

**BROWN-HEADED COWBIRD PARASITISM ON ENDANGERED SPECIES:
RELATIONSHIPS WITH NEIGHBORING AVIAN SPECIES**

A Thesis

by

SHANNON LEIGH FARRELL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2007

Major Subject: Wildlife and Fisheries Sciences

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Approved by:

Co-Chairs of Committee,	R. Douglas Slack Michael L. Morrison
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ABSTRACT

Brown-headed Cowbird Parasitism on Endangered Species: Relationships with
Neighboring Avian Species. (May 2007)

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Brown-headed cowbird (*Molothrus ater*) parasitism on the endangered black-capped vireo (*Vireo atricapilla*) is a management concern. Management for black-capped vireos in east-central Texas has focused on habitat restoration through vegetation modification. Loss of productivity due to parasitism, however, may limit the potential habitat restoration in restoring black-capped vireo populations. I investigated the relationships between frequency of parasitism on black-capped and white-eyed (*V. griseus*) vireos and characteristics of the neighboring avian assemblage to identify avian characteristics useful for predicting expected frequency of parasitism. I located and monitored vireo nests in March–July 2006 to determine frequency of cowbird parasitism on the 2 vireo species on 6 study sites on private land in east-central Texas. I conducted 100-m-radius circular-plot point count surveys on study sites from 1 April–31 June 2006 to identify neighboring avian assemblages.

All black-capped vireo nests ($n = 20$) and 81% of white-eyed vireo nests ($n = 27$) were parasitized. Species richness, species evenness, cumulative bird abundance, and cowbird host abundance did not differ significantly among study sites. Parasitism frequency was positively correlated with the number of cowbirds detected ($r^2 = 0.673$, P

= 0.045). Parasitism frequency was negatively correlated with abundance ($r^2 = 0.687$, $P = 0.042$) and proportion of ($r^2 = 0.692$, $P = 0.040$) of black-and-white warblers (*Mniotilta varia*), known cowbird hosts. I did not find a relationship between parasitism frequency and abundance of other cowbird hosts. The relationship between black-and-white warbler abundance and parasitism frequency may reflect an interaction between parasitism and the vegetation characteristics associated with black-and-white warblers, suggesting the need for future study of the relationships between parasitism frequency and vegetation characteristics in the study region. The frequency of parasitism I observed suggests that cowbird control may be an important management tool if management objectives in the study region continue to include recovery of black-capped vireo populations. Number of cowbirds may be a reasonable predictor of expected parasitism frequency in an area, which may be useful to land managers in selecting areas for implementation of cowbird control.

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INTRODUCTION

The black-capped vireo (*Vireo atricapilla*) was listed as a federally endangered songbird in 1987. The current black-capped vireo breeding range includes central Texas, northern Coahuila, Mexico, and several patches in Oklahoma (U. S. Fish and Wildlife Service 1991, Grzybowski 1995), and its wintering range occurs on the Pacific slope of Mexico. Habitat loss and brown-headed cowbird (*Molothrus ater*) parasitism were given as reasons for the listing of black-capped vireos (U. S. Fish and Wildlife Service 1991). Fire suppression and human development, including ranching and agriculture, have contributed to loss of breeding habitat, while brood parasitism by brown-headed cowbirds results in nest failure for the vireos (Graber 1961, Grzybowski 1995).

Presence/absence surveys conducted in my study region from 2003–2005 detected black-capped vireos at 5% of survey stations (Leon River Restoration Project, Texas A&M University, unpublished data; however, these presence/ absence surveys did not provide information about the reproductive success of the vireos (Ralph et al. 1991, Thompson 2002). Nest monitoring of black-capped vireos has been conducted on Fort Hood military base in central Texas (Tazik et al. 1989, Weinberg et al. 1998), but estimates of black-capped vireo reproductive success on Fort Hood are not applicable off-base where cowbird control is not conducted. Researchers on Fort Hood reported cowbird parasitism frequency on black-capped vireos as high as 90% (Weinberg et al. 1998) prior to implementation of cowbird trapping. Grzybowski et al (1986) observed

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parasitism frequencies as high as 93% for the black-capped vireo in Oklahoma. The findings of previous research suggest that low reproductive success due to parasitism may limit the success of vegetation-focused restoration for black-capped vireos.

Habitat restoration for black-capped vireos has been integrated into brush management regimes in my study region in east-central Texas, and includes use of fire and selective cutting of juniper (*Juniperus ashei*) (Leon River Restoration Project 2002). Cowbird trapping in the study region has been sporadic; area-wide, continuous cowbird control has not been implemented in the area surrounding Fort Hood (Steve Manning, Leon River Restoration Project, personal communication). However, cowbird control is being considered for future use in the effort to recover black-capped vireo populations.

Barber and Martin (1997) found that parasitism frequency on black-capped vireos was correlated with cumulative bird density and density of northern cardinals (*Cardinalis cardinalis*). Tewksbury et al (1999) found correlations between host density and cowbird abundance. Quantifying parasitism frequency on black-capped vireos in my study region is necessary to determine whether cowbird control should be implemented; the results of Barber and Martin (1997) and Tewksbury (1999) suggest that characteristics of the neighboring avian assemblage may help us decide where cowbird control should be implemented.

Control of cowbirds through trapping or shooting can be costly and energy intensive. Cowbirds may travel >10 km between feeding sites, commonly agricultural fields or pastures, and breeding sites (Robinson et al. 1995, Goguen and Mathews 1998). Tewksbury et al (1999) found that proximity to agricultural or ranching areas was a

strong predictor of parasitism frequency (Tewksbury et al. 2006). Anthropogenic habitat fragmentation in the study region has created small patches of black-capped vireo habitat interspersed with agriculture and ranching areas; all black-capped vireo habitat patches in the study area are within 10 km of agricultural or pasture. The conditions in the study region suggest that cowbird control may be an important consideration. Focusing cowbird control on specific sites where we expect it to be most successful or most needed may help increase efficiency and efficacy of the management strategy.

Previous studies provide varied, conflicting descriptions of the vegetation characteristics of black-capped vireo habitat (Bunker 1910, Graber 1961, Barlow 1967, Marshall et al. 1985, Benson and Benson 1990, Grzybowski et al. 1994), suggesting that the neighboring avian assemblage in black-capped vireo habitat may also vary among locations. Characteristics of the neighboring avian assemblage may affect the dynamics of cowbird parasitism in an area. Host species, those that are parasitized by cowbirds, may respond to parasitism in 2 ways. Rejecters eject cowbird eggs from their nest, build a new nest on top of the cowbird egg, or abandon the parasitized nest (Graham 1988). Acceptors keep and raise the cowbird eggs. In some cases, both rejecting and accepting behavior may be seen within one species (Ortega 1998), but most species are consistent acceptors or rejecters (Smith et al. 2000). Some bird species are not parasitized. The density and proportion of hosts, acceptors, and rejecters in an area may influence cowbird breeding territory selection, the distribution of cowbird eggs, and the parasitism frequency experienced by a given species (Mason 1986a; b, Burhaus 1997).

I expected low abundance of black-capped vireos in the study region (Leon River Restoration Project, Texas A&M University, unpublished data), thus I included white-eyed vireos (*V. griseus*) in my study. White-eyed vireos are closely related to black-capped vireos, show similar natural history characteristics and breeding behaviors (Hopp et al. 1995), co-occur with black-capped vireos in the study region, and have been reported to experience similar parasitism frequencies (Ward and Smith 2000).

My goal was to investigate the relationship between frequency of parasitism on black-capped and white-eyed vireos and characteristics of the neighboring avian assemblage. My first objective was to quantify parasitism frequency on black-capped and white-eyed vireos in the study region. My second objective was to examine the relationships between parasitism frequency and 1) total bird abundance, 2) known cowbird host abundance and cowbird egg acceptor abundance, 3) abundance of each species detected, 4) proportional abundance of each species detected, and 5) count number and abundance of brown-headed cowbirds detected, to identify avian assemblage characteristics useful for predicting expected parasitism frequency. By identifying characteristics correlated with parasitism frequency, my data will provide tools for predicting relative levels of parasitism on various sites and information to support management decisions selecting areas for implementation of cowbird control. My results may also provoke future study of the associations between parasitism and bird assemblage or vegetation characteristics in the study region and expand the information available for developing restoration management strategies.

STUDY AREA

My study area was located in Coryell County, Texas, in the Leon River watershed, which covers approximately 140,000 ha of eastern central Texas along the eastern portion of the black-capped vireo range. The majority of land in the study region is privately-owned; excluding Forth Hood, about 88% of the land in Coryell County is used for agriculture or ranching (U. S. Census Bureau 2005).

I planned to randomly select 10 study sites from those meeting the following criteria: 1) contain black-capped vireos, 2) ≥ 8 hectares in size, to accommodate ≥ 2 black-capped vireo pairs according to average territory (Grzybowski 1995), 3) accessible during the entire breeding season, from 1 March –31 August.

I contacted landowners at 22 sites where black-capped vireos were detected at least once during point count surveys conducted for the Leon River Restoration Project [LRRP] in 2003–2005 (Leon River Restoration Project, Texas A&M University, unpublished data). I was granted access to 12 of the 22 prospective study sites. I used ArcGIS™ technology (ArcMap 2005) and digital imagery of the study region to identify possible additional sites, locating sites that appeared to have vegetation within the range of possible suitable habitat for black-capped vireos (Graber 1961, Barlow 1967, Benson and Benson 1990, Grzybowski et al. 1994, Grzybowski 1995). I searched for possible sites using digital imagery because conducting area searches across the study region was not feasible due to limitations in access, time, and effort. I identified and was granted access to 2 additional sites through this process.

METHODS

Area search surveys

I conducted area searches at each of the prospective study sites from 15 March until 3 weeks after the first male black-capped vireo was detected in the study region. I followed the area search methods of Ralph et al (1991) and Dieni and Jones (2002), but recorded black-capped vireo detections only. I played black-capped vireo song recordings during searches in an effort to improve chances of detection. I detected black-capped vireos at 6 of the 12 prospective sites; I used all 6 sites where I detected black-capped vireos as study sites.

Nest finding and monitoring

I conducted nest finding and monitoring from 20 March–20 July, with the assistance of several other observers. We followed vireos at a distance of at least 20 m to avoid harassment and marked waypoints at each singing perch (Ralph et al. 1991) for the first 2 to 3 weeks after their arrival to identify territories. We used territory-mapping (Bibby 1992, Shankar Raman 2003, Probst et al. 2005) to estimate territory locations to facilitate efficient nest searching.

We monitored each territory 2 times per week, between 15 min before local sunrise and 6 or more hours after sunrise. We used behavioral observation and systematic search techniques (Martin and Geupel 1993) to locate nests. We checked nests every 1–4 days and recorded contents, including host and cowbird eggs and young. We recorded the outcome of all nests at completion and recorded descriptive

observations, such as signs of predation, broken eggshells, or adult birds carrying food to help confirm the outcome.

Identifying avian assemblage

I used 100-m-radius circular-plot point counts (Rosenstock et al. 2002) to determine bird species composition and abundance. I systematically placed 4 to 7 point count stations within each study site at a minimum 200 m apart to cover the study sites adequately. I used additional observers to conduct some of the surveys, to avoid bias due to using only 1 observer. We conducted 3 visits to each point count station from 1 April to 1 June 2006, between 15 minutes before local sunrise and 3 hours after local sunrise. Surveys consisted of 6 minutes of passive listening, during which we recorded all birds detected within the 100-m radius, detection type (song, call, or visual), gender (male, female, juvenile, or unknown), and distance (0–50 m or 50–100 m) for each individual.

ANALYSIS

Calculating parasitism frequency

I used nests that had reached at least laying stage and whose contents we observed at each nest check for analysis. I counted any nest as parasitized that had received a cowbird egg during laying or within the first 5 days of incubation. Black-capped vireo incubation period is estimated to be 14–17 days (Graber 1961); white-eyed vireo incubation is estimated to be 13-15 days (Hopp et al. 1995). Brown-headed cowbird incubation period is estimated to be 10-12 days (Nice 1953, Briskie and Sealy 1990). Cowbird eggs laid by day 5 of black-capped or white-eyed vireo incubation are likely to hatch with or before black-capped vireo nestlings. I calculated frequency of parasitism as the proportion of parasitized nests among total nests monitored at each study site. I calculated parasitism frequency for the black-capped vireo, the white-eyed vireo, and combined parasitism frequency for both species. I used a Chi-square test to test for difference in parasitism frequency among study sites (Daniel 1990:181–198).

Point count surveys

I included only species for which there have been confirmed nesting records in Coryell, Hamilton, or directly adjacent counties (Texas A&M University System 2001) in the data set for analysis. I used PRESENCE (Presence 2006) to compare detection probabilities for my 3-visit point count and 6-visit point count data, to determine whether my 3-visit data were reliable compared to data gathered with twice the survey effort. The 6-visit data were collected in my study region as part of a larger bird-monitoring project from 1 April 2006–1 June 2006 (Leon River Restoration Project,

Texas A&M University, unpublished data); the survey methods used for collecting the 6-visit data were consistent with my methods.

I limited my analysis to 5 species because of time and data constraints. I compared detection probabilities of northern cardinal and painted bunting (*Passerina ciris*), relatively abundant species in the study area; rufous-crowned sparrow (*Aimophila ruficeps*) and black-and-white warbler (*Mniotilta varia*), relatively rare in the study area; and the American crow (*Corvus brachyrhynchos*) which showed a patchy distribution, clustered in some areas and not observed at many others. I used this subsample of species to represent the relationship between detection probabilities for the 3 and 6-visit data for birds with both high and low abundances. I calculated detection probabilities of the 5 species for my 3-visit survey data, for the 6-visit data using all 210 points, and for randomly selected subsets of 30 points from the 6-visit data to control for the effect of the number of points counted.

Estimating abundance

Estimating abundance or density from fixed-radius point count data has been criticized for not incorporating consideration of distance-based detection probabilities (Ellingson and Lukacs 2003); models for estimating density by incorporating distance based detection functions have been created (Buckland et al. 2004). I was not able to use this type of model due to too few detections of many species; these models are not useful for rare or even moderately abundant species (Queheillalt et al. 2002, Purcell et al. 2005).

I assumed that probability of detecting each species and the proportion of each species present that I detected was consistent across the 6 study sites. The presence of

black-capped vireos on the 6 sites and the relatively high detection probabilities for my 3-visit method suggest homogeneity in vegetation characteristics among sites, suggesting that my assumption is reasonable. I calculated an index of cumulative bird abundance, abundance of known cowbird hosts, and abundance of individual species using data within the 50-m and 100-m point count radius. I calculated abundance as the number of birds detected per count station for each survey visit and a mean value for all 3 visits per site. I compared the abundance estimates for within 50-m and 100-m radii to determine whether it was reasonable to use data from within the 100-m radius for all further analysis. I also estimated the proportion of birds of a given species among all birds detected per survey visit for all 3 visits; this value represented one aspect of the species composition. I counted the number of species detected at each site, calculated Shannon's H and E indices (Onaindia et al. 2004, Joern 2005) to examine species richness and evenness among study sites, and used Sorensen's similarity index to examine levels of similarity between sites (Amezaga et al. 2004).

Because of small sample sizes, I used a Kruskal-Wallis test to test for difference in assemblage characteristics among study sites (Zar 1984:176–179, Daniel 1990:226–231). I tested for difference among study sites for: 1) cumulative bird abundance, 2) cowbird host abundance and acceptor abundance, and 3) abundance and proportion of individual species.

Parasitism frequency and avian assemblage relationships

I used scatter plots to examine trends in the data. Because of small sample sizes, I could not assume the data were normally distributed, so I used Pearson correlation to identify

relationships between parasitism frequency and the avian assemblage variables (Zar 1984:318–320). I examined the relationship between parasitism frequency and 1) cumulative bird abundance, 2) host abundance, 3) abundance of each species detected, 4) proportion of each species detected, and 5) total count of brown-headed cowbirds detected. I also used multiple entry methods for linear regression to look for possible subsets of assemblage characteristics that resulted in strong predictive relationships.

RESULTS

Parasitism frequency

I monitored 20 black-capped vireo nests from approximately 15 pairs, and 27 white-eyed vireo nests from approximately 38 pairs. All black-capped vireo nests ($n=20$) and 81% of white-eyed vireo nests ($n=27$) were parasitized. I observed 8 of the 20 parasitized black-capped vireo nests containing 2 cowbird eggs or young and 3 nests containing ≥ 3 cowbirds eggs or young. I observed 9 of the 22 parasitized white-eyed vireo nests containing 2 cowbird eggs or young and none with ≥ 3 cowbird eggs or young. I did not find parasitism frequency to differ significantly among study sites ($\chi^2=4.298$, $df=5$, $P=0.507$). Combined parasitism frequency ranged from 0.71 to 1 ($\bar{\chi} = 0.89$; $SE = 0.04$). Parasitism frequency appeared similar across sites for both species with the exception of site Q. I found 3 white eyed vireo nests on site Q; 1 was parasitized. With the exception of site Q, observed parasitism frequency on white-eyed vireo nest was lower than on black-capped vireos by 0–25% ($\bar{\chi} = 11\%$; $SE = 5\%$) (Figure 1). The earliest clutch initiation date I observed for white-eyed vireos was 6 April and for black capped vireos was 14 April. No black-capped vireo nests and 5 white-eyed vireo nests were initiated after 15 June. Of the 5 white-eyed vireo nests that were initiated after 15 June, only 1 of these 5 nests was parasitized.

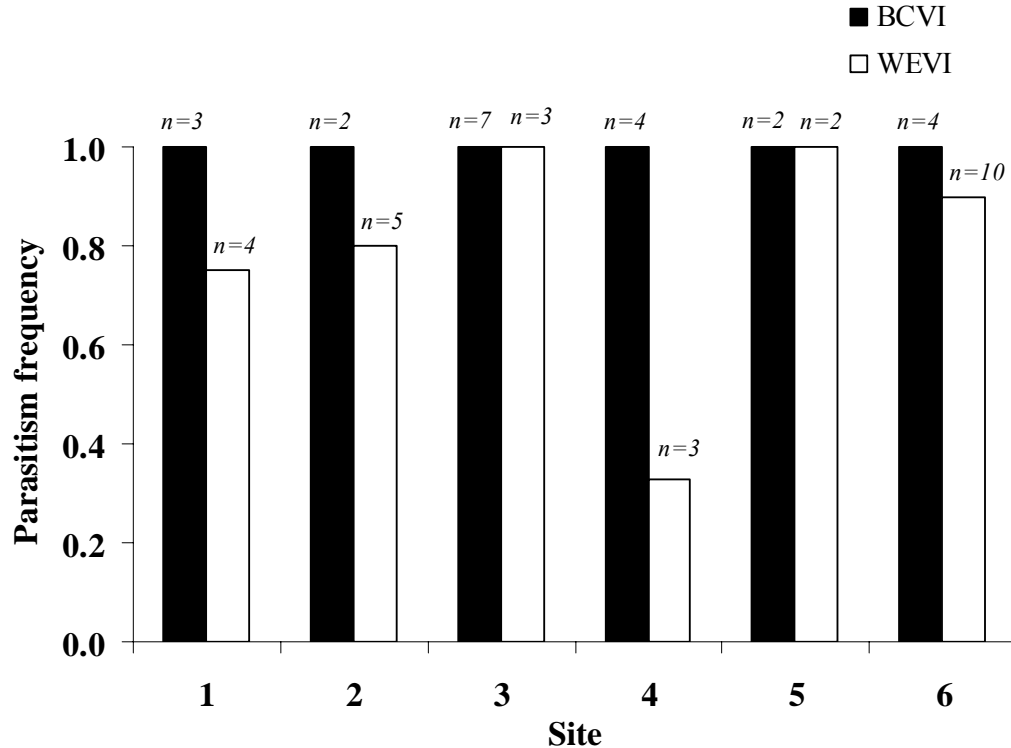


Figure 1. Observed parasitism frequency on black-capped [BCVI] and white-eyed [WEVI] vireos for 6 study sites in Coryell County, Texas, in 2006.

Point count surveys

Detection probabilities of the 5 selected species for 3-visits were equal to or greater than those for 6-visits, suggesting that the data from the 3-visit surveys were at least as reliable as data obtained with twice as much survey effort (Table 1).

Table 1. Detection probabilities of 5 species for 3 and 6 visit surveys.

Survey type	Species				
	Northern cardinal	Painted bunting	Rufous-crowned sparrow	Black-and-white warbler	American crow
6-visit	0.91	0.35	0.18	0.19	0.16
3-visit	0.92	0.53	0.28	0.31	0.18

Avian assemblage

I detected 33 species of birds known to breed in the study region (See Appendix A for a list of all species detected). The number of species detected per site ranged from 17 to 25 ($\bar{\chi} = 21$; SE ± 3). The values for Sorensen's similarity index ranged from 0.76 to 0.95 ($\bar{\chi} = 0.82$; SE = 0.01), suggesting a high level of similarity in species present among the sampling units (Table 2). Similarity index values among sites did not differ significantly ($H = 8.051$, $df = 5$, $P = 0.153$). Shannon's H and Shannon's E indices of species richness and evenness were similar for all 6 study sites (Table 3). Shannon's H values ranged from 2.3 to 2.8 ($\bar{\chi} = 2.5$; SE = 0.07) and Shannon's E value ranged from 0.75 to 0.88 ($\bar{\chi} = 0.84$; SE = 0.02).

Table 2. Pair wise comparisons for Sorensen's similarity index between sampling units.

Site	Site					
	1	2	3	4	5	6
1	1.00	0.86	0.83	0.85	0.82	0.83
2	0.86	1.00	0.80	0.95	0.79	0.83
3	0.83	0.80	1.00	0.77	0.77	0.76
4	0.85	0.95	0.77	1.00	0.83	0.82
5	0.82	0.79	0.77	0.83	1.00	0.83
6	0.83	0.83	0.76	0.82	0.83	1.00

Table 3. Shannon's H and Shannon's E for 6 study sites.

	Site					
	1	2	3	4	5	6
Shannon's H	2.45	2.56	2.51	2.59	2.81	2.30
Shannon's E	0.87	0.83	0.81	0.88	0.87	0.75

Cumulative bird abundance estimated within the 100-m radius was $50\% \pm 5\%$ higher than abundance estimated from data within the 50-m radius, and this relationship

was consistent among sites (Figure 2). Thus, I used data taken within the 100-m radius for all subsequent analyses because the low number of birds detected within the 50-m radius provided limited information for subsequent analyses and the relationship between abundance at 50-m and 100-m radii was consistent across study sites. I omitted from further analysis any species for which I fewer than 2 total detections for the 3 survey visits on all study sites.

Cumulative bird abundance ranged from 7.9 to 11.3 birds per point ($\bar{\chi} = 9.9$; SE = 0.5) within the 100-m radius. I did not find a significant difference in cumulative bird abundance among study sites ($H = 4.392$, $df = 5$, $P = 0.494$) or for any pair wise comparison between study sites. I detected 9.0 ± 0.4 known cowbird hosts per 100-m-radius point count. I did not find a significant difference in abundance of known cowbird hosts among study sites ($H = 4.368$, $df = 5$, $P = 0.498$) or for any pair wise comparison between sites.

On all sites, northern cardinals had the highest abundance of 1.9 to 2.7 birds per point ($\bar{\chi} = 2.2$; SE = 0.1). White-eyed vireos were the second most abundant species with 0.3 to 2.5 birds per point ($\bar{\chi} = 1.19$; SE = 0.3), followed by brown-headed cowbirds with 0.5 to 1.3 birds per point ($\bar{\chi} = 0.91$; SE = 0.1), and blue-gray gnatcatchers (*Polioptila caerulea*) (with 0.5 to 1.3 birds per point ($\bar{\chi} = 0.84$; SE = 0.13). I found the seven-fold difference in white-eyed vireo abundance among study sites was statistically significant ($H = 12.541$, $df = 5$, $P = 0.028$). Similarly, I found abundance of Bewick's wrens (*Thryomanes bewickii*) varied almost 6-fold among study sites, from 0.1 to 0.8 birds per point ($\bar{\chi} = 0.45$; SE = 0.1) ($H = 9.420$, $df = 5$, $P = 0.093$).

On all study sites, I found northern cardinals to comprise the proportional majority of the bird assemblage, accounting for 17% to 28% ($\bar{\chi} = 23$; SE= 0.01) of birds detected. White-eyed vireos comprised from 3% to 23 % ($\bar{\chi} = 12$; SE = 0.03) of the total birds detected on each study site; proportion of white-eyed vireos varied more than seven-fold among study sites ($H = 13.117$, $df = 5$, $P = 0.022$).

On 2 of 6 study sites, black-capped vireos were not detected during point count surveys. Information gathered during intensive nest searching shows abundance of black-capped vireos varied from 1 to 6 pairs per site with a mean of 2 pairs per site.

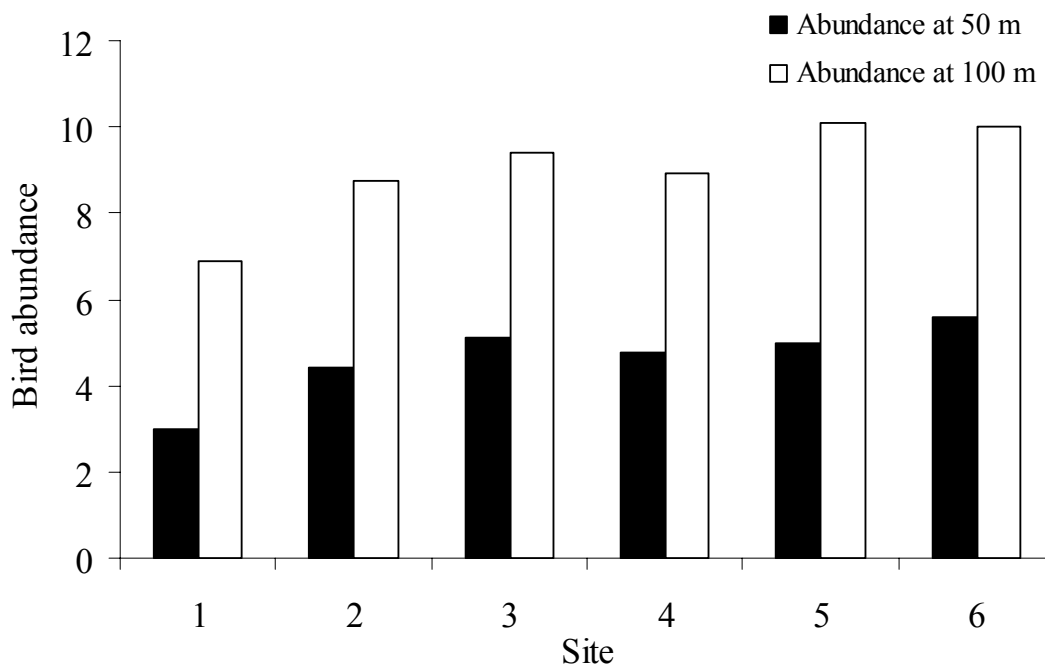


Figure 2. Cumulative bird abundance estimates at 50-m and 100-m radii for point count surveys conducted 1 April–1 June 2006 in Coryell County, Texas.

Parasitism frequency and avian assemblage relationships

I did not find any statistical relationship between parasitism frequency and species diversity, species richness, or species evenness. I found a statistical correlation between parasitism and cumulative bird abundance ($r^2 = 0.386$, $df = 4$, $P = 0.188$) that I thought may have represented a weak trend. However, when I omitted brown-headed cowbirds from the cumulative abundance estimate, the correlation decreased ($r^2 = 0.216$, $df = 4$, $P = 0.353$). I found a significant relationship between parasitism frequency and brown-headed cowbird abundance ($r^2 = 0.590$, $df = 4$, $P = 0.037$). I also used the total number of cowbirds detected on all 3 visits for each study site as an independent variable; this was a raw count number, not scaled per point. I found a strong statistical relationship between the total number of cowbirds and parasitism frequency ($r^2 = 0.682$, $df = 4$, $P = 0.021$) (Figure 3). Parasitism frequency ranged from 0.71 to 1; the total number of cowbirds detected at each site ranged from 6 to 19.

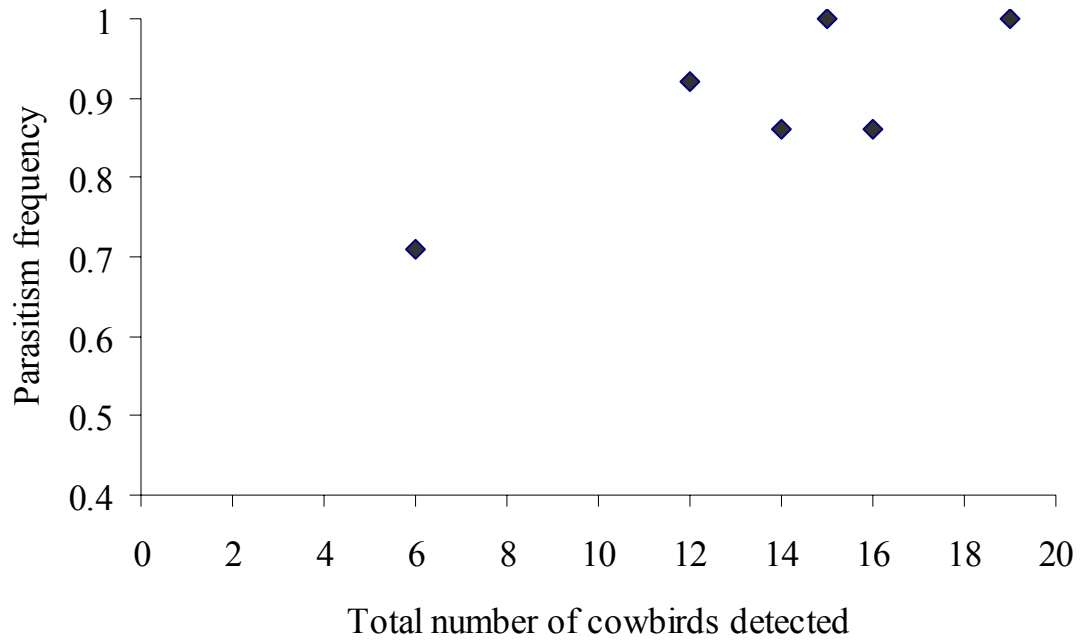


Figure 3. Observed parasitism frequency on black-capped and white-eyed vireo nests plotted against the total number of cowbirds detected during 3 point count survey visits on each of 6 study sites in Coryell County, Texas, in 2006.

I found parasitism frequency to decline with an increase in black-and-white warbler abundance ($r^2 = 0.687$, $df = 4$, $P = 0.021$) and proportion ($r^2 = 0.661$, $df = 4$, $P = 0.025$). (Figures 4 and 5).

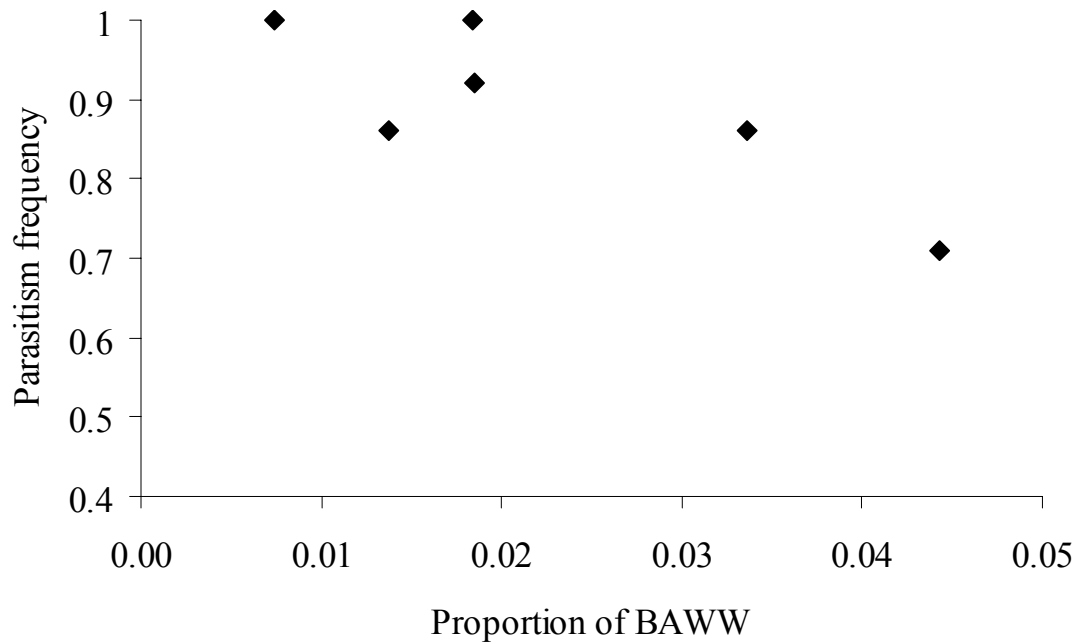


Figure 4. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against proportion of black-and-white warblers [BAWW], on 6 study sites in Coryell County, Texas, in 2006.

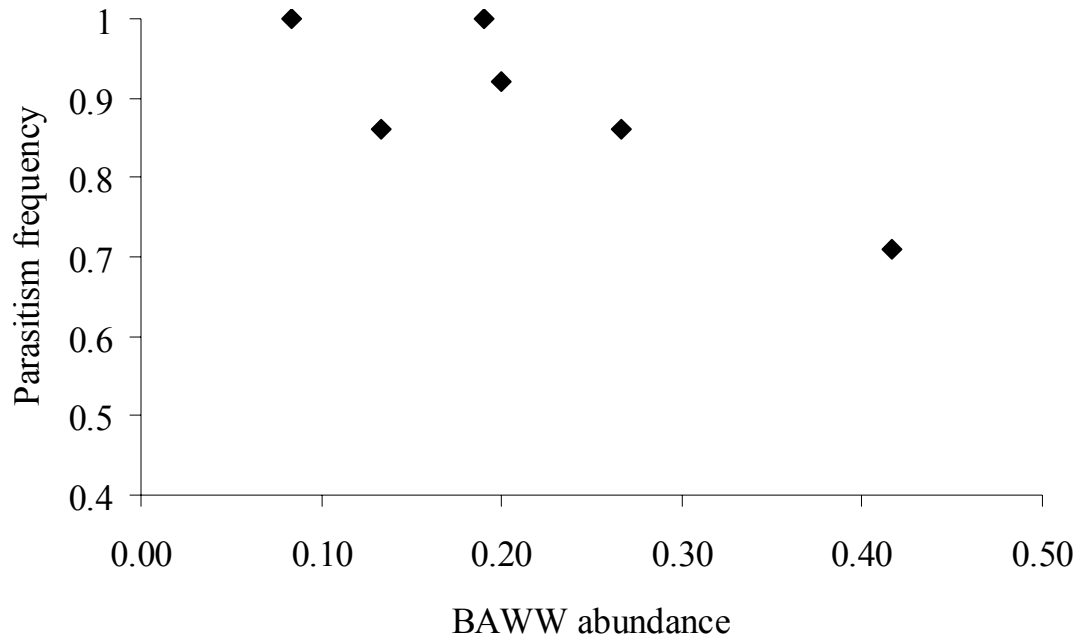


Figure 5. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against black-and-white warbler [BAWW] abundance, on 6 study sites in Coryell County, Texas, in 2006.

I did not find any statistically significant correlations between observed parasitism frequency and any other assemblage characteristic. However, I observed some patterns in data that may suggest other kinds of ecological relationships, such as thresholds. At higher bird abundances, observed parasitism frequencies are higher but the relationship does not appear to scale linearly or curvilinearly (Figure 6). Because of the lack of cowbird non-host species and rejecter species in this area, this relationship

looked similar when I plotted parasitism frequency against acceptor abundance (Figure 7).

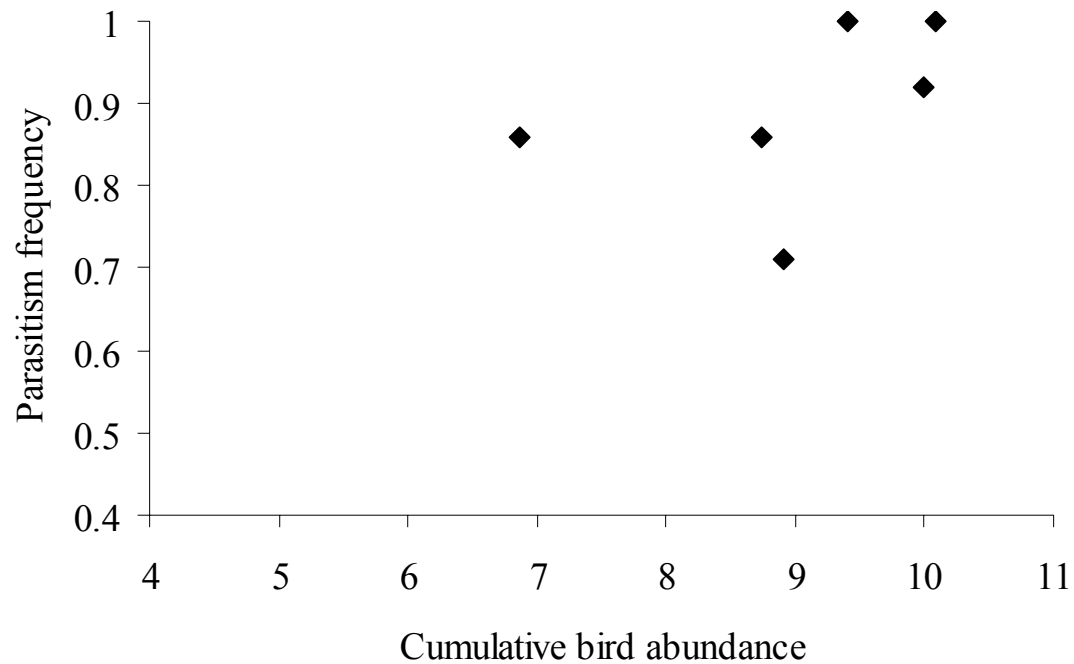


Figure 6. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against cumulative bird abundance, calculated as birds per point, on 6 study sites in Coryell County, Texas, in 2006.

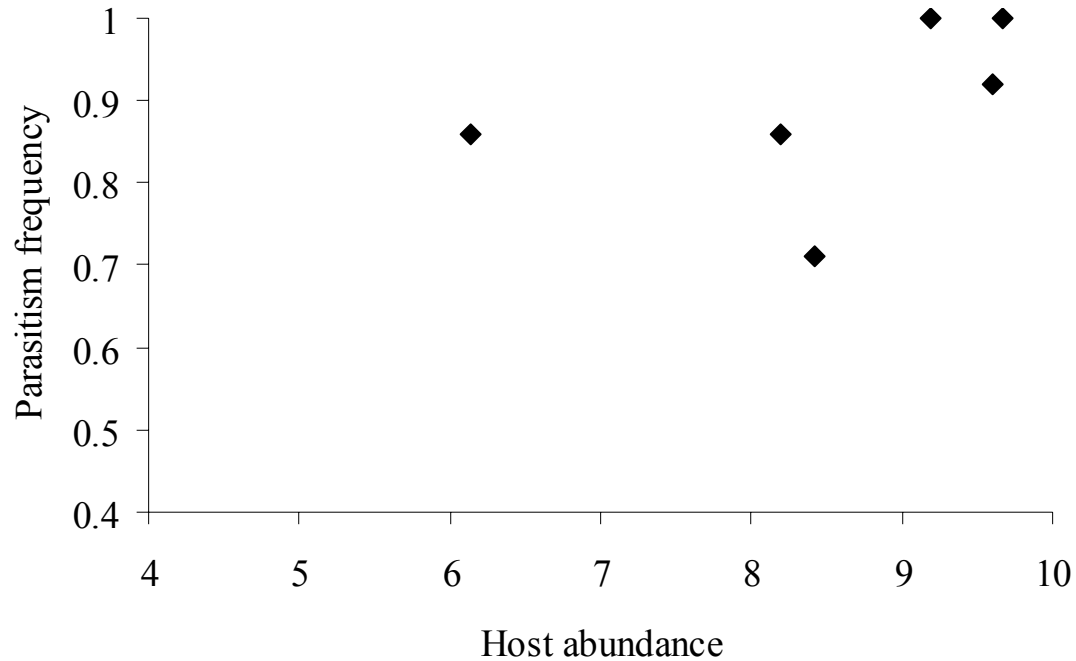


Figure 7. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against abundance of known cowbird host species detected during point count surveys, on 6 study sites in Coryell County, Texas, in 2006.

I also observed patterns in several plots of the data that, while not statistically significant, may suggest an ecologically meaningful relationship exists. There appeared to be a decrease in parasitism frequency with increasing abundance of northern mockingbirds (*Mimus polyglottos*) ($r^2 = 0.352$, $df = 4$, $P = 0.107$); however, northern mockingbirds abundance was zero on 3 of the 6 sites (Figure 8).

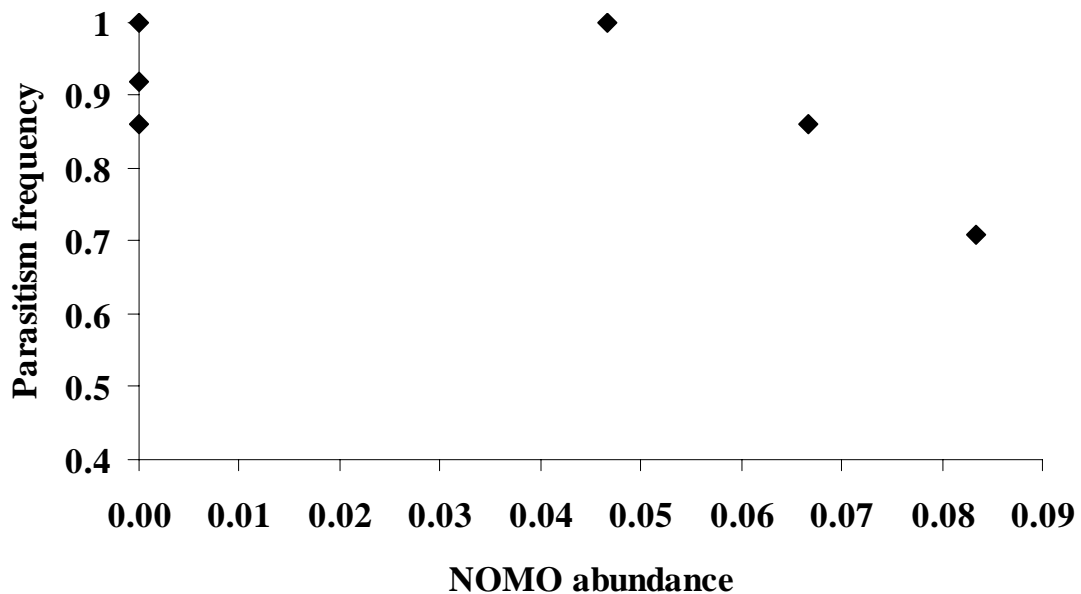


Figure 8. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against abundance of northern mockingbirds [NOMO], on 6 study sites in Coryell County, Texas, in 2006.

The plots of parasitism frequency by abundance and proportion of woodpecker species may show a slight decline in parasitism with increasing proportion of woodpecker species and woodpecker species abundance (Figures 9 and 10), though not statistically significant. However, it is important to note that proportion of woodpeckers ranged from 0 to 1.8% of the total assemblage.

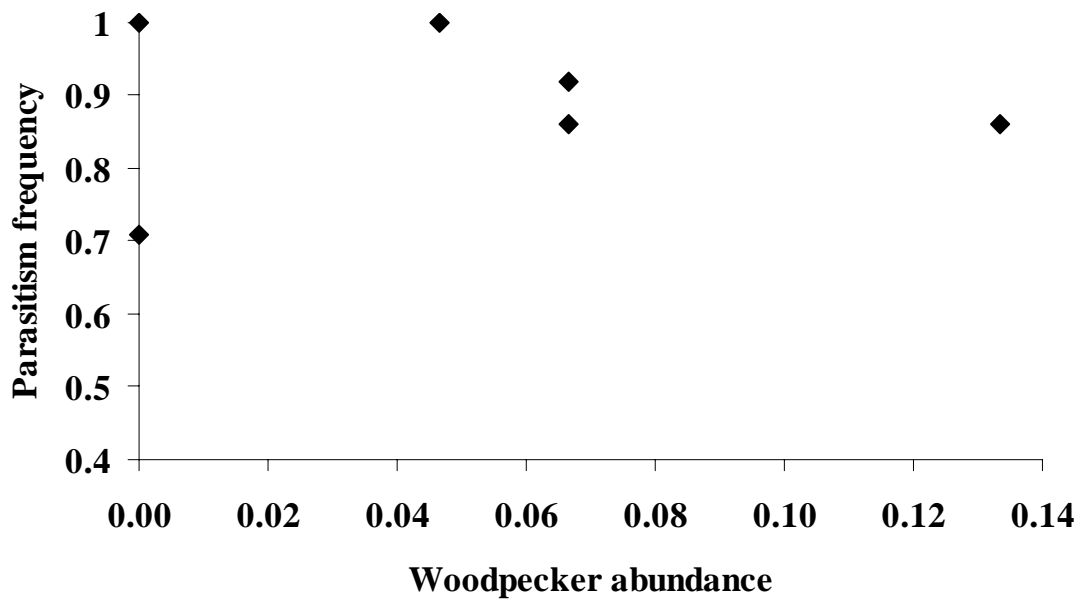


Figure 9. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against abundance of woodpecker species, on 6 study sites in Coryell County, Texas, in 2006.

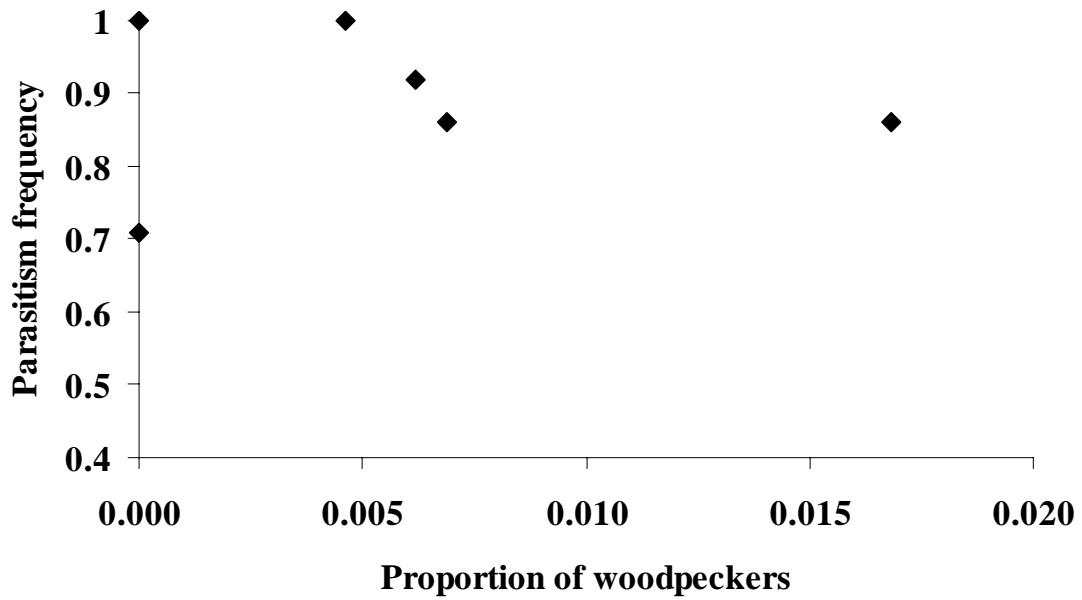


Figure 10. Observed brown-headed cowbird parasitism frequency on black-capped and white-eyed vireo nests plotted against proportion of woodpeckers, on 6 study sites in Coryell County, Texas, in 2006.

DISCUSSION

My estimates of parasitism frequency for the black-capped and white-eyed vireos were high enough to significantly limit productivity. My findings show a significant relationship between both number and abundance of cowbirds and parasitism frequency, suggesting that the number of cowbirds detected at a site may be a useful predictor of expected parasitism frequency. I did not find parasitism frequency to be correlated with cumulative assemblage characteristics including species richness, evenness, cumulative bird and cowbird host abundance, but I did find relationships between parasitism frequency and the abundance of several other individual bird species, suggesting that individual species' characteristics may be more useful predictors of parasitism frequency than cumulative assemblage characteristics.

Nest monitoring and parasitism frequency

My sample size of monitored nests was small ($n=20$), but was obtained by sampling 6 of the 7 locations in the study region where black-capped vireos were detected in 2006.

This sample accounts for most of the black-capped vireo pairs in the study region.

Cowbird abundance and parasitism frequency may vary temporally (Heltzel and Earnst 2006), but 100% parasitism for ≥ 1 year will have an important effect on productivity.

Additionally, cowbirds were detected at 80–90% of point count stations in the study region each year from 2003–2006, suggesting that cowbird abundance has been consistently high across the study region since surveys began in 2003 (Leon River Restoration Project, Texas A&M University, unpublished data). My results, in

conjunction with the findings of previous research suggest that cowbirds are an important limiting factor for the 2 vireos in the study region.

The range of parasitism frequencies I observed among the 6 study sites was small. Parasitism frequency may have been similar among study sites due to similar vegetation and avian assemblage characteristics. The reason for the 20% difference in parasitism frequency between white-eyed and black-capped vireos is not clear. The response to parasitism does not appear to vary between the two species; neither species routinely abandons parasitized nests or ejects or buries cowbird eggs. Nest locations are often indistinguishable between the 2 vireo species; nestling diets appear to be similar as well (Grzybowski 1995, Hopp et al. 1995). Differences in behavior at or near the nest may be a possible explanation, as previous observational studies have concluded that female cowbirds may locate nests by watching adults build nests (Hann 1837;1941); further study quantifying behavior at parasitized and unparasitized nests of these 2 vireo species may help to explain the differences I observed.

The presence of multiple cowbird eggs in more than half of the black-capped vireo nests was observed; this may suggest that the abundance of cowbirds in the study region is high, relative to the number of available host nests (Trine 2000). If my sample was representative of black-capped vireos breeding elsewhere in the region, my results would indicate that the black-capped vireo population in the study region produced few, if any, young in 2006. This further suggests that efforts to recover the species will be limited in their success by loss of black-capped vireo productivity due to cowbird parasitism.

Point count surveys

Detection probabilities from my 3-visit surveys may be higher than those from the 6-visit data due to high homogeneity of site characteristics among my study sites. The low detection probabilities I found for species of low abundance in the study area may be due, in part, to limitations of the model used to estimate detection probabilities (Presence 2006). The model does not account for heterogeneity in occupancy among survey points (Royle et al. 2005, Royle 2006), and can lead to low estimates of detection probability.

Parasitism frequency and avian assemblage relationships

The relationship I observed between brown-headed cowbird abundance and parasitism frequency suggests that this characteristic may be useful for predicting parasitism frequency. It is important to note that the range of parasitism frequencies I observed was small; this relationship may be different for a wider range of parasitism frequencies. Further study that incorporates sites with a wide range of parasitism frequencies and cowbird abundances will be important for examining this relationship further, possibly identifying a threshold of cowbird abundance at which parasitism frequency changes significantly.

The relationship I found between parasitism frequency and black-and-white warbler abundance may be due to the vegetation characteristics with which they are associated. Black-and-white warblers are known cowbird hosts (Hahn and Hatfield 1995). This relationship may be due to a dilution effect; that is, as more black-and-white warblers receive cowbird eggs, fewer eggs are placed in vireo nests. However, abundance of other, more abundant, host species did not show any correlation with

parasitism frequency. I also observed a slight decrease in parasitism with an increase in woodpecker abundance, but woodpeckers are rarely cowbird egg recipients. Both species are associated with mature trees, suggesting that there may be an interaction between surrounding vegetation characteristics and observed parasitism frequency. There is a large body of literature devoted to debate over whether cowbird parasitism decreases, increases, or does not change as a habitat becomes more forested (Lowther and Johnston 1977, Hahn and Hatfield 1995, Burhaus 1997, Goguen and Mathews 2000, Jensen and Cully 2005), suggesting that this dynamic between vegetation and parasitism frequency may vary regionally or with cowbird density. Further investigation of the relationships between parasitism frequency and not only avian species density and composition but also vegetation characteristics or habitat types may help to clarify the relationship between parasitism frequency and vegetation characteristics in the study region.

I expected higher abundances of host species to be correlated with lower frequency of parasitism on the focal species. I did not find any relationship between observed parasitism frequencies and either cumulative bird abundance or cumulative cowbird host abundance, suggesting that the number of possible hosts in an area did not affect parasitism frequency on the 2 vireo species, at least at the observed cowbird abundances. However, the trend may vary within a wider range of cowbird abundances. My results did not agree with the findings of Barber and Martin (1997) that increasing abundance of northern cardinals was correlated with increasing parasitism frequency on black-capped vireos; however, abundance of northern cardinals did not differ

significantly among my study sites, and thus, the small range of values may not have been sufficient to examine this relationship. My data represent only a small range of values for both bird density and parasitism frequency, and further study of a wider range of value will provide more room for investigating larger patterns in the dynamics of parasitism.

SUMMARY OF MANAGEMENT IMPLICATIONS

The relationship between parasitism frequency on the 2 vireo species and both abundance and total number of cowbirds detected suggests that cowbird numbers may be a reasonable predictor of expected parasitism frequency, providing useful information for management decision support. Sampling to determine total number of cowbirds detected can be done easily, with minimal training and effort; adjusting estimates for detection probabilities may not be important in this context. The resulting information can be used to determine the expected relative levels of parasitism on areas of interest. Land managers can choose to implement cowbird control in select areas depending on their objectives. It may be effective to select sites with relatively low cowbird abundance for cowbird control; on these locations, the effects of cowbird control on black-capped vireo productivity may be apparent more quickly. Areas with high expected parasitism may require longer or more intensive cowbird control before cowbird abundance is reduced to a level that enables a significant increase in black-capped vireo productivity. The high frequency of parasitism and cowbird abundance I observed on my study sites suggests that cowbird control may be an important management consideration in the study region, and may be an important tool for increasing the success of black-capped vireo restoration efforts.

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APPENDIX A

Species detected during point count surveys listed by decreasing mean abundance, calculated as birds per point. A * indicates species that are known cowbird egg recipients.

Common Name	Scientific Name	Mean abundance (birds per point)
Northern cardinal *	<i>Cardinalis cardinalis</i>	2.3
White-eyed vireo *	<i>Vireo griseus</i>	1.2
Brown-headed cowbird	<i>Molothrus ater</i>	0.9
Blue-grey gnatcatcher *	<i>Polioptila caerulea</i>	0.9
Painted bunting *	<i>Passerina ciris</i>	0.8
Carolina chickadee *	<i>Poecile carolinensis</i>	0.6
Bewick's wren *	<i>Thryomanes bewickii</i>	0.5
Black-crested titmouse *	<i>Baeolophus atricristatus</i>	0.4
Carolina wren *	<i>Thryothorus ludovicianus</i>	0.4
Mourning dove *	<i>Zenaida macroura</i>	0.3
American crow *	<i>Corvus brachyrhynchos</i>	0.2
Black-and-white warbler *	<i>Mniotilta varia</i>	0.2
Golden-cheeked warbler *	<i>Dendroica chrysoparia</i>	0.2
Black-capped vireo *	<i>Vireo atricapilla</i>	0.2
Yellow-billed cuckoo *	<i>Coccyzus americanus</i>	0.1
Field sparrow *	<i>Spizella pusilla</i>	0.1

Lark sparrow *	<i>Chondestes grammacus</i>	0.1
Rufous-crowned sparrow *	<i>Aimophila ruficeps</i>	0.1
Northern bobwhite	<i>Colinus virginianus</i>	0.1
Black-chinned hummingbird	<i>Archilocus alexandri</i>	0.1
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>	0.1
Summer tanager *	<i>Piranga rubra</i>	0.1
Wild turkey	<i>Meleagris gallopavo</i>	>0.05
Indigo bunting *	<i>Passerina cyanea</i>	>0.05
Lesser goldfinch *	<i>Carduelis psaltria</i>	>0.05
Northern mockingbird *	<i>Mimus polyglottos</i>	>0.05
Chipping sparrow *	<i>Spizella passerine</i>	>0.05
Greater roadrunner	<i>Geococcyx californianus</i>	>0.05
Blue jay *	<i>Cyanocitta cristata</i>	>0.05
Eastern bluebird *	<i>Sialia sialis</i>	>0.05
Great-crested flycatcher *	<i>Myiarchus crinitus</i>	>0.05
Louisiana waterthrush *	<i>Seiuris motacilla</i>	>0.05
Scissor-tailed flycatcher *	<i>Tyrannus forficatus</i>	>0.05

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