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PREY USE AND PROVISIONING RATES OF URBAN-NESTING MISSISSIPPI KITES IN WEST TEXAS

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ABSTRACT.—Urban ecosystems are attractive to several raptor species, including the Mississippi Kite (*Ictinia mississippiensis*). To better understand the niche filled by urban-nesting Mississippi Kites, we observed nesting kites at 10 nests for a total of 269 hr during the breeding seasons of 2010 and 2011. We assessed prey delivery rates and prey use within and between years, evaluated the influences of nestling age, time of day, day of year, and local atmospheric conditions on delivery rates, and examined provisioning rates by male and female kites. A 62% decrease in the prey delivery rate, measured by the number of prey deliveries, from 2010 to 2011 was likely attributable to extreme heat and drought during the 2011 breeding season. However, total biomass of identified deliveries increased 38.9% in 2011 due to an increase in the percentage of avian prey (from 1% to 16% of identified deliveries). We suspect that differences in weather conditions between years influenced the type of prey delivered, and our modeling efforts indicated that year, nestling age, time of day, and temperature best explained the number of prey deliveries made per hour. On average, females delivered more prey items than males, but variability among nests suggested additional factors may influence parental effort. Our results suggest that Mississippi Kites exhibit prey switching under differing conditions.

KEY WORDS: *Mississippi Kite*; Ictinia mississippiensis; *diet*; *nesting*; *parental care*; *prey*; *provisioning rates.*

USO DE PRESAS Y TASAS DE APROVISIONAMIENTO DE *ICTINIA MISSISSIPPIENSIS* NIDIFICANTES EN AMBIENTES URBANOS EN EL OESTE DE TEXAS

RESUMEN.—Los ecosistemas urbanos resultan atractivos para varias especies de aves rapaces, incluyendo a *Ictinia mississippiensis*. Para entender mejor el nicho que ocupan los individuos de *I. mississippiensis* que nidifican en ambientes urbanos, observamos individuos reproductivos en 10 nidos durante un total de 269 horas en las épocas reproductivas de 2010 y 2011. Estimamos las tasas de aprovisionamiento de presas y el uso de presas dentro y entre los años de estudio; evaluamos la influencia de la edad de los pollos, la hora del día, el día del año y las condiciones atmosféricas locales en las tasas de aprovisionamiento; y examinamos las tasas de aprovisionamiento de machos y hembras. La disminución en un 62% de la tasa de aprovisionamiento de presas entre el año 2010 y el 2011 medida como el número de presas aportadas, se debió probablemente al calor extremo y a la sequía durante la época reproductiva del 2011. Sin embargo, la biomasa total de las presas aportadas identificadas aumentó un 38.9% en 2011 debido al incremento en el porcentaje de presas en forma de aves (de 1% a 16% de los aportes identificados). Sospechamos que las diferencias interanuales en las condiciones climatológicas influenciaron el tipo de presa aportada y nuestros modelos indican que el año, la edad del pollo, la hora del día y la temperatura fueron los parámetros que mejor explicaron el número de presas aportadas por hora. En promedio, las hembras aportaron al nido más presas que los machos, pero la variabilidad entre los nidos sugiere que otros factores pueden estar influyendo en el esfuerzo parental. Nuestros resultados sugieren que *I. mississippiensis* cambia sus presas bajo condiciones diferentes.

[Traducción del equipo editorial]

Habitat modification from natural to urban areas is a common trend worldwide (Grimm et al. 2000). Compared to undeveloped landscapes, urban ecosystems tend to promote occupancy by a greater density, but reduced diversity of species (Clergeau et al. 1998). In an early urban wildlife study, Emlen

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(1974) found that granivorous, nectarivorous, and insectivorous birds could be supported in urban environments. Later studies, however, demonstrated that urban ecosystems were also attractive to several raptor species (see Bird et al. 1996, Mannan and Boal 2004 for reviews).

There are several possible reasons why some raptor species thrive in urban areas. Urban raptors may benefit by having a lower abundance of predators and reduced human persecution (Mannan and Boal 2004). Urbanization-mediated changes in the structural diversity of a landscape may be attractive and promote settling by some raptors. For example, urbanization in arid or agricultural regions may result in the provision of suitable nesting sites through the introduction of taller woody plant species (Boal and Mannan 1998, Rottenborn 2000, Skipper 2013), and increased abundance or availability of food and water (Mannan and Boal 2004). Indeed, some raptor species that colonize urban areas show increased reproductive success that is nearly double that of conspecifics in rural areas (Parker 1996, Smith 2010). However, human activities occurring in close proximity to nests may increase mortality if birds begin to lose their instinctive fear of humans. Though some degree of habituation to humans may be necessary for urban birds to carry out daily feeding or resting activities, it may also make them more susceptible to human persecution (Whittaker and Knight 1998). In addition, noise generated from nearby roadways and other sources may hinder communication between individuals by decreasing the distance that auditory signals (e.g., alarm calls, contact calls) can be perceived (Barber et al. 2010), and increased exposure to disease in urban landscapes can lead to decreased reproductive success (Boal et al. 1998, Boal and Mannan 1999). Yet, in studies of urban-dwelling raptors, an apparent positive relationship between prey abundance and reproductive success (Newton 1998) seems to explain higher reproductive performance in urban compared to rural settings (Smith 2010).

Mississippi Kites (*Ictinia mississippiensis*) may be the most abundant urban-nesting raptor in the United States (Parker 1996). Prior to the early 20th century, breeding Mississippi Kites were distributed from eastern Texas to South Carolina, and along the Mississippi Valley as far north as Iowa (Parker and Ogden 1979). The distribution of the species has since expanded westward to Arizona and northward into the Southern Great Plains of Colorado, Kansas, Nebraska, and Oklahoma (Bolen and Flores 1993). Previous researchers suggest that expansion was facilitated by human-mediated vegetation changes as the Southern Great Plains were settled, resulting in subsequent changes in the distribution and abundance of prey species and suitable nesting sites (Bolen and Flores 1993). Mississippi Kite populations nesting on the Great Plains currently concentrate in urban and semiurban areas, often nesting on golf courses, college campuses, or in city parks (Parker 1999, Skipper 2013).

Limited information is available on how environmental conditions or time of day may influence the feeding ecology and reproductive behaviors of this primarily insectivorous raptor (Parker 1999, Chiavacci et al. 2014). Temporal and spatial aspects of their foraging behavior are likely dictated by their invertebrate prey species, such as cicadas (Hemiptera) and grasshoppers (Orthoptera), which exhibit behavioral responses to changes in weather and time of day (Pfadt 2002). Parental foraging behaviors of Mississippi Kites also change with nestling age (Bolen and Flores 1993). Glinski and Ohmart (1983) identified seasonal changes in the types of prey delivered, but did not examine prey delivery rate in context of time of day or environmental conditions at nonurban Mississippi Kite nests in Arizona. Botelho et al. (1993) correlated prey delivery rate with nestling age at a single urban Mississippi Kite nest in New Mexico, but the inferential value of the study was limited by the sample size. Sex-specific differences in the types of prey delivered and changes in diet associated with nestling age and environmental conditions were assessed via video recording at kite nests in swamplands of eastern Arkansas (Bader and Bednarz 2011, Chiavacci et al. 2014). Ultimately, despite their relative abundance, little quantitative data are available describing the food habits and breeding ecology of Mississippi Kites, and except for the limited New Mexico study (Botelho et al. 1993), no data are available for urban-nesting kites.

We examined the breeding ecology and food habits of Mississippi Kites in Lubbock, Texas, during the breeding seasons of 2010 and 2011. The objectives of our study were to (1) assess prey delivery rates, (2) develop an understanding of parental roles and changes in parental care with nestling age, and (3) examine the influence of weather conditions and time of day on the rate of prey delivery (items/hr) and prey type delivered to nestlings by urban-nesting Mississippi Kites.

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METHODS

Study Area. We conducted our study in Lubbock, Texas, (population 236 065; City-Data 2013) located on the Southern High Plains region of western Texas and within the southernmost portion of the Great Plains. Lubbock is 922 masl, receives an average annual precipitation of 47.5 cm, and has average high temperatures ranging from 11.1°C in January to 33.3°C in July. Our study sites were on the Texas Tech University campus and nearby Wagner Park. The Texas Tech University campus is located in a highly urbanized area adjacent to both commercial and residential properties. Wagner Park is in a residential area <1.6 km from Texas Tech University. Predominant tree species on Texas Tech University campus and at Wagner Park included thornless honey locust (*Gleditsia triacanthos inermis*), cedar elm (*Ulmus crassifolia*), live oak (*Quercus virginiana*), bur oak (*Quercus macrocarpa*), red oak (*Quercus rubra*), Chinese pistache (*Pistacia chinensis*), lacebark elm (*Ulmus parvifolia*), pine (*Pinus* spp.), Bradford pear (*Pyrus calleryana*), Shantung maple (*Acer truncatum*), and Arizona ash (*Fraxinus velutina*). The ground level of study sites is primarily mowed lawns with very little shrub cover.

Nest Observations. During the 2010 and 2011 breeding seasons, we conducted direct observations at five successful urban nests each year, with each nest having one nestling. Nine breeding pairs were observed, one of which was monitored in both years, but all nest locations were unique. We conducted nest observations between 07:30–21:30 H. This 14-hr observational day was split into seven 2-hr time blocks and each nest was monitored twice during each of the 2-hr time blocks across the brood-rearing period. Nests were observed between hatching and fledging, 11 July to 23 August. Initial nestling presence was determined in the field by observed behaviors of adult kites (e.g., feeding nestlings), and hatch dates were estimated by back-dating 36 d from fledging and ensuring consistency with documented growth markers (Parker 1999, Welch 2011) throughout the nestling stage.

We used two Nikon Fieldscope III spotting scopes with an objective diameter of 60 mm and a 20–60× zoom eyepiece. The magnification used for the spotting scope varied depending on the observers' distance from the nest tree. One scope was used to observe the nest and activities of kites, and the second was attached to a camera to digitally photograph every prey delivery observed. We made observations from the ground at distances of 30–100 m from the nest tree. Observation points were located under the concealment of nearby vegetation and a large umbrella positioned by the observer. At no time during observations did any kite appear to differentiate the observers' presence from the normal foot traffic in the study area.

We identified prey during direct observations when possible and subsequently confirmed identifications with the digital pictures when photographic quality permitted (22.4% of identified prey). Insect prey were identified to the level of order and vertebrate prey were identified to class. We recorded the time of each delivery with a digital watch, and obtained measures of atmospheric conditions during the time of each observation from the Texas Tech University Mesonet (2015). Finally, we often identified the delivering parent based on color bands on the legs of all five breeding pairs in 2010 and two breeding pairs in 2011; three nests in 2011 were occupied by unbanded adults (Skipper 2013). Color bands permitted parental identity to be confirmed for 91.3% of deliveries made at nests where adult birds were color-banded.

Statistical Analysis. We restricted the analysis to data collected after hatching and prior to fledging. For this study, we defined fledging as the age at which a nestling began moving onto main branches that were not supporting the nest, or to a tree other than the nest tree. Descriptive values reported throughout are estimates of mean ± SE unless otherwise noted.

We used program R (http://www.r-project.org/) and relevant packages for all statistical tests and modeling unless otherwise noted. We compared mean prey delivery rates (defined as the number of deliveries/hr) among nests within year with a Kruskal-Wallis rank sum test because equal variance and normality of delivery rates among nests were not achieved (Zar 2010). We used an unpaired *t*-test to contrast delivery rates between nests in 2010 and 2011, as data pooled across nests were normally distributed, exhibited equal variance, and different nest locations were sampled between years (although one pair of birds was monitored in both years, at different locations).

We estimated the frequency of occurrence and biomass for each identified prey type among nests and between years. We excluded prey that could not be identified due to obstructed views or poor prey condition (e.g., masticated beyond identification) from calculations of the proportion that each prey category contributed to the diet of kite nestlings.

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Decapitation and removal of feathers from avian prey limited species identification.

We suspect many of the avian prey were nestling Mourning Doves (*Zenaida macroura*) due to the abundance of the species in our study area and the apparent ease with which kites could access their nests in the open-canopy trees common in the area. However, to be conservative, we estimated mass of unknown avian prey as 28.1 g, which was the average mass of over 300 House Sparrows (*Passer domesticus*) captured in the area as part of a nuisance bird abatement program (C. Boal unpubl. data). Mass of identified insect prey were estimated using previously published values from Strobel (2007) and Wiesenborn (2011). We estimated biomass delivery rates (g/hr) for all prey items delivered within a season and also for insects only. The change in average biomass delivered/hr throughout each breeding season for all prey items was estimated by pooling data into categories of nestling age by week. Age estimations were based on documented growth markers and stages of motor-skill development (Parker 1999, Welch 2011). We examined average biomass delivered/hr/wk separately for each year due to substantial differences in the total sum of biomass delivered to all nests in the two years.

To evaluate changes in the type of prey delivered, we estimated the average biomass of insect prey delivered/hr for both years. We also used contingency tables to examine patterns of prey species delivered to nests across the brood-rearing period of each year (Fowler et al. 1998). Although we attempted to assess differences in the type of prey delivered on a 7-d basis, we pooled deliveries from the first two weeks (i.e., ages 0–14 d) to meet test assumptions. Additionally, due to small samples, we pooled all prey except cicadas and dragonflies into an ''other'' category.

In addition, we estimated the diversity of all identified prey among nests with a modified Simpson's Index of Diversity (1/D; Williams 1964, MacArthur 1972). We estimated evenness of prey delivered to nests with Smith and Wilson's Index of Evenness (E_{var}; Smith and Wilson 1996) using Ecological Evenness Calculator Software (Smith 2015). We used an unpaired, two-sample *t*-test to assess differences in diversity and evenness of prey types delivered between years. To further analyze the type of prey delivered to nestling kites, we examined dietary overlap among nests with Horn's Modification of Morisita's Index of Similarity (C_H; Horn 1966).

We used an information-theoretic approach (Burnham and Anderson 2002) to assess the influences a set of descriptive variables had on the number of prey deliveries made during our 2-hr observational periods. Parameters used for modeling were nestling age (d), time of day (2-hr interval), temperature (°C), wind speed (m/sec), % relative humidity, barometric pressure (hPa), year, and day of year. The atmospheric conditions we included in models were based on factors that likely affect temporal abundances of insects (Paige 1995, Grüebler et al. 2008), and were averaged for each 2-hr observation. Some observations in 2011 extended beyond 2 hr; therefore, we included only the first 2-hr interval in the dataset used for modeling. Temperature, barometric pressure, age, day of year, and time of day were modeled as simple main effects. All parameters were included in a global AIC (Akaike Information Criterion) model and thirteen other models were created to test for combinations of effects. We determined the residual sum of squares (RSS) for each model. The second-order AIC corrected for small sample sizes (AIC_c), distance between each model and the proposed best model (Δ_i), and Akaike weight (w_i) were estimated from the obtained RSS using Microsoft Excel 2007 (Burnham and Anderson 2002).

RESULTS

We recorded 281 prey deliveries during 135 hr of direct observation at Mississippi Kite nests in 2010, and 108 prey deliveries during 134 hr of observation at nests in 2011 (Table 1). The prey delivery rate in 2010 ranged from 1.47 to 2.94 items/hr and varied significantly among nests ($H_4 = 10.20$, $P = 0.04$). In contrast, the prey delivery rate in 2011 was markedly lower, ranging from 0.63 to 1.08 items/hr, but variance among nests was not significant ($H_4 = 1.43$, $P = 0.84$). The mean prey delivery rate was significantly greater ($t_8 = 4.85$, $P = 0.001$) in 2010 (2.08 ± 0.25 items/hr) compared to 2011 (0.81 ± 0.8 items/hr). During observational periods when parental identity was confirmed for all deliveries made, females delivered 55.2% and males delivered 44.8% of prey items.

We identified 64% and 69% of the prey items delivered in 2010 and 2011, respectively (Table 2). Cicadas (Hemiptera) made up 40% and dragonflies (Odonata) composed 35% of identified prey delivered to nests. Beetles (Coleoptera; 14%), grasshoppers (Orthoptera; 5%), birds (Aves; 5%), and flies (Diptera; 2%) were the only other identified prey recorded (Table 2).

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Table 1. Prey delivery at urban Mississippi Kite nests in Lubbock, Texas, 2010 and 2011.

Year and Nest	Prey Deliveries	Hr of Observation[a]	Deliveries/Hr[b]	Deliveries by Female[c]		Deliveries by Male[c]		Deliveries by Unk[c]	1/D[d]	Even[e]	Richness[f]
	n			*n*	%	*n*	%	*n*			
2010											
110	55	27.1	2.03	29	55.8	23	44.2	3	2.67	0.55	4
210	80	27.2	2.94	46	63.9	26	36.1	8	2.72	0.38	5
310	60	27.3	2.2	27	45.0	33	55.0	0	2.99	0.67	4
410	40	27.1	1.47	16	57.1	12	42.9	12	2.46	0.82	3
510	46	26.6	1.73	24	54.5	20	45.5	2	3.08	0.53	4
2010 pooled	281	135.4	2.08 (0.25)[g]	142	55.3	114	44.7	25	2.78	0.59	4
2011											
511	23	26.9	0.86	8	34.8	15	65.2	0	2.27	0.55	3
611	18	26.7	0.67					18	2.63	0.91	3
711	17	26.8	0.63					17	4.48	0.9	5
811	21	26.8	0.79	15	75.0	5	25.0	1	2.98	1	3
1011	29	26.9	1.08					29	3.78	0.61	6
2011 pooled	108	134.1	0.81 (0.80)[g]	23	54.9	20	45.1	65	3.23	0.79	4
Total	389	134.1	1.44 (0.24)[g]	165	55.2	134	44.8	90	3.01	0.69	4

[a] Hours of direct observation at nest.
[b] Mean delivery rate from deliveries per hour (total number of prey deliveries observed (*n*) divided by total hours of observation).
[c] Deliveries recorded by females, males, or birds of unknown sex.
[d] Simpson's Reciprocal Index of Diversity.
[e] Smith and Wilson's Evenness Index.
[f] Number of identified prey categories.
[g] Mean (SE).

Table 2. Frequency of occurrence and biomass of prey delivered to Mississippi Kite nests in Lubbock, Texas, 2010 and 2011.

	Number of Prey Items						Estimated Total Biomass (g)		Biomass Contribution by Taxon (%)		Insect Biomass Only (%)	
	2010[a]		2011[a]		Total							
Prey Group	*n*	%[b]	*n*	%[b]	*n*	%[b]	2010	2011	2010	2011	2010	2011
Aves	1	0.6	12	16.0	13	5.1	77.4	928.2	21.2	90.3		
Coleoptera	24	13.3	12	16.0	36	14.1	24.0	12.0	6.6	1.2	8.4	12.0
Hemiptera	74	41.1	26	34.7	100	39.2	222.0	78.0	60.9	7.6	77.4	78.0
Odonata	69	38.3	20	26.7	89	34.9	27.6	8.0	7.6	0.8	9.6	8.0
Orthoptera	11	6.1	1	1.3	12	4.7	13.2	1.2	3.6	0.1	4.6	1.2
Diptera	1	0.6	4	5.3	5	2.0	0.2	0.8	0.1	0.1	0.1	0.8
Total identified	180	64.1[c]	75	69.4[c]	255	65.6[c]	364.4	1028.2	100.0	100.0	100.0	100.0
Total unidentified	101	35.9[d]	33	30.6[d]	134	34.4[d]						
Total	281		108		389							

[a] $n = 5$ nests each year.
[b] Percent of identified prey only.
[c] Percent of total prey deliveries that were identified to taxon.
[d] Percent of total prey deliveries that were not identifiable to taxon.

For 2010, we estimated 314.5 g (2.33 ± 0.42 g/hr) of identified prey were delivered to nestlings during our observation periods. In contrast, an estimated 436.9 g (3.26 ± 1.60 g/hr) were delivered to nests during observations in 2011. We attribute this 38.9% increase in biomass delivery rate, despite a 61.0% decrease in the prey delivery rate (by number), to a greater percentage of birds in the diet (Table 2). When considering only invertebrate prey, we found a 65.1% decrease in biomass delivery rate between 2010 (2.12 ± 0.48 g/hr) and 2011 (0.74 ± 0.11 g/hr). Among invertebrates, cicadas contributed the greatest biomass to nestling diets in both years, followed by dragonflies in 2010 and beetles in 2011 (Table 2). In both years, the prey delivery rate (Fig. 1) and biomass delivery rate (Fig. 2) increased after nestlings reached 7 d of age, but remained relatively consistent throughout the remainder of the nestling stage. We found no statistical difference in the species of prey delivered by Mississippi Kites across discrete periods of the brood-rearing period in 2010 ($\chi^2_6 = 3.736$, $P > 0.05$) or 2011 ($\chi^2_6 = 2.259$, $P > 0.05$).

Measures of diversity and equitability of all prey delivered to kite nests were low in both breeding seasons (Table 1). We found no significant difference ($t_8 = -1.07$, $P = 0.32$) in prey diversity between 2010 (1/D = 2.96) and 2011 (1/D = 4.07). Similarly, prey evenness did not vary significantly ($t_8 = -1.79$, $P = 0.11$) between 2010 ($E_{var} = 0.19$) and 2011 ($E_{var} = 0.44$), with a mean value of 0.69 (±SE 0.06, range = 0.38 to 1). Dietary overlap (C_H) for nests was high in 2010 (mean = 0.90), with values ranging from 0.76 to 0.98 (out of a range from 0–1), with four of the five nests observed overlapping >90%. In contrast, the diet of nestlings was broader in 2011 and dietary overlap ranged from 0.51 to 0.92 (mean = 0.70). The overall dietary overlap between 2010 and 2011 nests was 0.92.

When assessing variables associated with the prey delivery rate during 2-hr observations, we found two competitive models (Table 3). The strongest model included the parameters of year and nestling age, with a model weight of 74.2%. The competitive model had a ΔAIC_c of 2.19 from the top model, but a model weight of 24.8%; this model included the same parameters of the top model with the addition of time of day and temperature. Combined, these four parameters accounted for 99.0% of model weight (Table 3).

Discussion

The average prey delivery rate observed at Mississippi Kite nests in this study was lower than the estimated 3–5 prey items/hr in Illinois (Hardin et al. 1977, Evans 1981), and the 5.5 prey items/hr in Kansas (Fitch 1963). Our results are more similar to the 22.5–24.5 prey items/d revealed by 24-hr surveillance systems at nonurban Mississippi Kite nests in eastern Arkansas (Bader and Bednarz 2011).

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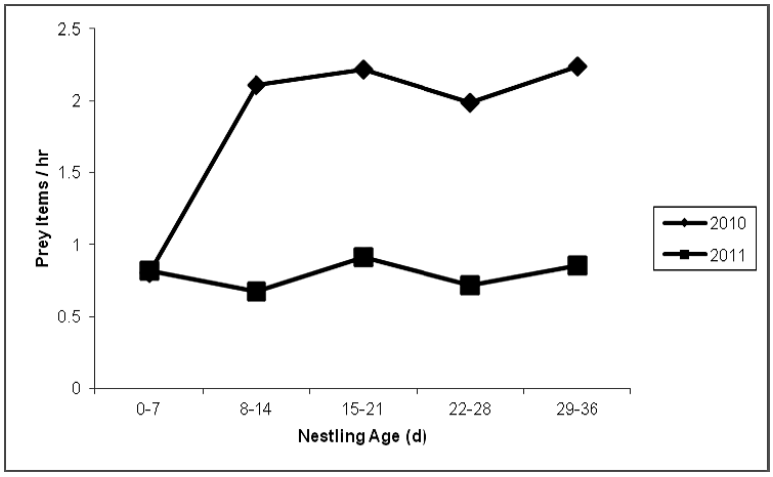


Figure 1. Average prey delivery rate by week at Mississippi Kite nests in Lubbock, Texas, 2010–2011.

However, the variation in estimated prey delivery rates may be influenced by the methods used and local prey availability.

Although we did not assess prey availability, it appears to have differed substantively between the years of our study. First, the prey delivery rate (by number) in 2011 was decreased 61% from that in 2010, suggesting reduced prey availability. Second, fledging dates in 2011 were 5–14 d later than the last fledged nest monitored in 2010 (Welch 2011). Studies on other aerial predators have found that females laid eggs earlier in the season during times of increased insect abundance (Nooker et al. 2005); similar results have been found in supplemental feeding experiments (Daan et al. 1986, Martin 1987). We believe a reduction in prey availability was the result of extreme drought and heat. During the 2011 Mississippi Kite breeding season, temperatures in the Lubbock area set new monthly ''all-time-high records,'' surpassing previous records by 1.4–1.7°C. Between June and September 2011, temperatures above 32.2°C were recorded for 100

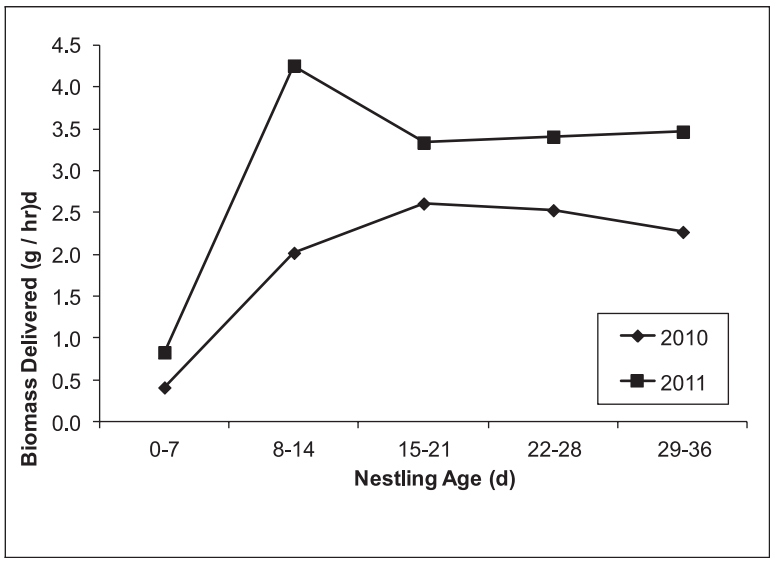


Figure 2. Average biomass delivery rate by week at Mississippi Kite nests in Lubbock, Texas, 2010–2011.

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Table 3. Akaike's Information Criterion ranked candidate models describing the prey delivery rates during 2-hr observational periods at urban Mississippi Kite nests in Lubbock, Texas, 2010–2011.

MODEL[a]	K[b]	AIC_c[c]	Δ_i[d]	ω_i[e]
YR + NLA	3	74.21	0.00	0.74
TEMP + NLA + TIME + YR	5	76.41	2.19	0.25
Global	9	85.09	10.88	0.00
TEMP + RH + NLA	4	86.95	12.74	0.00
TEMP + RH	3	87.78	13.57	0.00
BP	2	88.01	13.80	0.00
TEMP	2	88.11	13.90	0.00
TEMP + RH + BP	4	88.12	13.91	0.00
TEMP + NLA	3	89.25	15.04	0.00
DAY + TEMP	3	89.91	15.70	0.00
TEMP + WIND	3	90.06	15.85	0.00
NLA	2	90.16	15.94	0.00
DAY	2	90.29	16.08	0.00
TEMP + BP + NLA	4	90.48	16.27	0.00
TIME	2	91.05	16.84	0.00
TEMP + NLA + TIME	4	91.10	16.88	0.00
TEMP + WIND + NLA	4	91.17	16.95	0.00
NLA + TIME	3	92.23	18.02	0.00
DAY + TIME	3	92.37	18.16	0.00

[a] NLA = nestling age, TIME = time of day, TEMP = temperature, WIND = wind speed, RH = relative humidity, BP = barometric pressure, YR = year, DAY = day of year.
[b] Number of estimated parameters.
[c] Corrected AIC value for finite sample size.
[d] Distance between best model and $model_i$.
[e] Akaike weight.

consecutive d, with 48 d reaching temperatures over 37.8°C. Concurrent with this was the driest summer on record, with only 0.99 cm of rainfall. Ultimately, Lubbock and surrounding areas were considered under ''Exceptional Drought,'' which is the severest drought category of the Palmer Drought Index (National Oceanic and Atmospheric Administration 2014). Although not quantified in this study and validated, we suspect the lack of moisture had a substantial influence on invertebrate prey. Insects can be affected, directly or indirectly, by temperature, humidity, and rainfall (Negussie 2009). Extreme temperatures can cause mortality, affect maturation rates of insects, cause changes in activity rates, and affect host plant species that support insect populations (Negussie 2009). Moisture also has direct and indirect effects on insects, which may intensify when coupled with other climactic factors such as temperature (Negussie 2009). It is likely that this particularly extends to insects that develop in moist soils (e.g., cicadas) and aquatic environments (e.g., dragonflies). This may explain why, despite a reduced prey delivery rate and greater proportion of birds in the diet in 2011, presumably due to the drought, there was no significant difference between the proportions of cicadas and dragonflies delivered to kite nests across the brood-rearing periods in either year. This is, however, counter to reports of changes in the predominance of these two insect groups in kite diets across the breeding season in natural areas (Glinski and Ohmart 1983, Chiavacci et al. 2014).

We found that cicadas made up the majority of prey items delivered to nestlings, followed by dragonflies, which was consistent with previous studies (Evans 1981, Glinski and Ohmart 1983, Botelho et al. 1993, Parker 1999). Despite a markedly lower prey delivery rate (by number of prey items) in 2011, biomass delivery rate was substantively greater than the rate in 2010. We believe the presumed low density of insects in 2011 resulted in prey switching and increased use of avian prey by kites. Steenhof and Kochert (1988) and others suggested that prey switching in raptors occurs not as a function of the most abundant prey type, but rather due to decreased abundance of preferred prey. Thus, we suggest prey switching to birds resulted in an

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increase in biomass provided to nestling kites in 2011. An increase in biomass delivery rate, however, may not necessarily equate to increased productivity or condition of young. Health and growth of nestlings is likely dependent upon a relatively constant input of adequate nutrition. For example, to maximize their health and growth, captive-reared nestling raptors are fed 4 to 5 times daily (Fox 1995, Krijgsveld et al. 1998, Jenny et al. 2004). Although there was a 38.9% increase in biomass delivery rate in our study in 2011, prey delivery rate by number decreased by 156%; thus, some Mississippi Kite nestlings may have received the occasional ''large'' meal in 2011, but not a satisfactory amount of regularly delivered daily nutrition to facilitate growth and development.

Though several pieces of evidence suggest decreased invertebrate prey abundance between years, we did not have data on local prey abundances to include in our modeling of variables that influence the prey delivery rate. However, we did find a strong year effect and nestling age, temperature, and time of day also appear to influence the prey delivery rate. We suspect this may be due to the increasing energetic demands as nestlings grow combined with temporal patterns of activity of aerial invertebrate prey. Regardless, studies on food habits are essential for identification of factors permitting some species, such as kites, to thrive in urban areas while others do not.

Mississippi Kites commonly forage beyond the view of the observer; thus, estimating parental effort based on prey delivery rates requires the assumption that the delivering parent was also the individual that captured the prey. Some raptor species, such as Marsh Harriers (*Circus aeruginosus*), are known to make aerial prey transfers (Johannesson 1975, Fernández and Azkona 1993), and many other species make perched transfers of prey. Although similar behavior has not been reported among Mississippi Kites, it is possible some prey deliveries were the result of a prey exchange occurring outside of the nesting area and unknown to the observer. Given this caveat, our finding that females delivered 55.2% of prey is a departure from the usual pattern of male raptors capturing and delivering the majority of prey to the nest and females primarily providing nestling care and protection (Newton 1979). Shaw (1985) observed similar patterns to ours, but Glinski and Ohmart (1983), Airth-Kindree (1988), and Bader and Bednarz (2011) found male Mississippi Kites delivered more prey items than females, even if not statistically significant.

Our study and others' suggest that sex-specific differences in prey delivery rates by parental Mississippi Kites are slight or nonexistent. We suspect this may be the result of the body size and food habits of the species. Reversed sexual-size dimorphism in raptors may allow greater diversity in prey use, as smaller males are more energy-efficient foragers (Massemin et al. 2000) and larger females are more capable of nest defense and capturing larger prey (Storer 1966). In contrast to most North American raptors, however, Mississippi Kites are minimally dimorphic (Skipper 2013) and primarily insectivorous (Welch 2011); thus, they may experience limited value in partitioning foraging effort or nest defense compared to other raptors. Additionally, foraging by both members of the breeding pair may be a necessity in order to capture sufficient numbers of small prey to successfully rear a nestling.

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