Fall 2015

Nesting Success and Parental Behavior of the Prothonotary Warbler (Protonotaria Citrea) in Southwestern Missouri

Kathryn Marie Siverly

NESTING SUCCESS AND PARENTAL BEHAVIOR OF THE PROTHONOTARY WARBLER (*PROTONOTARIA CITREA*) IN SOUTHWESTERN MISSOURI

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Biology

By

Kathryn Siverly

December 2015

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Biology

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ABSTRACT

The breeding biology and singing rates of Prothonotary Warblers (*Protonotaria citrea*) were studied in southwestern Missouri in 2014 and 2015, using wooden nesting boxes. Data were collected on clutch and brood sizes, the numbers of young fledged, parental care and male singing rates. Five pairs were studied over the course of the two summers. Of 28 eggs laid, 14 young fledged. In 2015, significant flooding resulted in the loss of all young and eggs for that year. First clutches were larger than second clutches. Observations suggest females may contribute more to the care of offspring, in terms of foraging and fecal sac dispersal. Male singing rates did not differ significantly through laying, incubation and the nestling stage. However, after the young fledged, males sang significantly less. Data were also compiled for ten years of nesting success at the Springfield Conservation Nature Center. From 2006 to 2015, the nature center saw an overall success rate of 61.4%.

KEYWORDS: prothonotary warbler, southwestern missouri, nesting biology, nesting behavior, singing rates

This abstract is approved as to form and content

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Dr. Janice Greene
Chairperson, Advisory Committee
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ACKNOWLEDGEMENTS

I would like to take this opportunity to thank those that have supported me through the completion of this project. I am thankful for the guidance, support and assistance, provided by my advisor, Dr. Janice Greene, who helped me to shape and complete this project. I also thank those on my committee, Dr. Alicia Mathis and Dr. Brian Greene, who provided me with the knowledge necessary for developing and completing my own research.

Many thanks go to those working at the Springfield Conservation Nature Center, for allowing me to complete my research there, and providing valuable information for this study.

And finally, this project needed the help of volunteers, who made my life a little less stressful over the last two summers.

This project would also not have been possible without funding from the Biology Department and Graduate College. Thank you.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

The Prothonotary Warbler (*Protonotaria citrea*) is one of only two cavity-nesting warblers in the family Parulidae (wood warblers; Bent, 1953). The species is easily noticed due to the male's bright yellow breeding plumage on the head, neck, breast and belly. Its back is an olive green, and the wings and tail are slate blue. The underside of the tail is white fringed with black. In females and immature birds, the olive coloration of the back extends over the head, making them duller than the males. Some individuals may have orange on the forehead or face. They are a medium-sized warbler, about 13.8 cm in length and weighing 16.5 g (Walkinshaw, 1953; Stephenson & Whittle, 2013).

As a migratory species, Prothonotary Warblers winter in the Neotropics and have a breeding range in the eastern United States. This species requires swampy or riparian habitat for nesting. These warblers readily use artificial nest boxes, which make them easy to study and observe (Walkinshaw, 1953; Petit, Fleming, Petit, & Petit, 1987; Petit, 1989; Blem & Blem, 1991; Podlesak & Blem, 2001). The use of nest boxes, accompanied with the species being relatively accepting of observers, makes them ideal for behavioral studies (Fleming & Petit, 1986).

Knowledge of behavior and nesting success is important for management and conservation of the species as suitable breeding and wintering habitat areas decline due to forest fragmentation and destruction of mangrove forests (Petit, 1999; Rosenberg et al., 2014). The parental behavior and nesting success of Prothonotary Warblers has been extensively studied in other portions of their breeding range, including Virginia (Blem & Blem, 1991, 1992; Blem, Blem, & Barrientos, 1999; Blem, Blem, & Berlinghoff, 1999),

Tennessee (Walkinshaw, 1941; Petit & Petit, 1987; Petit, 1989), and Michigan (Walkinshaw, 1941). With Missouri being on the western edge of their distribution, it is important to study their success in the region to compare with other parts of their range.

Males generally arrive to breeding grounds a few days to a week before females. They immediately begin to set up a territory and scout potential nesting sites; they may also build dummy nests, which confuse predators (Bent, 1953; Walkinshaw, 1953). Upon arrival, females will select a nest location and build the nest herself while the male follows but rarely assists (Bent, 1953). A dry cup made of grasses and leaves is built on a layer of moist, green bryophytes. This thick layer it built up until the female can see out of the nest entrance. The shape, size and depth of the nest depends on the type of cavity used (Walkinshaw, 1938; Bent, 1953; Petit, 1989; Blem & Blem, 1992).

Song is key in communication among individuals of the species. Male Prothonotary Warblers have a single primary song and, less used, extended song that includes portions of the primary song with added notes (Spector, 1992). The primary song is used throughout the breeding season, functioning as a means of territory defense and mate attraction (Catchpole & Slater, 1995). The fertility announcement hypothesis predicts that song rate should increase when the female is fertile thereby protecting the male's paternity (Møller, 1991). Therefore, high song rates would be observed during the stages of the breeding season when the female is most fertile. How song rates vary over the breeding season has not been extensively studied in the Prothonotary Warbler, though males that acquire territories sooner sing more frequently (Clarkson, 2007). Other studies have looked at other species in Parulidae. Willow Warblers (*Phylloscopus trochilus*) sang very little during the period when female fertility was highest (Gil, Graves, & Slater,

1999), and American Redstarts (*Setophaga ruticilla*) had lowest song rates when their mates were building nests and when males were feeding nestlings or fledglings (Staicer, Ingalls, & Sherry, 2006). Non-Parulid species have also shown variations when singing rates differed. Indigo Buntings (*Passerina cyanea*) had highest singing rates during the pre-pairing period, while no other stages differed (Beckett & Ritchison, 2010). Song Sparrows sang most before pairing (Turner & Barber, 2004) and while females were incubating (Foote & Barber, 2009), while Northern Mockingbirds (*Mimus polyglottos*) increased singing rates during nest building and decreased singing during incubation and care of offspring (Logan, 1983). This variation over different species shows there is no uniform peak time in singing rates.

This study was conducted to provide further data concerning the nesting behavior and success of the Prothonotary Warbler in southwestern Missouri that can be used to compare with previous studies in other parts of their range. The following breeding characteristics were investigated in this study: (1) timing of first and second nesting; (2) size of clutches; (3) number of young fledged; (4) male and female parental care; and (5) male singing rates at different stages of the nesting cycle. This study also analyzes the nesting success of Prothonotary Warblers at one site, the Springfield Conservation Nature Center, from 2006–2015.

METHODS

Study Sites

I conducted this study from April to August in 2014 and 2015. Artificial nest boxes were placed in riparian habitat found at Springfield Conservation Nature Center along Galloway Creek, Lake Springfield, the James River and the Watershed Center at Valley Water Mill Park. All sites were located within Greene County in southwestern Missouri. Flooding was a problem at study sites located on Galloway Creek, Lake Springfield and the James River in 2015.

Two different sizes of boxes were used. One, a modified bluebird box, had dimensions of 10.2 cm x 14.0 cm x 22.9 cm, with 3.8 cm entrance holes. The other box measured 16.5 cm x 16.5 cm x 19 cm with 2.5 cm entrance holes. Boxes were fastened to 3.05 m (10 ft) conduit poles and placed over water, with each box being at least 1 m from the surface. In total, 35 boxes were used.

Boxes were placed prior to the arrival of males. To prevent predation, Noel predator guards were applied to the boxes. Entrance holes were small enough to prevent Brown-headed Cowbird (*Molothrus ater*) parasitism. Petroleum jelly was added to the inside roof of each box to prevent wasps from nesting within them.

Field Observations

Starting 20 April 2014 and 12 April 2015, nest boxes were initially monitored two or more times a week until a male was detected. Once a male was seen or heard, I monitored him 1-hr daily for singing behavior as he set up his territory before the arrival

of the female. An attempt was made for all observations to occur before 1200 hours. The number of times the male sang per hour was recorded. A song was defined as a series of at least four notes, with a pause of at least two seconds between songs. Singing behavior observations continued throughout the breeding season.

The breeding season was divided into four periods: (1) initiation- the period from pairing until the last egg laid; (2) incubation- from the day last egg laid to the day before first egg hatched; (3) nestling- from first egg hatched to the day before young fledged; and (4) post-fledging- from the day young leave the nest to the time of second clutch initiation or when young leave territory. Periods were determined by counting back days based on incubation time (13 d) and time to fledging (10 d).

Once a male and female were seen in the vicinity of a box, that box was observed for at least one hour each day to document behavior in addition to the male singing rate. After young hatched, feeding rates and fecal sac removal by both parents were recorded. In addition, the time of each visit was noted. Feeding rates were quantified as the number of times per hour each parent returned to the box with food. Fecal sac removal was similarly quantified as the number of times per hour each parent left the nest with a fecal sac.

Boxes were disturbed no more than three times during the nesting cycle to determine clutch size, the number of young hatched and to check for instances of cowbird parasitism or predation of young. Once it became clear the female was laying, at least a week was given to reach a full clutch before boxes were checked. Hatching dates were estimated by when the male began to actively bring food to the box. The boxes were not checked again until after the young had hatched and were beyond day 5.

Because this study was purely observational and did not involve handling of live animals, the project was considered by IACUC to be exempt from the need of prior approval.

Data Analysis

For analysis of male singing rates, feeding rates and fecal sac dispersal, only first clutch data were used due to lack of second clutch data. Five pairs were used in parental care analysis, and three males were used in the singing rate analysis. A Friedman test was used to compare singing rates at different stages of the breeding cycle. Wilcoxon signed rank tests for paired data were used to compare male versus female in fecal sac dispersal and foraging trips. All analyses were run using Minitab 17.

RESULTS

Occupancy

Over the two years of this study, five pairs were observed. Prothonotary Warblers occupied 11.4% (4 of 35) of nesting boxes. Two of the boxes were used in both 2014 and 2015. In 2014, three pairs were observed. Three additional males were heard in the vicinity of other boxes, and in some cases, the males inspected the boxes, though those boxes were never utilized by the warblers. In 2015, two pairs were observed. Four additional males were heard near boxes. In one case, a nearby bluebird box was used in a second clutch attempt by one pair.

Nest boxes were used by one other species, the Carolina Chickadee (*Poecile carolinensis*), occupying 37.1% (13 of 35) of nesting boxes.

Nesting Success

Most pairs attempted two clutches. First clutches in 2015 were initiated earlier than first clutches in 2014 (Table 1). Of the five females, three had successful first clutches. Of the three females nesting in 2014, only two attempted a second clutch. In 2015, first clutches and a re-nesting attempt were unsuccessful due to extensive and frequent flooding of sites. No third attempts were made. First clutches were generally larger than second clutches (mean = 5.60 ± 0.55 eggs; mean = 4.25 ± 0.50 eggs). Overall in 2014 and 2015, 45 eggs were laid, 35 hatched (77.8%), and 18 young fledged (40.0%).

Table 1. Dates of clutch initiation, defined as the date of first egg laid.

Initiation Date	Number of Clutches	
16 May 2014	2	
17 May 2014	1	
22 Jun 2014	1	
10 Jul 2014	1	
8 May 2015	1	
14 May 2015	1	
12 Jun 2015	2	*

* 2015 re-nesting after flooding event

Flooding was the primary cause for re-nesting in warblers and death of young. In 2015, there were repeated flooding events (Figure 1). Boxes were completely submerged in at least four instances. Of 20 eggs laid, flooding caused the loss of 11 hatchlings and 9 eggs. There were no instances of flooding in 2014.

Predator guards and a small entrance hole were successful in preventing predation and nest parasitism by Brown-headed Cowbirds. There was one instance of predation on a Carolina Chickadee nest, possibly by a raccoon (*Procyon lotor*).

Singing Rates

In total, singing rates of five males were collected throughout the breeding season, however, due to flooding events, the singing rates of three males were used for analysis. There was no significant difference between the four stages. However, there was an

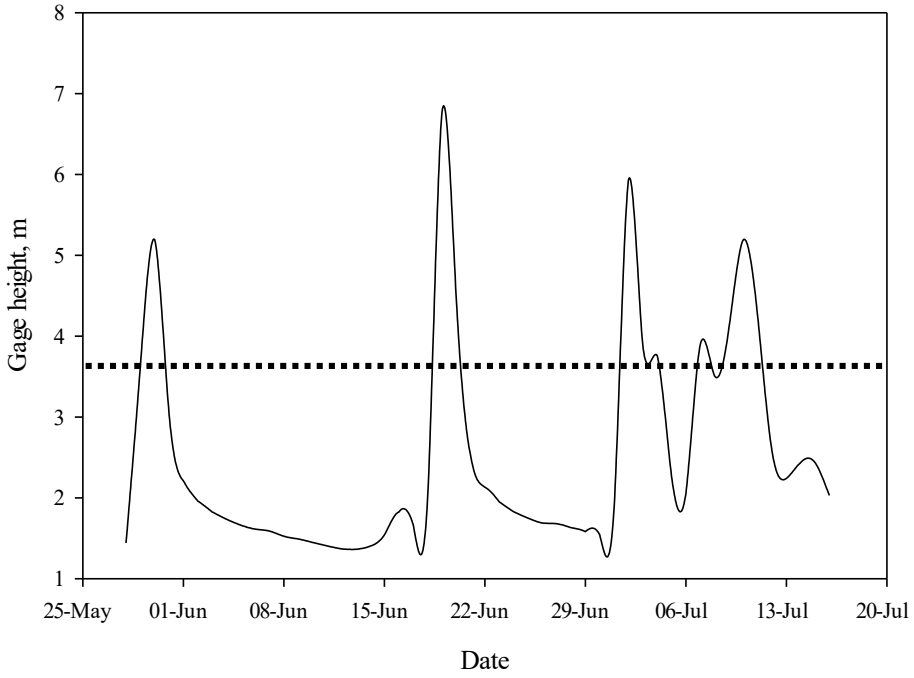

Figure 1. James River gage height during summer 2015 flooding. Dotted line represents flood stage of the river (3.66 m).

overall decreasing trend in singing rates through the breeding season, with singing rates being lowest at the post-fledging stage (Figure 2).

Parental Care

The data show an increasing trend in frequency of foraging trips through the nestling period (Figure 3). In the first two days after hatching, the males made more trips than females. After the third day, females began to provide more for the young than did males.

Throughout the hatchling period, females removed more fecal sacs than males, with an overall increasing trend (Figure 4).

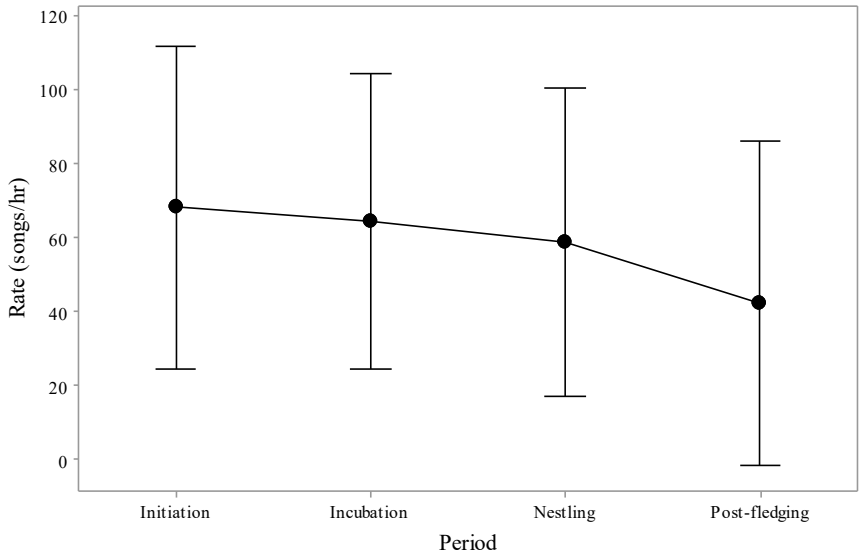

Figure 2. Singing rates of three males during the four breeding stages. Means represented with 95% confidence intervals.

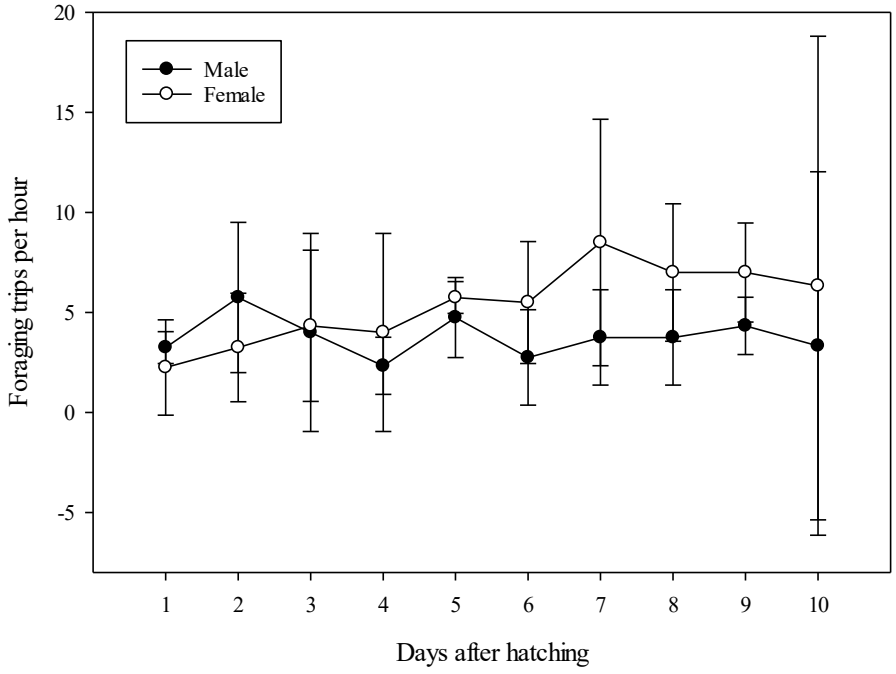

Figure 3. The frequency of foraging trips for five pairs from hatching to fledging in first clutches. Means represented with 95% confidence intervals.

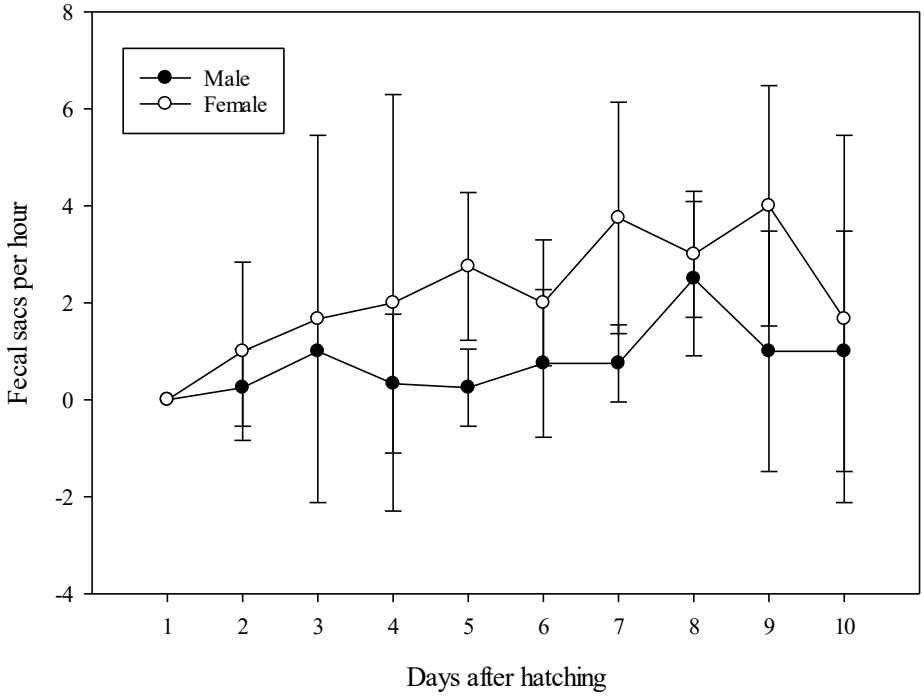

Figure 4. The frequency of trips for fecal sac dispersal of five pairs from hatching to fledging in first clutches. Means represented with 95% confidence intervals.

Ten-year Nesting Success

From 2006–2015, nesting data were collected at the Springfield Conservation Nature Center. Due to some years of no second clutch observations, this analysis was limited to first clutch nesting success. The Nature Center saw, on average, three pairs per year. Overall, 89 young fledged from 145 eggs laid or 61.4% fledging success (Table 2).

Table 2. Success of first clutches at the Springfield Conservation Nature Center, 2006–2015.

Year	Number of Pairs	Eggs Laid	Young Fledged	Success Rate % (eggs laid/young fledged)
2006	4	18	8	44.4%
2007	3	10	10	100.0%
2008	3	13	8	61.5%
2009	5	19	7	36.8%
2010	2	9	8	88.9%
2011	3	13	8	61.5%
2012	3	14	8	57.1%
2013	4	21	18	85.7%
2014	3	17	14	82.4%
2015	2	11	0	0.0%

DISCUSSION

The Prothonotary Warbler is in decline across much of its range and is currently listed on the Yellow Watch List for the 2014 State of the Birds report (Rosenberg et al., 2014). This report takes into account factors compiled in the Partners in Flight Species Assessment Database, which determines the vulnerability of species based on population size, distribution (breeding and non-breeding), population trend, and future threats to their ranges. The species is currently listed as endangered in Canada and as a bird of conservation concern in the United States. A better understanding of their habitat requirements and their breeding success in areas of their range is needed to help develop conservation plans.

This study focuses on the behavior of the species during the breeding season and their nesting success. While breeding pairs were successful in fledging young in 2014, flooding became a major issue in 2015 with the loss of all clutches. Continued study, with a greater area of coverage, would help in determining the success of Prothonotary Warblers in this area and would be beneficial in the conservation of the species.

Occupancy

Nest box occupancy in this study was lower than that of similar studies in other regions (31.3%, Petit, 1986; 15.2%, Blem & Blem, 1991), and by a previous study in the same region (30%, Cantrell, 1996). In these previous studies, the boxes were also used by Carolina Chickadee (*Poecile carolinensis*), Carolina Wren (*Thryothorus ludovicianus*),

House Wren (*Troglodytes aedon*), and Tree Swallow (*Tachycineta bicolor*), whereas in this study the boxes were only used by Carolina Chickadee.

Of the two box sizes used, only the larger, older, already present boxes were occupied by the warblers. While the new, smaller boxes were investigated by some males, no females visited these boxes, opting for natural cavities or larger boxes nearby. It is possible these boxes were too small, however Petit et al. (1987) found that the warblers had a preference for smaller artificial cavities (milk cartons and PVC pipes), and they used those smaller cavities more than the larger, wooden nest boxes. They suggest that a greater volume of a nest box may discourage use because of the extra effort required to fill the box. Other factors that deterred the use of these boxes could include box placement or the age of the boxes. Most of the smaller boxes were placed along the James River near a highway, which resulted in a high noise level in the area. The larger boxes used were those already located at the Springfield Conservation Nature Center and may have been re-used by returning warblers. These boxes had been there a number of years in the same locations, along the waterways at the Nature Center. The same boxes at the Nature Center were used in both years by the warblers.

Nesting Success

While there were no instances of predation or brood parasitism, flooding was a major problem in 2015. All boxes were flooded on multiple occasions during the peak times for warbler nesting. Re-nesting occurred in boxes different from those used in the first clutch, and no third attempts were made. This may be due to added stress on the females, or the continued flooding into mid-July prevented another re-nesting attempt.

Two clutches are typical in many parts of their range, although, Walkinshaw (1941) did not observe any pairs in Michigan attempting a second clutch after a successful first attempt. Mean clutch size (first clutch: 5.60 eggs; second clutch: 4.25 eggs) in this study was higher than in earlier studies (first clutch: 4.95, second clutch: 4.56, Petit, 1989; first clutch: 4.74, second clutch: 4.11, Cantrell, 1996), with a majority of pairs laying clutches of six in their first clutch while five eggs was the majority in these other studies.

Predation was not an issue in this study. Having all boxes placed over water with predator guards and smaller entrance holes may have helped reduce the likelihood of predation. In the one instance of known predation of a Carolina Chickadee nest, a low hanging branch likely provided access to the box. Previous Prothonotary Warbler nest box studies noted predation by raccoons (*Procyon lotor*), cotton mice (*Peromyscus gossypinus*), white-footed mice (*P. leucopus*), and black rat snakes (*Elaphe obsoleta*). Predation rates were higher in those studies where boxes were attached to trees near water and not always over water (41%, Walkinshaw, 1941; 13.4%, Petit, 1986; 20.9%, Petit, 1989; 10%, Blem & Blem, 1991). In studies with lower predation rates, boxes were placed directly over water and approached by boat or by wading (1-2%, Fleming & Petit, 1986; 3.82%, Cantrell, 1996). Based upon results of this study, placement of boxes over water, with the use of the conduit poles, and the addition of predator guards with small entrance holes is recommended to maximize the success of nesting boxes for conservation efforts.

While Brown-headed Cowbirds were observed investigating boxes, they were unable to enter the boxes. This observation further supports the use of boxes with smaller

entrance holes in conservation efforts for the species. Brood parasitism has been an issue in other Prothonotary Warbler nesting studies, though the frequency can vary from year to year, even within the same study due to annual variation in densities of cowbirds. Petit (1989) had one year with 20.3% of nests being parasitized, while two years later no nests were used by cowbirds.

Singing Rates

In this study, the males sang less in the post-fledging stage than during the initiation, incubation and hatchling stages. This difference may be due to males taking a more active role in raising the newly fledged young. Prothonotary Warblers typically take care of the young for up to 30 days after fledging, during which time they continue to occasionally feed the young and offer some protection. Males and females will split the brood of newly fledged young and each care for half of the chicks. Therefore, it is possible the males do not take the opportunity to sing, or they do not want to draw attention to themselves and their nearby young.

Knowing when the Prothonotary Warbler males sing less frequently is beneficial for census surveys that use calls. After fledging, males were heard no more than ten times over the period of an hour on some days. During this time, those taking a count may inaccurately determine a lack of presence for the species in an area, so it would be beneficial to take counts earlier in the breeding season, before young leave the nests.

Parental Care

While the males do not incubate the eggs, they were seen occasionally feeding the females while they sat on the nest. The females spent a majority of the day on the nests, and it is possible that the male provides her food to minimize nest predation (Morse, 1989). Spending more time on the nests also reduces the chance of Brown-headed Cowbirds parasitizing the nest, as the nest parasites will typically lay their eggs in the host nest when the parents are absent (Hoover, 2003).

After hatching, the male makes more foraging trips than the female to feed the young. After day three, the female begins to take more trips than the male. Those first three days after hatching are a critical time for the young chicks, because they are unable to thermoregulate and require more brooding time by the female. This time spent brooding begins to decline after the third day, and by the fifth, the young have developed thermoregulatory abilities (Morse, 1989).

When returning to the nest, males would often perch in trees within 5 m of the boxes, singing while holding the food item in their beaks for up to five minutes. While females occasionally perched on nearby branches and chipped before entering the nest, more often they would silently approach and enter the box immediately. Males and females exhibited similar behaviors when leaving the nests, with the males taking time to perch on the predator guard before flying away, while females left more swiftly.

Removal of fecal sacs is important to the survival of the young, and both parents help in maintaining a clean nest. There are several possible advantages to the removal, including (1) reducing the likelihood of arthropod infestation, (2) maintaining a warm and dry nest, and (3) reducing the chance of attracting predators (Morton, 1979;

Weatherhead, 1984; Petit, Petit, & Petit, 1989). In the early days after hatching, parents may ingest the waste produced by nestlings before they begin to carry the sacs away from the nest when nestlings may produce too many or sacs too large for parents to ingest (Morton, 1979). Similar to Petit and Petit (1987), in this study, parents appeared to take a different path from a typical observed foraging direction when leaving with a fecal sac, and most were dropped over water.

The young in this study left the nest on day 10, which is the usual fledging date for the species, though they may also fledge on days 9 or 11 (Walkinshaw, 1941; Cantrell, 1996; Petit, 1999). After fledging, the young were seen with the parents up to about 30 days after leaving the nest. Each parent took half the brood and were observed feeding the young on occasion. The first clutch nestlings were not seen once the female began to lay her second clutch.

Ten-year Nesting Success

The Springfield Conservation Nature Center has utilized modified bluebird boxes for a number of years to attract Prothonotary Warblers, and they've been successful in maintaining at least three pairs per year for the last ten years with an average success rate for first clutches of 61.4% over the last ten years. Their success further promotes the use of nesting boxes for Prothonotary Warbler conservation.

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