

MANAGING RIPARIAN VEGETATION TO CONTROL COWBIRDS

CARA A. STAAB AND MICHAEL L. MORRISON

Abstract. Management strategies are needed to reduce the rate at which Brown-headed Cowbirds (*Molothrus ater*) parasitize their hosts. We investigated whether vegetation management could be used to reduce parasitism by seeking differences in nest-site microhabitats of hosts in a riparian area of central Arizona. During 1993 and 1994, we quantified vegetation characteristics in 0.04 ha plots centered on 128 nests of four commonly parasitized species and four infrequently parasitized species. We compared characteristics between parasitized and unparasitized nests of common hosts, and between nests of common and infrequent hosts. Factors associated with likelihood of parasitization were vegetation volume at nest, size of nest substrate, distance from nest to visual obstruction below nest, and presence of large trees near the nest. Whether nests belonged to common hosts or infrequent hosts was best predicted by nest height. Our results indicate riparian areas can be managed for large trees and numerous shrubs when the goal is to reduce parasitization.

Key Words: Arizona, avian reproduction, brood parasitism, Brown-headed Cowbird, host selection, microhabitat, *Molothrus ater*, nest selection, riparian.

It is well documented that brood parasitism by Brown-headed Cowbirds (*Molothrus ater*) causes many species of birds to fledge significantly fewer of their own young (e.g., Elliot 1978, Marvil and Cruz 1989). Consequently, some host species have undergone population declines that are at least partly due to parasitization (Mayfield 1977, Franzreb 1990). A few management strategies have been developed to minimize the potential impact of cowbirds on their hosts. Trapping and shooting can be done on or near host breeding grounds to reduce the number of cowbirds (Kelly and DeCapita 1982, Robinson et al. 1993). Host nests also can be located, allowing managers to monitor and remove cowbird eggs from the nests, or place artificial cowbird eggs in them, which act as a deterrent to subsequent parasitization (Ortega et al. 1994). These programs have the greatest potential when used to aid the recovery of threatened or endangered species (Robinson et al. 1993, Ortega et al. 1994). Because these strategies need to be repeated annually, have high costs, are labor-intensive, and have a restricted area of effectiveness, they may not be feasible for widespread use.

One way to control the effects of cowbirds on hosts would be to reduce the quality of cowbird breeding habitat, as measured by the proportion of nests that are vulnerable to parasitization. If a link existed between the vegetation surrounding available nests (i.e., nest-site microhabitat) and rates of parasitization, vegetation could be manipulated to reduce the number of nests being parasitized.

Within their breeding habitat, cowbirds appear to prefer edges (e.g., forest-meadow interfaces and perimeters of clearcuts; Brittingham and Temple 1983, Coker and Capen 1995). Managers can try to minimize the extent, rate, or lo-

cation of further fragmentation to minimize the risk that new areas will experience an increase in parasitization. However, this strategy will not work in areas that are, by nature, edges. Riparian zones of the southwestern United States are one example. These areas consist of narrow strips of vegetation that are characterized by a more diverse structure and assemblage of plant species than the surrounding, more xeric, environments. Because southwestern riparian areas support very high densities of breeding birds (Carothers 1974, Mills et al. 1991), and because parasitism rates have been positively correlated with density, many of these areas should be evaluated in regard to cowbird management needs.

We examined nest-site microhabitat characteristics of four common host species and four infrequent host species to determine if vegetative composition and structure influenced the susceptibility of a nest to parasitism by Brown-headed Cowbirds. Our specific objectives were to: (1) determine if differences existed between nest-site microhabitat of parasitized and unparasitized nests of common hosts, and (2) determine if differences existed between nest-site microhabitat of common hosts and infrequent hosts. From these data, we developed recommendations for habitat management that could minimize the impact cowbirds have on avian communities in southwestern riparian vegetation.

STUDY AREA

We worked along Walnut and Apache creeks, Yavapai County, Arizona, on about 50 ha of public (Prescott National Forest) and private lands at 1530–1580 m elevation. Vegetation consisted of 0.5–5.0 ha patches of riparian woodlands separated by grassy openings or strips of willow (*Salix* spp.). Following Szaro's

(1989) classification scheme, most patches were community type (1) *Acer negundo*-mixed broadleaf, (2) *Populus fremontii*, or (3) *Juglans major*; *Acer negundo*-mixed broadleaf was the most extensive type present. Mean annual precipitation was 40 cm, and mean annual temperature was 11.2 C (National Oceanic and Atmospheric Administration 1994).

METHODS

SPECIES STUDIED

Parasitization rates among species that accept cowbird eggs are highly variable, and indicate that factors other than egg rejection can influence the impact cowbirds have on a species. We used the natural patterns of variations in parasitization rates to divide the accepters into two groups: common hosts and infrequent hosts. Common hosts are those species that are frequently parasitized ($\geq 25\%$) in most of their range. Infrequent hosts are species that are rarely parasitized ($< 25\%$) in large portions of their range, despite their apparent suitability or tolerance as hosts. By these definitions, infrequent hosts in Arizona can include species that are rarely parasitized in the western US, even if they are more commonly parasitized in the east (or vice versa). By studying these two groups, researchers might gain additional insight into what features make a potential host susceptible to parasitization, which would lead to ways to lessen the impact cowbirds have on common hosts.

In 1993 and 1994, we searched for nests of four common host species and four infrequent host species that (1) are known Brown-headed Cowbird hosts (Friedmann and Kiff 1985), (2) are not known to reject cowbird eggs, (3) are open-cup nesters, and (4) breed during the same period that cowbirds do. The common hosts were Plumbeous Vireo (*Vireo plumbeus*), Yellow Warbler (*Dendroica petechia*), Yellow-breasted Chat (*Icteria virens*), and Blue Grosbeak (*Guiraca caerulea*). The infrequent hosts were Western Wood-Pewee (*Contopus sordidulus*), Black-headed Grosbeak (*Pheucticus melanocephalus*), House Finch (*Carpodacus mexicanus*), and Spotted Towhee (*Pipilo maculatus*). Staab (1995) presented details on classification of these species as common or infrequent host, and as acceptor or rejector.

NEST SEARCHES

We located nests by watching potential hosts (Ralph et al. 1993) and by conducting intensive searches through vegetation. We identified distinct stands of vegetation to serve as relocatable units to be searched. Nest searches were conducted from May through July to correspond with the egg-laying period of cowbirds (Best

1978). We revisited each stand every 10–12 d, yielding 5–7 visits per stand. We usually began searching for nests within 1 hr of sunrise, and concluded within 1 hr of sunset.

To determine if microhabitats differed between parasitized and unparasitized nests of common hosts, we included nests in our sample only if they could be classified with a high degree of certainty as parasitized or unparasitized. Nests were classified as unparasitized only if they contained a complete clutch of host eggs and no cowbird eggs, or a full brood of host young and no cowbird young or eggs. We classified nests as parasitized if they contained at least one cowbird egg or chick, regardless of what stage the nest was in when discovered, or whether the nest had been abandoned by the host (see Staab 1995 for further details). All nests were used in our analysis of common versus infrequent hosts regardless of parasitization status.

HABITAT CHARACTERISTICS

We established a 0.04 ha circular plot centered on each nest by stretching a tape measure out to 11.3 m in each of the cardinal directions. By defining the plot in this fashion, there were four transects (along the tape measure) and four quadrants (between the transects). We estimated the following variables modified from Noon (1981) and Mills et al. (1991) within each plot: (1) A vertical profile of vegetation volume was measured at 9 sampling points per nest by holding a pole perpendicular to the ground at each of the sampling points (1 at the nest, and 2 per transect [1 at the mid-point, and 1 at the edge of the plot]). For each m of the pole, we recorded the number of dm intervals that had woody vegetation (i.e., number of hits by species) within a radius of 1 dm from the pole; measurements above 8 m were visually estimated. (2) Distance to and height of the nearest shrub (woody vegetation > 1 m tall and < 3 cm dbh [diameter at breast height]), sapling (woody vegetation > 1 m tall and $3 \text{ cm} \leq \text{dbh} < 8 \text{ cm}$) and tree (woody vegetation > 1 m tall and $\geq 8 \text{ cm dbh}$) in each of the four quadrants. (3) Dbh size class of all standing trees (3–23 cm, 23–69 cm, and > 69 cm). (4) We estimated shrub density at breast height by counting the number of woody stems $< 3 \text{ cm dbh}$ that intersected our bodies and outstretched arms at breast height as we walked along each transect. (5) We estimated percent ground cover and live canopy cover by sighting through an ocular tube at five equidistant points along each of the four transects. (6) We used a clinometer or visual estimation to obtain average, minimum, and maximum canopy height within the plot. (7) Nest substrate type (i.e., tree, shrub, or ground), species, and dbh size class (if

tree). (8) Distance to and size of nearest opening (<10% canopy cover and <10% ground cover of shrubs). We estimated size of opening by visually estimating the length and width by size class (≤ 10 , 11–25, 26–50, 51–100, or >100 m). (9) Percentage class (0%, 1–25%, 26–50%, 51–75%, and 76–100%) of nest visible from the nearest tree and shrub in each quadrant, and from the end of each transect (visually estimated). (10) Position of the nest within the nest substrate. For each nest, we measured its height above the ground, distance to trunk (if in tree; distance was 0 if nest was in a shrub), distance to the edge of the substrate along the 4 transects, and total height of the nest substrate. We also recorded the distance to where $\geq 50\%$ of the nest was visually obstructed by vegetation directly above and below the nest.

DATA ANALYSIS

We used the logistic regression procedure of the SPSS statistical program to test for differences in parasitization status (within common hosts only) and between host types (SPSS 1992). All data were analyzed without regard to year of collection, because sample sizes were too small in 1993 to permit statistically valid analyses. To test for differences in parasitization status, we used presence or absence of parasitization as the dependent variable ("parasitization model"). To test for differences between host types, we used host type (common or infrequent) as the dependent variable ("host type model").

We used forward stepwise variable selection, with identical independent variables, to build both models. The score statistic was used to determine variable entry, and the likelihood ratio statistic to determine variable removal. The host type model was built with an entry P-value of 0.05, and a removal P-value of 0.10. The same set of P-values did not identify any significant variables when they were applied to the parasitization model; therefore, this model was built with an entry P-value of 0.10, and a removal P-value of 0.11. We used these sets of P-values because they resulted in models with an overall classification rate >70%, no outlying cases with studentized residuals >2.00, and a small number of variables. Models with few variables are more likely to be numerically stable, and are more easily generalized, than models with many variables (Hosmer and Lemeshow 1989:83).

We assessed the fit of our final models by examining the model chi-square (SPSS 1992). This tests the null hypothesis that the coefficients for all of the terms in a model, except the constant, are 0. To interpret the final models, we examined the odds ratio of each variable, which indicates how much more (or less) likely it is for the out-

TABLE 1. NUMBER OF PARASITIZED, UNPARASITIZED, AND UNKNOWN PARASITIZED NESTS, AND TOTAL SAMPLE SIZE FOR ALL COMMON AND INFREQUENT HOST SPECIES IN ARIZONA, 1993–94

Species (N)	% Parasitized	% Unparasitized	% Unknown
Common hosts			
Plumbeous Vireo (29)	45	31	24
Yellow Warbler (12)	33	50	17
Yellow-breasted Chat (31)	32	48	19
Blue Grosbeak (12)	50	33	17
Total (84)	39	40	20
Infrequent hosts			
Western Wood-Pewee (21)	0	57	43
Black-headed Grosbeak (6)	0	100	0
House Finch (10)	0	40	60
Spotted Towhee (7)	0	57	43
Total (44)	0	59	41

come (i.e., parasitization or common host type) to be present for a 1 unit change in the independent variable.

The variable "distance to obstruction below nest" required further analysis, as was partly indicated by the large confidence interval of the estimated odds ratios. From each nest, the distance was measured to the point where vegetation provided $\geq 50\%$ obscurement. Where there was not enough vegetation to meet this criterion, we recorded the distance from the nest to the ground, even though there was <50% concealment. Our purpose was to minimize the number of cases excluded from analysis due to missing values in the covariate. To clarify the relationship between parasitism and the distance to obstruction below nests, we performed a 2×2 contingency table analysis with the obstruction amount coded as $\geq 50\%$ or <50%.

RESULTS

PARASITIZATION RATES

Minimum parasitization rates for common hosts were 32–50%, and no infrequent hosts were known to be parasitized (Table 1). No nests of either host type were known to contain buried cowbird eggs, nor showed evidence that cowbird eggs had been removed (e.g., broken eggs on ground).

PARASITIZED VS. UNPARASITIZED NESTS OF COMMON HOSTS

Four variables were included in the final logistic regression model of the parasitism data set (Table 2). The odds ratio for the variable dis-

TABLE 2. LOGISTIC COEFFICIENT (β), STANDARD ERROR (SE), ODDS RATIO (Y), AND 95% CONFIDENCE INTERVAL OF ODDS RATIO (CI Y) FOR VARIABLES IN PARASITIZATION MODEL

Variable	β	SE	Y	95% CI Y
Distance to obstruction below nest (m)	0.426	0.332	1.53	0.80, 2.93
Volume at nest (m ³)	-0.648	0.263	0.52	0.31, 0.88
Trees >69 cm dbh present	-1.768	0.872	0.17	0.03, 0.94
Nest substrate dbh (3–23 cm) ^a				
24–69 cm	-2.716	1.005	0.07	0.01, 0.47
<3 cm	-1.614	0.720	0.20	0.05, 0.82
Constant	2.143	0.912		

^a Reference category.

tance to obstruction below nest indicates that parasitization was 1.5 times more likely to occur with each 1 m increase to vegetation below the nest (Table 2). The odds ratio of vegetation volume at nest was <1, reflecting that as the volume increased, chances of parasitization decreased (Table 2). For each 1 m³ increase of vegetation in a vertical cylinder around the nest, parasitization was half as likely to occur.

Interpretation of the categorical variables is slightly modified, because a reference category is involved. The odds ratio for the presence of large trees was 0.17, the inverse of which indicates that nests with at least one large dbh tree within 11.3 m from them were 6 times less likely to be parasitized than nests where no large trees were nearby (Table 2). The variable nest substrate dbh had a reference category of small trees (3–23 cm dbh). Therefore, the effect of nests in shrubs and mid-sized trees were compared to the effect of nests in small trees. Nests in shrubs and mid-sized dbh trees were 5 and 15 times less likely to be parasitized than nests in small trees, respectively (Table 2). There was no category for large trees because no common host nests were in large trees. The model chi-square indicated that the model fit the data well; all of the coefficients in the model were significantly different from zero ($P < 0.001$, $\chi^2 = 20.034$, $df = 5$). The largest correlation coefficient had an absolute value of $r = 0.37$.

In our additional analysis on the variable distance to obstruction below nest, we found an association between parasitization and the amount of obscurement below the nests ($P = 0.048$, $\chi^2 = 3.91$, $df = 1$). Parasitized nests had $\geq 50\%$ obscurement less frequently than was expected, and unparasitized nests had $\geq 50\%$ obscurement more frequently than expected.

COMMON VS. INFREQUENT HOSTS

The best fitting model of the host type data set involved only one variable, the height of nest above ground level. Nests <3 m above ground were 7.7 times more likely to belong to a com-

mon host than nests >3 m above ground (coeff = -2.074, SE = 0.426). The coefficient of the nest height variable was different from zero ($P < 0.001$, $\chi^2 = 27.34$, $df = 1$).

DISCUSSION

PARASITIZED VS. UNPARASITIZED NESTS

The amount and arrangement of vegetation in a vertical profile above and below nests were associated with likelihood of parasitization. Unparasitized nests had greater vegetation volume and shorter distance to concealing vegetation below the nest. A large vegetation volume could reduce a cowbird's line-of-site as she follows a host during nest-building activities, camouflage a nest, or swamp appropriate search cues with numerous inappropriate images. A short distance to cover below a nest would conceal the nest from more angles that originate below it than a longer distance would. This would be most effective in preventing discovery if cowbirds were searching from the ground or relatively low perches.

The third variable associated large-diameter trees on plots with reduced likelihood of parasitization. On our study site, these trees were always tall cottonwoods, which provided few perch sites in the canopy range from which we sampled nests. Although low perches provided by smaller trees and shrubs generally did not appear to be limited within our study area, they may have been less abundant where large trees dominated plots.

Nests in small dbh trees were at far greater risk of parasitization than those in shrubs or mid-sized trees. Small trees may increase the likelihood of parasitization not only by providing search perches as discussed above, but also by providing less vegetation to conceal a nest. Curson (1996) reported decreased parasitization in trees with a large dbh when he examined Plumbeous Vireos in a pinyon-juniper woodland, although he did not relate it to concealment.

Although we did not investigate any mechanisms as to why vegetation immediately around a nest would affect the likelihood of parasitization, it could be that vegetation may influence a cowbird's ability to locate a nest by providing concealment, camouflage, or search perches. These ideas have also been hypothesized in other studies. In a different Southwestern riparian area, Averill (1996) showed that parasitized Yellow-breasted Chat nests were less concealed from below than unparasitized nests were. When she analyzed four common host species together (including two species common to our study), she found that parasitized nests had less ground cover immediately below them, and that shrubs were farther away when compared to unparasitized nests. Nice (1937) found that parasitized Song Sparrow (*Melospiza melodia*) nests were less concealed from human view than those that were not parasitized. Brittingham and Temple (1996) combined 12 species and found that parasitized nests had a more open canopy and subcanopy. Although they did not relate this to concealment per se, they did suggest it could reflect nest-searching strategies or local variations in host densities.

In contrast to these supportive studies, Anderson and Storer (1976) reported no relationship to concealment at parasitized Kirtland's Warbler (*Dendroica kirtlandii*) nests, although they did not specify how they measured concealment. However, they did report that availability of appropriate perch sites was associated with parasitized nests, as did Freeman et al. (1990). Curson (1996) examined relationships between vegetation and parasitization for several host species, but concluded that differential parasitization was more likely a response to host behavior than vegetation attributes.

COMMON VS. INFREQUENT HOSTS

The host type model indicated that nest height was the key microhabitat feature that distinguished nests of common and infrequent hosts.

Briskie et al. (1990) observed the same phenomenon in their study of Least Flycatchers (*Empidonax minimus*, an infrequent host) and Yellow Warblers. They suggested that nest height constituted a nest-detection curve for cowbirds. This was supported by Norman and Robertson (1975), who observed that cowbirds often searched for nests from the ground.

Our results indicate that management for mid-sized and large trees, along with a well-developed shrub layer, might effectively reduce parasitization rates in Southwestern riparian areas. The plant density and species composition required is a location-specific decision. In general, however, these goals can be achieved by planting seedlings in areas where regeneration is not occurring naturally, prohibiting overgrazing by livestock, restricting the area trampled by humans in high-use recreation zones, and eliminating the cutting of trees for development and fuelwood. Watershed management is also important, because properly functioning watersheds can lessen the severity of floods, which can result in fewer losses of large trees during high volume flood events (Groeneveld and Griepentrog 1985).

Although we can alter vegetation, we cannot control nest-site selection processes. The challenge is to alter structure so that conditions are less favorable for cowbirds, yet they are still within the range of habitat characteristics that are acceptable to most hosts. This range must be defined location-specific for the hosts in question as well as for cowbirds. Achieving these characteristics would maximize breeding habitat quality for hosts by providing them with options for suitable nest sites that are less susceptible to brood parasitism by Brown-headed Cowbirds.

ACKNOWLEDGMENTS

We thank A. Rogers, J. Cornell, and T. Riede for field assistance, and the Box L and K-4 ranches for access to their lands. R. W. Mannan and C. Schwalbe reviewed earlier drafts. Funding was provided by the USDA Forest Service, Prescott National Forest.