21??

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Source and sink habitats of Red-winged blackbirds

Abstract

The objectives of this study were to 1) determine the source and sink habitats of Red-winged blackbirds (*Agelaius phoeniceus*), and 2) determine the use of source and sink habitats by these birds. In 1996, I monitored 228 Red-winged blackbird nests in natural (wetland, tallgrass prairie) and anthropogenic (hayfields, roadside ditches) habitats. Red-winged blackbirds experienced higher reproductive success in natural habitats (60-77%) than in anthropogenic habitats (<25%). Predation was the major cause of nest failures, but did not differ significantly between natural and anthropogenic habitats. Natural habitats tended to act as sources while anthropogenic habitats tended to act as sinks. Habitat utilization did not accurately reflect the quality of habitat. Tallgrass prairie functioned as a strong source habitat but was utilized by only 3% of the blackbirds in Boulder; this may be related to microsite preference by the blackbirds. The majority of birds nested in wetlands (62%) and wetlands functioned as source habitats. While productivity for hayfields and roadside ditches was approximately equal, twice as many Red-winged blackbirds nested in hayfields (22.5%) than in ditches (10%). These data suggest that habitat utilization does not reflect habitat quality and that a large percentage (roughly 33%) of Red-winged blackbirds breeding in Boulder are utilizing sink habitats.

Objectives and hypotheses

A continuum of habitat quality exists for species concerning reproduction and mortality. The concept of source and sink population dynamics relates specifically to this variability of habitat quality. Source habitats are those in which reproduction exceeds mortality whereas mortality exceeds reproduction in sink habitats (Pulliam 1988). While many models exist which detail source and sink population dynamics, few field studies have adequately tested these models. My overall objective is to determine the source and sink habitats of the Red-winged blackbird (*Agelaius phoeniceus*) in a mosaic of habitats that are natural (wetland, tallgrass prairie) and anthropogenic (roadside ditches, hayfields). Additionally, I will examine the utilization of source and sink habitats by this species.

I tested three hypotheses in relation to this study:

Hypothesis 1: **Predation is a prime determinant of breeding habitat quality.**

Prediction:	Predation is higher in anthropogenic habitats than in natural habitats.
Hypothesis 2:	**Habitat-specific predation rates determine which habitats functions as sources or a sinks.**
Prediction 1:	Source habitats will have lower predation rates than sink habitats.
Prediction 2:	Natural habitats will function as sources whereas anthropogenic habitats will function as sinks.
Hypothesis 3:	**Habitats are occupied according to their quality.**
Prediction:	Higher abundances of Red-winged blackbirds will be found in source habitats than in sink habitats.

Study sites

The study sites were located throughout Boulder and were primarily properties owned by Open Space. I studied Red-winged blackbird population dynamics in the following habitat types: wetlands with both Yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) and Red-winged blackbirds, wetlands without Yellow-headed blackbirds, tallgrass prairie, hayfields, and roadside ditches.

Methodology

Predation rates

I monitored 228 nests during the summer of 1996 every 2-3 days in the above habitats. If the nest contents disappeared prior to the fledging of young, a predation event occurred. I quantified the frequency of predation rates on nests in the different habitats and statistically analyzed the data using a contingency table (Zar 1984). Although I present the data as percentages, I used the frequency of predation compared to the total sample size for the statistical analysis.

Source and sink determination

Determination of source and sink habitats requires both reproductive and mortality data. Using the method outlined by Donovan et al. (1995), I can estimate the minimum number of fledglings required to offset adult mortality. A population will replace itself if:

Equation 1:

1- adult survivorship = mean # of female offspring/female/year x juvenile survivorship

(Ricklefs 1973); rearranging equation 1 yields equation 2, which can be used to determine source and sink habitats.

Equation 2:

1- adult survivorship/juvenile survivorship = mean # of female offspring/female/year

If the observed productivity (mean number of female offspring/female/year) is less than (1-adult survivorship)/juvenile survivorship, I will conclude that the population is a sink (Donovan et al. 1995). Conversely, if the observed productivity exceeds (1-adult survivorship)/juvenile survivorship, I will conclude that the population is a source.

The calculation of the mean number of female offspring per female requires the use of four different parameters: the mean number of female offspring produced per successful nest, habitat-specific reproductive success, the number of renests, and the number of broods per year (Donovan et al. 1995). During the 1996 breeding seasons, I gathered data on the reproductive parameters needed to calculate the mean number of female offspring/female/year. I calculated reproductive success using the Mayfield method (1975) and all other values were gathered through observation.

The calculation of source and sink habitats also requires the use of mortality data. While habitat-specific mortality may occur, I will assume similar mortality rates among habitats for the following reasons. First, mortality rates among breeding habitats may be relatively insignificant compared to overwinter mortality. The highest rates of mortality for most birds occur during the winter and since Red-winged blackbirds from all breeding habitats form winter flocks, these birds are subject to the same winter mortality pressures regardless of their breeding habitats. In addition, acquisition of habitat-specific mortality data require a long term study and this is not feasible within the time framework of this project. For these reasons, I will use published estimates of Red-winged blackbird for the above calculations. Annual adult survival estimates range from 52-62% while the survival of juveniles in the first year ranges from 49-59% (Fankhauser 1961, Stewart 1978, Beletsky 1996). For use in equation 1, an adult survivorship average of 60% was used (Beletsky 1996) while survival of juveniles in the first year was 54%. Incorporation of these values into equation 2 indicate that those populations producing fewer than .74 female fledglings/female/year may be considered sinks while those producing more than .74 female fledglings/female/year may be considered sources. I did a correlation between the number of female fledglings/female/year and the rate of predation to determine the relationship between these two variables.

Habitat utilization and habitat quality

Between May and July, 1996, I censused for Red-winged blackbirds in 48 quarter sections located in the townships of ElDorado Springs, Boulder, and Hygiene. Within each quarter section ($801m^2$), three observers walked transects 200m apart and recorded all adult males, first year males, and females (Nelms et al. 1995). All censuses were conducted between sunrise and 1100 or from 1700 to sunset.

Habitat utilization by Red-winged blackbirds was obtained by recording the type of habitat occupied by the bird during the time of the census. Habitats used for this study included 1) wetlands, 2) tallgrass prairie, 3) short/mixed grass prairie, 4) hayfields, 5) residential/commercial, 6) cultivated fields, 7) shrubs, roadside ditches, and railroad right-of-ways, 8) woodland, and 9) other (i.e. grazed fields).

Results

I monitored 228 nests in five different habitats in Boulder County (Table 1). With the exception of roadside ditches, all of these sites were owned by the Open Space Department.

Table 1. Types of habitat, number of study sites, and number of Red-winged blackbird nests monitored throughout the 1996 breeding season. YHBLs refer to Yellow-headed blackbirds.

Habitat types	Number of study sites	Number of nests
Natural habitats		
Wetlands with YHBLs	2	5
Wetlands without YHBLs	2	148
Tallgrass prairie	2	13
Anthropogenic habitats		
Cultivated hayfields	2	24
Roadside ditches	3	38

Predation rates among habitats

Predation was the main cause of nest failures in the different habitats (Table 2). However, predation did not differ significantly between habitats (χ^2=4.0, df=4, p>.05). Birds nesting in roadside ditches experienced the greatest amount of predation while birds breeding in wetland areas experienced the lowest predation rates. On average, 44% of all nests in natural habitats were depredated whereas 66% of all nests in anthropogenic habitats were depredated.

Table 2. Predation rates on Red-winged blackbird nests in Boulder County during the 1996 breeding season. YHBL refers to yellow-headed blackbirds. * Mowing accounted for 13% of failed nests in hayfields in 1996.

Habitat types	%Failure	% Predation	% Abandoned	%Other
Natural habitats				
Wetlands with YHBLs	40	40	0	0
Wetlands without YHBLs	51	46	4	1
Tallgrass prairie	23	23	0	0
Anthropogenic habitats				
Cultivated hayfields	79	54	12	13
Roadside ditches	76	74	2	0

Source and sink determination

In order to determine source and sink habitats, data on reproductive success and productivity were gathered (Table 3). Reproductive success differed significantly between habitats (χ^2=13.3, df=4, p<.01) with natural habitats experiencing the highest success and anthropogenic habitats experiencing the lowest success. Productivity, the average number of fledglings/nest, also differed significantly between habitats (F=6.8, df=4, p<.0001). Nests in natural habitats fledged more young on average (1.6-2.2) than did anthropogenic habitats (.73-.75).

Table 3. Reproductive success (calculated as the number of nests successful in fledging at least one young/all nests) and productivity (average number of fledglings/all nests ± s.e.) of Red-winged blackbirds nesting in different habitats in 1996. YHBLs refers to Yellow-headed blackbirds.

Habitat types	Reproductive success (%)	Productivity
Natural habitats		
Wetlands with YHBLs	60	1.6 (± .68)
Wetlands without YHBLs	50	1.6 (± .12)
Tallgrass prairie	77	2.2 (± .42)
Anthropogenic habitats		
Cultivated hayfields	21	0.75 (± .31)
Roadside ditches	24	0.73 (± .22)

Calculation of the mean number of female fledglings/female/year for both 1995 and 1996 suggests that natural habitats function as sources while anthropogenic habitats function as sinks. Wetlands without Yellow-headed blackbirds and tallgrass prairies functioned as strong sources whereas wetlands with both Yellow-headed blackbirds and Red-winged blackbirds, roadside ditches and hayfields functioned as sinks.

In general, habitats with high predation rates (roadside ditches, wetlands with Yellow-headed blackbirds) tended to function as sinks while those with lower predation rates function as sources. Predation rates and the mean number of female fledglings/female/year were negatively correlated (-0.76). This suggests that higher values of predation lead to lower productivity values; hayfields do not quite match the predicted productivity because many of the nest failures occurred due to mowing.

Table 4. Source and sink habitats in 1995 and 1996 in Boulder and the relationship to predation rates. The number of female fledglings/female per year needs to be greater than .74 for a habitat to function as a source and less than .74 to function as a sink. YHBLs refers to Yellow-headed blackbirds.

Habitat types	Predation rate (%)	# female fledglings/female/year
Natural habitats		
Wetlands with YHBLs	55	.49
Wetlands without YHBLs	45	.85
Tallgrass prairie	42	.97
Anthropogenic habitats		
Cultivated hayfields	44	.27
Roadside ditches	79	.02

Habitat utilization and habitat quality

Red-winged blackbirds did not use habitat according to its quality. Wetlands without Yellow-headed blackbirds and tallgrass prairie were the highest quality habitats (as determined by their source/sink productivity), but they were used in very different amounts; 62% of the birds utilized wetlands whereas only 3% utilized tallgrass prairie. Hayfields were used by 22.5% of the population and roadside ditches were utilized by the remaining 10% of the population. The remaining birds (approximately 3%) were located in habitats other than those above (i.e. woodland).

Discussion and Conclusions

For Red-winged blackbirds, predation was the prime determinant of habitat quality. Birds breeding in anthropogenic habitats suffered higher predation rates than those which nested in natural habitats. This difference may be due in large part to the presence of human-commensal predators, such as domestic cats (*Felis catus*) and raccoons (*Procyon lotor*). Raccoons often destroy nests during predation and this pattern of nest destruction was often present in the anthropogenic habitats.

The level of predation in a habitat was a good predictor of whether that habitat functioned as a source or sink. In general, habitats with high predation rates functioned as sinks whereas habitats with low predation rates functioned as sources. A similar relationship between predation and source/sink habitats was found for migratory birds nesting in fragmented versus unfragmented forests in North America. Birds nesting in fragmented forests suffered higher rates of predation and parasitism by Brown-headed cowbirds (*Molothrus ater*); in general, the fragmented forests acted as sinks whereas unfragmented forests appeared to be population sources (Donovan et al. 1995).

The interpretation of the data concerning habitat utilization and its relationship to habitat quality depends upon the scale used. On a coarse scale, birds used habitat according to its availability; 65% used source habitats and 33% used sink habitats. However, utilization of the two source habitats did not reflect habitat quality. Few birds (3%) utilized tallgrass prairie sites, despite their strength as source habitats and this may be related to microsite preference. Red-winged blackbirds typically use the moister microsites within a tallgrass prairie site (Zimmerman 1993), and these types of microsites may be rare in Boulder tallgrass prairie.

Similarly, habitat utilization within the sink habitats did not reflect habitat quality. Greater than one fifth (22%) of the blackbird population in Boulder utilized hayfields, which have been noted to function as sink habitats in other studies (Frawley 1989). Roadside ditches were equally as productive as hayfields, but only 10% of Red-winged blackbirds in Boulder utilized roadside ditches. While other studies have not recorded low reproductive rates in ditches (Paruk 1992), ditches in Boulder acted as strong sinks. The differences in the use of hayfields and roadside ditches may again relate to differences in microsite quality or some aspect of site fidelity.

The results of this study can be used by the Open space department in a number of ways. First, this study suggests that natural habitats (wetlands, tallgrass prairie) are essential to maintaining Red-winged blackbird populations. Their use of these habitats in large part reflects the importance of these habitats to their population dynamics. However, the large proportion of birds occupying sinks may be equally important to the dynamics of this bird. Sink populations augment metapopulation size and may be important in a rescue effect, should catastrophic occurrences affect source populations (Howe et al. 1991).

Second, this study identifies predation as a major factor influencing source and sink dynamics. In many ways, the Red-winged blackbird functions as a model species for other passerines in the Boulder landscape. Those populations breeding in wetlands or tallgrass prairie may have a better chance of functioning as source populations, simply because they experience lower predation rates. However, factors such as landscape context may be a confounding factor affecting source and sink dynamics which has not been examined in this study.

Finally, the results of the habitat use vs. habitat quality study suggest that caution should be used when trying to assess the quality of a habitat simply through a measure of abundance (Van Horne 1983). For Red-winged blackbirds, management plans based on a census would indicate that hayfields and roadside ditches were more important to the populations than tallgrass prairie. This study suggests that any inference as to habitat quality based on census data alone should be done with caution.

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HUMAN-COMMENSAL PREDATORS AND THEIR IMPACT IN RED-WINGED BLACKBIRD (*AGELAIUS PHOENICEUS*) BREEDING HABITAT.

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Abstract - The objectives of this study were to identify the major predators in Red-winged blackbird (*Agelaius phoeniceus*) breeding habitats in Boulder County and to examine their relationship to habitat type. Using artificial nests with modeling clay eggs and a quail egg, I identified predators by marks left on the clay egg during a predation event. I placed twenty five artificial nests in natural habitats (wetlands, tallgrass prairie) and anthropogenic habitats (hayfields, roadside ditches) during a single nine day trial. I conducted two trials during late May and early June, 1996. Nests in tallgrass prairie suffered the greatest amount of predation (46 of 50 nests were depredated) and 67% of the nests were depredated by corvids. In contrast, fewer than 4 predation events were recorded in each of the other habitat types. Additional trials are necessary to determine if habitat type is a major determinant of the predators responsible for nest failure in Red-winged blackbird breeding habitats.

Objectives and hypothesis

Predation is a major factor affecting species population dynamics. Although predation is recognized as one of the prime causes of nest failure in avian species (Martin 1995), the identity of the predators is often unknown. The objectives of this study were to identify the major predators in Red-winged blackbird (*Agelaius phoeniceus*) breeding habitats in Boulder County and to examine their relationship to habitat type.

Habitat type may influence the presence of predators, especially in reference to human activity. It is generally recognized that human-commensal predators such as corvids, raccoons (*Procyon lotor*), and domestic cats (*Felis catus*) may be important predators in areas of human activity (e.g. suburbs). While other studies have addressed predator identity as it differs among habitat type (Angelstam 1986, Picman 1988, Laurence et al. 1993), none do so when examining different habitat types in a suburban landscape.

I tested the hypothesis that habitat type (natural versus anthropogenic) is a prime determinant of predator identity with the prediction that a high proportion of artificial nests will be depredated by human-commensal mammals in anthropogenic habitats. The alternative prediction was that habitat type does not affect the frequency of depredation by human-commensal predators. This may be particularly true if suburban context is more important than habitat type.

Methodology

I purchased 100 grass bird nests (from Pier 1 Imports) which were similar in size to Red-winged blackbird nests. In each nest, I placed one Chinese quail egg (*Excalfactoria chinensis*) and one modeling clay egg. The clay egg was anchored to the nest with small drapery hooks in the bottom of the nest. I wore rubber gloves during this time in order to minimize human scent which might be used by mammals to locate the nests. In addition, I incubated both the modeling clay eggs and the nests in paper bags with vegetation and detritus for two weeks prior to the beginning of the experiment so as to mask any unnatural odors.

I ran a linear transect through the following Red-winged breeding habitats: wetlands, hayfields, tallgrass prairie, and roadside ditches. Again, I wore rubber gloves and boots in order to minimize human scent (Nol and Brooks 1982, Yahner and Delong 1991). The nests were placed 5 meters away from the transect every 10 meters in an alternate fashion (one on the left, one on the right, etc.). I placed nests at variable heights to mimic Red-winged blackbird nest placement.

Twenty five nests were set out in each habitat type during a single trial and two separate trials were conducted. While more trials were planned, the quail egg supplier was unable to supply eggs until the end of May and only two trials were run before the hayfields were mowed. Red-winged blackbird incubation typically lasts 9-10 days, so artificial nests remained in the field for 9 days. Since extended periods of exposure may result in egg putrefaction (Leimgruber et al. 1994), new eggs were used in each trial. Artificial nests were monitored every 2-3 days, at which time nest contents were examined. If nests were depredated, I removed the clay egg and stored it for later identification, I identified the beak teeth marks on the clay eggs with impressions made from museum specimens on a modeling clay template. I am unable to statistically compare 1) the frequency of depredation between habitats, and 2) the frequency of depredation by different species between habitats using a contingency table because 3 of the 4 habitats had fewer than 5 predation events; this renders any chi-square test unusable (Zar 1984).

Results

The frequency of predation differed significantly between habitats. Forty six out of the fifty artificial nests in tallgrass prairie were depredated (92%) during the study. In contrast, 6% of the nests in wetlands were depredated, and 4% of the artificial nests in hayfields and roadside ditches were depredated.

Avian predators, primarily corvids, comprised the major predators in tallgrass prairie (Table 1). Black-billed magpies (*Pica pica*) depredated 35% of the nests in this habitat and Blue jays (*Cyanocitta cristata*) depredated 30% of the nests. Common grackles (*Quiscala quiscala*) and American crows (*Corvus brachyrhynchos*) were each responsible for 2% of all predation events.

Very few mammalian species depredated nests in this study. Raccoons (*Procyon lotor*) were only responsible for two predation events in wetlands, although this represented 67% of the predation events in this habitat type. Domestic cats and small rodents also were recorded as predators, but again, they accounted for relatively few predation events.

Table 1. Predation frequency on artificial nests in four different habitats. Black-billed magpies (BBMA), Blue jays (BLJA), American crows (AMCR), Common grackles (COGR) constituted the avian predators.

	wetlands	tallgrass	hayfields	ditches
BBMA	0	16	1	0
BLJA	0	14	0	0
AMCR	0	1	0	0
COGR	1	1	0	1
domestic cats	0	2	0	0
raccoon	2	0	0	0
small rodent	0	2	1	0
no mark	0	5	0	0
unidentifiable mark	0	5	0	1

Approximately 20% of the clay eggs either had no marks on them or had unidentifiable marks present. Snakes are noted to be "clean" predators (i.e. leaving no signs at the nest) (Major 1991); they may be responsible for depredating nests and leaving no marks on the clay eggs. However, the lack of marks may also be due to the clay egg appearance/smell; if the predators did not like either the appearance or smell of the clay egg, they may not have attempted to take the clay egg.

Discussion and Conclusions

Mammals were responsible for relatively few predation events. In addition, the impact by human-commensal mammalian predators such as raccoons and domestic cats was minimal in all of the above habitats. In contrast, active nests in these habitats are often destroyed in a manner usually attributed to raccoons. Since mammals hunt primarily through olfactory cues, there may be a scent associated with active nests which was absent in the artificial nest experiments (but see Gottfried and Thompson 1978).

While I took measures to ensure that no human scent was left on the nests or in the vicinity of the nests, it is possible that some human scent remained on the eggs from the egg supplier. However, predation rates by mammals were extremely low, so the influence of human scent on the eggs from the egg supplier was probably negligible.

Avian predation was high in this experiment and this may be partly related to the absence of parent birds. Parent birds are active defenders of their nests and in a natural situation, parents may be more successful in driving off avian predators than mammalian predators. With the absence of a parent bird, avian predators may have been more successful than they might otherwise be in a natural situation.

The frequency of predation differed significantly between habitats with tallgrass prairie experiencing the highest level of predation. One reason why tallgrass prairie nests experienced high levels of nest predation may be due to nest placement. Artificial nests were not always placed within concealing vegetation because those clumps did not always occur at the designated placement sites. This lack of concealment may have made it easier for visual predators such as birds to locate nests. In contrast, the nests in the other habitats were always placed in somewhat concealing microsites because those were uniformly available in those habitat types.

There are two major conclusions from this study which will contribute to the management needs of the Open Space Department, although they must all be viewed with caution because they are based on a relatively small sample size. First, the results of this study failed to support the hypothesis that predator identity differed between habitat types. Human-commensal predators (Raccoons, Black-billed magpies, Blue jays) were associated with predation events in almost all the habitats. This suggests that in addition to habitat type, landscape context may also be important in determining the predator community. More experiments will be necessary to determine if habitat type influences the frequency and identity of predators on passerine nests.

Second, the frequency of predation on artificial nests did not reflect predation on active nests. In a study which was concurrent with this artificial nest study, Red-winged blackbird nests in wetlands, tallgrass prairie, hayfields, and roadside ditches were monitored over the summer. Active nests in roadside ditches experienced almost 80% predation rates, yet artificial nests suffered only 4% predation. The disparity in artificial versus active nest predation suggests that interpreting data concerning predation rates based solely on artificial nests must be done with caution.

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