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BREEDING BIOLOGY OF THE STRIPE-TAILED YELLOW-FINCH (*SICALIS CITRINA*) IN CENTRAL BRAZILIAN CERRADO

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Resumo. – Biologia reprodutiva do canário-rasteiro (*Sicalis citrina*) no Cerrado do Brasil central. – O canário-rasteiro (*Sicalis citrina*) habita cerrados, áreas montanhosas e habitats alterados da Argentina ao Suriname. Diante da escassez de informações a respeito de sua biologia reprodutiva, descrevemos aqui diversos aspectos de sua história natural e uso de habitat. Para determinar o habitat da espécie no Parque Nacional de Brasília realizamos censos por pontos e verificamos que antigas áreas de extração de cascalho são o principal local ocupado pela espécie durante o período reprodutivo. Encontramos 99 ninhos entre janeiro e maio de 2007 e estimamos a duração do período reprodutivo da espécie entre o fim de dezembro e o fim de maio. Os ninhos são em formato de cesto aberto, sustentados pela base e construídos ca. 30 cm acima do solo. A maioria dos ninhos (62%) foi construída em pteridófitas (*Dicranopteris flexuosa*) e em menor freqüência em arbustos (*Miconia albicans*; 22%), moitas de gramíneas (15%) e vassouras (*Baccharis* sp.; 1%). O tamanho de ninhada foi geralmente de três ovos, variando de um a três ovos de fundo azul turquesa com manchas marrons. Massa, comprimento e largura dos ovos foram 1,6 ± 0,01 g, 17,5 ± 0,1 mm e 13,0 ± 0,04 mm, respectivamente (n = 103). Estimamos o período de incubação em 11,8 ± 0,3 dias (10 a 13, n = 11) e o período de permanência dos ninhegos no ninho em 12,8 ± 0,4 dias (11 a 15, n = 9). O sucesso reprodutivo da espécie foi maior em pteridófitas (35%) que em arbustos (21%) e moitas de gramíneas (20%). A biologia reprodutiva do canário-rasteiro é similar a dos outros membros do gênero e dentro do padrão teórico esperado para um emberizídeo neotropical.

Abstract. – The Stripe-tailed Yellow-finch (*Sicalis citrina*) inhabits open savannas, mountain slopes, and human-altered habitats from Argentina to Suriname. Little is known about their breeding biology; therefore, we describe here many life history traits and habitat use patterns. We made point counts to identify the species breeding habitat in Brasília National Park, central Brazilian cerrado, and verified that old mining pits are the preferred breeding habitat of the species in the study area. We found 99 nests from January to May 2007. The estimated breeding season was from late December to late May. Nests are open-cups supported from their base and built ~ 30 cm from the ground. Most nests (62%) were in ferns (*Dicranopteris flexuosa*), but also in shrubs (*Miconia albicans*; 22%), grass tussocks (15%), and brooms (*Baccharis* sp.; 1%). Clutch size was usually three eggs, ranging from one to three ovoid eggs that were speckled brown on a turquoise background. Egg mass, length, and width were 1.6 ± 0.01 g, 17.5 ± 0.1 mm and 13.0 ± 0.04 mm, respectively (n = 103). The incubation period was estimated at 11.8 ± 0.3 days, ranging from 10 to 13 (n = 11), and nestlings fledged at 12.8 ± 0.4 days of age (range = 11-15, n = 9). Nest success was higher in ferns (35%) than in shrubs (21%) and grass tussocks (20%). The breeding biology of the Stripe-tailed Yellow-finches was similar to other congeners and within the expected theoretical patterns for a Neotropical finch. *Accepted 9 May 2011.*

Key words: Stripe-tailed Yellow-finch, *Sicalis citrina*, Brazil, Cerrado, natural history, Emberizidae.

INTRODUCTION

Stripe-tailed Yellow-finches (*Sicalis citrina*) are migratory with a wide distribution ranging from Suriname to Argentina (Hilty & Brown 1986, Narosky & Yzurieta 1987, Sick 1997, Silveira & Méndez 1999). These finches usually forage on the ground and inhabit rocky grasslands, often called *campo rupestre*, and open cerrados (Hilty & Brown 1986, Sick 1997, Vasconcelos *et al.* 2007). Two subspecies occur in Brazil, *Sicalis citrina citrina* in central Brazilian cerrado and *Sicalis citrina browni* in northern Brazil (Silveira & Méndez 1999).

Little is known about the breeding biology of the Stripe-tailed Yellow-finch, including habitat use during the breeding season (Sick 1997, Vasconcelos *et al.* 2007, Vasconcelos & Endrigo 2008). Detailed knowledge of the species' breeding biology can help clarify the phylogenetic relationship of the species with other *Sicalis* finches and within the taxonomically troublesome nine-primaried oscines group (Lougheed *et al.* 2000). We describe several aspects of the Stripe-tailed Yellow-finch's breeding biology in a human-altered habitat with information on breeding habitat, nest, eggs, clutch size, incubation and nestling periods, nest sites, and time of breeding as well as nesting success.

METHODS

Study area. We conducted our study in central Brazil in Brasília National Park (BNP; 15°35'–15°45'S and 47°55'–48°55'W), a reserve that covers ≥ 30,000 ha of typical cerrado vegetation ranging from grasslands to dense woodlands, gallery forests, and disturbed areas. Many mining pits were created in BNP in the late 1950s–1960s when the city of Brasília was under construction. These areas still lack significant vegetation cover and have advanced erosion features, including several gullies ranging from < 0.5 to 15 m depth. *Dicranopteris flexuosa* ferns (Gleicheniaceae), *Miconia albicans* shrubs (Melastomataceae), grass tussock (Poaceae), and *Baccharis* sp. brooms (Asteraceae) are concentrated in the shallow part of the gullies (up to 0.5 m depth). Most of the ground surface outside the gullies is exposed, with scarce grass cover. Ferns are notably more abundant than other plants. The climate of the cerrado region is seasonal with a rainy warm season (October–March) and a dry cool season (April–September). The mean annual temperature varies from 20 to 26° C, and mean annual rainfall from 1500 to 1750 mm.

Field procedures. Stripe-tailed Yellow-finches can be easily found in open areas in BNP (Antas 1995), and we surveyed them in five distinct open habitats. We describe the main habitat of the species during the breeding season by calculating an abundance index in each of the five habitat types: (1) *campo sujo* (shrubby grassland), (2) *campo limpo* (grassland), (3) *cerrado* (savanna woodland), (4) invasive molasses grass (*Melinis minutiflora*) dominated habitat, and (5) in old mining pits. We sampled four old mining pit areas to study the abundance of the Stripe-tailed Yellow-finch in this type of habitat. We conducted point counts in three different locations in each area, at least 100 m away from each other and 50 m away from the habitat edge. We randomly surveyed points three times during March 2007, at each pre-established morning periods (06:00–07:00, 07:00–08:00, and 08:00 –09:00 h) and counted every observed or heard Stripe-tailed Yellow-finch in a 50-m radius of each fixed point. One of us (DTG) practiced distance estimation before initiating point counts. Surveys lasted 15 min at each fixed point and care was taken to avoid counting the same bird twice. We divided the total number of contacts by the number of point counts to calculate the abundance index.

We located active nests from mid January to early May 2007 by searching every possible nest substrate in the old mining pits, and by observing adults carrying nest material and feeding nestlings. Nests were often located when females were flushed as we walked close to their nests in tussock grasses, shrubs, and ferns. We noted the coordinates of each nest location using GPS units and identified each nest site with colored tape placed 5 m north. We monitored nests at 3–4 day intervals until fledging or failure. We found active nests with nestlings at the beginning of the study and estimated the initiation date of the first nest by backdating from nestlings' age (nest initiation = nestling age – incubation period – clutch size). We also estimated the day of fledging of the latest nest found to estimate the end of the breeding period. Body parameters of nestlings monitored since hatching were used to estimate nestlings' age. We identified nest substrates (plant species) and measured the height of nests above ground. We also measured external and internal diameter, nest height, and internal depth of nests with a digital caliper (± 0.1 mm) of nests found during the laying period or in the first week of incubation to avoid measuring nests deformed due to use or rainfall.

We measured egg length and width with a caliper to the nearest 0.1 mm and mass with a 10 g spring scale to the nearest 0.1 g. We only weighed eggs found in early stage of incubation (1–4 days of age) to avoid bias due to water loss. Nestlings wing chord, tarsus, tail, and bill length were measured with a caliper (± 0.1 mm), and weighed with a 10 g or a 50 g spring balance to the nearest 0.1 g and 0.5 g, respectively. We painted the tarsus of each nestling with a non-toxic pen to permit further identification. We used measurements and body mass data of nestlings flushed from the nest and caught on the nest border to compare nestlings' body parameters at fledging with those of mist-netted adult birds. Such nestlings were placed back into the nests and monitored until we were sure they stayed.

To estimate clutch size we used the maximum number of eggs in the nest in at least two consecutive nest checks. We only used nests found under construction or with incomplete clutches to estimate the duration of the incubation period, defined as the period from the day the last egg was laid to the day nestlings hatched. Nestlings' age was used to estimate hatching date for nests where hatching occurred between nest checks and for nests found during the nestling period. Nestling period was estimated from the day of hatching to the day of fledging, only from successful nests where at least one nestling fledged. Fledging dates did not always coincide with nest checks because we monitored nests every 3–4 days. We estimated the fledging date for those nests using the middle date between nest checks (Mayfield 1975). We noted the gender of the adult incubating eggs or brooding nestlings at every nest check.

We estimated survival rates following Mayfield (Mayfield 1961, 1975). Daily survival rates (DSR), as well as apparent nest survival (proportion of successful nests), were estimated for all nests and for each subset according to nest substrate (ferns, shrubs, and grass tussocks). Care was taken during nest checks not to attract attention of nest predators and not to damage the vegetation surrounding the nests.

Statistical analyses. We used Chi-square tests to test the predominance of plant species used as nest substrate, predominance of clutch sizes, and nest success among substrates. T-tests were used to test differences in the body parameters between fledglings and adults. We used R (R Development Core Team 2007) for statistical analyses and set significance at 5%. Values are given as means ± SE.

RESULTS

Stripe-tailed Yellow-finches were only found in old mining pits, with none recorded in other habitat types. The abundance index for all other habitats (*campo sujo*, *campo limpo*, *cerrado*, and invasive *M. minutiflora*-dominated habitat) was zero, whereas the abundance index for all four old mining pits was 1.6 birds/point count (range = 0.7–2.2).

We found 99 Stripe-tailed Yellow-finch nests, but 21 were not active after being located. Nests were thick, shallow cup shaped structures made of grass leaves with sides and base made of larger leaves than the internal lining. Nest dimensions and height (mean ± SE) from the ground are given in Table 1. Most Stripe-tailed Yellow-finch nests (57 of 92 nests for which we identified nest substrate) were in *Dicranopteris flexuosa* ferns (Gleicheniaceae). Other plant species used as nest substrates were *Miconia albicans* shrubs (Melastomataceae; n = 20), tussock grass (Poaceae; n = 14), and *Baccharis* sp. brooms (Asteraceae; n = 1). There was a significant predominance of ferns as substrate for finch nests in comparison to other plants (χ^2_3 = 75.2, $P < 0.001$).

Eggs were ovoid-shaped and turquoise-blue with brownish speckles concentrated on the obtuse pole. The mean ± SE egg mass, length, and width were 1.6 ± 0.01 g, 17.5 ± 0.1 mm, and 13.0 ± 0.04 mm, respectively (n = 103). Clutches of three eggs were more common (n = 23; χ^2_2 = 18.95, $P < 0.001$) than those of two eggs (n = 16) and one egg (n = 1). Nestlings hatched with their bodies covered with clear gray down, large abdomens and bulging closed eyes; mouth lining was reddish. Some body regions, like the belly, were not entirely feathered at fledging. Observations (n = 3) indicated that during the first days out of the nests fledglings move on the ground through small flights, and are fed by adults near the nest. White speckles in the tail feathers are already visible during the first week after leaving the nest, as found in adults. Nestlings' body parts grew disproportionately by the time of fledging (Table 2). Only the tarsus of young at fledging was not significantly shorter compared to those of adults (t = 0.894, df = 30, P = 0.3785). We observed newly hatched nestlings (0–1 days old, n = 9 nests) having nearly the same size and mass in nine nest checks, so we could state that hatching is synchronous and incubation starts after the laying of the last egg. Some nests were found before the first egg was layed or during the laying period. The difference between the number of eggs in such nests in the next visit equaled the number of days elapsed since they were found, suggesting that egg laying occurs on consecutive days (one egg/day). Mean ± SE incubation and nestling periods were 11.8 ± 0.3 days (range = 10–13, n = 11) and 12.8 ± 0.4 days (range = 11–15, n = 9), respectively. Only females were observed incubating eggs and brooding nestlings.

The breeding period of Stripe-tailed Yellow-finches extended from at least late December to late May. Most nest initiations (day of the first egg laying) occurred between early January and mid March (Fig. 1). We estimated that the earliest nest was initiated on 28 December and nestlings of the latest nest

TABLE 1. Characteristics of the nests (n = 59) of Stripe-tailed Yellow-finches during the 2007 breeding season in Brasília National Park, Brazil.

Nest characteristics	Mean	SE	Minimum	Maximum
Height from the ground (m)	0.3	0.02	0.1	0.6
Nest height (mm)	64.5	1.3	41.4	96.5
Nest depth (mm)	39.9	0.8	30.7	76.1
External diameter (mm)	82.5	1.2	61	100.5
Internal diameter (mm)	53.7	0.4	48.9	61.1

fledged on 28 May. Thus, the duration of the breeding season was at least 152 days but could be longer as we did not search for nests before late December and after early May.

Fifty-nine nests were included in the nest survival analyses (one single nest built in a *Baccharis* sp. was excluded). Overall apparent success, Mayfield success, and DSR were 28.8, 21.2, and 0.94%, respectively (n = 59 nests). Apparent success was significantly greater in ferns (36.7%, n = 30 nests; $\chi^2_2 = 6.59$, $P = 0.0370$) compared to *M. albicans* shrubs and tussock grass (21.4%, n = 14 and 20%, n = 15, respectively). Mayfield success was also greater in ferns (21.4%, DSR = 0.96) than in *M. albicans* (16.2%, DSR = 0.93) and tussock grass (9.4%, DSR = 0.91), but did not differ significantly ($\chi^2_2 = 4.62$, $P = 0.099$).

DISCUSSION

In our study area, Stripe-tailed Yellow-finches nested in old mining pits, although they likely forage in other habitat types during the breeding season. The species is usually found in open cerrado areas (Antas 1995, Sick 1997, Bagno 1998, Tubelis & Cavalcanti 2001, MAM unpubl. data), including disturbed sites (Hilty & Brown 1986, Sick 1997, Melo-Júnior *et al.* 2001, Valadão *et al.* 2006). Our observations indicate that old mining pits act as a substitute for the natural rocky grassland *campo rupestre* habitat typically inhabited by the Stripe-tailed Yellow-finch (Straube *et al.* 2005).

Timing and duration of the breeding season of the Stripe-tailed Yellow-finch in our study area were similar to those reported for other species of migratory granivorous birds breeding in the cerrado region, including Blue-black Grassquits (*Volatinia jacarina*; Aguilar *et al.* 2008) and Double-collared Seedeaters (*Sporophila caerulescens*; Antas & Cavalcanti 1988, Francisco 2006) that breed from November to April and from December to May, respectively. The full duration of its breeding season could be longer because our study lasted only five months, although the species is not found in the central Brazilian cerrado outside the rainy season (April–September; Braz 2008). Reproduction is seasonal for the Stripe-tailed Yellow-finch and shows little time overlap with the reproduction period in non-granivorous birds, that usually occurs from September to December in the cerrado region (Marini & Durães 2001, Lopes & Marini 2005, Duca 2007, Medeiros & Marini 2007, Marini *et al.* 2009a, 2009b).

Life history traits vary considerably among *Sicalis* species. All *Sicalis* build open cups, but most are secondary cavity nesters, e.g., Puna Yellow-finch (*S. lutea*), Bright-rumped Yellow-finch (*S. uropygialis*), Greater Yellow-finch (*S. auriventris*), Greenish Yellow-finch (*S. olivascens*), Patagonian Yellow-finch (*S. lebruni*), Orange-fronted Yellow-finch (*S. columbiana*), and Saffron Finch (*S. flaveola*) (Ramo & Busto 1984, De la Peña 1987, 2005, Vuileumier 1993, Di Giacomo 2005, Aves

TABLE 2. Body mass (g) and morphological parameters (mm) of Stripe-tailed Yellow-finch nestlings at hatching (n = 9), nestlings flushed from the nest or perched on the edge of nests (n = 15), and adults captured in mist nets (n = 17). Values are means ± SE.

	Nestlings		Adults
	At hatching	Perched on nest edge or flushed from nest	
Mass	1.47 ± 0.1	11.4 ± 0.4	13.2 ± 0.6
Wing chord	5.53 ± 0.1	40.3 ± 0.6	63.0 ± 0.7
Tail length	1.20 ± 0.0	12.1 ± 0.6	49.7 ± 0.9
Tarsus length	5.31 ± 0.0	15.5 ± 0.1	15.9 ± 0.4
Bill length	1.82 ± 0.0	4.2 ± 0.0	6.7 ± 0.1

de Chile 2009, Rennó 2010). Grassland Yellow-finches (*S. luteola*) build open cup nests near the base of grass tussocks (Euler 1900, von Ihering 1900, De la Peña 1987, 1996), and along with Stripe-tailed Yellow-finches are exceptions to the general pattern in *Sicalis* of nest concealment. The nests of the Stripe-tailed Yellow-finch found in our study were similar in structure to those illustrated in Silva e Silva (2004), Buzzetti & Silva (2005), and described in Vasconcelos *et al.* (2007).

Open nesters usually lay eggs with speckles over the surface (Skutch 1976, Gill 1989). The eggs of Stripe-tailed Yellow-finches fit this pattern but are similar to those of other *Sicalis* finches that build nests in holes or abandoned closed nests, such as Saffron Finch, Greenish Yellow-finch, and Bright-rumped Yellow-finch (Ramo & Busto 1984, De La Peña 1987, 1996, Lindell 1996, Di Giacomo 2005). Other cavity-nesters, such as Pu-na and Patagonian Yellow-finch, lay immaculate eggs (De la Peña 1987, 2005) as can be expected for cavity-nesting birds (Gill 1989).

Members of *Sicalis* that have larger clutch sizes than the Stripe-tailed Yellow-finch (i.e., more than three eggs) nest in cavities (Ramo & Busto 1984, De la Peña 1987, 2005, Di Giacomo 2005). This is expected for cavity-nesters due to predicted lower nest predation risk compared to open-nesters (Slagsvold 1982), except for the Grassland Yellow-finch, an open-nester with clutches of 4–5 eggs (De La Peña 1996, 2005). No information on the breeding biology of Citron-headed Yellow-finch (*S. luteocephala*), Raimondi's Yellow-finch (*S. raimondii*), and Sulphur-throated Finch (*S. taczanowskii*) could be found in literature.

The estimated duration of the incubation period of the Stripe-tailed Yellow-finch in our study is the same as that of the cavity-nesting Saffron Finch (13 days; Palmerio & Massoni 2009). However, nestlings of the Stripe-tailed Yellow-finch fledge sooner (13 days on average) than those of the Saffron Finch (14 days; Palmerio & Massoni 2009). Shorter nestling periods are likely an anti-predatory strategy for open-nesting species, reducing the amount of time that young are at risk of predation (Winkler 2001).

The majority of the Stripe-tailed Yellow-finch's nests we found was built on the *D. flexuosa* ferns and had higher nest survival rates than those in other substrates. Such higher rates may be explained by the potential-prey-site hypothesis, which states that the probability of predation of nests decreases with increased density of the plants used for nest placement (Martin 1993). Alternatively, high

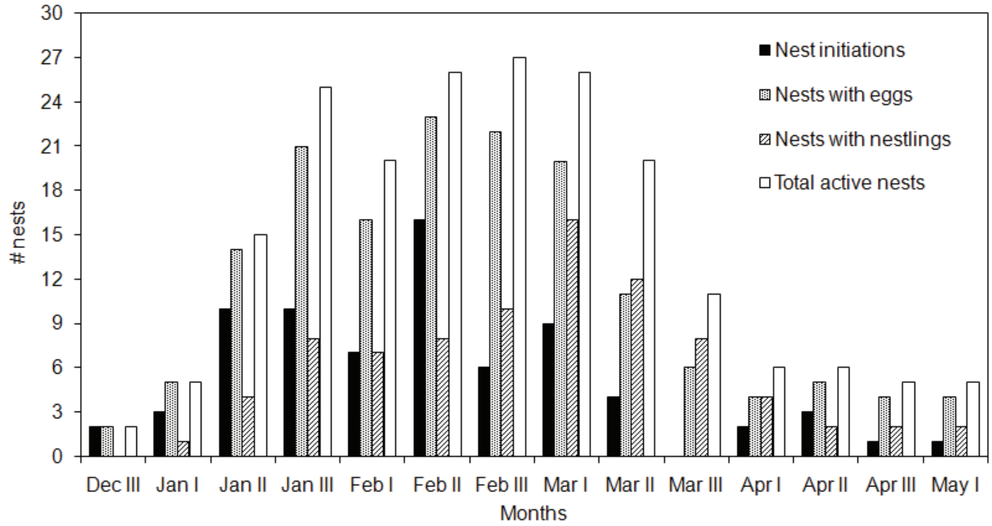

FIG. 1. Number of active nests of Stripe-tailed Yellow-finch during the 2007 breeding season in Brasília National Park, central Brazil. Study months were divided in three 10-day periods (I, II, and III). Hatchings occurred in some nests within a given period, so a single nest can be accounted for "Nests with eggs" and "Nests with nestlings", but not counted twice in the sum of "Total active nests".

use of ferns may be due to their higher abundance in the study sites. Although we have not surveyed plant species abundances in the study area, ferns are notably more conspicuous than other plants and disproportionally account for more suitable nest sites. A single Stripe-tailed Yellow-finch nest found by Vasconcelos *et al.* (2007) was in a tussock grass, also used as nest substrate by Stripe-tailed Yellow-finches in our study area.

The Stripe-tailed Yellow-finch breeds successfully in disturbed areas at Brasília National Park. Its apparent overall nest success in old mining pits (28.8%) was within apparent nest success values reported for the Blue-black Grassquit (24%; Aguilar *et al.* 2008) and the Double-collared Seedeater (32%; Francisco 2006), both occurring in disturbed areas in the cerrado region. Mayfield nest success (21.2%) was lower than reported for the Saffron Finch (82%) nesting in abandoned domed nests of the Rufous Hornero (*Furnarius rufus*; Mason 1985). Survival rates tend to be higher in closed in relation to open nests, such as Stripe-tailed Yellow-finch nests (Oniki 1979, Mason 1985, Martin & Li 1992).

The breeding biology of the Stripe-tailed Yellow-finch was similar to other congeners and within the expected theoretical patterns for Neotropical finches. Comparisons with other birds may prove to be useful for phylogenetic, behavioral, and ecological studies. Successful breeding at old mining pits reveals that artificial habitats in disturbed areas might be useful in conservation programs. Also, this species proved to be an appropriate object for future studies because of its high abundance, nest accessibility, and acceptance of observers' intrusion.

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