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First description of the nest and eggs of Ceará Leaf-tosser *Sclerurus cearensis*, with a review of the breeding biology of genus *Sclerurus*

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SUMMARY.—*Sclerurus* is a genus of morphologically uniform, strict understorey, leaf litter specialists. We present the first description of the nest and eggs of Ceará Leaf-tosser *S. cearensis* from north-east Brazil and review breeding data for the genus. Based on three nests, the nest of *S. cearensis* was classified as cavity/with-tunnel/low cup, the type typical of the genus. The nests were excavated in banks at a mean height of 1.48 ± 0.22 m above ground. Tunnels measured 50.83 ± 4.25 cm and terminated in an expanded, globular chamber where a small cup of sticks harbours the two white eggs. Eggs at one nest measured 25.7×19.8 mm and 24.3×19.6 mm, and weighed 5.1 g and 4.5 g, respectively. Available breeding data for the genus *Sclerurus* are remarkably uniform in all aspects and match our observations of Ceará Leaf-tosser.

Sclerurus is a monophyletic group (Derryberry *et al.* 2011) comprising six to eight species according to different authorities (del Hoyo & Collar 2016, Billerman *et al.* 2020, Remsen *et al.* 2021), and at least 28 taxa (Winkler *et al.* 2020) of morphologically uniform, strict understorey, leaf litter specialists (Vaurie 1980). All are secretive and highly sensitive to habitat disturbance, and possess similar general behaviour and ecology (Vaurie 1980). Geographical ranges of *Sclerurus* species are dissected by the major biogeographical barriers in the Neotropics and encompass most forested environments from central Mexico to southern Brazil (d’Horta *et al.* 2012).

Ceará Leaf-tosser *Sclerurus cearensis*, until recently considered conspecific with Rufous-breasted Leaf-tosser *S. scansor*, differs in its slightly smaller size, slightly brighter back and underparts, clear white vs. dusky-scaled throat, and song (del Hoyo & Collar 2016). Genetic data support *cearensis* as an independent evolutionary lineage (d’Horta *et al.* 2011), although some authors (Billerman *et al.* 2020, Gill *et al.* 2021, Remsen *et al.* 2021) continue to treat it as a subspecies of *S. scansor*. *S. cearensis* is endemic to north-east Brazil, from southern Ceará to northern Bahia (del Hoyo & Collar 2016), and restricted to humid and dry forest habitats, with severely fragmented populations in ongoing decline due to deforestation caused by logging and agricultural expansion (Girão e Silva *et al.* 2018). It appeared (as a subspecies) in the Brazilian Red List for the first time in 2003 (MMA 2003), and is currently listed as Vulnerable (ICMBio 2018). Following recognition as a species, it was also categorised as Vulnerable on the IUCN Red List in 2016, where it remains until the present (BirdLife International 2021).

Breeding data for five of the seven *Sclerurus* species are available and are very similar (Vaurie 1980), but large knowledge gaps exist for both Short-billed Leaf-tosser *S. rufifularis* and *S. cearensis* (del Hoyo *et al.* 2020, Remsen 2020). Generally, *Sclerurus* nests in excavated cavities in banks or steep slopes (Sick 1997, Hilty 2002), occasionally in the soil around upended tree roots (del Hoyo & Collar 2016). The only breeding data for Ceará Leaf-tosser

indicate that the species excavates burrows in banks (Girão & Albano 2008). Here, we review breeding data for the genus *Sclerurus* and present the first description of the nest and eggs of Ceará Leaf-tosser.

Methods

Nest description.—This was based on three nests found at two localities in Ceará state, Brazil. One was found in the Floresta Nacional do Araripe-Apodi (FLONA Araripe), a protected area in Barbalha municipality (07°17'10"S, 39°27'49"W), southern Ceará, mainly covered by typical Cerrado formations—*carrasco*, *cerrado* and *cerradão*—with wet forest on slopes (Silva *et al.* 2018). Climate is classified as 'hot semi-arid' under the Köppen-Geiger system (Peel *et al.* 2007) and is characterised by low and highly irregular rainfall, strong insulation, high evaporation rates and mean temperatures of *c.*27°C. Relative humidity is usually low, and the few rains are concentrated in November–April. Nevertheless, rainfall is extremely scarce in some years, causing more severe droughts. Elevation varies between 760 and 970 m (960 m at the nest site).

The second (active) and third (inactive) nests were found at the village of Catolé (04°21'23.628"S, 39°01'21.66"W; 820 m), Mulungu municipality, in the Serra de Baturité, an Atlantic Forest remnant within the Caatinga biome in northern Ceará. This remnant covers 32,690 ha and forms part of the Serra de Baturité Environmental Protection Area. Considered one of the most important forested areas in north-eastern Brazil, the Serra de Baturité is the richest area of Ceará in terms of biodiversity. Part of the serra is humid even during the long dry season. Local climate is classified as tropical with dry winter (Peel *et al.* 2007). Rainfall is concentrated in November–April with a well-defined dry season across the rest of the year. Mean temperatures vary between 19 and 22°C and mean annual rainfall is 1,500 mm.

At each location we made *c.*10 hours of observation with binoculars. Nests were measured using tape (accurate to 1 mm). Eggs were measured with analogue callipers (0.05 mm accuracy) and weighed using a digital scale (0.1 g accuracy). Nest type was determined by reference to Simon & Pacheco (2005).

***Sclerurus* breeding biology review.**—We reviewed the primary and some secondary literature concerning the breeding ecology of *Sclerurus* (Goeldi 1896, Stone 1918, Todd & Carriker 1922, Pinto 1953, Herklots 1961, Skutch 1966, Monroe 1968, Skutch 1969, Wetmore 1972, Vaurie 1980, Rowley 1984, Skutch 1985, Hilty & Brown 1986, Stiles & Skutch 1989, Tostain *et al.* 1992, Haverschmidt & Mees 1994, Walters 1995, Kiff 1996, Zyskowski & Prum 1999, Denton & Blue-Smith 2000, Hilty 2002, Greeney *et al.* 2004). To update previous information, we provide a compilation of published data for each of the seven recognised species (following del Hoyo & Collar 2016).

Results

Nest, eggs and parental care of Ceará Leaf-tosser.—Three nests were found. The first active nest was found on 21 December 2019 (Fig. 1) in FLONA Araripe, when an adult was seen departing a bank in wet forest. It held two pure white eggs, which measured 25.7 × 19.8 mm and 24.3 × 19.6 mm, mass 5.1 g and 4.5 g, respectively.

The second nest was found on 1 June 2020, again in a bank, in the backyard of a residence in Catolé village. The nest was near a door in the house, where there was constant movement of people, and at the top of the bank, *c.*0.5 m from the nest, there was a frequently used trail (Fig. 2). Around the nest were several ornamental plants.



Figure 1. Nest entrance (A), location (B) and egg (C) of Ceará Leaf-tosser *Sclerurus cearensis*, FLONA Araripe, Barbalha, Ceará, Brazil, December 2019 (Cicero Santos)



Figure 2. Nest entrance (A) and partial view of the nest site (B–C) of Ceará Leaf-tosser *Sclerurus cearensis*, Catolé, Ceará, Brazil, June 2020 (Cecília Licarião)

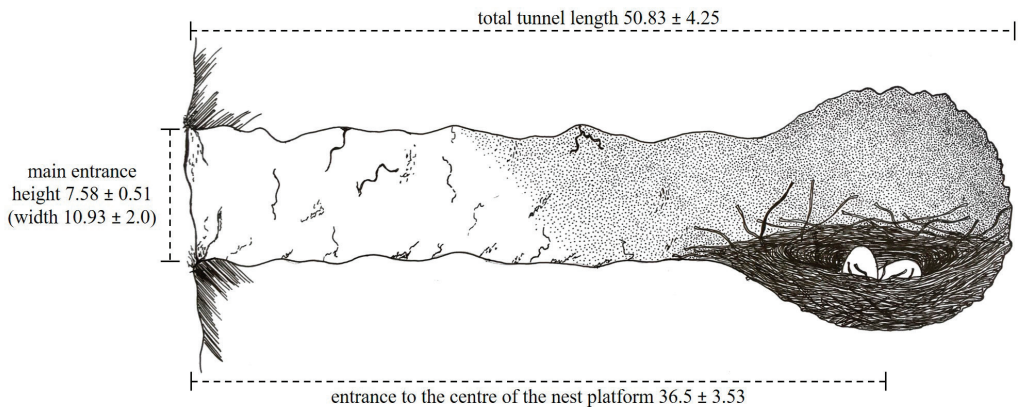


Figure 3. Schematic drawing of a Ceará Leaf-tosser *Sclerurus cearensis* nest. Mean measurements of the three nests are presented in cm \pm standard deviation.

At the third nest, found by the owner of the same house, a fledgling had departed just a few days before CL arrived (1 June) at the site. This nest was in a ravine beside a dirt road in daily use by vehicles. Above the bank there was dense vegetation with 5–10 m-tall trees.

As exemplified by Fig. 3, the nest of Ceará Leaf-tosser can be classified as cavity/with-tunnel/low cup (*sensu* Simon & Pacheco 2005). Tunnels are oval in cross-section (longest on the horizontal axis) and end in a globular, expanded chamber. The cup is constructed of sticks. All three nests were excavated in earth banks 1.48 ± 0.22 m above ground. Tunnel entrances were clean and not concealed, e.g., by vegetation. Nests had the following measurements: entrance width 10.93 ± 2.0 cm ($n = 3$), entrance height 7.58 ± 0.51 cm ($n = 3$), total tunnel length (from entrance to back wall of chamber) 50.83 ± 4.25 cm ($n = 3$), and the centre of the nest platform was 36.5 ± 3.53 cm ($n = 2$) from the tunnel entrance.

Parental care.—While we measured the first nest, the adults remained in the vicinity and one approached three times trying to enter. Adults were vigilant but permitted close approach (*c.* 5 m). When one adult was in the nest, the other always remained nearby outside, and gave an alarm call at the slightest indication of threat.

On 12 June 2020, a fledgling at the second nest made its first flight. At 07.36 h, one of the young left the nest followed by an adult. The fledgling's first flight was at a height of 1.60 m above ground. It landed 3 m from the nest, then flew again, a further 2 m. The adult gave an alarm call, flew to the nest bank, and the young flew >1 m above ground in a straight line. A few minutes later, a persistent vocalisation was heard for >10 minutes, then an adult was seen flying to the nest and perching at the entrance. When it noticed the observer (CL), it flew to a branch 2 m from the nest, uttered a series of calls and performed an agitated display. The very loud vocalisation of another young bird was heard close by, from the ground or a nearby branch. It called for *c.* 1 minute, then flew away. The nest's contents were checked at 09.37 h using an endoscopic camera. Only recent faeces were present.

Our observations show that the breeding season occupies at least December to June. A summary of the available breeding data for each *Sclerurus* species based on the literature is shown in Table 1. More detailed information is as follows.

MIDDLE AMERICAN LEAFTOSSER *Sclerurus mexicanus*

Season December–April in Costa Rica (Stiles & Skutch 1989), possibly until at least May elsewhere. A female collected in southern Mexico in April with a fully formed egg in the oviduct (Rowley 1984), and a few specimens in breeding condition in April–May in northern

TABLE 1
Summary of available breeding information for the species of *Sclerurus*.

Species	Breeding season	Nest place	Clutch size	Incubation period (days)	Nestling period (days)	Parental care
Middle American Leaf-tosser <i>S. mexicanus</i>	December–May	in ground / between roots of fallen tree	2	unknown	unknown	unknown
Short-billed Leaf-tosser <i>S. ruficularis</i>	unknown	between upturned roots	unknown	unknown	unknown	unknown
Scaly-throated Leaf-tosser <i>S. guatemalensis</i>	August–June	in banks / between roots of fallen trees	2	21	14–15	biparental
Black-tailed Leaf-tosser <i>S. caudacutus</i>	April–June	in banks / between upturned roots	2	unknown	unknown	biparental
Grey-throated Leaf-tosser <i>S. albigularis</i>	October–June	in banks	2	unknown	unknown	unknown
Rufous-breasted Leaf-tosser <i>S. scansor</i>	August–February	in ground / between roots of fallen trees	2–3	unknown	unknown	unknown
Ceará Leaf-tosser <i>S. cearensis</i>	December–June	in banks	2	unknown	unknown	biparental

Colombia (Hilty & Brown 1986). In August in eastern Ecuador, an adult was seen carrying leaves to a hole excavated 1 m up in the soil surrounding the roots of a fallen tree (Greeney *et al.* 2004). In the extreme south-east of the same country, G. M. Kirwan (*in litt.* 2021) found an active nest in a hole in an earth bank beside a little-used trail in late December. Nest a loose cup of compound-leaf rachises and dry twigs, 10 cm in diameter (Stiles & Skutch 1989) at end of a burrow (*c.*50 cm long) in the ground or among the roots of a fallen tree (Tostain *et al.* 1992). Greeney *et al.* (2004) recorded a 4 cm tunnel opening into a cavity roughly 20 cm in diameter. Eggs first described by Rowley (1984). Clutch two, unmarked white eggs (Stiles & Skutch 1989, Tostain *et al.* 1992, Kiff 1996).

SHORT-BILLED LEAFTOSSER *Sclerurus ruficularis*

Said to be similar to others of genus (Hilty 2002), but nothing seems to have been published except brief reports from Suriname and French Guiana, respectively, in Haverschmidt & Mees (1994) and Greeney *et al.* (2004).

SCALY-THROATED LEAFTOSSER *Sclerurus guatemalensis*

Based on his work in Costa Rica, Skutch presented the first and most detailed information for this species, which digs tunnels in banks or in the mass of clay clinging to the roots of a fallen tree (Skutch 1966, 1969). Hole entrance 40 cm above the base of a bank (Monroe 1968). Unlike most congeners, tunnel curved, thus the eggs are not visible from the entrance. At the end of the tunnel, *c.*1 m long (Monroe 1968), there is a chamber and a ‘thick but shallowly cupped nest’, but the eggs rest on bare soil (Skutch 1969). Nesting starts August–September and the last young fledge in late June, a long season. All observed clutches ($n = 4$) two pure white eggs (Skutch 1966, 1985), measuring 27.4×21.0 mm and 27.4×20.6 mm (Skutch 1969). Stone (1918) described eggs of this species as ‘glossy white, smaller one very sparingly speckled with deep rich brown, larger one more heavily marked with spots and specks of olive-brown’, from near Gatún, Panama. However, the size of the eggs (24.6×16.2 mm and 23.3×15.4 mm) reported by Stone is *c.*20% smaller than those presented by Skutch (1969), and his nest description does not correspond to any *Sclerurus*. Walters’ (1995) description from Belize is also erroneous for this species: ‘[the eggs] were speckled with reddish-brown,

and dark chocolate markings. The markings were more concentrated at the broad end of the eggs. These marks were too clearly defined and regular to constitute staining'. Walters (1995) described the nest as having an oval-shaped entrance 2 cm high × 5.5 cm wide, which also does not correspond to Scaly-throated Leaf Tosser. Stone's description was discounted by Wetmore (1972) and both these descriptions were comprehensively rejected by Kiff (1996). Incubation and feeding of nestlings are apparently shared by the sexes (Skutch 1969). Incubation lasts 21 days and nestlings fledge after 14–15 days (Skutch 1969). Of the three observed nests, two were successful (Skutch 1966).

BLACK-TAILED LEAFTOSSER *Sclerurus caudacutus*

Pinto (1953) described the nest and eggs of *S. c. pallidus* from Mata do Utinga, Belém, Pará, Brazil. The nest, sited at the end of a 0.5 m-tunnel excavated in an earth bank, was a shallow cup 12–15 cm in diameter, made exclusively of dry, curved leaf petioles. Clutch was two, 26 × 20 mm, white and almost unglossed eggs, found in April 1925 (Pinto 1953). Nest in burrows in upturned roots (Greeney *et al.* 2004). Denton & Blue-Smith (2000) described two nestlings from June 1998 and measured a nest in the Tambopata Reserved Zone, Madre de Dios, Peru. The nest was a 'shallow ... cup interior 5 cm in width and 1.75 cm in height. The straight, undeviating burrow was 50 cm in length with an entrance tunnel 5 cm high and 13 cm wide. The burrow was horizontally excavated in the vertical wall of a depression'. Both adults provisioned the young (Denton & Blue-Smith 2000).

GREY-THROATED LEAFTOSSER *Sclerurus albigularis*

Nests found in May and June in Colombia (Todd & Carriker 1922). Breeds October–May, peak December–February, on Trinidad (Herklots 1961). The incubation chamber is lined with only 'a few mid ribs of leaves placed side by side'. Todd & Carriker (1922) reported that 'the nest is placed at the end of a tunnel-shaped excavation, made by the birds themselves, in a more or less perpendicular bank of earth along some small creek or road through the heavy forest...The cavity is about fifteen inches in length, the main portion being about two inches in diameter, while the nest cavity is enlarged to about twice that amount. The two ovoid, white eggs are deposited on a scant bed of dead leaves'. The curving burrow varies from c.30.5 to 46.0 cm in length.

RUFOUS-BREASTED LEAFTOSSER *Sclerurus scansor*

Nest excavated at end of a dirt bank tunnel or placed in earth caught among roots of fallen trees (del Hoyo *et al.* 2020). Eggs in August and birds in breeding condition in September and December (del Hoyo *et al.* 2020). A nest found in August 1895 in the Serra dos Órgãos, Rio de Janeiro, comprised only dry leaf-ribs (Goeldi 1896); brood patch observed in one individual in southern Brazil in February (Bugoni *et al.* 2002); clutch two pure white eggs (28 × 21 mm). The circular hole and tunnel, which made a deviation to the right, was 5 cm wide with a terminal cavity 21 cm in diameter containing the nest (Goeldi 1896).

Discussion

Breeding data for *Sclerurus* spp. show a remarkable uniformity in all aspects and are congruent with those presented here for Ceará Leaf Tosser. All species with available data excavate their burrows in earth masses (in the ground, in river and road banks, or in the root masses of fallen trees), and build a simple cup, usually of leaf rachises, within an expanded chamber (Zyskowski & Prum 1999). Like congenetics, probably both sexes of Ceará Leaf Tosser engage in all aspects of breeding. At one nest of *S. cearensis*, we observed two adults sharing incubation and nestling care. Although the birds were not marked and

sexed, Ceará Leaf-tosser probably is monogamous, like *S. guatemalensis* (Skutch 1969, Ruth & Schreck 2020).

The apparent breeding season of Ceará Leaf-tosser (December–June) coincides with that of Middle American Leaf-tosser (December–April) in Costa Rica (Stiles & Skutch 1989). Scaly-throated Leaf-tosser (Skutch 1969) and Grey-throated Leaf-tosser (Herklots 1961) nest during October–May in Costa Rica and on Trinidad, respectively, although the latter has been found with eggs as late as June in Colombia (Todd & Carriker 1922). Species with fragmentary information also nest within this period, e.g., a Black-tailed Leaf-tosser with eggs in April in northern Brazil (Pinto 1953) or nestlings in June in Peru (Remsen 2020). Rufous-breasted Leaf-tosser starts breeding earlier, with eggs in August (del Hoyo *et al.* 2020).

There is a great uniformity in nests of the genus, as its more or less rudimentary structure does not seem to vary much between species (Vaurie 1980). Some, such as Middle American, Scaly-throated and Rufous-breasted Leaf-tossers, can use large masses of soil trapped in the roots of fallen trees to build their nests (Skutch 1969, Tostain *et al.* 1992, Greeney *et al.* 2004, del Hoyo *et al.* 2020). Such sites perhaps offer an alternative in level-ground sites, where banks with exposed soil can be a scarce resource.

Burrow length varies slightly among species, but is nearly always between 0.3 and 1.0 m, with the exception a 4 cm-tunnel reported by Greeney *et al.* (2004). Tunnels are usually straight but can be curved in Scaly-throated (Skutch 1969) and Rufous-breasted Leaf-tossers (Goeldi 1896), obscuring the contents from view at the entrance. Eggs of the slightly larger sister species, Rufous-breasted Leaf-tosser are 8% greater in size than those of Ceará Leaf-tosser reported here.

Nests placed in self-excavated or adopted cavities, such as a subterranean burrow, are a feature of several other furnariid genera (Zyskowski & Prum 1999). For example, all species of *Geositta*, which is sister to *Sclerurus* (Irestedt *et al.* 2006, d'Horta *et al.* 2012), breed in cavities excavated by the birds themselves or other animals (birds or mammals) (Fraga & Narosky 1985, Silva 2015, Machado *et al.* 2017).

For those *Sclerurus* with available data, the clutch is always two eggs, with just one unconfirmed report of a Rufous-breasted Leaf-tosser nest holding three eggs (del Hoyo *et al.* 2020). Eggs are always white and unmarked, but can become soiled with mud and thus appear spotted as incubation proceeds (Skutch 1969, Kiff 1996).

There are still large gaps in our knowledge of *Sclerurus* breeding biology, e.g., for most species, information on the length of the incubation and nestling periods, breeding success and predators are still unknown (Table 1). Short-billed Leaf-tosser is the least known species, with virtually no information on its reproductive habits.

Further studies of the biology of *S. cearensis* are essential to more fully understand its seasonality, nest site preferences and clutch size. Deforestation is the main threat to the species and, consequently, its reproductive success, but other factors that can negatively impact the latter are unknown, and deserve study.

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