous areas of grassland without wetlands or shelterbelts and were placed in grasslands (mostly Conservation Reserve Program fields) of similar vegetative structure. Distance between any two transects was >1.6 km.

Simulated nests consisted of a commercial wicker nest (9 cm in diameter and 5 cm deep) lined with grass and other local vegetation. In each nest, we placed one Japanese Quail (*Coturnix japonica*) egg and one painted modeling clay egg. Modeling clay eggs were used to help detect and identify predators based on beak and tooth marks (Major 1991; Bayne et al. 1997) because predators cannot be identified from nest remains (Larivière 1999). We wore rubber boots and gloves while handling nests and eggs to reduce human scent.

We deployed nests on the ground at 20-m intervals and at random distances (5-25 m) from transect lines, alternating sides for consecutive nests. Twenty-five nests were deployed per transect for a total of 75 nests per site. Simulated nests were exposed for 12 days to mimic a typical songbird incubation period (Rudnicky and Hunter 1993).

We visited simulated nests every four days and removed destroyed nests from transects. We considered a nest destroyed if at least one egg was missing or destroyed or if any marks were left on the modeling clay eggs. Each year we conducted two trials (early June and early July) to mimic the peak nesting and renesting period of grassland songbirds in North Dakota (Stewart and Kantrud 1972).

To identify predators, we compared width of teeth marks to measurements of 10-15 skulls of each species of small mammals and ground squirrels from the Biology Museum, University of Saskatchewan. Because many species have overlapping tooth patterns (N. Dion, unpublished data), we grouped predators according to ecological relatedness: small mammals (*Peromyscus* spp., *Microtus* spp., *Clethrionomys* spp.), ground squirrels, medium-sized carnivores (Striped Skunk, Raccoon, American Badger, Red Fox), birds (primarily Sedge Wren, *Cistothorus platensis*, and

Brown-headed Cowbirds, *Mlolothrus ater*). Modeling clay eggs left without marks or with confusing marks were classified as being destroyed by unknown predators.

At each nest, we positioned one egg on a timing device (modified from Ball et al. 1994). Timing devices consisted of stopwatch glued to the sides of a wicker nest (to provide stability of the clock), with an egg placed on the stop switch. Clocks were adjusted to current time, and removal of the egg from the switch (following depredation) stopped the clock and recorded the time of depredation. Because the number of timers was smaller than the total number of nests, we placed timers at the last 20 nests of each transect.

Times of depredation were compared using circular statistics. We first tested data sets for uniformity using Rayleigh's uniformity test, then compared samples using Watson's F-test for circular means.

Results

Trappers removed 1166 and 908 medium-sized predators from the experimental sites in 1995 and 1996, respectively (Garretson et al. 1996). During both years, trappers removed primarily Raccoon (42%), Striped Skunk (31%), and Red Fox (24%). American Badger and American Mink (*Mustela vison*) comprised the remaining 3%. Because predator densities were not monitored, it is unknown to what degree removal operations affected predator densities or communities. However, because of the high effort and number of animals removed, we suspect most of the resident target animals were removed during trapping.

We monitored nest fate for 1125 and 1161 nests in 1995 and 1996, respectively. Of those, timers were placed at 951 nests (42% of monitored nests), and 242 were depredated (25%, n = 951). Timers recorded 155 depredation events (64%). Because of the small sample of nests, we could not test for effects of year or trial. Instead, we focused on the more important effects of predator type and treatment (removal versus non-removal sites).

Depredation events were distributed uniformly throughout the day (Rayleigh test of uniformity, P = 0.22; Figure 1A). However, specific predator groups did not prey on nests uniformly throughout the day (medium mammals, P = 0.03; ground squirrels, P < 0.01; small mammals, P = 0.10; birds, P = 0.10). Mean depredation time differed between all groups (Watson's *F*-tests for two-circular samples, multiple comparisons adjusted with Bonferonni correction, all F > 8.50, all P < 0.01). Mean depredation times averaged 07:41, 12:57, 17:50, and 22:47 for small mammals, ground squirrels, birds, and medium-sized mammals, respectively (Figure 1B, C, D, E).

Time of nest destruction was evenly distributed throughout the day on non-removal sites (Rayleigh test of uniformity, P = 0.88), but not on removal sites (P = 0.02). Mean depredation time differed (Watson's



FIGURE 1. Temporal patterns of depredation by various predators of simulated nests of grassland songbirds in north-eastern North Dakota, 1995-1996. *n* indicates the number of nests. Concentric dotted lines equal one predation event. Dark lines indicate time of predation events.





Figure 2. Temporal patterns of depredation of simulated nests of grassland songbirds on sites where duck nest predators were removed (removal) and not removed (non-removal) in northeastern North Dakota, 1995-1996. *n* indicates the number of nests. Concentric dotted lines equal one predation event. Dark lines indicate time of predation events.

F-test for two circular means, F = 5.22, P = 0.02) between nests depredated on removal sites (mean = 14:13, n = 65) and nest depredated on non-removal sites (mean = 06:26, n = 90; Figure 2).

We tested whether depredation times differed for each predator group following removal of duck nest predators. Using Bonferroni corrections to compensate for multiple comparisons, we considered values <0.0125 as significant. Consequently, we detected no differences in depredation times between removal and non-removal sites for nests depredated by birds (F = 1.37, P = 0.25, mean = 17:50, n = 28), small mammals (F = 0.02, P = 0.88, mean = 07:41, n = 14), ground squirrels (F = 0.06, P = 0.81, mean = 12:57, n = 31), or medium mammals (F = 3.76, P = 0.06, mean = 22:47, n = 38).

Discussion

We did not detect differences in depredation times between removal and non-removal sites for any of the predator groups. Previously, we showed that predators at lower trophic levels (e.g., ground squirrels and small mammals) depredated nests with different vegetative characteristics, suggesting a spatial response to the removal of predators at higher trophic levels (Dion et al. 2000). Similar depredation times between removal and non-removal sites for each individual predator group suggest that differences observed between areas were caused by the relative importance of each predator group (Dion et al. 1999). Specifically, ground squirrels were more important as predators on removal sites, and their mean predation time was in midday (12:57), which would shift the mean depredation time for removal sites toward early afternoon, a pattern that corresponds with what we observed (Figure 2).

The study of temporal patterns of nest predation is still relatively new (Ball et al. 1994) and hence few data are available for comparison (Ball et al. 1994; Picman and Schmirl 1994; Bayne and Hobson 1997; Larivière and Messier 2001). With the development of more sophisticated methods such as video cameras to monitor bird nests (e.g., Pietz and Granfors 2000), new insights into the behavior of nest predators will be gained. Although our sample of nests with timers was limited, our study emphasized the usefulness of timer nests in examining the nature and dynamics of predation on grassland songbird communities. Combined with the use of clay eggs or photographic means of recording predators, timer nests should be encouraged as a refinement to the more common use of artificial nests to study nest predation.

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