2013

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Short Communication

J. Raptor Res. 47(4):410–415

Influence of Latitude on the Winter Abundance of Red-tailed Hawks (*Buteo jamaicensis*) and American Kestrels (*Falco sparverius*) in Illinois

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Key Words: *Red-tailed Hawk*; Buteo jamaicensis; *American Kestrel*; Falco sparverius; *abundance*; *Illinois*; *latitude*; *winter abundance*.

Red-tailed Hawks (*Buteo jamaicensis*) and American Kestrels (*Falco sparverius*) are among the most common overwintering raptors in Illinois (Bohlen 1989, Kleen et al. 2004, Preston and Beane 2009); however, no comprehensive study has documented their winter abundance and distribution in Illinois for more than 50 yr (Graber and Golden 1960, Graber and Graber 1963). Because Illinois has a long north-south extent (603.5 km) spanning approximately 5.5 degrees of latitude, temperature and snowfall throughout the state vary considerably. Winter survival of Red-tailed Hawks and American Kestrels can be negatively affected by cold temperatures and heavy snow cover (Mills 1975, Root 1988, Lish and Burge 1995). Snow cover may also influence prey availability and decreases in the abundance and vulnerability of prey have been associated with reduced observations of both species (e.g., Baker and Brooks 1981, Preston 1990).

Through a series of automobile surveys, we evaluated the temporal stability of a distributional pattern first reported more than 100 yr ago and reconfirmed some 50 yr ago that the winter abundance of both species decreases with latitude, being higher in the central regions of Illinois than in the northern regions (Forbes and Gross 1923, Graber and Golden 1960, Graber and Graber 1963). Substantial habitat changes have occurred within these regions during the past 50 yr (Walk et al. 2010) and unlike the previous surveys, our survey protocol was designed specifically to detect raptors. Because changes have been projected for North America's climate in the coming decades (e.g., USGCRP 2009), this study will provide useful data for predicting the future winter distributions of these two species in the midwestern U.S. We also present additional observations of age classes of Red-tailed Hawks and sexes of American Kestrels, which were not documented in the earlier studies.

Study Area

All automobile survey routes were within the Northern and Central Divisions of Illinois (Gault et al. 1922) and spanned approximately 2°17′ of latitude (Fig. 1). The latitude and longitude for the Northern Division of Illinois were: northernmost = 42°30′N; southernmost = 40°55′N; westernmost = 91°05′W; easternmost = 87°31′W (Fig. 1). The latitude and longitude for the Central Division were: northernmost = 41°44′N; southernmost = 39°00′N; westernmost = 91°30′W; easternmost = 87°32′W (Fig. 1). Walk et al. (2010) classified the state's land cover into three broad categories: corn (*Zea mays*) and soybean (*Glycine max*) row crops (i.e., cultivated), development, and deciduous forest. In 2006–2008, the Northern Division of Illinois was 12% forested, 28% developed, and 54% cultivated, while the Central Division was 8% forested, 4% developed, and 85% cultivated (smaller percentages of habitat types are not included; data from Walk et al. 2010). During the surveys, most corn fields contained corn stubble while most soybean fields had sparse plant residue. On all routes some of the crop fields had been plowed, with the fields consisting of exposed soil when they were not covered by snow.

Methods

We assessed winter abundances of both species using a preexisting database of surveys initiated by the Illinois

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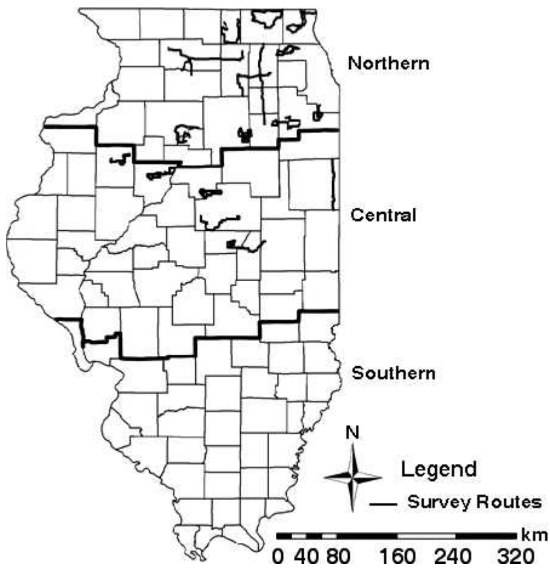

Figure 1. Automobile survey routes and the Northern, Central, and Southern Divisions of Illinois U.S.A. Divisions are based on Gault et al. (1922).

Beach State Park Hawk Watch in the Northern and Central Divisions of Illinois (i.e., no surveys were conducted in the Southern Division). We analyzed 143 raptor surveys from 18 different survey routes (Fig. 1). Volunteer surveyors with raptor identification experience chose the routes (49.1–99.6 km in length) based on their knowledge of local roadways that had a mix of potential habitat and tractable traffic. Surveys were completed via automobile once per month (December–February) from 2004–2005 to 2008–2009, between approximately 1000 H and 1600 H, on days when inclement weather would not decrease raptor detectability (e.g., heavy precipitation and/or constant high winds). This was the same monthly time period of winter raptor surveys used in previous studies (Graber and Graber 1963). Approximately 80% of surveys were completed by 1420 H, the maximum cutoff for avoiding time-of-day effects on Red-tailed Hawk abundance (Bunn et al. 1995; they found no such effects on American Kestrels). Most surveys spanned both the morning and afternoon time periods, and during several months surveys were not conducted on some routes. Surveyors drove personal vehicles, maintained an appropriate speed for spotting raptors (approximately 24–56 km/hr) and stopped as necessary to identify birds using binoculars and/or spotting scopes. At least two surveyors participated in each survey. Surveyors recorded the species, age class (for Red-tailed Hawks only), and sex (for American Kestrels only) of the raptors that were observed. To estimate the potential effects of weather on raptor abundance, we compared monthly temperature and snowfall data from major weather stations (Illinois State Climatologist's Office 2012) in northern (Chicago O'Hare International Airport, 41°58.75′N) and central Illinois (Greater Peoria Airport, 40°40.25′N).

Christmas Bird Count (CBC) data were obtained from the online CBC database (National Audubon Society 2010). CBCs were conducted annually across the state between 14 December and 5 January by volunteers assigned a specified route through a 24-km diameter circle. CBC surveys were conducted via multiple methods (e.g., on foot, by automobile) and every bird seen or heard was counted. The eBird data, which were collected via point counts, transects, and area searches conducted by bird watchers, were obtained from an online database (eBird 2012). For both CBC and eBird datasets, data were obtained for the same counties in which winter raptor survey routes were conducted.

We analyzed data with R 2.15.1 software (R Development Core Team 2012). Abundance data met normality assumptions after square-root transformation (Shapiro-Wilk test, $\alpha = 0.01$) and were tested using one-way ANOVA ($\alpha = 0.05$). We tested the relationship between abundance (mean individuals per 1000 km driven) and survey route latitude with a linear regression. The latitudinal midpoint of each route was calculated using the latitudes of the northernmost and southernmost points on each route using ArcMap 10 (ESRI 2011). We tested differences in temperature and snowfall measured at the Chicago and Peoria, Illinois, weather stations among years with two-way ANOVAs.

RESULTS

Surveyors made 1746 observations of Red-tailed Hawks and 601 observations of American Kestrels. There was a significant negative relationship between latitude and the mean number of all Red-tailed Hawks per 1000 km driven ($F_{1,16} = 5.3$, $P = 0.035$, $R^2 = 0.20$; Fig. 2a), and the mean number of all American Kestrels per 1000 km driven ($F_{1,16} = 32$, $P < 0.001$, $R^2 = 0.64$; Fig. 2b). When comparing Red-tailed Hawks by age class, there was no significant relationship between latitude and the mean number of adults ($F_{1,16} = 3.77$, $P = 0.07$), but there was a significant negative relationship for juveniles ($F_{1,16} = 5.65$, $P = 0.03$, $R^2 = 0.21$). There were highly significant negative relationships between latitude and mean abundance for both male American Kestrels ($F_{1,16} = 16.0$, $P = 0.001$, $R^2 = 0.47$) and females ($F_{1,16} = 31.9$, $P = 0.0001$, $R^2 = 0.65$). Mean monthly temperatures at the Greater Peoria Airport were higher than at the Chicago O'Hare International Airport in 14 of 15 mo of the study period (mean difference = 0.9°C), and mean monthly snowfall was greater in Chicago than Peoria in 13 of the 15 mo surveyed (mean difference = 13.6 cm). At Peoria, the mean monthly temperature was −2.3°C (low = −12.3°C, high = 6.9°C) and the mean monthly snowfall was 16.6 cm (minimum = 0 cm, maximum = 43.2 cm), while in Chicago the mean monthly temperature was −3.2°C (low = −13.4°C, high = 5.6°C) and the mean monthly snowfall was 30.2 cm (minimum = 1.5 cm, maximum = 70.6 cm). However, none of the differences were significant ($P > 0.05$).

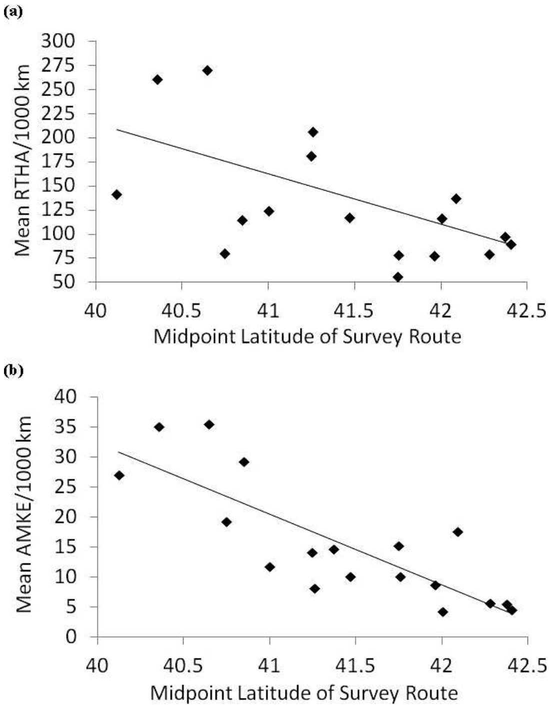

Figure 2. (a) Mean overall Red-tailed Hawk (RTHA) abundance per 1000 km relative to the latitudinal midpoint of each survey route, and (b) mean overall American Kestrel (AMKE) abundance per 1000 km relative to the latitudinal midpoint of each survey route.

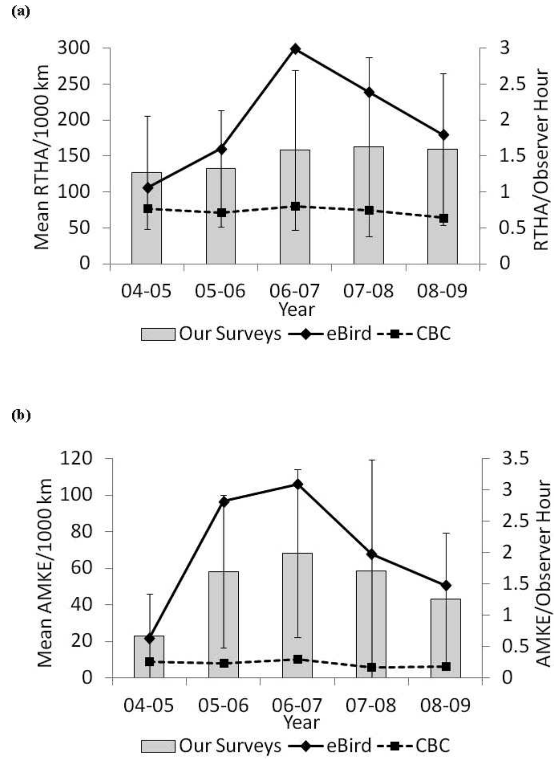

Figure 3. (a) Mean ± SD Red-tailed Hawk (RTHA) abundance per 1000 km across survey years, compared to mean CBC and eBird data (per observer hour), and (b) mean ± SD American Kestrel (AMKE) abundance per 1000 km across survey years, compared to mean CBC and eBird data (per observer hour).

There was no significant difference in the abundance of Red-tailed Hawks (mean = 147.2 Red-tailed Hawks/1000 km) across years ($F_{1,141} = 1.8$, $P = 0.18$) or months ($F_{1,141} = 2.3$, $P = 0.13$), nor was there a significant difference for American Kestrels (mean = 51.1 kestrels/1000 km) across years ($F_{1,141} = 0.88$, $P = 0.35$) or months ($F_{1,141} = 0.87$, $P = 0.35$). The data from CBC counts and eBird (December–February) data for both species showed trends similar to those detected in our automobile surveys (Fig. 3). Of the 78% of Red-tailed Hawks identified by age class in our surveys, 10% were juveniles and 90% were adults. Of the 80% of kestrels identified to sex in our surveys, 64% were males and 36% were females.

DISCUSSION

We found increases in the overall abundance of both species from the Northern to the Central Divisions of Illinois, although adult Red-tailed Hawks showed no significant relationship. Lish and Burge (1995) suggested that adult Red-tailed Hawks may winter farther north than juveniles in order to remain closer to nesting territories. Graber and Golden (1960) and Graber and Graber (1963) suggested that their detected latitudinal gradients in the abundance of both species in Illinois from the early 1900s to the 1950s may have been due to temperature. Enderson (1960) found a negative correlation between American Kestrel abundance and low temperatures and high wind velocities in December and January in east-central Illinois. Root's (1988) analysis of CBC data indicated that temperature was a major factor associated with the abundance patterns of both species, with peak abundances of each in the central U.S. at approximately the same latitudes as the Central Division of Illinois.

Although mean monthly temperatures were generally colder and snowfall was greater in Chicago compared to Peoria, we found no significant differences between the values reported by the two weather stations. Local weather conditions along individual survey routes may have differed from those at the weather stations (e.g., blowing and drifting snow on some routes but not on others), and raptor abundance may have been linked with severe weather events that were averaged out in the monthly weather data records. It is also likely that weather data from only two stations may not represent general weather conditions across the two regions, as pronounced snowfall and temperature gradients existed from the Northern through the Southern Divisions of Illinois throughout the past 30–50 yr (Changnon et al. 2004, Illinois State Climatologist's Office 2012). There have not been significant changes in average winter temperatures in Illinois during the past century (Illinois State Climatologist's Office 2012), although this does not account for yearly variability and extreme weather events. However, it is predicted that under global climate change, Illinois will experience milder, wetter winters with the climate similar to the current southern Mississippi River valley by mid-century (USGCRP 2009). Such changes will likely lead to a northward shift of winter abundance for both species if temperature is the dominant weather-related controlling factor.

The winter abundance of both Red-tailed Hawks and American Kestrels remained steady throughout the study. Craighead and Craighead (1956) also found that winter Red-tailed Hawk populations in Michigan were stable in January and February. Migration apparently had little influence on the observed abundances in our study, despite the fact that Bohlen (1989) reported that Red-tailed Hawk spring migration in Illinois began in mid- to late February, and Enderson (1960) reported that the spring American Kestrel migration in east-central Illinois began in early February. We observed much higher abundances than those recorded by Schnell (1967) via automobile surveys in northern Illinois in the winters of 1964–1965 and 1965–1966. He documented a December–February mean of 13.8 Red-tailed Hawks/1000 km (compared to our 147.2/1000 km) and 3.2 American Kestrels/1000 km (compared to our 51.1/1000 km). These increases agree with substantial increases in CBC sightings for both species in that time period (e.g., National Audubon Society 2010, McCay et al. 2001), which are likely due to their adaptability to human-dominated landscapes and widespread increases in woodland-agricultural edge habitat (McCay et al. 2001). Graber and Golden (1960) and Graber and Graber (1963) found that winter populations of both species declined in Illinois from the early 1900s to the 1950s. It is possible that environmental contaminants (e.g., organochlorine pesticides) may have decreased the abundance of American Kestrels in Illinois in the 1950s (Walk et al. 2010) when the last comprehensive winter raptor surveys were conducted.

Our observation that adult Red-tailed Hawks on our surveys greatly outnumbered juveniles was not unexpected as juvenile Red-tailed Hawks have lower survival rates than adults (Henny and Wight 1972, Santana and Temple 1988). Greater numbers of wintering adult than juvenile Red-tailed Hawks have also been reported by Gates (1972) and by Lish and Burge (1995). A factor that may have influenced our male-biased sex ratio of kestrels is that males have been observed wintering farther north than females, which affects the sex ratio of the species at the northern boundaries of their range (approximately at the northern border of Illinois; Smallwood and Bird 2002).

Our abundance values for Red-tailed Hawks were lower than those recorded by Lish and Burge (1995) in Oklahoma (October–March, 378.4 Red-tailed Hawks/1000 km) and by Garner and Bednarz (2000) in Arkansas (December–March, 502 Red-tailed Hawks/1000 km). For American Kestrels, observed abundances were much lower than Pearlstine et al. (2006) reported in south Florida (October–April, 310 kestrels/1000 km). These studies across the U.S. agree with our observed trends that show increased winter abundance of both species with decreasing latitude from northern to central Illinois. There has been temporal stability in this pattern during the past 100 yr (Forbes and Gross 1923, Graber and Golden 1960, Graber and Graber 1963) despite substantial changes in both habitat and agricultural practices in the last 50 yr that likely reduced habitat availability and quality. The abundance of hay land (and likely pastures) declined substantially over this period and agricultural practices shifted throughout the state as the alternate growing of corn and soybeans displaced a corn-oats (*Avena* spp.)-alfalfa (*Medicago lucerne*) rotation (Walk et al. 2010). Such a shift to intensive row crop practices likely reduced rodent populations (e.g., Cummings and Vessey 1994), which suggests that prey abundance was not the major determinant of Red-tailed Hawk and American Kestrel abundance. Currently, agricultural practices in Illinois are undergoing profound changes through the expansion of row crops (especially corn) at the expense of Conservation Reserve Program and other grasslands (Meehan et al. 2010), and the use of genetically modified crops that may actually allow for more intensive use of pesticides (Benbrook 2012). Predictions of the impacts of these landscape changes on winter raptor abundance are difficult to make but such changes highlight the importance of baseline data through standardized raptor counts.

INFLUENCIA DE LA LATITUD EN LA ABUNDANCIA INVERNAL DE *BUTEO JAMAICENSIS* Y *FALCO SPARVERIUS* EN ILLINOIS

Resumen.—Utilizamos cinco años de datos de 18 rutas censadas para determinar la estabilidad temporal de un patrón reportado por primera vez hace 100 años, y reconfirmado hace 50 años, de que la abundancia invernal de *Buteo jamaicensis* y *Falco sparverius* disminuye al aumentar la latitud, siendo más elevada en las regiones centrales de Illinos que en las regiones del norte. Voluntarios entrenados llevaron a cabo muestreos (n = 143) mensuales conduciendo por rutas seleccionadas de diciembre a febrero, desde 2004–2005 hasta 2008–2009. Encontramos incrementos significativos en la abundancia de ambas especies desde las regiones del norte hacia las regiones centrales de Illinois. No se evidenciaron efectos significativos del año o del mes en la abundancia de *B. jamaicensis* (media general = 147.2 individuos de *B. jamaicensis*/1000 km) y en la abundancia de *F. sparverius* (media general = 51.1 individuos de *F. sparverius*/1000 km). Del 78% de los individuos de *B. jamaicensis* identificados por clase de edad, 10% fueron juveniles y 90% fueron adultos. Del 80% de los individuos de *F. sparverius* identificados por sexo, 64% fueron machos y

36% fueron hembras. Nuestros hallazgos indican que ha habido una estabilidad temporal de 100 años en el patrón de incremento de la abundancia invernal de ambas especies desde el norte hacia el centro de Illinois, a pesar de cambios substanciales tanto en el hábitat como en las prácticas agrícolas durante los últimos 50 años.

[Traducción del equipo editorial]

ACKNOWLEDGMENTS

We thank the additional individuals responsible for conducting the winter raptor surveys: Joan Bruchman, Eric Delbecq, Roger Digges, Thad and Jan Edmonds, Norman Emerick, Bob and Karen Fisher, Matt Fraker, Richard Gibson, Jim Kriss, Karen Lund, Dick Riner, Darryl Shambaugh, Anne Straight, Chris Whittier, Matthew Winks, and Jerry Zamirowski. Will Jaeckle, Ed Pandolfino, and anonymous reviewers provided useful comments on the manuscript. RGH thanks Wendell and Virginia Kingsolver for their support.

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Received 4 August 2012; accepted 30 April 2013
Associate Editor: Jessi L. Brown