INFLUENCE OF LIGHT AND TEMPERATURE ON ABUNDANCE OF SWALLOW NESTS

by

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ABSTRACT

Habitat parameters affecting survival and reproduction can be enhanced or degraded by human activities including disturbance and development. While development of human-made structures can obviously reduce a species' survival and reproduction through loss of habitat, human structures might also promote population growth by providing nesting and roosting habitat. My study examined the overlap (spatially and temporally) of Cliff Swallows (*Petrochelidon pyrrhonota*) and Cave Swallows (*P. fulva*) during nesting season and seasonal use of five bridges in Central Texas by both species. The five sites are: B1-Colorado River, B2- Plum Creek, B3-Blanco Bridge, B4- Guadalupe River, and B5- Blanco State Park. Specifically I examined seasonal use of bridges by both species of swallow and spatial isolation of nests at nest sites based on thermal and ambient light properties. For both years of this study, Cliff and Cave Swallows were present during our surveys; while numbers were variable between years and among bridges, Cliff Swallows were the dominant species present. In contrast, Cave Swallows were recorded only at two of the five sites: B2-Plum Creek, and B5-Blanco State Park during both years. I found no interaction ($F = 0.901$, $P = 0.493$) between bridges and data loggers for mean temperature (°C) but the three bridges (B2, B3, B5) differed ($F = 15.104$, $P < 0.001$) in mean temperature with B2 being warmer than B3 and B5. For mean light (Lux), I found a interaction ($F = 63.75$, $P < 0.001$) between bridge and data logger with interior spans of all bridges receiving less light than the outer spans and bridges differing in overall ambient light; in order of decreasing light: B3, B2 and B5. Cave Swallows were found only within the interior spans of bridges (i.e. darker areas) and at the two bridges that received the less light. However, Cave Swallows did not appear to be influenced by temperature because they occupied one the warmest (B2) and coolest (B5) bridges. Based on my results, Cave Swallows are selecting bridge sites that are relatively dark but do not appear to be influenced by temperature at the nest site.

Future studies are warranted to continue investigating the nest site selection of Cave Swallows as they continue to expand their range into the south western United States.

1. INTRODUCTION

Avian species use different resources within a variety of habitats for all stages of their life cycle including nesting, foraging, and overwintering. Some habitats have parameters that may promote survival and reproduction while other habitats have parameters that negatively impact the species' life history. Habitat parameters that affect survival and reproduction can be enhanced or degraded by human activities including disturbance and development. The development of human-made structures can obviously degrade a species' ability to survive and reproduce through loss of habitat, but, at the same time, can also enhance population growth through the use of these structures for nesting and roosting. Such structures might also remove environmental barriers limiting a species' range and potentially result in overlapping ranges of closely related species (i.e. from allopatry to sympatry). This appears to be occurring in two closely-related swallow species, Cliff Swallow (*Petrochelidon pyrrhonota*) and Cave Swallow (*P. fulva*), in south and central Texas. Cave Swallows have expanded their range in Texas and into south Florida (Martin 1974, Kosciuch et al. 2006, Strickler and West 2011). This species has incorporated culverts, bridges and parking garages beyond the usual use of caves for nesting and roosting sites. While the range of the Cliff Swallow has not changed, they have recently incorporated human-made structures for nesting and roosting sites (Kosciuch et al. 2006, Holderby et al. 2009, Strickler and West 2011). The increase in range overlap (contact zone) because of anthropogenic structures provides an opportunity to examine spatial and temporal resource use between two closely related species.

The majority of existing work on Cave and Cliff Swallows has focused on brood parasitism, colony size effect between species, egg transfer, and parasites (Weaver and Brown 2004, 2005). My study will examine the nesting overlap (spatially and temporally) of Cliff Swallows and Cave Swallows as well as seasonal use of human-made structure (bridges, parking garages) in Central Texas where both species occur. Seasonal use of bridges and parking garages is of interest because temporal variation in use may affect spatial occupancy (i.e. early arrivals choose nesting locations) as well as nesting productivity and survival of offspring. The contact zone in south and central Texas between Cave and Cliff swallows is an ideal region to examine colony interactions and potential differences in colonization of these sites (Holderby et al. 2009).

In my study we also examined potential spatial proximity of nests within nesting structures based on thermal and ambient light properties. While both species of swallow may select the same nesting structure, species preferences for nest sites might still result in spatial and/or temporal separation within the structure. In a study of mixed-species waterbird colonies, Pius and Leberg (2002) hypothesized that Black Skimmer (*Rhynchops niger*) might be attracted to Gull-billed Terns (*Sterna nilotica*) within mixed-species colonies and therefore may nest in close association with Gull-billed Terns. However, Pius and Leberg (2002) found Black Skimmers nested in greater numbers next to skimmer decoys as opposed to tern decoys, suggesting that within, mixed-species colonies nesting, individuals still opt to nest closer to conspecifics than other species.

In a 30-year study of Cliff Swallows in Nebraska, Brown et.al (2013) found that "colony size in Cliff Swallows is temporally and spatially unpredictable when viewed across the 30 years of this study". The authors looked at average colony size; and the size distributions change annually in response to ecological factors (Brown et al. 2013:512). Brown et al. also looked at site characteristics; and patterns in colony size variability within sites over time and ecological variables potentially associated with these size changes. They concluded by saying that the variation in colony size of Cliff Swallows could be due to evolutionary, ecological, and behavioral processes working in various ways (Brown et al. 2013: 527). In my study, I examined spatial isolation between swallow species and investigated the influence of temperature and ambient light on nest site selection.

Study Species

Cave Swallow and Cliff Swallows are morphologically very similar species. The most noticeable morphological differences are in the forehead patch color and throat color, with both areas tan in Cave Swallows and white and chestnut, respectively, in Cliff Swallows (Brown and Brown 1995, Strickler and West 2011). Sexes are difficult to distinguish, but females of both species have a brood patch and in Cliff Swallows, the males have a dark blue patch at the base of the throat (Brown and Brown 1995).

Both species are insectivorous and have been documented aerially foraging together in mixed–species flocks. Swallows have been observed in mixed species colonies where they act like a single colony in their calls and foraging (Brown and Brown 1995, Weaver and Brown 2005, Strickler and West 2011). Cliff Swallows migrate to Central and South America for the winter. Cave Swallows migrate to South America, but some Texas birds overwinter in the southern portion of Texas (Holderby et al. 2009). Cliff Swallow breeding range is from Alaska southward to Baja California and Mexico and eastward into Connecticut (Brown and Brown 1995). The wintering range is from Brazil southward into Paraguay (Brown and Brown 1995). Cave Swallow breeding range is from N.E. New Mexico eastward into West and Central Texas southward into Mexico. They also breed in Southern Florida and Greater Antilles (Strickler and West 2011). The wintering range is similar to the breeding range since they migrate southward toward the borders of New Mexico and Texas (Strickler and West 2011). In southern Florida they migrate to the Caribbean Islands (Strickler and West 2011), and in central Texas they have been documented wintering in their same breeding range (Strickler and West 2011).

During the breeding season both species make nests from mud. They form the nests by adding mud with their beaks to the substrate (human-made or natural, see Fig. 1). Both species will use pre-existing nests and repair them if needed as long as the old nests are not infested with swallow bugs *Oeciacus vicarius* (Brown and Brown 1996). Both species line nests with dry algae and plant material like grasses and cotton (Brown and Brown 1995, Strickler and West 2011). Swallows typically begin nesting in March/April and breeding season extends to as late as August (Brown and Brown 1995, Strickler and West 2011).

The overall goal of my research was to examine resource use by swallows nesting in human-made structures and to investigate interactions between these swallow species during the breeding season. Specifically, I examined 1) seasonal use of bridges by both species of swallow and, 2) spatial isolation of nests at nest sites (e.g. spatial proximity of nests within nesting structure) based on thermal and ambient light properties.

2. METHODS

Study Site

I conducted this study at five bridges in central Texas (Table 1, Fig. 2). I examined the selected study sites *a prior* for the presence of swallow nest substrate. I evaluated the heights of the bridges because height might potentially limit the ability to count nests and mount environmental data loggers. The height of the bridges over water bodies in decreasing height, are as follows: Guadalupe River site 4 (B4) at 14.17 m, Colorado River bridge site 1 (B1) at 7.10 m, Plum Creek site 2 (B2) at 7.47 m, Blanco River site 3(B3) at 6.89 m and the Blanco State Park site 5 (B5) is the shortest at 4.94 m (Orsak 2014). The amount of vegetation, or openness, around each bridge could also potentially affect species occupancy and abundance (Fig. 3). The vegetation around the bridge can block flight path to and from the nest site which could be unfavorable to swallows. Based on the degree of openness (0-3, open to closed), the bridges were classified as follows: B1 = 3, B2 = 3, B3 = 1, B4 = 2, and B5 = 0 (Orsak 2014).

Survey Methodology

I observed and documented for two years, 2013 and 2014, the arrival, placement and numbers of active nests at each site on a weekly basis from February - August or until breeding swallows were no longer present. I recorded nest occupancy by species through direct observation with spotting scope or binoculars. I defined an active nest as a nest with presence of swallows and/or signs of recently added materials. Swallows often reuse nests from previous seasons, but add material (usually mud) prior to nest initiation (Fig. 4 and 5; Brown and Brown 1995, 1996). Figure 4 shows the different stages that a Cliff Swallow nest goes through before it is complete. Figure 5 shows a complete Cave Swallow nest. There are similarities between a complete Cave Swallow and a partially completed Cliff Swallow nest, so to correctly identify the nest, I confirmed presence of Cave Swallows by sight or sound. In addition, I photographed nests prior to arrival of swallows and then again periodically throughout the breeding season to document spatial and temporal changes in colony size and count complete nests.

During weekly surveys, I counted all completed Cliff and Cave Swallow nests. To better estimate abundance numbers, based on complete Cave Swallow nests, I examined photographs taken during both breeding seasons. Both number of birds and total number of nests observed provide an index of nesting activity and the maximum number of potential nests (MNPN) at each of the sites.

Effects of Temperature and Ambient Light

In 2014, I examined thermal and ambient light differences that may influence spatial segregation of Cave and Cliff Swallow nests within and between study sites (B2, B3, and B5).These bridges were chosen because of the confirmed presence of both species. I placed Hobo® temperature/light data loggers at each site, two within the interior spans of bridges and two along the exterior spans of the bridge. A span is defined as the area where birds nest which is at a right angle to where the girder meets the deck as described in Orsak (2014). All data loggers were placed along spans that contained nesting swallows. The data loggers were installed March 2014 and taken down in September 2014. The bridges have an east-west orientation so the data loggers were labeled as follows: North outer, North interior, South interior and South outer. I compared ambient temperature (°C) and light (Lux) measurements between bridges and within bridges, between spans, with the number of Cliff and Cave Swallow nests to determine if light and/or temperature influences nest placement by each species. I conducted a multivariate analysis of variance (MANOVA) to examine differences in ambient light and temperature both within each bridge (between spans) and between bridges.

3. RESULTS

Bridge Surveys

Cliff and Cave Swallows were present during both years of this study in our surveys. While numbers varied between years and among bridges, in general, Cliff Swallows were present at all bridges and were the numerically dominant species within nesting colonies at all of the sampled bridges. In contrast, I recorded Cave Swallows at B2 and B5 during both years. At these sites, nesting Cave Swallows still comprised a small number of individuals compared with Cliff Swallow.

At all bridges, the maximum number of complete nests indicated the maximum number of nesting pairs occupying the site. The complete nests counted were the nests that had recently added mud or appeared complete based on photos. The number of birds was the count taken from when I did my surveys, birds were counted when they were at a nest. The bird count and nest count includes both species of birds. For B1, I counted a maximum of 900 and 550 nests in 2013 and 2014, respectively (Fig.6), and a maximum number of 345 and 201 birds during my surveys in June 2013 and April 2014, respectively. For B2, I counted a maximum of 220 and 280 nests in 2013 and 2014, respectively (Fig.7), and a maximum number of 50 and 32 birds during my surveys in June 2013 and March of 2014, respectively. For B3, I counted a maximum of 800 and 780 nests in 2013 and 2014, respectively (Fig.8), and a maximum number of 245 and 240 birds during my surveys in May 2013 and April 2014, respectively. For B4, I counted a maximum of 300 and 290 nests in 2013 and 2014, respectively (Fig.9), and a maximum number of 108 and 90 birds during my surveys in April 2013 and 2014. For B5, I counted a maximum of 123 and 110 nests in 2013 and 2014, respectively (Fig.10), and a maximum number of 85 and 75 birds during my surveys in May 2013 and April 2014, respectively.

For B2, I counted six Cave Swallow nests (three on North Interior, three on South Interior spans) in July 2013 and June 2014, respectively (Table 2). I found no Cave Swallow nests in either years at B3. At B5 I counted three Cave Swallow nests (two on North Outer, and one on North Interior spans) counted in July 2013 and June 2014, respectively.

Effects of Temperature and Ambient Light

I found no interaction between bridge and span (F = 0.901, $P = 0.493$) for mean temperature (°C) but the three bridges (B2, B3, B5) differed in mean temperature with B2 being warmer than B3 and B5 (F = 15.104, $P < 0.001$; Tables 3-5). For mean light (Lux), I found an interaction between bridges and span (F = 63.75, $P < 0.001$) with all bridges receiving less light at interior spans than at the outer spans. The bridges differed in overall ambient light, in order of decreasing light: B3, B2, and B5.

4. DISCUSSION

At all sites and during both years, the number of birds counted during these surveys was considerably less than the number of complete “active” nests. This was most likely due to the possibility that during surveys I may have missed birds. Swallows are rarely at a nest for any lengthy period of time, often making repeated trips to and from the nest throughout the day to feed themselves, their mate and/or young (Brown and Brown 1996). When birds are present for any lengthy period of time, it is typically for incubation. However, when the female is incubating, she may be difficult to observe because the chimney shaped nest precludes internal observation of nest contents. Nevertheless, these bird surveys provide an index of nesting activity (i.e. presence/ absence) and colony/nest phenology (incubation, hatching, etc.).

My results present both number of birds and total number of nests observed to provide an index of nesting activity and the MNPN at each of the sites. The number of complete nests represents the total number of nests that were observed and classified as completely built. However, a complete nest does not necessarily represent an active nest but indicates the potential for nesting to occur. Nests and incomplete nests (e.g. partial nests) are present year round at sites and are likely re-used annually by nesting swallow pairs (Brown and Brown 1996). However, it should be noted that my estimated bird surveys do not that suggest maximum colony sizes were reached during either nesting season.

My examination of the influence of light and temperature on spatial segregation of nesting swallows revealed differences between bridges (temperature) and between and within bridges (light). For temperature, B2 was surprisingly the warmest of the three measured bridges. This was surprising because the bridge was more vegetated (3 rating on open-closed scale) and had greater average discharge of water underneath it than B5 or B3. Intuitively, the interior and outer spans differed significantly in light received with the interior portion of all bridges being darker. This is reasonable because the sun will hit the outer portion of the bridge for longer periods of time then the inner. The bridges did differ in light received with B3 receiving the most sunlight. B3 had no vegetation around the bridge and was higher in height than B5. While B2 was of similar height to B3, B2 was heavily vegetated which presumably blocked sunlight. Therefore increased sunlight may at least partially explain why no Cave Swallows were detected at B3.

Cave Swallows were found only within the interior spans of bridges (i.e. darker areas) and at the two bridges that received the less light. However, Cave Swallows did not appear to be influenced by temperature as Cave Swallows occupied the hottest (B2) and coolest (B5) of the three bridges. Based on my results, it appears Cave Swallows are selecting bridge site that are relatively dark but appear not to be influenced as much by temperature at the nest site. Future studies are warranted to continue investigating the nest site selection of Cave Swallows as they continue to expand their range into the southwestern United States (Kosciuch et al. 2006, Holderby et al. 2009).

Kosciuch and Arnold (2003) first reported Cave Swallows using bridges but interestingly, all documented nests were in old Barn Swallow (*Hirundo rustica*) nests. They did not report use of Cliff Swallow nests or nesting in close association with Cliff Swallows by Cave Swallows. My study is the first to report this novel nesting behavior. Future studies should investigate possible competition between Cliff and Cave Swallows and conduct a comparison of nesting success between the two congeneric species. Lastly, as Cave Swallows have only been recently documented to over-winter in Texas (Holderby et al. 2009), future studies examining the influence of temperature and light on overwintering birds would add new insights into the continuing range expansion of Cave Swallows and potential impacts on Cliff Swallows.

Figure 1: Example of Cliff Swallow *(Petrochelidon pyrrhonota)* nests and how each nest was classified according to nest building stage. Note color differences in nest substrate materials also indicate new material (i.e. mud) added during observed breeding season at B3-Blanco Bridge in Blanco, Texas, 2013.

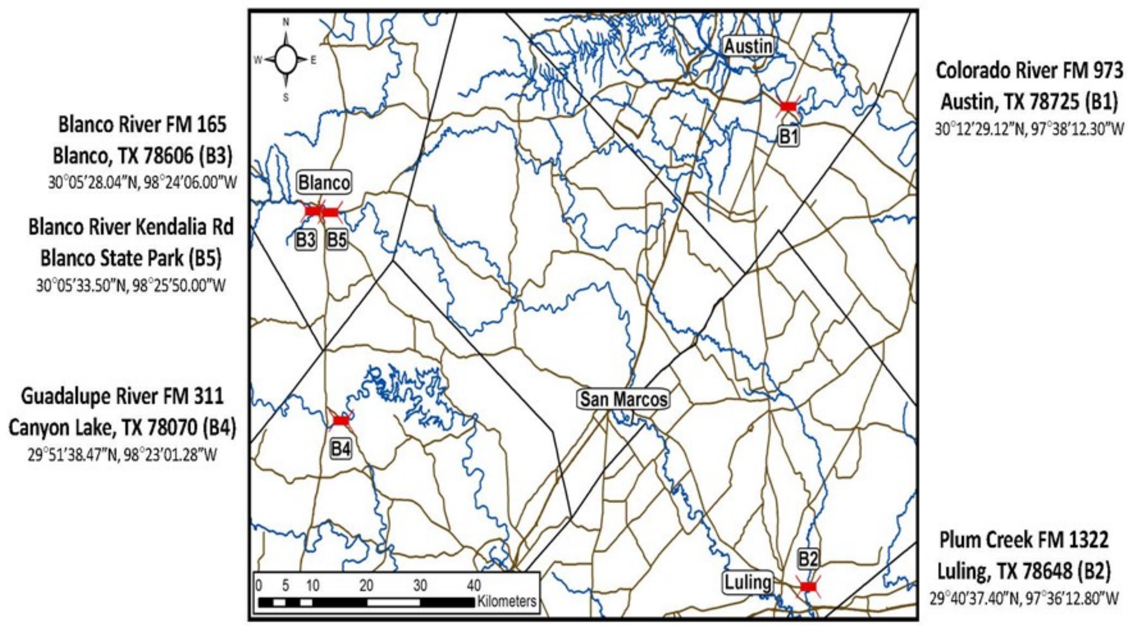

Figure 2: Locations of the five bridges surveyed weekly for the presence and relative abundance of swallow (*Petrochelidon* sp.) nesting colonies in Texas, 2013-2014.

Figure 3: Numerical values of the openness of vegetation (0 – 3 with 0 being no vegetation and 3 being heavily vegetated) at the study sites used for the study in 2013-2014 in San Marcos, Texas.

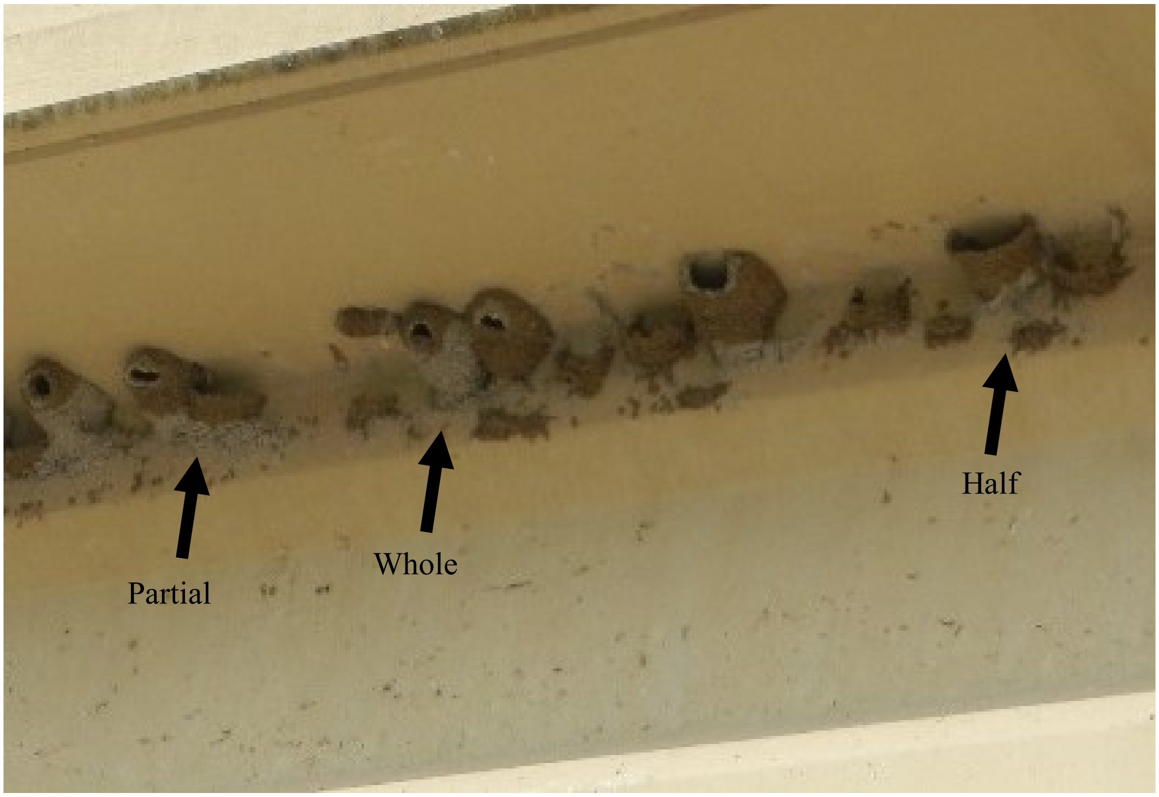

Figure 4: Example of Cliff Swallow nests at the different stages of development at B3-Blanco Bridge in Blanco, Texas, 2013.

Figure 5: Example of a Cave Swallow nest that would be counted as complete at B5-Blanco State Park in Blanco, Texas, 2014.

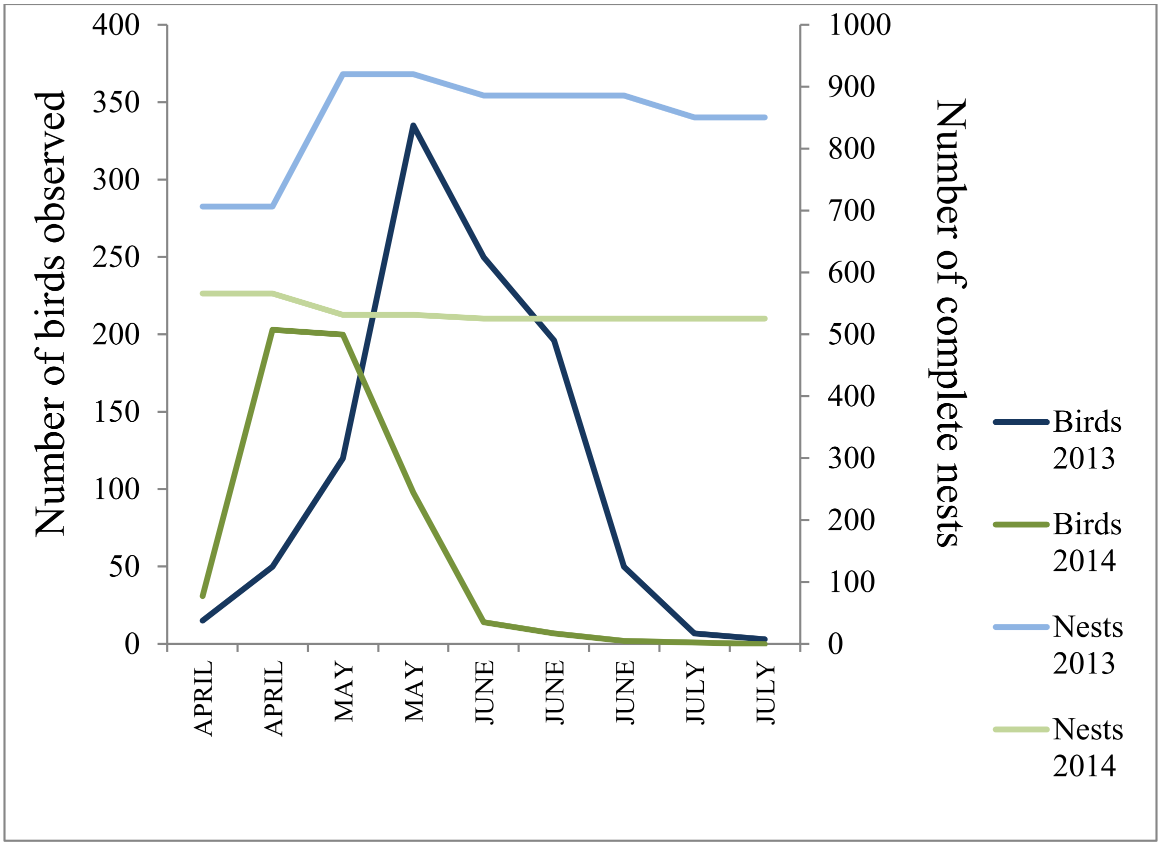

Figure 6: Seasonal surveys (2013-2014) of number of birds observed and number of completed (whole) nests observed at B1- Colorado River in Austin, Texas (FM 973 over Colorado River).

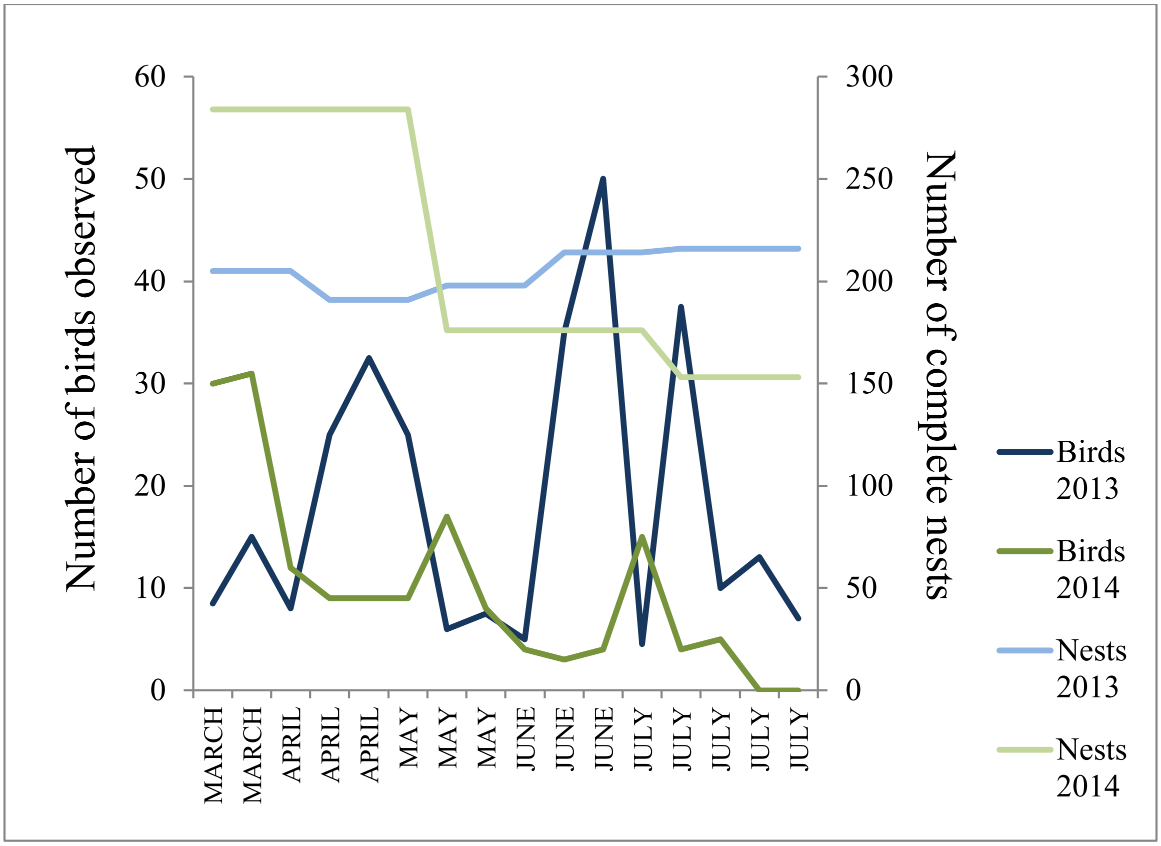

Figure 7: Seasonal surveys (2013-2014) of number of birds observed and number of completed (whole) nests observed at B2- Plum Creek in Luling, Texas (FM1322 over Plum Creek).

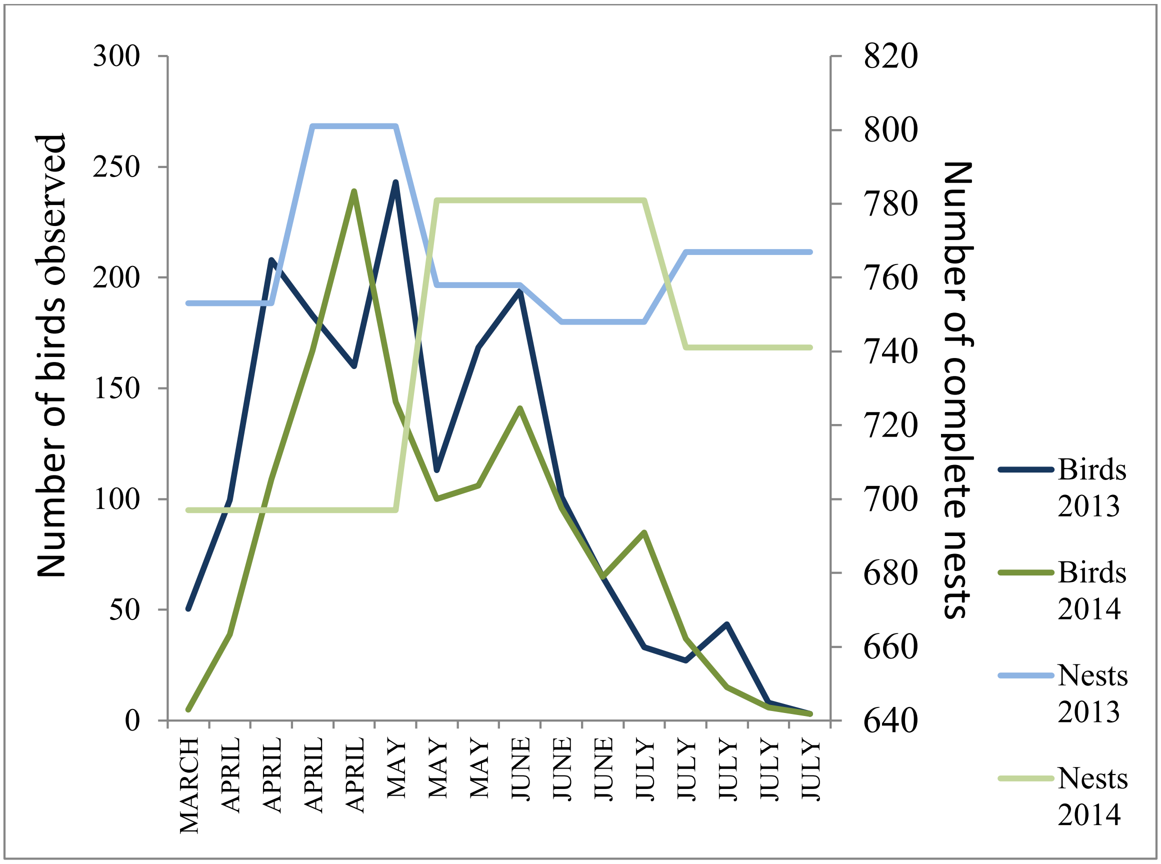

Figure 8: Seasonal surveys (2013-2014) of number of birds observed and number of completed (whole) nests observed at B3-Blanco Bridge in Blanco, Texas (FM165 over Blanco River).

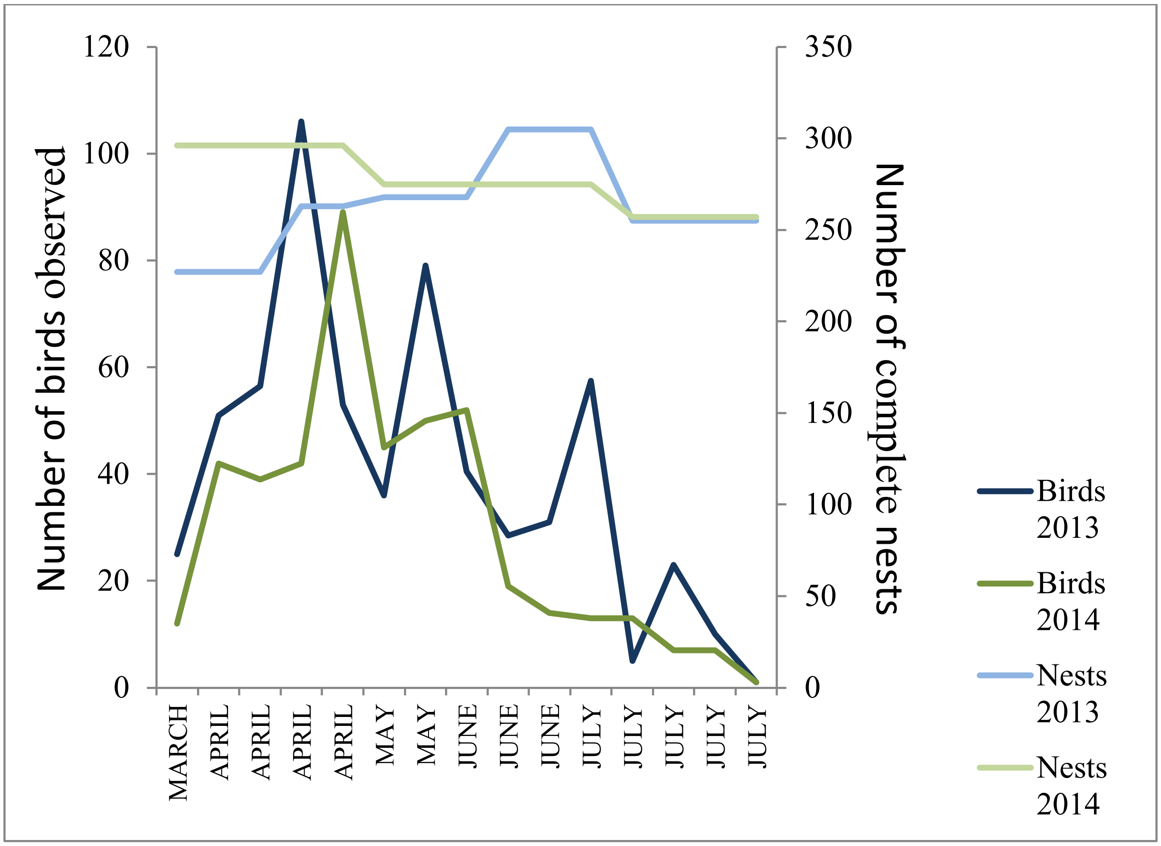

Figure 9: Seasonal surveys (2013-2014) of number of birds observed and number of completed (whole) nests observed at B4- Guadalupe River in Canyon Lake, Texas (FM311 over Guadalupe River).

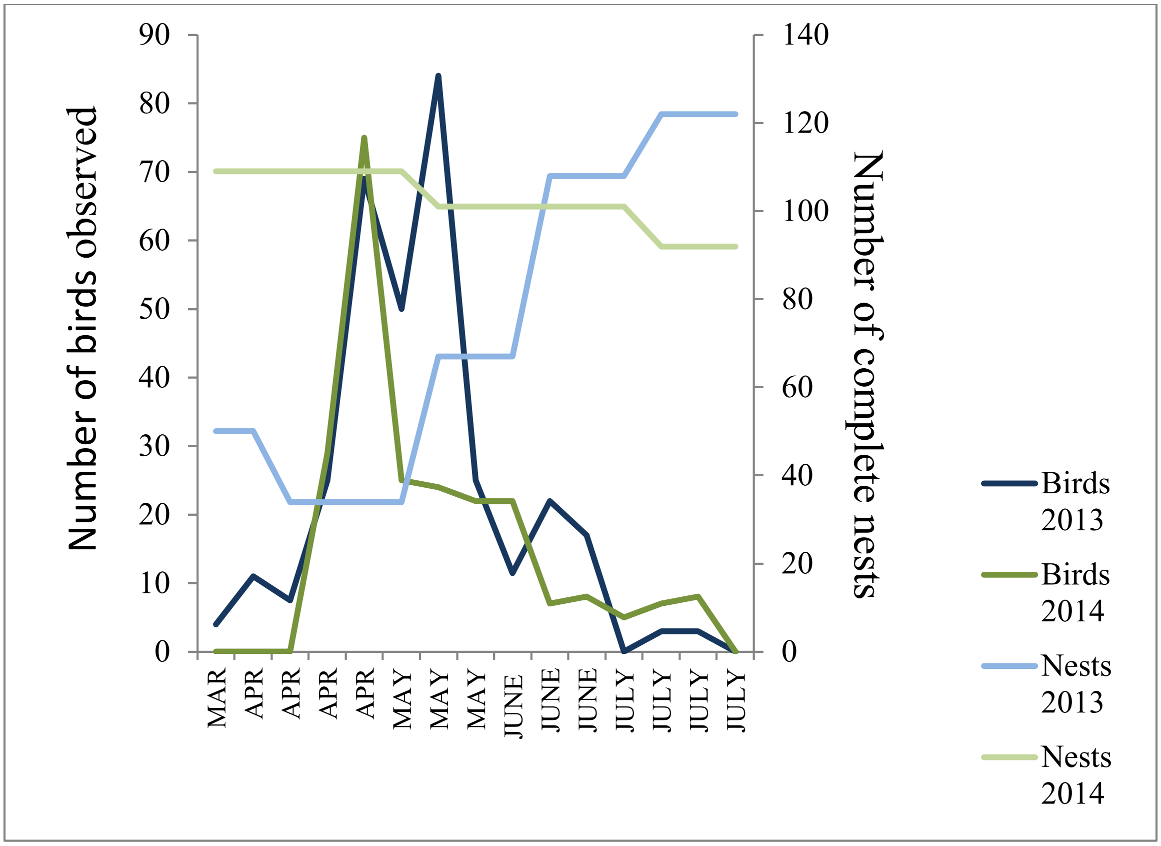

Figure 10: Seasonal surveys (2013-2014) of number of birds observed and number of completed (whole) nests observed at B5- Blanco State Park in Blanco, Texas (Kendalia road over Blanco River).

Table 1: Bridge locations and mean discharge rate from March 2013 to August 2014 of surveyed sites in Central Texas region in 2013-2014.

Bridge	River	Nearest City	Latitude	Longitude	USGS Station	Mean discharge(ft^3/s)
B1-Colorado River	Colorado	Austin, TX	30° 12' 30.67" N	97° 38' 17.05" W	08158000	336.13
B2-Plum Creek	Plum Creek	Luling, TX	29° 40' 37.38"N	97° 36' 13.14" W	08173000	82.21
B3-Blanco Bridge	Blanco	Blanco, TX	30° 5' 28.19" N	98° 24" 7.09" W	08171000	57.74
B4-Guadalupe River	Guadalupe	Spring Branch, TX	29° 51' 38.98" N	98° 23' 1.27" W	08167500	49.08
B5-Blanco State Park	Blanco	Blanco, TX	30° 5' 33.37" N	98° 25' 49.95" W	08171000	57.74

Table 2: Number of complete swallow nests at B2, B3, and B5 by spans of bridges in 2013, 2014. Estimated numbers of complete nests are Cliff Swallows (number of Cave Swallows).

Name	Year	North Outer	North Interior	South Interior	South Outer
B2-Plum Creek	2013	0	115(3)	127(3)	0
	2014	0	115(3)	129(3)	0
B3-Blanco Bridge	2013	533	0	4	248
	2014	541	0	4	248
B5-Blanco State Park	2013	101(2)	5(1)	2	0
	2014	101(2)	5(1)	2	0

Table 3: Comparison of mean temperature (°C) and mean ambient light (Lux) between the three study sites (i.e. bridges) and between spans. All bridges were oriented approximately along east-west axis, therefore data loggers were positioned on outer and interior spans, north and south facing.

	Mean Temp (°C)	Mean Light (Lux)
Bridge		
B2-Plum Creek	26.34 ± 0.22 A[1]	3374.40 ± 99.03 A
B3-Blanco Bridge	25.01 ± 0.21 B	3992.76 ± 128.83 B
B5-Blanco State Park	24.83 ± 0.21 B	1951.13 ± 68.93 C
Span		
North Outer	25.41 ± 0.25 A	5258.40 ± 89.89 A
North Interior	25.55 ± 0.25 A	1002.97 ± 24.70 B
South Interior	25.69 ± 0.25 A	878.63 ± 25.64 B
South Outer	24.92 ± 0.24 A	5288.41 ± 113.96 A

[1]Different letters within each subset (i.e. Mean Temperature at bridges) denotes significant differences based on Tukey's HSD post-hoc test.

Table 4: Hobo® data logger results (mean ± (S.E.)) for the three sites (Plum Creek, Blanco, and Blanco State Park), 2014.

	Bridge 2				Bridge 3				Bridge 5			
Data Loggers	North Outer	North Inner	South Inner	South Outer	North Outer	North Inner	South Inner	South Outer	North Outer	North Inner	South Inner	South Outer
Variables												
$Temp_{min}$[1]	21.23 (0.48)	23.42 (0.48)	23.58 (0.48)	20.74 (0.49)	20.25 (0.47)	21.18 (0.47)	21.25 (0.46)	19.61 (0.45)	20.57 (0.46)	21.27 (0.46)	21.27 (0.44)	20.32 (0.44)
$Temp_{max}$	31.79 (0.43)	30.34 (0.41)	30.38 (0.42)	31.08 (0.41)	31.22 (0.46)	28.92 (0.41)	28.97 (0.42)	30.5 (0.44)	31.18 (0.47)	28.75 (0.41)	28.86 (0.43)	28.98 (0.40)
$Temp_{mean}$	25.89 (0.43)	26.94 (0.44)	26.97 (0.44)	25.55 (0.42)	25.32 (0.43)	24.84 (0.44)	25.15 (0.43)	24.72 (0.41)	25.01 (0.43)	24.94 (0.42)	24.87 (0.42)	24.49 (0.40)
$Temp_{midpt}$[2]	26.51 (0.44)	26.88 (0.44)	26.98 (0.44)	25.91 (0.43)	25.74 (0.44)	25.05 (0.43)	25.11 (0.42)	25.05 (0.42)	25.88 (0.44)	25.01 (0.42)	25.07 (0.42)	24.65 (0.40)
$Light_{min}$	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
$Light_{max}$	23979 (407.4)	6276 (147.8)	3955 (74.4)	20707 (349.3)	22584 (386.6)	4208 (80.4)	4413 (84.1)	28046 (540.0)	16844 (523.9)	2419 (255.3)	3072 (199.4)	13755 (327.5)
$Light_{mean}$	5800 (139.2)	1371 (36.6)	1039 (48.6)	5298 (120.9)	6177 (160.4)	1223 (27.2)	1233 (29.2)	7338 (207.3)	3798 (85.6)	363 (10.5)	414 (9.6)	6200 (2981.5)
$Light_{midpt}$	11990 (203.7)	3138 (73.9)	1977 (37.2)	10353 (174.6)	11292 (193.3)	2104 (40.2)	2206 (42.1)	14023 (270.0)	8422 (261.9)	1210 (127.6)	1536 (99.7)	6877 (163.77)

[1]The min and max values are the minimum and maximum daily values for temperature and light.
[2]The midpoint is the range of the min and max divided by two.

Table 5: MANOVA results from data logger data for the three sites (Plum Creek, Blanco, and Blanco State Park), 2014.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
$MEAN_{temp}$					
Corrected Total	1187.10	11	107.918	3.744	$P < 0.001$
Intercept	1237161.81	1	1237161.81	42926.0	$P < 0.001$
Bridge	870.64	2	435.317	15.104	$P < 0.001$
Span	159.45	3	53.149	1.844	$P = 0.137$
Bridge * Span	155.82	6	25.970	0.901	$P = 0.493$
Error	54961.27	1907	28.821		
Total	1293305.83	1919			
$MEAN_{light}$					
Corrected Total	1.103×10^{10}	11	1.003×10^{9}	617.59	$P < 0.001$
Intercept	1.853×10^{10}	1	1.853×10^{10}	11405.36	$P < 0.001$
Bridge	1.404×10^{9}	2	701961904	432.15	$P < 0.001$
Span	9.009×10^{9}	3	3.003×10^{9}	1848.85	$P < 0.001$
Bridge * Span	621328605	6	103443767	63.75	$P < 0.001$
Error	3.098×10^{9}	1907	1624339		
Total	3.265×10^{10}	1919			

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