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Breeding season diet of the Red-shouldered Hawk (*Buteo lineatus extimus*) in southern Florida

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ABSTRACT—The diet of the Red-shouldered Hawk (*Buteo lineatus*) has been described in at least 12 states. The diet of this species has not yet been described in Florida, although this state contains an endemic subspecies (*B. l. extimus*) first described more than 100 years ago. This study characterizes the prey items Red-shouldered Hawks provided to their nestlings in southern Florida using nest cameras at 2 nests in spring 2018 and 4 nests in spring 2019. Seventy-two percent of 1,024 recorded prey deliveries were identifiable to class. Reptiles and amphibians were the most frequently consumed prey classes, as expected, given that Red-shouldered Hawks were previously found to consume more mammals in their northern range and more amphibians and reptiles in their southern range. The diet breadth was lowest at the most urban nest in this study. Each pair successfully fledged all nestlings present when the cameras were installed, although they provided a wide variety of prey amounts and types. *Received 3 December 2021. Accepted 24 December 2022.*

Key words: diet breadth, habitat analysis, nest camera, nonnative prey, urban gradient.

Dieta de temporada reproductiva del gavilán *Buteo lineatus extimus* en el sudeste de Florida

RESUMEN (Spanish)—La dieta del gavilán *Buteo lineatus* ha sido descrita en al menos 12 estados. La dieta de esta especie no ha sido aún descrita en Florida, aunque en el estado se ha registrado una subespecie endémica (*Buteo lineatus extimus*) descrita por primera vez hace más de 100 años. Este estudio caracteriza las presas que los gavilanes *Buteo lineatus* usaban para alimentar a sus polluelos en el sudeste de Florida usando cámaras en 2 nidos en la primavera del 2018 y en 4 nidos en la primavera del 2019. Setenta y dos por ciento de las 1024 presas llevadas registradas fueron identificadas a clase. Reptiles y anfibios eran las clases de presas más frecuentemente consumidas, como era esperado, ya que los gavilanes *Buteo lineatus* consumen más mamíferos en la parte norteña de su distribución y más anfibios y reptiles en la parte sureña. La amplitud de dieta era menor en la mayoría de nidos urbanos en este estudio. Cada pareja tuvo éxito en emancipar a los polluelos que fueron grabados, aunque les dieron presas que variaron ampliamente en tipo y cantidad.

Palabras clave: amplitud de dieta, análisis de hábitat, cámaras en el nido, gradiente urbano, presas no nativas.

The Red-shouldered Hawk (*Buteo lineatus*) is a medium-sized hawk that occurs throughout riparian forests and wetlands across North America (Hull et al. 2008, Dykstra et al. 2018). Five subspecies are currently recognized, including *B. l. alleni* in the southeastern United States and *B. l. extimus* in southern Florida (Hull et al. 2008). In Florida, the Red-shouldered Hawk is one of the most abundant and widely distributed hawk species (Nicholson 1930, Ogden 1974). The endemic Florida subspecies (*B. l. extimus*) was first described over 100 years ago (Bangs 1920), yet little natural history information on this subspecies has been published since that time. Anecdotal reports suggest a number of differences between *B. l. extimus* and its conspecifics elsewhere such as a lower clutch size (Stewart 1949), smaller body size (Dykstra et al. 2020), and earlier laying dates (Dykstra et al. 2020).

Diet studies provide foundational natural history information for predator species like raptors (Lewis et al. 2004). The diet of Red-shouldered Hawks has been examined in at least 12 states (Strobel and Boal 2010). Generally, Red-shouldered Hawks use open areas, marshes, and wetlands for hunting (Morrison et al. 2007). Red-shouldered Hawks in northern latitudes consume mostly mammals while Red-shouldered Hawks in southern states consume mostly amphibians (Strobel and Boal 2010). This may be due to the broad differences in habitat selection by Red-shouldered Hawks in the 2 regions. In most of eastern North America, Red-shouldered Hawk habitat is dominated by large areas of mature forests whereas in Florida, Red-shouldered Hawk habitat has been described as primarily grassland and wetland with less than 10% forest cover (Dykstra et al. 2018).

South Florida's fast-growing cities are converting wetlands to urbanized land uses at a rapid pace (Nijman and Clery 2015). If conservation measures are required for this subspecies in the future, they would likely benefit from baseline natural

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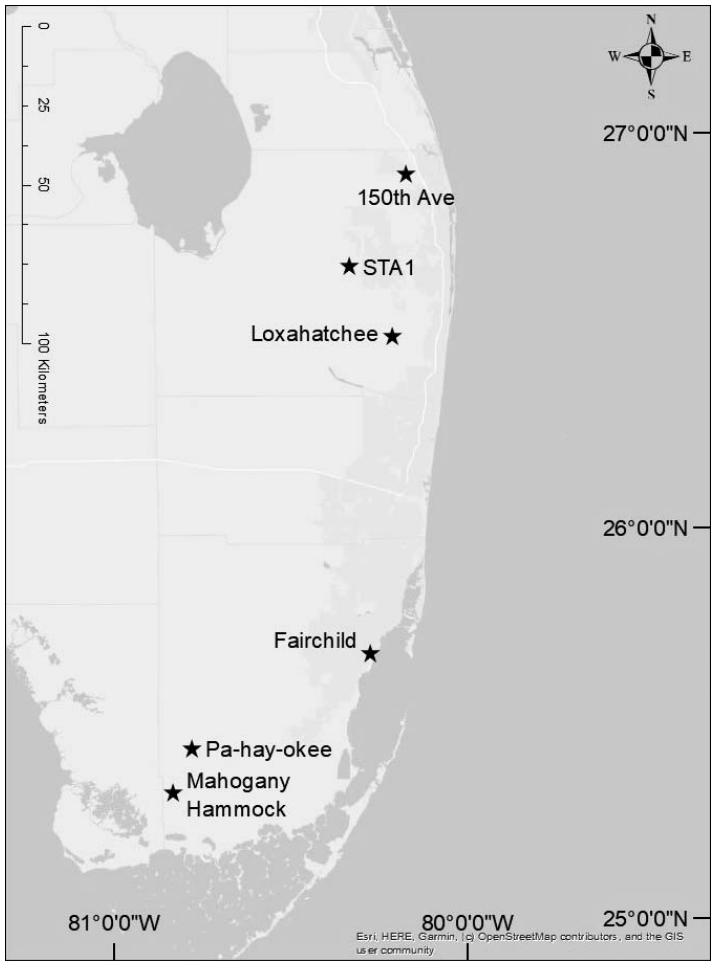

Figure 1. Southern Florida and localities for the study of breeding season diet of the Red-shouldered Hawk.

history information collected from this population. Given the many documented differences between *B. l. extimus* and its conspecifics outside of Florida, it may be inappropriate to assume its feeding habits are equivalent to Red-shouldered Hawks in other states. Therefore, my study set out to gather the first diet data of Red-shouldered Hawks nesting in southern Florida.

Methods

I investigated the diet of nesting Red-shouldered Hawks at sites in Miami-Dade and Palm Beach counties, Florida, in April and May 2018 and in March–May 2019 (Fig. 1). North–south boundary lines split each county nearly in half with state- and federally protected Everglades wetlands to the west and urban areas to the east (Nijman and Clery 2015). The human population in these 3 counties has quintupled to over 5 million people since the 1960s, with urban development expanding westward, in some places directly bordering protected lands (Nijman and Clery 2015).

Red-shouldered Hawk nests were found by playing conspecific calls in areas known to have Red-shouldered Hawk activity according to eBird (2020) and from direct reports to the author. If adult hawks responded to playbacks, their behavior was monitored until the hawks returned to their nest site. Nests were found on federal, state, county, and private land.

Table 1. Summary data for Red-shouldered Hawk nests monitored in southern Florida, 2018–2019. Dates recorded are followed in parentheses by the total number of days in that period. Age represents the approximate age of nestlings at the start of recording. Total prey deliveries (PDs) represent all prey deliveries recorded. The land-cover categorizations within 500 m of each nest may not add up to 100% due to rounding.

	Nest					
Data	150th Ave.	Fairchild	Loxahatchee	Mahogany Hammock	Pa-hay-okee	STA 1
Dates recorded (d)	11–28 Apr 2019 (18)	30 Apr–28 May 2019 (29)	12 Apr–3 May 2018 (22)	11–26 Mar 2019 (16)	13 Apr–15 May 2018 (33)	28 Mar–19 Apr 2019 (23)
Brood size	2	2	2	3	2	1
Age of nestlings at start	4 weeks	2 weeks	3 weeks	4 weeks	2 weeks	3 weeks
Total prey deliveries (PDs)	223	265	260	88	90	98
Dense wetland (%)	0	0	4	9	28	41
Sparse wetland (%)	22	0	41	56	58	25
Grass (%)	20	7	26	0	0	1
Trees (%)	45	65	21	34	13	0
Impervious surface (%)	9	18	5	1	1	1
Water (%)	5	9	3	0	0	31

As part of a larger study (Marain 2020), habitat maps quantifying 6 land-cover types within 500 m of each nest were developed. The 6 land-cover categories mapped were (1) dense wetland (i.e., dense cattail, wetland shrubbery, or floating vegetation), where the hawks are unlikely to hunt but these areas likely still provide habitat for prey; (2) sparse wetland, where the hawks hunt; (3) grass, also likely used for hunting; (4) trees, which provide nesting places; (5) impervious surface (including buildings, roads, gravel levees, and sand); and (6) deep water. A brief summary of the land-cover surrounding each nest in this study is provided for context (Table 1).

We installed waterproof 24 h color/infrared video security cameras (product no. PC177IRHR-8, Supercircuits, Austin, Texas, USA) at suitable nest sites where permission was granted by the landowner or land manager. As part of a larger study (Marain 2020), 82 breeding attempts were documented at 41 nest sites over 3 years. Twenty-seven percent of the nests found during this study were constructed in palm trees, which were considered unsuitable for camera deployment. An additional 13% of nests were located in swamp habitats where water levels fluctuated widely over the course of the breeding season. We did not install nest cameras at these sites because we could not guarantee that the recording station on the ground would remain dry. When I found suitable nests, I requested permission to install nest cameras, which was denied by both public and private landowners for at least 6 potential sites. Ultimately, only 6 sites had the appropriate tree type, ground cover, and landowner permissions to install nest cameras.

Cameras were installed either by tree climbers or by a biologist using a mechanical lift to approach the nest. Each camera was mounted ~0.6 m above the nest and the camera view was checked with a handheld video monitor (model HLT 71, Haier, Camden, South Carolina, USA). Each camera was covered with camouflage-patterned tape to reduce its conspicuousness to the birds. The cameras were connected by an 18 m cable to a mini digital video recorder (model AKR-200, Seorim Technology Co., Ltd., Seoul, South Korea) situated in a waterproof tub at the base of the tree. Also inside the tub was a 12-volt deep-cycle marine battery that powered the system. It included a programmable timer (CN101 DC 12V 16A Digital LCD Power Programmable Timer Time Switch Relay, FAVOLCANO, Fort Lee, New Jersey, USA) to limit recording to 14 h per day, beginning 1 h before sunrise and ending 1 h after sunset. Video was recorded at a rate of 10 frames per second with a 704 × 480 resolution. Batteries and SD cards were replaced every 3 d.

Cameras were installed after eggs had hatched, when the chicks were approximately 2–4 weeks of age (Table 1). Ages were estimated based on visual observations of chick development. Nestlings were

lowered to assistants on the ground during camera installation, which took 15–90 min depending on the site and ascension method. Recording began immediately after camera deployment and ended once nestlings began to move out of the nest to adjacent branches. Cameras were removed at least 1 month after the cessation of recording to ensure the nest was no longer in use.

I reviewed all video to identify prey brought to the nest. Prey items were identified to class because video quality was insufficient for lower taxonomic classification in most cases. Identifications below the class level were noted when possible. Biomass, a measure typical of raptor diet studies, was not estimated in this study because species identifications could not be determined for most prey deliveries. Summary statistics describe the overall diet at the studied nests for the reader's convenience but should not be taken as representative of the Red-shouldered Hawk diet in southern Florida due to the low sample size and nonrandom sampling method. Levins' index ($B = 1/\Sigma p_i^2$, where p is the proportion of each identifiable prey class in the diet), was calculated as a measure of diet breadth at each nest (Levins 1968). A higher Levins' index indicates a more diverse diet.

Results

I monitored prey deliveries at 6 Red-shouldered Hawk nests for periods ranging from 16 to 29 d (Table 1). Video recording occurred at 2 nests in 2018 and at 4 nests in 2019. Three of the 6 nests were located in federally protected parks, 1 (STA1) in state protected wetlands, 1 (150th Avenue) in a suburban yard that bordered county-protected wetlands, and 1 in a large private botanical garden in a suburban area (Fairchild). These nests varied widely in their surrounding land-cover. Range of available nesting habitat (trees) was 0–65%, range of preferred hunting habitat (sparse wetland and grass) was 7–67%, and range of habitat not directly used by the hawks (water, dense wetland, and impervious surface) was 10–73% (Table 1). All nestlings present at the beginning of recording were raised to fledging.

In total, 1,568 h of video captured 1,024 prey deliveries across all nests; 71.5% of prey deliveries were identifiable to class. Unidentifiable items were often consumed very quickly (55% of unidentified items were consumed in 15 s or less), providing limited opportunity for identification. Identifiable prey items came from 7 classes: 58% Reptilia, 18% Amphibia, 10% Mammalia, 9% Aves, 3% Actinopterygii, 2% Malacostraca, and <1% Insecta. The lowest taxonomic category identified within each class are as follows: Actinopterygii, walking catfish (*Clarias batrachus*); Amphibia, unidentified frogs; Aves, Common Gallinule (*Gallinula galeata*), Common Yellowthroat (*Geothlypis trichas*), Eastern Screech-Owl (*Megascops asio*), House Sparrow (*Passer domesticus*), unidentified passerines and herons; Insecta, unidentified grasshoppers; Malacostraca, unidentified crayfish; Mammalia, juvenile eastern gray squirrel (*Sciurus carolinensis*), unidentified rodents and rabbits; Reptilia, juvenile American alligator (*Alligator mississippiensis*), Cuban knight anole (*Anolis equestris*), green anole (*Anolis carolinensis*), green iguana (*Iguana iguana*), unidentified lizards, snakes, and turtles. Not all classes of prey were consumed at every nest (Table 2). Reptiles and amphibians were the only prey classes consumed at all 6 nests in this study and constituted 76% of identifiable prey items.

Fairchild was the only nest in the study fully surrounded by urban development. It had the lowest percentage of preferred hunting habitat surrounding the nest (7%) and the lowest measured diet breadth of the 6 nests (Table 2). At this nest, reptiles were the main prey item (175 of 265 total prey items) and green iguanas, an invasive species, made up 44% of the reptiles. Loxahatchee and STA 1 had the highest Levins' index. Loxahatchee had the highest proportion of preferred hunting habitat surrounding the nest (67%) and STA 1 had the highest proportion of dense wetland, which likely provided habitat for the hawks' prey species.

Discussion

A previous study found that Red-shouldered Hawks eat more mammals in the northern part of their distribution and more amphibians and reptiles in the southern part of their distribution (Strobel and Boal 2010). The 6 Red-shouldered Hawk pairs included in this study generally conformed to this pattern, although the low sample size and opportunistic sampling method meant this prelim-

Table 2. Red-shouldered Hawk prey in southern Florida. Number of individuals of each prey class consumed at each nest and the Levins' index of diet breadth for each nest.

	Nest sites					
Prey type	150th Ave.	Fairchild	Loxahatchee	Mahogany Hammock	Pa-hay-okee	STA 1
Actinopterygii	2	–	2	4	15	–
Amphibia	30	8	71	12	7	3
Aves	–	6	18	–	2	40
Insecta	3	–	–	–	–	–
Malacostraca	–	–	–	7	4	–
Mammalia	13	17	20	4	2	20
Reptilia	54	175	78	47	43	28
Unidentifiable	121	59	71	17	17	7
Levins' index	2.60	1.36	3.01	2.25	2.48	2.96

inary study provides only limited information on breeding season diets of Red-shouldered Hawks in southern Florida. Overall, the Florida birds studied here consumed reptiles most frequently (58%) and amphibians secondarily (18%), which is most similar to Red-shouldered Hawks in Texas (31% reptiles, 8% amphibians; Strobel and Boal 2010). However, the prey composition at each nest within this study varied, although 4 pairs fed reptiles most often, 1 pair fed small, unidentifiable prey items most often, and another fed birds most often (Table 2). The diets also varied in their specificity as demonstrated by the range of Levins' indexes.

The nest located in the most urban setting in this study had the lowest diet breadth of the 6 studied. Iguanas are one of the most visible animal species at this location, with a very dense breeding population (pers. obs.). Some studies of other urban raptors have also found a similar narrowing of the prey base at urban nests, e.g., a reliance on Rock Pigeons (*Columba livia*) by urban Cooper's Hawks (*Accipiter cooperii*) in Arizona (Estes and Mannan 2003) and nonnative rodents for Barn Owls (*Tyto alba*) in Argentina (Teta et al. 2012).

Multiple meta-analyses have connected a raptor species' adaptability to urban environments with their diet (Kettel et al. 2017), and more specifically with their diet breadth (Boal 2018). Strobel and Boal (2010) credit the dietary flexibility of Red-shouldered Hawks for their broad distribution across the continent. My study supports the findings of Strobel and Boal (2010) by adding the first data from Florida to the literature on the breeding season diet of Red-shouldered Hawks. This study also likely documented new prey species, both native and nonnative, for Red-shouldered Hawks (juvenile American alligators, green iguanas, Cuban knight anoles) and is the first diet study of this species to examine urban and exurban nests simultaneously (Dykstra et al. 2018).

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