Volume 7

Article 103

2012

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ANNUAL VARIATION IN NORTHERN BOBWHITE SURVIVAL AND RAPTOR MIGRATION

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ABSTRACT

We estimated survival of radio-marked northern bobwhite (*Colinus virginianus*) on a managed prairie site in northeast Mississippi during 2 disparate winters (15 Sep-14 Apr 2000–2002). We retrospectively examined factors that may influence bobwhite survival. Pooled survival rates differed substantially between years ($S = 0.03 \pm 0.02$ in 2000–2001 and $S = 0.36 \pm 0.16$ in 2001–2002). Regional relative abundance of 3 species of raptors thought to be important predators of bobwhite was greater during 2000 compared to 2001 based on kriging of Christmas Bird Count (CBC) data. We demonstrate an approach for characterizing annual variation in spatial distribution of migratory raptors and suggest that annual variation in local winter predator context may be useful for explaining annual variation in winter survival of local bobwhite populations.

Citation: Holt, R. D., L. W. Burger Jr., B. D. Leopold, and K. D. Godwin. 2012. Annual variation in northern bobwhite survival and raptor migration. Proceedings of the National Quail Symposium 7:265–270.

Key words: *Colinus virginianus*, Mississippi, northern bobwhite, predation, raptors, Survival

INTRODUCTION

Northern bobwhites experienced range-wide population declines during the last 3 decades of the twentieth century (Droege and Sauer 1990, Brennan 1991, Church et al. 1993). Bobwhite populations declined at a rate of 3.8% per year in the southeastern United States between 1966 and 1999 (Sauer et al. 2000). The most likely cause of bobwhite population declines is the reduction of suitable habitat (Klimstra 1982) associated with changes in farming practices (Roseberry and Klimstra 1984), changes in silvicultural practices (Brennan 1991), advancing stages of plant succession (Roseberry et al. 1979), and reduction in the intensity and frequency of natural disturbance (Stoddard 1931).

Bobwhites are associated with early successional ground cover for nesting, brood-rearing, and foraging. Bobwhite populations respond positively to habitat management and may be locally abundant in managed landscapes (Burger and Linduska 1967, Ellis et al. 1969, Webb and Guthery 1982). Populations in intensively managed areas have remained stable in contrast to regionally declining population trends (Brennan et al. 2000). Habitat management is generally designed to create and maintain native herbaceous ground cover. Commonly implemented management practices include disking, rotational agriculture, and prescribed fire. Specific management objectives of these practices include provision of seasonal resources (i.e., annual seed producing plants, appropriate nesting structure, invertebrates, etc.) and maximizing usable space through time. The latter objective is clearly a desirable goal for increasing or stabilizing local bobwhite populations, as there are other factors beyond the control of land managers that may influence bobwhite population demographics. Spatial and temporal variation in weather (Guthery 1997, 2002), landscape context (Thompson et al. 2002), landscape composition (Staller et al. 2002), predator space use (Chalfoun et al. 2002), and predator context (Burger 2002) may influence predation processes and demographics.

Numerous important bobwhite predators are migratory raptors and include sharp-shinned hawks (*Accipiter striatus*), Cooper's hawks (*A. cooperii*), northern harriers (*Circus cyaneus*), and red-tailed hawks (*Buteo jamaicen-*

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sis). It is likely that none of these raptors prey exclusively, or even primarily, on bobwhites (Rosene 1969), but individual species and their collective impact may substantially influence local bobwhite survival. Bobwhites may not constitute an important food source for avian predators, but avian predators may contribute substantially to bobwhite mortality (Burger et al. 1995, 1998). Previous research has suggested that composition of the raptor community and abundance of specific species of predators rather than the overall raptor density influences bobwhite survival (Holschneider et al. 2002). A local bobwhite population decline in Texas was attributed to an unusual seasonal influx of avian predators (Jackson 1947). Migration patterns of raptors likely vary from year to year and influence local predator community composition.

The objective of our study was to retrospectively examine annual variation in raptor migration that may account for variation in bobwhite survival estimates. A retrospective analysis does not constitute a rigorous test of cause and effect, nor even correlative evidence given the short duration of the study. Thus, we demonstrate an approach for using large-scale regional abundance information such as Christmas Bird Counts (CBC) to characterize annual variation in local abundance of migratory predators as a covariate for use in studies designed to explore annual variation in bobwhite demographics.

METHODS

We conducted research on the Black Prairie Wildlife Management Area (BPWMA) in southern Lowndes County, Mississippi in the Blackland Prairie physiographic region. The mean annual temperature was 16.5 °C with a range from 4.4 °C in January to 27.0 °C in July (NOAA 2000). The study area was $\sim$ 2,300 ha and is managed by the Mississippi Department of Wildlife, Fisheries and Parks (MDWFP). The purpose of BPWMA is to demonstrate wildlife friendly management practices in an agricultural landscape. The overwinter period defined for our study was from 15 September until 14 April.

Bobwhites were captured during fall and spring of each year, 2000–2002. Fall capture occurred during 2 weeks in September and 2 weeks in November of each year using walk-in style wire traps (Stoddard 1931) baited with cracked corn. We classified sex and age of each bird captured and weighed, and banded all birds on the right leg with a #7 numbered aluminum band. Each bird was fitted with a 5-6-g necklace style radio transmitter (American Wildlife Enterprises, Monticello, FL, USA) and released at the capture site. Radio transmitters had a 12-hr mortality sensor. Additional bobwhites were captured by night netting throughout the study (Truitt and Dailey 2000).

Radio-marked bobwhites were located at least 5 days each week using a programmable scanning receiver and a handheld 3-element Yagi antenna (Advanced Telemetry Systems Inc., Isanti, MN, USA). Remains of bobwhite were recovered upon receiving a mortality signal with the telemetry receiver. An approximate cause of mortality was assigned at the site of the radio transmitter when possible (Dumke and Pils 1973). Mortality factors were classified as avian, mammalian, unknown, or other. Seasonal cause-specific mortality rates were calculated using Program MICROMORT (Heisey and Fuller 1985).

Seasonal survival rates were estimated for the 2000–2001 and 2001–2002 over-winter periods using the Kaplan-Meier approach modified for staggered entry (Pollock et al. 1989). Birds with unknown fates (radio failure, emigration from study area, mortality attributed to research, or survival past 14 Apr of each year) were right censored. We assumed that right censoring mechanisms were independent of the bird's fate and left censored bobwhite had similar survival distributions to birds that were previously included in the risk set. We also assumed the sample of bobwhites used was random, survival times were independent for all individuals, and capture, handling, and marking did not affect survival. Radio-marked bobwhites were entered into the risk set on the first day following capture with no adjustment period to account for acute effects of time since capture, handling, and marking on survival (Holt et al. 2009).

Christmas Bird Count (CBC) data indexing year-specific relative abundance and spatial distribution of migratory raptors during December were downloaded from the National Audubon Society Christmas Bird Counts for 1985–2001 (National Audubon Society 2002). We were interested in mean relative raptor abundances over a longer period in addition to between years of our study. The CBC data were collected for chosen count circles in a 14 state area including Alabama, Arkansas, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, and Kentucky. All CBC circles chosen were south of latitude 40.54, north of latitude 29.21, east of longitude –95.33, and west of longitude –81.27. The CBC circles used were chosen from available CBC circles based on continuity of data over time and even distribution over the region.

We used data from 181 CBC circles. Data were used from 176 CBC circles in 2000 and 173 circles in 1999. The number of CBC circles used in this analysis during the 17 years from 1985 to 2001 ranged from 120 in 1985 to 177 in 1998. Locations of CBC circles were georeferenced in ArcView 3.2. Attribute information for each circle included the number of birds per hour counted for sharp-shinned hawks, Cooper's hawks, northern harriers, and red-tailed hawks. We used kriging to generate a year-specific surface of regional relative abundance of each raptor species during December. We used universal kriging, because it allows for a trend to be present in the spatial data (Isaaks and Srivastava 1989). The kriged surface of relative raptor abundance was developed with a cell size of 0.1^2 decimal degrees, which equaled $\sim$ 10,424 ha within the latitudes of interest.

We defined 6 latitudinal bands to describe year-specific spatial patterns in relative raptor abundance. Latitude bands were 1° wide from north to south and 11° wide from east to west. The northernmost latitude used was 37° and the southernmost latitude was 31°. Each band was $\sim$ 111 km wide from north to south. There were

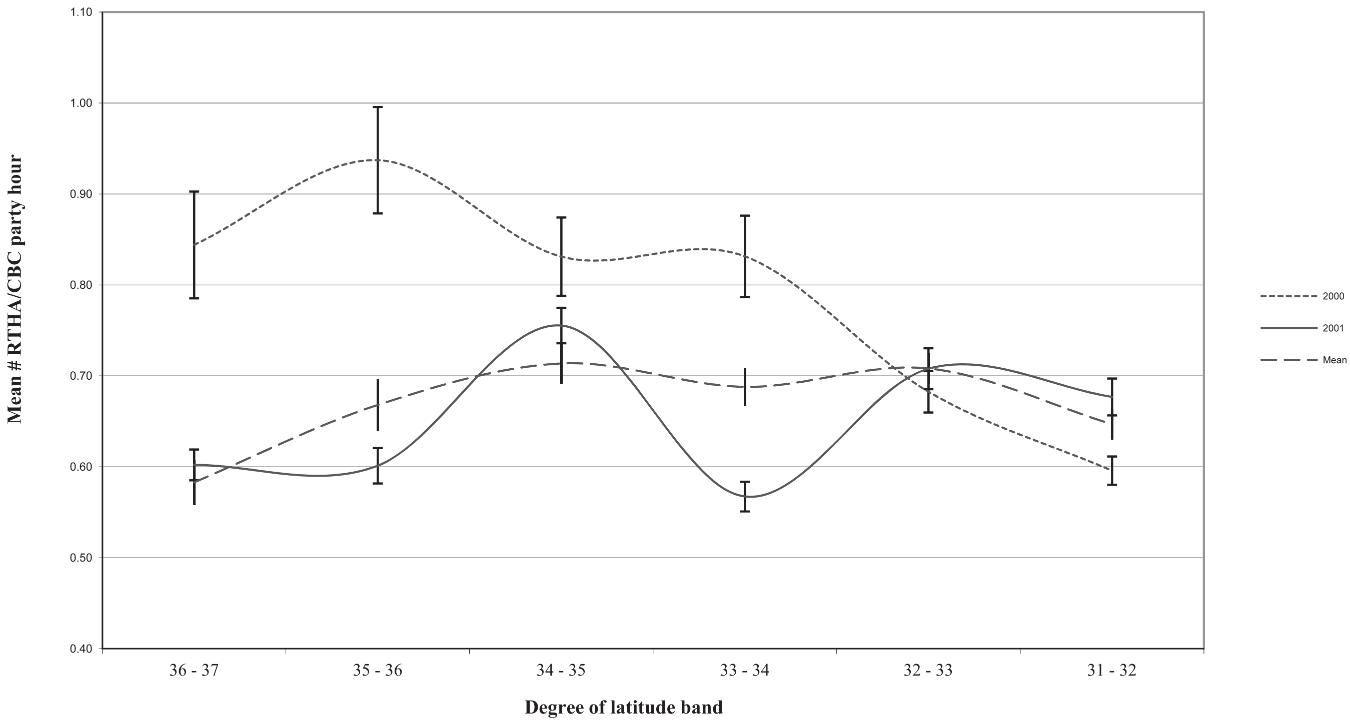

Fig. 1. Mean relative abundance of red-tailed hawks (RTHA) within 1° latitude bands based on surface kriged from Audubon Society Christmas Bird Counts during 2000, 2001, and averaged from 1985 to 2001.

1,100 cell grids in each band. We calculated means and standard errors of relative abundance of selected raptor species as estimated from the kriged surface of CBC data for each latitude band.

RESULTS

Seasonal Survival and Cause-specific Mortality

We captured and marked 173 bobwhites during the 2000–2001 season and 71 during the 2001–2002 season. Over-winter survival estimates were 0.03 $\pm$ 0.02 for the 2000–2001 season and 0.36 $\pm$ 0.16 for the 2001–2002 season. Avian predators were the primary mortality factor during both seasons with cause-specific mortality rates of 0.50 $\pm$ 0.78 during the 2000–2001 season and 0.28 $\pm$ 0.13 during the 2001–2002 season. This was followed in each year by mammalian cause-specific mortality rates of 0.37 $\pm$ 0.08 during the 2000–2001 season and 0.23 $\pm$ 0.14 during the 2001–2002 season; unknown cause-specific mortality rates were 0.09 $\pm$ 0.04 during the 2000–2001 season and 0.13 $\pm$ 0.10 during the 2001–2002 season. Cause-specific mortality rates for other causes were 0.01 $\pm$ 0.02 during the 2000–2001 seasons. There were no mortalities due to other mortality factors during the 2001–2002 season.

Raptor Migration Phenology

There were greater relative abundances of red-tailed hawks (Fig. 1) and Cooper's hawks (Fig. 2) in 2000 compared to 2001 and to the 17-year mean (1985–2001) in the latitude band that contains BPWMA (33°-34°) based on the estimated index of regional raptor relative abundance from CBC data. There was greater relative abundance of northern harriers (Fig. 3) in 2000 compared to 2001 and during both years of our study compared to the 17-year mean (1985–2001) in latitude band 33°-34°. Estimated relative abundance of sharp-shinned hawks (Fig. 4) from the same data showed greater relative abundance in 2001 than in 2000 and for the 17-year mean (1985–2001) in latitude band 33°-34°. Estimated relative abundance of sharp-shinned hawks (Fig. 4) was about equal between 2000 and the 17-year mean (1985–2001) in latitude band 33°-34°.

DISCUSSION

Annual studies of bobwhite have reported greater mortality rates during the overwinter period (Roseberry and Klimstra 1984; Curtis et al. 1988; Burger et al. 1995, 1998) than during other times of the year. Overwinter survival (0.03) observed on BPWMA during the 2000–2001 season was less than any previously reported study (Burger et al. 1995, Townsend et al. 1999) and clearly would not allow the population to be self-sustaining.

We observed greater regional relative abundance of migratory raptors in the latitude band containing BPWMA concurrent with high winter avian mortality in 2000. Cooper's hawks, sharp-shinned hawks, red-tailed hawks, red-shouldered hawks (*Buteo lineatus*), and great horned owls (*Bubo virginianus*) contribute to bobwhite mortality during the breeding season. However, mortality of bobwhite due to mammalian predators is generally greater

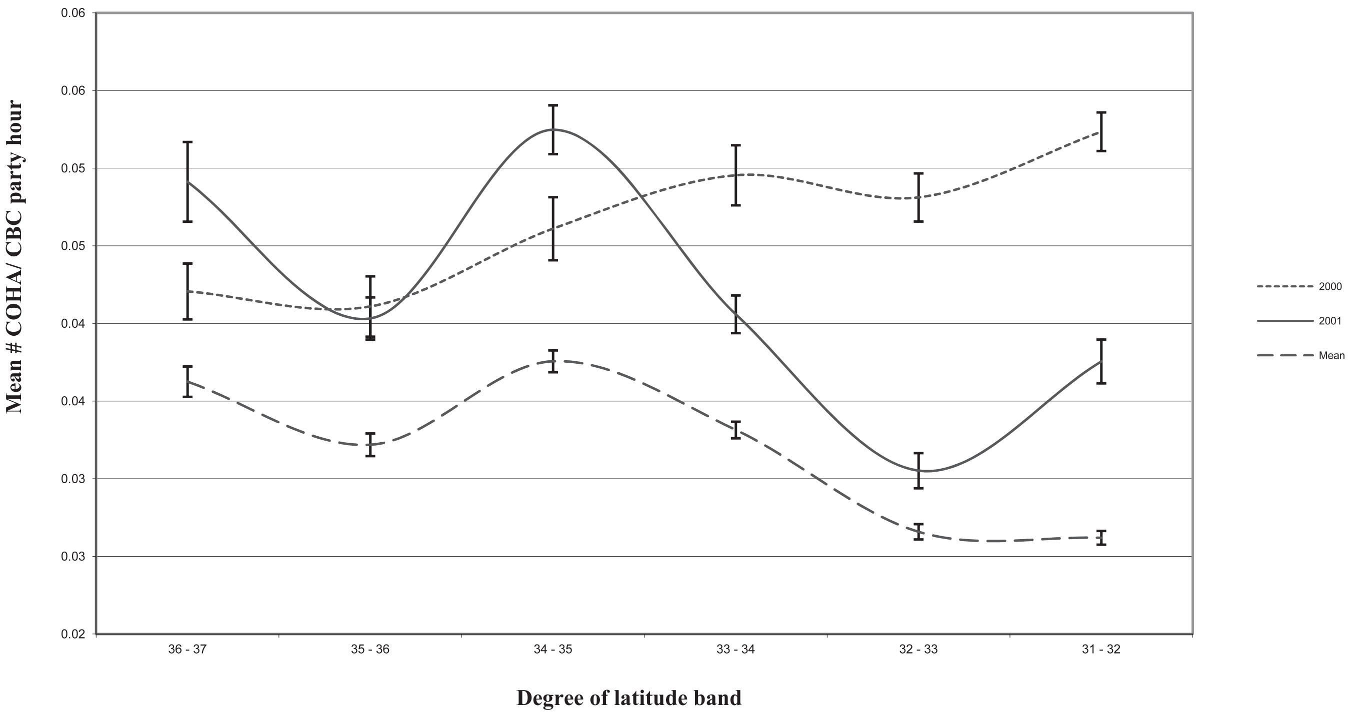

Fig. 2. Mean relative abundance of Cooper's hawks (COHA) within 1° latitude bands based on surface kriged from Audubon Society Christmas Bird Counts during 2000, 2001, and averaged from 1985 to 2001.

than that due to avian predators during the bobwhite nesting season (Burger et al. 1995, 1998). Previous studies have suggested that seasonal variation in relative abundance of specific raptors might affect bobwhite overwinter survival (Jackson 1947, Holschneider 2002). Specifically, Jackson (1947) reported that an unusually high wintering population of migratory northern harriers reduced a high density local bobwhite population.

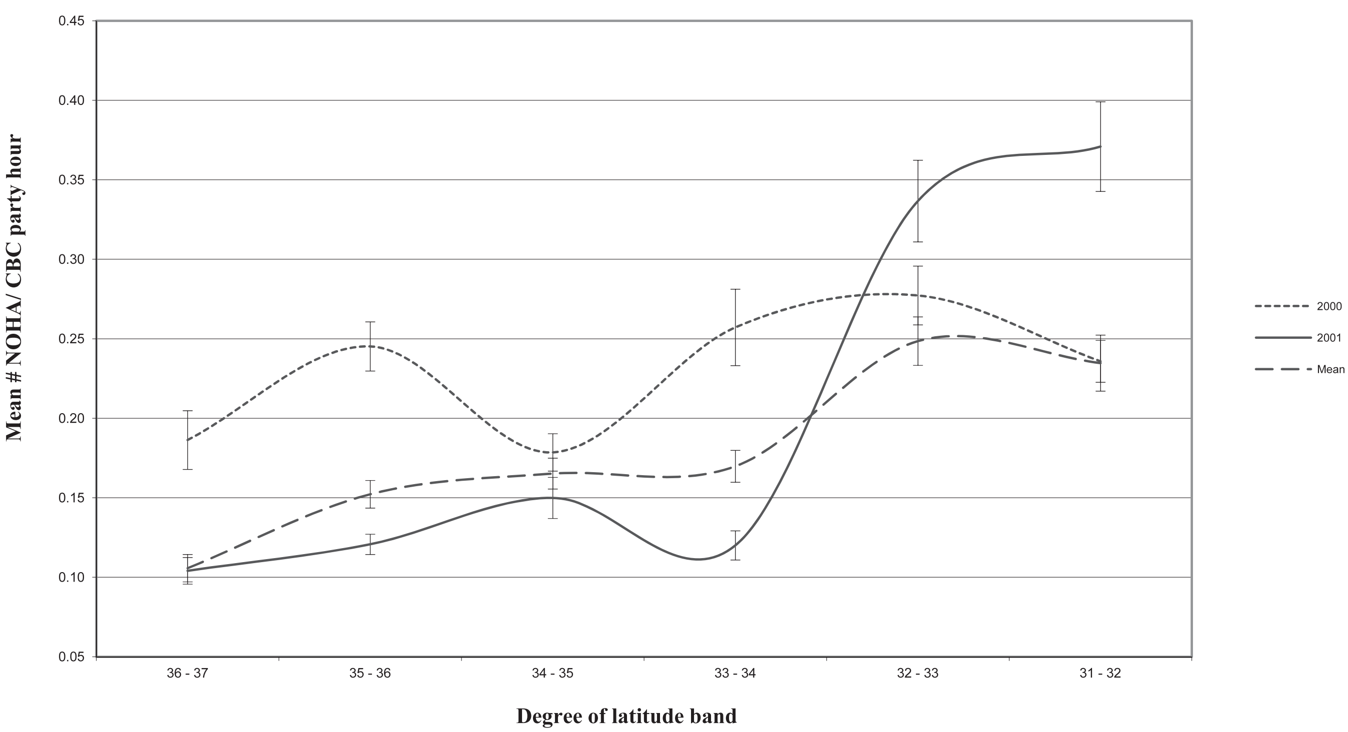

Fig. 3. Mean relative abundance of northern harriers (NOHA) within 1° latitude bands based on surface kriged from Audubon Society Christmas Bird Counts during 2000, 2001, and averaged from 1985 to 2001.

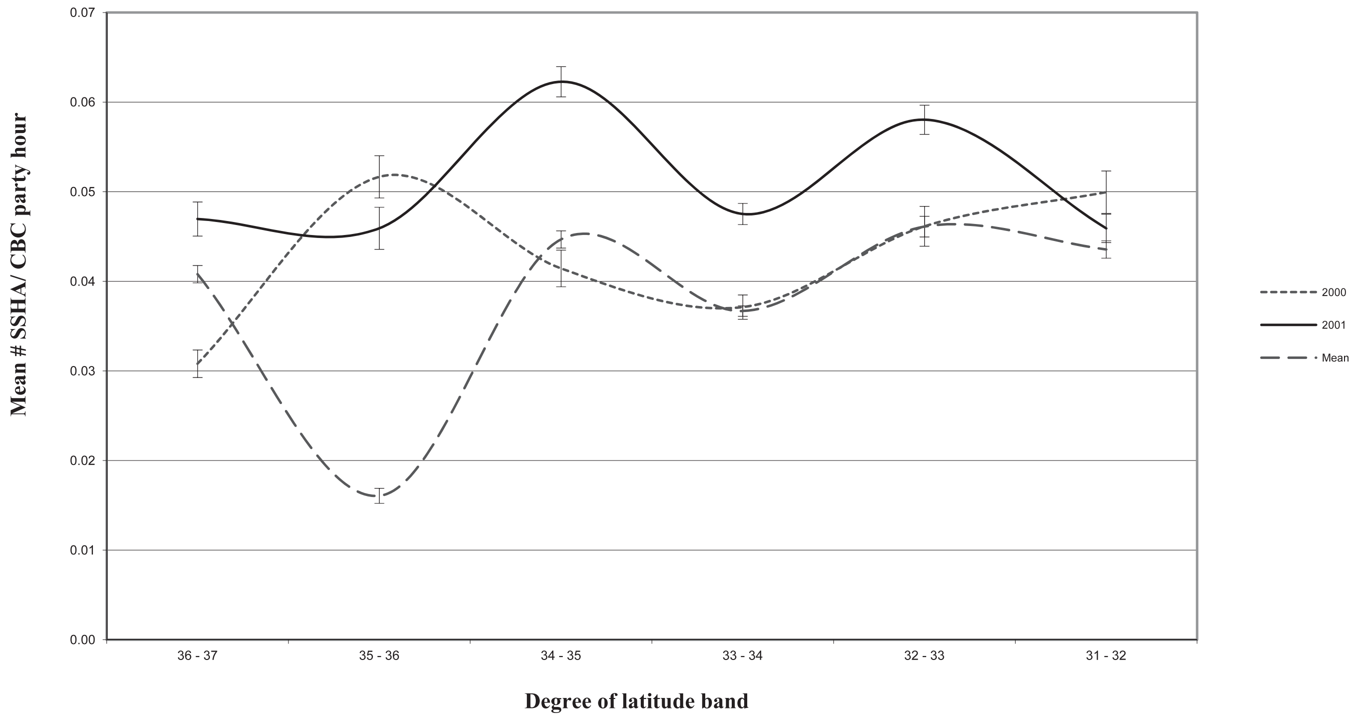

Fig. 4. Mean relative abundance of sharp-shinned hawks (SSHA) within 1° latitude bands based on surface kriged from Audubon Society Christmas Bird Counts during 2000, 2001, and averaged from 1985 to 2001.

Holscheider (2002) reported a weak correlation between abundance of all raptor species and total bobwhite mortality, but a stronger correlation between predation of bobwhite from raptors and *Accipiter* spp. abundance.

Migratory birds may appear in southerly latitudes in different densities and at different times annually (Saunders 1959, Wedemeyer 1973, Welty 1982). Abundance of wintering raptors at a given location may be expected to vary annually in relation to prevailing climatic conditions. A major migration may occur, but influxes of avian predators may happen throughout the season as cold fronts move into an area (Mueller and Berger 1961).

Our data suggests that for at least 3 species (red-tailed hawks, Cooper's hawks, and northern harriers), there were greater relative abundances present during the season of poor over-winter survival (2000–2001) at the latitude band that included BPWMA. The poor over-winter survival experienced by bobwhites during the first year could be the result of the culmination of a number of factors working together. We cannot attribute cause and effect, and hypothesize that independent of local habitat composition and landscape context; annual variation in local abundance of migratory raptors interacts with year-specific herbaceous ground cover conditions to influence annual variation in winter survival of bobwhite.

We demonstrated a technique to model annual change in relative abundance of migratory raptors. We made the assumption that annual differences in relative abundances at a regional scale translate to corresponding differences at the local or study site scale. This method has limitations as it does not provide *post-hoc* estimates of raptor abundance or density at either the local or regional scale. The method provides an index of relative abundance of raptors compared to other years or long-term means over a regional scale. We believe this method has utility to re-examine one factor that could influence annual variation in survival of bobwhites when more data are available.

This method allows for validation where local raptor survey data are available. We suggest spatial modeling of large-scale relative abundance information, such as from CBCs, when coupled with long-term local demographic studies, could provide insight into annual variation in winter survival.

ACKNOWLEDGMENTS

We gratefully acknowledge the support and funding provided to this study by the Mississippi Department of Wildlife, Fisheries, and Parks, the staff at Black Prairie Wildlife Management Area, and the Editor and 2 reviewers for providing constructive comments during the review process.

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