Conservation Measures to Increase Breeding Success of Cliff Swallows (*Petrochelidon pyrrhonota*) in Massachusetts

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Abstract – The Cliff Swallow (*Petrochelidon pyrrhonota*) is experiencing significant population declines in parts of its breeding range, particularly in northeastern North America. At 12 active Cliff Swallow colonies in western Massachusetts in 2019–2020, we examined the extent to which installation of artificial nests, providing of mud sources, and House Sparrow (*Passer domesticus*) control affected Cliff Swallow colony-size increase and reproductive success. While there was a trend for colony size to increase at sites with artificial nests, there was not a significant size increase at these sites from 2019–2020. Cliff Swallow nesting success was significantly lower at colony sites where House Sparrows were present, compared to those at which they were absent. The number of nesting Cliff Swallows at two sites where mud sources were enhanced increased from 2019–2020. House Sparrow control efforts at one site (by shooting) were unsuccessful. Our study suggests that without effective control of House Sparrows, Cliff Swallows are likely to keep declining in Massachusetts, regardless of other management techniques used.

Introduction

The Cliff Swallow historically nested on vertical cliff faces underneath horizontal overhangs, primarily in western North America but with smaller numbers farther east. With European settlement of the continent, Cliff Swallows expanded their range, as they shifted to artificial structures such as buildings, bridges, and highway culverts for nesting (Bent 1942, Brown et al. 2020). However, the introduction in the mid-1800s of non-native House Sparrows that compete with Cliff Swallows for nests (Brown et al. 2020, Forbush 1929) led to a population decline of Cliff Swallows in the northeastern United States that has continued to date and has perhaps intensified in recent years: for example, the species decreased in Massachusetts by about 48% since 1985 and by about 27% since 2000 (Sauer et al. 2017). In 1992 there were 34 Cliff Swallow colonies known in Massachusetts (Silver 1993), but by 2020 the number of colonies statewide had dropped to only 15 known colonies (M. Silver, unpubl. data).

Perhaps because the Cliff Swallow is so abundant in the western half of the country, few studies range-wide have been done on ways to enhance reproductive success and colony persistence. Early work in the mid-West showed that removal of old nests prevented House Sparrows from becoming entrenched at a site and also reduced infestations of ectoparasites such as fleas and cimicid swallow bugs that overwinter in old nests (Buss 1942, Emlen 1986, Krapu 1986). Swallows have responded to nest removal by dramatically increasing colony size each year at some sites (Buss 1942, Emlen 1986, Krapu 1986). In other cases, however, removal of old nests can lead to birds' avoiding the site in subsequent years because of the apparent lack of "public information" that the site is suitable (Brown and Brown 1996, Brown et al. 2000). Leaving old nests but fumigating them to remove ectoparasites also leads to colony size increases and persistence of colonies in Nebraska (Brown and Brown 2015), although application of chemicals has been done primarily for research to date and not for management. Construction of alternative nesting structures has been done in some areas, primarily in the West (Brown et al. 2020), and Cliff Swallows have occupied such sites, but typically the objective has been to entice large colonies to move off of structures where the birds were unwanted.

Existing conservation measures for Cliff Swallows have been enacted mostly in the northeastern United States (Kitson and McNaught 1991, Silver 1995). There, the birds face the same issues associated with House Sparrow competition and ectoparasitism as elsewhere, but in the Northeast many colonies have the additional challenge of being situated on the sides of wooden barns or buildings where nests tend not to adhere well and often fall from the substrate, either during the nesting season or afterwards. Efforts to increase colony size and encourage colony persistence from year to year have focused on providing the birds with artificial nests, which are more stable and that Cliff Swallows readily occupy in our Massachusetts study area (Silver 1995, 2012). Cliff Swallows also respond to artificial nests by building natural nests around them. In addition, some evidence has indicated that birds in Massachusetts may respond to the presence of a nearby mud source by being more likely to build nests at a site (Silver 1995, 2012), although mud seems to have little effect on Cliff Swallow site use in Nebraska (Brown and Brown 1996).

Our goal in this study was to present results of three conservation measures at Cliff Swallow colonies in western Massachusetts previously suggested to increase breeding success: (*i*) provisioning colony sites with artificial nests, (*ii*) creation of a mud source at a colony site; and (*iii*) local control of House Sparrows at a colony site. The rarity of the species in the state and the relatively small number of extant colonies meant that it was impossible to do a systematic, controlled study of the different management methods. Rather, here we report the apparent effect that each had, recognizing that a larger sample size of colonies would be desirable. However, such studies will not be possible until we stabilize and reverse declines of this uncommon species in the state. The results described here may help toward that goal.

Study area and methods

We conducted our work at 12 Cliff Swallow colonies in northwestern Massachusetts: three in Franklin County and nine in Berkshire County (Table 1). All but two colonies were under the eaves of buildings, generally in rural settings (farms, often with livestock) or on buildings in relatively small towns. The two bridge sites were on the Housatonic River. Most of these sites had been monitored by us in earlier years, except for two that were first discovered in 2020.

In 2020, before the nesting season began, we installed fired clay artificial nests (Fig. 1) at eight of the colony sites that had been active in 2019. A total of 125 artificial nests were installed among the colonies (Table 1). Where complete nests were too difficult to install due to the shape of building eaves, artificial nest "ledges" (which resemble partially built nests) were installed. At the two bridge sites (NLR, GB), nests were installed by a climber (Fig. 2), as access was not possible from the ground. At the remaining sites, artificial nests were installed under building eaves using a ladder. At the HR colony, a mud source approximately 12 m from the colony was created by periodically hosing down an approximately 15 m^2 area of a ploughed field as needed to keep it a muddy consistency throughout the nesting season. At the BCC colony, a 6 m^2 mud source was created in a turf area approximately 15 m from the colony. Sod was removed from a wet drainage area, leaving a shallow hole which was periodically filled with 20 l of natural clay mixed with existing soil and water to create mud of sticky consistency. The puddle was agitated approximately twice a week to maintain the sticky consistency. At the HR colony House Sparrow control was implemented using an air rifle.

In 2019 and 2020, 8 colonies were visited approximately twice per week to determine the number of breeding pairs (the colony size), and in 2020 we monitored nesting success at 12 colonies (Table 1). We assessed numbers of breeding pairs by visually observing colonies for 1-3 h per visit. We used the behavior of adult birds at nests to ascertain active nests. This included signs of nest-building (e.g., wet mud), bird activity at nests, and feeding of nestlings or removal of fecal sacs. At about 12 days old nestlings are vocal and can be observed begging at nest entrances (Brown et al. 2020). Nesting success was determined by observation from the ground. Nesting success was assumed if at least one chick reached fledging stage, indicated by ≥ 12 day-old juveniles begging at nest entrances and/or observations of fledging. We assumed nesting failure if nesting activity ended before nestlings could have reached fledgling stage or if House Sparrows occupied a nest. Additionally, naturally built active nests that fell during the nesting season before nestlings fledged were considered nesting failures. Nesting success was calculated as the percent of successful nests of the total nests at a colony. Cliff Swallows usually produce a single brood per season (Brown et al. 2020), but will re-nest if they lose nests early during the nesting period. Re-nesting attempts were excluded to avoid having the same individuals potentially represented more than once at a colony.

Results

At the eight colonies at which artificial nests were installed in 2020 (Table 1), the average (± SE) percentage change in colony size from 2019 was 40.55 % (± 29.20), but this change did not differ significantly from zero (one-sample *t*-test, $t = 1.39$, $p = 0.21$). At the sites where the number of nesting pairs increased, the percentage increase varied from 16.7 to 225% (Table 1).

House Sparrows were present at nine of the 12 colonies in our study (Table 1). At these nine sites, Cliff Swallow nesting success (mean ± SE) was significantly lower (37.8% ± 10.08) compared to nesting success at the three sites at which House Sparrows were absent (95.6% ± 2.30; Wilcoxon test, $Z = 2.43$, $p = 0.015$). House Sparrows were observed taking over Cliff Swallow nests and defending nearby nests. We also observed formerly active Cliff Swallow nests filled with House Sparrow nesting material and dead chicks at nest entrances and on the ground under nests. The three smallest colonies in our study were abandoned during the nesting season; House Sparrows were observed harassing Cliff Swallows at these three colonies. At the one colony where House Sparrow control was undertaken, this measure did not succeed in reducing the House Sparrow population. House Sparrows infiltrated the site faster than they were removed, and control measures were terminated before the end of the nesting season.

At one colony (BCC), where a mud source was created in 2019 and maintained through the 2020 nesting season, the number of active nests increased from 1 in 2018 to 10 in 2019 and 16 in 2020. At the second colony (HR) with a mud source created in 2019, the number of active nests was 18 in 2019 and 21 in 2020. Both colony sites also had artificial nests.

Discussion

In our study, the colony size of Cliff Swallows increased at the majority of sites where artificial nests were installed, but the increase was not significant. Artificial nests have the benefit of not falling from the substrate, unlike naturally built nests, especially in humid conditions (Emlen 1954, Silver 1993, 1995). This benefit of artificial nests, however, appeared to be offset by interference from House Sparrows, which begin nesting earlier in the season than Cliff Swallows and often usurp some or all artificial nests at a colony site. Our results seem to indicate that installation of artificial nests, at least when House Sparrows are present, may confer relatively little positive effect on local Cliff Swallow persistence at a site. In addition, artificial nests may promote build-ups of ectoparasites (Loye 1985), although our study did not address benefits of parasite control. Because Cliff Swallow colonies in Massachusetts in general are relatively small, parasites there probably do not reach the high levels in large colonies documented in large colonies in other areas (e.g., Oklahoma, Nebraska) that cause reduced nesting success and nest and colony-site abandonment (Brown and Brown 1996, Loye and Carroll 1991).

The greatest impediment to nesting success of Cliff Swallows in our study was nest-site competition from House Sparrows. Our finding of a mean 37.8% Cliff Swallow nesting success at colonies with House Sparrows is consistent with studies in Arkansas that found Cliff Swallow nesting success was about 30% in sections of a colony with high House Sparrow activity (Leasure et al. 2010). Even only a few pairs of House Sparrows can have a detrimental impact on a colony, defending not only the nest the sparrows occupy, but several nests surrounding it (Samuel 1969, Brown and Brown 1996). In a study in North Dakota, there was a greater than 80% annual increase in colony size when House Sparrows were controlled (Krapu 1986). In Wisconsin, the colony at one site increased from 1 to more than 2000 nests over a 38-year period with House Sparrow control (Buss 1942). The most efficient method for eliminating House Sparrows at Cliff Swallows colonies is by shooting them before Cliff Swallows return in the spring (Brown et al. 2020); however, shooting was not effective in our study and furthermore is not practical especially in village centers and at privately owned buildings. In more urban areas, trapping might be more feasible but is less targeted at the particular sparrows causing the problems (C. Brown, pers. obs.).

At the two sites where mud was made available in 2020, the colony size increased slightly at both sites (Table 1). A mud source has been suggested to attract Cliff Swallows to a nesting site (Silver 1995), although controlled studies on the effect of mud on Cliff Swallow colony site occupancy have not been done (Brown and Brown 1996), and our study did not include enough colony sites for a definitive test. Even at colonies with artificial nests, Cliff Swallows use mud to "finish" the artificial nests (Kitson and McNaught 1991), adding mud to both the entrances and the interior of nests. Historically, mud was plentiful at many Cliff Swallow sites in Massachusetts, as colonies were most commonly found on farms. With the decline of agriculture, the apparent availability of mud has also diminished (M. Silver, pers. obs.).

The 2020 field season allowed us to take the first steps in establishing a protocol for Cliff Swallow conservation/management. Although it was known that House Sparrows are a threat to Cliff Swallows, until this study we did not fully understand the extent to which sparrows reduce Cliff Swallow breeding success. House Sparrows were present at the majority of Cliff Swallow colony sites in our study and significantly reduced breeding success at these sites (Table 1). Cliff Swallows are likely to keep decreasing in Massachusetts, even with implementation of the other management techniques we used. Further research into effective and practical methods to control House Sparrows at colonies is urgently needed to inform future conservation actions, especially at the larger Cliff Swallow colonies. The two largest colonies in the state in 2020, one with 99 active nests and another with 38, account for 48% of the known Cliff Swallows nesting in Massachusetts. If House Sparrows were successfully controlled at just these two sites, approximately half the nesting population in the state would benefit. While multiple drivers have been suggested to contribute to the decline of aerial insectivorous birds in North America (Nebel et al. 2010, Spiller and Dettmers 2019), the Cliff Swallow has been increasing in much of North America (Sauer et al. 2017). Thus, its decline in the Northeast is probably still tied directly to House Sparrow interference, as first suggested almost a century ago (Forbush 1929).

Acknowledgments

We thank Steve Johnson and Christopher Hyytinen for installation of artificial nests, Matt Kelly for use of his photograph (Fig. 2B), and the many landowners who granted us access to their property. Funding for this project was provided by the Blake-Nuttall Fund of the Nuttall Ornithological Club.

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Table 1. Cliff swallow colonies studied in northwestern Massachusetts in 2019-2020.

Colony site	County	Latitude N	Longitude W	Nesting substrate	Colony size 2019	Number of artificial nests installed 2020	Colony size 2020	% change in number of active nests	Number of successful nests 2020	Estimated % breeding success	House Sparrows present at colony
HR	Franklin	42°27'17"	72°34'52"	Eaves	18	25	21	+16.7	12	57.1	Yes
RR	Franklin	42°37'21"	72°41'34"	Eaves	-	-	2	-	0	0	Yes
RTH	Franklin	42°41'41"	72°53'54"	Eaves	26	42	36	+38.5	34	94.4	No
NLR	Berkshire	42°23'38"	73°14'25"	Bridge	8	12	26	+225	24	92.3	No
AHF	Berkshire	42°35'55"	73°06'30"	Eaves	-	-	38	-	18	47.4	Yes
HF	Berkshire	42°35'36"	73°06'32"	Eaves	4	8	6	+50	3	50	Yes
GB	Berkshire	42°16'58"	73.20'32"	Bridge	27	12	15	–44.4	15	100	No
GMF	Berkshire	42°24'24"	73°22'03"	Eaves	28	20	22	–21.4	9	40.9	Yes
BCC	Berkshire	42°27'35"	73°18'59"	Eaves	10	8	16	+60	11	68.8	Yes
SMB	Berkshire	42°20'04"	73°22'05"	Eaves	3	8	3	0	0	0	Yes

SRC*	Berkshire	42°12'22"	73°22'53"	Eaves	-	-	99	-	75	75.8	Yes
CSWS*	Berkshire	42°20'01"	73°22'03"	Eaves	-	-	1	-	0	0	Yes

*Colonies were discovered in 2020.

Figure 1. Cliff Swallow nestlings in an artificial nest. Mud has been added to the nest entrance by the nest owners.

A

B

Figure 2. A climber installing artificial Cliff Swallow nests (A) under a bridge over the Housatonic River in western Massachusetts and positioning of nests after installation (B).