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TREE SWALLOW *(Tachycineta bicolor)* ABUNDANCE, DENSITY, AND NEST OUTCOMES AT RED SLOUGH WILDLIFE MANAGEMENT AREA, MCCURTAIN COUNTY, OKLAHOMA

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Abstract—Tree Swallows *(Tachycineta bicolor)* expanded their range into southern Oklahoma and northern Texas over the last 20 years. From 2009-2012, we monitored 229 Tree Swallow nests at the Red Slough Wildlife Management Area in southeastern Oklahoma to determine nest outcomes. Point counts were conducted to develop a population index and density estimate for Tree Swallows at Red Slough Wildlife Management Area. Population abundance was 3.6 Tree Swallows detected/point and population density was 4.5 Tree Swallows/ha. From 2009-2012, 77% of Tree Swallow nests fledged ≥1 young. Tree Swallows had a mean clutch size of 5.2 eggs and a mean of 3.5 nestlings/nest attempt hatched. Tree Swallows fledged a mean of 3.3 young/nest attempt. Tree Swallow nest success varied among years, mainly due to predation and brood reduction from unhatched eggs and early nestling mortality. Tree Swallows in southeastern Oklahoma demonstrated nest success rates similar to other published studies, however fledging rates were lower than other reported estimates. We documented high rates of successful second nest attempts at Red Slough Wildlife Management Area compared to Tree Swallows at higher latitudes.

INTRODUCTION

The Tree Swallow *(Tachycineta bicolor)* is a Nearctic-Nearctic migrant species that historically nests in the northern half of the United States and Canada and winters in the sub-tropics (Winkler *et al.* 2011). The Breeding Bird Survey suggests that Tree Swallows have been increasing by 0.33% per year since 2002 throughout the species' range (Sauer *et al.* 2014). Contrary to many other North American bird species, Tree Swallows expanded their range southward over the last 20 years and now occur in Oklahoma during the breeding season (Neeld 1993, Long and Long 1997, Brown 2004). The cause of this geographic expansion is not known (Winkler *et al.* 2011), although Heck (1999) speculated that the creation of water reservoirs in the 1950s and 1960s created large numbers of dead trees (i.e., snags) over open water suitable for nesting Tree Swallows. No literature has been published documenting population density, abundance trends, or nest success of this species in the southern portion of the Tree Swallows' range.

Tree Swallows are a secondary cavity nester that typically nest in a tree cavity abandoned by woodpeckers (Erskine and McLaren 1972). Mean nest height of cavities used by Tree Swallows is 3.4 m (Peterson and Gauthier 1985). For research and management purposes, nest boxes can be installed and used by Tree Swallows throughout their range (Lumsden 1986). Tree Swallows begin nesting in Oklahoma in April and May and finish nesting by July (Neeld 1993, Long and Long 1997, Heck 1999, Brown 2004). They typically nest in open areas near water with dead trees (Winkler *et al.* 2011). Most Tree Swallows nest only once per year, although second broods are known to occur (Hussell 1983). Clutch size is typically 4–7 eggs which females exclusively incubate for 14–15 days (Austin and Low 1932, Paynter 1954). Young fledge in 18–24 days (Austin and Low 1932, Kuerzi 1941, Brown 2004).

Published Tree Swallow nest success rates ranged from moderate to high in disparate portions of the species' range. In Ohio, Doherty and Grubb Jr. (1998) documented 100% nest success (i.e., defined as a nest with ≥1 fledgling). Using unpublished data, Winkler *et al.* (2011) documented 72% nest success in New York and Cristol (*in* Winkler *et al.* 2011) documented 89% nest success in Virginia. However, nest boxes in these studies were protected by anti-predator guards. In southern Quebec, Ghilain and Belisle (2008) reported only 65% nest success from nest boxes without predator guards.

Our research objectives included establishing nest box arrays at the Red Slough Wildlife Management Area (hereafter RSWMA), determining nest outcomes, cause-specific nest loss, and population density and abundance estimates for Tree Swallows in southeastern Oklahoma.

STUDY AREA AND METHODS

Research was conducted at the RSWMA (Fig. 1), McCurtain County, in southeastern Oklahoma (33 44'58.92"N, 94 39'14.32"W), during the 2009-2012 nesting seasons. RSWMA is 3157 ha of restored wetlands and moist soil management units, with 161 ha of reservoirs. Prior to 2009, several nest boxes were installed at RSWMA and used by Tree Swallows (D. Arbour, Oklahoma Department of Wildlife Conservation, pers. comm.). In April 2009, we placed 59 nest boxes without predator guards along the margins of reservoirs and intermittently-flooded moist soil management units at RSWMA. We monitored 57-59 nest boxes annually from April-July through 2012. Initially, nests were checked every 3-4 days until nesting was initiated, then nests were checked more frequently near hatching and fledging. We recorded nest box use, clutch size, number of hatchlings, and number of fledglings per nest. We documented brood reduction events and cause-specific nest loss when a nest failed.

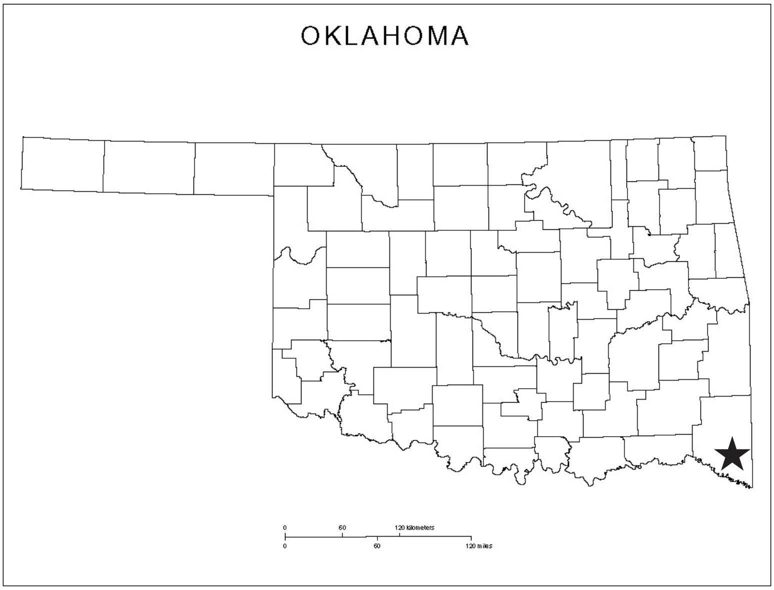

Figure 1. Star indicates location of Red Slough Wildlife Management Area, McCurtain County, Oklahoma.

Point counts were conducted from 2010-2012 to develop estimates of Tree Swallow population density and relative abundance at RSWMA. Each week during the breeding season, we conducted a 5-minute point count at 9 point count stations among our nest box arrays (Reynolds *et al.* 1980, Morrison *et al.* 1981). Points were separated by ≥ 0.4 km and the maximum number of individuals seen simultaneously during each point count was used as the abundance estimate. This method likely resulted in conservative estimates of Tree Swallow abundance at each point. We used a 50-m fixed radius point count and counts were conducted only when Breeding Bird Survey weather conditions were met (Robbins *et al.* 1986). As part of a broader research project, Tree Swallows were banded to identify nest attempts by territorial pairs (Wood *et al.* 2014).

We tested the hypotheses that nest success parameters and population density did not vary between years. IBM SPSS Statistics 20 software was used for all statistical analyses with an *a priori* alpha level of 0.05. Point count and nest success parameter data exhibited normal data distribution, therefore we used a one-way ANOVA to test for differences among years. If differences among years were detected, LSD tests were conducted to determine significance between years.

RESULTS

Population Abundance and Density

The mean number of Tree Swallows detected per point was 3.6 ± 3.3 SD for all years combined. Tree Swallow population abundance was not statistically different among years ($F_{2, 257} = 2.78$, $P = 0.064$), although Tree Swallows were most abundant in 2011 (4.1 ± 3.7 SD), followed by 2012 (3.6 ± 2.9 SD) and 2010 (3.0 ± 3.1 SD). Overall population density was 4.5 Tree Swallows/ha from 2010-2012. Tree Swallows population density increased from 3.8/ha in 2010 to 5.2/ha in 2011, but decreased to 4.6/ha in 2012.

Nest Outcomes

We documented 229 Tree Swallow nests and the number of nests increased annually from 27 to 82 (Table 1). The highest percentage of nests that hatched ≥1 young was 91% in 2010, although hatching rate averaged 85% from 2009-2012 (Table 1). The fledging rate was also highest in 2010 (87%), with an average of 77% (range 65-87%) from 2009-2012 (Table 1). Tree Swallows laid 1187 eggs and the number of eggs increased every year from 132 in 2009 to 418 in 2012 (Table 2). The highest number of hatchlings (263) was also in 2011 with a total of 810 hatchlings surviving ≥2 days (Table 2). The highest number of fledglings also was in 2011 with 256 (Table 2), although the highest fledging rate by percentage was in 2010 at 75% (Table 2). From 2009-2012, 64% of eggs laid ultimately fledged (753 fledglings/1187 eggs) (Table 2).

Table 1. Number of Tree Swallow nests, percent of nests that had ≥1 egg hatch, and percent of nests that fledged ≥1 young at Red Slough Wildlife Management Area, Oklahoma, 2009-2012.

Year	n	% Hatched	% Fledged
2009	27	89	70
2010	47	91	87
2011	73	88	85
2012	82	71	65
TOTALS	229	85	77

Table 2. Number of Tree Swallow nests, number of eggs, number of hatchlings that survived ≥2 days, number of fledglings, and percentage of eggs that ultimately fledged young at Red Slough Wildlife Management Area, 2009-2012.

Year	n	# Eggs	# Hatchlings	# Fledged	% Eggs Fledged
2009	27	132	95	79	60
2010	47	258	204	194	75
2011	73	379	263	256	68
2012	82	418	248	224	54
TOTALS	229	1187	810	753	64

Of 229 total nests, 58 (25%) were second nest attempts. Among these 58 original nest events, 59% were successful and 41% failed. Thus, 59% were second nest attempts following a successful first nest attempt, whereas 41% were re-nesting attempts after initial nest failure. Among those that attempted a second brood, 78% fledged ≥1 young, whereas 22% failed due to various causes.

Nest Loss and Brood Reduction

Predators consumed 190 eggs and nestlings resulting in the largest source of nest failure and brood reduction (Table 3). Western rat snake (*Pantherophis obsoletus*) predation accounted for 71 eggs and nestlings, whereas raccoons (*Procyon lotor*) accounted for 57 eggs and nestlings. Unidentified predators accounted for another 62 eggs and nestlings. The largest single source of brood reduction at the egg stage were 138 eggs that hatched but died within 2 days. Fifty-three eggs failed to hatch due to incomplete incubation, were infertile, or for undetermined reasons. Abandonment accounted for 43 eggs and nestlings lost and a flood event accounted for 10 eggs and nestlings lost in 2009 (Table 3).

Nest Success Parameters

From 2009-2012, overall mean clutch size was 5.2 and mean clutch size did not differ among years ($F_{3, 225}$ = 1.8, P = 0.147). Mean clutch size was highest in 2010 and lowest in 2009 (Table 4). From 2009-2012, the overall mean number of hatchlings was 3.5 and the mean number of hatchlings differed among years ($F_{3, 225}$ = 4.11, P = 0.007). The mean number of hatchlings was significantly higher in 2010 compared to 2012 (P = 0.001) (Table 4); however, no differences occurred among other year comparisons. From 2009-2012, the overall number of fledglings was 3.3 and the mean number of fledglings differed among years ($F_{3, 225}$ = 4.62, P = 0.004). Mean number of fledglings was significantly higher in 2010 than 2009 (P = 0.023) and 2012 (P = 0.001) (Table 4). The mean number of fledglings was higher in 2011 than 2012 (P = 0.028) (Table 4). No other differences were detected among years.

Table 3. Nest loss by cause-specific mortality factors at Red Slough Wildlife Management Area, Oklahoma, 2009-2012. Nest loss codes include HBD = eggs hatched but died ≤2 days, UNH = unhatched eggs due to infertility or other factors, SN = western rat snake predation, RAC = raccoon predation, UNP = unidentified predator, FLD = flooding, AB = abandoned by parents or parent depredated.

Year	Parameter	HBD	UNH	SN	RAC	UNP	FLD	AB	Total
2009	Eggs	21	1	4	-	6	5	-	37
	Nestlings	-	-	6	5	-	5	-	16
2010	Eggs	35	1	-	-	13	-	5	54
	Nestlings	-	-	6	-	4	-	-	10
2011	Eggs	47	29	11	4	10	-	15	116
	Nestlings	-	-	2	-	-	-	5	7
2012	Eggs	35	22	18	48	29	-	18	170
	Nestlings	-	-	24	-	-	-	-	24
Combined	Eggs	138	53	33	52	58	5	38	377
	Nestlings	-	-	38	5	4	5	5	57

Table 4. Mean clutch size, number hatched, and number fledged among Tree Swallow nests at Red Slough Wildlife Management Area, Oklahoma, 2009-2012. Data given are means ± SD.

Year	n	Clutch Size	Number Hatched	Number Fledged
2009	27	4.9 ± 1.2	3.5 ± 1.9	2.9 ± 2.2
2010	47	5.5 ± 1.1	4.3 ± 1.8	4.1 ± 1.9
2011	73	5.2 ± 2.0	3.6 ± 2.0	3.5 ± 2.0
2012	82	5.1 ± 1.3	3.0 ± 2.4	2.7 ± 2.4
Combined	229	5.2 ± 1.2	3.5 ± 2.1	3.3 ± 2.2

DISCUSSION

Population abundance ranged from 3.0-4.1 Tree Swallows detected/point. Tree Swallow density averaged 4.5/ha with the highest density of 5.2/ha in 2011. We were unable to find similar published estimates of Tree Swallow abundance or density at the local level. The Breeding Bird Survey provides density estimates, but only as a function of number of Tree Swallows per count route (Sauer *et al.* 2014). Thus, direct comparisons are not available. Our data represent a baseline for future comparisons of Tree Swallow density in southern Oklahoma or elsewhere in its range.

The earliest date a Tree Swallow egg was laid at RSWMA was 3 April, 2011, although this was earlier than the majority of first egg laying dates which occurred from 14-29 April throughout our study. This result was much earlier than previously published estimates of first egg dates. In Virginia, Cristol (*in* Winkler *et al.* 2011) reported 19 April as the earliest egg laying date for Tree Swallows. Similarly, Ardia and Rice (2006) reported a median first egg date of 21 April in Tennessee. Because Tree Swallows arrive at RSWMA as early as March, nesting activity begins earlier than in other more northerly areas of the Tree Swallow's range. Earlier warm temperatures and insect emergence likely allow Tree Swallows to initiate egg laying before their northern counterparts.

We documented an average hatching success rate of 85% at RSWMA, with the highest rate (91%) in 2010. This result is similar to other studies. Doherty and Grubb Jr. (1998), in Ohio, reported an 88% hatching success rate. Similarly, in Quebec, Ghilain and Belisle (2008) documented an 86% hatching success rate. The average fledging rate (77%) at RSWMA was lower than other studies. In Quebec, 88% of nestlings fledged (Ghilain and Belisle 2008) and Doherty and Grubb Jr. (1998) reported a 94% fledging success rate in Ohio. Our lower fledging rate was strongly influenced by higher predation rates in 2011-2012. Our rate is closer to Ghilain and Belisle (2008) who also used nest boxes without anti-predator guards, whereas Doherty and Grubb Jr. (1998) used anti-predator guards. In Quebec, Ghilain and Belisle (2008) documented 65% of Tree Swallow nests fledged ≥1 young. At RSWMA, 77% of Tree Swallow nests fledged ≥1 young. However our result was lower than Doherty and Grubb Jr. (1998) who reported that 100% of Tree Swallow nests in Ohio fledged ≥1 young.

Unhatched eggs and eggs that hatched, but died in ≤ 2 days, accounted for 50% of all eggs lost during nesting. Predation by western rat snakes, raccoons, and undetermined predators accounted for 190 eggs and nestlings lost during incubation. To determine a baseline of predation impact on Tree Swallow nests, we did not install anti-predator guards. In Quebec, Ghilain and Belisle (2008) documented a 65% nest success rate without anti-predator guards. We documented a higher nest success rate of 77% at RSWMA without anti-predator guards. Doherty and Grubb Jr. (1998) documented a 100% nest success rate in Ohio with the use of anti-predator guards. Robertson and Rendell (1990) documented 77% nest failure in nest boxes without anti-predator guards, but predation dropped to negligible rates after they installed predator guards. We observed little predation in 2009-2010, but predation rates spiked in 2011-2012 along with increased nesting activity. We speculate that predators developed a search image for Tree Swallow nests based on a variety of potential factors including: more nesting activity, researcher presence, variable water levels, or increased predator density. We recommend installing anti-predator guards at RSWMA.

Tree Swallows in northern latitudes frequently attempt nesting once and are rarely double brooded (Kuerzi 1941, Paynter 1954, Winkler *et al.* 2011). Hussell (1983) documented double brooding in Ontario, but with a small sample size. However, in Virginia, Monroe *et al.* (2008) documented 5% of all female Tree Swallows that successfully nested had a second successful brood. Rooneem and Robertson (1997) experimentally removed active clutches from Tree Swallows in Ontario. Forty-one percent of females re-nested. We report a much higher rate (25%) of second nest attempts and double brooding by Tree Swallows at RSWMA. We documented 58 second nest attempts of which 59% resulted from a successful first nest attempt and only 41% were the result of initial nest failure. Seventy-eight percent of second nest attempts fledged ≥1 young. Tree Swallows at RSWMA were able to increase their annual productivity by double brooding. Monroe *et al.* (2008) speculated that the higher rate of second nest attempts was related to the longer potential nesting season at southern latitudes like Virginia and Oklahoma.

We documented a mean clutch size of 5.2 eggs/nest, which was the same size reported by Kuerzi (1941) in Connecticut, Chapman (1955) in New Jersey, Ghilain and Belisle (2008) in Quebec, and nearly the same 5.3 eggs/nest in Wisconsin (Nooker *et al.* 2005). Clutch size at RSWMA was higher than the 4.7 eggs/nest reported by Low (1934) in Massachusetts and 4.8 eggs/nest reported by St. Louis and Barlow (1993) in Ontario. Other studies documented higher clutch sizes of 6.0 eggs/nest (DeSteven 1978) and 6.2 eggs/nest (Quinney 1983) in Ontario.

We documented 3.5 hatchlings/nest at RSWMA, although a significantly higher mean was achieved in 2010. We observed a high degree of brood reduction, approximately 2 young/nest, due to unhatched eggs and early nest mortality. Brood reduction has been documented in Tree Swallows, although other studies did not quantify the number of hatchlings surviving (i.e., only reported percentage of nests that had ≥1 young fledge). Chapman (1955) cited cold weather events as an explanation for partial or complete brood loss, whereas predation and abandonment were also factors (Winkler *et al.* 2011). Cold weather was not a major cause of brood reduction at RSWMA. Only one cold, rainy event occurred in 2009 resulting in two nests being abandoned during that event. High temperatures and heat stress on nestlings may also contribute to brood reduction (Lombardo 1994), but we observed Tree Swallows fledging successfully as late as 13 July.

The mean number of Tree Swallows fledged per nest at RSWMA was 3.3. This number was lower than other published estimates. Doherty and Grubb Jr. (1998) reported 4.5 young fledged/nest in Ohio and Ghilain and Belisle (2008) reported 4.0 young fledged/nest in Quebec. Although fledgling numbers were lower at RSWMA, second nest attempts may have offset losses due to brood reduction

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MANUSCRIPTS NEEDED

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