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A TEMPORAL ANALYSIS OF A SINGLE LIVE OAK TREE'S BIRD COMMUNITY IN CENTRAL FLORIDA DURING AUTUMN WARBLER MIGRATION

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Abstract.—The composition and structure of terrestrial avian communities of inland Florida, particularly in relation to the time of day, have been relatively little studied. This study employed a novel technique for investigating a bird community that uses a single live oak tree in central Florida. By recording field observations during four different time blocks over the course of ten weeks, we quantified the composition of the community that uses this tree during the fall. Thirty species were recorded, comprised primarily of year-round residents. Migratory species made up 22% of the total abundance. Blue-Gray Gnatcatchers (*Polioptila caerulea*) spent a highly disproportional amount of time in the tree per visit as compared to Blue Jays (*Cyanocitta cristata*) and Mockingbirds (*Mimus polyglottos*) (these were the three most common species observed). Gnatcatchers were found to stay longer because they use the live oak as a foraging site, whereas the latter two species did not often feed at the tree. Overall species richness and total bird density increased as winter approached; these variables correlated with migration induced by the changing of the seasons rather than to individual weather conditions. Birds were most abundant and diverse during the early afternoon (1200-1500) time block. Average vertical zonation in the tree changed dramatically from time block to time block, showing the effects of daily temperature variations on the behavioral patterns of this avian community.

Several studies have focused on the influence of abiotic factors on bird diversity, activity, and behavior. However, one critical factor that has been little studied in the wild is the time of day in relation to activity patterns (Steiger et al. 2013). Although studies have focused on one particular bird species in relation to circadian rhythm (Kumar et al. 1992, Lehman et al. 2012, Pandey and Bhardwaj 2011), none have focused specifically on the temporal activity patterns of an entire community of terrestrial birds in a temperate forest ecosystem. Thus, there remains a prominent void in knowledge regarding the changing behavioral patterns of a community of birds in relation to the various times of day.

Moreover, there have been no studies in temperate regions documenting the composition of a community that uses an individual tree. A single tree has the potential to be a good standard by which to compare avian diversity and activity patterns from habitat to habitat. We analyzed how bird diversity at a single tree changes throughout the course of the day, identifying trends that indicate which abiotic variables have the greatest effect on bird activity, abundance, and species richness. The concept of studying birds in relation to a specific species of tree has been utilized before (Howe 1977, Chavez-Ramirez and Stack 1994), but the interest of this study is to focus not just on one species of tree, but on one individual tree.

Avian species richness is correlated to the complexity and diversity of foliage height in a habitat (MacArthur and MacArthur 1961, MacArthur 1964, Willson 1974), so we chose a tree that has a variety of foliage heights but is also a common enough species that the results will remain relevant across multiple types of habitats. By and large, the most common tree in central Florida is the live oak (*Quercus virginiana*). Live oaks are sought after by both insectivores and acorn-eating birds (Kushlan and Hines 2014). This variety of nutritional opportunities has a direct relationship with the variation of species that inhabit this environment (MacArthur and MacArthur 1961, Willson 1974). Live oaks also provide a variety of niches that may be used by different species of birds, which may prove valuable to this study because each species chooses its habitat according to the resources available (Lack 1971, Lanyon 1981). Our results could potentially be applied to broader applications in a variety of live oak-dominated habitats throughout the state.

Due to the number of variables under investigation, this study has multiple specific aims.

- To quantify the composition and structure of the tree community during autumn and early winter (the term “tree community” used henceforth in this paper refers to birds observed on the tree being studied)
- To find patterns and trends tracking the tree community’s responses to abiotic factors (weather conditions, etc.)
- To determine how species richness, bird abundance, and total minutes spent in each vertical zone of the tree varies according to the time of day (specifically in regard to four pre-determined time blocks)

It is expected that time of day and weather patterns will have the most prominent effects on bird diversity and activity. By casual observation, it seems that most birds in hot climates tend to become active early in the morning (in the first hour or two after sunrise) and again in the late afternoon. Therefore, we propose that the highest total number of birds will be active during the 0600-0900 time block and the 1500-1800 time block. Additionally, due to the hot temperatures of the early afternoon, we expect the 1200-1500 time block to be the least productive in terms of avian abundance.

Study Site and Methods

This study was conducted on a tree in a field lightly interspersed with live oaks and slash pines (*Pinus elliottii*) on a minimally-disturbed, suburban area of property (28° 3' N, 81° 56' W) owned by Southeastern University. The specific field study site (Fig. 1) is comprised of two live oaks (*Quercus virginiana*; hereafter called "the study tree") with overlapping canopies that are situated 22 m from the lakeside vegetation of Lake Holloway in Lakeland, Florida. Maximum height of the tree is approximately 9.5 m. The two trees are fairly typical for live oaks in size, structure, and surrounding habitat, and thus have no specific advantage over other live oak trees. There is one slash pine and one live oak 15 meters and 13.5 meters away, respectively, from the study tree.

From August 22 to November 4, 2014, a total of twenty 3-hour observations were made between 0600 and 1800, with this time period divided into 3-hour time blocks. During each study, researchers actively watched for birds in the area; one primarily responsible for data recording, and the other responsible for identifying each species. The observers remained under a low-profile, camouflaged shelter unless an unidentifiable species flew into the target tree, in which case, researchers would walk around the tree in order to identify the species visually or by camera.

Environmental variables were recorded (from weather.com under current hourly weather conditions for zip code 33801), and each bird was recorded, noting its species, behavior, and total time spent in the tree. If the researchers did not actually see the time that the bird left, then the bird was recorded as having stayed in the tree for a standard of five minutes. Behaviors (especially foraging behaviors) were recorded using sequential observations rather than point observations, which permits the researcher to observe the same individual bird through a broader range of activities (Morrison 1984).

Figure 1. The field study "tree;" two *Quercus virginiana* trees with overlapping canopies.

Abbreviations for various behavioral notes were used when applicable for singing, calling, resting, feeding on vegetation, feeding on arthropods, and preening.

Species interactions and interesting observations were also recorded. The relative vertical location of each bird within the tree was also recorded throughout the duration of its visit. Birds of prey were recorded if they passed over the site, flew by the tree, or landed. The reason birds of prey were recorded as they passed by was due to the slight impact that they might have on the behavior of passerine birds currently in the tree at the time. Non-raptorial species that passed by overhead were not recorded because they are not a reputable source for a population density estimate (Sutherland et al. 2004). Coefficients of correlation (Table 4) were calculated by standard statistical procedures (Triola 2011). Graphs and tables were produced by Microsoft Excel and Microsoft Word, respectively.

RESULTS

Tree community composition & structure

Throughout the period of this ten week study, a total of 30 bird species were recorded and 415 individual birds were counted (Table 1). Excluding the birds of prey that passed by the tree and never landed, 43% of the birds recorded were either blue jays or mockingbirds (Table 2). Greatest in species richness at this tree, according to foraging behavior, were species that glean insects from vegetation: Gnatcatchers, warblers, and so forth. Ground foragers, including Blue Jays and Northern Mockingbirds, were second in diversity. Blue-gray Gnatcatchers spent a far greater amount of time in the tree per visit than did ground foragers (Table 3).

Due to autumn being a peak time for migration in warblers and other birds, the composition of this avian community shifted according to the outflow and influx of migratory species. Warbler abundance clearly peaked in mid to late October (Fig. 2). Resident species comprised 77.5% of the birds observed at the tree. Winter visitors (18.6%) were well-represented, whereas summer visitors (3.9%) were scarce.

Environmental conditions

Temperature and humidity at this site are inversely proportional (Table 4). Although temperature and relative humidity seemed to play important roles in determining the species richness and total number of birds that were present in the tree at any given time, statistical analysis proved no significant correlation. Trending from the first week of the study to the final week, there are weak positive correlations of time of season to species richness and total bird abundance. As winter approached, the average richness and abundance of birds observed per study increased as the temperature decreased. Other biotic and abiotic factors that were measured seemed to have negligible influence.

Table 1. Total number of birds seen per species at the study site in Lakeland, FL. W = winter visitor; S = summer visitor; R = year-round resident (based on Dunn and Alderfer 2008). Relative abundance measured in birds seen per daylight hour of field study. Abundance at study tree based off of relative abundance values given by Stevenson and Anderson (1994), and only indicates birds at this one tree. Note that migration is not taken into account for the values.

Scientific name	English name	Residence	Count	Relative abundance	Abundance at study tree
Cyanocitta cristata	Blue Jay	R	109	2.02	Common
Mimus polyglottos	Northern Mockingbird	R	60	1.11	Common
Polioptila caerulea	Blue-gray Gnatcatcher	R	57	1.06	Common
Dendroica palmarum	Palm Warbler	W	43	0.80	Fairly common
Melanerpes carolinus	Red-bellied Woodpecker	R	20	0.37	Fairly common
Buteo lineatus	Red-shouldered Hawk	R	14	0.26	Uncommon
Dendroica discolor	Prairie Warbler	W	11	0.20	Uncommon
Sayornis phoebe	Eastern Phoebe	W	10	0.19	Uncommon
Baeolophus bicolor	Tufted Titmouse	R	9	0.17	Uncommon
Dendroica dominica	Yellow-throated Warbler	R	8	0.15	Uncommon
Cardinalis cardinalis	Northern Cardinal	R	8	0.15	Uncommon
Myiarchus crinitis	Great-crested Flycatcher	S	7	0.13	Uncommon
Picoides pubescens	Downy Woodpecker	R	6	0.11	Uncommon
Vireo griseus	White-eyed Vireo	R	6	0.11	Uncommon
Dendroica pinus	Pine Warbler	R	6	0.11	Uncommon
Vireo olivaceus	Red-eyed Vireo	S	5	0.09	Uncommon
Haliaeetus leucocephalus	Bald Eagle	R	4	0.07	Uncommon
Zenaida asiatica	White-winged Dove	R	4	0.07	Uncommon
Parula americana	Northern Parula	S	4	0.07	Uncommon
Mniotilta varia	Black-and-white Warbler	W	4	0.07	Uncommon
Pandion haliaetus	Osprey	R	3	0.06	Uncommon
Thryothorus ludovicianus	Carolina Wren	R	3	0.06	Uncommon
Vireo solitaries	Blue-headed Vireo	W	2	0.04	Rare
Cistothorus palustris	Marsh Wren	W	2	0.04	Rare
Regulus calendula	Ruby-crowned Kinglet	W	2	0.04	Rare

Table 1. (Continued) Total number of birds seen per species at the study site in Lakeland, FL. W = winter visitor; S = summer visitor; R = year-round resident (based on Dunn and Alderfer 2008). Relative abundance measured in birds seen per daylight hour of field study. Abundance at study tree based off of relative abundance values given by Stevenson and Anderson (1994), and only indicates birds at this one tree. Note that migration is not taken into account for the values.

Scientific name	English name	Residence	Count	Relative abundance	Abundance at study tree
Dumetella carolinensis	Gray Catbird	W	2	0.04	Rare
Buteo jamaicensis	Red-tailed Hawk	R	1	0.02	Rare
Falco sparverius	American Kestrel	W	1	0.02	Rare
Zenaida macroura	Mourning Dove	R	1	0.02	Rare
Toxostoma rufum	Brown Thrasher	R	1	0.02	Rare

Table 2. Total number of birds versus total time spent in the tree.

	Quantity	% of total	Minutes	% of total
Blue Jays & mockingbirds	169	**43%**	879	20%
Blue-gray Gnatcatchers	57	15%	1,877	**42%**
Warblers (6 spp.)	76	19%	1,024	23%
Other birds (16 spp.)	90	23%	688	15%

Time of day

Surprisingly, the highest average diversity per study occurred during the 1200-1500 time block (Table 5). The lowest average was recorded in the late afternoon (1500-1800). Total bird abundance per study followed a similar trend. A total of 130 birds were recorded in the early afternoon (1200-1500), making that the most abundant and species-rich time block.

Collectively, birds were found to be active primarily (80%) in the mid and outer canopy during the early morning (Fig. 3). Lower, medium, and high branches were utilized somewhat evenly during the late morning. Early afternoon saw mid-level activity skyrocket, with more than twice as much time spent here as spent high in the canopy. Late afternoon reversed this trend, with over 50% of the birds moving back into the high canopy. Overall, data shows a marked reversal of which vertical zones of the tree are collectively most utilized, varying according to the time of day.

Discussion

Tree community composition & structure

In quantifying the composition and structure of the bird community that uses this tree during the autumn, the most clearly marked pattern is the way in which each species behaves during its visits to the tree. Although Blue-gray Gnatcatchers were not the most abundant species

Table 3. Relative prevalence of feeding activity observed at the tree.

	Total individuals seen at tree	Individuals seen feeding at tree	% of total
Blue Jays & Northern Mockingbirds	169	37	22%
Blue-gray Gnatcatchers	57	36	**63%**
Warblers (6 spp.)	76	28	37%
Other birds (16 spp.)	90	34	38%
All species total*	392	135	34%

* Excluding birds of prey

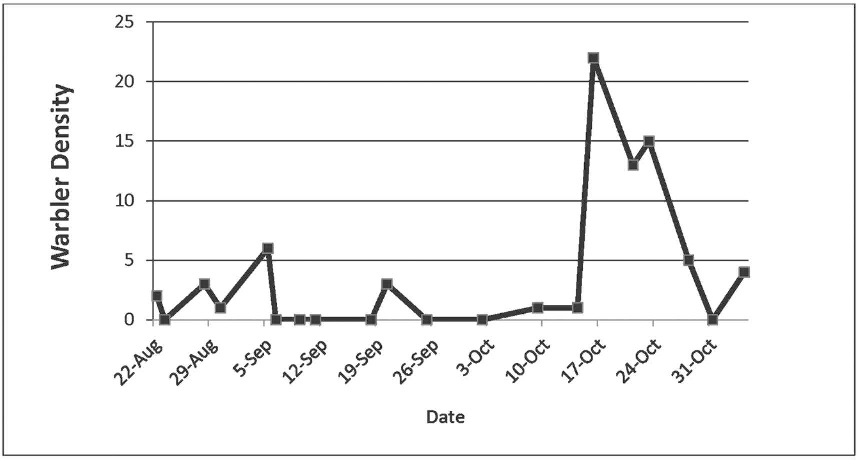

Figure 2. Warbler abundance per week of field study.

at the study tree, each gnatcatcher spent a far longer amount of time in the tree than did either of the two most abundant species (Table 2). Clear trends show that gnatcatchers exhibit a much higher feeding rate in the study tree than blue jays and mockingbirds (Table 3); gnatcatchers spend more time in the tree because the majority of them are there to feed. Blue jays and mockingbirds use the tree much less for feeding, and thus do not need to spend extended periods of time there. This is consistent with the fact that mockingbirds and blue jays are primarily ground foragers (Derrickson and Breitwisch 1992, Tarvin and Woolfenden 1999), whereas gnatcatchers are foliage-gleaning insectivores (Kershner and Ellison 2012).

Environmental conditions

Throughout the course of the study, the composition of this tree community shifted with the arrival of migratory species. For example, the warbler abundance trend (Fig. 2) shows strong incidence of migratory behavior, peaking in mid to late October. Overall, the collected data suggests that abiotic factors such as temperature and humidity do not directly correlate to the activity of this community; rather, it is the cumulative effects of seasonal changes that brings in migratory species that increase both the abundance and diversity of birds at the tree (Table 4).

However, these data may or may not represent this community's functioning in the long term. Ecosystem processes tend to vary widely based on factors such as temperature fluctuations, herbivore or pathogen outbreaks, and the production at a given trophic level

Table 4. Coefficient of correlation (*r*) values for selected variables.

First variable	Second variable	*r*	Explanation
Temperature	Humidity	-0.7156	Moderate negative correlation
Total abundance`	Humidity	+0.2316	Very weak positive correlation
Species richness	Humidity	-0.0393	No correlation
Total abundance	Temperature	-0.1834	Negligible; weak negative correlation
Species richness	Temperature	-0.1510	Negligible; weak negative correlation
Total abundance	Approaching winter*	+0.3825	Weak positive correlation
Species richness	Approaching winter*	+0.4649	Weak to moderate positive correlation

*Approaching winter denotes progression of dates from the beginning of the field study to its end.

Table 5. Effects of time of day on bird activity.

Time	Mean total abundance	Mean species richness	Mean visit length (min)
0600-0900	20.6	6.6	10
0900-1200	18.6	7.2	15
1200-1500	26	8.4	11
1500-1800	18.2	5.2	10

oscillating back and forth from being predator-limited to food-limited (Chapin et al. 2002). A large proportion of the variability is due to climatic variation, which may or may not be predictable. Therefore, continuing data collection for a decade or more would yield much better long-term results that would balance out any potentially misleading results from data being collected on a year that does not represent the long-term average.

Time of day

The largest number of individual birds seen was during the early afternoon (1200-1500) time block: 130 birds. As we had originally predicted that this would be the least productive time block due to it being the hottest part of the day, this spike was very much unexpected. However, during this time block they did not stay as long as they did in other times of day. It was instead the 0900-1200 block during which the birds spent the most amount of time in the tree (Table 5). In fact, the birds spent an average of 46% longer in the tree during 0900-1200 than during the early afternoon, despite the latter seeing the highest number of visits. Essentially, birds most frequently visited the tree during the early afternoon, but they stayed for much longer during more infrequent late morning visits. This is likely due to increased foraging during the late morning.

The clearest trend pertaining to temporal activity in this avian community was regarding what vertical zone of the tree was collectively most utilized by birds during a given time block (Fig. 3). Our data support the conclusion that as the temperature rises during the heat of midday, many birds move their activity into the middle of the tree to stay protected from the hot sun. Then later, as the intensity of the sun on the outer canopy of the tree decreases, more birds return their activity to the exterior of the tree, which allows for quicker identification of threats from predators. Thus, only during one of four time blocks (1200-1500) did thermal requirements outweigh the obligation to be in a better location to detect avian predators. This is consistent with the previously proposed idea that safety from predators (Villén-Pérez et al. 2013) is more important than thermal requirements (Du Plessis et al. 2012).

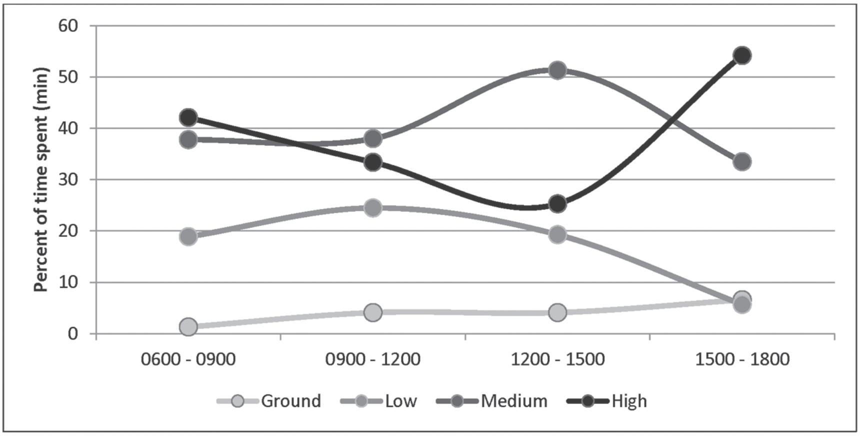

Figure 3. Mean vertical zonation by time block.

The data from this study have implications for avian community ecology on a local and regional scale. Future studies could compare avian activity patterns between natural areas and nearby residential areas, using trees of the same species, with similar size and foliage volume, as the common factor.

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Literature Cited

Chapin, F. S., III, P. A. Matson, and P. Vitousek. 2002. Principles of Terrestrial Ecosystem Ecology. Springer.

Chavez-Ramirez, F., and R. D. Slack 1994. Effects of avian foraging and post-foraging behavior on seed dispersal patterns of Ashe juniper. Oikos. 71:40–46.

Derrickson, K. C., and R. Breitwisch. 1992. Northern Mockingbird (*Mimus polyglottos*). *In* The Birds of North America, No. 7 (A. Poole, Ed.). The Birds of North America Online, Ithaca, New York. Retrieved from the Cornell Lab of Ornithology All About Birds: http://www.allaboutbirds.org/guide/Northern_Mockingbird/lifehistory.

DU PLESSIS, K., R. MARTIN, P. HOCKEY, S. CUNNINGHAM, AND A. RIDLEY. 2012. The costs of keeping cool in a warming world: implications of high temperatures for foraging, thermoregulation and body condition of an arid-zone bird. Global Change Biology. 18(10):3063–3070.

DUNN, J. L., AND J. ALDERFER. 2008. National Geographic Field Guide to the Birds of Eastern North America. National Geographic Society: Washington, D.C.

HOWE, H. F. 1977. Bird activity and seed dispersal of a tropical wet forest tree. Ecology 58(3):539–550.

KERSHNER, E. L., AND W. G. ELLISON. 2012. Blue-gray Gnatcatcher (*Polioptila caerulea*). *In* The Birds of North America Online, No. 23 (A. Poole, Ed.). Cornell Lab of Ornithology, Ithaca, New York. Retrieved from the Cornell Lab of Ornithology All About Birds: <http://www.allaboutbirds.org/guide/Blue-gray_Gnatcatcher/lifehistory>

KUMAR V., B. S. KUMAR, AND B. P. SINGH. 1992. Photostimulation of blackheaded bunting: subjective interpretation of day and night depends upon both photophase contrast and light intensity. Physiology & Behavior. 51:1213–1217.

KUSHLAN, J.A., AND K. HINES. 2014. Attracting Birds to South Florida Gardens. UPF, Gainesville, Florida.

LACK, D. 1971. Ecological Isolation in Birds. Harvard University Press, Cambridge, Massachusetts.

LANYON, W. E. 1981. Breeding birds and old field succession on fallow Long Island farmland. Bulletin of the American Museum of Natural History. 168:1–60.

LEHMAN, M., K. SPOELSTRA, M.E. VISSER, AND B. HELM. 2012. Effects of Temperature on Circadian Clock and Chronotype: An Experimental Study on a Passerine Bird. Chronobiology International 29(8):1062–1071.

MACARTHUR, R. H., AND J. W. MACARTHUR. 1961. On bird species diversity. Ecology 42:594–598.

MACARTHUR, R. H. 1964. Environmental factors affecting bird species diversity. American Naturalist 98:387–397.

MORRISON, M. L. 1984. Influence of sample size and sampling design on analysis of avian foraging behavior. Condor 86:146–150.

PANDEY, R., AND S. BHARDWAJ S. 2011. Circadian and seasonal responses in Indian Weaver Bird: Subjective interpretation of day and night depends upon both light intensity and contrast between illuminations. Chronobiology International: The Journal Of Biological & Medical Rhythm Research. 28(9):758–763.

STEIGER, S., M. VALCU, K. SPOELSTRA, B. HELM, M. WIKELSKI, AND B. KEMPENAERS. 2013. When the sun never sets: diverse activity rhythms under continuous daylight in free-living arctic-breeding birds. Proceedings of The Royal Society B: Biological Sciences. 280(1764):1.

SUTHERLAND, W. J., I. NEWTON, AND R. E. GREEN. 2004. Bird Ecology and Conservation: A Handbook of Techniques. Oxford University Press, Oxford, United Kingdom.

TARVIN, K. A., AND G. E. WOOLFENDEN. 1999. Blue Jay (*Cyanocitta cristata*). *In* The Birds of North America, No. 469 (A. Poole, Ed.). The Birds of North America Online, Ithaca, New York. Retrieved from the Cornell Lab of Ornithology All About Birds: <http://www.allaboutbirds.org/guide/blue_jay/lifehistory>

TRIOLA, M. F. 2011. Essentials of Statistics, 4th ed. Addison-Wesley.

VILLÉN-PÉREZ, S., L. CARRASCAL, AND J. SEOANE. 2013. Foraging patch selection in winter: A balance between predation risk and thermoregulation benefit. Plos ONE. 8(7):1–10.

WILLSON, M. F. 1974. Avian community organization and habitat structure. Ecology 55:1017–1029.