BIRDS

NEST SITE USE, BREEDING SUCCESS, AND REPRODUCTIVE RATES OF CHIMNEY SWIFTS IN ST. ADOLPHE, MB, 2010-2013

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Chimney swift (*Chaetura pelagica)* populations have declined since the mid-1960s, as have populations of other aerial insectivores.[1,2,3] In 2009, the chimney swift was listed as Threatened (Schedule 1, Species At Risk Act).[4] The reduction of chimney swift populations has been attributed primarily to the loss of nesting and roosting habitat, pesticide use, and the associated decline of aerial insects.[1,2,5] It is, therefore, important to have data on the reproductive rates of chimney swifts occupying the remaining limited habitat as continued breeding success is necessary for the perpetuation of this species.

Data from chimney swifts nesting in five chimneys on four historic buildings in St. Adolphe, MB, between 2007 and 2009 have been reported.[6] The five chimneys represent the highest concentration of known nest sites in the province, which led the Manitoba Chimney Swift Initiative (MCSI) to designate St. Adolphe the "Chimney Swift Nesting Capital of Manitoba".[7] Situated approximately 15 km south of Winnipeg, St. Adolphe is near the northern periphery of the chimney swift breeding range.[6] The sequence of entry and exit events at a chimney, plus the associated duration-in and between-visit time intervals reflected different nesting stages.[6,8] Feeding rates of non-brooded juveniles were higher in St. Adolphe compared to chimney swifts nesting at southern latitudes.[6,9,10] Based on behavioural data, St. Adolphe chimney swifts had lower rates of successful nesting attempts and lower numbers of fledglings produced per successful attempt compared to birds in more southerly portions of the range.[6,9,10,11,12]

The St. Adolphe nest sites were monitored through four additional seasons (2010-2013) to increase the size of our data set on breeding success. We also used our behavioural observations to assess whether there is variability

in feeding rates with respect to weather and prey availability, and other factors associated with nest failures. We used the fallen nesting remains at two nest sites, each autumn and the following spring, to estimate reproductive rates. Clutch sizes, hatching rates, and fledging rates were confirmed at these sites. Estimates of fledging success based on physical evidence were compared to those based on behavioural observations.

Methods

Daytime and roosting hour (½ hour before sunset to ½ hour after sunset) observations were made following our previous studies.[6,8] Nesting occurred in five chimneys in St. Adolphe designated as (1) SE Club Amical, (2) NE Club Amical, (3) Brodeur Bros., (4) Church, and (5) Main St. (see Stewart and Stewart 2010 for details).[6] The times of entries and exits were recorded, and notes on associated behaviour (direction and speed of approach/departure, vocalizations, presence of other chimney swifts), weather (temperature, wind speed and direction, precipitation, cloud cover) and other notable environmental events (e.g., crop dusting on fields adjacent to St. Adolphe) were documented. Daytime observations were made at more than one site on any given day. Simultaneous multi-site roosting hour observations, timed to the second with synchronized digital watches, allowed us to count chimney swifts in St. Adolphe.

Fledging success was estimated for all five nest sites using behavioural data: the number of juveniles observed in the air or entering chimneys; roosting totals within 48 hours of fledging; and simultaneous multi-site roosting totals. At two chimneys which have accessible clean-outs, Brodeur Bros. and Main St., the fallen remnants of nesting attempts (nests, eggshells etc.) were recovered each autumn and the following spring. Whole eggs and egg fragments were used to estimate the number of eggs in the clutch. Intact eggs were used to estimate the proportion of the clutch that hatched. The number of nestling carcasses was subtracted from the number of hatchlings to estimate the maximum number of fledglings possible. In other words, if there was no in-chimney evidence of mortality, a hatched egg was assumed to have produced a fledgling. However, this number was retained only if there was no other evidence suggesting unobserved mortalities.

Recently hatched chimney swifts and unhatched egg. Hatchlings cannot regulate their body temperature and require brooding until they are 6-7 days old. -Bruce Di Labio

Results

All five chimneys were occupied by a nesting pair in each year from 2010 through 2013. Three times, two nests were started in the same chimney in the same season. To describe overall nesting patterns, we selected the more 'typical' of each for further analysis (see Table 1 for details). The phenology of the remaining 20 nesting attempts did not differ appreciably from that previously described for 2007 to 2009.[6] Therefore, we combined data from 2007-2009 with the 2010-2013 data, increasing the sample size from 10 to 30 nesting attempts (Table 1) with known outcomes.

We used the phenology over all years to calculate median dates for the onset of each nesting stage (Table 1). Sample sizes for median dates vary as nests fail and because there are some missing data. The median arrival date of nesting pairs was May 18, although arrival dates ranged from May 10 to June 25 (46 days). In five attempts, the second

bird of a pair arrived several days after the first, skewing the median arrival date, and were not included in this calculation (see Table 1). A secondary arrival of chimney swifts typically occurred in the third week of June. It is not known whether these birds were relocating from nearby areas or migrants arriving from the south. Since 2009, all five sites have been used and breeding pairs typically occupied the Church, NE Club Amical, and Main St. chimneys first. The SE Club Amical and Brodeur Bros. sites were the last to be occupied.

Nest building started soon after arrival (median date: May 22) and also spanned a wide range of dates (May 12-June 25, 44 d). In the absence of a partner, nest building proceeded with a single bird (e.g., SE Club Amical, 2013). Nest building tended to start immediately if a pair arrived in the third week of June. Overall, incubation started on June 26 (June 3-July 16, 43 d) and the median date on which feeding of non-brooded young started was July 6 (June 26-July 30, 34 d). Generally, feeding non-brooded young started on July 14 (July 7-30, 23 d) and fledging took place on August 1 (July 27-August 16, 20 d). The median date on which daytime use of nest sites ended was August 15 (August 7-28, 21 d).

Feeding rates in 2010-2013 varied more within years than reported previously for 2007-2009.[6] Minimum feeding rates of 1 entry/h were seen in most nest sites prior to nest failure. Maximum feeding rates were highly variable among years. In 2013, all non-brooded juveniles in the three successful nest sites were fed six to eight times per hour from mid-July through to fledging. The maximum feeding rate for non-brooded juveniles was 22 entries/h at Main St. in 2013.

Our behavioural observations indicated that 19 of 30 nesting attempts (63%) failed. The 11 successful nesting attempts produced an estimated 19 fledglings (median: 2; range: 1-3 per nest; Tables 1, 2).

We used the nesting debris observed in the Brodeur Bros. and Main St. chimney clean-outs to calculate clutch sizes and hatching rates, and to estimate fledging rates (Table 2). In 2009, the nest at Main St. failed during feeding of non-brooded juveniles (two dead nestlings were observed) but clutch size could not be verified due to a historical accumulation of debris in the clean-out.[6] Incubation behaviour was recorded at Brodeur Bros. in 2012, but no eggs were found

Table 1. Phenology for five chimney swift nest sites in St. Adolphe, MB. Years 2007-2009 are from Stewart and Stewart 2010. Dates indicate the onset of the nesting stage and all arrival dates are based on when a pair arrived, unless otherwise indicated. Three nesting starts (in italics) that were not representative of typical phenology were excluded

Year (hours of observation)	SITE	ARRIVAL DATE	NEST BUILDING	INCUBATE	FEED BROODED	FEED NON-BROODED	FLEDGE DATE **(Number fledged)**	DATE OF LAST USE D = DAY R = ROOST
2007 (32)	NE Club Amical	May 16	May 16-27	June 11	July 4	July 7	July 27-Aug. 1 **(3 V)**	R:Aug. 13-19
	Church	June 3	Nest failed Aug. 3					D:Aug. 3 R:Aug. 14-22
	Main St.					First observed July 26	Unknown	D:Aug. 1-14
2008 (122)	NE Club Amical	May 14-17	May 17-27	June 19	July 9	Failed July 13		R:Aug. 13
	Church	May 18	May 27-29	June 11	July 3	July 10-13	July 31 **(2 V)**	R:Sept. 2
	Main St.	May 18 n=1 June 17 n=1	May 30	June 30; Nest failed July 18-21				D:July 23 R:Aug. 5-14
2009 (174)	SE Club Amical	June 13-17	June 17-19	June 30-July 2; Nest failed July 21.				D:July 21 R:Aug. 14
	NE Cub Amical	May 19-26	May 19-26	June 9-13	July 2-8	July 16	Aug. 4 **(2 V)**	D:Aug. 11 R:Aug. 12
	Brodeur Bros.	June 19	~June 19	July 10-16; Nest failed July 26.				D:July 26 R:Aug. 3-6
	Church	May 11-21	May 29-June 2	June 3-7	June 26-July 13	July 18-20	Aug. 1 **(1 V)**	D:Aug. 28 R:Aug. 28
	Main St.	May 21 n=1 June 2-7 n=1	May 24	June 30-July 3	July 17-19	July 24-25; Nest failed July 29-30		D:July 31
2010 (253)	SE Club Amical	*May 16 n=1; May 17-19 n=2*	*May 17-19; ~ 1 day use*					
		June 20 n=3, Extra bird present	June 20 Extra bird presence variable until leaves ~June 30	July 11-12 Unstable July 15-19; long unattended periods	July 30; Nest failed Aug. 2=Day 4 of feeding			D:July 31-Aug. 2 R:Aug. 3-16
	NE Club Amical	May 16	May 17-19	June 23	July 8; Nest failed July 10=Day 3 of feeding			
			July 19; second nest	*July 30; Nest failed Aug. 2*				*D:Aug. 5-16 R:Aug. 16-26*
	Brodeur Bros.	May 21 n=1 June 1 n=2	May 22 n=1 June 1 n=2	June 25-28	July 16	July 22 Extra bird arrived Aug. 11	Aug. 16=Day 32 of feeding **(2 V&P)**	D:Aug. 25 R:Aug. 27-Sept. 4
	Church	May 15 n=1 May 16 n=2 May 26 n=3, Extra bird present	May 17-19	June 16-19 Extra bird leaves ~June 19	July 1-3 Extra bird arrives ~July 5	Date unknown. Extra bird present first unattended = July 19	July 28~Day 28 of feeding **(1 V)**	D:Aug. 7 R:Aug. 27-Sept. 4
	Main St.	May 21	May 22	June 17-19	July 4; Nest failed July 8=Day 5 of feeding			D:July 10 R:July 31

from the primary analysis. The number of fledged young is the best estimate based on visual observations of birds entering and exiting the chimney (V) or physical evidence from the chimney inspection (P) (see Table 2 for details).

2011 (136)	SE Club Amical	*Unknown*	*May 25 n=1*	*Nesting attempt by single bird - abandoned June 6*				*D:June 6; R:unknown*
		June 11-16	June 11-19 n=1; June 21 n=2	July 7; Nest failed July 19=Day 12 of incubation				D:July 18 R:Aug. 9
	NE Club Amical	June 1-4	June 1-4	June 26-28	July 11	July 17	Aug. 6=Day 27 of feeding **(1 V)**	D:Aug. 14 R:Aug. 15-16
	Brodeur Bros.	May 25-26	May 26	June 25 (Extra bird onsite July 9-15); Nest failed July 16=Day 22 of incubation; no indication of hatching				D:July 15 R:Aug. 11-12
	Church	May 13	May 15	June 23-24	July 9	July 15; Nest failed Aug. 2=Day 25 of feeding.		D:Aug. 1 R:Aug. 7-8
	Main St.	Unknown	May 24	July 1-2 Nest failed July 19=Day 19 of incubation; no indication of hatching				D:July 18 R:unknown
2012 (102)	SE Club Amical	May 16 n=1 May 24 n=2	May 31	June 25-27 (Unstable activity July 8-11); Nest failed July 12-13				D:July 11-12 R:Aug. 13-18
	NE Club Amical	May 12	May 12	June 26-29	July 15	July 20; Nest failed July 31=Day 17 of feeding		D:July 30 R:Aug. 2-5
	Brodeur Bros./Big Country RV	May 16	May 24-31	June 25-27 incubation behaviour; Nest failed June 28-July 3; no eggs recovered				D: June 27-July 2 R: Aug. 13-16
	Church	May 17-18	May 17-18	June 14-21	July 4-7; Nest failed July 9-10			D:July 8-9 R:Aug. 6-12
	Main St.	May 10-16	May 14-16	June 22-27	July 9 Extra bird onsite July 11	July 14=Day 6 of feeding	Aug. 5= Day 28 of feeding **(4 P)**	D:Aug. 13-15 R:Aug. 16-19
2013 (145)	SE Club Amical	May 22-26 n=1; June 18-24 n=2	June 18-24	June 25-28	July 15	Nest failed July 20=Day 6 of feeding		D:July 20 R:Aug. 4-10
	NE Club Amical	May 12-22	May 12-22	June 25-29	July 8-10	July 14	Aug. 3~Day 27 **(2 V)**	D:Aug. 10 R:Aug. 12-21
	Brodeur Bros./Big Country RV	June 18-25	June 18-25	July 7-10	July 23	July 30; Nest failed Aug. 10 =Day 19 of feeding		D:Aug. 10 R:Aug. 12-21
	Church	May 12-22	May 12-22	June 18-24	June 30- July 3	July 11-13; Extra bird onsite July 22-23	Aug. 1 ~Day 30 **(2 V)**	D:Aug. 17-20 R:Aug. 23-24
	Main St.	May 12-22	May 12-22	June 24- July 1	July 9-11	July 12-15	Aug. 9 **(5 P)**	D:Aug. 12-18 R:Aug. 20-21
Summary								
	Earliest start	May 10	May 12	June 3	June 26	July 7	July 27	Aug. 7
	Latest start	June 25	June 25	July 16	July 30	July 30	Aug. 16	Aug. 28
	Median start	May 18*	May 22**	June 26	July 6	July 14	Aug. 1	Aug. 15
	n	25	24	29	21	14	11	8

* If pairs that did not arrive within 2 d of each other are included, the median date is May 25 (n=30).
** If nests started by one bird are included, the median date is unchanged (n=29).

Table 2. Summary of nesting outcomes for five St. Adolphe chimneys, 2007-2013. Estimates of fledging success based on visual observations of birds entering and exiting the chimney (V) and, for two chimneys, examination of physical remains of nesting attempts (P) in the chimney clean-out after the birds left (and before arrival, if indicated). The Best Estimate uses physical evidence when present unless otherwise noted.

Year	Site	Fledgling Visual Estimate	Physical evidence	Fledgling Physical estimate	Fledgling Best Estimate	Comments
2007	SE Club Amical					No chimney swifts seen using this chimney.
	NE Club Amical	3			3	
	Brodeur Bros.					Not identified as a nest site until 2009.
	Church	0			0	
	Main St.	unknown				Identified as nest site on July 26. Outcome unknown.
2008	SE Club Amical					No chimney swifts seen using this chimney.
	NE Club Amical	0			0	
	Brodeur Bros.					Not identified as a nest site until 2009.
	Church	2			2	
	Main St.	0			0	
2009	SE Club Amical	0			0	
	NE Club Amical	2			2	
	Brodeur Bros.	0	4 unhatched eggs. **Clutch size = 4**	0	0	
	Church	1			1	
	Main St.	0	2 recent carcasses		0	First inspection; many years of debris; clutch size undetermined
2010	SE Club Amical	0			0	
	NE Club Amical	0			0	
	Brodeur Bros.	2	6 half eggshells; 1 broken egg; 1 dead juv. ~20 d old; no nest. **Clutch size = 4**	2	2	
	Church	1			1	
	Main St.	0	Sept. 2010: 1 egg with protruding beak; 8 half eggshells; 4 dead juv.; no nest. April 2011: 1 unhatched egg in 2010 nest. **Clutch size = 6**	0	0	
2011	SE Club Amical	0			0	
	NE Club Amical	1			1	
	Brodeur Bros.	0	4 unhatched eggs; 3 empty eggs with small holes; no nest. **Clutch size = 7**.	0	0	
	Church	0			0	
	Main St.	0	July 2011: 7 half eggshells; 2 dead juveniles ~1-2 days old; no nest; April 2012: 2011 nest; 1 unhatched egg. **Clutch size = 5**	(2)	0	Last day-time use: July 18. Nest failed; remains of two dead nestlings were not recovered.
2012	SE Club Amical	0			0	
	NE Club Amical	0			0	
	Brodeur Bros./Big Country RV	0	no eggs; no intact nest. **clutch size undetermined**	?	0	The presence of twig clumps, feathers, and guano support observational evidence of a nesting attempt.
	Church	0			0	
	Main St.	1	residue of 2011 eggshells; intact nest; 9 half eggshells; 1 dead juvenile ~ 7 d old. **Clutch size = 5**	4	4	
2013	SE Club Amical	0			0	
	NE Club Amical	2			2	
	Brodeur Bros./Big Country RV	0	5 half eggshells; shell fragments; 3 carcasses. **Clutch size = 3**	0	0	The presence of large clumps of twigs and pieces of mortar suggest the nest fell.
	Church	2			2	
	Main St.	2	10 half eggshells; no carcasses; no nest. **Clutch size = 5**	5	5	

Adult chimney swift incubating eggs. Note the long, tapered wings which extend past the short, stubby tail. Bristles on the tail feathers help brace a chimney swift clinging to the wall of a chimney.
-Bruce Di Labio

in the chimney clean-out material (Table 2). Thirty-nine eggs were recovered from chimney clean-outs indicating clutch sizes ranging from 3-7 eggs/nest (mode: 5, Table 2).[6] Overall, the hatching rate was 56% (22/39 eggs) and the fledging rate was 28% (11/39 eggs). Nesting attempts in the two chimneys had markedly different outcomes. The Brodeur Bros. site produced 18 eggs, of which 6 hatched (33%) and 2 fledged (11%) while Main St. produced 21 eggs, of which 16 hatched (76%) and 9 fledged (43%).

Extra adults were seen entering nest sites before the young had fledged. Three or more consecutive entries or exits indicated that more than a breeding pair was using the nest site. However, no hostile takeover of nest sites was documented.

Discussion

Generally, the time-frames for nesting stages in 2010-2013 were as described for 2007-2009.[6] Some variation could result from the limitations of behavioural sampling. Interval sampling

approximates the onset of events. The start of incubation was not always obvious. The transition from incubating to feeding was clear, however, and we were able to back-calculate to the start of incubation using an incubation period of 18-21 days.[6,8,10] This indicated that the characteristic incubation exchanges in which one adult enters and one leaves the chimney within a minute, did not always occur in early incubation.

The transition from feeding brooded to non-brooded juveniles was not always obvious. This stage was usually confirmed by observing consecutive entries or exits, hence the young are "unattended", but monitoring sessions did not necessarily detect this pattern. Adults may simply move to the wall of the chimney after feeding the young.[11] An increase in feeding rates of three to four times per hour or more indicated that older juveniles were in the nest.

Behavioural evidence of fledging was a classic 'parade' of juveniles or fluttery entries by inexperienced birds.[10] Low flying juveniles also were identified by wing edges which were intact at a time when adults had notches or gaps with missing feathers due to moulting. However, counting fledglings is challenging. It is not always possible to evaluate wing margins as birds enter or exit a chimney and fledglings quickly develop flight proficiency. As adults often redistribute themselves locally shortly after fledging, an increase in the number of birds roosting in a nest site did not always reflect fledglings returning to their natal chimney. Problematically, juveniles fledged at more than one site within days of each other and shared common flight training grounds. Juveniles also entered non-natal sites to rest.

In five cases, physical evidence of in-chimney mortality agreed with visual estimates of the number of fledglings (Table 2). However, estimating fledging success from the physical remains found in the chimney may produce an over estimate if all evidence of in-chimney mortality is not recovered. At Main St. in 2011, nesting remains accounted for only three of the five eggs laid, which by simplistic arithmetic, would suggest two fledged. But the nest was abandoned on July 18 during incubation so the physical evidence alone was misleading. In the remaining two cases, the physical evidence indicated there could have been four, instead of one, and five instead of two fledglings but the exact number of fledglings cannot be estimated with certainty.

Using chimney clean-out observations, clutch sizes in St. Adolphe ranged from 3-7 which resemble those in Texas but are somewhat higher than the 3-5 eggs typically found in mid-range New York and Illinois.[10,11,13] The overall St. Adolphe hatching rate (percent of eggs laid that hatched) was 56%, significantly lower (X^2 goodness-of-fit, $P < 0.0001$) than the 90.7% hatching rate reported in 1958 for New York.[1,9,12] The overall fledging rate (percent of eggs that produced fledglings) of 28% is also significantly lower (X^2 goodness-of-fit, $P < 0.0001$) than the 86% reported for New York.[1,9,12] In one season in Kansas, 71% of hatchlings fledged.[1] Using this alternative method of calculation (fledglings/hatchling), St. Adolphe had a 50% fledging rate (11/22) overall and was much lower at Brodeur Bros. (33%; 2/6) than the Main St. site (56%; 9/16). Using either method of calculating fledging success yields lower rates in St. Adolphe than any published estimates.

Another measure of breeding success is the number of young fledged/nest. We compared the estimates from chimney clean-outs to those based on behaviour observations. Between 2010 and 2013, when we had complete data for both sites, the Brodeur Bros. and Main St. sites produced 11 fledglings from 8 nesting attempts, a rate of 1.4 fledglings/nest. Behavioural observations for the same period indicated only five fledged from these two chimneys, an underestimate of approximately 50%. If behaviour observations similarly underestimated fledgling counts for all nest sites with inaccessible chimney clean-outs, the adjusted total for 2007-2013 would be 38 fledglings from 30 nesting attempts, or 1.3 fledglings/nest. For other (unspecified) geographic areas, a mean of 3 fledglings/nest is cited in the COSEWIC report and 3.7 fledglings/nest is reported for New York.[1,9,12] Clearly, breeding success in St. Adolphe is lower compared to other areas farther south. There are no comparable published data for elsewhere in Canada.

Reproductive rates can also be underestimated if clean-outs are not examined systematically. For example, at Main St. in 2011, remains were observed in the autumn but the nest and another egg were not seen until the inspection in the spring of 2012. Some eggshells/young may not be recovered at all if material clings to the rough interior surfaces of the chimney or is caught in spider webs.

It appears that the only nesting

attempt without pre-fledging mortality was Main St. in 2013. Otherwise, failures occurred at every nesting stage from nest building to feeding non-brooded young. The factors implicated in nest failures include structural integrity of the habitat, late arrival, general weather patterns and prevailing local conditions, and the availability of aerial insects.

and appeared to have been unoccupied until 2009. An artificial chimney erected in 2010 by MCSI near the Church has never been occupied, suggesting nesting habitat may not be limiting in St. Adolphe.[7]

Since 2009, all five nest sites identified in St. Adolphe have been occupied every year including 2013. However, the chimneys

Non-brooded chimney swifts in the bowl of the nest. At approximately 21 days of age, juveniles will move to the wall beside the nest and begin short flights inside the chimney. Fledging, or flying outside of the chimney, occurs at 28-30 days of age. -Ben Di Labio

In 2007 and 2008, the SE Club Amical site was observed regularly and not occupied by chimney swifts. The Brodeur Bros. site was observed sporadically

do not appear to be equally attractive to chimney swifts. The Brodeur Bros. chimney vents an oil-powered furnace and it is one of the last chimneys to be

occupied in the spring. Although more attractive to the chimney swifts, the Main St. site had crumbling mortar prior to the spring of 2010 when the chimney was repaired.[7] Breeding success has been higher in Main St. since the above-roof portion was rebuilt, suggesting some previous failures may have resulted from the structural decline.[6]

A minimum of 9 weeks is required to build a nest and fledge young so chimney swifts in St. Adolphe have time for only one clutch.[6,9,10,12] A breeding pair must begin nest construction by the end of May or early June to be successful. No chimney swifts arriving in late-June were ever successful at nesting. As a result, attempts at the Brodeur Bros. and SE Club Amical chimneys were the least successful of the sites in St. Adolphe.

An abundance of suitable insects, which is reflected in feeding rates, is required for successful nesting. Chimney swifts are vulnerable to periods of reduced feeding opportunities or prey availability.[1,10,13] Generally, aerial insect abundance is tied directly to weather patterns and more time elapses between feeding visits with increasing temperature, wind speed, and precipitation.[13] In St. Adolphe, some nests failed after several consecutive days of continuous rain (e.g., NE Club Amical, 2010) or extended periods of extreme heat (>30 C) combined with high humidity (humidex >35 C) and strong winds (>50 kph) (e.g., Church, 2011). The lowest breeding success rates occurred in 2011 and 2012 (Tables 1, 2), years that had extreme weather patterns and low mosquito counts.[14,15,16,17] Feeding rates at the Church in 2011 often were below the local average of 3-4 times per hour for non-brooded juveniles, falling to 1 entry/h for 23-24 day-old young.[6] Although there were two carcasses of 1-2 d old birds in the clean-out at Main St. in 2011 (Table 2), there was no change in rates of entry which denote hatching, that is, normal feeding rates were not seen.[6] Conversely, the highest breeding success rates in St. Adolphe occurred in 2013 when three sites produced an estimated nine fledglings (Tables 1, 2).[6] There were no extended periods of heat, humidity, high winds, or sustained periods of rain, and mosquito counts were generally average to above average.[18] At successful nest sites, feeding rates in 2013 were at or above average for non-brooded juveniles and the highest feeding rate we have recorded (22 entries/h) was at Main St. on July 22.[6]

Prey availability can also be affected by human activities. St. Adolphe is part of the City of Winnipeg buffer zone for mosquito abatement.[18] It is also surrounded by agricultural land where aerial spraying of pesticides is used to control aphids on soybean crops (A. Lagasse, pers. comm.). Pesticides may affect birds directly by reducing their prey base or indirectly by impairing reproduction.[2,19,20] A recent Ontario study of chimney swift guano demonstrated links between the historical use of DDT and dietary shifts in chimney swifts.[5] Pesticide use altered prey abundance, food quality, and type.[5] Dietary changes are likely related to the declining populations of chimney swifts.[5] Local pesticide use may be affecting the quality and quantity of insects available for nesting chimney swifts in St. Adolphe given the evidence for low reproductive success.

Weather conditions, hence prey availability, appear to influence migration dates. In years with favourable weather, when feeding rates were average or above average, pre-migratory groups (e.g., 2010 and 2013, Table 1) congregated at successful nesting chimneys.[6] Such relocations took place shortly after fledging had occurred from at least one site. Unsuccessful pairs were the first to relocate, then successful pairs and their offspring. If the departure of the birds from a nest chimney resulted in a decline in the total St. Adolphe count, we concluded the chimney swifts had begun their fall migration. Leaving directly from the nest site was more common in poor weather years such as 2011 and 2012 (Table 1). The start of migration was characterized by the general decline in numbers of roosting birds until the counts reached zero. Thereafter, small numbers of migrants (usually one or two) occasionally roosted at one of the sites before all site use ended for the season.

In St. Adolphe, extra birds entering nest sites have disturbed incubation and feeding activity. In 2011, the Brodeur Bros. nest failed on Day 22 of incubation (full term eggs). Three of the seven eggs observed in the clean-out had small holes in them; the interiors were empty. The eggs appeared to have been infertile as a developed embryo should have been present. We noted the entrance of extra adults the day before the 2011 nest failure occurred at Brodeur Bros. Mortality resulting from non-parental aggression in St. Adolphe is possible but we cannot confirm it.

While an abundance of aerial

insects is required for successful fledging, the location of prey is an important factor too. In fragmented habitats, areas of concentrated prey occur beyond the foraging distance where adults can make a timely return to the nest site with food. Chimney swifts do not always forage near nest sites but rapidly approach a chimney and leave the area quickly upon exit. Also, there is typically a decline in the use of the nest site area post-fledging and no swifts were seen feeding locally in the daytime by one week post-fledging; chimney swifts returned for roosting only.[6] The variation seen in the presence of chimney swifts feeding near the nest sites and the variation in feeding rates suggest that the optimum foraging patch is not always near the chimneys. Nestlings may starve if the adults are unable to adequately feed them.

The only source of confirmed adult mortality in St. Adolphe was entrapment i.e., adults leaving a chimney through gaps and being confined to an area where they could not feed.[6] Unconfirmed mortality of a chimney swift followed a predation attempt. Two migrant chimney swifts circling Club Amical at the end of the roosting hour were pursued vigorously by two Cooper's or Sharp- shinned hawks (Aug. 17, 2011); one chimney swift returned shortly thereafter. No estimate of juvenile mortality outside of the chimneys post-fledging has been made.

In conclusion, we found that the availability of nest sites in St. Adolphe does not appear to be limiting population growth. Chimney swifts in St. Adolphe have a short breeding season and if nesting does not begin by June 1st it is likely to fail. Nest failure rates were high when severe weather reduced prey availability, hence feeding rates. While clutch sizes were within the range of published values, hatching and fledging rates in St. Adolphe are lower than published data for the United States; there are no comparable published data from Canada. Factors influencing the low hatching and fledging rates warrant further study.

Acknowledgements

Our thanks are extended to the community of St. Adolphe, the RM of Ritchot, innumerable chimney monitors, and the MCSI Steering Committee for their contributions to this project. We especially thank the avian landlords S. Leclerc, A. Leclerc, H. Brodeur, and A. Biggar for access to their chimneys. J. Machovec, F. Machovec, L. Cocks, and M. Quigley provided

much appreciated monitoring assistance. L. Verhaeghe kindly coordinated the Church logistics. A. Lagassé will be remembered fondly as a supporter of the chimney swift program. This manuscript benefitted from reviews and assistance provided by *Blue Jay* editors.

1. COSEWIC (2007) COSEWIC assessment and status report on the Chimney Swift *Chaetura pelagica* in Canada. Committee on the Status of Endangered Wildlife in Canada. <http://www.sararegistry.gc.ca/default.asp?lang=En&n=B2AFC099-1>

2. Nebel S, Mills A, McCracken JD, Taylor PD (2010) Declines of aerial insectivores in North America follow a geographic gradient. *Avian Conservation and Ecology* 5(2):1. <http://www.ace-eco.org/vol5/iss2/art1/>

3. Sauer JR, Hines JE, Fallon J (2007) The North American Breeding Bird Survey, results and analysis 1966-2006. Version 10.13.2007. USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA. <http://www.mbr-pwrc.usgs.gov/bbs/bbs2006.html>

4. Government of Canada (2009) Species At Risk Public Registry. Species Profile: Chimney Swift. <http://www.sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=951>

5. Nocera JJ, Blais JM, Beresford DV, Finity LK, Grooms C, Kimpe LE, Kyser K, Michelutti N, Reudink MW, Smol JP (2012) Historical pesticide applications coincided with an altered diet of aerially foraging insectivorous chimney swifts. *Proceedings of the Royal Society B* 279(1740):3114-3120.

6. Stewart BE, Stewart REA (2010) Nest site use and breeding success of chimney swifts in St. Adolphe, MB, 2007 – 2009. *Blue Jay* 68(3):124-132.

7. Manitoba Chimney Swift Initiative (2013) http://www.mbchimneyswift.ca/resources.html

8. Stewart BE, Stewart REA (2011) Manitoba Chimney Swift Initiative guide for monitoring chimney swift nest sites: how to identify stages of nesting and determine breeding success. <http://www.mbchimneyswift.ca/Documents/Monitoring%20guide_april%202011.pdf>

9. Cink CL, Collins CT (2002) Chimney Swift (*Chaetura pelagica*). In: Poole, A, Gill, F. (eds) The Birds of North America, No. 646. The

Birds of North America, Inc., Philadelphia, PA.

10. Kyle GZ, Kyle PD (2005) Chimney Swifts. America's Mysterious Birds above the Fireplace. Texas A & M University, College Station, TX.

11. Cornell Lab of Ornithology (2009) Chimney Swift nestcam. http://watch.birds.cornell.edu/nestcams/camera/view?cameraID=C100060

12. Fischer RB (1958) The Breeding Biology of the Chimney Swift*: Chaetura pelagica* (Linnaeus). *New York State Museum and Science Service Bulletin* 368:1-148.

13. Zammuto RM, Franks EC, Preston CR (1981) Factors associated with the interval between feeding visits in brood-rearing chimney swifts. *Journal of Field Ornithology* 52(2):134-139

14. A Weather Moment (2012) 1 September: August Continues Winnipeg's Heat Streak. http://aweathermoment.tumblr.com/post/30673350039/august-continues-winnipegs-heat-streak

15. CBC News Archives (2011) 4 August: Winnipeg mosquitoe count hits 30-year low. http://www.cbc.ca/news/canada/manitoba/story/2011/08/04/man-mosquitoes.html

16. Winnipeg Free Press (2011) 8 August: If you like it hot, you loved July. <http://www.winnipegfreepress.com/local/if-you-like-it-hot-you-loved-july-126652153.html>

17. Winnipeg Free Press (2012) 5 July: Low trap numbers mean no fogging for mosquitoes. http://www.winnipegfreepress.com/breakingnews/Low-trap-numbers-mean-no-fogging-for-mosquitoes-161482295.html

18. City of Winnipeg (2013) Mosquito control. <http://winnipeg.ca/publicworks/bugline/default.stm#mosquitoes>; Nuisance mosquitoe trap counts. http://winnipeg.ca/publicworks/bugline/mosquitoes/trapcounts.stm

19. Colborn T, vom Saal FS, Soto AM (1993) Developmental effects of endocrine-disrupting chemicals in wildlife and humans. *Environmental Health Perspectives* 101(5):378-384.

20. Goldstein MI, Lacher TE, Woodbridge B, Bechard MJ, Canavelli SB, Zaccagnini ME, Cobb GP, Scollon EJ, Tribolet R, Hooper MJ (1999) Monocrotophos-induced mass mortality of Swainson's hawks in Argentina, 1995-96. *Ecotoxicology* 8(3):201-214.

Top and bottom - Chimney swifts flying *- Christian Artuso*