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Nesting biology of the Narrow-billed Woodcreeper (*Lepidocolaptes angustirostris*) in a southern temperate forest of central-east Argentina

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ABSTRACT

We present data on the nesting biology of the Narrow-billed Woodcreeper (*Lepidocolaptes angustirostris*) in a natural forest in central-east Argentina. A total of 18 nests were found during four breeding seasons (2015–2019; from September to January), located in cavities (natural, artificial and woodpecker cavities). The incubation period lasted 16 days and eggs were larger than those from northern populations. Nestlings stayed in the nest for 17 days and we could measure nestlings at two nests. Within the forest, nests were built in large native trees. Seven nests were successful, nine were depredated and two were abandoned. The average nest daily survival rate (DSR) was estimated as 0.96, giving a cumulative chance of nest survival in a nesting cycle of 24%. Our study provides the first estimate of the nest DSR for the species and new records on the nesting biology of a poorly known Neotropical bird.

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Breeding parameters; breeding phenology; cavity-nesting birds; daily survival rate; Furnariidae; nest survival

Introduction

Woodcreepers [Furnariidae (~293 species): Dendrocolaptinae (~51 species)] (Derryberry et al. 2011) are a group of Neotropical cavity-nesting birds that inhabit and breed throughout many South and Central American habitats (Marantz et al. 2003). Information on this group breeding habits has increased significantly in the last 15 years (for example: Luz et al. 2007; Bodrati & Cockle 2011; Bodrati et al. 2018); nonetheless, regional comparisons are scarce and data on nest daily survival rates are still lacking in the literature.

The genus *Lepidocolaptes* comprises 10 species (Remsen et al. 2018) of mid-sized woodcreepers that have a curved bill (Bodrati & Cockle 2011). Bodrati & Cockle (2011) argued that their nesting habits are characterized by: nest chambers lined with bark flakes, biparental activity along the nesting cycle, incubation periods of 15–17 days and nestling periods of 18–19 days. Despite this statement, the widest descriptions of *Lepidocolaptes* breeding habits were made by Skutch (1969) on *L. affinis* and *L. souleyetii*. Besides Bodrati & Cockle's (2011) description on *L. falcinellus* nesting behavior (based on one nest) and anecdotal observations on *L. angustirostris* (Luz et al. 2007; Salvador 2013; De la Peña 2016), other *Lepidocolaptes* species (such as *L. leucogaster*, *L. albolineatus* and *L. squamatus*) breeding habits have been poorly studied (Marantz et al. 2003).

The Narrow-billed Woodcreeper (*L. angustirostris*) is a sexually monomorphic (but regionally polymorphic; Bolívar-Leguizamón 2014) species that inhabits diverse types of habitats (forests, semi-open forests, savannas, urban areas) along Brazil, Paraguay, Bolivia and Argentina (Marantz et al. 2003). The species breeds from late August to early November in central Brazil (Marini et al. 2012) and from late September to early January in central Argentina (De la Peña 2016). According to the reports available, clutch size is 2–4 eggs (Marini et al. 2012; De la Peña 2016), eggs are incubated for 15–16 days (Salvador 2013), weigh 3.9–5.3 g, are 24–27.3 mm long and 17.5–20 mm wide (Marini et al. 2012; De la Peña 2016). Nestlings are born with a body mass of 3.9 g (Salvador 2013) and the nestling period appears to have a wide range, from the 15 days reported by Salvador (2013) to the 22 days reported by Marini et al. (2012). In accordance with the lack of information of nestling measures (only found in Salvador 2013), nest fate was only reported for one nest (Luz et al. 2007). Even though the basic aspects of the breeding biology of the species have been described from anecdotal observations (Di Giacomo 2005; Luz et al. 2007; Marini et al. 2012; Salvador 2013; De la Peña 2016), no study to date has provided information on nest daily survival rate.

The purpose of this study was to provide an extensive report on *L. angustirostris* nesting biology in a

natural forest in central-east Argentina. We present novel data on overall nest success and daily nest survival rates and compare our results with other reports on the species, the genus, and other cavity nesters.

Material and methods

Study site

We conducted this study on two private farms ('Luis Chico' – 35°20'02.54"S, 57°11'43.92"W and 'La Matilde' – 35°21'03.40"S, 57°11'14.53"W; 8 m asl) located in the northeast of Buenos Aires Province (Argentina), within the Biosphere Reserve Parque Costero del Sur (MAB-UNESCO 1984). The area has a temperate climate and is composed of semi-open grasslands and forest patches (locally known as Talares) that can be parallel and close to the La Plata River or isolated. These forests are mainly composed of the native *Celtis ehrenbergiana* and *Scutia buxifolia* and secondarily by *Erythrina crista-galli*, *Schinus longifolius*, among other species. Some exotic species such as *Gleditsia triacanthos*, *Eucalyptus* spp. and *Populus* spp. are also well represented. This area is in the midst of an ongoing degradation process due to human activity (Arturi & Goya 2004).

Nest monitoring and breeding parameters

We collected data as part of a project on avian breeding biology during three consecutive breeding seasons (October 2015–January 2016; October 2016–January 2017; October 2017–January 2018). We also collected data of two nests during the 2018–2019 breeding season although we did not search for nests throughout the entire breeding season. We found nests by identifying territories using adult vocalization, and by following individuals when they entered and left cavities (during construction, incubation or nestling stages; Martin & Geupel 1993). Once found, we visited the nests every 3–4 days and checked cavity content by using a mirror (attached to a pole) and a small flashlight. We monitored all nests until nestlings fledged or the nest failed. We considered a nest successful when at least one nestling fledged. We considered a nest predated if all the eggs or nestlings (without being old enough to fledge) disappeared between two consecutive visits, and no parental activity was detected near the nest. We considered a nest abandoned if we did not observe the breeding pair near the nest (or signs of activity) during two consecutive visits.

Because *L. angustirostris* nest chambers are difficult to access, we were only able to take egg measurements

(weight, length, and width) in five nests and nestling measurements (weight, wing, tarsus, and bill) in two nests. We also measured eggs from the Ornithology Collection of La Plata Museum (MLP) and calculated egg volumes following Hoyt (1979). Both eggs and nestlings were weighed using a Pesola scale (10 ± 0.1 g, 20 ± 0.2 g and 50 ± 0.5 g) and measured to the nearest 0.05 mm using Vernier calipers.

Once we confirmed that the nestlings fledged or the nest failed, we took measurements of the entrance hole height and diameter and the cavity depth. We also determined the type of cavity used (natural, excavated by woodpeckers or other type of cavity), nest-tree diameter at breast height (DBH) and the nest tree species.

Each nest was assigned a clutch-initiation date (time of breeding season), corresponding to the laying of the first egg. Clutch-initiation dates were determined directly for nests found during egg-laying, or indirectly through backdating from hatching dates for nests found during incubation. The incubation period was estimated as the number of days elapsed from laying of the last egg until hatching of the last egg. Nestling period was estimated as the number of days elapsed since hatching of the last egg until fledging (Segura et al. 2015). When nestlings were fully feathered and disappeared between two successive visits without predation signals, we assumed fledge date to be at the midpoint between those visits. We calculated nest productivity as number of fledglings/clutch size. We estimated daily nest survival rate (DSR) by creating a null model (without explanatory variables) using the RMark package (2.2.4; Laake 2013), where nest outcome was the response variable (0 = successful; 1 = failed). We examined the linear effect of time of breeding and compared this model and the null model using Akaike's information criterion corrected for small samples (AICc) (see protocol details in Segura & Reboreda 2012). Cumulative probability of nest survival was calculated by raising the daily survival rate to an exponent represented by the nesting cycle duration (days elapsed between the laying of the first egg and fledging). We tested differences in egg volume across regions by comparing our data with that available for tropical-subtropical areas (eggs from La Plata Museum Collection [Yungas ecoregion]; Di Giacomo 2005 [Chaco ecoregion]; Marini et al. 2012 [Cerrado ecoregion, Brazil]) using a generalized linear mixed model where the breeding pair was modeled as a random effect, egg volume was the response variable and the region was the explanatory variable (0 = our data; 1 = tropical-subtropical data). All analyses were developed in R 3.4.4 software (R Development Core Team 2018). Reported values are means \pm SE and we

considered $\alpha = 0.05$. Legal permits to conduct this research were provided by the 'Organismo Provincial para el Desarrollo Sostenible (OPDS)' – Disposición 003/16.

Results

We found 18 Narrow-billed Woodcreeper nests (five in 2015–2016, five in 2016–2017, six in 2017–2018 and two in 2018–2019 breeding seasons). We found three nests during the laying stage, 11 during incubation, one during hatching, two during the nestling stage, and in one nest, found during construction, egg laying never started. The earliest nest started on 15 October and the latest on 30 December, while the earliest and latest fledging dates were 25 November and 22 January, respectively. Clutch initiation showed a unimodal frequency distribution along the season, with a peak in November (three nests started in October, nine in November, four in December and one in January).

Nest and nest site characteristics

Seven nests were built in woodpecker cavities (by either *Colaptes melanochloros* or *Colaptes campestris*), 10 in natural cavities in tree trunks or branches and one nest was built in a hole in the wall of an abandoned house. Sixteen nests were built in *Celtis ehrenbergiana* and one in *Erythrina crista-galli* (two native species). In general, nests in natural cavities were built in tree trunks that had become hollowed by fungi or insect degradation or in trunks with some sort of inner fracture. One nest was built in a fallen branch that was hanging from the tree. Cavity entrance heights were 163.5 ± 17.6 cm (range = 75–310 cm; N = 18) and cavity depths were 40.4 ± 3.7 cm (range = 25–42 cm; N = 18). The maximum diameter of the entrance hole was 11.51 ± 2.9 cm (range = 3.5–18 cm; N = 10) for natural cavities and 6.83 ± 0.4 cm (range = 6–8 cm; N = 7) for woodpecker cavities. Nest-trees had a diameter at breast height (DBH) of 48.8 ± 6 cm (range = 22.2–81 cm; N = 17).

Nest chambers were lined with bark pieces (mainly from *Celtis ehrenbergiana*). On two occasions, we observed both members of the breeding pair carrying material to the nest and we once observed an adult adding material during the incubation stage.

Breeding parameters

Mean clutch size was 2.9 ± 0.3 eggs (range = 2–3 eggs; N = 11). Eggs were always elliptical ovate and immaculate white (Figure 1), weighed 5.5 ± 0.2 g (range = 5.2–6.8 g), were 27 ± 0.3 mm long (range = 24.3–28.4 mm),

19.8 ± 0.15 mm wide (range = 19.1–21.1 mm) and had a volume of 6.1 ± 0.8 cm³ (range = 5.5–6.5 cm³) (N = 14 eggs from five nests). The eggs from the La Plata Museum [MLP] collection (from the Yungas ecoregion, northwest Argentina) were 26.3 ± 0.4 mm long (range = 25.6–27.6 mm), 19 ± 0.2 mm wide (range = 18.5–19.7 mm) and had a volume of 5.9 ± 0.6 cm³ (range = 5.7–6.1 cm³) (N = 5 eggs from two nests). Eggs from our study site were marginally larger ($t = -2.91$; p -value = 0.022) than the eggs from tropical-subtropical regions. At one nest, we were able to record the incubation period (16 days), which started with the laying of the second egg (two nestlings hatched together and the third one hatched one day later). Out of the total nests monitored, 61% survived the egg stage (11 nests out of 18). Of those 11 nests, we could not determine the hatching success of five nests that survived the egg stage because two were found at nestling stage and in the other three nests, we could not record

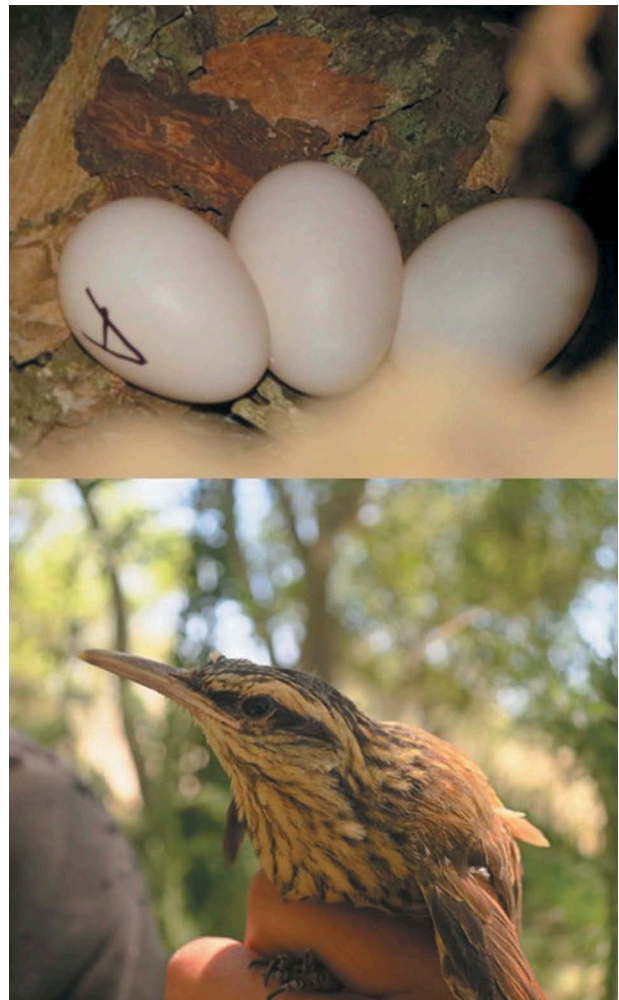


Figure 1. Clutch of *Lepidocolaptes angustirostris* (upper photo) and nestling prior to fledge (age: 16 days; lower photo).

how many eggs hatched. Taking this into account, hatching success was 100% for six nests.

We were able to extract and measure the nestlings in two nests (Table 1). Before fledging (16–17 days old), the nestlings' bodies were fully covered with brown feathers and presented the typically fluted throat (Figure 1). We found subcutaneous botfly larvae (*Philornis* sp.) in the nestlings of two nests (5–10 larvae per nestling). None of the nestlings died due to *Philornis* botfly parasitism during the observation period until fledging. In the majority of the visits during nestling stage, we observed both members of the breeding pair near the nest (in an alert behavior) and on one of those visits, we observed the adults carrying food for the nestlings. Of the nests that reached the nestling stage, 70% were able to raise fledglings (seven out of 10 nests) and 62.5% of the nestlings were able to fledge successfully (15 out of 24 nestlings). Nest productivity was 73%. Each nest produced 2.1 ± 0.2 fledglings (range = 2–3 fledglings; $N = 7$) and the nestlings remained in the nest for 16.9 ± 0.3 days (range = 16–18 days; $N = 7$).

Overall, seven nests were successful (39%), nine were predated (50%), and two were abandoned (11%). The cause of nest abandonment was unknown in one case and in the other, the eggs were defective, given that they were incubated for 25 days without hatching. Estimated daily nest survival rate was 0.96. The model that included time of breeding had higher AICc value than the null model and, therefore, had no important effect on nest survival.

Discussion

With this contribution, we report the first estimates of a woodcreeper nest daily survival rate (DSR) and an extensive report on the entire nesting cycle of the Narrow-billed Woodcreeper. Full nesting cycle was estimated to last 35 days (assuming a clutch size of three eggs, 16 days of incubation period starting with the second egg, and 17 days of nestling period); hence, cumulative nest survival was estimated to be 24%. This chance of survival is relatively low for a Neotropical cavity-nesting bird (Martin 1992). Since we do not have confident data of re-nesting attempts from the

same pair (because we did not band adults), we cannot confirm that this low reproductive success is compensated with several nesting attempts along the breeding season (like other Neotropical passerines with relatively low daily survival rates; Martin 1996; Segura & Reboreda 2012). However, given the long breeding season of our population (compared to the one reported by Marini et al. 2012 for a tropical population) and the report of two *L. falcinellus* nesting attempts within the same breeding season (Marques-Santos et al. 2015), it could be possible that this population compensates the low success with several nesting attempts throughout the breeding season.

In addition, nest predation was the main cause of nest failure (accounting for ~80% of the cases). Nests were built in cavities (using natural, artificial, and woodpecker cavities) and show certain plasticity in terms of the deepness, height and entrance hole diameter selected. This variance may be due to low availability of cavities with better conditions for a cavity-nesting bird (i.e. cavities with smaller entrances and higher above the ground – Cockle et al. 2015; Studer et al. 2018) that force Narrow-billed Woodcreeper to use non-optimal cavities which would increase predation rates. Moreover, other features such as parental behavior (Cockle et al. 2015), canopy connectivity (Britt et al. 2014) or nest age (Brightsmith 2005), may influence nest daily survival rates of cavity-nesting birds. Future studies should be undertaken in order to achieve a better interpretation of the responses of this bird group to different environments and predator communities.

In regards to predator communities, Berkunsky et al. (2011) found that *Phylodryas baroni* was a frequent nestling predator of a Neotropical cavity-nesting parrot in central Argentina. Similarly, Cockle et al. (2016) documented a predation event by the white-eared opossum (*Didelphis albiventris*) on a trogon cavity-nest in north-east Argentina. Both *Didelphis albiventris* and *Phylodryas* species are well represented on the study area (Abba et al. 2009; Williams & Kacolis 2009) and we were able to detect predation events by these species in other cavity-nesters during nest monitoring (AJ, pers. obs.). Therefore, we believe that these species were likely to

Table 1. Features of *Lepidocolaptes angustirostris* nestlings measured at different ages in two nests (N_1 had two nestlings in all the visits and N_2 had three nestlings on the first visit and two on the second and third visits). Values are mean \pm SD.

Features	Age (d)				
	2–3 (N_1)	4–5 (N_1)	7–8 (N_2)	10–12 ($N_{1,2}$)	16–17 (N_2)
Weight (g)	13.9 \pm 1.2	22.3 \pm 0.7	35.6 \pm 1	39.9 \pm 0.5	41.2 \pm 0.2
Bill length (mm)	9.6 \pm 0.2	10.8 \pm 0.3	14.2 \pm 0.1	16.3 \pm 0.6	18.7 \pm 0.2
Wing length (mm)	13.4 \pm 0.7	19.1 \pm 0	36.6 \pm 2.6	48.5 \pm 0.9	73 \pm 5.7
Tarsus (mm)	13.6 \pm 0.5	17.1 \pm 0.3	19.9 \pm 0.2	20.1 \pm 0.3	20.4 \pm 0.2

be partially responsible of predation events on *L. angustirostris* nests. In addition, jaguarundi (*Herpailurus yagouaroundi*), American Kestrel (*Falco sparverius*) and small rodents (*Akodon*, *Oligoryzomys* and *Oxymycterus* spp.) appear as other probable cavity predators at our study area (AJ, pers. obs.).

Similar to the reports on *L. angustirostris* (Di Giacomo 2005; Salvador 2013) and other members of the genus (Skutch 1969; Bodrati & Cockle 2011), we observed that both adults built the nest (i.e. participate in material hauling) and at least one of the breeding pair members continued adding material to the nest once the laying had started. It is likely that both members of the breeding pair feed the nestlings, which needs to be confirmed sampling individual marked birds. The egg size at our study site was similar to that reported from Buenos Aires province (Babarskas & López Lanús 1993), but bigger than the eggs from northern regions (Yungas ecoregion (La Plata Museum Collection eggs); Chaco ecoregion (Di Giacomo 2005); and the Cerrado ecoregion (Marini et al. 2012)). While Christians (2002) assessed egg size variation related to female body size, to environmental features or to the female physiological system, Martin (2008) argues that egg size variation is caused by differences in egg energetic requirements. *Lepidocolaptes angustirostris* body size varies throughout its distribution (Bolívar-Leguizamón 2014) but female body size explains less than 20% of the egg size variation (Christians 2002). In addition, Christians (2002) found that only 15% of egg size variation is explained by environmental features (food availability or temperature) and that egg size may be a characteristic of individual females. On the other hand, long absences of the breeding pair during incubation lead to cooler egg temperatures and larger embryonic periods that could cause an increase in relative egg size (as found for songbirds; Martin 2008). We believe it is likely that differences in egg size between populations may be caused by a differential behavior during incubation, but further studies on adult behavior, the female physiological system, and comparisons between populations would help to understand this species patterns regarding egg size. Moreover, if egg size is greater in southern populations (due to long absences of the breeding pair during incubation) and the species experiences longer breeding seasons with several breeding attempts (due to a high predation rate; Martin 1996), is likely that these features evolved independently and in response to different mechanisms.

The clutch size found in this study was similar to previous reports for the species (Di Giacomo 2005; Luz et al. 2007 but see Salvador 2013) and the incubation

period was in accordance with the findings of Salvador (2013). On the other hand, the nestling period we observed was shorter than that reported for the species in tropical/subtropical areas (Luz et al. 2007; Marini et al. 2012) but was equal to the nestling period found in central Argentina (Salvador 2013). Shortening the nestling period could be a mechanism of southern populations to reduce nest exposure in response to high predation rates (Martin 1996). In short, except for a shorter nestling period, our findings coincide with Bodrati & Cockle's (2011) general considerations for the genus.

Despite the presence and abundance of exotic tree species within the study site (Arturi & Goya 2004), *L. angustirostris* only used native species to nest. In addition, the trees used were larger than those of conspecifics available in the area (~39.2 cm DBH; AJ unpubl. data). The 'Talaes' is a forest type that is under a strong and permanent degradation process due to deleterious human activities and it is currently common to find forest remnants composed of small immature trees (Arturi & Goya 2004). Therefore, conservation of 'Talaes' fragments with a high proportion of native and mature (i.e. large) trees would help breeding populations of Narrow-billed Woodcreeper to endure.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Geolocation information

Punta Indio, Buenos Aires, Argentina (point): 35°20'S, 57° 11'W.

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