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Breeding ecology of Rufous *Casiornis Casiornis rufus* in south-east Brazil

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SUMMARY.—We present new reproductive information for the Rufous *Casiornis Casiornis rufus*, based on studies undertaken during 1991–99 and in 2018, in the municipality of Arcos, Minas Gerais, south-east Brazil. We found eight nests, all sited in cavities of dead trees or wooden fence posts, on average 62.8 cm above ground. Clutch size was usually three eggs, pale beige overlain with complex markings throughout, similar to those of the genus *Myiarchus*. Eggs measured on average 22.8 × 16.96 mm, mass *c.* 3 g. Incubation lasted *c.* 15 days, and nestlings remained in the nest 15–17 days, being fed by both adults, mainly with orthopterans. Three of the eight nests produced young that fledged. One nest was predated by both a Black-striped Capuchin *Sapajus libidinosus* and a Crane Hawk *Geranoospiza caerulescens*, and another by a Black-tufted Marmoset *Callithrix cf. penicillata*. Nests were constructed in August, and the last nestlings fledged in late October. Most aspects of the breeding ecology of *Casiornis* are identical to those of other members of the Myiarchini.

The genus *Casiornis* comprises just two species confined to South America (Dickinson & Christidis 2014). Ash-throated *Casiornis C. fuscus* is endemic to Brazil and is broadly distributed across the north-east of the country. Rufous *Casiornis C. rufus* occurs from northern Argentina and Uruguay (Claramunt & González 1999, Vizentin-Bugoni *et al.* 2015) to Tocantins in northern Brazil, also in Maranhão and Piauí (although it is largely absent from the Caatinga), and west to Acre, as well as Bolivia and (as a migrant) south-east Peru (de la Peña 1996, Sick 1997, Pacheco 2004, Pedroza *et al.* 2020, Scholes 2020, Scholes *et al.* 2020).

Both species are migratory. *C. fuscus* vacates the Caatinga, where it presumably breeds, during the dry season (April–October) moving into the Cerrado and eastern Amazonia (Lees 2016). *C. rufus* tends to migrate north during the austral winter (June–September) (Chesser 1994, Lees 2016, Capllonch 2018).

Nothing has been published on the reproductive behaviour of *C. fuscus* and very few data are available for *C. rufus* (Eisenraut 1935, Lanyon 1985, de la Peña 2005, Crozariol 2016), for which just one nest with a three-egg clutch has been described in detail, from Argentina (de la Peña 2005). There is no information on the species' incubation and nestling periods. Here we describe several previously unknown facets of the breeding ecology of *C. rufus*, as well as nest predation, based on observations made in south-east Brazil.

Materials and Methods

The nests described here were found during 1991–99 (*n* = 4) and in 2018 (*n* = 4) at various localities in the rural municipality of Arcos, in the Cerrado of central Minas Gerais (20°17'S, 45°32'W; 700–850 m). This area, in general, is heavily impacted by human activity, and the main natural vegetation are remnant secondary forests bordering cattle pastures. The avifauna and habitats found in this region were described by Lopes *et al.* (2017).

Once an active nest was located, it was subject to brief visits every two days. At two nests containing young the interval between adult arrivals was recorded, by measuring the period between two consecutive visits to the nest, even if an adult individual was already inside it. In total, these two nests were observed for 967 minutes (274 minutes at the nest with three nestlings and 693 minutes at the nest with two nestlings). Observations were made from hides sited between 4 and 8 m from the nests. Two nests were monitored using a camera trap, which enabled us to identify predators. None of the nests was collected.

Results

Breeding season.— Eight nests were found, all active between the second half of August and the second half of October, with observations of nest construction and nests with eggs in August and the last young fledging in October (Fig. 1). Specifically, nests were located on 20 August 1991 (with three eggs), 15 September 1997 (three nestlings, *c.*2 days old), 20 August 1998 (two eggs, incomplete clutch), 23 August 1998 (building), 27 August 2018 (three eggs), 12 September 2018 (three eggs), 24 September 2018 (three nestlings, a day prior to fledging), and 5 October 2018 (two eggs, apparently complete clutch).

Nest characteristics.— Sites used for nesting were edges of secondary forests bordering pastures or around clearings, mostly in regenerating forests, with many broken, cut and fallen old trees. The understorey was generally rather open.

All nests were open cups, constructed of soft materials, and sited within cavities, either in tree stumps ($n = 6$) or wooden fence posts ($n = 2$) (Fig. 2A). Both stumps, usually broken off naturally at the top, and posts, had cavities in their upper portions caused by natural decay. In most cases, the cavity opening was positioned above the nest chamber. Twice, however, the nest was almost level with the entrance. One nest was constructed in a large log that had been cut and left lying on the ground, with one of its cut branches pointing up.

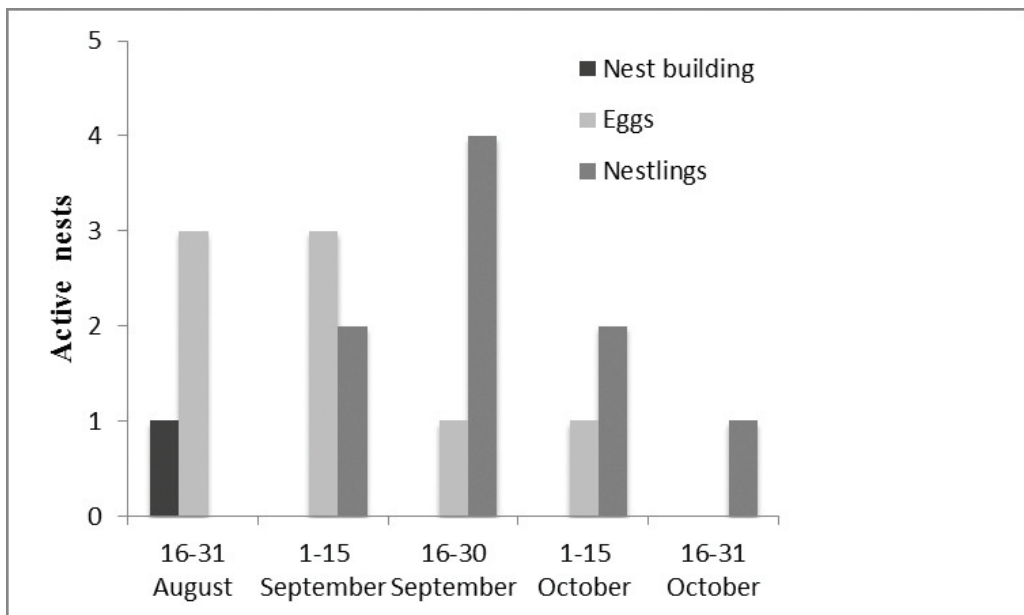


Figure 1. Reproductive period of Rufous Casiornis *Casiornis rufus* based on eight active nests found in Minas Gerais, Brazil; note that data from an individual nest may cover more than a single phase and two-week period.



Figure 2. (A) Internal view of a Rufous *Casiornis Casiornis rufus* nest; (B) eggs of *C. rufus* from another nest.

A cavity had formed, as in other cases, due to the wood decaying, and this nest was closest to the ground. One of the stumps used for nesting was at the edge of a swampy area.

Nests generally were not very high above ground, between 22 and 120 cm (mean 62.8 ± 34.7 cm; $n = 6$). The diameter of the opening at one nest was 9 cm, and another 12 cm, whilst the access tunnel, measured from the cavity entrance to the nest, was 25–60 cm long (mean 41.6 ± 17.5 cm; $n = 3$). The internal diameter of one nest cup was 4 cm. The base of those cavities we could access ($n = 3$) was lined with soft materials such as mammal hair (e.g. of Tapeti *Sylvilagus brasiliensis* and rodents), shed snakeskin ($n = 2$), mammal skin ($n = 1$) and feathers ($n = 1$).

Eggs and incubation.—One nest was destroyed and of the remaining seven nests, one had two eggs, whilst the other six each had three eggs ($n = 4$) (mean 2.8 ± 0.44 eggs) or nestlings ($n = 2$), with a total mean of 2.85 ± 0.37 . Egg size, based on two clutches ($n = 6$), was 21.0–24.2 mm (mean 22.8 ± 1.11 mm) \times 16.6–17.2 mm (16.96 ± 0.29 mm), and mass was 2.9–3.1 g (mean 3.0 ± 0.07 g; $n = 5$). Shape was oval, and the ground colour was pale beige, overlain with complex markings throughout, especially irregular and narrow dark purple-brown streaks and larger blotches of a slightly paler colour (Fig. 2B). At two nests that were

TABLE 1

Food items brought by adults of Rufous Casiornis *Casiornis rufus* to a nest with three nestlings during 274 minutes of observation, according to the age of the nestlings.

Food item	Age (days)			Totals
	7	12	17	
Spiders	1	1		2
Lepidoptera (adult)	1		1	2
Lepidoptera (caterpillar)	1		1	2
Homoptera	2	2	1	5
Orthoptera	8	5	2	15
Unidentified	4	3		7
Berry fruits	2			2

followed, the incubation period was apparently *c.*15 days, but both already had three eggs when found; in both cases the eggs hatched on the same day (synchronous hatching).

Nestlings.—Approximately 1–2 days after hatching, nestlings have pink skin with long but sparse blue-grey down, whitish commissure and yellowish mouth lining. At *c.*12–13 days, the feathers are similar in colour to those of the adult, but the throat region is slightly orange. At the two nests followed from hatching, the young fledged at 15 and 17 days, respectively. In a nest with three nestlings, which fledged on day 17, the first left the nest at 08.10 h accompanying an adult, whereas the others both fledged two minutes later, landing on a nearby vine.

Parental care.—In this species, in common with many Tyrannidae, there is no visible sexual dimorphism, so we were unable to distinguish the contribution made by each sex. We can affirm, however, that both individuals provisioned the young, because when one arrived with food in its bill and entered the nest, not infrequently the other also brought food to the nest simultaneously or it would wait nearby, taking its prey to the nest as soon as the other bird departed. This latter situation, when both individuals are in the nest or close to it, occurred in 11.1% of observations (from a total of 63 visits).

Two nests were followed, one with two and the other with three nestlings. At the nest with two young intervals between visits were longer (mean 16.72 ± 12.65 minutes; $n = 24$) compared to that with three nestlings (mean 7.58 ± 6.90 minutes; $n = 29$). We were unable to follow the nest with three nestlings in more detail because observation time was shorter (274 minutes). However, at the nest with two nestlings (693 minutes) intervals between visits tended to decrease as the young developed, from a mean 22.11 ± 18.38 minutes when they were two days old, to 15.63 ± 10.73 minutes at six days old and 12.66 ± 5.07 minutes when nine days old.

At the nest with three chicks, we observed 35 food items brought by the adults, most of which were invertebrates, especially Orthoptera (Table 1). We did not record the length of time adults stayed in the nest on each visit to provision the nestlings. Once, however, a visit lasted three minutes when an adult arrived with a cicada, which was torn apart and fed incrementally to each chick in turn. At this nest, we could partially view inside via a small hole in the broken bark. Usually, when food was delivered the adult immediately departed again, with some visits as short as 2–8 seconds. At times, however, an adult would remain longer in the nest, thereby increasing the interval to the next visit. Occasionally, adults vocalised nearby on arrival, giving the species' common call (a weak *psee* note; Scholes 2020), but most visits were silent. Adults carried faeces away from the nests following most visits, and sometimes on three consecutive occasions.

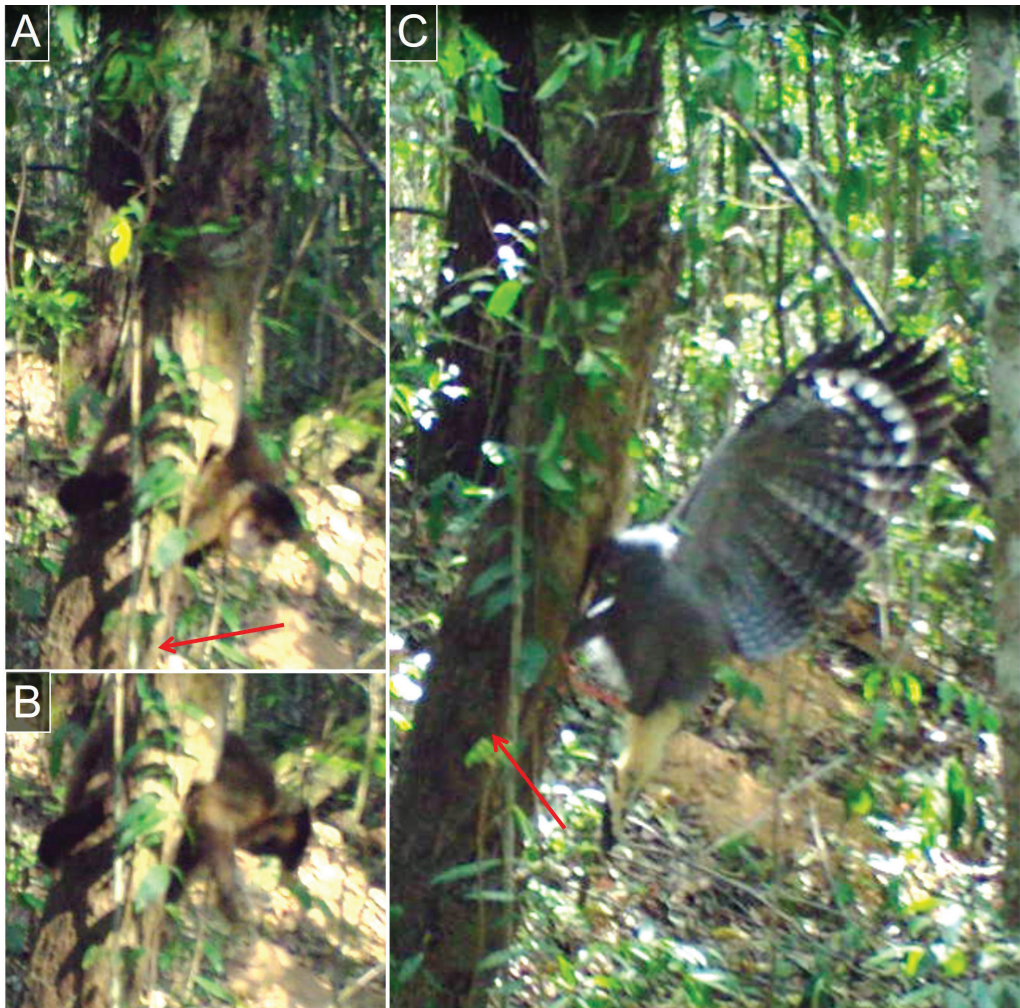


Figure 3. Evidence from a camera-trap of predation of the same nest of Rufous Casiornis *Casiornis rufus* by (A) Black-striped Capuchin *Sapajus libidinosus*, with its arm inserted in the nest cavity; (B) and examining the contents removed from the cavity interior; and on the same date by (C) Crane Hawk *Geranospiza caerulescens* with its right talon inserted into the cavity. Arrows indicate the nest's approximate location in the cavity.

Predation and loss of nests.—Of the eight nests found, three were successful, of which two fledged three nestlings each, and the remaining nest two. Of the five unsuccessful nests, one was found destroyed while still under construction (possibly after the first egg was laid, although this is not certain) and at another all three eggs disappeared. The other three nests failed during the nestling phase. In one of these, just one of the three eggs hatched, and the single nestling, already with well-developed feathering, was subsequently found dead with a thorn stuck in its throat, which the young had apparently attempted to swallow.

A nest with two nestlings was predated by a group of apparently three individuals of Black-striped Capuchin *Sapajus libidinosus*, at c.08.15 h. One of the monkeys inserted its arm into the cavity and with its hand seized a nestling, which was taken to the ground, next to the tree, and consumed. The animal then climbed the tree again, removed most of the nest material from the cavity, but apparently did not take any more nestlings (Fig. 3A–B). The monkeys remained in the vicinity for c.5 minutes. Subsequently, at 13.42 h, a Crane



Figure 4. Evidence from a camera-trap of predation of a Rufous Casiornis *Casiornis rufus* nest by Black-tufted Marmoset *Callithrix cf. penicillata*: (A) the monkey entering the nest via the opening at the top of the stump, and (B) eating the nestling, head first. The arrow indicates the nest's approximate location in the cavity.

Hawk *Geranospiza caerulescens* landed at the entrance to the same nest and, from an upright position, inserted its head into the cavity, seemingly trying to detect any noise inside. After c.30 seconds, the raptor inserted its left leg completely into the cavity but, on failing to capture anything, reinserted its head. The hawk continued this behaviour for c.10 minutes, variously inserting either leg into the cavity (Fig. 3C). A few times it removed a considerable amount of material from the cavity, threw this to the ground, and then dropped down to investigate the contents. It proved impossible to confirm that a nestling was taken by the hawk, but as there were originally two chicks in the nest, and only one was seen to be eaten by the monkey, we suspect that the second was predated by the raptor.

Finally, another nest, also with two nestlings, was predated by two Black-tufted Marmosets *Callithrix cf. penicillata*, at 09.30 h. They were able to completely enter the large cavity where the nest was sited, seizing the nestlings at its base, and eating them, head first. From the video, one chick continued to flap its wings while being eaten (Fig. 4). The marmosets remained for c.10 minutes.

Ectoparasites.—In the same nest just described, prior to their predation both chicks were found to be infested by the larvae of flies of the genus *Philornis*. Some 28 larvae were removed from under the skin of the two nestlings.

Discussion

The breeding period of *C. rufus* in this region of Minas Gerais appears well delimited, considering the span of observations between 1991 and 2018. Nest construction occurs mainly in the first half of August, and nestlings fledge principally in October or early November. In the state of São Paulo, a female with an enlarged ovary was collected in late August (Krabbe 2007), whilst in Argentina males were collected with well-developed gonads (5 × 4 mm, 9 × 5 mm; $n = 2$) in November (Darrieu & Camperi 1992), the same month when a nest was found with three eggs (de la Peña 2005). The WikiAves (WA) website has records of active nests in late August in Goiás (C. S. Rodrigues; WA2091799) and mid October in Minas Gerais (G. A. Serpa; WA747431), and fledglings in early September in Minas Gerais (M. T. Castro; WA153647) and late October in Goiás (F. R. Pina; WA834846).

The nests described here are consistent with the generally brief descriptions already available for the species (Eisentraut 1935, Short 1975, Lanyon 1985, Sick 1997, de la Peña 2005, Scholes 2020), although there is just one reasonably detailed description (de la Peña 2005; repeated in de la Peña 2013, 2016). Three eggs have been described previously, also from Argentina (de la Peña 2005), and these were similar in size and colour to those described here.

We present the first data on incubation period, a description of the nestlings, and the fledging period. Parasitism of nestlings by *Philornis* fly larvae had already been documented for the species in Argentina (Salvador & Bodrati 2013).

Almost nothing is known concerning other aspects of the natural history of *C. rufus*, and our dietary records, although limited in scope, are the most complete to date. In ten adult stomachs sampled in Mato Grosso do Sul, Brazil, nine contained insects alone, and one insects and fruits (Piratelli & Pereira 2002), with no details of the insects involved; contents of ten specimens reported by Vasconcelos *et al.* (2006) were similar. In Argentina, consumption of *Psychotria carthagenensis* fruit has been reported (Bodrati & Haene 2006, *apud* de la Peña 2016).

Monkeys of the genus *Sapajus* have previously been documented preying on bird nests in cavities (Cockle *et al.* 2016), as have *Callithrix* (Gomes & Lima-Gomes 2011, Alexandrino *et al.* 2012). Crane Hawk *Geranospiza caerulescens* is also a known predator of animals in cavities or other places of concealment (Bokermann 1978a), including nestlings (Bierregaard *et al.* 2020).

Animal behaviour can provide valuable indication of evolutionary relationships (Whitman 1898, Wenzel 1992, Prum 1990) and, in birds, nest architecture is of proven value in this respect (Winkler & Sheldon 1993, Zyskowski & Prum 1999, Hall *et al.* 2015). For genus *Casiornis*, some earlier authors suggested that better knowledge of nests could inform its systematic placement (e.g. Snow 1973, Lanyon 1982, Lanyon & Fitzpatrick 1983). The nest of *C. rufus*, of the type 'cavity/with tunnel/low basket' (*sensu* Simon & Pacheco 2005), as well as use of hair, feathers and, principally, snakeskin to line the egg chamber, are closely aligned with the nests of most *Myiarchus*, as well as those of the genera *Ramphotrigon*, *Deltarhynchus* and *Rhytipterna* (Traylor 1977, Lanyon 1978, 1982, Parker 1984, Tostain 1989, Lebbin *et al.* 2007, Gomes & Barreiros 2011, Snow *et al.* 2017). Egg colour, incubation and nestling periods, are also consistent with these other genera (Bokermann 1978b, Lanyon 1982, Tostain 1989, Snow *et al.* 2017).

The genus *Casiornis* was long placed in the Cotingidae alongside the genus *Attila*, forming a subfamily Attilinae, based on the morphology of the tarsus (see Snow 1973). Subsequently, based on syringeal morphology, the genus *Casiornis* was removed with others from the Cotingidae, to the Tyrannidae, where it was grouped with *Myiarchus*

(Ames 1971). Based on anatomical and behavioral studies (Lanyon 1982, 1985, Lanyon & Fitzpatrick 1983, Birdsley 2002, Donegan 2013), as well as molecular phylogenetics (Chaves *et al.* 2008, Ohlson *et al.* 2008, 2013, Tello *et al.* 2009), the genus *Casiornis* is now placed alongside the genera *Myiarchus*, *Rhytipterna* and *Sirystes* in the tribe Myiarchini. From the perspective of breeding ecology, our observations are consistent with the latter placement, although very few data are available for the genera *Sirystes* and *Rhytipterna* in this respect (see review in Crozariol 2016).

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