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ARTICLE

Breeding biology of the White-collared Swift *Streptoprocne zonaris* in southeastern Brazil

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ABSTRACT: White-collared Swifts *Streptoprocne zonaris* are common throughout the tropical Americas. They usually breed in colonies in wet caves and next to waterfalls. Despite their widespread range, little is known about their breeding biology. Here I present data gathered from 2012 to 2014 at two breeding sites, Luminosa Cave and Água Comprida waterfall, located within Intervales State Park, in the state of São Paulo, Brazil. More than 30 nests were found in the cave and one behind a waterfall. The egg-laying period began in late October and lasted until the first week of November. Nests were made mostly of bryophytes, with some fresh and dry leaves and sand. Eggs were dull white, and had an oval shape. Nestlings per nest varied from 1 to 3. The fledging period was between 41-51 days. This is the first record for this species of a successful nest with 3 nestlings. The species showed high nest site fidelity. Plumage development was similar to other species in the genus.

KEY-WORDS: Apodidae, caves, nest, nestlings, *Streptoprocne*.

INTRODUCTION

The White-collared Swift *Streptoprocne zonaris* is a common species with a wide range throughout the Americas, occurring from South Mexico to the southern Andean highlands (Chantler 1999). In Brazil, it has been recorded from Amazonas to Rio Grande do Sul. One of the largest known concentrations of the species is in Aripuanã, Mato Grosso, where, together with Great Dusky Swifts, *Cypseloides senex*, they form a colony of more than one million individuals (Sick 2001, De Luca *et al*. 2009).

Adult White-collared Swifts have a distinctive black and brown plumage with a clear white collar circling the entire neck (Sick 2001). Like other swifts of the Cypseloidinae subfamily, White-collared Swifts breed near waterfalls, in canyons and wet caves in large colonies and show high nest site fidelity (Lack 1956, Rowley & Orr 1965, Whitacre 1989, Marín & Stiles 1992). They forage in large flocks, and it is common to see mixed groups with Biscutate Swifts, *Streptoprocne biscutata*, other *Cypseloides* and *Chaetura* spp., and Neotropical Palm Swifts, *Tachornis squamata* (Pichorim 2002, Chávez-Portilla *et al*. 2007, Pearman *et al*. 2010). Although its range is well documented and the species is relatively common in this country, there is a lack of information on its breeding biology in Brazil and in South America, with few reliable records (Marín & Carrión 1994, De Luca *et al*. 2009, Passeggi 2011).

The objective of this work is to describe the nests, eggs and nestlings of White-collared Swifts based on observations conducted between December 2012 and February 2014 at two breeding sites in a fragment of Atlantic rainforest in southeastern Brazil.

METHODS

The study was conducted between March 2012 and February 2014 at two sites, Luminosa Cave and Água Comprida waterfall, both located in Intervales State Park (ISP), municipality of Ribeirão Grande, São Paulo, Brazil (24º12' / 24º25'S and 48º03' / 48º30'W). The climate is classified as Cfb in Koppen's International System and the rainy season lasts from late October to March (Koppen 1948, Furlan & Leite 2009).

Luminosa Cave is a limestone cave located within the buffer zone of ISP. It has three entrances: one is a large opening at the top, resembling a skylight, from where water drips down, and two others at the entrance and the exit of Lajeado River that cascades over an approximately 7 m high vertical cliff and flows into the cave. It has variable luminosity conditions throughout the day, but the innermost area remains dark. The floor is composed of piled rocky blocks and boulders, sand, leaves and guano. Just next to the cave's riverside entrance, on the left side, a high rock wall is used by the swifts to roost.

Água Comprida waterfall is a small waterfall, approximately 4 meters high, formed by the Água Comprida River. On the left side of the falls there is a rock wall covered with moss where both White-collared Swifts and Sooty Swifts, *Cypseloides fumigatus* are known to breed and roost.

Active nest searching and monitoring was conducted in March and December 2012 (10 h of observation), from January to March 2013 (16 h) and from October 2013 to February 2014 (51 h). Visits both to the cave and the falls were made throughout the day (7 – 10 h; 14 – 17 h) and at three occasions at night (20 – 23 h). Direct observations of adults and chicks were made with Nikon Monarch 8 x 42 binoculars. A ladder and flashlights were used to access the nests. Measurements were taken with digital calipers, measuring tapes and 100g (+- 1 g) Pesola spring scales. Photographs were taken with Canon Rebel XSi, T3i and PowerShot SX50 cameras, Sigma 150-500 lens and with an IPhone 4S mobile phone.

RESULTS

The breeding season of the White-collared Swift lasted from mid-October to early January. Luminosa cave nests were concentrated in four distinct areas, many of which did not receive any direct sunlight. Most nests were isolated from each other by natural barriers such as openings, stalactites or vertical walls that barred any possible movement of offspring from one nest to another. More than 30 nests were found in Luminosa Cave between the 2012 and 2013 breeding seasons, but most were inaccessible. Only 25 nests were monitored (Table 1). The most accessible nest measured: inside diameter 12 cm, outside height 7 cm, internal depth 1.4 cm and height above ground 1.7 m.

In Água Comprida waterfall, I found a single White-collared Swift nest. Nest measurements taken in 2013 were: external diameter 17.5 cm, inside diameter 14 cm, outside height 13.5 cm, internal depth 1.8 cm and height above ground 2.7 m. It was built on a rock wall that had no protection from direct sunlight. It was directly exposed to spray from the waterfall and was located above a Sooty Swift nest. During nocturnal visits, two adult White-collared Swifts were observed roosting next to their nest.

These observations revealed variations in the shape of White-collared Swift nests. While Luminosa Cave nests were disk-shaped and positioned on horizontal rock shelfs and ledges, with a much shorter mud base, the Água Comprida waterfall nest was truncated and cone-shaped and built on a vertical rock wall, with a solid mud base. Nests were made of bryophytes, along with some roots, fresh and dry leaves of angiosperms, ferns, sand, and mud. Fresh material was continuously added to the nests during the incubation period. Although some nests looked ready to use, they remained empty, with no signs of incubating adults or eggs. At the end of the season, when most nestlings had fledged, nests in Luminosa looked completely different from their original shape, and many were reduced to just a thin layer of sand. The opposite was observed in the Água Comprida nest, which was almost intact and the moss that covered the exterior part was fresh and green, both in the 2012/2013 and 2013/2014 breeding seasons.

Two oval shaped eggs were found and measured (egg 1: 13g, 37 x 25 mm; egg 2: 12 g, 35 x 26 mm). One was larger than the other, and also exhibited a mud-stained coloration while the other was dull white.

Adults were observed in their nests incubating at the beginning of the egg laying period in mid October and would remain in the same position for long periods. Many broken egg-shells were found on the ground near the nesting walls during the egg laying period. No attempts were made to replace lost eggs or nestlings. One clutch was laid per nest per reproductive season.

Nestlings per nest varied between 1 (n = 9), 2 (n = 16) and 3 (n =1). I did not observe any newly hatched chicks. Nestlings were active and many were clinging to the rock wall, seemingly curious with the flashlights. On the same day I found a single nest in Água Comprida waterfall with two chicks. Their bodies were covered with semiplumes and they left their nest within the difference of a day, between January 5th and 6th 2013, and were observed roosting on the rock wall below their nest two weeks later, during an afternoon visit. On November 25th 2013, a chick was observed together with an adult in Água Comprida waterfall. It had its body covered with a thin layer of gray semiplumes. On December 18th the nest was empty.

I was able to follow the development of six nestlings during the 2013/2014 breeding season. On November 25th 2013 two nestlings were observed (Figure 1). Determining the age of nestlings was based on our previous observations of the nest with two eggs on November 15th 2013 and by comparisons with more detailed data for the species. Nestlings were assumed to be between 6-10 days old. Both had pink skin with short light gray semiplumes on the mantle and on the rump. On the crown and on the coverts the semiplumes were just emerging from the skin. Feet were large and pinkish with dark gray nails. An egg tooth was visible on the point of the beak with a pinkish commissure. Only one of the nestlings had its eyes open. Both were lethargic, simply resting their heads on the nest's rim. Two broken eggs shells were found on a rock 1 m below it. The nest was covered with fresh green moss and mud and two fecal sacs were observed in the back. When 11-15 days old, the nestlings were more active.

FIGURE 1. Chronology of White-collared Swift nestlings: A: with 6-10 days; B: with 11-15 days; C: with 19-23 days; D: with 22-26 days; E: with 23-27 days; F: with 26-30 days; G: with 29-33 days; H: with 34-38 days. Photos: A, B, D, G, H: Renato Paiva; C, E, F: Renata Biancalana.

TABLE 1. Fates of eggs and nestlings of the White-collared Swift found at Intervales State Park in 2012 and 2013. Whenever information on eggs is lacking for active nests during a given year, their content at the time could not be visually inspected.

Nest Number	Usage		Eggs		Fledglings	Event
	2012	2013	Laid	Hatched		
Água Comprida waterfall						
N1	+				2	
		+	2	1		Disappeared
Luminosa Cave						
N1	+				2	
		+		2	2	
N2	+				1	
		+			2	
N3	+				1	
		+	1	0		Disappeared
N4	+				1	
N5	+				2	
N6	+				1	
		+			2	
N7	+				1	
		+	2	2	2	
N8	+				2	
		+	2	2	2	
N9	+				2	
		+	2	2	2	
N10	+				2	
		+			2	
N11	+				2	
		+			3	
N12	+				1	
		+	2	2	2	
N13	+				1	
		+	2	2	2	
N14		+			1	

Their bodies were covered with a thicker layer of light gray semiplumes, with a bare strip near the abdomen. The feet were darker, with a grayish coloration. In the loral area and around the beak many tiny spots of feathers in pin could be seen. The beak was dark gray. The eyes were black and opaque blue. From this day onwards, the nest became increasingly dry and exhibited a less muddy aspect. When 19-24 days old their bodies and heads were covered with semiplumes, with the coverts covering part of the wings and primaries and secondaries breaking the sheaths. Tail feathers were growing and exhibited pointy shafts. Chicks used to be very vocal when approached and handled, emitting a sequence of high-pitched "pee-pee-pee" squeals. Nestlings would occasionally peck each other on the head and on the back. When they were 22-27 days old, the primaries were growing and the all-surrounding white collar was not yet completely formed. Semiplumes were visible on the neck, mantle, nape and flanks. The head was covered with feathers. There was a bare area on the eye patch with tiny feathers in pins coming out. When 26-31 days old, the head and body were covered with contour feathers with semiplumes still visible on the flanks, mantle and axillaries. With 29-34 days, the nape and mantle were covered with semiplumes, with a few feathers emerging from the sheaths. Semiplumes were visible on the flanks. Lesser coverts and the alula had feathers with thin whitish tips. Primaries and upper tail coverts also had pale border markings. When 32-37 days old, the body was largely covered with contour feathers and semiplumes were only visible on the flanks. When the nestlings were 37-42 days old, their body was fully covered with contour feathers and it was possible to observe the completed white neck collar and a light white patch on the chest. Semiplumes were still visible only on the thighs and on the flanks. One of the nestlings was out of its nest, resting on a rock 1 m below it. On December 30th, the nest with two nestlings was empty, with no signs of the fledgings. Insect fragments were found next to all nests; it was not possible to determine if they had been present in excrement or had been dropped during chick provisioning.

An unusual nest with 3 chicks was discovered on December 8th 2013. The three chicks were covered with a thick layer of semiplumes. They were very active and exhibited a wing raising display when approached. On

December 11th, the chicks already exhibited white feathers on the nape, but they were different with regard to their body size and feather development. Two of them had their heads covered with contour feathers, whereas the third still had semiplumes showing on its crown. Nestlings left the nest within a space of 5 days. The first left between January 3rd and 6th 2014, and the second and the third between January 6th and 8th (Figure 2). The nest was monitored until all three nestlings fledged.

On February 13th 2014 we observed a large amount of feathers and droppings, mostly a combination of insect fragments and guano, on the cave floor.

Adults were observed flying in and out of Luminosa Cave all day long, and could be seen at night on the roost wall, next to the cave's entrance. When clinging on the wall, they would occupy themselves with preening activities, raising their wings and turning their heads towards each other. They were very active and vocal.

Large flocks of White-collared Swifts, sometimes with more than 100 individuals, were observed foraging mostly during cloudy and stormy afternoons. When leaving or entering the cave or flying over a gorge they would begin voicing loud harsh calls. They were also observed foraging with Sooty Swifts but in smaller groups.

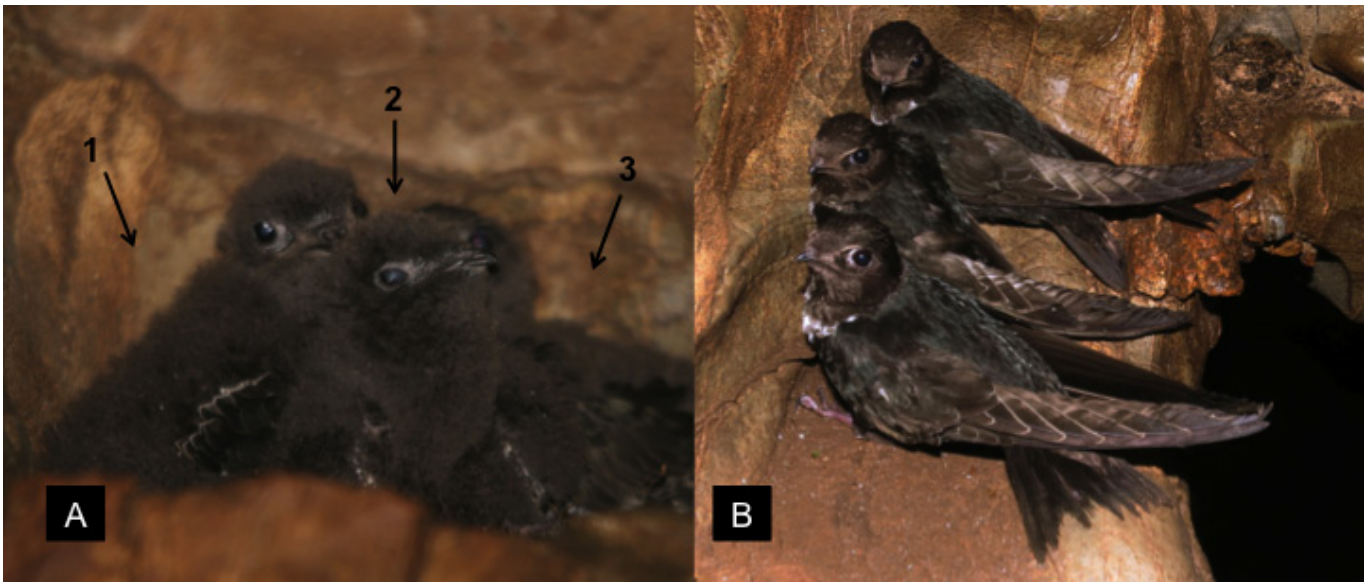

FIGURE 2. Nest with three nestlings: A. On December 8th 2013, when I discovered the nest; B. On January 3rd 2014, the last time they were seen together. Photos: A. Renata Biancalana; B: Renato Paiva.

DISCUSSION

Breeding activity started in mid-October. Egg-laying occurred at the beginning of the rainy season, the same period described for the species in Argentina (Passeggi 2011). The presence of broken eggs on the cave floor was noted by other authors for White-naped, *S. semicollaris*, Biscutate and White-collared Swifts and was analyzed in different ways. Some thought it was the result of accidental ejections, while others attributed these findings to nest disputes, brood parasitism or even from the intentional riddance of infertile eggs (Lack & Lack 1951, Rowley & Orr 1965, Pichorim 2002). Whitacre (1989) states that egg rolling would also be a main cause of reproductive failure of White-naped Swifts in Mexico. Pichorim & Monteiro-Filho (2008) even considered egg ejection as a means of possible brood population control by adults, depending on the foraging conditions they might face. Hotta (1994) suggests that egg ejection occurs as a consequence of severe competition for nests, which are a valuable asset since they last for many years and are costly in time and energy to construct.

Nests were similar in shape and the materials used to those described in previous studies (Rowley & Orr 1965, Whitacre 1989, Marín & Stiles 1992, Marín & Carrión 1994). Many Luminosa nests were far from waterfall spray and were located in drier areas of the cave, which is different from what is described by some authors as the typical position for the nests of this species (Chantler 1999).

Like other species of the Cypseloidinae subfamily, White-collared Swifts showed high nest site fidelity, reusing the same niches and crevices in the cave and even the same structure of previous nests, in the falls. This agrees with previous observations (Marín & Stiles 1992). After carefully looking at and comparing the pictures of nests both at the beginning and at the end of the breeding season, it was possible to observe that all nests at Luminosa Cave collapsed and were transformed into a thin layer of sand, probably due to the movements of nestlings and the decomposition of plant material in a dark environment. This suggests that Luminosa Cave nests are rebuilt at the beginning of the rainy season each year. On the other hand, the nest in Água Comprida contained live moss

and was left almost intact during the whole year. The large structure of some nests is probably due to material accumulation during several years of use. The proximity of White-collared Swift nests to other Cypseloidinae species breeding at the same site was also observed in Argentina by Pearman *et al*. (2010), with the difference that in Água Comprida waterfall two more nests of Sooty Swifts were located higher than that of White-collared Swifts.

Eggs were similar to those detailed in other studies, regarding coloration and measurements, although the eggs found were more oval-shaped than the sub-eliptical form described in previous papers (Passeggi 2011, Dabbene 1918, Marín & Carrión 1994). Clutch size was similar to that observed in Mexico, Costa Rica and Argentina, except for the single nest with three chicks (Whitacre 1989, Marín & Stiles 1992, Passeggi 2011). Plumage development chronology resembled that described by Pergolani (1944) in Argentina, by Marín & Stiles (1992) for White-collared Swifts in Costa Rica. Nestlings were accompanied by an adult until they were covered with a thick layer of semiplumes, usually during the three first weeks. Similarly to what was discussed for *Cypseloides* spp., the presence of an adult can be analyzed as a way of providing smaller nestlings with thermal protection from the cold environment in which the nest is located, either a cave or next to a waterfall (Marín & Stiles 1992). During the weeks that followed older chicks would remain alone for several hours and probably were fed at night as observed for other Cypseloidinae species (RNB *pers. obs*.; Collins 1998, Collins & Peterson 1998). Fledgings left the nest between 41-51 days, similar to what was observed in Costa Rica and Argentina (Marín & Stiles 1992, Passeggi 2011). The wing raising display is an agonistic behavior commonly observed in species of the Cypseloidinae and was noted right from the tender age of nestlings (Marín & Stiles 1992, Marín 1997, Chantler 1999).

The large amount of feathers found on the cave floor a few weeks after the last fledgings left their nests suggests that adults might begin molt immediately after the breeding period. After that, the number of swifts that use the cave diminishes, as they probably migrate to unknown sites assumingly with better foraging conditions.

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