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# Breeding biology and biometrics of Silver-beaked Tanager *Ramphocelus carbo connectens* in south-west Brazilian Amazonia

*by Jônatas Lima & Edson Guilherme*

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Summary.—We present new data on the breeding biology and biometrics of Silver-beaked Tanager *Ramphocelus carbo* in south-west Brazilian Amazonia. *R. carbo* is widely distributed in South America, but its reproductive ecology is little studied. We made observations on the species in a *terra firme* forest fragment in the capital city of the state of Acre, between 1999 and 2020. We monitored 12 nests between 2012 and 2020, built at a mean height of 1.3 m above ground. Clutch size was two eggs, incubated for 13 days. We monitored the development of 11 nestlings: minimum hatch weight was 1 g and young fledged with a mean mass of *c*.18.9 g. The constant growth rate (*K*) of nestlings was 0.48 with a growth asymptote of 22.1 g. Daily survival rate was 91% and 98% during the incubation and nestling periods, respectively. Mayfield success in the incubation and nestling periods was 28% and 74%, respectively. Apparent nesting success in the incubation and nestling periods was 62% and 82%, respectively. We recorded a minimum longevity of 11 years, six months and 28 days. The subspecies *R. c. connectens* breeds mainly in the rainy season (October–January) overlapping with the moult period.

Studies of the reproductive biology of birds reveal important data that can aid understanding of ecological relationships and contribute to conservation of species (Martin 2004). The start of a breeding season is influenced, for example, by the availability of food (Sick 1997). Reproduction in the appropriate period combined with choice of nest site and time invested in parental care are crucial for the survival of nestlings (Saether 1985, Mezquida & Marone 2001). Aspects such as incubation and nestling period are of practical and theoretical importance, but not all studies of avian breeding biology have given these issues the attention they deserve (Skutch 1945). Overall, very little is known concerning the reproduction of Neotropical birds (del Hoyo *et al*. 2020) and in Amazonia basic details on the breeding cycle of many species, even common birds such as Silver-beaked Tanager (Hilty 2020), are still unknown.

The genus *Ramphocelus* comprises ten species (del Hoyo *et al*. 2020), three of which occur in Brazil (Piacentini *et al*. 2015), two of them in Brazilian Amazonia (Sick 1997). Of these, the commonest and most widely distributed is Silver-beaked Tanager *R. carbo* (Hilty 2020). Eight subspecies of *R. carbo* are recognised (Hilty 2020) of which that in south-west Brazilian Amazonia (Acre state) is *R. c. connectens* (Pinto & Camargo 1954, Novaes 1957, Guilherme 2016). Despite its widespread distribution, including throughout Amazonia, knowledge of the reproduction of Silver-beaked Tanager is still limited (Carvalho 1957, Skutch 1968, Valente 2000, Greeney *et al*. 2018, Hilty 2020). Here we present new information on the breeding biology and biometrics of *R. c. connectens* from a lowland *terra firme* forest in south-west Brazilian Amazonia.

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## Methods

***Study area***.—We conducted this study at the Zoobotanical Park of the Federal University of Acre (UFAC), in Rio Branco, capital of the Brazilian state of Acre. The Zoobotanical Park (09°57′08.9″S, 67°52′22.5″W) is a forest fragment with an area of *c*.100 ha surrounded by an urban matrix. For detailed descriptions of its vegetation, climate and avifauna see Meneses-Filho *et al*. (1995), Duarte (2006) and Guilherme (2001), respectively.

***Nest searches***.—Nests were found during non-systematic observations made between 2012 and January 2020. We monitored all nests found, irrespective of stage, until they became inactive. We measured eggs and nestlings using a millimetre ruler and analogue (2012–14) or digital callipers accurate to 0.01 mm (2015–20). We weighed eggs and nestlings using a Pesola® scale with a capacity of 100 g and accurate to the nearest 1 g (2012–14) or a digital scale accurate to 0.05 g (2015–20). We collected nests after they became inactive and deposited them in the collection of the UFAC ornithology laboratory. Nests were described according to the standardised scheme proposed by Simon & Pacheco (2005).

***Biometrics***.—We trapped and ringed Silver-beaked Tanagers in the years 1999–2002 (1,624.8 net / hours), 2004–06 (1,367.3 net / hours) and 2009–19 (57,948.2 net / hours). We used 12.0 × 2.5 m mist-nets with 36-mm mesh and banded individuals with numbered metal rings supplied by CEMAVE (Centro Nacional de Pesquisa e Conservação de Aves Silvestres), under the scope of project 1099, coordinated by EG (senior bird bander, reg. no. 324654). Morphometric data (wing, tarsus, bill, head, tail, total length and cloacal temperature) were collected from 2002 following the protocol outlined by Proctor & Lynch (1993). We used a Pesola® scale with a capacity of 100 g (1 g precision) to weigh birds and nestlings prior to 2014, and a digital scale (0.05 g precision) during 2015–20. We used a millimetre ruler to measure wing, tail and total length, and analogue callipers (0.05 mm precision) until 2014 and digital callipers (0.01 mm precision) in 2015–20 to measure bill and tarsus. For each biometric, data were taken from each individual only the first time it was trapped, for males and females separately. During ringing, we distinguished adults and juveniles based on the presence of juvenile plumage (basic plumage from first and second juvenile cycles, see Sibley 2010, Johnson *et al*. 2011). We examined each trapped individual to determine moult in the remiges and rectrices (Sibley 2010) and presence or absence of a brood patch (Redfern 2010). We measured cloacal temperature with a digital thermometer (32.0–42.9°C, accurate to 0.1°C) and calculated minimum longevity from the first day an individual was banded to its final recapture (Scholer *et al*. 2018).

***Incubation and nestling development***.—The incubation period was calculated from the date the last egg was laid until the second chick hatched. Post-hatching, we measured the mass of nestlings every two days to minimise our impact on nests. We banded young with a numbered metal ring while still in the nest. We considered the nestling development period based on the hatching of the first nestling and the abandonment of the nest by the second chick. The day of hatching was treated as day 0 (Oniki & Willis 2001). For nests found with nestlings, we estimated age based on the mass of the nestlings, comparing them with data for young monitored from hatching. We applied the equation proposed by Ricklefs (1967) to determine the growth rate of the nestlings: $W(t) = A/(1+e[-K(t-ti)])$, where $W(t)$ is the mass of the nestling at age t, $A$ is the asymptote of the growth curve, $K$ is the constant growth rate and ti is the inflection point of the growth curve. This equation was run in R software, version 3.5.1 (R Core Team 2018). We used the Mayfield (1961) method to calculate reproductive success rates, and determined apparent success as the ratio between the number of successful nests and the total number found (Jehle *et al*. 2004).

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## Results

***Nest characteristics***.—We found 12 Silver-beaked Tanager nests, of which 11 were active (Table 1). All nests were constructed in open areas or at the edge of forest on different substrates. Two nests were built in a stump of the palm *Attalea butyracea* (Fig. 1A–B), three in forks of *Theobroma grandiflorum* (Fig. 1D) and four nests in ornamental plants such as *Dracaena fragrans*, *D. terminalis* and *Polyscias guilfoylei* (Table 1). We did not identify the support plant at one nest. On average, nests were placed 1.30 m above ground (range 0.87–2.10 m). We found one nest under construction, six with eggs (three of which had been abandoned), four with nestlings in the first day of life, and one was empty. Most nests were built of dry leaves (Fig. 1D) lined internally with narrow, pliable blades of dry grass arranged concentrically (Fig. 1E). In one nest we found blue plastic threads in its inner lining. All nests conformed to the low cup / base, low cup / lateral or low cup / fork types (Figs. 1A, 1D, 2D). Mean measurements of nests ($n$ = 9) were: height of the external wall = 68.66 mm (range 55.66–93.8 mm; SD = 13.7); wall thickness = 16.68 mm (12.12–22.25 mm; SD = 3.21), internal diameter of cup = 63.90 mm (52.93–77.85 mm; SD = 6.9), external diameter of cup = 97.26 mm (85.21–116.41 mm; SD = 10.42), depth of cup = 49.08 mm (40.05–60.35 mm; SD = 6.0) and mass = 12.38 g (8.30–17.37 g; SD = 3.77).

***Eggs and incubation***.—In six nests found with eggs, clutch size was two. Only nest 6 contained a single egg that had been abandoned (Table 1). Eggs were predominantly white with pale and dark brown blotches, generally concentrated at the larger end (Fig. 1C). Mean egg ($n$ = 13) mass was 3 g (range 2.0–3.5 g) and size 21.23 × 16.00 mm (20–22 × 15–17 mm). Only females were seen incubating. Of all the nests monitored with eggs, only at nest 2 did one of the eggs fail to hatch (Table 1). Incubation period was 13 days (nest 5; Table 1).

TABLE 1
Characteristics of Silver-beaked Tanager *Ramphocelus carbo connectens* nests found between 2012 and 2020, in a *terra firme* forest fragment in Acre, Brazil, south-west Amazonia.

| Nest | Date of discovery | Supporting plant | Height above ground (m) | Clutch or brood size | Type/insertion | Date of hatching | Date of fledging (*n* of nestlings) |
|---|---|---|---|---|---|---|---|
| 1 | 27 Jan 2012 | *Theobroma grandiflorum* | 1.0 | 2 nestlings | Low cup/lateral | | |
| 2 | 14 Nov 2012 | *Attalea butyracea* | 2.1 | 2 eggs | Low cup/base | 16 Nov 2012 | 1—26 Nov 2012 |
| 3 | 21 Nov 2012 | *Dracaena fragrans* | 1.75 | 2 eggs | Low cup/base | 27/28 Nov 2012 | 2—12 Dec 2012 |
| 4 | 16 Jan 2013 | *Attalea butyracea* | 2.1 | 2 eggs | Low cup/base | 24/25 Jan 2013 | 2—4 Feb 2013 |
| 5 | 21 Jan 2013 | *Dracaena fragrans* | 1.61 | 2 eggs | Low cup/base | 5/6 Feb 2013 | 0 |
| 6 | 22 Feb 2013 | *Coffea arabica* | 1.2 | 1 egg/abandoned | Low cup/fork | | |
| 7 | 8 Oct 2013 | *Polyscias guilfoylei* | 1.0 | 2 eggs/abandoned | Low cup/lateral | | |
| 8 | 16 Jan 2014 | Not identified | 1.0 | 2 eggs/abandoned | Low cup/base | | |
| 9 | 7 Oct 2015 | *Dracaena fragrans* | 1.15 | 2 nestlings | Low cup/base | | |
| 10 | 26 Nov 2019 | *Theobroma grandiflorum* | 1.0 | 2 nestlings | Low cup/fork | Almost 22 Nov 2019 | 2—4 Dec 2019 |
| 11 | 6 Feb 2020 | *Theobroma grandiflorum* | 0.87 | 2 nestlings | Low cup/fork | | |
| 12 | 20 Feb 2020 | *Dracaena terminalis* | 1.3 | Empty | Low cup/base | | |

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Figure 1. Nests of Silver-beaked Tanager *Ramphocelus carbo connectens* found in a *terra firme* forest fragment in south-west Amazonia: (A) *Attalea butyracea* palm stump where nests 2 and 4 (Table 1) were sited (red circle); (B) detail of nest 2 with the female incubating (red arrow); (C) detail of the eggs; (D) lateral and (E) internal view of nest characteristics (A–C and E: Jônatas Lima; D: Edson Guilherme)

***Nestlings***.—We monitored the development of 11 nestlings in eight nests, three of which are depicted in Fig. 3. Nestlings hatch with dark pink skin, plumes on the back and head, and eyes closed (Fig. 2A–B). After five days, the eyes are slightly open, and the feathers of the remiges and rectrices start to develop (Fig. 2C). Nestlings in nests 2–4 were monitored from hatching (Table 1). Minimum hatch weight was 1 g (range 1.0–4.0 g; SD = 1.5; $n$ = 4) and nestling mass reached a mean 20 g ($n$ = 3) after 9–10 days, and 21.5 g ($n$ = 2) on day 12 (Figs. 2D, 3; nest 10), the heaviest recorded of any nestling (Fig. 3; nest 10). Chicks at nests 2 and 4 fledged on days 10 and 11, respectively (Table 1, Fig. 3; nest 4) while those from nests 3 and 10 fledged on day 12 (Table 1, Fig. 3). Only the chicks at nest 3 were ringed in the nest (ring codes G105802 and G105801). Of the 11 nestlings monitored, the two at nest 5 were predated eight days after hatching (Table 1), when they weighed 12 and 15 g. The longest nestling period was 12 days (Fig. 3, nest 10; Table 1) and chicks fledged at a mean mass of 18.9 g (range 17.0–21.1 g; SD = 1.9; $n$ = 8).

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Figure 2. Development of Silver-beaked Tanager *Ramphocelus carbo connectens* nestlings in a *terra firme* forest fragment in south-west Amazonia: (A–B) recently hatched nestlings (nest 10; Table 1); (C) five-day-old nestlings (nest 3; Table 1); (D) 12-day-old nestlings (nest 10). (A, B and D: Edson Guilherme; C: Jônatas Lima)

The constant growth rate ($K$) of the nestlings was 0.48 (range 0.35–0.57; SE = 0.05) with a growth asymptote of 22.1 g (20.81–23.82 g; SE = 6.2; Fig. 4). Daily survival rate for nests during the incubation period was 91% and for nestlings 98%. Mayfield success during the incubation period was 28%, assuming a duration of 13 days, and 74% in the nestling period, assuming chicks remained in the nest for 12 days. Apparent success was 62% in the incubation period and 82% in the nestling period.

***Breeding season***.—We trapped and banded adults ($n$ = 246) and young individuals ($n$ = 59) in all months of the year. However, the vast majority of young were mist-netted between September and March ($n$ = 40; Fig. 5). Active nests were found in January, February, October and November (Fig. 5), and we recorded individuals with a brood patch between October and March ($n$ = 12; Fig. 5) while the majority of individuals in moult were mist-netted in January–May ($n$ = 78; Fig. 5).

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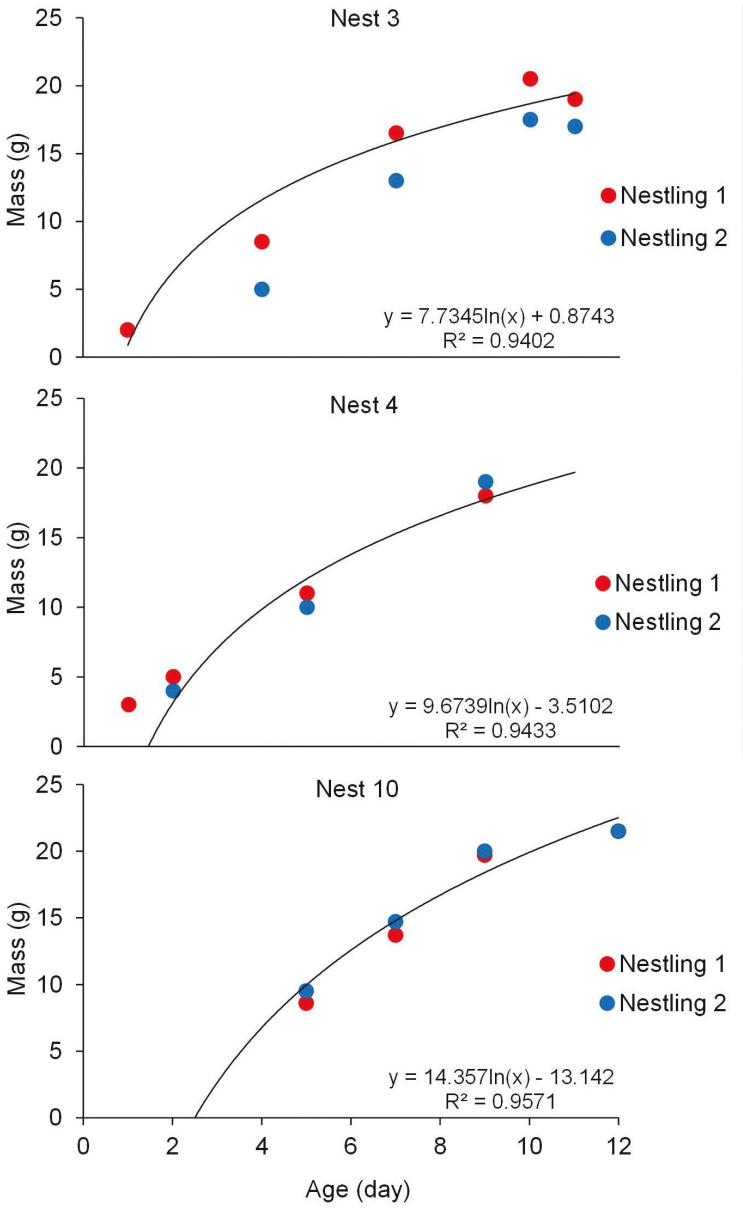



Figure 3. Development and body mass of six nestlings of Silver-beaked Tanager *Ramphocelus carbo connectens*, monitored in a *terra firme* forest fragment in south-west Amazonia between 2012 and 2019. The logarithmic equation is based on the most developed chick. Other nests found with nestlings (Table 1) are not shown here because they were predated or because we did not obtain continuous development data.

***Morphometrics***.—Between 2002 and 2019 we trapped and banded 99 females and 147 adult males. Morphometrics for females and males, respectively, were: mass 26.6 and 27.0 g (range 22–38 g, SD = 2.7, *n* = 99; 22–37 g, SD = 2.5, *n* = 145); wing 75.0 and 78.3 mm (65–85 mm, SD = 3.9, *n* = 99; 60–89 mm, SD = 3.8, *n* = 146); tarsus 20.2 and 21.5 mm (14–28 mm, SD = 2.5, *n* = 97; 17–28 mm, SD = 2.8, *n* = 141); bill 15.8 and 16.1 mm (12–20 mm, SD = 2.0, *n* = 54; 12–20 mm, SD = 1.7, *n* = 76); head 35.7 and 35.6 mm (34.9–36.7 mm, SD = 0.7, *n* = 5; 34.4–37.2 mm, SD = 0.8, *n* = 14); tail 75.5 and 77.0 mm (54–85 mm, SD = 5.2, *n* = 98; 58–89 mm, SD = 4.3, *n* = 143); total length 178.1 and 182.1 mm (164–189 mm, SD = 6.0, *n* = 88; 156–200 mm, SD = 7.3, *n* = 132) and cloacal temperature 41.9 and 42.4°C (41.3–42.5°C, SD = 0.6, *n* = 3; 41.7–42.9°C, SD = 0.5, *n* = 4).

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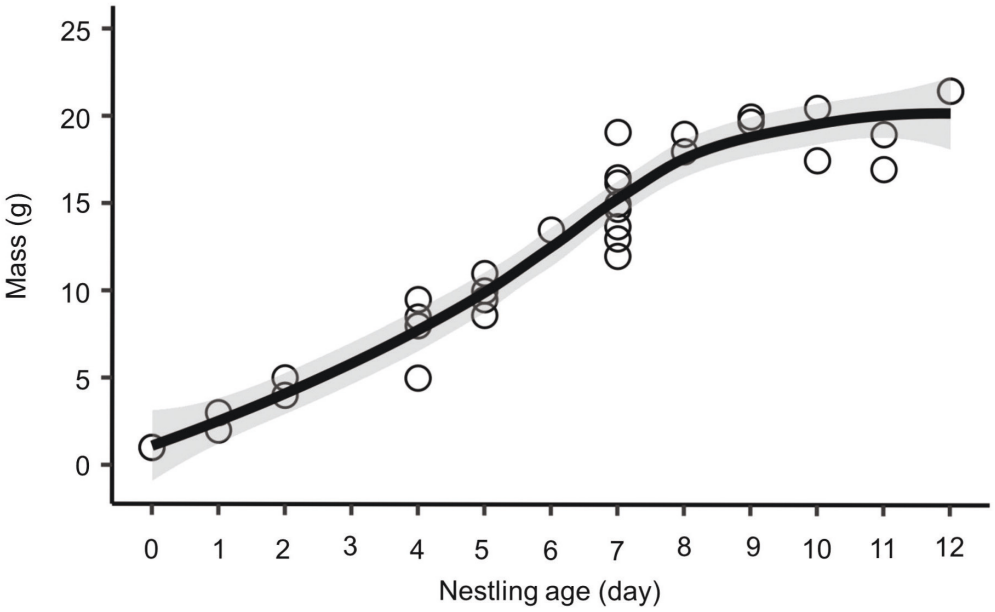



Figure 4. Logistic growth curve for 11 nestlings of Silver-beaked Tanager *Ramphocelus carbo connectens*, monitored in a *terra firme* forest fragment in south-west Amazonia between 2012 and 2020. Each circle represents a different nestling.

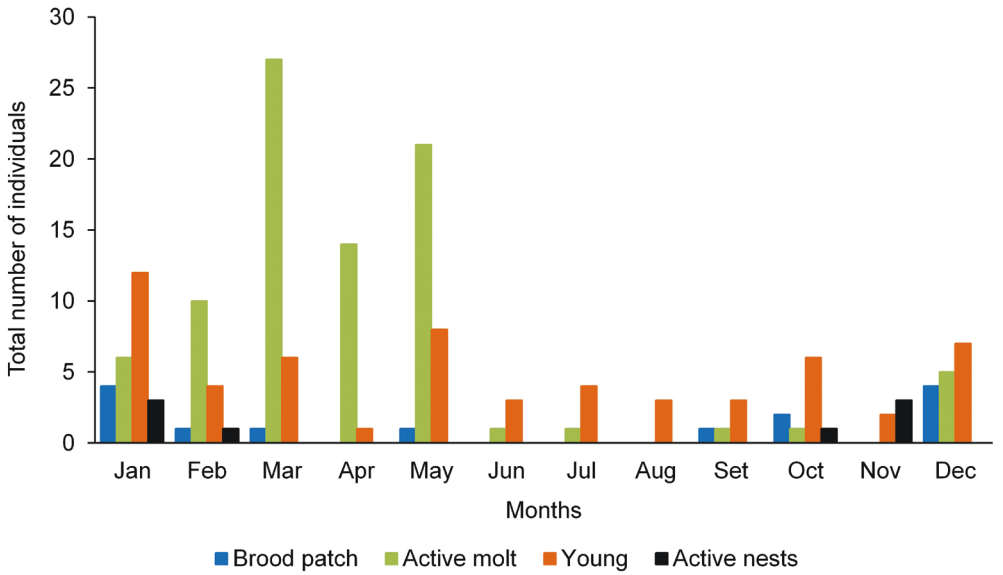



Figure 5. Silver-beaked Tanagers *Ramphocelus carbo connectens* trapped during the study period in a fragment of *terra firme* forest in south-west Amazonia in 1999–2002, 2004–06 and 2009–19, and active nests during 2012 to 2020. The bars show the numbers of ringed juveniles, moulting individuals, the presence of vascularised brood patches and active nests. Re-traps are not shown.

***Minimum longevity***.—Between 1999 and 2019 we made a total of 423 captures, 309 individuals which we banded and 114 of which involved re-traps. Of the ringed individuals, 53.5% were recaptured more than once ($n$ = 61). Longest minimum longevity

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was recorded for a male (G39942) banded as an adult by EG on 1 September 1999 and last re-trapped on 28 June 2011 (11 years, six months and 28 days, or 4,226 days after banding). The second longest-lived individual was a female (G91795), banded in 2011 and re-trapped in 2018 (seven years, two months and 25 days, or 2,642 days later). Males G39983 (2004–11) and G39984 (2004–10) had a minimum longevity of six years or 2,499 and 2,243 days, respectively. We re-trapped two females (G39954, G121045) and two males (G57713, G34989), all after four years (1,468–1,768 days); two females (G 39981, G34960) and one male (G91811) after three years (1,129–1,245 days); five males (G34958, G14447, G14452, G91725, G91854) and a female (G39979) after two years (766–1,091 days) and the other 44 individuals at intervals of <2 years (1–711 days).

## Discussion

Silver-beaked Tanager is common in open areas of the campus and inside forest at the Zoobotanical Park (Guilherme 2001). It inhabits the edge of forest, near reservoirs and secondary vegetation undergoing regeneration. In Acre, it is very common in gardens and urban areas (Guilherme 2016). In the region, *R. carbo* occurs sympatrically with Masked Crimson Tanager *R. nigrogularis* (Guilherme 2016). The latter is less common and preferentially inhabits floodplain forest, avoiding upland forests and urban areas, thereby minimising competition with Silver-beaked Tanager.

The few data concerning reproduction by Silver-beaked Tanager pertain to subspecies that occur in central and northern Brazil (Carvalho 1957, Lopes *et al*. 2013) and in Venezuela, Suriname and Ecuador (Skutch 1968, Isler & Isler 1987, Greeney *et al*. 2018). The breeding information presented here is the first for *R. c. connectens* (south-east Peru, adjacent north-west Bolivia, and extreme south-west Brazil). In our study area, Silver-beaked Tanager appears to prefer to nest in largely open areas and uses exotic (cultivated) plants or palms in sites with much human activity. Nesting by this species in disturbed areas was also observed elsewhere in Amazonia (Carvalho 1957, Skutch 1968, Lopes *et al*. 2013, Lima *et al*. 2019). The species constructs its nest low above ground (<3 m) as reported in French Guiana (Ingels 1977), Suriname (Isler & Isler 1987), Ecuador (Greeney *et al*. 2018) and Brazil (Almeida *et al*. 2012).

Nest shape (low cup / base, lateral or fork types) was similar to those of *R. c. venezuelensis* and *R. c. carbo* described by Skutch (1968) and Ingels (1978) from Venezuela and French Guiana, respectively, and Collins & Araya (1998) for Trinidad, as 'a compact open cup', and those of *R. c. carbo* that Carvalho (1957) followed in Brazilian Amazonia. This nest type is typical of many Thraupidae, such as Brazilian Tanager *R. bresilius* (Castiglioni 1998). Use of man-made material to construct nests is not uncommon in *R. carbo*. In a *cerrado* in south-west Mato Grosso, Almeida *et al*. (2012) reported that several bird species used synthetic wool, fabric and plastic in their nests, including Silver-beaked Tanager. As it is a species highly adapted to anthropogenic environments, the availability of suitable plant material may sometimes be insufficient for nest construction, which leads to the birds using material discarded by humans (Borges & Marini 2010, Marini *et al*. 2012, Suárez-Rodriguez *et al*. 2017, Batisteli *et al*. 2020).

Clutch size and egg characters are similar to Skutch's (1968) descriptions from Venezuela, Gibson (1987) based on captive birds, and those that Carvalho (1957) and Hellmayr (1910) described in Brazil. We recorded an incubation time equal to that reported by Skutch (1968) in Venezuela, by Isler & Isler (1987) in Suriname, and data for Brazilian Tanager in coastal *restinga* in south-east Brazil (Castiglioni & Gonzaga 1999). Nestling morphology and mass at hatching were similar to the data reported by Carvalho (1957), who found that two nestlings remained in the nest for 11 days. In the same study, he reported that one

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of the chicks fledged with a mass of 19.6 g, similar to our findings. Regarding the growth rate of nestlings, ours are only the second calculations for Silver-beaked Tanager. Our rate (0.48) was very similar to that calculated by Oniki & Ricklefs (1981) for *R. carbo* in Manaus (0.50) and higher than those calculated for Multicoloured Tanager *Chlorochrysa nitidissima* in Colombia (Loaiza-Muñoz *et al*. 2017) and White-winged Shrike-Tanager *Lanio versicolor* in Peru (Céron-Cardona *et al*. 2018). Growth rate was similar but marginally higher than that calculated for Hauxwell's Thrush *Turdus hauxwelli* at the same study site (Guilherme & Lima 2019).

Predation of Silver-beaked Tanager nestlings has also been observed in other studies (Carvalho 1957, Pinho & Marini 2014). Pinho & Marini (2014) found that of 27 active nests of Silver-beaked Tanager in the Pantanal, 92.6% were predated, with a success rate of just 7.4%. In contrast, only one of the nests with chicks that we monitored failed as a result of such pressures, indicating that locally the species' nests do not appear to be heavily predated.

Although young birds were trapped year-round, in Acre Silver-beaked Tanager breeds largely during the rainy season, in October–April. This seasonal relationship was demonstrated by active nests and individuals trapped with a brood patch during this period, unlike in central Amazonia, where the percentage of individuals with an incubation patch was higher in the dry season than the wet (Stouffer *et al*. 2013). Other studies of the species' breeding cycle in Brazilian Amazonia corroborate the hypothesis that Silver-beaked Tanager starts nesting in the late dry season (September) or the early rainy season (October) (Carvalho 1957, Valente 2000, Lopes *et al*. 2013, Lima *et al*. 2019). In the Pantanal, nests were found mainly during the rainy season (Pinho & Marini 2014), and the same was true at a *cerrado* enclave near Santarém, in the Brazilian state of Pará (Sanaiotti & Cintra 2001). In contrast, Skutch (1968) monitored active nests of *R. carbo* in Venezuela during April–May, which are months of low rainfall, while Hellebrekers (1942) reported eggs in Suriname from every month except November, but mostly January to July. Oniki & Willis (1999) recorded brood patches also in the dry season in a Brazilian *cerrado*. Moult was similar to data collated by Valente (2000) from specimens collected across the Brazilian Amazon and deposited at the Goeldi museum (Belém). According to the latter study, the majority of moulting birds were collected during the wettest months, December–June, thus overlapping with breeding activity.

Mean body mass for the species is consistent with other studies (King & Laarhoven 2003, Silva *et al*. 1990, Guilherme *et al*. 2018), and variation in this character was similar to data for the species from the Brazilian Cerrado (Marini *et al*. 1997). Based on just one individual of the subspecies *R. c. centralis*, also from a Brazilian *cerrado*, Piratelli *et al*. (2001) presented bill and tarsus data similar to ours for both sexes, but wings and tail were longer. Wing, tail and bill lengths of both sexes measured by Pinto & Camargo (1954) in the environs of Rio Branco and Plácido de Castro, both in Acre, and Hellmayr (1910) in Rondônia, are similar to those observed by us. Males measured in Rondônia by Guilherme *et al*. (2018) had a mean total length less than that of males at our study site, but values in both studies are within the overall range for the species. Head length data had not previously been reported for Silver-beaked Tanager. The cloacal temperatures that we recorded were similar to those reported by Oniki & Willis (1999) for Silver-beaked Tanager in a Brazilian *cerrado*.

Few previous longevity data for wild Silver-beaked Tanagers were available, but individuals have lived as long as 17 years in captivity in Illinois, USA (Pingry 2000). Snow & Lill (1974) re-trapped two females with a minimum longevity of eight and 9.5 years on Trinidad. The variation in our minimum longevity records is consistent with the those available for other thraupids, e.g. Grey-headed Tanager *Eucometis penicillata* (eight years old) and Palm Tanager *Thraupis palmarum* (nine years old) in Venezuela (Lentino *et al*. 2003),

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and Blue-capped Tanager *T. cyanocephala* (six years old) in south-east Peru (Scholer *et al*. 2018). With a diet of invertebrates and fruit (Wilman *et al*. 2014), Silver-beaked Tanager belongs to the same guild of bird species that is more long-lived in Madagascar rainforests (Woog *et al*. 2018). That Silver-beaked Tanager forages in monospecific flocks may explain its relative longevity, due to decreased mortality from predation, as observed by Julien & Clobert (2000) for other species of Neotropical birds.

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