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Factors Influencing Apparent Nest Success in Eastern Bluebirds

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Factors influencing apparent nest success in Eastern Bluebirds

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Collection of basic breeding biology data and analysis of factors that can impact the apparent nest success of passerines is critical in tracking population dynamics and making decisions concerning conservation. The Eastern Bluebird (*Sialis sialis*) is one species of concern whose declines in abundances fueled the common practice of establishing artificial nest boxes. I carried out my study in 2019 on the SUNY Brockport campus using 20 Audubon and 20 Peterson nest boxes to investigate what variables may impact fledgling success, including egg and nestling traits as well as site characteristics. Egg mass and volume tended to be larger in Audubon boxes, which also appeared to have higher success rates, but only egg volume was significant. Peterson style boxes were chosen more often, however. Vegetation variables revealed no statistical significance between successful and unsuccessful nests, but literature supports their strong effect on nest success. Larger sample sizes would have helped reinforce my results. However, they do offer interesting opportunities for conservationists in terms of box type and habitat when considering Eastern Bluebird nesting success.

INTRODUCTION

Songbird population declines are of increasing concern to bird enthusiasts as well as ecologists. The ability to track population fluctuations results from decades of data collection by citizen scientists and committed ornithologists on basic breeding ecology. These include fertility patterns, fledgling success or fitness, and constraints on breeding habitat. One species that has attracted attention is the Eastern Bluebird (*Sialis sialis)*, a popular cavity-nesting passerine. Being one of the more familiar species throughout eastern North America, Eastern Bluebirds are a useful study subject for projects seeking to track population changes and discover what variables hold the greatest influence over such dynamics (Sauer and Droege 1990; Sauer *et al.* 1996; Wetzel and Krupa 2013).

Multiple factors impact the apparent nest success of Eastern Bluebirds, which I define as any nest that fledges a minimum of one nestling. With the egg-viability and clutch-cooling hypotheses acting as their foundation, several projects have researched the effects of temperature on seasonal and latitudinal patterns in hatching failure and clutch size trends across large geographical gradients (Cooper *et al*. 2005; Cooper *et al.* 2006). Localized studies focus at a smaller scale, assessing a greater diversity of variables that include predation risk, inter- and intraspecific competition, breeding habitat suitability, nesting history, behavior, and philopatry (Nice 1957; Pinkowski 1979 a, b; Horn *et al*. 1996). Complex datasets like these provide information on how such factors influence nest success, but they can a require long-term research commitment. Thus, very few intensive basic breeding biology studies have been performed on Eastern Bluebirds. For example, growth and development of juveniles has only been reported on in a few papers (Pinkowski 1975). Natal philopatry and juvenile dispersal patterns also need more research (Gowaty and Plissner 2020). These gaps in ecological data support the idea that other aspects of Eastern Bluebird breeding biology require further investigation.

Pinpointing any single factor that determines whether a nest will successfully hatch is highly improbable. However, determining what causes a nest to fail can help narrow down the possibilities. Recording basic information on egg dimensions and monitoring growth of nestlings is often the basis for defining fitness variables relating to parent birds and their young (Pinkowski 1975; Pinkowski 1979 b). Nest site fidelity, or the presence of high-quality nesting environments that warrant a return in future seasons, is also a key character in nest site selection, which ultimately contributes to nest success (Stanback and Rockwell 2003). This illustrates the impact of habitat characteristics, like predation risk, prevalence of competitors, food supply, orientation of the nest entrance, and the availability of other prime nest sites, on fledgling success (Davis *et al*. 1994; Meek and Robertson 1994; Stanback and Rockwell 2003; Navara and Anderson 2011). As a multi-brooded altricial passerine, these stressors on Eastern Bluebirds are compounded as temperate seasons advance, influencing optimal temperature ranges for embryo development (Cooper *et al*. 1995) and fluctuating resource availability. This impacts another factor in nest success—the female's body condition and experience (Robinson *et al*. 2010).

The objective of my study was to assess factors that affect apparent nest success in Eastern Bluebirds and provide basic breeding biology data for the species. I measured egg and nestling traits and tracked nesting cycles during clutch initiation, hatching, and fledging. I also performed vegetation measurements and observed specific breeding behaviors. The presence of two types of nest boxes, the Audubon and Peterson, was a guiding factor when I analyzed my data. In considering the conservation of Eastern Bluebirds or other passerine birds, basic knowledge of life history strategies is critical, especially in a time of unprecedented environmental change.

METHODS

I studied Eastern Bluebird breeding ecology on the SUNY College at Brockport campus, Town of Sweden, Monroe County, NY during the 2019 breeding season starting in early April and ending in late August. There were 20 Eastern Bluebird nest box sites placed throughout the campus sports fields and aquaculture ponds, each with a pair of boxes, totaling 40 nest boxes (Figure 1). An Audubon and Peterson box, two common types of Eastern Bluebird nest boxes, compose each of the pairs. Audubon boxes are tall, rectangular, and have dimensions around 20 x 13 x 8 inches (51 x 33 x 20 cm). Peterson boxes have a unique tapered appearance and are typically 7 x 9 x 14 inches (18 x 23 x 36 cm) (Figure 2). A majority of the sites were established in 2017, with additional boxes placed in 2018, by Andie Graham (Department of Environmental Science and Ecology, College of Brockport). Ms. Graham has supervised the project since its inception. Each box was checked once every week at minimum and once every day at most to reduce disturbance.

I observed nest sites from a distance before approaching to assess the intensity of bluebird activity, presence of other species (within a 15 m radius) and any other events of note, like individual behavior. At the nest box I counted the number of eggs, measured their length, width, and mass using Vernier calipers and weighed them using a 5-g spring scale, once it was confirmed that no more eggs would be laid within the clutch (~ 1 week). Hatchability, or the percent of eggs laid that successfully hatch, was also calculated and does not include eggs that were predated (Hendricks and Norment 1994). I also counted the number of nestlings, weighed them with a 40-g spring scale, and measured primary feather length, tarsus, and wing chord lengths using Vernier calipers and a metal ruler. This was done, or as close as possible to, 14 days after hatching, just before the minimum age of fledging (Pinkowski 1975; Gowaty and Plissner 2020). Any evidence of predation was also recorded.

I conducted vegetation surveys at each box during mid-July. I measured a circle with a 10 m radius around each box using a tape reel. At every 1 m interval in all four cardinal directions, I indicated canopy cover as present or absent using an ocular tube directed straight up. All 40 points were combined into a percentage afterward. The tallest vegetation was measured within a 1 m radius of the box using a meter stick and distance to the closest woody vegetation (dead or alive) was also recorded with the tape reel. Two values were recorded for this variable, one for plants under 2 m tall and one for those greater than 2 m. I also estimated percent mowed area within the 10 m radius and distance to the closest mowed area. Finally, the magnetic orientation of the box's opening was determined using a compass.

The statistical analyses I performed were largely nonparametric due to small sample sizes and the lack of normal distributions for many variables. I used a *t*-test and boxplots to analyze egg mass, volume, and clutch size based on individual nest means to avoid pseudoreplication (Hurlbert 1984). A Kruskal-Wallis test and chi-squared test for association was used to assess fledgling success, between years and nest box types, while a *t*-test and Mann-Whitney tests compared vegetation characteristics between successful and unsuccessful sites. Data from 2017 and 2018, provided by Ms. Graham, were available for clutch sizes and nest success as well as some vegetation characteristics and were used in comparative analyses whenever possible.

RESULTS

Nesting Cycle

Several key dates occur during a bluebird's nesting cycle: the date of clutch initiation, hatching, and fledging. These typically range over several weeks depending on when a bird nests. The nest cycle I compiled is shown in Figure 3. Of the 2019 nests studied (n=20), two were determined to be double broods, what I defined as pairs who used the same box and had the same outcome for both nesting attempts (successful or not successful). In this instance, it was the Audubon at site 2 and the Peterson at site 12. Both broods fledged successfully at these sites and were likely from the same parental pair. There were no sites where both nest boxes were occupied by Eastern Bluebirds at the same time. Clutch initiation for first broods ranged from April 11 to July 27, hatching period began around April 25 and lasted until early August, fledging events started around May 22 and continued until August 27. Median dates show high concentrations of each event occurring on earlier dates with a few late breeders initiating towards the end of the season. The pair of second broods had a combined cycle beginning on June 23 with clutch initiation and fledging occurring by the end of July.

Other species that nested in the bluebird boxes included House Sparrows (*Passer domesticus*), Tree Swallows (*Tachycineta bicolor*), and House Wrens (*Troglodytes aedon*). Sites with an active Eastern Bluebird nest did not usually have another species present in the neighboring box. House Wren nests were also typically the sole occupant at each site where they built a nest. One site had a bluebird nest and House Wren nest at the same time, each with eggs. The bluebird nestlings at this site disappeared several days after hatching. House Sparrows and Tree Swallows would often occupy both boxes at the same site simultaneously.

Egg Traits

The presence of two types of nest boxes at each site poses an interesting opportunity to compare breeding biology variables between them. Only 15 nests provided egg trait data due to predation of the remaining 5. Both egg mass and egg volume tended to be larger in Audubon boxes (Figure 4 and 5). A two-sample t-test indicated that only egg volume was significantly different between the nest box types (t = -3.51, p = 0.017). Mean egg mass and volume (mean ± SE) for Peterson boxes was 2.78 ± 0.06 g and 2662.6 ± 62.8 mm^3, respectively, and 2.96 ± 0.08 g and 3094.0 ± 105.6 mm^3 for the Audubon boxes. Calculated averages across nest means for both box types yielded 2.83 ± 0.05 g and 2777.6 ± 72.8 mm^3.

Clutch Size

Clutch size variation across all years (2017-2019, n = 43) ranged from two nests with two eggs in 2019, one nest of three in 2019, and one nest of six eggs in 2017, while all others were clutches of four or five eggs (Table 1). A Kruskal-Wallis test revealed no significant difference among years. The mean clutch size for all boxes observed between 2017 and 2019 was 4.3 ± 0.1. No significant difference was found between the Peterson (n = 19) and Audubon (n = 24) nest boxes, whose averages were 4.2 ± 0.2 and 4.6 ± 0.1 eggs respectively (t = -1.46, p = 0.154).

Nestling Characteristics and Apparent Nest Success

I was unable to collect enough nestling biology data to perform proper statistical analyses, but for those that could be handled without fear of forced fledging or parental stress, summary data is provided. Nestlings from five nests, totaling 18 birds, had an average mass of 28.9 ± 0.5 g, tarsus length of 20.4 ± 0.1 mm, and wing chord length of 55.2 ± 2.8 mm. The length of the first primary feather was also determined on a few individuals, but consistency in measuring was lacking, so I did not include data for this variable. Averages across individual nestlings were used rather than nest means because of low sample size and to provide relative information on body characteristics for comparison with other studies. No significance was found between the number of fledglings and the year ($H = 4.21$, $p = 0.122$) (Figure 6). The number of offspring that successfully fledged between the Peterson and Audubon boxes across all years did not differ significantly ($x^2 = 2.052$, $p = 0.152$), but Audubon boxes appeared to have a tendency for higher success rates when considering the ratio of boxes selected and those that fledged at least one nestling (Figures 7 and 8). A 68% hatchability rate was found for first clutches using Hendricks and Norment's method (1994).

Vegetation Variables

Out of all vegetation variables measured, only the tallest vegetation within 1 m was normally distributed and could be analyzed with a *t*-test. All others were assessed using the Mann-Whitney test. No vegetation variables differed significantly between successful and unsuccessful sites (Table 2), but some tentative patterns were observed in the woody vegetation <2 m tall and canopy cover. Figure 9 illustrates the distance a nest box is from the nearest tall woody vegetation. All successful sites were 10 m or closer while Figure 10 shows all successful sites had 30% or less canopy cover.

I did not measure disturbance in this study, but an interesting discovery was made regarding site 12, which was used once in 2018 and twice in 2019 by Eastern Bluebirds. It is the most disturbed set of boxes in terms of human presence. The Peterson box at this site successfully fledged all hatchlings every time it was used.

DISCUSSION

Most of the basic breeding biology data I collected can be compared to values found in other studies that have also researched Eastern Bluebird breeding ecology. These include egg mass, egg volume, clutch size, and nestling traits. A few of my vegetation variables can also be compared with literature relating to habitat characteristics and how they affect apparent nest success.

Songbird egg size is a common variable used to assess the fitness of both the parents and their young. In general, smaller broods and chicks hatched from larger eggs have a greater probability of survival while those in double broods with smaller eggs have decreased success due to less reproductive investment from degrading parental body condition (Pinkowski. 1979 b). Average egg mass and volume of all nests in my study were 2.83 ± 0.05 g and 2777.6 ± 72.8 mm^3. According to Gowaty and Plissner (2020), Eastern Bluebird eggs have an average mass of 3.6 g in Tennessee and 3.07 g in South Carolina. Pinkowski (1979 b) showed that female bluebirds who were laying their first clutch had egg volumes averaging 2999.1 mm^3. In comparison, SUNY Brockport nests had smaller eggs than those in more southern areas. The earlier onset of winter and migration in northern latitudes dictates resource allocation of the parents who must maintain their own physical condition on top of the eggs and young (Ritchison 2000). Out of the 18 first clutches laid during the 2019 season, 11 successfully fledged at least one juvenile bluebird and hatchability was lower than expected. Percent hatching rates in other studies for Eastern Bluebirds range from 63.0-80.1% (Nice 1957) and as high as 83% (Gowaty and Plissner 2020).

Since each site had a pair of nest boxes, comparison of the measured variables between the two types presented a unique opportunity. For first clutches in 2019, 15 were laid in Peterson boxes and 4 in Audubon boxes. My data showed no significant difference in egg mass between the Audubon and Peterson nest boxes, but it tended to be larger in the former type. Egg volume was significantly different between the nest boxes and followed the same trend as egg mass with Audubon clutch volumes being larger. This, coupled with the fact that all Audubon nests successfully fledged a higher proportion of young, is an intriguing discovery in terms of how best to increase nest success within the species. Despite having high apparent nest success, the number of nests within Audubon boxes was small compared to Peterson boxes during 2019. The Peterson and Audubon boxes are the two most popular designs for bluebirds and begs the question how choice by the parents is influenced by the different boxes. One study involving multiple sites and bluebird box types showed high preference for Peterson types, followed by PVC and Audubon styles, respectively (Berner 1995). Another study found that Eastern Bluebird choice of artificial nests had no solid association with the entrance diameter and box depth (Munro and Rounds 1985). Comparison of nest success between the two throughout this paper offers insight for conservationists and birders alike who wish to assist in increasing their numbers as efficiently as possible. The fact that Eastern Bluebirds choose Peterson boxes more often but appear to be more successful in the Audubon style within my study, might lay the groundwork for further experiments in manipulation of box types.

As mentioned before, multiple factors may influence apparent nest success. I also investigated clutch sizes to find any patterns in relation to fledgling success across years and between nest box types. Some headway has been made in a small number of studies led by Cooper *et al* (2005, 2006) on Eastern Bluebirds that investigated the egg-viability and clutch-cooling hypotheses, but they found no concrete trends. Data involving clutch sizes was available for 2017 and 2018 for comparison with my results. On average, clutches at SUNY Brockport contained either 4 or 5 eggs. This is a well-supported trend although Eastern Bluebird clutches can range from 2 to 7 eggs (Crowell and Rothstein 1979). The few small clutch sizes in my study may have been due to predation or abandonment of an egg by the parents, but I could not determine the culprit. Smaller clutches are also laid later in the season because of lower survival probabilities influenced by resource availability or degrading parental condition (Ritchison 2000). Ultimately, no significant in clutch size difference between nest box types or across all years was found. This follows trends in the literature concerning the limited success in defining variables influencing local clutch size trends (Cooper *et al*. 2005, Cooper *et al*. 2006).

Nestling body condition is another set of measurements used to determine general fitness and is most likely a factor in fledgling success. Determination of a normal growth rate is key and has been performed on several species as it allows for several experimental studies and the analyses of population dynamics (Pinkowski. 1975). Due to time, local circumstances, parental disturbance, and risk of premature fledging, I could only measure a small number of nestlings to provide summary data.

Towards the end of the nestling period, young bluebirds weigh about 90% of a typical adult weight, or 27.2 g, have a tarsus length of around 21 to 22 mm, and wing chord length around day 14 is 58.70 ± 2.84 mm (Pinkowski. 1975). All three of these variables were extremely similar to the ones averaged amongst all the Brockport nestlings. Mass was slightly higher and tarsus/chord length fractionally smaller, but these were only marginal differences that would not be significantly different if tested. As such, the nestlings within this study follow typical distributions presented in the literature.

Data from previous years allowed me to test for significant differences in fledgling numbers between 2017, 2018, and 2019. No significant difference was found, suggesting there were no extrinsic environmental variables that may have affected nest success. The number of Eastern Bluebird hatchlings that successfully fledge ranges between 75-90% (Gowaty and Plissner 2020). From 2017 to 2019, the number of juvenile Eastern Bluebird eggs that made it to fledging in my study was 57.8%, which is much lower than reported estimates. Fledgling success also did not significantly differ between the Audubon and Peterson boxes. However, there was a tendency for Audubon boxes to have greater success rates than Peterson boxes. A larger sample size would be required to fully examine these variables, but this provides a basis for future study.

My analyses found no significant evidence that vegetation characteristics affected apparent nest success, but I believe this might have been due to low sample size. Many studies have shown habitat characteristics surrounding the nest site can affect the survival of the eggs and young. Eastern Bluebirds are dependent upon perches but avoid areas with dense undercover or shrubs (Munro and Rounds 1985). This is likely due to the ability of predators and competitors to conceal themselves in such environments. House Wrens most likely destroyed several nests in my study. Nest sites that neighbored thick forest borders often held the dense stick nests of the House Wren. Site 9 and 17 are two examples where eggs were pipped or young nestlings disappeared, activities performed by House Wrens to remove competitors. Another box that had meter high grass surrounding it lost hatchlings a few days shy of fledging. This was likely the result of a non-avian predator whose approach was masked by the thick grass. Sites with very little or no tall vegetation surrounding the box had high occupation rates while those with tall herbaceous plants nearby were largely uninhabited (Navara and Anderson 2011). This illustrates the preference of Eastern Bluebirds for nesting in open areas with scarce woody vegetation. Horn *et* al. found that successful nests were, on average, 6.55 ± 1.88 m, but unsuccessful nests were around 2.67 ± 0.73 m away. These patterns are similar to the ones shown in Figure 9 for my own data. Unsuccessful nests in my study had a large tree either very close or a decent distance away while successful nests fell below 10 m. The avoidance of forested and shrubby areas is reinforced by these patterns and demonstrated in Figure 10.

Disturbance is another influential factor that is estimated in many studies. I did not collect data on this variable, but site 12 was unique in that it was within 10 m of a parking lot and only a few meters from a sidewalk leading into the college campus. The entire area is mowed except for strip of scrubby hedgerow nearby the sidewalk. This site was unique due to the highest success rates for any nest box location over three years. Investigation as to how such man-made structures and human contact influences fledgling success would be interesting. Their effects on parental behavior could also be studied as the pair that nested here twice in 2019 was highly aggressive when I approached their nest box.

CONCLUSION

The intent of my study was to collect basic breeding biology data on Eastern Bluebirds and analyze several variables that may influence apparent nest success within the species. Egg traits, like mass and volume, as well as nestling measurements of mass, tarsus, and wing chord lengths provide fitness data that are used in many studies involving breeding or nesting biology. These basic parameters are easily collected and combined with regional data to produce population statistics across entire landscapes. Vegetation surveys are another common analysis performed within a study site due to the wide-ranging effects habitat can wield over avian breeding success. A fascinating opportunity was presented to me because of the way each site is outfitted with two different box types, an Audubon and a Peterson. This offered another variable in apparent nest success since they are the most widely used designs for bluebird nest boxes.

Most of my results followed typical trends reported in the literature. Hatchability and fledgling success were lower than expected and indicate that the SUNY Brockport campus may have unfavorable site conditions. My most intriguing discovery was the differences found between clutches laid in the Peterson and Audubon nest boxes. Not only did eggs tend to be larger in the Audubons, those nests were also the most successful with zero failing to produce fledglings. Clutch sizes and fledging success did not significantly differ in my analyses, but there is an obvious trend for the Audubon box type to be more successful. Very few Audubon boxes were selected in comparison to the number of Peterson boxes, and yet there is a higher proportion of nest success in the Audubon boxes (Figures 7 and 8). This presents an intriguing opportunity to further study how each box influences apparent nest success. Is it the interior shape that makes Petersons more alluring? What is it about Audubons that make them more successful and produce larger eggs? More intensive study of surrounding vegetation and habitat characteristics would also be interesting to study since several of my variables offered significant influence over apparent nest success. The nature of the SUNY Brockport sites offers numerous habitat types. Within my 20 sites, their individual variability was quite extensive. Some sites were in the middle of a mowed field while others were surrounded by meadow grass. Some had overhanging branches touching the boxes while others only had a few sparse trees a fair distance away. One site was surrounded by cattails and several bordered the forest. And site 12 was the most disturbed of all yet fledged all nestlings multiple times. Having a study focused more on site characteristics could offer deep insight into how much vegetation influences apparent nest success.

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LITERATURE CITED

Berner, K. L. 1995. Comparison of use of several styles of nest boxes by cavity nesting birds: an update. Sialia 17:127-135

Cooper, C. B., W. M. Hochachka, G. Butcher, and A. A. Dhondt. 2005. Seasonal and latitutidinal trends in clutch size: thermal constraints during laying and incubation. Ecology 86:2018-2031.

Cooper, C. B., W. M. Hochachka, T. B. Phillips, and A. A. Dhondt. 2006. Geographical and seasonal gradients in hatching failure in Eastern Bluebirds *Sialis sialis* reinforce clutch size trends. Ibis 148:221-230.

Crowell, K. L. and S. I. Rothstein. 1979. Clutch sizes and breeding strategies among Bermudan and North American passerines. Ibis 123:42-50.

Davis, W. H., P. J. Kalisz, and R. J. Wells. 1994. Eastern Bluebirds prefer boxes containing old nests. Journal of Field Ornithology 65:250-253.

Gowaty, P. A. and J. H. Plissner. 2020. Eastern Bluebird *Sialis sialis*, version 1.0. [Online.] Cornell Lab of Ornithology, Ithaca, New York. Available at: https://birdsoftheworld.org/bow/species/easblu/cur/introduction. Accessed 26 March 2020.

Hendricks, P. and C. J. Norment. 1994. Hatchability of American Pipit eggs in the Beartooth

Mountains, Wyoming. The Wilson Bulletin 106:392-399.

Horn, D. J., M. Benninger-Truax, and D. W. Ulaszewski. 1996. The influence of habitat characteristics on nestbox selection by Eastern Bluebirds (*Sialis sialis*) and four competitors. Ohio Journal of Science 96:57-59.

Hurlbert, S. H. 1984. Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54:187-211.

Meek, S. B. and R. J. Robertson. 1994. Interspecific competition for nestboxes affects mate guarding in Eastern Bluebirds, *Sialis sialis*. Animal Behaviour 47:295-302.

Munro, H. L. and R. C. Rounds. 1985. Selection of artificial nest sites by five sympatric passerines. Journal of Wildlife Management 49:264-276.

Navara, K. J. and E. M. Anderson. 2011. Eastern Bluebirds choose nest boxes based on box orientation. Southeastern Naturalist 10:713-720

Nice, M. M. 1957. Nesting success in altricial birds. Auk 74:305-321.

Pinkowski, B. C. 1975. Growth and development of Eastern Bluebirds. Bird-Banding 46:273-289.

Pinkowski, B. C. 1979. a. Annual productivity and its measurement in a multi-brooded passerine, the Eastern Bluebird. Auk 96:562-572.

Pinkowski, B. C. 1979. b. Effect of nesting history on egg size in Eastern Bluebirds. Condor 81:210.

Pinkowski, B. C. 1979. c. Nest site selection in Eastern Bluebirds. Condor 81:435-436

Ritchison, G. 2000. Wild bird guides: Eastern Bluebird. First Edition. Stackpole Books, Mechanicsburg, Pennsylvania, USA.

Robinson, T. J., L. Siefferman, and T. S. Risch. 2010. Seasonal tradeoffs in reproductive investment in a multi-brooded passerine. Condor 112:390-398.

Sauer, J. R., G. W. Pendleton, and B. G. Peterjohn. 1996. Evaluating causes of population change in North American insectivorous songbirds. Conservation Biology 10:465-478.

Sauer, J. R. and S. Droege. 1990. Recent population trends of the eastern bluebird. The Wilson Bulletin 102:239-252.

Stanback, M. T. and E. K. Rockwell. 2003. Nest-site fidelity in Eastern Bluebirds (*sialis sialis*) depends on the quality of alternate cavities. The Auk 120:1029-1032.

Wetzel, D. P. and J. J. Krupa. 2013. Where are the bluebirds of the bluegrass? Eastern bluebird decline in central Kentucky. American Midland Naturalist 169:398-408.

TABLES AND FIGURES

Table 1. Distribution and totals for clutch sizes of first broods for 2017, 2018, and 2019. Peterson: n = 24; Audubon: n = 19.

	Clutch Size				
Year	2	3	4	5	6
2017	0	0	5	8	0
2018	0	0	4	5	1
2019	2	1	12	5	0
Total	2	1	21	18	1

Table 2. Descriptive and test statistics for each vegetation variable at successful and unsuccessful sites. Mean ± standard error of the mean.

Test	**Mean (Successful)**	**Mean (Unsuccessful)**	**Test Statistic**	***p***
Two Sample *t*-test	89.4 ± 20.8	97.4 ± 25.2	-0.25	0.81
Mann-Whitney	17.3 ± 7.5	6.8 ± 2.6	114.5	0.39
Mann-Whitney	7.4 ± 2.3	8.3 ± 3.9	107.5	0.82
Mann-Whitney	22.6 ± 8.4	39.4 ± 12.7	94.0	0.36
Mann-Whitney	65.1 ± 7.6	62.6 ± 7.6	101.0	0.79
Mann-Whitney	0.8 ± 0.5	0.6 ± 0.2	100.5	0.74

Figure 1. Map showing the location of paired nest box sites on the SUNY Brockport campus.

Figure 2. The Peterson and Audubon Eastern Bluebird nest boxes used at each site (Stovall Products and Woodlink).

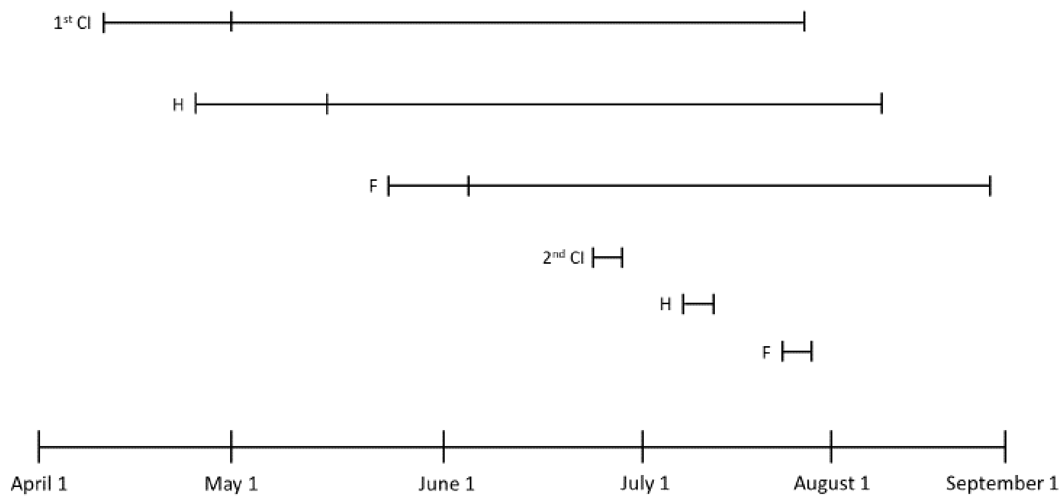

Figure 3. Nesting cycle for 2019 Eastern Bluebird breeding season at SUNY Brockport. Date ranges and medians for clutch initiation (CI), hatching (H), and fledging (F) are shown for both first and second broods. First brood: n = 18 for CI, n = 14 for H, n = 11 for F. Second brood: n = 2 for CI, H, and F.

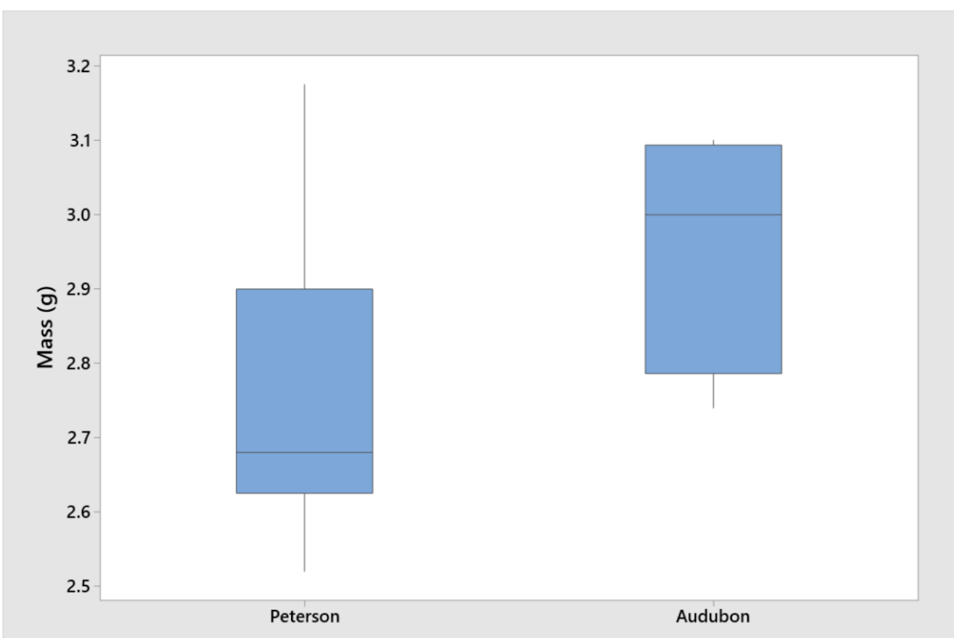

Figure 4. Mean egg mass distributions of first clutches in Peterson and Audubon nest boxes for 2019: n = 11 for Peterson and n = 4 for Audubon. Box and whiskers represent range of egg mass means with the center horizontal line showing the median of the data.

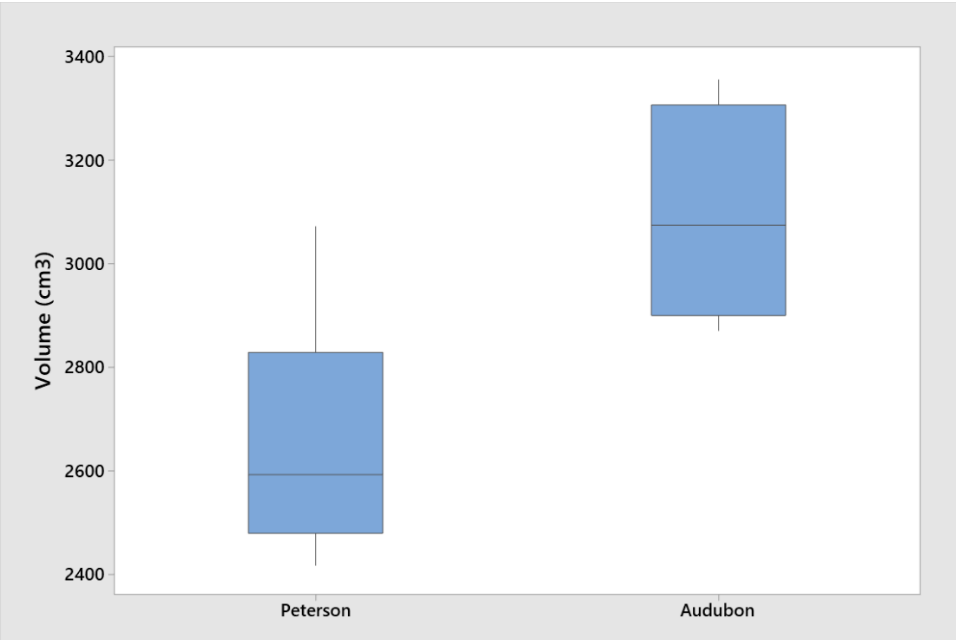

Figure 5. Mean egg volumes for first clutches in the two nest boxes: n = 11 for Peterson and n = 4 for Audubon. Box and whiskers represent range of egg volume means with the center horizontal line showing the median of the data.

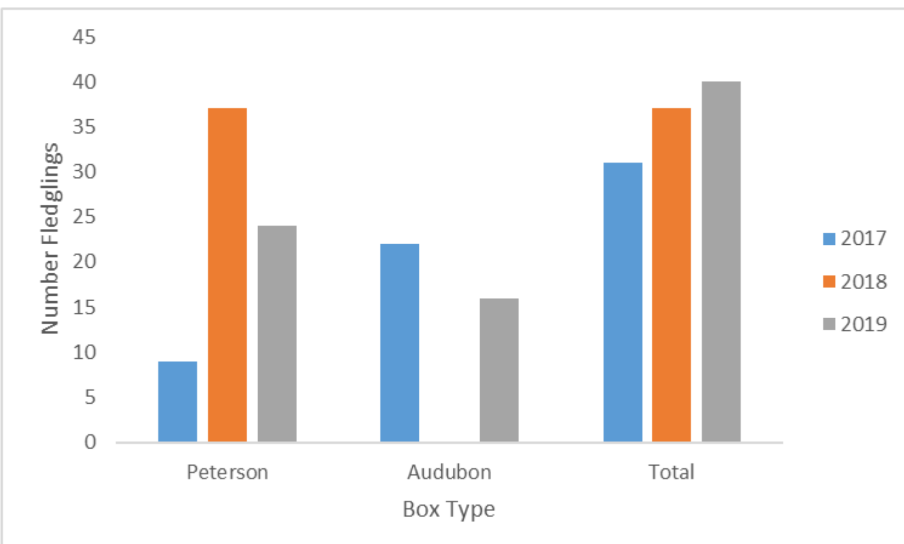

Figure 6. Number of Eastern Bluebird nestlings that successfully fledged from the two nest box types across years.

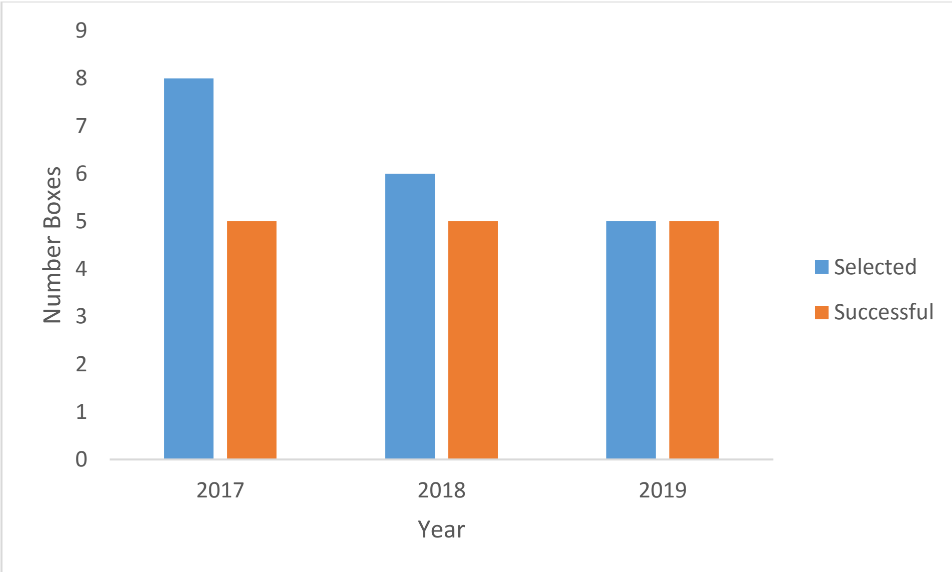

Figure 7. Comparison of the number of Audubon nest boxes used by Eastern Bluebirds and those that fledged at least one nestling across years.

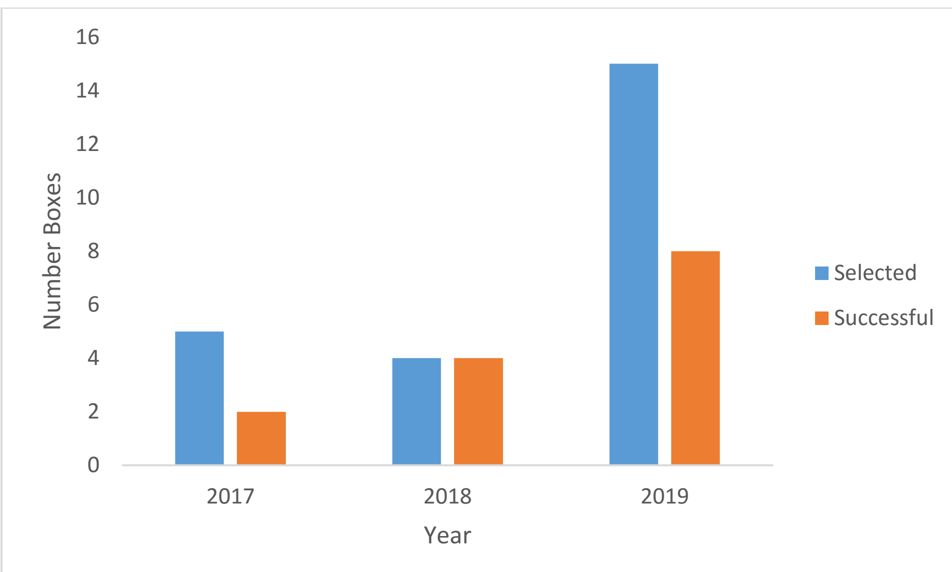

Figure 8. Comparison of the number of Peterson nest boxes used by Eastern Bluebirds and those that fledged at least one nestling across years.

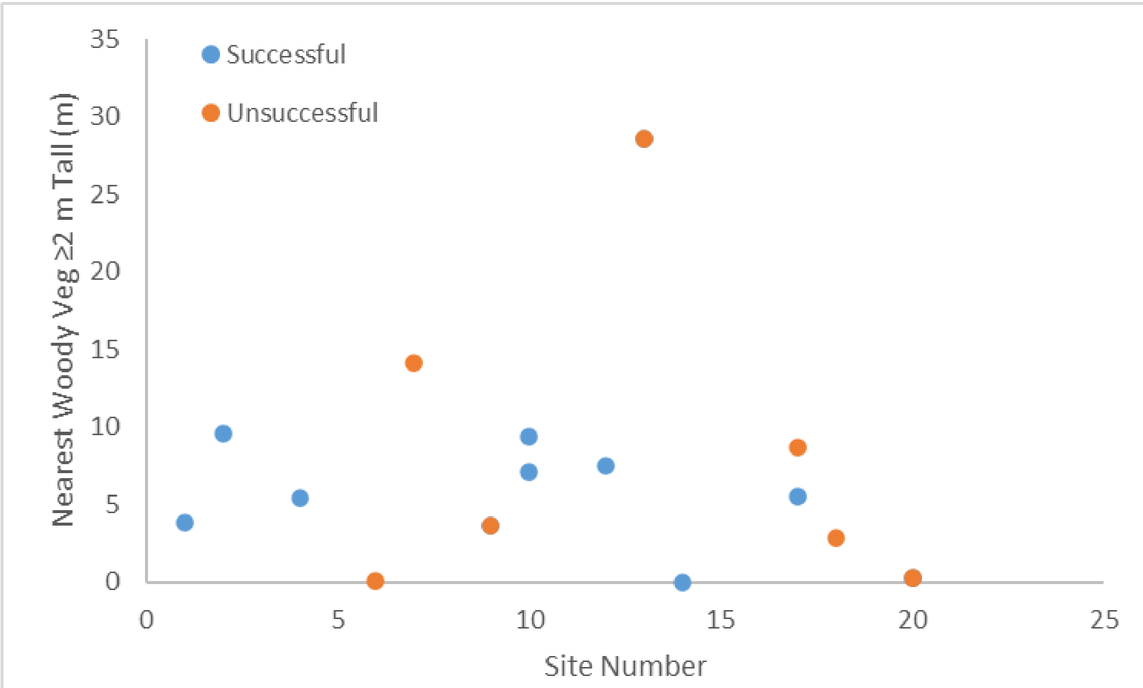

Figure 9. Distance to the nearest woody vegetation greater than 2 m in height for successful and unsuccessful 2019 Eastern Bluebird nests.

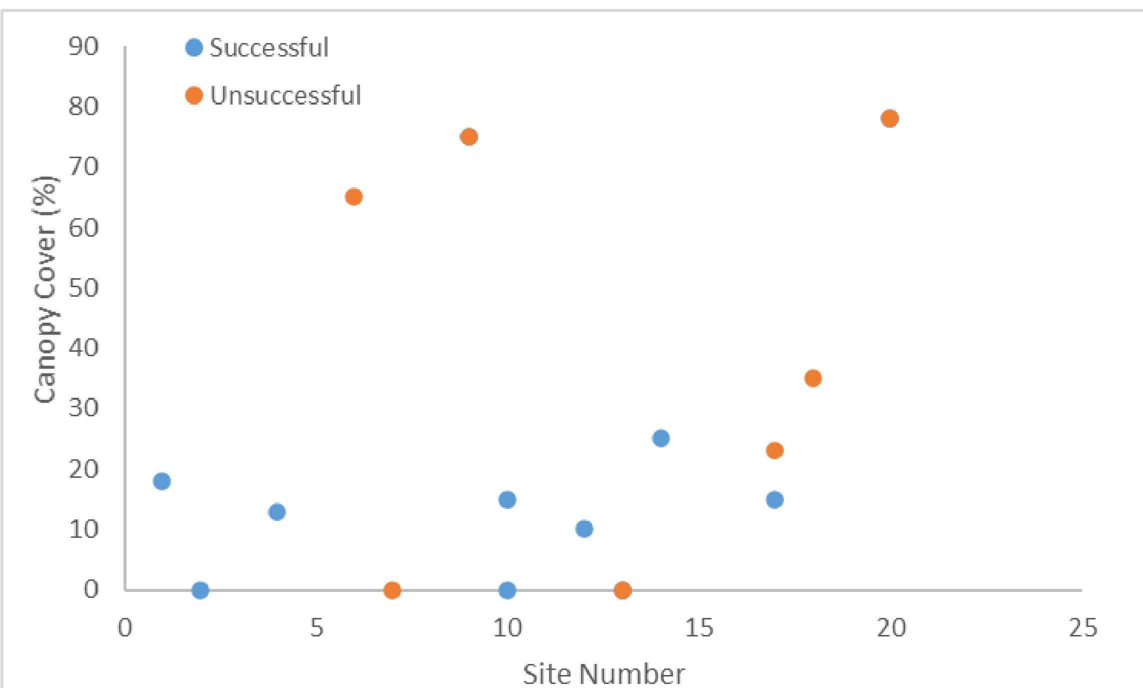

Figure 10. Percent canopy cover for successful and unsuccessful 2019 Eastern Bluebird nests.