Revista Brasileira de Ornitologia 27(2): 63–69.
June 2019

ARTICLE

Breeding biology of the Cipo Cinclodes *Cinclodes espinhacensis*, a micro-endemic furnariid of the southeastern Brazilian mountains

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Received on 08 August 2018. Accepted on 21 June 2019.

ABSTRACT: The Cipo Cinclodes *Cinclodes espinhacensis* is a recently described furnariid endemic to the *campos rupestres* of Serra do Cipó, southern Espinhaço Range, southeastern Brazil. It is an "Endangered" species and its natural history is poorly known. We studied the Cipo Cinclodes breeding biology at Serra do Breu, where we found six nests on rock outcrops in 2009 and 2012. At least one nest was reused in different years. Breeding season was from September (nest building) to January (dependent juveniles). Nests were shallow cups or beds placed in chambers at the end of earthen and/or rocky tunnels or crevices on rock outcrops. Clutch size was 2–3 eggs. It exhibited biparental care during all nest stages. We demonstrated that the nesting habits of Cipo Cinclodes agree with those reported for other species of the genus, although some details differ from what is known for the closely related species, the Long-tailed Cinclodes *Cinclodes pabsti*.

KEY-WORDS: cavity nest, *campos rupestres*, egg, fledgling, Furnariidae, nest, nestling, reproduction.

INTRODUCTION

The Cipo Cinclodes *Cinclodes espinhacensis* is a recently described furnariid endemic to *campo rupestre* vegetation mosaic from the highest mountaintops of Serra do Cipó, southern Espinhaço Range, Brazil (Freitas *et al.* 2012 & 2019). The species is isolated by more than 1000 km from its closest relative, the Long-tailed Cinclodes *Cinclodes pabsti* from the Serra Geral, southern Brazil (Freitas *et al.* 2008 & 2012, Chaves *et al.* 2015). Cipo Cinclodes is included in the Brazilian Red List as "Endangered" (MMA 2014), and the Long-tailed Cinclodes as "Near-Threatened" (ICMBio 2014). The global Red List considers the Long-tailed Cinclodes, including the Cipo Cinclodes as subspecies, as "Near-Threatened" (BirdLife International 2019).

A recent study investigated the population and spatial ecology of Cipo Cinclodes, improving our understanding of their basic biology and distribution and supporting the designation as "Endangered" on the Brazilian Red List (Freitas *et al.* 2019). Beyond that, nothing else has been published about the natural history of Cipo Cinclodes since its description (Freitas *et al.* 2012). About its breeding biology, it is only known that it nests in cavities (Freitas *et al.* 2012), which is a common pattern within the genus (Zyskowski & Prum 1999, Remsen-Jr. 2019). However, a variety of cavity types are used by members of the genus, existing some evidence of species-specificity and also intra-specific differentiation (Hahn *et al.* 2005, Ojeda 2016).

Recognizing the importance of breeding data not only to species conservation, but also to investigate ecological and evolutionary hypotheses (Zyskowski & Prum 1999, Hahn *et al.* 2011), we present information about the breeding biology of Cipo Cinclodes, including data on its nest, nest site, clutch size, egg, nestling, fledgling, breeding season and parental care.

METHODS

We studied a Cipo Cinclodes population at Serra do Breu, Santana do Riacho municipally, state of Minas Gerais, from 2009 to 2017. The study area comprises

~295 ha of *campo rupestre* – a high altitude complex mosaic of vegetation (see Alves *et al.* 2014, Silveira *et al.* 2016) – where quartzite outcrops predominate within grasslands, traversed by several streams bordered by low riparian vegetation. We marked birds and searched for nests by following the adults during nine visits (4–7 days each): two in 2009 (November and December), six in 2012–2013 (July, September, October, December, January and February), and one in 2017 (January). Birds were captured with mist nets and marked with color and metallic numbered leg bands, and with radio transmitters (Biotrack Pip Ag393; details in Freitas *et al.* 2019).

We measured with a metric tape (to the nearest 0.5 cm) the following nest and nest site attributes: height of the entrance above ground, distance of the entrance to the top of the bank/hillside, width and height of the entrance, length of the tunnel or crevice (distance from the entrance to nest cup) and total length of the cavity (distance from the entrance to the end of the chamber; "burrow depth" *sensu* Hansell 2000), inclination (angle of inclination of the tunnel or crevice, measured with a protractor); width and height of the chamber containing the nest; nest external and internal diameter and depth ("nest diameter", "cup diameter", and "cup depth", respectively, *sensu* Hansell 2000). We weighted (*Pesola*© spring scales to the nearest 0.1 g) and measured (with a Mitutoyo© caliper to the nearest 0.1 mm) eggs (width and height), nestlings (tarsus, total culmen, bill width at gape, total body length and total head length – from the tip of the bill to the occiput) and fledglings (body length) (Baldwin *et al*. 1931).

Some nests and its contents were not reachable (neither visible) inside their cavities to be measured, and the nest stage was inferred from the adults' behavior (*e.g.*, staying long periods inside the nest or taking food). For nest shape, site and attachment descriptions we follow the terminology of Simon & Pacheco (2005) and Hansell (2000).

RESULTS

We found six nests, four in the breeding season of 2009 and two in 2012. One of those nests found in 2009 was active again in 2012. Nesting period extended from September, when we observed nest building activity, through November and December, when eggs and nestlings were found. Juveniles dependent on parental were observed in December and January.

All nests were found within cavities on rocky outcrops (Fig. 1) and consisted of a shallow cup made of fragments of thin and pliable material, with some soil among them (Figs. 2A & B). Nest materials were mostly from plants, such as dry grass-like narrow leaves, inflorescences of small Eriocaulaceae, and green mosses, but also from animals, like mammals' hair and feathers from other bird species. The nests were placed inside chambers that were preceded by narrower entrances that frequently had a small amount of the same nest materials, notably large flight feathers. The entrances were mainly tunnels in soil among the rocks (n = 4) or rocky crevices or gallery (n = 2). The chambers with nests were always positioned above the opening of the entrances, so tunnels were inclined upwardly. The narrow entrances communicated with the exterior directly (*i.e.*, the openings were visible to an external observer; n = 2), or, most frequently, it opened inside a rocky shelter or cave (*i.e.*, the openings were hidden to an external observer; n = 4). The substrates delimiting the chambers and entrances (*i.e.*, their walls, ceilings, and floors) were the quartzitic rock itself and the dark, moist, peat soil with some fine roots of the above plants emerging. The nest shape and site of Cipo Cinclodes can be described as cups or beds placed in ground hole/cavity (*sensu* Hansell 2000), and classified as cavity/with-tunnel/low cup (or cavity/with-tunnel/simple/platform) with an inclined tunnel (*sensu* Simon & Pacheco 2005). Nests are individually described below (see Fig. 1 & Table 1).

The clutch size was three (n = 2 nests) or two (n = 1 nest) eggs. Eggs were white with overall (varying) oval shape (Fig. 2C, Table 1). At hatching, nestlings had closed eyes, pinkish skin and tarsus, gray natal down feathers (neossoptiles), brown nails with whitish tips, orange bill with brownish tip and an egg-tooth, vivid orange inner mouth and light yellow enlarged gape flanges (Fig. 2D). At fledging, the black-colored bill and the overall plumage appearance were similar to the adults, but the enlarged yellow gape and some neossoptiles at the tips of some feathers were retained, the flight feathers (still growing) were shorter, and the breast had a scaled appearance (Fig. 2E). Those features were still observed in the post-fledgling period but were gradually being lost, being the scaled breast the most persistent feature (Fig. 2F). Both parents were seeing entering into the nest cavity during all nest phases, carrying nest material during nest building and incubation, and taking food to nestlings. In some occasions, both parents were observed inside the nest cavity simultaneously.

The nest one was found on 18 November 2009 with three eggs. It was built inside a chamber at the end of a tunnel at the ceiling of a rocky cave (Fig. 1A), *c.* 2.6 m from the cave entrance, that was 1.4 m wide. The tunnel had its superior part composed of rock and the inferior of soil (Fig. 1B). The chamber containing the nest was entirely composed of soil, with fine roots emerging. There were many worn feathers from other bird species and other nest materials lining the tunnel and loosely placed at the ground of the cave below the tunnel entrance,

Table 1. Attributes of the Cipo Cinclodes *Cinclodes espinhacensis* nests, eggs, nestling and fledglings found from 2009 to 2012 at Serra do Breu, Serra do Cipó, Brazil. Entrance type: tunnel on soil (T), rocky crevice or gallery (S); entrance opening: hidden (H), visible (V). Eggs 1–3 and all nestlings were from nest one; eggs 3–6 from nest 3 (egg 6 was rotten); eggs 7–8 and all fledglings from nest 4.

	Identification numbers of measured unities												
Nest Sites Entrance	**1**	**2**	**3**	**4**	**5**	**6**			***n***	**Mean**	**SD**	**Min**	**Max**
Type/opening	T/H	T/V	T/H	T/V	S/H	S/H							
Height above ground (cm)	90.0	210.0	292.0	133.0	239.5	195.0			6	193.3	72.8	90.0	292.0
Distance to top (cm)	-	34.0	40.0	28.0	-	-			3	34.0	6.0	28.0	40.0
Opening width (cm)	16.0	18.0	5.0	13.0	44.0	-			5	19.2	14.7	5.0	44.0
Opening height (cm)	7.0	20.5	13.0	11.0	56.0	19.5			6	21.2	17.8	7.0	56.0
Length of the tunnel or crevice (until nest; cm)	48.0	70.0	12.0	17.0	84.5	114.0			6	57.6	39.7	12.0	114.0
Total length of the cavity (including chamber; cm)	63.5	90.0	36.0	87.0	101.5	-			5	75.6	26.1	36.0	101.5
Inclination (°)	43.0	20.0	55.0	-	45.0	-			4	40.8	14.8	20.0	55.0
Chamber with nest													
Width (cm)	19.0	-	21.0	-	-	-			2	20.0	1.4	19.0	21.0
Height (cm)	14.0	-	20.0	-	-	-			2	17.0	4.2	14.0	20.0
Nests	**1**	**2**	**3**	**4**	**5**	**6**							
External diameter (cm)	-	-	15.0	24.0	-	-			2	19.5	6.4	15.0	24.0
Internal diameter (cm)	-	-	10.0	12.0	-	-			2	11.0	1.4	10.0	12.0
Depth (cm)	-	-	4.0	2.5	-	-			2	3.3	1.1	2.5	4.0
Eggs	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**					
Width (mm)	21.6	21.5	21.6	21.1	20.9	-	20.5	19.4	7	20.9	0.8	19.4	21.6
Height (mm)	27.2	28.0	27.0	28.4	27.6	-	26.4	27.5	7	27.4	0.7	26.4	28.4
Mass (g)	6.1	5.9	6.0	6.0	5.6	5.3	5.2	5.1	8	5.7	0.4	5.1	6.1
Nestlings (0–1 day)	**1**	**2**	**3**										
Body mass (g)	6.7	4.8	9.1						3	6.8	2.2	4.8	9.1
Body length (mm)	53.0	47.0	53.5						3	51.2	3.6	47.0	53.5
Tarsus length (mm)	11.4	10.5	12.0						3	11.3	0.8	10.5	12.0
Total culmen length (mm)	9.8	8.7	9.8						3	9.4	0.6	8.7	9.8
Bill width (mm)	12.0	9.7	12.1						3	11.3	1.4	9.7	12.1
Total head length (mm)		19.1	21.3						2	20.2	1.6	19.1	21.3
Fledglings (0 day)	**1**	**2**											
Body mass (g)	51.2	52.2							2	51.7	0.7	51.2	52.2
Body length (mm)	150.0	165.0							2	157.5	10.6	150.0	165.0

apparently dropped from it. One of the birds attending this nest was observed energetically shaking and mashing a flight feather from other species with the mandibles before taking it to the nest. On 22 November 2009, three nestlings were born (Fig. 2B) and on 16 December 2009, the nest was empty.

Three years later, on 09 September 2012, this nest was active again. Two birds were carrying narrow straws and gray mammal hairs to the nest, one non-marked and another banded in July 2012. Given that just one of the paired birds was banded in 2009 (and disappeared in 2012), it is possible that at least one member of the pair was the same at both breeding attempts. On 10 December 2012, the marked bird was feeding a juvenile outside the nest. After four years, on 04 January 2017, the nest was not active, but the pile of nest materials below the tunnel entrance was still there, where we found white eggshell fragments.

The nest two was discovered on 20 November 2009, apparently with eggs. It was inside a long tunnel – so deep

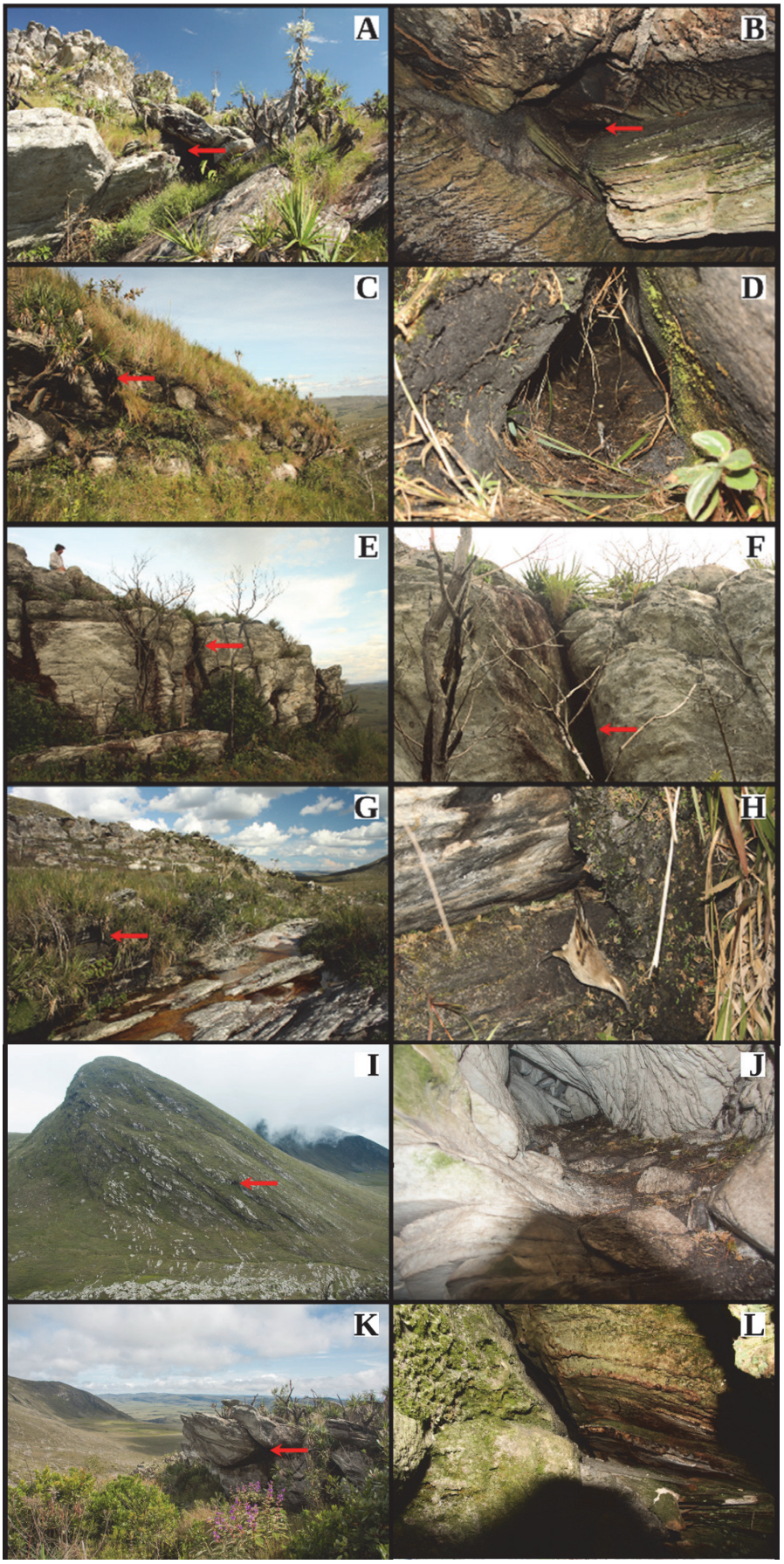

Figure 1. Nest sites of the Cipo Cinclodes *Cinclodes espinhacensis* at Serra do Breu, southern Espinhaço Range, Brazil. For each nest two pictures show the overall (left) and close-up (right) location of the nest cavities (red arrows indicate entrances). Nest 1 (**A** & **B**), nest 2 (**C** & **D**), nest 3 (**E** & **F**), nest 4 (**G** & **H**), nest 5 (**I** & **J**), and nest 6 (**K** & **L**). Photo author: G.H.S. Freitas.

Figure 2. Shallow cupped nests inside (**A**) and removed from the cavity (**B**), eggs (**C**), hatchlings (**D**), fledglings (**E**), and a dependent juvenile (**F**) of the Cipo Cinclodes *Cinclodes espinhacensis* at Serra do Breu, southern Espinhaço Range, Brazil. At (**B**), approximately 30 cm of a metric tape is apparent; at (**C**) and (**D**), part of a caliper with 1 mm graduation is apparent. Photo author: G.H.S. Freitas (**A** & **C**–**F**) and L.M. Costa (**B**).

that the content was not accessible – at the border of a rocky outcrop (Fig. 1C). The cross section of the tunnel was triangular, with one rocky wall and the remaining sides of soil with rootlets (Fig. 1D). The floor was lined with feathers and thin dry grass-like leaves. Both adults were observed entering the tunnel. On 17 December 2009, we witnessed an adult carrying food to the nest that apparently contained at least one well-developed nestling.

The nest three was found on 19 November 2009 with three eggs, being one of them rotten. The nest was within a chamber of soil, after a tunnel with rock and soil that opened inside a rocky crevice, *c.* 45 cm of the outside (Figs. 1E & F). In the tunnel, we found feathers and thin grass leaves near the nest. We observed one adult taking nest material into the nest cavity. On 16 December 2009, the nest was empty.

The nest four was first observed on 21 November 2009 with two eggs. It was located in a rocky outcrop bordering a stream (Fig. 1G). The entrance was a short, not inclined, roughly triangular tunnel, with one rocky wall and the other sides were soil (Fig. 1H). There was a small hole on the opposite side of the cavity containing the nest. Twenty-five days later, on 16 December, two juveniles fledged when we approached the nest. Those were captured and collected (paratypes described in Freitas *et al.* 2012; Fig. 2C). One was a male and the other a female, both heavier than adults (*c.* 45 g).

The nest five was detected on 09 December 2012, with nestlings. Adults were seen taking food to the nest and nestlings begging calls were heard. The nest was placed at the end of a long rocky gallery (Fig. 1J) that opened inside a small cave located in the middle of a mountain slope (Fig. 1I).

The nest six was found on 13 December 2012, probably with eggs. The nest was unreachable inside a rocky crevice at the end of an extensive and narrow crevice between two large boulders (Figs. 1K & L). Two adults visited the nest, sometimes carrying nest material in the beak.

DISCUSSION

The Cipo Cinclodes is socially monogamous with biparental care during all nest stages. The breeding season length was at least four to five months, from

early September (nest building) to January (dependent juveniles). The habitat used for nesting was rock outcrops, the typical environment of the *campos rupestres* landscape that occurs among grasslands, in slopes or bordering streams. Although Cipo Cinclodes uses all habitat types available in our study area, including rocky outcrops, grasslands, and riparian areas, a recent habitat selection analyses revealed the importance of riparian areas for foraging (Freitas *et al.* 2019), while the present study evidenced the importance of the rocky outcrops to complete the Cipo Cinclodes life cycle.

The breeding biology of the Cipo Cinclodes is overall similar to that reported (observed or presumed) for its congeners. There are at least minimal information about the breeding of all of the ~16 species recognized in the genus (Cawkell & Hamilton 1961, Sick 1973, Narosky *et al.* 1983, Belton 1984, de la Peña 1987 & 2019, Graves & Arango 1988, Bertolero & Zavalaga 2003, Greeney *et al.* 2011, Salvador & Salvador 2012, Avalos & Gómez 2014, Salvador 2015, Ojeda 2016, Vizcarra *et al.* 2018, Remsen-Jr. 2019). The Cipo Cinclodes' sister species, the Long-tailed Cinclodes, nests at end of tunnel excavated in soil banks (some with rocks), frequently at roadcuts, or in roof beam within farm-house attics (Sick 1973, Belton 1984). While for some species there are records of nest only in earthen banks (the Chestnut-winged Cinclodes *C. albidiventris*, the Cream-winged Cinclodes *C. albiventris*, and the Stout-billed Cinclodes *C. excelsior*; Graves & Arango 1988, Greeney *et al.* 2011, Salvador 2015), others seem to breed exclusively in natural rocky crevices (the Royal Cinclodes *C. aricomae*, the Surf Cinclodes *C. taczanowskii*, and the White-bellied Cinclodes *C. palliatus*; Bertolero & Zavalaga 2003, Avalos & Gómez 2014, Vizcarra *et al.* 2018, Remsen-Jr. 2019). However, this differentiation can be due to a lack of adequate sampling, since for the remaining species of the genus there are records for both types of cavities, with some species nesting also in other kinds of burrows, such as tree holes (Cawkell & Hamilton 1961, Narosky *et al.* 1983, de la Peña 1987 & 2019, Salvador & Salvador 2012, Ojeda 2016). Cipo Cinclodes lies within that third group since the nests can be placed in natural holes among the rocks or at the end of tunnels in an earthen substrate, although the tunnels were always bordering a rock. Although we did not observe the birds actively excavating tunnels as others did for congeneric species (*e.g.*, Sick 1973, Graves & Arango 1988, Greeney *et al.* 2011), we suspect that this occurred in some nests, since the burrows seemed to be recently made, with rootlets visible.

The nest architecture of the Cipo Cinclodes was a shallow, flattened cup, composed of very fragmented and pliable material. The nests of the Long-tailed Cinclodes also differ by having some sticks within the soft cushion (Sick 1973). When classifying the nest shape and site of Cipo Cinclodes following the standardized classification schemes (Hansell 2000, Simon & Pacheco 2005) we found some difficulties. One of them was to classify the nests without typical tunnels preceding it as cavity/without-tunnel, because their entrances did not open directly to the exterior (like the Fig. 4A in Simon & Pacheco 2005), but were always preceded by narrowing rock entrances; so we kept it as cavity/with-tunnel. A further doubt we have was about the elementary nest standard. Due to the imprecision of the terms, we think that the nests could be classified both as low cups and as simple/platforms (*sensu* Simon & Pacheco 2005), or its equivalents cups and beds (*sensu* Hansell 2000). Cups were suggested as the *Cinclodes* nest type by Simon & Pacheco (2005) and Zyskowski & Prum (1999). Those last authors, in their nest-based phylogenetic analysis of the Furnariidae, hypothesize that platforms and cups are two ordered derived states of nests built in cavities, showing the putative importance in distinguishing between these nest types. We observed a thick platform with a prominent depression in the middle, which is dissimilar to those nests of Olrog's Cinclodes (*C. olrogi*) and Cordoba Cinclodes (*C. comechingonus*) as can be seen on photographs in Salvador & Salvador (2012) that are distinctly cup-like and composed of less fragmented material, mostly by broader straw-like grasses.

Here, we provide the first detailed information on many aspects of the breeding biology of Cipo Cinclodes. However, more information is required for a complete understanding of the breeding ecology of Cipo Cinclodes, such as the duration of the nest stages, nestling and fledgling development, and reproductive success. We demonstrated that it agrees with those reported for other species of the genus, although some details differ from what is known for the closely related species, the Long-tailed Cinclodes. The rock outcrop habitat of the *campos rupestres* could be key to the breeding of Cipo Cinclodes, as also documented for the other furnariid endemic to the *campos rupestres*, and sympatric at our study area, the Cipo Canastero *Asthenes luizae*, despite their distinct nesting habits (Costa *et al.* 2019). Investigating the availability of suitable nesting sites for Cipo Cinclodes may elucidate possible restrictions on their occupancy. Detailed studies on the breeding biology of other Cinclodes are needed, allowing to detect intra-generic and intra-specific differentiation, and to better understand the evolution of the breeding strategies in Furnariidae.

ACKNOWLEDGEMENTS

We thank the *Fundação Grupo Boticário de Proteção à Natureza* (0885_20102), CAPES, CNPq and FAPEMIG for the funding received; ICMBio and IBAMA/CEMAVE

for permits. We are grateful to all people that helped in fieldwork, especially to Claudiney L. Silva and Roberto Cardoso (*in memorian*). We thank two anonymous reviewers for suggestions that improved our manuscript.

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Associate Editor: Marcos P. Dantas.