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Habitat Selection by *Anolis carolinensis* (Green Anole) in Open Pine Forests in Eastern Texas

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Abstract - We initiated a mark-recapture study to determine the effects of shrub density on *Anolis carolinensis* (Green Anole) populations. Green Anole perch site, shrub species, and shrub volume preferences were also examined. We established two study plots of different shrub densities in open pine forests on the Angelina National Forest in eastern Texas. In late spring, the Green Anole population at the higher shrub-density plot was estimated to be 16 times greater than the population at the lower shrub-density plot. Green Anoles most commonly perched on live shrubs, but exhibited very little preference or avoidance of any particular species of live shrub or shrub-level vine. However, shrubs used by Green Anoles were 4–6 times greater in volume than plot averages.

Introduction

Anolis carolinensis Voigt (Green Anole) is an abundant arboreal lizard with a wide distribution in the southeastern United States (Conant and Collins 1998). It is preyed upon by numerous taxa within its range, especially during warmer months when it is most active (Arndt 1995, Corey 1988, Kennedy 1964, Yosef and Grubb 1993). We were particularly interested in the importance of Green Anoles in the diet of *Falco sparverius paulus* (Howe and King) (Southeastern American Kestrel), a subspecies of conservation concern. Thus, this study was closely associated with ongoing research where the Green Anole has proven to be the single most common prey item delivered to nestling Southeastern American Kestrels in eastern Texas (R.R. Schaefer, unpubl. data). Breeding Southeastern American Kestrels in Florida were also reported to feed heavily on anoles and other lizards (Bohall-Wood and Collopy 1987, Smallwood and Bird 2002).

Green Anoles and Southeastern American Kestrels occur together in relatively open pine communities in the southeastern United States. Historically, periodic wildfire was the principal disturbance mechanism that maintained the open character of these pine communities. Strictly controlled prescribed fire has now largely replaced wildfire throughout much of the southeastern United States. Varying densities of shrub growth develop following these fires as plants resprout. The density of shrubs at a given site is dependent

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on soils, moisture, and fire frequency and intensity, among other factors (Gilliam et al. 1993, Glitzenstein et al. 1995). Green Anoles prefer dense shrubbery in more open areas (Dundee and Rossman 1989). Open pine communities with a greater shrub density may harbor a greater abundance of anoles and provide higher quality foraging habitat for kestrels during seasons when anoles are most active.

Numerous studies of *Anolis* lizards, especially Caribbean species, have sought answers to both interspecific and intraspecific habitat-related questions (Irschick et al. 2005, Jenssen 1973, Rodríguez-Robles et al. 2005, Schoener 1975), but to our knowledge, none have addressed the relationship between shrub density and population size. We estimated the Green Anole population size and characterized habitat use at two upland pine sites in eastern Texas. We suspected that greater shrub density would correspond with higher anole populations by providing more perch sites, increased food resources, and greater concealment from predators. We were primarily interested in relationships between shrub density and Green Anole population size, but we also examined anole perch site, shrub species, and shrub volume preferences.

Field-site Description

We established two 0.5-ha study plots, separated by a distance of approximately 2.7 km, on the southern Angelina National Forest in eastern Texas. Because of our interest in the predator-prey relationship between Southeastern American Kestrels and Green Anoles, we selected plots within known kestrel foraging areas. Plots were located within open pine forests dominated by the fire-adapted *Pinus palustris* P. Mill. (Longleaf Pine), and receive periodic prescribed fires by forest managers. One plot contained a higher density of shrub-level vegetation (shrubs and shrub-level vines) and the other had a much lower density. Hereafter, they will be referred to as the "high-density plot" and the "low-density plot." Prior to study initiation in May 2004, the most recent prescribed fire occurred on 31 January 2001 at the high-density plot and on 1 February 2001 at the low-density plot. Shrub-level vegetation at the high-density plot was not contiguous and was irregularly dispersed throughout the plot.

Controlled fires maintained an open character by impeding the encroachment of woody shrub and mid-story vegetation of non-Longleaf Pine species (Platt et al. 1988, Provencher et al. 2001). A portion of the mid-story vegetation survived these fires, depending on the species as well as timing and intensity of the fire (R.R. Schaefer, pers. observ.). However, most shrub species were killed back to ground level since they are much smaller in diameter and more vulnerable to even low intensity fires, resulting in the resprouting of an even-aged layer of woody, shrub-level vegetation (R.R. Schaefer, pers. observ.). Soil and moisture further influenced the density and species composition of woody vegetation (Gilliam et al. 1993). Ground-cover vegetation was more prevalent in areas where fewer shrub and mid-story plants allowed sunlight to penetrate to ground level (Masters et al. 1996). Greater shrub and mid-story densities, especially hardwoods, resulted in more area of bare ground and leaf litter.

Methods

During mid-summer of 2004, we conducted a complete census of all shrub, mid-story, and canopy plants within each plot. Woody vegetation was categorized based on height: ground level (<0.5 m), shrub (≥0.5 m and <3 m), mid-story (≥3 m and below the canopy), and canopy. We used a 1-m pole marked with 0.1-m increments to measure the height (m) and width (m) of each live, woody shrub-level plant (shrubs and vines) within each plot and calculated the percent of total shrub volume (height x width^2) occupied by each shrub-level species. A clinometer was used to measure the height (m) of each mid-story tree, and calipers were used to obtain diameter at breast height (DBH; cm) for each mid-story and canopy tree. We divided each plot into four equal subplots. At the center point of each subplot, we measured canopy height (m) with a clinometer; estimated percent ground cover of woody vegetation, herbaceous vegetation, and bare ground/leaf litter; and used a one-factor metric basal area prism to measure basal area (m^2/ha) of pine canopy, hardwood canopy, pine mid-story, and hardwood mid-story.

All Green Anole data were collected during late spring/early summer (11 May–2 July) and late summer (1–13 Sept.) of 2004. Hereafter, these time frames will be referred to as "late spring" and "late summer." Mark-recapture data were obtained during late spring (11–27 May) and late summer (1–13 Sept.) at the high-density plot, and during the late spring (25 May–4 June) at the low-density plot. There were 5 mark-recapture sampling events in the high-density plot during both late spring and late summer, and 3 sampling events in the low-density plot during late spring. Two to four observers conducted a search for Green Anoles within the entire plot, from ground level up to mid-story level, during each sampling event. The upper portion of canopy trees was not included in the searches since we could not adequately locate anoles at that height, but the lower portion of canopy tree boles (<5.0 m above ground) was searched. Green Anoles were captured by hand and ventrally marked in numerical order using a nontoxic permanent marker. Those escaping capture were recorded as such. We measured snout-to-vent length (svl) to the nearest 1.0 mm on all captured anoles. Those measuring ≥40 mm were considered adult, and those <40 mm were considered juvenile (Jenssen et al. 1998). Individuals escaping capture were visually determined to be adult or juvenile. Sex was not consistently recorded since it was not relevant to our study objectives. However, we did record the sex of very obvious individuals (e.g., large, displaying males). We recorded Green Anole perch height (m) where first sighted, perch site, and perch-site plant species for each individual observed, including those that escaped capture. We noted 14 different perch sites (Table 1). We used paired *t*-tests (paired by plot and date) to compare adult and juvenile perch heights, and included only those dates when both age categories were observed. We also recorded the height (m), width (m), and subsequently calculated the volume (m^3) of all live, shrub-level plants on which Green Anoles were observed.

We assumed mark-recapture data were collected over short enough time spans within each season (17 and 13 days during late spring and late summer, respectively, at the high-density plot; 11 days during late spring at the low-density plot) that the effects of migration, mortality, and recruitment at each plot were negligible. Thus, we assumed plot populations of Green Anoles were closed (Seber 1986, 2001). We used the program CAPTURE (Otis et al. 1978) to select the appropriate capture model and estimate population size within each plot. Search time for a given day varied, and all searches were conducted between 1015 and 1616 within cloud cover (0–100%) and temperature (23.5–33.0 °C) ranges conducive to Green Anole activity. Temperature was more important than cloud cover in influencing anole activity. We experienced good success in locating anoles when the percent cloud cover was high as long as temperatures were at least within the range given above.

We determined Green Anole preference and avoidance of various shrub-level species by calculating the selection index and confidence limits for Manly et al.'s (1993) Design II, and conducting a complete census of avail-

Table 1. Perch sites used by *Anolis carolinensis* (Green Anole) at two study plots in eastern Texas.

	High shrub density plot		Low shrub density plot[A]
Perch site	Late spring % (# observations)	Late summer % (# observations)	Late spring % (# observations)
Shrub vegetation[B]			
Live shrub	61.8 (115)	67.3 (70)	60.0 (21)
Dead shrub	1.6 (3)	2.9 (3)	2.9 (1)
Live within dead shrub[C]	2.2 (4)	4.8 (5)	0.0 (0)
Woody vine at shrub level	3.8 (7)	6.7 (7)	28.6 (10)
Debris lodged in live shrub	1.1 (2)	1.0 (1)	0.0 (0)
Mid-story vegetation[D]			
Pine midstory	0.5 (1)	0.0 (0)	0.0 (0)
Hardwood midstory	16.1 (30)	3.9 (4)	2.9 (1)
Woody vine at midstory level	0.0 (0)	1.9 (2)	0.0 (0)
Canopy pine trunk	2.2 (4)	2.9 (3)	0.0 (0)
Live woody ground vegetation[E]	1.1 (2)	4.8 (5)	0.0 (0)
Bracken Fern[F]	1.1 (2)	0.0 (0)	0.0 (0)
Tree stump	1.1 (2)	1.9 (2)	2.9 (1)
Log/limb on ground	5.4 (10)	1.0 (1)	2.9 (1)
Bare ground/leaf litter	2.2 (4)	1.0 (1)	0.0 (0)
Total observations	100.0 (186)	100.0 (104)	100.0 (35)

[A]No data for late summer.
[B]Shrubs = ≥0.5 m and <3.0 m in height.
[C]Resprouting shrub following a prescribed fire, with the live portion at shrub level and the fire-killed portion still standing.
[D]Midstory = ≥3.0 m in height and below canopy.
[E]Ground = <0.5 m in height.
[F]*Pteridium aquilinum* (L.) Kuhn (Bracken Fern).

able resources. In this case, "available resources" refers to volume of all live shrub-level plant species. In these analyses, if the 95% confidence interval around the selection index includes 1.00, the species was considered neutral (i.e., neither preferred nor avoided). If the upper confidence limit was less than 1.00, the species was considered avoided. If the lower confidence limit was greater than 1.00, the species was considered preferred. However, those species with an upper or lower confidence limit between 0.90 and 1.10 were considered "borderline avoided" or "borderline preferred," respectively. Green Anoles escaping capture and marking were omitted here since individuals must be identifiable for these calculations.

We calculated the mean width, height, and volume of all available shrub-level woody plants in each plot. We compared the means to similar values calculated for those plants harboring Green Anoles in an effort to identify shrub-structure preferences. Because all woody vegetation was measured (not sampled) in each plot, statistical comparisons were unnecessary.

Results

Canopy height was similar between plots, but the high-density plot contained 1.5 times more pine canopy trees than the low-density plot (Table 2). There were 66 hardwood mid-story trees in the high-density plot versus only

Table 2. Forest habitat measurements at two *Anolis carolinensis* (Green Anole) mark-recapture study plots in eastern Texas.

Habitat variable	High shrub-density	Low shrub-density
Canopy height (m)[A]	24.6	25.1
Pine canopy basal area (m^2/ha)[A]	22.0	15.6
Total pine canopy trees	81	52
Pine canopy diameter at breast height (cm)[B]	41.0	40.5
Pine mid-story basal area (m^2/ha)[AC]	2.5	1.8
Total pine mid-story trees[C]	32	37
Pine mid-story diameter at breast height (cm)[BC]	11.7	15.8
Pine mid-story height (m)[BC]	12.0	15.9
Hardwood canopy basal area (m^2/ha)[A]	0.3	0.0
Total hardwood canopy trees	1	0
Hardwood canopy diameter at breast height (cm)[B]	42.5	0.0
Hardwood mid-story basal area (m^2/ha)[AC]	2.9	0.0
Total hardwood mid-story trees[C]	66	1
Hardwood mid-story diameter at breast height (cm)[BC]	14.9	30.5
Hardwood mid-story height (m)[BC]	9.2	11.4
Total shrubs and shrub-level vines[D]	1517	598
Woody ground cover (%)[AE]	13.7	42.5
Herbaceous ground cover (%)[AE]	16.3	30.0
Bare ground/leaf litter (%)[AE]	70.0	27.5

[A]The mean for this variable was derived from measurements taken at 4 subplots within each shrub plot.
[B]The mean for this variable was calculated using the total number of plants within each shrub plot.
[C]Midstory = vegetation ≥3.0 m in height and below canopy.
[D]Shrub = vegetation ≥0.5 m and <3.0 m in height.
[E]Ground = vegetation <0.5 m in height.

1 in the low-density plot. The number of pine mid-story trees was slightly greater in the low-density plot (37 versus 32). Canopy hardwoods were nonexistent in the low-density plot, and only one occurred in the high-density plot. The total number of live shrubs and shrub-level woody vines was more than 2.5 times greater in the high-density plot than in the low-density plot. Both woody and herbaceous ground covers were better developed in the low-density plot, perhaps due to the near absence of hardwood mid-story. Bare ground/leaf litter cover was 2.5 times greater in the high-density plot where hardwood mid-story was much more common.

Totals of 37 and 15 woody shrub-level species were found in the high-density and low-density plots, respectively, indicating greater species richness in the former (Table 3). A species' abundance did not necessarily correlate with the percent of volume occupied by that species within a plot. For example, *Sassafras albidum* (Sassafras) made up 16% (242 plants) of total shrubs in the high-density plot, making it the most abundant species there. However, it accounted for only 2.6% of the total shrub volume in that plot. Conversely, *Callicarpa americana* (American Beautyberry) made up 3.8% (58 plants) of all shrubs in the high-density plot, yet accounted for 14.5% of the total shrub volume. Similarly, *Rhus copallina* (Shining Sumac) made up 45.3% (271 plants) of total shrubs in the low-density plot, but accounted for only 15.5% of the total shrub volume. *Vitis aestivalis* (Summer Grape) made up only 6.9% (41 plants) of total shrubs in the low-density plot, but accounted for 24% of the total shrub volume.

Green Anole abundance was much greater at the plot with a higher density of shrubs (Table 4). During mark-recapture sampling events, 87 and 74 individuals were marked at the high-density plot during late spring and late summer, respectively. Eight were marked at the low-density plot during late spring. The program CAPTURE selected model M_t (capture probabilities vary with time) to derive a Green Anole population estimate of 211 at the high-density plot during late spring. The model M_o (capture probabilities are constant) was selected for calculations of Green Anole populations of 160 at the high-density plot during late summer and 13 at the low-density plot during late spring.

Green Anoles were observed on live shrubs much more often than any other perch site in both plots during late spring and in the high-density plot during late summer (Table 1). No late summer data are available for the low-density plot. Green Anoles at the high-density plot were found on live shrubs 61.8% (n = 115) of the time followed by hardwood mid-story at 16.1% (n = 30). Adult males, often displaying, accounted for 56.7% (n = 17) of anole observations on hardwood mid-story trees. Eight juveniles accounted for only 7% of all marked individuals at the high-density plot during late spring. Green Anole age distribution shifted dramatically by late summer at the high-density plot, where juveniles accounted for 71.6% (n = 53) of marked individuals. Live shrubs remained the most frequently observed perch site at 67.3% (n = 70), followed by woody vines at shrub-level at 6.7% (n = 7).

Observations on hardwood mid-story vegetation were reduced to 3.9% ($n = 4$) of the total. Only adults ($n = 10$) were captured at the low-density plot prior to 28 June. Juveniles made up 50% ($n = 5$) of initial captures ($n = 10$) at the low-density plot from 28 June to 2 July. Live shrubs were again the most commonly used perch site at the low-density plot at 60% ($n = 21$) followed by woody vines at shrub level at 28.6% ($n = 10$) of total observations.

Juvenile Green Anoles ($n = 8$) captured at the high-density plot during late spring had a mean svl of 37.6 mm, and we found no significant difference between adult perch height (mean = 0.72 ± 0.03 m) and juvenile perch height (mean = 0.65 ± 0.13 m, $t = 0.60$, df = 5, $P = 0.57$). All juveniles ($n = 5$) captured at the low-density plot were found during early summer (28 June–2 July) and had a mean svl of 24.0 mm. Adult perch height (mean = 0.65 ± 0.13 m) was not significantly greater than juvenile perch height (mean = 0.41 ± 0.16 m, $t = 0.81$, df = 2, $P = 0.50$) at the low-density plot. Juveniles ($n = 53$) captured at the high-density plot during late summer had a mean svl of 31.5 mm, and adult perch height (mean = 1.0 ± 0.06 m) was significantly greater than juvenile perch height (mean = 0.77 ± 0.09 m, $t = 6.73$, df = 4, $P = 0.003$).

Green Anoles exhibited very little preference for, or avoidance of, any particular species of live shrub or shrub-level vine. However, many species were too uncommon within the plots to detect preference or avoidance by anoles. Many other shrub-level species were considered neutral in preference since the number of expected anole observations was similar to the number of actual observations. Only 17 of 37 available shrub-level species were used by Green Anoles at the high-density plot during late spring. Of the unused species, only *Asimina parviflora* (Dwarf Pawpaw) was common enough to expect to be used at least once. Of the used species, *Quercus stellata* (Post Oak) and Muscadine Grape were considered avoided by Green Anoles and *Quercus marilandica* (Blackjack Oak) was ranked as preferred. *Ilex vomitoria* (Yaupon) was considered borderline avoided (upper confidence limit for the selection index was 1.00), and *Carya texana* (Black Hickory) was borderline preferred (lower confidence limit for the selection index was 0.93). Twelve species used by Green Anoles were ranked as neutral.

Green Anoles again used only 17 of 37 available shrub-level species at the high-density plot during late summer. Of the unused shrub-level species, only Sassafras occurred in sufficient volume to expect use by anoles. Yaupon was ranked as avoided and Black Hickory was considered preferred. Fifteen species used by Green Anoles were ranked as neutral.

Seven of 15 available shrub-level species were used by Green Anoles at the low-density plot during late spring, but none were ranked as preferred. Of the unused species, only Shining Sumac occurred in sufficient volume to expect use by anoles. *Quercus incana* (Bluejack Oak) was borderline avoided (upper confidence limit for the selection index was 1.00). Six species used by Green Anoles were ranked as neutral.

Shrubs and shrub-level vines harboring Green Anoles averaged wider, taller, and greater in volume than available shrubs present in each plot in

Table 3. Percent of total plants, number of plants, and percent of total volume of live shrub-level woody vegetation by species and frequencies of use by *Anolis carolinensis* (Green Anole) at two study plots in eastern Texas.

	High shrub-density plot[B]			Low shrub-density plot		
Shrub species[A]	% (# of plants)	% of total volume	% (# anole observations)[C]	% (# of plants)	% of total volume	% (# anole observations)[C]
Asimina parviflora (Michx.) Dunal (Dwarf Pawpaw)	3.1 (47)	1.46	0.5 (1)	0.5 (3)	0.06	0.0 (0)
Berchemia scandens (Hill) K. Koch (Alabama Supplejack)	0.1 (1)	0.03	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Callicarpa americana L. (American Beautyberry)	3.8 (58)	14.48	17.3 (36)	7.5 (45)	32.89	45.2 (14)
Carya texana Buckl. (Black Hickory)	9.6 (145)	9.25	15.8 (33)	0.8 (5)	1.63	3.2 (1)
Chionanthus virginicus L. (Fringetree)	0.1 (2)	0.25	0.5 (1)	0.0 (0)	0.00	0.0 (0)
Cornus florida L. (Flowering Dogwood)	2.6 (40)	1.10	1.9 (4)	0.2 (1)	1.10	0.0 (0)
Crataegus spp. L. (hawthorn species)	0.5 (8)	0.10	0.5 (1)	0.0 (0)	0.00	0.0 (0)
Gelsemium sempervirens (L.) St. Hil. (Carolina Jessamine)	1.5 (23)	0.58	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Hypericum spp. L. (St. John's-wort species)	0.2 (3)	0.03	0.0 (0)	0.7 (4)	0.21	0.0 (0)
Ilex decidua Walt. (Possumhaw)	0.1 (1)	0.01	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Ilex opaca Ait. (American Holly)	0.5 (7)	0.46	2.9 (6)	0.0 (0)	0.00	0.0 (0)
Ilex vomitoria Ait. (Yaupon)	12.3 (187)	21.26	13.5 (28)	3.7 (22)	4.81	3.2 (1)
Liquidambar styraciflua L. (Sweetgum)	6.7 (101)	17.51	17.30 (36)	0.7 (4)	2.04	0.0 (0)
Myrica cerifera L. (Wax Myrtle)	5.2 (79)	1.75	1.0 (2)	0.0 (0)	0.00	0.0 (0)
Nyssa sylvatica Marsh. (Blackgum)	0.9 (14)	0.54	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Parthenocissus quinquefolia (L.) Planch. (Virginia Creeper)	0.3 (4)	0.13	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Persea borbonia (L.) Spreng. (Redbay)	0.7 (11)	1.58	3.4 (7)	0.0 (0)	0.00	0.0 (0)
Pinus echinata P. Mill. (Shortleaf Pine)	0.1 (1)	0.01	0.0 (0)	0.3 (2)	0.08	0.0 (0)
Pinus palustris P. Mill. (Longleaf Pine)	0.3 (5)	0.10	0.0 (0)	0.2 (1)	0.08	0.0 (0)
Prunus serotina Ehrh. (Black Cherry)	0.1 (2)	0.03	0.0 (0)	0.0 (0)	0.00	0.0 (0)

Table 3, continued.

Shrub species[A]	High shrub-density plot[B] % (# of plants)	High shrub-density plot[B] % of total volume	High shrub-density plot[B] % (# anole observations)[C]	Low shrub-density plot % (# of plants)	Low shrub-density plot % of total volume	Low shrub-density plot % (# anole observations)[C]
Prunus spp. L. (non-*P. serotina* plum species)	0.1 (1)	0.10	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Quercus alba L. (White Oak)	1.9 (29)	2.89	3.9 (8)	0.00	0.0(0)	0.0 (0)
Quercus falcata Michx. (Southern Red Oak)	4.4 (66)	2.69	2.9 (6)	8.2 (49)	6.22	3.2 (1)
Quercus hemisphaerica Bartr. ex Willd. (Darlington Oak)	0.5 (7)	0.10	0.0 (0)	1.7 (10)	2.15	3.2 (1)
Quercus incana Bartr. (Bluejack Oak)	2.1 (32)	0.65	0.5 (1)	21.1 (126)	8.88	6.5 (2)
Quercus marilandica Muenchh. (Blackjack Oak)	4.6 (69)	1.34	4.3 (9)	0.0 (0)	0.00	0.0 (0)
Quercus nigra L. (Water Oak)	1.7 (26)	0.35	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Quercus phellos L. (Willow Oak)	0.1 (2)	0.07	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Quercus stellata Wangenh. (Post Oak)	3.1 (47)	1.98	1.0 (2)	0.0 (0)	0.00	0.0 (0)
Quercus spp. L. (oak species)	0.20 (3)	0.02	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Rhus copallina L. (Shining Sumac)	0.6 (9)	0.22	0.5 (1)	45.3 (271)	15.54	3.2 (1)
Rubus spp. L. (blackberry species)	2.0 (30)	0.20	0.5 (1)	0.0 (0)	0.00	0.0 (0)
Sassafras albidum (Nutt.) Nees (Sassafras)	16.0 (242)	2.55	1.0 (2)	2.3 (14)	0.30	0.0 (0)
Smilax spp. L. (greenbrier species)	0.3 (5)	0.14	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Vaccinium spp. L. (blueberry species)	11.6 (176)	3.08	4.3 (9)	0.0 (0)	0.00	0.0 (0)
Viburnum rufidulum Raf. (Rusty Blackhaw)	0.1 (2)	0.02	0.0 (0)	0.0 (0)	0.00	0.0 (0)
Vitis aestivalis Michx. (Summer Grape)	1.7 (26)	1.02	1.0 (2)	6.9 (41)	24.01	32.3 (10)
Vitis rotundifolia Michx. (Muscadine Grape)	0.4 (6)	11.93	5.8 (12)	0.0 (0)	0.00	0.0 (0)
Total observations	100.0 (1517)	100.00	100.0 (208)	100.0 (598)	100.00	100.0 (31)

[A]Shrub = woody vegetation (including vines) ≥0.5 m and <3.0 m in height.
[B]Late spring and late summer Green Anole observations are combined.
[C]Includes observations of Green Anoles that escaped capture.

both late spring and late summer (Table 5). On both the high- and low-density plots, most available shrubs (76.3% and 86.3%, respectively) were <1.0 m^3. On the high-density plot, only 81 (5.3%) and 47 (3.1%) of 1517 available shrubs had a volume ≥4.0 m^3 and ≥6.0 m^3, respectively. In late spring, 31% (*n* = 39) of all Green Anole observations on live shrub-level vegetation were on shrubs ≥4.0 m^3. By late summer, 34.1% (*n* = 28) of all Green Anoles were observed on live shrub-level plants ≥6.0 m^3. At the low-density plot, only 24 (4.0%) of 598 available shrubs had a volume ≥4.0 m^3. In late spring, 45% (*n* = 14) of all Green Anoles were observed on live shrub-level vegetation ≥4.0 m^3. The use of voluminous shrubs by Green Anoles was proportionally greater than their availability at both plots.

Discussion

Green Anole population size was much higher at the plot with greater shrub density. Live shrubs were by far the most commonly used perch substrate in both plots. Visually displaying adult males regularly perched on hardwood mid-story trunks in the high-density plot during late spring. By late summer, the majority of Green Anoles were juveniles and hardwood mid-story stems were rarely used. Most adults at the high-density plot disappeared between late spring and late summer, possibly having succumbed to mortality. We do not know if a similar reduction in adult

Table 4. *Anolis carolinensis* (Green Anole) population size estimates (*N*) derived from the program CAPTURE for two study plots in eastern Texas.

Plot, season	Model[A]	*N*	SE	95% CI
High shrub-density plot, late spring	M_t	211	39.4	155–314
High shrub-density plot, late summer	M_o	160	28.5	120–236
Low shrub-density plot[B], late spring	M_o	13	6.0	9–39

[A]Population models selected by the program CAPTURE to estimate Green Anole population sizes: M_t = capture probabilities varied with time, M_o = capture probabilities were constant.
[B]No data for late summer.

Table 5. Width, height, and volume of live, shrub-level vegetation available to and used by *Anolis carolinensis* (Green Anole) at two study plots in eastern Texas.

	High shrub-density plot						Low shrub-density plot[A]			
			Used						Used	
Shrub	Available (*n* = 1517)		Late spring (*n* = 126)		Late summer (*n* = 82)		Available (*n* = 598)		Late spring (*n* = 31)	
dimension[B]	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Width (m)	0.76	0.01	1.41	0.09	1.80	0.19	0.68	0.02	1.52	0.12
Height (m)	0.93	0.01	1.44	0.05	1.56	0.07	0.71	0.01	1.23	0.09
Volume (m^3)	1.08	0.09	4.16	0.56	6.63	1.15	0.65	0.06	3.94	0.73

[A]No data for late summer.
[B]Shrub = vegetation ≥0.5 m and <3 m in height.

numbers occurred at the plot with fewer shrubs since we did not visit that plot during late summer.

Jenssen et al. (1998) showed that perch height increased with body size during "the beginning of the post-reproductive period." Our data support this as adults perched at significantly greater heights than juveniles at our high-density plot during late summer. However, this difference was not observed at the high-density plot during late spring, or at the low-density plot. Only a few large juveniles, that may have hatched the previous year, were captured at the high-density plot during late spring. Thus, the perch heights of these larger juveniles may approach that of the smaller adults. Few juveniles were captured at the low-density plot as well. In this case, they were nearer to hatchling-sized and clearly young of the year, but our very low sample size may have prevented a significant difference between adult and juvenile perch heights.

Green Anoles were the most common prey item (30% of total prey) delivered to Southeastern American Kestrel nestlings in eastern Texas (R.R. Schaefer, unpubl. data) and are a seasonally important prey item elsewhere within the subspecies' range (Smallwood and Bird 2002). A study involving the examination of fecal samples collected from snakes in our region found *Coluber constrictor* L. (Racer) and *Masticophis flagellum* Shaw (Coachwhip) to prey heavily on various lizards (D.C. Rudolph, unpubl. data). However, Green Anole remains were positively identified only from Racer (n = 1) and *Agkistrodon contortrix* L. (Copperhead, n = 2) fecal samples. Many lizard remains could not be identified to species (n = 34), making the extent of Green Anole predation by snakes in our region difficult to determine. Little information is available regarding Green Anole predation by other taxa in eastern Texas. Additional species occurring at our study plots that have been reported to prey on Green Anoles elsewhere within its range include *Melanerpes carolinus* L. (Red-bellied Woodpecker) (Arndt 1995), and *Vireo flavifrons* Vieillot (Yellow-throated Vireo) and *V. olivaceus* L. (Red-eyed Vireo) (Sykes et al. 2007). *Eumeces laticeps* Schneider (Broad-headed Skink), another potential predator found at our study plots, killed and consumed a Green Anole while in captivity (Neill 1940). Large predatory arthropods such as certain spiders may also prey on Green Anoles (Corey 1988). We observed one instance of cannibalism of a Green Anole hatchling during this study (R.R. Schaefer, pers. observ.). Other than the Southeastern American Kestrel, we know of no available information regarding the extent of Green Anole predation by these taxa in our region. It is not known if the various modes of predatory behavior exhibited by these taxa have any influence on Green Anole perch site selection.

We found no literature references addressing the question of Green Anole preference or avoidance of particular plant species. Our analyses revealed that very few shrub-level plant species were preferred or avoided by anoles. Green Anoles at both plots were found on shrubs with a greater average volume than that of available plants. Greater shrub volume is clearly an important feature to Green Anoles, and appears to have a greater influence than shrub species on an individual's choice of perch sites. Shrubs of greater volume were relatively scarce at both plots, and their use by Green Anoles was proportionally greater than their availability. Though we cannot say if Green Anoles seek larger shrubs for the purpose of avoiding certain predators, a potential benefit of occupying shrub-level plants of greater volume may be a reduction in the conspicuousness of anoles to avian predators. When a predatory bird does detect an anole, it seems probable the bird would have more difficulty retrieving the lizard from the interior of a larger shrub. Additionally, larger shrubs may provide a greater selection of escape routes for Green Anoles confronted by a predator. Sites with a higher volume of shrub-level vegetation provide a greater number of perches and presumably more arthropod prey, which in turn should support higher Green Anole populations.

Green Anoles are attracted to dense shrubbery in open areas (Dundee and Rossman 1989), making the fire-maintained pine habitats at our study plots ideal. The higher-density shrub plot did not contain a contiguous layer of woody, shrub-level vegetation. It was a mosaic of shrubs (single plants and clumped) and openings with herbaceous, woody, and bare/leaf litter ground cover. This vegetative structure provides good quality foraging habitat for the Southeastern American Kestrel, which requires an open understory for maneuverability and visual prey location (Hoffman and Collopy 1988, Smallwood and Bird 2002). The vegetative structure of our low-density shrub plot differed in that hardwood mid-story trees were nearly absent and shrub-level vegetation was much reduced. This created an even more open pine stand that still provided kestrel foraging habitat, but anole numbers were much reduced. A reduction in anoles may reduce foraging habitat quality for kestrels. On the other hand, a contiguously dense shrub layer may harbor more anoles but may also hinder kestrel maneuverability. Thus, some intermediate shrub density may provide optimal kestrel foraging habitat with regard to Green Anoles.

Our results suggest that Green Anole abundance varies in response to the density of shrub-level vegetation, but additional research with an expanded number of plots that exhibit a gradient of shrub densities would strengthen our understanding of the relationships between Green Anoles and shrub characteristics.

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