INVESTIGATING THE WINTER NOCTURNAL NEST BOX USE OF THE BLACK-CRESTED TITMOUSE (*BAEOLOPHUS ATRICRISTATUS*)

by

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LIST OF ABBREVIATIONS

Abbreviation	Description
BCTI	Black-crested Titmouse
LED	Light emitting Diode
PIT	Passive Integrated Transponder
VPB	Vegetation Profile Board

ABSTRACT

Nest boxes are used during the breeding season by many cavity-nesting birds; however, less is known about the use of nest boxes as sites for roosting during the winter non-breeding season. The Black-crested Titmouse (*Baeolophus atricristatus;* hereafter BCTI) is a member of the family Paridae, which is a family containing birds known to utilize nest boxes during the winter seasons. However, the BCTI is a species with undocumented or unknown roosting behavior. For this study, possible factors influencing the propensity for winter roosting in the BCTI were examined. I conducted nocturnal surveys on nest boxes with the use of a wireless infrared cavity inspection camera across two winter field seasons. I analyzed the influence of nightly weather conditions and vegetation on winter roosting. For the weather variables affecting the probability of roosting, a decrease in temperature was found to increase BCTI roosting. Vegetation density 15 m from nest boxes was also found to influence roosting with an increase in vegetation leading to an increase in roosting frequency. This study has shown nest boxes are of use to BCTI during the non-breeding season and has shed light on some of the factors influencing their winter roosting behavior. These findings can be useful to wildlife managers who aim to increase health and survival of their resident passerine populations.

I. INTRODUCTION

Information about the winter ecology of many avian species is lacking due to a general focus in the literature on breeding ecology. Hence, there are significant gaps in our understanding of the nature of behavior and social interactions of many wintering birds (Brawn and Samson 1983).

Wintering birds are confronted with various abiotic factors which can affect their behaviors and survival. Colder temperatures, a decrease in resource and food availability, and shorter day length leading to longer periods of fasting can all affect the energy balance of winter acclimatized birds (Mayer et al. 1982). The effects of colder temperatures are more pronounced at night for diurnal birds as they are not usually foraging, and temperatures are at their lowest, leading to a decrease in body temperature (Baldwin and Kendeigh 1932). Passerine species survival drops markedly after a decrease in winter temperatures (Krams et al. 2013; Macias-Duarte et al. 2017). However, some birds make behavioral and physiological adjustments in response to winter conditions. For example, the White-breasted Nuthatch (*Sitta carolinensis*) caches food reserves to obtain later when resources become scarce in winter (Carrascal and Moreno 1994). In addition, changes in insulation, body mass, feathers, or lipid content help passerines maintain thermoregulation (Evans 1969; Waite 1992; Gavrilov et al. 2013; Møller 2015; Petit et al. 2017).

The importance of thermoregulation to a bird can depend on several factors. Size, for example, can be a major advantage for thermoregulating. Small bodied animals have lower survivorship in cold temperatures compared to their larger bodied conspecifics (Riesenfeld 1981). An increase in size of passerines relates to lower metabolic stress with lowered body temperatures as well as a reduction in the relative amount of energy required by a bird (Kendeigh 1969; Buttemer 1985).

The selection by smaller-bodied birds of certain overnight roosting sites can minimize the demands of thermoregulation (Du Plessis and Williams 1994). Roosting in trees, dense vegetation, and both natural and artificial cavities helps birds to thermoregulate because wood is a good insulator of heat. For example, roosting in cavities is advantageous for House Sparrows (*Passer domesticus*) who conserve more energy on colder nights when in cavities (Kendeigh 1961). Mountain Chickadees (*Poecile gambeli*) and Juniper Titmice (*Baeolophus ridgwayi*) who roost overnight in introduced nest boxes have energy savings of 25% (Cooper 1999). Roosting sites also aid in reducing the impact of precipitation and wind. Phainopepla (*Phainopepla nitens*) receive more of a thermal benefit from the shielding of wind rather than insulation against radiation heat loss when in roosting sites (Walsberg 1986).

Overnight roosting behaviors vary among species. For example, Carolina Chickadees (*Poecile carolinensis*) prefer to roost alone overnight and switch between different roosts throughout the season (Pitts 1976), while others, such as the Downy Woodpecker (*Picoides pubescens*) and the White-breasted Nuthatch choose to use the same roost repeatedly (Kilham 1971). Some birds like the Eastern Bluebird (*Sialia sialis*), Pinyon Jay (*Gymnorhinus cyanocephalus*), and the Green Woodhoopoe (*Phoeniculus purpureus*) use huddling behaviors and communal roosting, both of which lead to enhanced thermoregulation (Frazier and Nolan 1959; Balda et al. 1977; Du Plessis and Williams 1994).

Due to the limited behavioral ecology research on the Black-crested Titmouse (*Baeolophus atricristatus;* hereafter BCTI) the species is an ideal candidate for research on winter roosting ecology. Little is known about roosting habits for BCTI, however Tufted Titmice (*Baeolophus bicolor*) seek out denser vegetation and canopy cover on especially cold and windy nights (Brawn and Samson 1983) and Tufted Titmice have been observed to use naturally occurring cavities for roosting (Pitts 1976). Great Tits (*Parus major*), another species within the family Paridae, also use denser coniferous vegetation significantly more than less dense leafy vegetation for both cold and windy aviary mimicked conditions (Vel'ky et. al 2010). But, even within species, roost use may not be consistent. For example, Blue Tits (*Cyanistes caeruleus*) in southern France use nest boxes for roosting while Blue Tits on the nearby island of Corsica do not (Dhondt et al. 2010).

In this study I examined if introduced nest boxes are used by BCTI during the non-breeding winter season and explored variables affecting winter roost site selection in nest boxes. I tested the hypothesis that temperature would affect the use of cavity nest boxes by BCTI, and I predicted BCTI roost in cavity nest boxes more frequently on nights of colder temperatures. I also tested the hypothesis that wind speed would affect the use of nest boxes by BCTI, and I predicted BCTI would roost in nest boxes more frequently on nights with higher wind speeds. Finally, I tested the hypothesis that vegetation surrounding nest boxes affects BCTI nest box use, predicting that BCTI preferentially roost in cavity nest boxes in areas with denser vegetation and canopy cover.

Study Species

The BCTI, a member of the Paridae family, is a small non-migratory songbird residing in the Edwards Plateau of central Texas (USA). The BCTI is characterized by mouse-gray plumage on the dorsum and light gray plumage on the venter with tawny-buff flanks. The black-crest can be seen on the male titmouse while females and juveniles have a dark to light gray crest. The BCTI reaches 15 to 22 cm in length and weighs 16.5 gm on average at maturity (Patten and Smith-Patten 2008; Peterson 2008).

As the BCTI is a permanent resident, it is an ideal species for year-round study. Until recently, the BCTI was considered to be a sub-species of the Tufted Titmouse, based partly on species hybridization. However, the degree of genetic differentiation between the BCTI and the Tufted Titmouse indicates the BCTI should be considered a distinct species (Braun, et al. 1984, Banks et al. 2002). Since the BCTI has been recognized as a different species for a relatively short period of time, there is a lack of research considering the behavioral ecology of the species apart from the Tufted Titmouse (Patten and Smith-Patten 2008).

Distribution of the BCTI is limited to central and southern Texas, extreme southern Oklahoma, and northeastern Mexico. They are territorial throughout the year and form socially monogamous breeding pairs as early as late January (Dixon 1954). Territories are established after the breakup of winter flocks around February and breeding occurs from February to late June (Harrap and Quinn 1995). In central Texas, the habitat consists largely of oak/juniper woodlands and riparian woodlands. The BCTI also utilizes suburban and urbanized areas with adequate vegetation (Dixon 1978).

II. METHODS

Study Site

This study was conducted at the Freeman Center, a 1416-hectare property, owned by Texas State University and located 10km northwest of San Marcos, Texas. Much of the habitat at the Freeman Center is dominated by oak-juniper woodland (*Quercus fusiformis, Juniperus ashei*) scattered with Honey Mesquite (*Prosopis glandulosa*), Huisache (*Acacia farnesiana*), and various shrubs and grasses. The Freeman Center was historically a working livestock ranch for free-range cattle, but the site is now largely undeveloped habitat aside from a few grazing pastures for cattle and sheep.

At the Freeman Center BCTI are relatively abundant throughout and have been studied at the site since 2013 (Rylander 2015). Since 2013, over 600 BCTI individuals have been uniquely marked with both aluminum and color bands and 71 nest boxes have been erected and monitored during the breeding season. Many BCTI pairs have used the nest boxes during the breeding season.

Winter Roosting

To examine the winter roosting habits of BCTI, I surveyed 40 of the 71 nest boxes located on the Freeman Center (Figure 1). I chose these 40 boxes because of their proximity to each other and to useable roads making it possible to survey several boxes in one night. I conducted surveys twice a week, checking 20 boxes one night of the week and the remaining 20 boxes another night of the same week. I began surveying no sooner than 30 minutes after sunset, late December through February in 2016 and early November through February in 2018. I surveyed with the use of a wireless infrared cavity inspection camera (ibwo.org 6-inch wireless light emitting diode (LED) camera system) to minimize disturbance to roosting activity (Santos et al. 2008; Tyller et al. 2012). The camera transmitted images to a handheld monitor which I used to capture still images or short videos. I checked each box for the presence/absence of BCTI or any other avian species. I recorded environmental conditions for each survey night using a Kestrel 4500 Weather Meter for wind speed, relative humidity, and temperature measurements. I also recorded a sky code measurement ranging from 0 to 3 with each score corresponding to a cloud coverage category (e.g., 0 for clear skies with 0 to 25 percent cloud cover, 1 for 25 to 50 percent cloud cover, 2 for 50 to 75 percent cloud cover, and 3 for 75 to 100 percent cloud cover) as well as time of sunset for each survey night.

Vegetation Analysis

I surveyed the vegetation surrounding used and unused nest boxes using a spherical densiometer while standing at the entrance hole of each nest box to measure canopy cover. A vegetation profile board (VPB), of 2.5 m in height and 30.5 cm wide, was used to measure horizontal vegetation cover. The VPB was marked with alternating white and orange sections at 0.5 m intervals each. VPB measurements were taken at the nest box from each cardinal direction and measured at 5 m and 15 m out from each direction. The proportion of each 0.5 m white and orange interval obstructed by vegetation was recorded as a score from 1 to 5 with each score corresponding to a range in percent cover (e.g., 1 corresponded to 0 to 20 percent cover, 2 being 20 to 40 percent, and so on). The VBP would be split in half for maneuverability into thicker vegetation and was reconnected once in place. The distance from each nest box to the nearest tree above 2 m was also measured. Lastly, habitat types at each box were recorded as woodland, shrubland, or grassland.

Statistical Analysis

To determine the weather variables affecting nest box use overnight I assessed presence and absence of BCTI, and other avian species, using logistic regression analysis with program R 3.3.1. I used general linear mixed effect models with temperature, humidity, sky code, and wind speed as fixed factors and the nest box as a random factor. I created two logistic regression models with the same factors as predictors. The first model with presence or absence of any bird as the response variable (model 1) and the second model having presence or absence of BCTI as the response variable (model 2).

I used poisson regression analysis to determine vegetation variables affecting box use. Once again, I created two models using the parameters of canopy cover, horizontal vegetation cover at 5 m, horizontal vegetation cover at 15 m, the nearest tree above 2 m, and habitat type. For the first model I used the total number of visits per nest box from any bird as the response variable (model 3). For the second model I used the total number of BCTI visits per box as the response variable (model 4). I combined the habitat type category of shrubland with the woodland category for analysis as only three boxes were designated as shrubland. The three shrubland designations were of similar vegetative composition to the woodland habitats having ample Live Oak and Ashe Juniper trees but with less pronounced tree height.

III. RESULTS

Across two seasons of overnight nest box surveys I conducted a total of 691 surveys on the 40 nest boxes, with a total of 111 surveys having bird presence. BCTI made up 54 of the 111 surveys, with the remainder consisting of 46 Ladder-backed Woodpeckers (*Picoides scalaris*) and 11 Bewick's Wrens (*Thryomanes bewickii*).

When I analyzed the weather variables potentially affecting box selection, the presence of any bird species increased with lower temperatures. Model 1 showed that lower temperature was a significant indicator of bird presence ($p < 0.001$; Table 1) as well as model 2 which showed lower temperature as a significant indicator of BCTI presence ($p < 0.01$; Table 2; Figure 2). No other weather variables were found to have a significant effect on bird or BCTI roost selection including wind speed. However, BCTI were found more often using next boxes when wind speeds were lower (Table 2; Figure 3).

When I analyzed the vegetation parameters taken for each nest box, the horizontal vegetation cover at 15 m from the nest box was shown to be a significant indicator of bird presence. As horizontal vegetation cover at 15 m out increased there was an increase in bird and BCTI presence. Model 3 showed horizontal vegetation cover at 15 m was a significant indicator for the presence of any bird species ($p < 0.01$; Table 3) as well as model 4 which also showed horizontal vegetation cover at 15 m as a significant indicator for BCTI presence ($p < 0.01$; Table 4; Figure 4). Habitat type, canopy cover, nearest tree, and horizontal vegetation cover within 5 m of the box did not influence box use for birds or BCTI.

IV. DISCUSSION

Prior to my research the winter roosting habits of BCTI were not well known. This study is the first to scientifically examine the factors influencing winter roosting behavior of the BCTI. This study has demonstrated nest boxes are used for winter roosting by BCTI, as well as Bewick's Wrens and Ladder-backed Woodpeckers, and has shed light on some of the variables influencing winter roosting.

I found support for the hypothesis that temperature affects nest box use by BCTI, because BCTI used boxes significantly more on nights with colder temperatures. BCTI likely use nest boxes more on colder nights to conserve energy and minimize heat loss. This is an advantageous strategy for BCTI, because other passerine species have decreased energy expenditure and heat loss when roosting in cavities (Kendeigh 1961; Mayer et al. 1982; Cooper 1999). Little Owls (*Athene noctua*) were also found to roost more frequently during colder nights (Bock et al. 2013). However, most of the research on cavity roosting in the field has been conducted in regions with extremely cold winters where birds roost consistently each night (Vel'ky et. al 2010; Dhondt and Eyckerman 1980). Since BCTI are only found in regions with relatively mild winters this study demonstrates nest boxes can be beneficial to individuals of a species other than those inhabiting regions with harsh winter climates.

Wind speed was not found to be a significant indicator of nest box use for BCTI. In tropical latitudes wind may not have the same influences on nest box use as temperature. However, wind speeds at the time wind was surveyed (after birds were already roosting) was not indicative of winds speeds when birds went to roost earlier in the evening. This finding could also be due to a lack of surveys nights with high wind speeds. BCTI were found roosting on the night the highest wind speed was recorded (34 kph), but most survey nights had relatively low wind speeds with the average wind speed across both seasons being 10.9 kph. However, it has been suggested that even extremely low wind speeds increase energy expenditure while roosting (Du Plessis et. al 1994). Furthermore, birds receive more thermal benefits from the shielding of wind than the shielding of temperature (Walsberg 1986; Webb and Rogers 1988). Thus, the limited range of collected wind speeds in this study's dataset might not adequately assess the effect of wind speed on nocturnal nest box use. Future studies should aim to increase the number of nights surveyed to incorporate a greater range for wind speeds.

Horizontal vegetation cover 15 m away from nest boxes was a significant indicator of BCTI nest box use. This finding was somewhat unexpected as research has shown several different bird species select roosting sites with denser vegetation comprising the roost or near the roost site (Walsberg 1986; Vel'ky et. al 2010). But, there may be benefits to roosting in sites with sparse vegetation directly around a site and dense vegetation in the periphery. Less vegetation directly surrounding a nest box may make accessing a box more difficult for nocturnal predators. In temperate latitudes, the greatest threat to birds during winter nights is more likely temperature than predators, thus warranting dense vegetation surrounding roosting sites. This may not be the case for birds roosting in subtropical latitudes. BCTI may use nest boxes in less dense vegetation to balance the tradeoff between the cost of predation with thermal benefits from a cavity.

There are differences in roosting preferences between species, but there may also be differences within species. Individual variation in roosting site preference or needs may influence nest box selection. The individual needs of a bird may affect their decisions on roosting. For example, healthier birds might not be as discerning when selecting sites which optimize their energetic needs. Whereas, less healthy individuals likely seek out the sites best able to maximize energetic benefits. Healthy birds may also outcompete less healthy individuals for the best roosting locations.

I investigated some of the variables potentially influencing nest box cavity roosting, but there are likely other variables affecting box use. Precipitation is a possible factor influencing roosting which was not factored into analysis due to a lack of rain during surveys. Precipitation was also a limiting factor on nights with extreme rainfall when equipment and survey routes would have been hindered. Another possible influence on roost site selection is the presence of ectoparasites. Ectoparasites are known to be a deterrent for nest box roosting birds, but their presence was neither observed nor tested (Christe et. al 1994). Insect presence was observed to potentially affect BCTI roost behavior on one occasion during surveys. A Mud Dauber (*Sceliphron spp.*) nest was discovered in a nest box which was only used once by a BCTI. The insect nest was concluded to be a deterrent to roosting and was removed.

My research has demonstrated nest boxes are useful for roosting in subtropical climates and serve as winter refuge sites for different bird species. These findings can be useful to wildlife managers who aim to increase health and survival of their resident passerine populations. Nest boxes are also a viable option for managers to implement in areas with few or decreasing natural cavities. Implementing nest boxes may also be an increasingly important management tool to consider as the effects of climate change continue to progress. Harsher winters due to fluctuating climate will increase the need for available roosting sites.

Future studies in this line of research may choose to identify BCTI individuals using nest boxes for roosting. This study was conducted in a way which minimized disturbance to roosting birds, to ensure repeated overnight visits could be sustained. But this method inhibited the ability to determine individual birds. Though many BCTI at the Freeman Center have unique color bands, these bands were never visible during nest box cavity inspections if present. However, as of the 2017 breeding season a number of BCTI are now equipped with passive integrated transponder (PIT) tags as well as color bands. Future research could still maintain a non-invasive approach to cavity inspection while gathering additional data on BCTI roosting patterns.

Table 1. Regression output from Model 1. Model 1 used bird presence or absence as the response variable and the predicters of: temperature, humidity, cloud cover, and wind speed.

Variable	Estimate	Standard Error	P-Value
Intercept	-2.290	0.747	0.002 **
Temperature	-0.065	0.021	0.002 **
Humidity	-0.003	0.008	0.678
Cloud Cover	-0.110	0.135	0.415
Wind Speed	0.006	0.020	0.763

Table 2. Regression output from Model 2. Model 2 used BCTI presence or absence as the response variable and the predicters of: temperature, humidity, cloud cover, and wind speed.

Variable	Estimate	Standard Error	P-Value
Intercept	-3.292	1.151	0.004 **
Temperature	-0.097	0.030	0.001 **
Humidity	-0.018	0.011	0.122
Cloud Cover	-0.017	0.199	0.931
Wind Speed	0.034	0.026	0.206

Table 3. Regression output from Model 3. Model 3 used bird visits as the response variable and the predicters of: canopy cover, density 5 meters, density 15 meters, habitat, and nearest tree.

Variable	Estimate	Standard Error	P-Value
Intercept	0.476	0.494	0.282
Canopy Cover	0.003	0.004	0.420
Density 5 Meters	-0.348	0.275	0.152
Density 15 Meters	0.408	0.142	0.003 **
Habitat	0.067	0.288	0.829
Nearest Tree	-0.060	0.039	0.121

Table 4. Regression output from Model 4. Model 4 used BCTI visits as the response variable and the predicters of: canopy cover, density 5 meters, density 15 meters, habitat, and nearest tree.

Variable	Estimate	Standard Error	P-Value
Intercept	-2.375	0.881	0.009 **
Canopy Cover	0.005	0.005	0.251
Density 5 Meters	0.406	0.354	0.329
Density 15 Meters	0.625	0.222	0.004 **
Habitat	-0.224	0.467	0.592
Nearest Tree	0.008	0.071	0.962

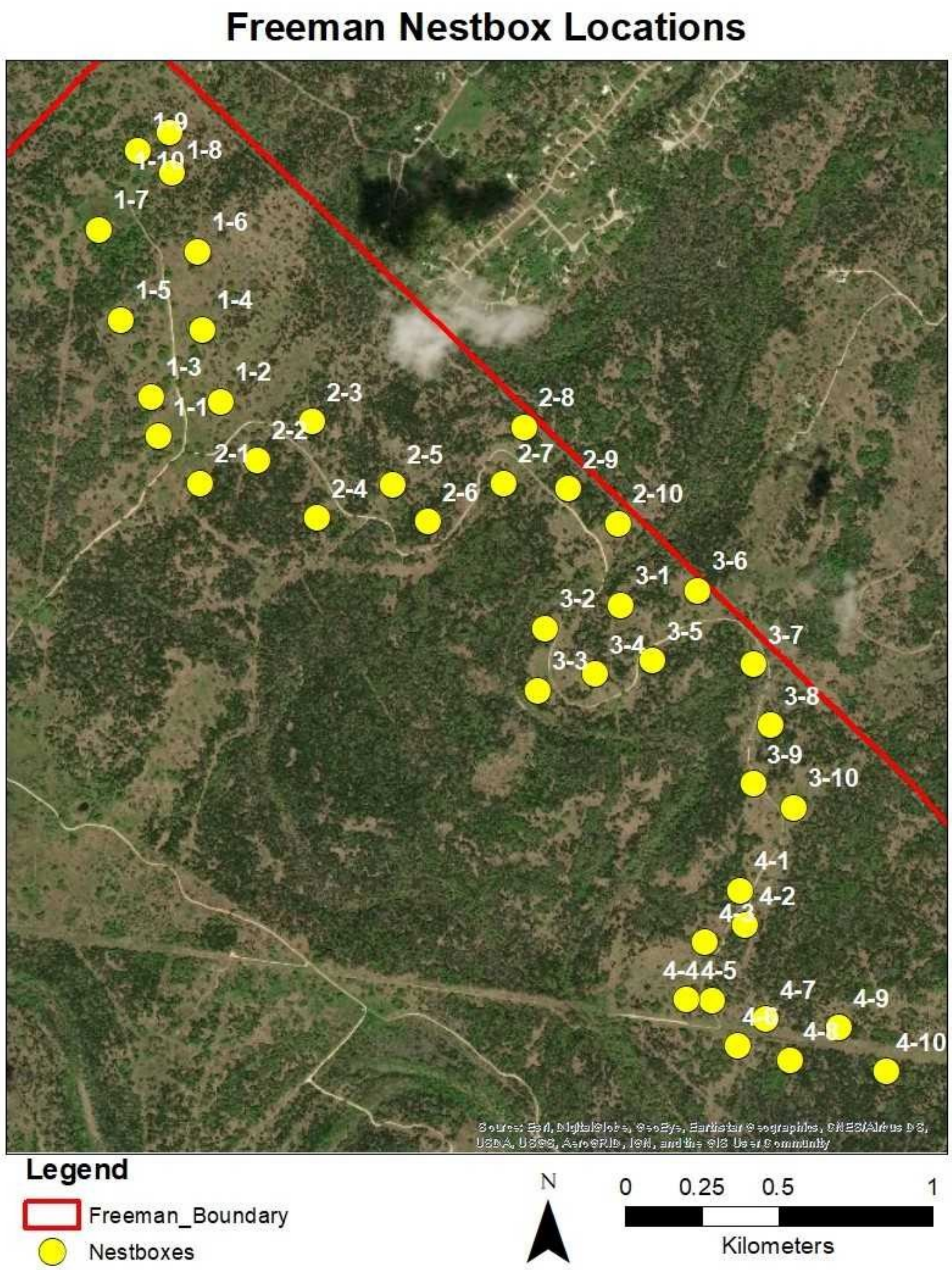

Figure 1. The 40 nest boxes used for nocturnal nest box surveys located at the Freeman Center surveyed December 2016 – February 2017 and November 2017 – February 2018.

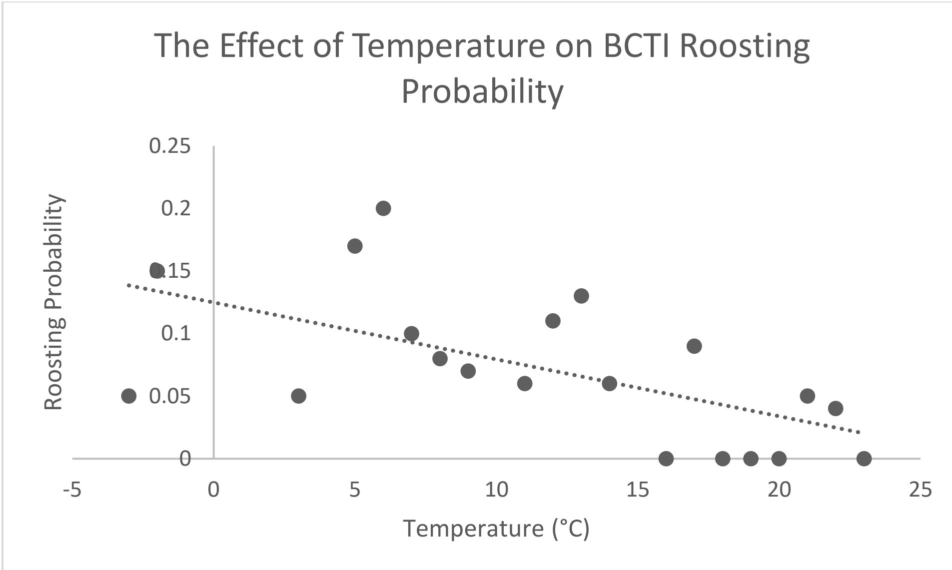

Figure 2. The temperature recorded for each BCTI visit to a nest box (n = 53) at the Freeman Center from December 2016 – February 2017 and November 2017 – February 2018. Temperature has a significant effect on BCTI roosting presence ($p < 0.01$).

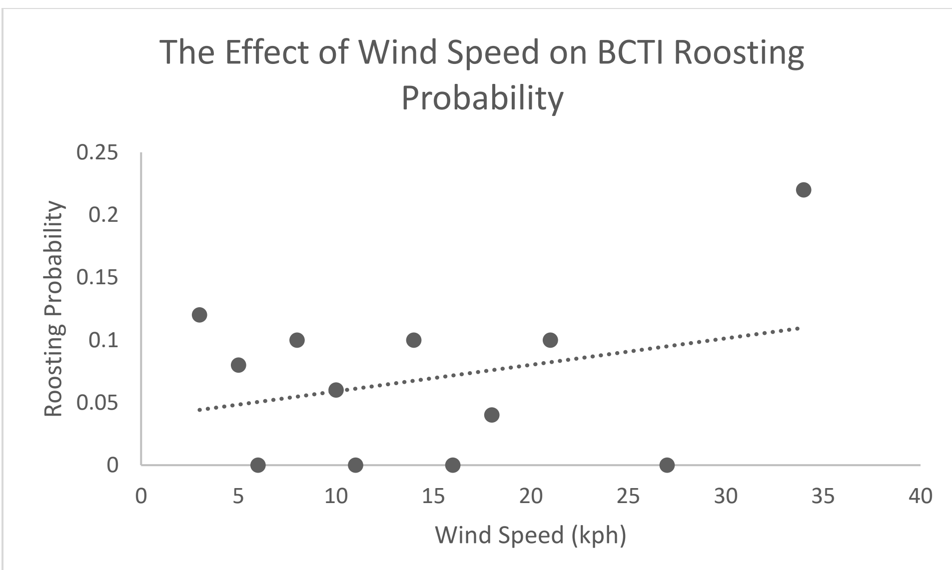

Figure 3. Wind Speed recordings for each BCTI visit to a nest box (n = 53) at the Freeman Center from December 2016 – February 2017 and November 2017 – February 2018. Wind Speed did not significantly influence BCTI roosting presence ($p = 0.256$).

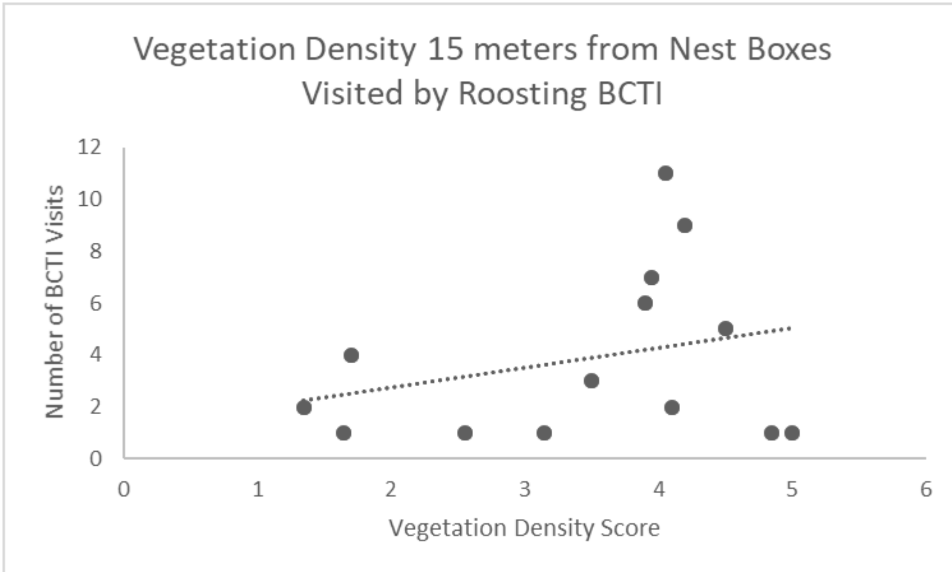

Figure 4. Vegetation density surrounding each nest box used by a BCTI for roosting. Vegetation scores correspond to a range in percent cover (1 = 0 to 20 percent, 2 = 20 to 40 percent, 3 = 40 to 60 percent, 4 = 60 to 80 percent, 5 = 80 to 100 percent) A total of 14 of the 40 nest boxes survey at the Freeman Center were used by BCTI during both winter field seasons.

LITERATURE CITED

Balda, R. P., Morrison M. L., and Bement T. R. (1977). Roosting Behavior of the Pinion Jay in Autumn and Winter. *The Auk* 94:494-504.

Baldwin, S. P., and Kendeigh, S. C. (1932). The Physiology of the Temperature of Birds. *Scientific Publication Cleveland Museum of Natural History*, 3: 1-5; 1-196.

Banks, R. C., C. Cicero, J. L. Dunn, A. W. Kratter, P. C. Rasmussen, J. V. Remsen, Jr., J. D.Rising, and D. F. Stotz. (2002). Forty-third supplement to the American Ornithologists' Union *Check-list of North American Birds*. *The* Auk 119(3):897-906.

Bock, A., Naef-Daenzer, B., Keil, H., Korner-Niegergelt, F., Perrig, M., Gruebler, M. U., and Sergio, F. (2013) Roost Site Selection by Little Owls *Athene noctua* in Relation to Environmental Conditions and Life-history Stages. I*bis*, 155(4), 847-856.

Braun, D., Kitto, G., and Braun, M. (1984). Molecular Population Genetics of Tufted and Black-Crested Forms of Parus bicolor. *The Auk, 101*(1), 170-173.

Brawn, J., and Samson, F. (1983). Winter Behavior of Tufted Titmice. *The Wilson Bulletin, 95*(2), 222-232.

Buttemer, W. (1985). Energy Relations of Winter Roost-Site Utilization by American Goldfinches (Carduelis tristis). *Oecologia,68*(1), 126-132.

Carrascal, L., and Moreno, E. (1994). Food caching versus immediate consumption in the nuthatch: The effect of social context. *Ardea*, 81(2), 135-141.

Christe, P., Oppliger, A., and Richner, H. (1994). Ectoparasite affects choice and use of roost sites in the great tit, *Parus major*. *Animal Behaviour*, 895.

Cooper, S. (1999). The Thermal and Energetic Significance of Cavity Roosting in Mountain Chickadees and Juniper Titmice. *The Condor, 101*(4), 863-866.

Dhondt, A., and Eyckerman, R. (1980). Competition Between the Great Tit and the Blue Tit Outside the Breeding Season in Field Experiments. *Ecology, 61*(6), 1291-1296.

Dhondt, A. A., Blondel, J., and Perret, P. (2010). Why do Corsican Blue Tits *Cyanistes caeruleus ofliastrae* not use nest boxes for roosting?. *Journal Of Ornithology*, 151(1), 95-101.

Dixon, K. (1954). Some Ecological Relations of Chickadees and Titmice in Central California. *The Condor, 56*(3), 113-124.

Dixon, K. (1978). A Distributional History of the Black-crested Titmouse. *The American Midland Naturalist, 100*(1), 29-42.

Du Plessis, M., Weathers, W., and Koenig, W. (1994). Energetic Benefits of Communal Roosting by Acorn Woodpeckers during the Nonbreeding Season. *The Condor, 96*(3), 631-637.

Du Plessis, M., and Williams, J. (1994). Communal Cavity Roosting in Green Woodhoopoes: Consequences for Energy Expenditure and the Seasonal Pattern of Mortality. *The Auk, 111*(2), 292-299.

Evans, P. (1969). Winter Fat Deposition and Overnight Survival of Yellow Buntings (Emberiza citrinella L.). *Journal of Animal Ecology, 38*(2), 415-423.

Frazier, A. and Nolan, V. (1959). Communal Roosting by the Eastern Bluebird in Winter. *Bird-Banding, 30*(4), 219-226.

Gavrilov V, Veselovskaya. E, Gavrilov V, Goretskaya M, Morgunova, G. (2013). Diurnal rhythms of locomotor activity, changes in body mass and fast reserves, standard metabolic rate, and respiratory quotient in the free-living coal tit (*Parus ater*) in the autumn-winter period. *Biology Bulletin*, 40(7): 678-683.

Harrap, S. and D. Quinn. (1995). Chickadees, tits, nuthatches and treecreepers. Princeton, NJ: Princeton Univ. Press.

Kendeigh, S. C. (1961). Energy of Birds Conserved by Roosting in Cavities. *The Wilson Bulletin, 73*(2), 140-147.

Kendeigh, S.C. (1969). Tolerance of Cold and Bergmann's Rule. *The Auk* 86 (1): 13–25.

Kilham, L. (1971). Roosting habits of White-breasted Nuthatches. *Condo*r no. 73:113-114.

Krams, I., Cirule, D., Vrubleyska, J., Nord, A., Rantala, M. J., and Krama, T. (2013) Nocturnal loss of body reserves reveals high survival risk for subordinate great tits wintering at extremely low ambient temperatures. *Oecologia*. 172(2), 339-346.

Lemmon, P.E. (1956). A Spherical Densiometer for Estimating Forest Overstory Density. *Forest Science*, 2(4), 314-320.

Macias-Duarte, A., Panjabi, A. O., Strasser, E. H., Levandoski, G. J., Ruvalcaba-Ortega, I., Doherty, P. F. and Ortega-Rosas, C. I. (2017), Winter survival of North American grassland birds is driven by weather and grassland condition in the Chihuahuan Desert. J. *Field Ornithology*., 88: 374-386.

Mayer, L. Lustick, S. Battersby B., (1982). The importance of cavity roosting and hypothermia to the energy balance of the winter acclimatized Carolina chickadee. *International Journal of Biometerology*. 26(3), 231-238.

Møller, A. (2015). The allometry of number of feathers in birds changes seasonally. *Avian Research*, 6(1).

Patten, Michael A. and Brenda D. Smith-Patten. (2008). Black-crested Titmouse (*Baeolophus atricristatus*), version The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: https://birdsna-org.libproxy.txstate.edu/Species-Account/bna/species/blctit4

Peterson, R. T. (2008). Field Guide to Birds of North America. Houghton Mifflin Company, New York. Pg 300.

Petit, M., Claviio-Baquet, S., and Vezina, F. (2017). Increasing Winter Maximal Metabolic Rate Improves Intrawinter Survival in Small Birds. *Physiological And Biochemical Zoology: PBZ*, 90(2), 166-177.

Pitts, T. D. (1976). Fall and winter roosting habits of Carolina Chickadees. *Wilson Bull.* no. 88:603-610.

Riesenfeld, A. (1981). The role of body mass in thermoregulation. *American Journal Of Physical Anthropology*, 55(1), 95-99.

Rylander, R. J. (2015). Mister Parid's Neighborhood - dispersal behavior and flocking dynamics of the social Black-crested Titmouse (*Baeolophus atricristatus*).

Santos, C D., Lourenco, P M., Miranda, A C., Granadeiro, J P., Palmeirim, J M., (2008). Birds after dark: an efficient and inexpensive system for making long-range observations at night. *Journal of Field Ornithology*, 79(3), 329-335.

Tyller, Z., Paclik, M., and Remes, V. (2012). Winter Night Inspections of Nest Boxes Affect their Occupancy and Reuse for Roosting by Cavity Nesting Birds. *Acta Ornithologica*, 47(1), 79-85.

Vel'ky, M., Kanuch, P., and Kristin, A. (2010). Selection of roosting vegetation in the great tit, *Parus major*, during the winter period. *Ethology Ecology And Evolution*, 22(3), 305-310.

Waite, T. (1992). Winter Fattening in Gray Jays: Seasonal, Diurnal and Climatic Correlates. *Ornis Scandinavica (Scandinavian Journal of Ornithology), 23*(4), 499-503.

Walsberg, G. (1986). Thermal Consequenses of Roost-Site Selection: The Relative Importance of Three Modes of Heat Conservation. *The Auk*, 103(1), 1-7.

Webb, D., and Rogers, C. (1988). Nocturnal Energy Expenditure of Dark-Eyed Juncos Roosting in Indiana During Winter. *The Condor*, 90(1), 107-112.