The Wilson Bulletin

PUBLISHED BY THE WILSON ORNITHOLOGICAL SOCIETY

VOL. 111, NO. 2 JUNE 1999 PAGES 157–302

(ISSN 0043-5643)

Burhans, Dirk E.; Thompson, Frank R., III. 1999. Habitat patch size and nesting success of Yellow-breasted chats. The Wilson Bulletin. 111(2): 210-215.

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Wilson Bull., 111(2), 1999, pp. 210–215

HABITAT PATCH SIZE AND NESTING SUCCESS OF YELLOW-BREASTED CHATS

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ABSTRACT.—We measured vegetation at shrub patches used for nesting by Yellow-breasted Chats (*Icteria virens*) to evaluate the importance of nesting habitat patch features on nest predation, cowbird parasitism, and nest site selection. Logistic regression models indicated that nests in small patches (average diameter <5.5 m) that were parasitized by Brown-headed Cowbirds (*Molothrus ater*) experienced higher predation than unparasitized nests in large patches. Nests in large patches were more likely to become parasitized by cowbirds, as were nests with more large stems (>10 cm dbh) nearby. Patches used by chats for nesting had larger average diameters than unused patches and tended to contain more small stems. Chats appeared to prefer large patches and experienced lower nest predation there. Although they might experience higher brood parasitism frequencies in large patches, losses to parasitism were balanced by higher nesting success because the mean number of chat young that fledged did not differ between nests in small versus large patches. *Received 12 Jan. 1998, accepted 28 Dec. 1998.*

The nest "patch" has been defined as the habitat patch immediately surrounding the nest (Martin and Roper 1988). Characteristics of the songbird nesting patch may differ from the habitat available (Martin and Roper 1988; Kelly 1993; Steele 1993; Kligo et al. 1996a, b) and there may be differences between successful and unsuccessful nests according to nest patch characteristics (Martin and Roper 1988, Kelly 1993, Norment 1993, Tarvin and Smith 1995). However, there is no consensus on exactly what determines a nest patch. Petersen and Best (1985) and Martin and Roper (1988) defined the nest patch as the area within 5 m of the nest, a criterion that other studies since have adopted (Kligo et al. 1996a, b; Barber and Martin 1997). Other workers have evaluated nest patches based upon other predetermined sizes (Conner et al. 1986, Kelly 1993, Norment 1993, Tarvin and Smith 1995), multiple radius patch sizes (Petit et al. 1988, Holway 1991, With 1994), or stem density (Holway 1991, Knopf and Sedgewick 1992). Knopf and Sedgwick (1992) based their patch definition upon vegetation height and radius descriptors rather than upon pre-determined size, and concluded that individual plants probably are functionally indistinguishable to Yellow Warblers (*Dendroica petechia*), which select nests based on patch characteristics rather than the nest plant.

We examined the relationship between nest patch characteristics and nest predation, brood parasitism, and nest site selection for the Yellow-breasted Chat (*Icteria virens*). Yellow-breasted Chats are a common songbird of shrub habitats (Nolan 1963, Thompson and Nolan 1973) and at our sites often nested in conspicuous dense thickets of shrubs. We combined two approaches by measuring vegetation structure in a fixed-radius plot centered on the nest and measuring dimensions of the shrub patch in which the nest was located. Our principle questions were: (1) are chat nests in large thickets, or patches, more likely to fledge young than nests in small patches or single shrubs and trees? and (2) are chat nests that are placed further from the edge of the nesting patch more likely to fledge young? We predicted that chats nesting in larger patches at greater distances from the patch edge would be more likely to avoid predation because large patches may impede the movements of predators (Bowman and Harris 1980, Holway 1991). Additionally, we predicted that nests near greater numbers of trees would experience higher frequencies of cowbird parasitism because Brown-headed Cowbirds (*Molothrus ater*) use trees to aid in finding nests (Anderson and Storer 1976, Romig and Crawford 1995, Clotfelter 1998). We also predicted that size of nest patches would differ from the size of patches selected at random. We tested these predictions by monitoring nest success and

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cowbird parasitism of chats and by measuring vegetation at nest sites and unused sites.

METHODS

We found Yellow-breasted Chat nests at Thomas Baskett Wildlife Research and Education Center near Ashland, (Boone County) Missouri, from 1992–1994 as part of a study of shrubland birds. Study sites were six old fields ranging from 2.4 to 16.3 ha and surrounded by oak-hickory forest (see Burhans 1997 for detailed site description). We monitored nests every 3–4 days and daily toward the end of the nestling period. We considered nests that avoided predation and succeeded in fledging either chat or cowbird young as "fledged". In most cases fledged nests were identified by observing adults carrying food or scolding, or by observing fledglings. Nests that were empty on the fledging day (day 8, where day of hatching = day 0) were classified as fledged if they were active the day before. We classified nests that were empty prior to this time as depredated unless there were signs of premature fledging, such as nearby fledglings or adult feeding activity. Parasitism status was determined for all nests and only those nests that were initiated during the period of cowbird parasitism (before the second week of July) were considered in the parasitism analysis.

Vegetation samples were taken at nest sites and unused sites at the end of the nesting season. We measured nest height to the bottom of the nest cup. We also measured nest "patch", which was defined as interlocking leafy shrub or tree vegetation at nest height within which the nest plant was situated. Nest patches varied in size from the single nest tree or shrub to an entire fencerow. We measured length and width of patches to the nearest 0.1 m for distances within 3 m and paced (calibrated at 1 m/pace) to the nearest m for greater distances. "Average patch diameter" was the sum of the length of the nest vegetation clump plus the width of the clump divided by two. Nest patch diameter varied greatly among patches (median = 5.5 m, range 0.3–65 m) so we grouped nests into "large" (≥5.5 m) or "small" patches for analyses (see below). "Patch-edge distance" was the distance (to the nearest 0.1 m) from the outside rim of the nest cup to the nearest leafy edge of the nest patch. In order to further characterize patches and evaluate potential cowbird perches, we counted woody stems 11–20, 21–50, and greater than 50 cm dbh (diameter at breast-height) in an 11.3 m radius circle centered on each nest. We counted shrub and sapling stems (≥1 m high) in a 5 m radius circle around each nest in categories less than 2, 2–5, and at least 5 cm dbh. Many chat nests were placed in large blackberry (*Rubus allegheniensis*) patches in which it was difficult to count stems. For large blackberry patches (>10% of the circle) we estimated number of blackberry stems by counting the number of stems in a square meter and extrapolating to the proportion of the 5 m circle that was blackberry.

Unused sites were located by pacing in a randomly determined compass direction to the first plant encountered of the same species and size category as the nest plant (at least 40 m from the nest). As with nest sites, we took patch diameter and stem count measurements for unused patches. We did not sample vegetation for 10 nests destroyed by flooding in 1993 and storms in 1994 and did not include these nests in the analysis. We also omitted 2 nests found immediately before fledging where it was not possible to inspect chicks to determine parasitism status without forcing fledging.

Data analyses.—We evaluated fledging success using both simple nesting success (number of successful nests/total nests) and the Mayfield method (Mayfield 1961, 1975). For the Mayfield method half the number of days between subsequent visits over which a nest was empty were added to the number of previous days the nest survived to obtain the total number of observation days for a nest. When calculating daily survival probabilities we only included mortality caused by nest predation. We calculated survival probabilities and variances with standard errors according to Johnson (1979). We compared survival probabilities using CONTRAST (DOS; Sauer and Williams 1989). Another species that nested at this site (Indigo Bunting; *Passerina cyanea*) suffered higher predation at parasitized nests (Dearborn in press), so we compared daily survival probabilities between parasitized and unparasitized nests. Simple nesting success was used for logistic regression models (below). Nests that fledged at least one chick (chat or cowbird) were considered "fledged". When calculating mean number of chat young fledged, we assumed that the number successfully fledged was equal to the number of chicks last counted in the nest. We compared mean number of chat chicks fledged from nests in large versus small patches with an independent sample two-tailed *t*-test.

We analyzed both nest predation and nest parasitsm with logistic regression models. Nest height, patch distance, average patch diameter, stems defined as above, total stems 10 cm dbh or smaller ("total small stems"), and cowbird parasitism status (parasitized or not) were evaluated in the nest predation model. Frequency of parasitism has been related to nest height and nest vegetation (Hahn and Hatfield 1995, Brittingham and Temple 1996), so we similarly used logistic regression to analyze parasitism against nest height, average patch diameter, patch distance, mean stems at least 10–20, 21–50, greater than 50 cm dbh, and combined stems greater than 10 cm dbh ("total large stems"). Model building for both nest predation and parasitism models followed the method of Hosmer and Lemeshow (1989) and consisted of running univariate logistic regression models and retaining variables with *P*-values of 0.25 or less in a full model. The final reduced models included those variables with $P < 0.05$. Decisions about which variables should be left in final models were based on probability values for individual variables from a set of alternative multivariate models. We performed Hosmer and Lemeshow (1989) goodness-of-fit tests on the final models.

TABLE 1. Parameter estimates, Wald χ^2 statistics and probability levels for final nest predation (top) and nest parasitism (bottom) logistic regression models.

Model/Variable	Parameter	χ^2	P
Nest predation			
Parasitism	−2.23	5.44	0.02
Average patch diameter	−1.52	4.24	0.04
Nest parasitism			
Average patch diameter	2.28	5.50	0.02
Total large stems (>10 cm dbh)	0.25	5.36	0.02

Nest sites and unused sites were compared with logistic regression rather than discriminant function because of the presence of binary explanatory variables and non-normal variance of other variables (Press and Wilson 1978, James and McCullogh 1990). Nest and unused site variables were screened with univariate logistic regression models, and multivariate models were developed similarly to the predation and brood parasitism models (above). Results for statistical tests are reported as mean ± SE.

RESULTS

Nesting success and predation/parasitism models.—Daily survival estimates of Yellow-breasted Chat nests did not differ among years from 1992–1994 (1992: 0.96 ± 0.01, 1993: 0.94 ± 0.02, 1994: 0.95 ± 0.02; $\chi^2 = 0.7$, df = 2, $P > 0.05$) so data from all nests were pooled for the predation analysis (0.95 ± 0.01; $n = 48$ nests). Brood parasitism frequency was 33% ($n = 15$ nests), 36% ($n = 14$ nests) and 23% ($n = 13$ nests) for 1992, 1993, and 1994 and did not differ between years (Fisher exact test; $P > 0.05$). Cowbird parasitism averaged 31% over all years during the seasonal period of parasitism ($n = 42$ nests). Parasitized nests did not have significantly different survival rates than unparasitized nests (parasitized nests 0.94 ± 0.02; unparasitized nests 0.96 ± 0.01; $\chi^2 = 1.7$, df = 1, $P > 0.05$).

Nest predation was best explained by a final logistic regression model including parasitism status and average patch diameter (Table 1; Log likelihood for model = 51.8, $\chi^2 = 8.7$, df = 2, $P = 0.01$). Nests that were parasitized and in small patches were more likely to suffer predation. However, the nest parasitism model indicated that nests in large patches were more likely to become parasitized. The nest parasitism model included the variables average patch diameter and total large stems (Table 1; Log likelihood for model = 40.9, $\chi^2 = 11.1$, df = 2, $P = 0.004$). Nests with more large stems were more likely to be parasitized, but large patches did not have greater mean values for total large stems than did small patches (large patches 2.27 ± 0.67; small patches 3.45 ± 1.01; $t = 0.99$, df = 40, $P > 0.05$). Distance from the nest to the edge of the patch tended to be greater for parasitized nests (Table 2), but was eliminated from the parasitism models because of the higher probability values associated with average patch diameter, with which patch-edge distance was positively correlated prior to transformation of the former variable ($r = 0.39$, $P = 0.009$). Mean number of chat young fledged did not vary between nests in small versus large patches (small patches: 1.04 ± 0.34 chat young per nest; large patches 1.43 ± 0.36 chat young per nest; $t = -0.79$, df = 44, $P > 0.05$).

Nest sites versus unused sites.—Univariate logistic regression models indicated that nest sites were situated in larger patches than unused sites (Table 3). When variables were combined in the multivariate model only average patch diameter was significant (Log likelihood for model = 121.07, $\chi^2 = 12.0$, $P = 0.001$).

DISCUSSION

As predicted, logistic regression models indicated that Yellow-breasted Chats experienced less predation in larger nest patches. As with Indigo Buntings at these sites (Dearborn, in press), predation was related to parasitism status at Yellow-breasted Chat nests; nests that were parasitized were more likely to experience predation. Chats tended to place nests in larger patches with more small stems than those in unused sites. Nests that were placed farther from the patch edge were more sus-

TABLE 2. Means (± standard error), parameter estimates, Wald χ^2 statistics, and probability levels for individual variables from logistic regressions on predation and parasitism.

Variable	Predation: Depredated	Predation: Fledged	Predation: Parameter	Predation: χ^2	Predation: P	Parasitism: Parasitized	Parasitism: Unparasitized	Parasitism: Parameter	Parasitism: χ^2	Parasitism: P
Parasitism (% of nests)	37%	11%	−1.55	3.33	0.07	—	—	—	—	—
Average patch diameter (% nests in large patches)	43%	63%	−0.83	1.84	0.18	77%	41%	1.55	4.19	0.04
Patch-edge distance (m)	0.78 ± 0.15	1.22 ± 0.42	−0.31	0.98	0.32	1.21 ± 0.30	0.70 ± 0.09	0.97	3.47	0.06
Nest height (m)	0.69 ± 0.06	0.74 ± 0.07	−0.52	0.29	0.59	0.70 ± 0.05	0.67 ± 0.07	0.37	0.10	0.75
Stems <2 cm dbh	347.04 ± 141.67	276.74 ± 181.35	0.00	0.1	0.75	—	—	—	—	—
Stems 2–5 cm dbh	3.00 ± 0.59	7.68 ± 2.26	−0.15	3.55	0.06	—	—	—	—	—
Stems 5–10 cm dbh	1.39 ± 0.31	1.68 ± 0.58	−0.07	0.24	0.62	—	—	—	—	—
Total small stems (≤10 cm dbh)	351.43 ± 141.43	286.11 ± 180.84	0.00	0.09	0.77	—	—	—	—	—
Stems 11–20 cm dbh	—	—	—	—	—	2.31 ± 0.71	1.38 ± 0.38	0.18	1.52	0.22
Stems 21–50 cm dbh	—	—	—	—	—	2.08 ± 0.78	0.69 ± 0.29	0.31	3.52	0.06
Stems >50 cm dbh	—	—	—	—	—	1.54 ± 1.04	0.00 ± 0.00	13.53	0.00	0.97
Total large stems (>10 cm dbh)	—	—	—	—	—	4.54 ± 1.38	2.07 ± 0.57	0.16	3.35	0.07

ceptible to parasitism (Table 2); however, we were unable to separate the importance of patch-edge distance from the size of the patch itself (patch diameter). Although nests in large patches were more likely to become parasitized, higher nesting success in large patches compensated for decrements in fitness caused cowbird parasitism because the number of host young that fledged was equal between small and large patches.

Petersen and Best (1985), Knopf and Sedgwick (1992), and Holway (1991) found that birds selected large shrubs or shrub stands for nest placement. Holway (1991) and Knopf and Sedgwick (1992) suggested that large patches offer improved nest concealment; Holway (1991) also believed that large patches could impede the movements of mammals, and could contain more potential nest sites for predators to search (see also Martin and Roper 1988).

Several researchers have found that birds place nests in denser cover than in unused sites (Knopf and Sedwick 1992, Sedgwick and Knopf 1992). Holway (1991) and Steele (1993) found higher foliage and shrub density at nests of Black-throated Blue Warblers (*Dendroica caerulescens*) than at random points. Wray and Whitmore (1979) and Norment (1993) found that successful Vesper Sparrow (*Pooecetes gramineus*) and Harris Sparrow (*Zonotrichia querula*) nests tended to be placed in denser cover than unsuccessful nests.

Chat nests parasitized by Brown-headed Cowbirds were more likely to become depredated. Dearborn (in press) found higher daily mortality at parasitized nests of Indigo Buntings in a five year study from the same sites we used. He suggested that louder vocalization by cowbird nestlings was partly the cause, although daily mortality was also higher at parasitized bunting nests during the incubation stage. In our study, the sample size of parasitized nests with cowbird chicks was too small (n = 4) to adequately compare daily mortality between nests with cowbird chicks and those without (Hensler and Nichols 1981).

Parasitized nests had more potential cowbird perches (large stems) than unparasitized nests. Recent studies have documented the importance of perch proximity in brood parasitism in both cuckoos (*Cuculus canorus*; Al-

TABLE 3. Means (± standard error), parameter estimates, Wald χ^2 statistics, and probability levels for individual variables from univariate logistic regressions comparing nest sites and unused sites.

Variable	Nest sites	Unused sites	Parameter	χ^2	P
Average patch diameter (% in large patches)	52%	19%	1.55	10.91	0.001
Stems <2 cm dbh	313.23 ± 108.47	60.19 ± 11.49	0.00	2.47	0.12
Stems 2–5 cm dbh	5.44 ± 1.14	4.17 ± 1.01	0.02	0.68	0.41
Stems 5–10 cm dbh	1.48 ± 0.29	1.10 ± 0.24	0.11	0.99	0.32
Stems 11–20 cm dbh	1.58 ± 0.31	2.15 ± 0.42	−0.09	1.12	0.29
Stems 21–50 cm dbh	1.06 ± 0.29	1.21 ± 0.32	−0.03	0.12	0.73
Stems >50 cm dbh	0.04 ± 0.03	0.02 ± 0.02	0.71	0.33	0.57
Total small stems (≤10 cm dbh)	320.14 ± 108.19	65.45 ± 11.51	0.00	2.77	0.10
Total large stems (>10 cm dbh)	2.69 ± 0.54	3.38 ± 0.65	−0.04	0.66	0.42

varez 1993, Øien et al. 1996) and cowbirds (Romig and Crawford 1995, Clotfelter 1998; see also Anderson and Storer 1979). Previous studies (Burhans 1997) on Field Sparrows (*Spizella pusilla*) and Indigo Buntings nesting at Thomas Baskett Wildlife Research and Education Center indicated no direct relationship between perches near the nest and frequency of parasitism. However, Yellow-breasted Chat nest sites generally are situated in patches with more trees and shrubs than old field nests of Indigo Buntings and Field Sparrows. The higher frequency of parasitism in large patches was not an artifact of patch size, because large patches did not necessarily contain more total large stems.

Nest site selection, nesting success, and frequency of cowbird parasitism at Yellow-breasted Chat nests appear to be influenced by patch size. However, relaxed predation in large patches did not improve host fledging success, because chats were more likely to become parasitized in large patches and fledge fewer of their own young. Although predation and parasitism appeared to differ across patch sizes, the effects of patch size on host fitness appear to cancel each other out. Future studies should look further at interactions between site selection, brood parasitism, and predation, and investigate tradeoffs in reproductive success associated with these factors according to different types of nest sites.

ACKNOWLEDGMENTS

Suggestions from D. Dearborn, and an anonymous reviewer greatly improved the manuscript. We are grateful to C. Freeman, D. Dearborn, D. Martasian, M. Alexander, and R. Kunza for help in the field and J. Demand for help with data entry. We thank J. Faaborg for his assistance. C. Freiling kindly allowed us to work on his property. This study was funded by the USDA Forest Service North Central Research Station.

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