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ARTICLE

Breeding biology of Long-tailed Cinclodes *Cinclodes pabsti* Sick, 1969 (Passeriformes: Furnariidae)

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Abstract. *Cinclodes pabsti* is an endemic passerine restricted to the highland areas in southern Brazil. The aim of this study was to provide information on its breeding biology. The nesting cavities along road cuts were monitored from May 2008 to March 2011. The survey was carried out monthly from May to July 2008, February to July 2009, 2010 (non-breeding season), weekly from August 2008 to January 2009, 2010 (breeding season), and on a 2 to 4-days basis from August 2010 to January 2011. The geographic location, physical characteristics, and soil/substrate type in which the nesting cavities were situated were recorded. The total number of cavities used in the three breeding seasons was 136, resulting in 295 nests. The distance of a nest to its nearest neighbor ranged from 24-2,368 m, with a higher number of nests (n = 34; 59.7%) in the distance interval of 24-500 m. There was a greater usage of cavities located in Inceptisols, and the distances of nesting cavity entrances to the ground and to the top of road cuts were 1.6 ± 0.9 m and 0.8 ± 0.62 m, respectively. The breeding season lasted 148 days from mid-August to early January. Clutch size (n = 256) varied from 2 to 3 eggs, and the eggs (n = 155) had a total length of 27.2 ± 1.3 mm, breadth of 20.9 ± 0.8 mm, and mass of 6.2 ± 0.7 g. The incubation phase lasted 17.3 ± 0.8 days and the nestling phase for 18.3 ± 1.5 days. The body mass of the chicks was 6.0 ± 1.0 g just after hatching and reached a maximum of 59.6 ± 2.4 g at 16 days of age. Our results can contribute to filling the gaps in knowledge of *C. pabsti* ecology, because its habitat is under high anthropic pressures and the information on its life history is yet limited.

Keywords. Breeding phenology; Cavity nesting; Highland grasslands; Parental care; Southern Brazil.

INTRODUCTION

Cinclodes pabsti Sick, 1969 is one of the 15 species (Remsen *et al.,* 2020) in the monophyletic genus *Cinclodes* Gray, 1840 (Furnariidae) found in South America (Chesser, 2004; Remsen *et al.,* 2020). It is an isolated lineage, basal to all other species in the genus (Chesser, 2004; Remsen *et al.,* 2020), along with the recently discovered *Cinclodes espinhacensis* Freitas, Chaves, Costa & Rodrigues, 2012 (hereinafter *Cinclodes pabsti espinhacensis,* according to Pacheco *et al.,* 2021). *Cinclodes pabsti* is endemic to the Brazilian highland areas of more than 750 m above sea level in the states of Rio Grande do Sul and Santa Catarina, South Brazil (Sick, 1969, 1973), while *C. espinhacensis* is endemic to highland areas of more than 1,100 m above sea level in the state of Minas Gerais, Southeast Brazil (Freitas *et al.,* 2012).

Cinclodes pabsti inhabits open grasslands and places with easy access to water, feeds on a wide range of invertebrates, and forages in rocky hills (Sick, 1973, 1997; Belton, 1984). However, it is not as closely associated with water as other *Cinclodes* spp. (Sick, 1997). Nesting is done in an underground nest located at the end of a gallery (Sick, 1997) excavated on natural cliffs and road cuts and in spaces under roofs in farm buildings (Belton, 1984). Sick (1973, 1997) reported reproductive activities in September and November.

Over the past few decades, numerous studies have been conducted on various species of this genus that dealt with a range of topics such as phylogenetics (Chesser, 2004; Sanín *et al.,* 2009; Freitas *et al.,* 2012; Rader *et al.,* 2015), biogeography (Chesser, 2004; Chaves *et al.,* 2015), osmoregulation and/or physiology (Sabat, 2000a, b;

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Sabat & Martínez Del Rio, 2002, 2005; Sabat & Gonzalez, 2003; Sabat *et al.,* 2003; Sabat *et al.,* 2004a, b; Sabat *et al.,* 2006a, b), and general ecology (Atkins, 1980; Hahn, 2006; Vizcarra, 2007, 2010; Martínez Del Rio *et al.,* 2009; Aucca *et al.,* 2015; Newsome *et al.,* 2015; Rader *et al.,* 2017). However, the life history, especially the breeding biology of most *Cinclodes* spp., remains poorly understood, as most studies till date have been short-term. There are some studies on the nesting of some species of *Cinclodes*, such as *Cinclodes antarcticus antarcticus* (Garnot, 1826) (Cawkell & Hamilton, 1961; Robbins *et al.,* 2001), *Cinclodes excelsior* Sclater, 1860 (Graves & Arango, 1988), *Cinclodes taczanowskii* Berlepsch & Stolzmann, 1892 (Bertolero & Zavalaga, 2003; Vizcarra *et al.,* 2018), *Cinclodes oustaleti baeckstroemii* Lönnberg, 1921 (Hahn *et al.,* 2005), *Cinclodes comechingonus* Zotta & Gavio, 1944, *Cinclodes olrogi* Nores & Yzurieta, 1979, *Cinclodes atacamensis schocolatinus* Reichenow, 1920 (Salvador & Salvador, 2012), *Cinclodes aricomae* (Carriker, 1932) (Avalos & Gómez, 2014), and *Cinclodes fuscus* Vieillot, 1818 (Ojeda, 2016).

Information about the biology of *C. pabsti* is limited to habitat use, nest site, nesting biology, reproduction (Belton, 1984; Sick, 1997), and nestling predation (Zocche *et al.,* 2017). Apart from the notes made by Sick (1969, 1973, 1997) and Belton (1984), preliminary data on Brazilian species ecology were published by Freitas *et al.* (2012), Zocche *et al.* (2017), Costa *et al.* (2019), and Freitas *et al.* (2019) only in the last decade. The last two cited studies presented information about the breeding biology and population and spatial ecology of *C. espinhacensis.*

The restricted area where *C. pabsti* occurs is under strong anthropic pressure, and the absence of basic biological information has led BirdLife International (2021a) to classify this species as "near threatened". Therefore, it is necessary to determine the basic aspects of the natural history of this species for future conservation action plans, especially to determine the species' resilience to habitat modification and investigate reports that it survives in cities and along roads (BirdLife International, 2021b). The aim of this study was to provide information on the breeding biology of this species in this regard.

MATERIAL AND METHODS

Study site

The study site was located in the municipalities of São José dos Ausentes (28°43′05″S and 50°02′59″W) and Bom Jesus (28°39′44″S and 50°26′23″W), northeastern state of Rio Grande do Sul, and Bom Jardim da Serra (21°28′32″S and 56°08′58″W), southeastern state of Santa Catarina (Fig. 1). The area lies within the realm of the Campos de Cima da Serra, a phytophysiognomy typical of the highlands of southern Brazil, characterized by a mosaic of open grasslands and *Araucaria angustifolia* (Bertol.) Kuntze (Araucariaceae) forests interspersed

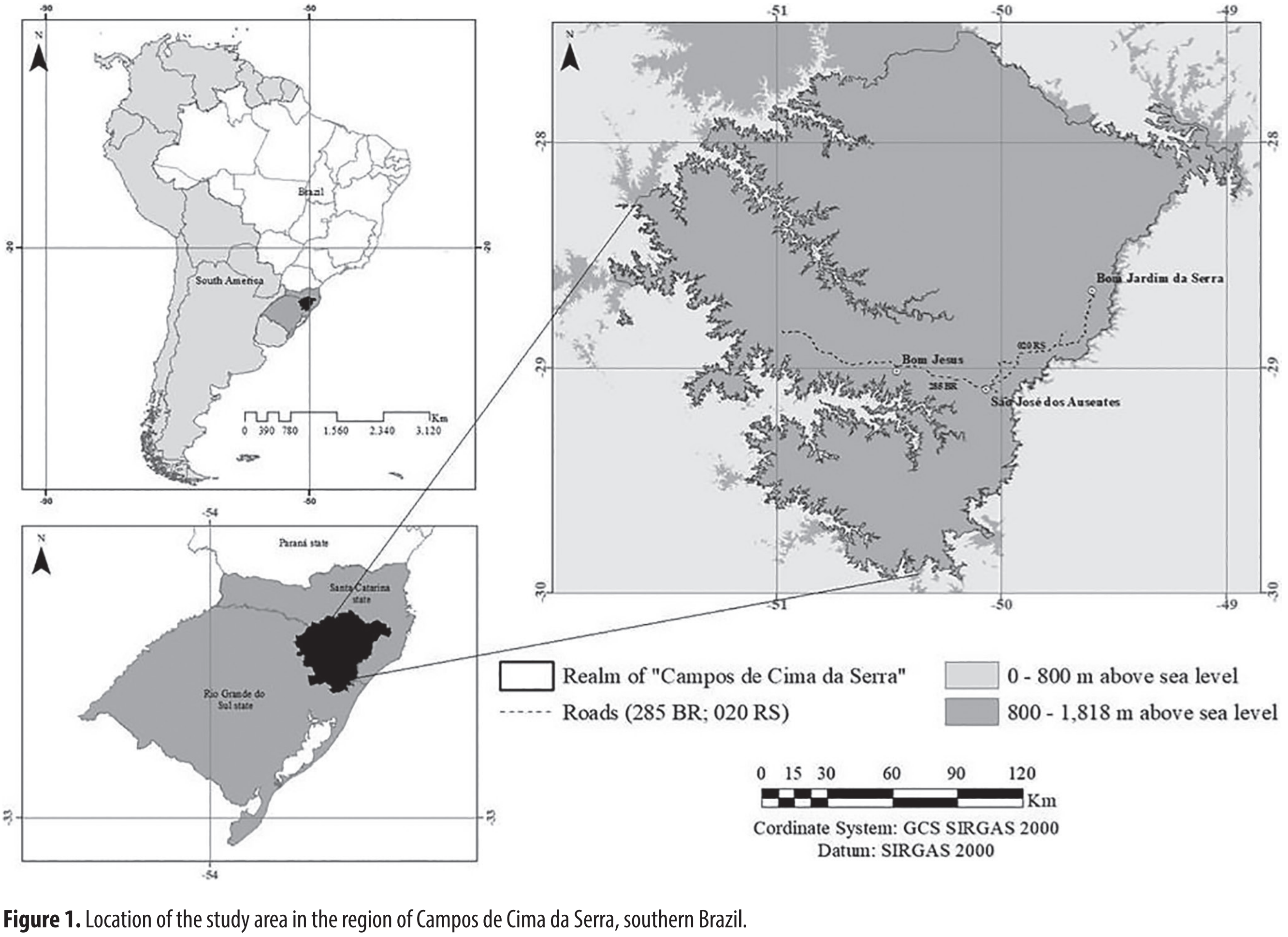

Figure 1. Location of the study area in the region of Campos de Cima da Serra, southern Brazil.

by rocky cliff faces (Behling *et al.,* 2004; Behling & Pillar, 2007; Overbeck *et al.,* 2007). The topography is undulating, with a maximum elevation of 1,800 m above sea level in the Santa Catarina state (Nimer, 1989).

The Köppen climate classification is Cfb (humid subtropical, without a dry season, and temperate summers) with a mean annual temperature of 14.0°C but ranging from -10.0-28°C (Alvares *et al.,* 2014). The mean winter temperature is 5°C, and the mean summer temperature is 14°C. Frost and snow occur during winter. Precipitation ranges from 1,450 to 1,650 mm per annum, and rainfall is well-distributed throughout the year (Nimer, 1989).

Grazing is the main land use activity and is traditionally associated with anthropogenic burning at the end of winter (August) (Quadros & Pillar, 2001). Both grazing and fire are essential for maintaining the physiognomic characteristics of the biome (Quadros & Pillar, 2001; Overbeck & Pfadenhauer, 2007). Extensive areas of grassland have also been transformed by plantations of *Pinus* spp. (Pinaceae), cultivated pastures, and crops of *Malus pumila* Mill. (Rosaceae), and more recently, vegetables including *Solanum tuberosum* L. (Solanaceae), *Brassica oleracea* L. (Brassicaceae), and *Capsicum annuum* L. (Solanaceae).

General protocol

Two existing roads were used as transects for sampling. The first had a south to north orientation and lay along a 120 km stretch of the RS-020 between the cities of São José dos Ausentes, Rio Grande do Sul, and Bom Jardim da Serra, Santa Catarina. The second was oriented from east to west and stretched along 50 km of the BR-285 from the border between Rio Grande do Sul and Santa Catarina states to the city of Bom Jesus, Rio Grande do Sul (Fig. 1). The differences in length and orientation of the two transects were because the area occupied by *C. pabsti* is longer on the north-south axis than on the east-west axis, as shown by Cordeiro (2001).

The existing nest cavities in road cuts along both transects were found in May 2008. The GPS coordinates for each cavity were recorded with an accuracy of 10 m, and the height and width of the entrance hole and its distance from the ground and the cliff edge were measured using a measuring tape. This procedure was repeated between May 2009 and May 2010. The survey was carried out monthly from May to July 2008, February to July 2009, and February to July 2010 and weekly from August 2008 to January 2009 and August 2009 to January 2010. The length of the transects surveyed was reduced to 70 km (40 km south-north and 30 km east-west) from August 2010 to January 2011 for feasibility, as monitoring was carried out at intervals of 2-4 days. It was possible to define the exact duration of the breeding season and the mean duration of each phenological phase by monitoring the nests every 2-4 days. The usage of the complete (170 km) or reduced (70 km) transect datasets was clearly stated in the analyses. Two researchers would then drive along both transects at a constant speed of 15 km/h looking for the presence of *C. pabsti* in or near marked cavities, or in or near new nesting sites, without the use of playback. Sampling was only performed when the meteorological conditions were favorable for the detection of birds. Thus, sampling was avoided on days with rain, strong to moderate winds, and fog (Best, 1981; Bibby *et al.,* 1992). Surveys began an hour after sunrise and ended at sunset, with a break during the hottest period of the day (usually between 12:00 and 14:00 h). The starting point was altered for each sampling event to minimize the time-related biases (Robbins, 1981).

Reproductive biology

The cavities in which adult birds were observed to be engaging in behaviors clearly related to reproduction, such as taking material into the cavity, extended length of time spent inside the nest, and feeding of the nestlings, were classified as nesting sites. Each occurrence of a nesting site was checked to see if it was a new record or had already been georeferenced, and all the required physical and biological data were recorded (see below). In addition to the data recorded in May 2008, May 2009, and May 2010, the total length of the cavity (tunnel plus nesting chamber) was recorded for each nesting site, and the soil/substrate type in which it was situated was identified using the United States Department of Agriculture Soil Taxonomy (USDA) (USDA, 2014).

The following variables were recorded for each nesting cavity in the 2010-2011 breeding season: digging, taking material into the cavity, number of eggs laid, number of eggs hatched, and number of nestlings produced. It was possible to exactly define the following by monitoring the nests every 2-4 days from August 2010 to January 2011: the laying phase duration (time between the first and last eggs being laid), incubation phase duration (time between the last egg laid and hatching of the first chick), nestling phase duration (time between the first chick hatching and the last one leaving the nest), reproductive event duration (time between the first egg being laid and the last nestling leaving the nest, in the same reproductive event), inter-reproductive event duration (time between subsequent reproductive events in the same cavity, in the same breeding season), number of reproductive events per cavity per breeding season, and the breeding season duration (time between the first egg being laid and the last nestling leaving the nest). The phenophases of nests that were inaccessible were determined from direct observation of the behavior exhibited by the occupants (*e.g.,* digging, taking material into the cavity, length of time spent inside the nest, and feeding of the nestlings) after the monitoring of nests began to be conducted every 2-4 days.

Biometry and sexing

Adult birds in their nests were captured for biometric measurements using a hand-held net (Fig. 2) in the 2009-2010 and 2010-2011 breeding seasons, and the eggs and nestlings were picked up directly. The *Instituto*

Chico Mendes de Conservação da Biodiversidade – ICMBio (SISBIO no. 17985) and *Centro Nacional de Pesquisa para a Conservação das Aves Silvestres* – CEMAVE (CEMAVE no. 3163) granted the necessary ethical permission for the methods employed. According to the procedures recommended by MMA/IBAMA (1994), all adult birds and nestlings older than 14 days were marked with a numbered metallic leg band. Additionally, adults (n = 22, from 18 nests) with a specific combination of colored bands were marked in the 2009-2010 and 2010-2011 breeding seasons to identify the nesting cavity of origin, while nestlings (n = 28, from 11 nests) received a combi-

Figure 2A-2B. Hand-held net used to capture adult birds of *Cinclodes pabsti* in their nests in the breeding seasons of 2008-2011 in Campos de Cima da Serra, southern Brazil.

Figure 3A-3D. Road cuts with the presence of holes used by *Cinclodes pabsti* as nesting cavities in the breeding seasons of 2008-2011 in Campos de Cima da Serra, southern Brazil. (3A) road cut with the presence of one nesting cavity in the B horizon of Inceptisol; (3B) researcher taking the measurements of the hole; (3C) road cut with the presence of several cavities side by side in the thin organic soil layer; (3D) detail of cavity proximity from the top of the road cut.

nation of colored bands corresponding to their parents' territory. This information was used to identify the reuse of cavities by the same adult individuals and the permanence of juveniles in their parents' territory.

The wing length (the flattened wing-chord), tail length (from the base of the tail to the tip of the longest rectrix), tarsus length (from the "knee" or depression in the angle of the inter-tarsal joint to the base of the last complete scale before the toes diverge), exposed culmen, and body mass were measured for adult birds (n = 23, from 23 nests). The body mass of nestlings was measured every 2 days from the day they hatched (n = 18, from eight nests) only in the 2010-2011 breading season. Biometric data were recorded using digital calipers (0.1 mm precision), a metallic roller (0.1 mm precision), and mass balance (0.1 g precision). The linear length and breadth of the eggs (n = 155, from 57 nests) were recorded using digital calipers (0.1 mm precision), while their mass (n = 122, from 57 nests) was recorded using a mass balance (precision of 0.1 g). Blood samples for identifying the sex of the adult birds (n = 23, from 19 nests) were collected on Whatman® FTA® cards throughout the 2009-2010 and 2010-2011 breeding seasons, and the polymerase chain reaction (PCR) technique was used, as described by Griffiths *et al.* (1998).

Data analysis

The physical data on nesting cavities was presented as histograms, and the class width was calculated for each variable according to Sturges (1926). The Chi-square test for equal expected proportions was used to determine whether there was selection for soil/substrate type associated with the occupation of the cavities for equal expected portions. Data are presented as mean ± SD standard deviation (SD). The variables were checked for normality using the Kolmogorov-Smirnov test and tested for adult sexual dimorphism in mass (g) and wing, tail, and tarsus lengths (mm) using the Student's t-test. The PAST 3.25 software (Hammer *et al.,* 2001) was used for all the statistical tests, and the statistical significance was set at a P value of 5%. We calculated the proximity between the nesting cavities in the Spatial Analysis Module of ArcGIS® v. 10.2.1, using as algorithm the Distance to the Nearest Neighbor.

RESULTS

The presence of 450 *C. pabsti* nesting cavities (Figs. 3A-3D) was recorded for use along the complete set of transects in May 2008, while 290 nesting cavities were recorded along the reduced set of transects in August 2010 (Table 1). Birds used 119 cavities (22%) for nesting in the breeding seasons of 2008-2009 and 2009-2010 (complete set of transects: 170 km) and 52 cavities (17.9%) for nesting in the 2010-2011 breeding season (reduced set of transects: 70 km). The proportion of cavities used in the complete set of transects in each season was 17.3% in 2008-2009 (n = 78) and 16.5% in 2009-2010 (n = 88). The total number of cavities used across the three breeding seasons was 136, and the Venn diagram in Fig. 4 shows the use and reuse of nesting cavities across breeding seasons.

Table 1. Existing cavities and cavities occupied for nesting by *Cinclodes pabsti* recorded in the road cuts in Campos de Cima da Serra, southern Brazil, between May 2008 and January 2011.

Breeding Seasons	Number of Cavities Recorded in each Transect					
	Complete Set of Transects (170 km)			Reduced Set of Transects (70 km)		
	Existing	Occupied	%	Existing	Occupied	%
2008-2009	450	78	17.3			
2009-2010	495	88	16.5			
2008-2009 and 2009-2010	540	119	22.0			
2010-2011				290	52	17.9

The shortest distance between two nesting cavities that were used simultaneously ranged from 31 to 5,390 m (in the 2008-2009 breeding season), 61 to 1,371 m (in the 2009-2010 breeding season), and 24 to 5,368 m (in the 2010-2011 breeding season) (Table 2). Considering the three breeding seasons together, there was a higher number of nesting cavities in the distance interval of 24-500 m (n = 34 cavities, 59.7%).

There was a greater usage of nesting cavities located in Inceptisols (n = 77), followed by cavities dug in the thin organic soil layer (n = 33), while the number of cavities located in other types of soil/substrate was much lower (Fig. 5A). *Cinclodes pabsti* had a greater affinity ($\chi^2 = 14.23$; $\chi^2_{0\cdot001}$; 1 = 10.827) towards cavities located in clay-type soils (Inceptisols and Psammentic Entisols), with almost 66.2% of the total number of nesting cavities in these substrate types. Out of the number of nests located in non-clay substrates, ten (7.3%) were in saprolite banks (Regolith) and three (2.2%) in other substrates (one in a rock wall at the base of a bridge and two in house roofs).

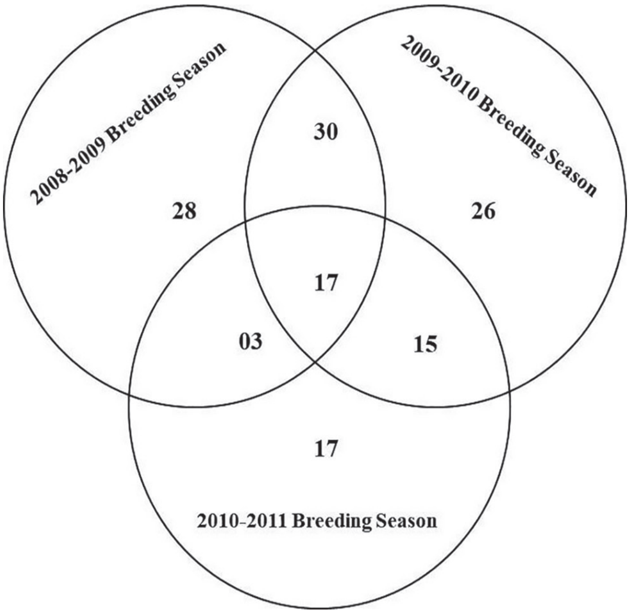

Figure 4. Venn diagram showing the reuse of cavities by *Cinclodes pabsti* between the breeding seasons of 2008-2009, 2009-2010, and 2010-2011 in Campos de Cima da Serra, southern Brazil.

Table 2. Number of nesting cavities used simultaneously by *Cinclodes pabsti* in the 2008-2009, 2009-2010, and 2010-2011 breeding seasons in Campos de Cima da Serra, southern Brazil, arranged according to the interval of distance from the nearest neighbor.

Distance Interval (m)	Number of Nesting Cavities in each Breeding Season			Totals	%
	2008-2009	2009-2010	2010-2011		
24 – 150	2	4	3	9	15.8
151 – 500	10	10	5	25	43.9
501 – 1,000	5	3	4	12	21.1
1,001 – 2,000	0	3	4	7	12.3
2,001 – 5,500	2	0	2	4	7.0
Totals	19	20	18	57	100

The distance between the cavity entrances and the top of road cliffs (or roofs) ranged from 0.02 (in the roofs) to 2.87 m (0.8 ± 0.62 m), with a higher number in the first three distance classes from the top of road cliffs (0.02-1.07 m; Fig. 5B). The greatest number were in the 0.02-0.35 m class (n = 40), followed by the class 0.70-1.07 m (n = 34) and 0.36-0.71 m (n = 29). The height of the cavity entrances above the ground (Fig. 5C) ranged from 0 to 7.51 m (1.6 ± 0.9 m), with the majority (58.1% of records) in the second height class above the ground (0.94-1.87 m).

The records of the depth, height, and width of the cavity entrances used by *C. pabsti* were plotted (Figs. 5D-5F). Cavity depth (tunnel plus the nest chamber) ranged from 0.15 to 2.20 m (0.6 ± 0.3 m) and was often (in about 84.6% of the depth classes) in either the 0.27-0.53 m (n = 67) or the 0.54-0.80 m (n = 48) classes. Abandoned *Colaptes campestris* (Vieillot, 1818) nesting cavities were also seen to be occupied by this species (n = 11). Entrance height ranged from 0.06 to 0.79 m (0.1 ± 0.1 m) with most cases (92.6%) in the 0.06-0.09 m (n = 66) and 0.10-0.19 m classes (n = 60). Cavity entrance width ranged from 0.05 to 0.63 m (0.1 ± 0.1 m) with most cases (91.9%) in the 0.08-0.15 m class (n = 125).

Cinclodes pabsti exhibited biparental care during all phases of the breeding cycle. Both sexes actively participated in the construction of both the cavity and the nest, using their beaks for excavation. As the depth of the cavity into the cliff increased, it formed a straight tunnel that varied from horizontal to a slight upward inclination at an angle between 5° and 15° from the horizontal. The end of the tunnel widened to form an oval-shaped chamber (bowl) with a diameter of approximately 0.20 m. The underside of the chamber was located slightly lower than the floor of the tunnel to form a slight depression to accommodate the nest. During excavation, the material was disposed of through the tunnel entrance in the form of small lumps with the aid of the feet, wings and tail. Cavity excavation occurred over the entire non-breeding season but intensified in the months prior to the start of the breeding season. During the breeding season, excavation mainly occurred between reproductive events. However, excavation was also recorded in cavities that were used for nesting, mainly at the beginning of incubation, with material deposited at the entrance of the nesting chamber probably for purpose of thermoregulation and to prevent predator access.

Nest construction generally began 2-3 days prior to laying the first egg. Nevertheless, eggs were sometimes laid before the nest construction had begun or before its completion. The nest was constructed quickly (between 4 and 6 h) around the egg in the latter cases. The bowl (Figs. 6A and 6B) was made with materials like roots, chaff, grass stems, and wing and tail feathers of other bird species (Table 3) that were deposited circularly and evenly intertwined to ensure that they remained intact even if removed from the cavity. Hair from cattle tails, wool, wads of mammal fur, and down feathers were also recorded

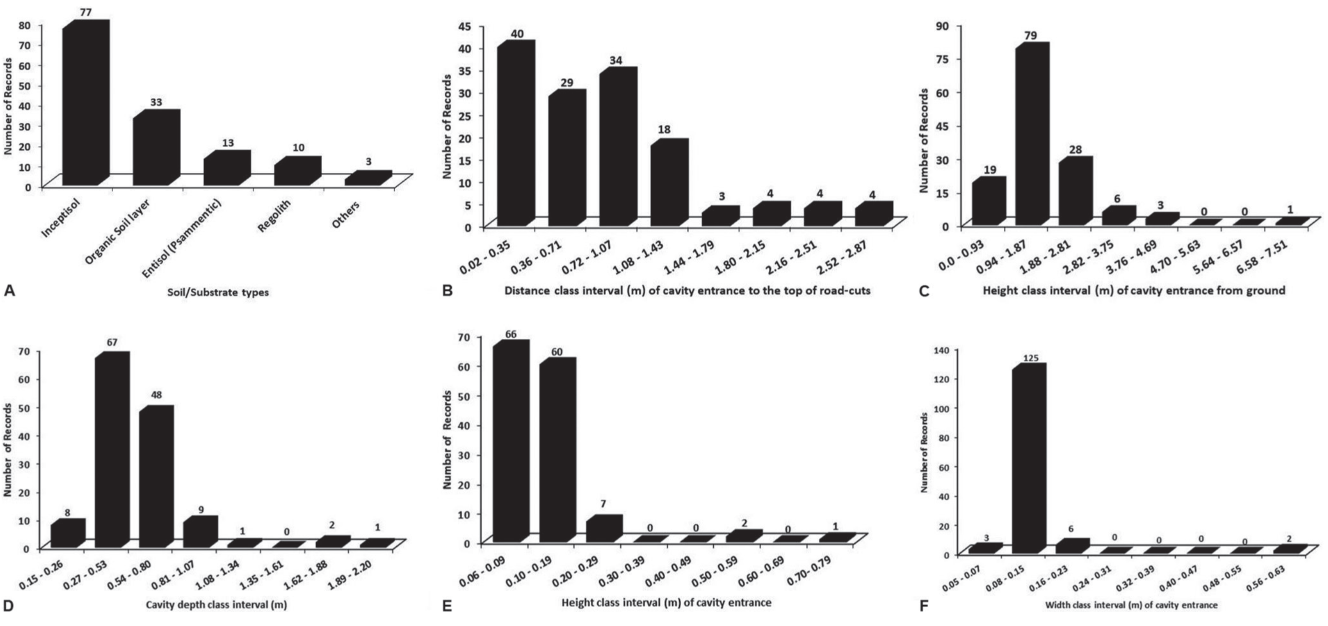

Figure 5A-5F. Physical characteristics of cavities used by *Cinclodes pabsti* as nesting cavities between 2008 and 2011 in Campos de Cima da Serra, southern Brazil. (5A) number of nesting cavities by soil/substrate types; (5B) number of cavities by distance class interval of cavity entrance from the top of road cuts; (5C) number of cavities by height class interval of cavity entrance from ground; (5D) number of cavities by depth class intervals; (5E) number of cavities by height class interval of cavity entrance; and (5F) number of cavities by width class interval of cavity entrance.

Figure 6A-6B. Nest of *Cinclodes pabsti* from Campos de Cima da Serra, southern Brazil, collected in the breeding season of 2009-2010. (6A) top view; and (6B) side view of *Cinclodes pabsti* nest showing the shape and materials used in the construction.

(Table 3), which were used to form a moderately deep cup. In addition to these materials, the pair would deposit chaff and wing and tail feathers of non-Passerine species along the entrance tunnel over the excreta of the nestlings during the nestling phase, possibly to avoid contact with it as they entered and exited the nest to attend the nestlings. Owl pellets, fresh sheep droppings, pieces of mammal skin with fur, and pellets of wool from sheep and wild mammals around the nest were often recorded in the nesting chamber of *C. pabsti* (Table 3). Oviposition occurred at 24 h intervals, and incubation began only after laying was complete (maximum clutch size of three). The nests remained vacant until laying was complete.

A total of 748 eggs produced in 295 nesting events in 136 monitored nesting cavities were recorded during the three reproduction seasons (Table 4). Most nesting cavities were home to only a single breeding event (n = 113 nests), while 55 were home to two (n = 110 nests), and 11 were home to three complete and consecutive reproductive events (n = 33 nests), highlighting the reutilization of cavities within and across breeding seasons. It was seen that certain cavities were used throughout the year, whereas others were used only during the reproductive season. As a rule, cavities that were used repeatedly during the breeding season were also used in the non-breeding season. The clutch size ranged from 1 to 3 eggs. Three eggs were recorded in most of the nests (81%) (Table 5), two eggs in 4.8% of the nests (n = 14 nests), and only one egg in 1% of the nests (n = 3 nests). No egg-laying was observed in 15 finished nests, while 24 nest cavities were inaccessible (Table 5). The eggs of *C. pabsti* (n = 155) obtained from 57 nests during the three breeding seasons were elliptical in shape, with a pure, translucent white coloration (Table 6). The length ranged from 22.2 to 29.6 mm (27.2 ± 1.3 mm), the breadth from 17.4 to 22.4 mm (20.9 ± 0.8 mm), and the mass from 3.0 to 8.0 g (6.1 ± 0.7 g) (Table 6).

The nestlings hatched with their ears open and eyes sealed. Hatching was highly synchronous within each clutch, with the nestlings hatching not more than 4 h apart. The nestling bodies were half-covered with brown, natal down feathers (neossoptiles) distributed over the head, wings, back, sides, thighs, and belly (Figs. 7A and 7B). The body mass of the nestlings at hatching (n = 18) ranged from 4.0 to 7.0 g (6.0 ± 1.0 g). The eyes opened partially at 4 days of age, and pin feather sheaths developed on the wings, tail, and some regions of the back, chest, and belly at 6 days of age. The nestlings were covered by feathers at 11 days of age, except for the neossoptiles beside the feather sheath in the wings and tail (Figs. 7C and 7D). The nestlings reached their maximum body mass at 16 days of age, ranging from 56 to 63 g (59.6 ± 2.4 g). Nestlings weighed on average 58.0 ± 4.6 g at the final weigh-in a day before leaving the nest, exceeding the average body mass of adults in the breeding season, where the body mass of males was 52.0 ± 2.4 g (n = 6) and that of females was 54.4 ± 3.4 g (n = 17) (Table 7). The parental pair removed fecal sacs from the nest in the days following the hatching of chicks and covered feces along the tunnel floor with several materials as the nestlings grew and the defecation rate increased. The time spent in the cavity by the parents decreased as the days passed. The parents remained near the nesting cavity on the day that the nestlings left the nest but were not seen feeding the nestlings. No differences were found in the average morphometric measurements between the sexes in adults of *C. pabsti* (Table 7).

Figure 8 shows the 148-day breeding chronology of *C. pabsti* in the 2010-2011 breeding season. It began with the first egg laid on August 15, 2010, and ended with fledgling by the last nestling on January 9, 2011. The duration of the reproductive phases of *C. pabsti* (incubation, nestling, and interval between two reproductive events) did not seem to vary a lot between pairs and breeding events. The incubation phase in the first reproductive event (n = 25 nests) ranged from 17 to 19 days (17.2 ± 0.5 days) and the nestling phase (n = 23 nests) from 17 to 22 days (18.4 ± 1.8 days), while the interval between the first and second reproductive

Table 3. Nest site data and nesting materials used by *Cinclodes* spp. according to the respective references, along with data collected between 2008 and 2011 in Campos de Cima da Serra, southern Brazil. References and number of observations: (1) Cawkell & Hamilton (1961) (n = 2 nests); (2) De La Peña (2016); (3) Vaurie (1980); (4) Viskarra *et al.* (2018) (n = 1 nest); (5) Bertolero & Zavalaga (2003) (n = 3 nests); (6) Ojeda (2016) (n = 51 nests from 26 nesting cavities); (7) Graves & Arango (1988) (n = 1 nest and 285 nesting cavities); (8) Hahn *et al.* (2005) (n = 6 nests); (9) Avalos & Gómez (2014) (n = 1 nest); (10) Salvador & Salvador (2012) (*C. comechingonus* (n = 16 nests); *C. olrogi* (n = 19 nests); and *C. a. schocolatinus* (n = 8 nests); (11) Costa *et al.* (2019) (n = 6 nests); (12) Sick (1973); (13) Sick (1997); (14) Belton (1984); Present study (n = 295 nests from 136 nesting cavities).

Cinclodes spp.	Nest Substrates and Positions	Nest Distance Entrance		Cavity Depth (m)	Cavity Entrance		Nesting Material	References
		from the Ground (m)	from the Top (m)		Height (m)	Width (m)		
C. antarcticus	Crevices between stones, ground cavities, vertical banks, artificial cover (*e.g.*, inverted bucket)						Dry grass, feathers, and wool	1
	Crevices and tunnels						Dry grass, and feathers	2
C. albiventris (R.A. Philippi y Landbeck, 1861)	Hollows, Crevices between stones, tunnels, cavities and, pipes	0.80 – 2.50		0.35	0.08	0.08	Soft vegetables, straws, hairs, bristles, wool, and feathers	2
C. patagonicus	Hollow in ravines and tree trunks, stone walls and constructions	4.0		0.35	0.16	0.16	Grass, and feathers	2
C. oustaleti Scott, 1900	Crevices or borrows in earth ravines						Fine vegetable fibers, cow hair, and hare hair	2
C. atacamensis (R.A. Philippi, 1857)	Holes or crevices in earth ravines or stones	2.6		0.4 – 1.0	0.06 – 0.1	0.06 – 0.1	Grass, hair, wool, feathers, and threads	2
C. nigrofumosus	Crevices of rocks or slopes, burrows in the earth, under the roofs, within the walls of edifices							3
C. taczanowskii	Rock crevices, vertical banks and escarpments along the coast						Vegetable remains, algae and feathers	4
		2.0 – 3.0		0.5	0.2	0.1	Pieces of vegetation, thin branches, and feathers	5
C. fuscus	Crevices, borrows, and pipes						Bristles, wool, and fur	2
	Holes in dams, under rock edges along streams, walls of manmade structures, under the roofs, under bridges, interior of occupied dwellings							2
	Tree cavities	0 – 9.0		0.3 ± 0.2	0.05 – 0.4	< 0.1		6
C. excelsior	Vertical embankments, in pumice strata of cliff faces formed by road cuts located in strata composed of pumice	0.8 – 10.0	0.05 – 2.3	0.6 – 1.1	0.7 – 0.9	0.7 – 0.9	Dry grass	7
C. o. baeckstroemii	Natural holes in steep rock faces and on rocky slopes/ridges	0 – 5.0	1.0 – 7.0	0.2	0.05 – 0.2	0.05 – 0.2		8
C. aricomae	Among large rocks on hillsides and on cavities and cracks in cliff faces	6.0		0.30	0.1	0.3	Dry grass	9
C. comechingonus	Hollows, crevices between stones, tunnels, cavities and, pipes						Soft vegetables, straws, hairs, bristles, wool, and feathers	2
	Earth ravines, rock crevices and old rock walls	0.8 – 3.8					Grass, thin branches, feathers, and bristles	10
C. olrogi	Crevices or burrows in earth ravines						Fine vegetable fibers, cow hair, hare hair	2
	Earth ravines, rock crevices and old rock walls	0.7 – 4.5					Grass, straw, fur, bristles, and feathers	10
C. a. schocolatinus	Earth ravines (usually wet), stream banks and rock crevices	1.8 – 8.0					Grass, straw, fur, bristles, and feathers	10
C. espinhacensis	Cavities in rocky outcrops	0.9 – 2.9	0.3 – 0.4	0.4 – 1.1	0.05 – 0.4	0.7 – 0.6	Dry grass like narrow leaves, inflorescences of small Eriocaulaceae, green moss, mammal hair, and feathers	11
C. pabsti	Cliff faces							12, 13
	Road cuts, and in spaces found under roofs in farm buildings							14
	Road cuts, rock wall, base of bridges, and in house roof	0 – 7.51	0.02 – 2.87	0.15 – 2.20	0.06 – 0.79	0.05 – 0.63	Roots, chaff, grass stems, wing and tail down feathers of other bird species, hair from cattle tails, wool, wads of mammal fur, and feathers	Present study

Table 4. Numbers of occupied cavities, constructed nests, and reproductive events of *Cinclodes pabsti* in each breeding season between 2008 and 2011 in Campos de Cima da Serra, southern Brazil.

Reproductive Events in each Breeding Season	Numbers of Occupied Cavities and Constructed Nests in each Breeding Season						Totals of Nests
	2008-2009		2009-2010		2010-2011		
	Cavities	Nests	Cavities	Nests	Cavities	Nests	
One Event	50	50	44	44	19	19	113
Two Events	17	34	19	38	19	38	110
Three Events	4	12	5	15	2	6	33
Without Egg Laying	6	6	6	6	3	3	15
Nest not Accessible	1	1	14	14	9	9	24
Total Cavities	78		88		52		
Nests		103		117		75	295

Table 5. Clutch size of *Cinclodes pabsti* recorded between 2008 and 2011 in Campos de Cima da Serra, southern Brazil.

Clutch Size	Number of Nests in each Breeding Season			Totals	%
	2008-2009	2009-2010	2010-2011		
Three Eggs	92	89	58	239	81
Two Eggs	3	6	5	14	4.8
One Egg	1	2	0	3	1
Without Egg Laying	6	6	3	15	5.1
Nest Not Accessible	1	14	9	24	8.1
Total	103	117	75	295	100

events (n = 18 nests) ranged from 9 to 31 days (21.8 ± 6.4 days). The incubation phase in the second reproductive event (n = 23 nests, with 17 reused cavities and six new nests) ranged from 17 to 21 days (17.4 ± 1.0 days) and the nestling phase (n = 19 nests) from 17 to 21 days (18.2 ± 1.3 days). However, the interval between the second and third reproductive events (n = 3 nests) ranged from 15 to 23 days (18.7 ± 4.0 days). Both the incubation (n = 4 nests) and nestling phases (n = 2 nests) occurred in exactly 17 days in the third reproductive event. The mean duration of the incubation phase during the 2010-2011 breeding season (n = 52 nests) was 17.2 ± 0.8 days. The nestling phase (n = 45 nests) lasted on average 18.2 ± 1.5 days, with practically the same number of days in the first two reproductive events but shorter in the third reproductive event. The mean interval between reproductive events was 21.4 ± 6.1 days (n = 21 nests).

The progression of reproductive phenophases in the 2010-2011 reproductive season (Fig. 9) indicated that peak laying (n = 28) and incubation (n = 33) occurred in September, and the greatest number of nestlings (n = 30) was found in October. The greatest number of active nests (n = 45) were recorded in October (approximately the middle of the breeding season), resulting from a combination of nests with nestlings from the first reproductive event and others with eggs from the second reproductive event.

DISCUSSION

Colaptes campestris plays an important role in the southern Brazil highland grasslands, providing a key structural feature (in the form of shallow cavities) which is a critical resource for *C. pabsti. Colaptes campestris* feeds almost exclusively on ant eggs, larvae, and pupae and forage by excavating several consecutive shallow cavities in cliff faces and road-cuts (Short, 1972). These shallow cavities were seen to be deepened later by *C. pabsti* and used as nesting cavities. Although *C. pabsti* is commonly reported to excavate its own burrows in the literature (Sick, 1973; Belton, 1984), there were no records of cavities excavated entirely by this species even after three years of fieldwork. Active cavity excavations were also not observed in *C. espinhacensis* (Costa *et al.,* 2019). *Cinclodes pabsti* was observed using abandoned *C. campestris* nesting cavities and increasing the depth of shallow cavities, in some cases, just after they had been excavated. *Cinclodes pabsti* individuals were found using the same cavity for both breeding and roosting during the breeding season. This has been recorded for other species in the genus, such as *C. fuscus* (Vaurie, 1980; Ojeda, 2016).

Studies on cavity-nesting birds have often supported the hypothesis of nest site limitations (Wiebe *et al.,* 2006; Wiebe, 2011). However, the conclusions of these studies are weakened by the fact that they are multivariate and do not involve the treatment of each factor independently, masking their true importance as limiting resources in the habitat (Brush, 1983). Considering that potential nesting cavities vary in quality, the availability of high-quality nesting cavities may be subject to a high degree of competition (Nilsson, 1984). However, no direct competition or heterospecific antagonistic behavior over *C. campestris* cavities by individuals of *C. pabsti* was observed. Several unoccupied nesting cavities were found next to each other, and several cavities that remained unused for several years were observed, leading to the conclusion that there was a surplus of cavities available for the use of *C. pabsti* in the study area. Nests were rarely located close together when the nesting was synchronous. The closest synchronous nests recorded were 24, 31, and 61 m away from each other, and this pattern could be related to the territory size of the pairs of Long-tailed Cinclodes. In addition, our data showed that between a fifth and a sixth of the total existing cavities on both sets of transects (complete and reduced) were occupied, providing evidence against the hypothesis of competition for high-quality cavities.

Burrowing birds discriminate the nesting substrates not only according to their quality but also by the position of the soil horizon in the bank in which the holes will be

Table 6. Characteristics of eggs and reproductive biology of *Cinclodes* spp. according to the respective references, along with data collected between 2008 and 2011 in Campos de Cima da Serra, southern Brazil. References and number of observations: (1) Cawkell & Hamilton (1961) (n = 2 nests and 5 eggs); (2) Salvador & Salvador (2012) (*C. comechingonus* (n = 16 nests and 22 eggs (22 eggs were measured, and 18 were weighed)); *C. olrogi* (n = 19 nests and 15 eggs (15 eggs were measured, and 8 were weighed)); and *C. a. schocolatinus* (n = 8 nests and 6 eggs)); (3) De La Peña (2016); (4) Costa *et al.* (2019) (n = 6 nests and 8 eggs); (5) Graves & Arango (1988) (n = 1 egg); (6) Bertolero & Zavalaga (2003) (n = 3 nests and 3 eggs); (7) Hahn *et al.* (2005) (n = 6 nests); (8) Ojeda (2016); (9) (9) Avalos & Gómez (2014) (n = 1 nest); (10) Viskarra *et al.* (2018) (n = 1 nest); Present study (n = 155 eggs from 57 nests).

Cinclodes spp.	Eggs Characteristics							Clutch Size (eggs)	Incubation Period (days)	Fledgling (days)	Breeding Season (1) Nesting (2)	References
	Color	Length (mm)		Breadth (mm)		Mass (g)						
		Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD					
C. antarcticus	Pure white, somewhat translucent	27 – 29.4	27.3 ± 0.9	20.5 – 22.7	21.6 ± 0.9			2-3	16	25	Oct. – Nov. (1)	1
	White							1 – 3			Sept. – Dec. (2)	3
C. albiventris	White							2-3			Nov. – Dec. (2)	3
C. taczanowskii											Oct. (2)	10
	Pale pink							2				6
C. patagonicus	White							3			Nov. – Jan. (2)	3
C. fuscus								2 – 4			Nov. – Mid-Jan.	8
	White							2-4			Sept. – Dec. (2)	3
C. excelsior	Pure cream colored, slightly glossy	28.5		22.0				2				5
C. oustaleti	White										Nov. – Dec. (2)	3
C. o. baeckstroemii								2 – 3			Nov. – Feb.	7
C. aricomae											Sept. – Mar.	9
C. comechingonus	White							2 – 3			Oct. – Jan. (2)	3
	Pure white, somewhat translucent	23.7 – 26.1	24.8 ± 0.8	18.1 – 19.1	19.3 ± 0.3	4.6 – 5.4	5.1 ± 0.3	2 – 3			Oct. – Jan. (2)	2
C. olrogi	White							2			Nov. – Dec. (2)	3
	Pure white, somewhat translucent	24.4 – 25.9	25.2 ± 0.5	18.4 – 19.2	18.9 ± 0.3	4.4 – 5.3	4.9 ± 0.3	2 – 3			Oct. – Jan. (2)	2
C. atacamensis	White							2			Oct. – Dec. (2)	3
C. a. schocolatinus	Pure white, somewhat translucent	25.8 – 27.3	26.4 ± 0.5	19.9 – 21.2	20.4 ± 0.5			2 – 3			Oct. – Dec. (2)	2
C. espinhacensis	white	26.4 – 28.4	27 ± 0.7	19.4 – 21.6	20.9 ± 0.8	5.1 – 6.1	5.7 ± 0.4	2 – 3	16		Sept. – Jan.	4
C. pabsti	Pure white, somewhat translucent	22.2 – 29.6	27.2 ± 1.3	17.4 – 22.4	20.9 ± 0.8	3 – 8	6.1 ± 0.7	2 – 3	17.2 ± 0.8	18.2 ± 1.5	Mid-Aug. – Early Jan.	Present study

Table 7. Biometric data of adult individuals of *Cinclodes pabsti* obtained from six males and 17 females belonging to 23 nesting cavities in Campos de Cima da Serra, southern Brazil, monitored during the 2009-2010 and 2010-2011 breeding seasons.

Biometric Data	Males (n = 6)		Females (n = 17)	
	Range	Mean ± SD	Range	Mean ± SD
Wing (mm)	112.0 – 117.0	113.17 ± 2.71	96.0 – 115.0	108.59 ± 5.43
Tail (mm)	91.0 – 95.0	93.58 ± 1.69	89.0 – 94.0	91.19 ± 1.97
Tarsus (mm)	31.03 – 33.41	31.85 ± 0.85	29.95 – 33.67	31.80 ± 1.11
Exposed Culmen (mm)	21.93 – 24.44	22.78 ± 0.96	21.27 – 24.36	23.07 ± 0.88
Body Mass (g)	49.0 – 55.0	52.01 ± 2.44	48.15 – 60.3	54.37 ± 3.39

excavated (Heneberg, 2008; Meireles *et al.,* 2018). Harder substrates are more difficult to dig and demand greater time and energy expenditure, while very loose substrates can result in the collapse of the nesting cavity (Meireles *et al.,* 2018). Thus, burrowing birds need to find a trade-off between cavity stability and ease of excavation, a principle known as the Heneberg compromise (Smalley *et al.,* 2013). By contrast, the different substrates in which the nesting cavity may be located respond differently to radiation, influencing the cavity microclimate (Mersten-Katz *et al.,* 2012; Maziarz & Wesolowski, 2013) and possibly nest site selection. Clay is an ideal substance for the construction of nests, as it is thermally insulating, as pointed out by Figueiredo (1995) for *Furnarius rufus* (Gmelin, 1788). It seems likely in our study that cavities in clay substrates were selected because of their thermal insulation, high moisture content (especially in drier times), and softness (making it easy to excavate) as well as their strength (offering stability and protection). This suggestion is supported by the fact that nest cavities were not observed on road cuts with soil profiles consisting of Oxisols and Ultisols. Both these soil types are well-drained with a low water storage capacity and contain little to no clay. Therefore, they are very porous, friable, and highly susceptible to

Figure 7A-7D. Nestlings of *Cinclodes pabsti* recorded in the breeding season of 2010-2011 in Campos de Cima da Serra, southern Brazil. (7A and 7B) istribution of brown, natal, down feathers (neossoptiles) in the semi-covered body, with closed eyes and opened ears in the new hatchling; (7C and 7D) body covered by feathers, except for the neossoptiles in the feather cannons of the wings and tail at 11 days of age.

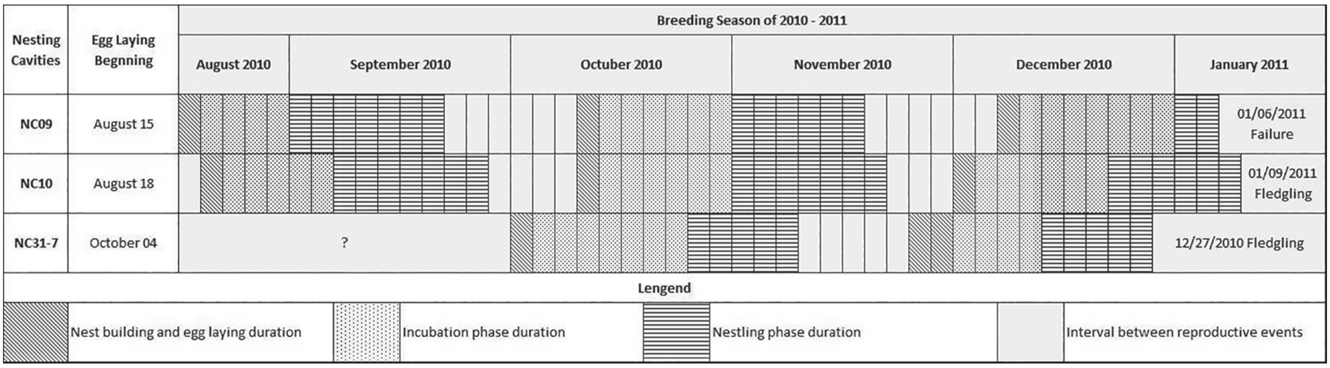

Figure 8. Breeding chronology of *Cinclodes pabsti* during the breeding season of 2010-2011 based on the monitoring of eight nests in three nesting cavities in Campos de Cima da Serra, southern Brazil. Scheme of phenophases based on Faria *et al.* (2008), evidencing: 08/15/2011 – Beginning of the 2010-2011 breeding season with the laying of the first egg in the nest of nesting cavity NC09 [Nesting Cavity 09]; 08/18/2010 – Beginning of the incubation phase of three eggs in the nest of the nesting cavity NC09 [Nesting Cavity 09]; and 01/09/2011 – End of the 2010-2011 breeding season with the nestlings fledgling from the nesting cavity NC10 [Nesting Cavity 10].

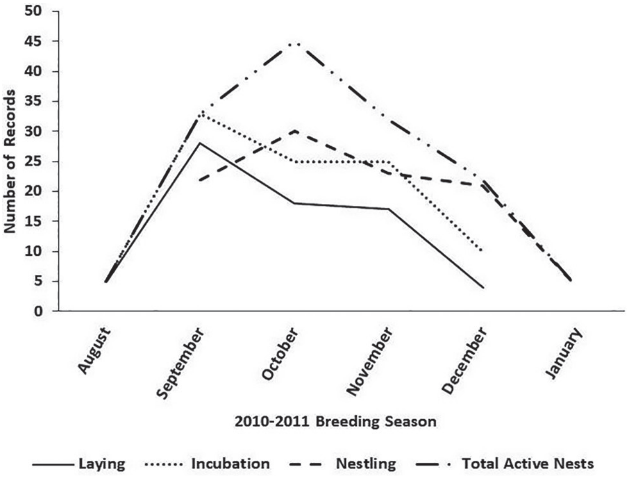

Figure 9. Number of *Cinclodes pabsti* nests in laying, incubation, and nestling phenophases, and the total number of active nests out of 52 nesting cavities monitored in the 2010-2011 breeding season in Campos de Cima da Serra, southern Brazil.

erosion (Vieira & Dortzbach, 2017) and are highly unstable and unsafe for the excavation of cavities, which may be the reason why they are avoided by cavity nesters.

Cinclodes pabsti constructed most of its nests in cavities located in road cuts in the present study, although nests on other substrates such as rock walls at the base of a bridge and house roofs were also recorded. Belton (1984) noted that this species usually constructed nest holes in extremely hard, rock-like materials that would take a long time to excavate. In general, *Cinclodes* spp. build their nests on several different substrates (Table 3). However, horizontal cavities independent of the substrate type are consistently used as breeding sites across all species of the *Cinclodes* genus (Vaurie, 1980; Narosky *et al.,* 1983; Sick, 1997; Ojeda, 2016). Generally, nests of *C. pabsti* are described as underground, with a chamber that widens towards its end to form a bowl (Sick, 1997), or as a cavity/with-tunnel/low cup type with a horizontal tunnel (Simon & Pacheco, 2005). However, individuals of this species in the present study were found to be nested in cavities in which the tunnel sloped slightly upwards, and in abandoned *C. campestris* nesting cavities, where the cavity depth (minimum of 15 cm) was represented only by the nesting chamber. They are classified as cavity/without-tunnel/simple/[lined]-type nests in this case (Simon & Pacheco, 2005).

The distance of the nest entrance from the ground and/or from the top of the vertical structure in which it is located is also a determinant of nest site selection. Nests located farther from the ground or the cliff top greatly decrease predation risk (Graves & Arango, 1988; Hahn *et al.,* 2005; Ojeda, 2016). Our results for *C. pabsti* showed that most cavity entrances were located up to 1 m from the cliff top and from 1-2 m off the ground. At least one-third of the cavity entrances close to the cliff top were present in the superficial layer of the soil (organic layer). This is similar to the results of another study on *C. excelsior* (Graves & Arango, 1988) in which the authors hypothesized that the consistent selection of the upper quartile of the road cut was influenced by the presence of a layer of pumice, which facilitated digging and provided protection against predation. Our data on the substrate type, physical characteristics of the nest, and nesting materials used by *C. pabsti* are also consistent with those of the nests of other *Cinclodes* spp., besides those of *C. excelsior* (Table 3). As 98% of the cavities in our study were in road cuts, changes in the road level due to road maintenance or engineering activities could alter the distance of the nest cavity entrance from the ground between breeding seasons owing to the extraction or deposition of materials. Our records of nesting cavity dimensions (depth, entrance height, and width) are consistent with those of the nests of other *Cinclodes* spp. (Table 3). However, at least four nesting cavities had depths greater than 1.08 m, which is unusual for species in this genus, and were therefore considered as outliers. The entrance width was generally 0.08-0.10 m; wider entrances were mostly due to erosion caused by the continuous movement of birds into and out of the nest. The tunnel depth and inclination and the distance of the cavity entrance from the cliff top are critical to the stability of the nest (to avoid collapse of the chamber ceiling – Faria *et al.,* 2008; Heneberg, 2008; Smalley *et al.,* 2013) and to reduce access for predators from the cliff top. Indeed, several nest predation events were recorded for cavities in the upper layer of soil, where predators had dug out the cavities from above (unpublished data). The steepness of the road cuts (usually greater than 80° and in some cases greater or equal to 90°), distance from the cliff top, distance from the ground, and the narrow entrance diameter make the burrows generally inaccessible to terrestrial predators, except for snakes (Zocche *et al.,* 2017). Additionally, overhanging vegetation conceals the burrow entrance to some degree in some instances, offering protection against aerial predators.

Cinclodes pabsti in this study used nesting materials similar to those used by other species of the genus (Table 3). The owl pellets, fresh sheep droppings, pieces of mammal skin with fur, and pellets of wool from sheep and wild mammals recorded around the nests of *C. pabsti* suggest that besides the function of thermoregulation, these materials are used for their strong and characteristic smell to mask the birds' scent from predators.

The eggs of species that nest in enclosed nests are generally white in color because they do not require camouflage (Oniki, 1985). The eggs of *C. pabsti,* along with congeneric and most other Furnariidae species, are consistent with this observation (Narosky *et al.,* 1983; Sick, 1997; De La Peña, 2016). This species has pure white, somewhat translucent eggs (De La Peña, 2016), and our data showed that the mean length, breadth, and mass of these eggs were higher than those of other species in the genus for which data are available (Table 6). The clutch size ranged from 1 to 3 eggs, which is consistent with that of other species in the genus (Table 6). *Cinclodes fuscus* is an exception with a clutch size of 2-4 eggs (Ojeda, 2016). The incubation period of *C. pabsti* is slightly higher, with the fledging period shorter, than that of its congeneric species (Table 6). Hatching is highly synchronous within each clutch, with the nestlings hatching not more than 4 h apart. This reinforces the hypothesis that the female does not incubate until the entire clutch is laid, an observation also recorded for *C. a. antarcticus* by Cawkell & Hamilton (1961).

The onset of breeding in the 2010-2011 breeding season was highly synchronous (except for three pairs, which began laying early in mid-August), beginning in the first week of September in 14 out of 52 monitored nesting cavities. The breeding season was longer than that of congeneric species (Table 6). However, synchronization decreased with time, mainly owing to nest failures for various reasons. *Cinclodes pabsti* began breeding in winter, an observation also recorded by Sick (1997), and the chicks were found ready to leave the nest on September 21, 2010, corroborating the observations by Belton (1984) and Repenning *et al.* (2010). Our results indicate an extension of the breeding season of the species from mid-August to mid-January.

Nesting cavities were often reused by *C. pabsti,* both within the same breeding season and in subsequent years, a fact also recorded for *C. excelsior* by Graves & Arango (1988) and for *C. fuscus* by Ojeda (2016). Sometimes, a nesting cavity would be abandoned between reproductive events or breeding seasons but reused in subsequent reproductive events or breeding seasons. The pair was absent from the nesting cavity during these abandonment periods and roosted in other cavities or sites in the vicinity. This behavior may be an adaptation to prevent infestation by parasites, to avoid septic conditions resulting from the build-up of feces in the nest, or a predator avoidance strategy.

Cinclodes pabsti pairs generally clean a nesting cavity before reusing it, moving all the old contents of the nest to the front of the cavity (Belton, 1984). Images in Vizcarra *et al.* (2018) suggest that *C. taczanowskii* adopts the same behavior between reproductive events. Although it could not be concluded for *C. espinhacensis,* Costa *et al.* (2019) reported the presence of feathers, nesting materials, and eggshell fragments on the ground below nesting cavities, indicating that they had been cleaned. Therefore, this seems to be a common behavior within the genus. In fact, the entanglement of these materials in the vegetation below road cuts, along with the strong green coloration of moss that grows below the entrance tunnel, was highly effective for locating nesting cavities.

Our data on the complete set of cavities monitored over the course of three years showed that the reuse of cavities between breeding seasons ranged from 14.7% between the 2008-2009 and 2010-2011 seasons and 34.6% between the 2008-2009 and 2009-2010 seasons. Alternatively, the reuse percentage ranged from 26.9% in the 2008-2009 breeding season to 40.4% in the 2010-2011 breeding season, if the reuse between reproductive events within the same breeding season is considered. This is lower than the proportion of nesting cavities reused by *C. fuscus* (72.2%) across multiple seasons, recorded by Ojeda (2016), but higher than that used by *C. espinhacensis* (25.0% (one of four)) in both 2009 and 2012 (Costa *et al.,* 2019). The reuse of nesting cavities, both within and between breeding seasons, could be a strategy to reduce the amount of time and energy spent excavating new cavities (Vergara *et al.,* 2010). However, reusing previously successful nesting sites could also be a way of maximizing individual fitness because of the greater assurance of success (Aitken *et al.,* 2002; Styrsky, 2005; Tobolka *et al.,* 2013), a feature termed as an "ecological magnet" by Hickey (1942). Indeed, Ojeda (2016) recorded that birds did not reuse four cavities located near the ground in which nesting had been unsuccessful in three previous years. Burrows in the southern Brazilian highland grasslands persist for many years until the road cut erodes, making them suitable for use for many years. In fact, the use of several nesting cavities has been recorded continuously for over 12 years, and several pairs marked with colored bands have used the same cavities over multiple years (unpublished data).

Hatchlings of *C. pabsti* are similar to their congeneric species with respect to the eyes, ears, skin color, distribution of natal down feathers (neossoptiles), and reliance on parental care. This includes *C. comechingonus, C. olrogi* (Salvador & Salvador, 2012), and *C. espinhacencis* (Costa *et al.,* 2019). The body mass of *C. comechingonus* nestlings ranged from 4.0 to 4.3 g. This is lower than the average egg mass (5.1 ± 0.3 g) and mean mass of *C. pabsti* nestlings recorded in this study (6.0 ± 1.0 g). Similar to the onset of incubation, hatching and fledging seemed to be highly synchronized. The high degree of similarity in the body mass of nestlings observed across several growth stages, even though they may initially be different at hatching, reinforces the hypothesis of synchrony in the hatching and development of nestlings. This agrees with the findings reported for other species in the genus of Cawkell & Hamilton (1961).

Cinclodes pabsti exhibit biparental care at all stages of the breeding cycle, similar to other species in the genus (Cawkell & Hamilton, 1961; Hahn *et al.,* 2005; Avalos & Gómez, 2014; Ojeda, 2016; Costa *et al.,* 2019). However, the time spent in the cavity by the parents decreased as the days passed, and on no occasion were the parents recorded feeding the young. This was similar to the observation recorded in *C. aricomae* (Avalos & Gómez, 2014). A pair foraging with three juveniles was recorded in a field of low grass on two occasions in our study. However, fledglings were not recorded in their parents' territory in either of the cases, as identified by using colored bands in adults and fledglings. Similarly, foraging family groups in *C. o. baeckstroemii* usually consist of two adults and two to three juveniles (Hahn *et al.,* 2005).

Recent studies in the southern Brazilian highland grasslands have shown that approximately 50% (Fontana *et al.,* 2016) to 60% (Andrade *et al.,* 2015) of the original grassland areas have been lost in the past decade (Andrade *et al.,* 2015). Land use has led to losses in species richness and the biotic homogenization of grassland remnants (Staude *et al.,* 2018). The conversion of highland grassland habitats is the most important predictor of the extinction risk of grassland birds (Machado & Loyola, 2013; Fontana *et al.,* 2016). The areas to which *C. pabsti* is endemic cover only 125,000 km² (BirdLife International, 2021a, b) and are under high anthropic pressures due to the replacement of natural grasslands by agriculture, cultivated pastures, and forestry plantations (Nabinger *et al.,* 2000; Overbeck *et al.,* 2007; Repenning *et al.,* 2010; Azpiroz *et al.,* 2012; Fontana *et al.,* 2016). The agrochemicals used for the crops of grassland areas are another problem that affect the quality of bird habitats (Rivera-Milán *et al.,* 2004). Nevertheless, the effects of habitat modification on *C. pabsti* remain unclear, as information about their life history patterns is still incipient.

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AUTHORS' CONTRIBUTIONS

JJZ: Conceptualization, Methodology, Field work, Visualization, Investigation, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. FC: Field work, Visualization, Investigation, Data curation, Formal analysis, Writing – original draft. APCN: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review. All the authors actively participated in the discussion of the results, they reviewed and approved the final version of the paper.

CONFLICTS OF INTEREST

Authors declare there are no conflicts of interest.

REFERENCES

Aitken, K.E.H.; Wiebe, K.L. & Martin, K. 2002. Nest-site reuse patterns for a cavity-nesting bird community in interior British Columbia. *Auk,* 119(2): 391-402. DOI

Alvares, C.A.; Starpe, J.L.; Sentelhas, P.C.; Gonçalves, J.L.M. & Sparovek, G. 2014. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift, Garmisch-Partenkirchen,* 22(6): 711-728. DOI

Andrade, B.O.; Koch, C.; Boldrini, I.I.; Vélez-Martin, E.; Hasenack, H.; Hermann, J.M.; Kollmann, J.; Pillar, V.D.P. & Overbeck, G.E. 2015. Grassland degradation and restoration: A conceptual framework of stages and thresholds illustrated by southern Brazilian grasslands. *Natureza & Conservação,* 13(2): 95-104. DOI

Atkins, N. 1980. Possible competition between Seaside Cinclodes (*Cinclodes nigrofumosus*) and Ruddy Turnstones (*Arenaria interpres*). *Condor,* 82(1): 107-108.

Aucca, C.; Olmos, F.; Santander, O.J. & Chamorro, A. 2015. Range extension and new habitat for the Royal Cinclodes *Cinclodes aricomae* a critically endangered andean endemic. *Cotinga,* 37: 12-17.

Avalos, V.R. & Gómez, M.I. 2014. Observations on nest site and parental care of the critically endangered Royal Cinclodes (*Cinclodes aricomae*) in Bolivia. *Ornitología Neotropical,* 25: 477-480.

Azpiroz, A.B.; Isacch, J.P.; Dias, R.A.; Di Giacomo, A.S.; Fontana, C.S. & Palarea, C.M. 2012. Ecology and conservation of grassland birds in southeastern South America: a review. *Journal of Field Ornithology,* 83(3): 217-246. DOI

Behling, H. & Pillar, V.D.P. 2007. Late Quaternary vegetation, biodiversity and fire dynamics on the southern Brazilian highland and their implication for conservation and management of modern Araucaria forest and grasslands ecosystems. *Philosophical Transactions of the Royal Society B,* 362(1478): 243-251. DOI

Behling, H.; Pillar, V.D.P.; Orlóci, L. & Bauermann, S.G. 2004. Late Quaternary Araucaria forest, grassland (Campos), fire and climate dynamics, studied by high-resolution pollen, charcoal and multivariate analysis of the Cambará do Sul core in southern Brazil. *Palaeogeography, Palaeoclimatology, Palaeoecology,* 203(3-4): 277-297. DOI

Belton, W. 1984. *Aves do Rio Grande do Sul, distribuição e biologia.* São Leopoldo, Editora Unisinos.

Bertolero, A. & Zavalaga, C. 2003. Observaciones sobre la biometría y la muda del churrete marisqueiro (*Cinclodes taczanowskii*) em Punta San Juan, costa sur del Perú. *Ornitologia Neotropical,* 14: 469-475.

Best, L.B. 1981. Seasonal changes in detection of individual bird species. *In:* Ralph, C.J. & Scott, J.M.– *Estimating numbers of terrestrial birds.* Lawrence, Allen Press. p. 252-261. (Studies in Avian Biology Nº 6)

Bibby, C.; Burgess, N. & Hill, D. 1992. *Bird census techniques.* London, Academic Press.

BirdLife International. 2021a. *Cinclodes pabsti. The IUCN Red List of Threatened Species 2016: e.T22702085A93859241.* Available: DOI. Access: 17/07/2021.

BirdLife International. 2021b. *Species Factsheet: Cinclodes pabsti.* Available: http://www.birdlife.org. Access: 17/07/2021.

Brush, T. 1983. Cavity use by secondary cavity-nesting birds and response to manipulations. *Condor,* 85(4): 461-466. DOI

Cawkell, E.M. & Hamilton, J.E. 1961. The birds of the Falkland Islands. *Ibis,* 103a(1): 1-27. DOI

Chaves, A.V.; Freitas, G.H.S.; Vasconcelos, M.F. & Santos, F.R. 2015. Biogeographic patterns, origin and speciation of the endemic birds from eastern Brazilian mountaintops: a review. *Systematics and Biodiversity,* 13(1): 1-16. DOI

Chesser, R.T. 2004. Systematics, evolution, and biogeography of the South American ovenbird genus *Cinclodes. Auk,* 121(3): 752-766. DOI

Cordeiro, P.H.C. 2001. Areografia dos Passeiriformes endêmicos da Mata Atlântica. *Ararajuba,* 9(2): 125-137.

Costa, L.M.; Freitas, G.H.S.; Silva, P.H.V.B.P.; Ribeiro, L.C.; Vasconcelos, M.F. & Rodrigues, M. 2019. Breeding biology of the Cipo Cinclodes *Cinclodes espinhacensis,* a micro-endemic furnariid of the southeastern Brazilian mountains. *Revista Brasileira de Ornitologia,* 27(2): 63-69.

De La Peña, M.R. 2016. Aves argentinas: descripción, comportamiento, reproducción y distribución: Trogonidae a Furnariidae. *Comunicaciones del Museo Provincial de Ciencias Naturales "Florentino Ameghino" (Nueva Serie),* 20(2): 1-620.

Faria, L.C.P.; Carrara, L.A. & Rodrigues, M. 2008. Biologia reprodutiva do fura-barreira *Hylocryptus rectirostris* (Aves: Furnariidae). *Revista Brasileira de Zoologia,* 25(2): 172-181. DOI

Figueiredo, L.F.A. 1995. A reprodução do joão-de-barro, *Furnarius rufus* (Gmelin, 1788). uma revisão. *Boletim do Centro de Estudos Ornitológicos,* 11: 2-33.

Fontana, C.S.; Dotta, G.; Marques, C.K.; Repenning, M.; Agne, C.E. & Santos, J.A. dos. 2016. Conservation of grassland birds in South Brazil: a land management perspective. *Natureza & Conservação,* 14(2): 83-87. DOI

Freitas, G.H.S.; Chaves, A.V.; Costa, L.M.; Santos, F.R. & Rodrigues, M. 2012. A new species of *Cinclodes* from the Espinhaço Range, southeastern Brazil: insights into the biogeographical history of the South American highlands. *Ibis,* 154(4): 738-755. DOI

Freitas, G.H.S.; Costa, L.M.; Silva, P.H.V.B.P.; Chaves, A.V.; Ribeiro, L.C. & Rodrigues, M. 2019. Spatial ecology and conservation of the microendemic ovenbird Cipo Cinclodes (*Cinclodes espinhacensis*) from the Brazilian highlands. *Journal of Field Ornithology,* 90(2): 128-142. DOI

Graves, G.R. & Arango, G. 1988. Nest-site selection, nest, and eggs of the Stout-billed Cinclodes (*Cinclodes excelsior*), a high Andean furnariid. *Condor,* 90(1): 251-253. DOI

Griffiths, R.; Double, M.C.; Orr, K. & Dawson, R.J.G. 1998. A DNA test to sex most birds. *Molecular Ecology,* 7(8): 1071-1075. DOI

Hahn, I. 2006. Bioacoustic characteristic and population numbers of endemic *Cinclodes oustaleti baeckstroemii* (Aves: Furnariidae) Lönnberg, 1921 of Alejandro Selkirk Island, Chile. *Bonner Zoologische Beiträge,* 55(2): 95-100.

Hahn, I.; Römer, U. & Schlatter, R.P. 2005. First description of nesting ecology of the endemic Grey-flanked Cinclodes *Cinclodes oustaleti baeckstroemii* from the Juan Fernández Islands, Chile. *Acta Ornithologica,* 40(2): 165-169. DOI

Hammer, Ø.; Harper, D.A.T. & Ryan, P.D. 2001. Past: paleontological statistics software package for education and data analysis. *Palaeontologia Electronica,* 4(1): 1-9. Available: http://priede.bf.lu.lv/ftp/pub/TIS/datu_analiize/PAST/2.17c/download.html. Access: 10/01/2020.

Heneberg, P. 2008. Soil penetrability as a key factor affecting the nesting of burrowing birds. *Ecological Research,* 24(2): 453-459. DOI

Hickey, J.J. 1942. Eastern population of the Duck Hawk. *Auk,* 59(2): 176-204. DOI

Machado, N. & Loyola, R.D. 2013. A comprehensive quantitative assessment of bird extinction risk in Brazil. *PLoS ONE,* 8(8): e72283. DOI

Martínez Del Rio, C.; Sabat, P.; Anderson-Sprecher, R. & Gonzalez, S.P. 2009. Dietary and isotopic specialization: the isotopic niche of three *Cinclodes* ovenbirds. *Oecologia,* 161(1): 149-159. DOI

Maziarz, M. & Wesołowski, T. 2013. Microclimate of tree cavities used by Great Tits (*Parus major*) in a primeval forest. *Avian Biology Research,* 6(1): 47-56. DOI

Meireles, R.C.; Teixeira, J.P.G.; Solar, R.; Vasconcelos, B.N.F.; Fernandes, R.B.A.; Lopes, L.E. 2018. Soil attributes drive nest-site selection by the campo miner *Geositta poeciloptera. PLoS ONE,* 13(1): e0192185. DOI

Mersten-Katz, C.; Barnea, A.; Yom-Tov, Y. & AR, A. 2012. The woodpecker's cavity microenvironment: advantageous or restricting? *Avian Biology Research,* 5(4): 227-237. DOI

Ministério do Meio Ambiente (MMA)/Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA). 1994. *Manual de anilhamento de aves silvestres.* Brasília, IBAMA – CEMAVE.

Nabinger, C.; Moraes, A. & Maraschin, G.E. 2000. Campos in Southern Brazil. *In:* Lemaire G.; Hodgson, J.; Moraes, A.; Nabinger, C. & Carvalho, P.C.F. *Grassland ecophysiology and grazing ecology.* Cambridge, University Press. part V, p. 355-376.

Narosky, T.; Fraga, R. & De La Peña, M. 1983. *Nidificación de las aves argentinas: (Dendrocolaptidae y Furnariidae).* Buenos Aires, Asociación Ornitológica del Plata.

Newsome, S.D.; Sabat, P.; Wolf, N.; Rader, J.A. & Martinez Del Rio, C. 2015. Multi-tissue δ^2H analysis reveals altitudinal migration and tissue-specific discrimination patterns in *Cinclodes. Ecosphere,* 6(11): 1-18. DOI

Nilsson, S.G. 1984. The evolution of nest-site selection among hole-nesting birds: The importance of nest predation and competition. *Ornis Scandanavica,* 15(3): 167-175. DOI

Nimer, E. 1989. *Climatologia do Brasil.* Rio de Janeiro, Fundação Instituto Brasileiro de Geografia e Estatística.

Ojeda, V.S. 2016. Tree-cavity nesting in Buff-Winged Cinclodes (*Cinclodes fuscus*) populations from Northwestern Argentine Patagonia. *Ornitología Neotropical,* 27(1): 35-46.

Oniki, Y. 1985. Why robin eggs are blue and birds build nests: statistical tests for Amazonian birds. *In:* Buckley, P.A.; Foster, M.S.; Morton, E.S.; Ridgely, R.S. & Buckley, F.G. *Neotropical ornithology.* Washington, American Ornithologist's Union. p. 536-545.

Overbeck, G.E. & Pfadenhauer, J. 2007. Adaptive strategies to fire in subtropical grasslands in southern Brazil. *Flora,* 202(1): 27-49. DOI

Overbeck, G.E.; Müller, S.C.; Fidelis, A.; Pfadenhauer, J.; Pillar, V.D.P.; Blanco, C.C.; Boldrini, I.I.; Both, R. & Forneck, E.D. 2007. Brazil's neglected biome: the South Brazilian Campos. *Perspectives in Plant Ecology, Evolution and Systematic,* 9(2): 101-116. DOI

Pacheco, J.F.; Silveira, L.F.; Aleixo, A.; Agne, C.E.; Bencke, G.A.; Bravo, G.A; Brito, G.R.R.; Cohn-Haft, M.; Maurício, G.N.; Naka, L.N.; Olmos, F.; Posso, S.; Lees, A.C.; Figueiredo, L.F.A.; Carrano, E.; Guedes, R.C.; Cesari, E.; Franz, I.; Schunck, F. & Piacentini, V.Q. 2021. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee – second edition. *Ornithology Research,* 29(2). DOI

Quadros, F.L.F. & Pillar, V.D.P. 2001. Dinâmica vegetacional em pastagem natural submetida a tratamentos de queima e pastejo. *Ciência Rural,* 31(5): 863-868. DOI

Rader, J.A.; Dillon, M.E.; Chesser, R.T.; Sabat, P. & Martínez Del Río, C. 2015. Morphological divergence in a continental adaptive radiation: South American ovenbirds of the genus *Cinclodes. Auk,* 132(1): 180-190. DOI

Rader, J.A.; Newsome, S.D.; Sabat, P.; Chesser, R.T.; Dillon, M.E. & Martínez Del Rio, C. 2017. Isotopic niches support the resource breadth hypothesis. *Journal of Animal Ecology,* 86(2): 405-413. DOI

Remsen, J.V.; Areta, J.I.; Bonaccorso, E.; Claramunt, S.; Jaramillo, A.; Pacheco, J.F.; Ribas, C.; Robbins, M.B.; Stiles, F.G.; Stotz, D.F. & Zimmer, K.J. 2020. *A classification of the bird species of South America.* Version 20 [11 February 2020]. American Ornithological Society. Available: http://www.museum.lsu.edu/~Remsen/SACCBaseline.htm. Access: 18/03/2020.

Repenning, M.; Rovedder, C.E. & Fontana, C.S. 2010. Distribuição e biologia de aves nos campos de altitude do sul do Planalto Meridional Brasileiro. *Revista Brasileira de Ornitologia,* 18(4): 283-306.

Rivera-Milán, F.F.; Zaccagnini, M.E. & Canavelli, S.B. 2004. Field trials of line-transect surveys of bird carcasses in agro-ecosystems of Argentina's Pampas region. *Wildlife Society Bulletin,* 32(4): 1219-1228. DOI

Robbins, C.S. 1981. Effect of time of day on bird activity. *Studies in Avian Biology,* 6(2): 275-286.

Robbins, R.G.; Sorkin, L.N. & Vuilleumier, F. 2001. First report of *Ixodes auritulus* Neumann (Acari: Ixodida: Ixodidae) from the blackish cinclodes, *Cinclodes antarcticus* (Garnot) (Aves: Passeriformes: Furnariidae), with additional records of parasitism of *Cinclodes* spp. by this tick species. *Proceedings of the Entomological Society of Washington,* 103(1): 265-268.

Sabat, P. 2000a. Birds in marine and saline environments: living in dry habitats. *Revista Chilena de Historia Natural,* 73(3): 401-410. DOI

Sabat, P. 2000b. Intestinal disaccharidases and aminopeptidase-N in two species of *Cinclodes* (Passerine: Furnaridae). *Revista Chilena de Historia Natural,* 73(2): 345-350. DOI

Sabat, P. & Gonzalez, S.P. 2003. Digestive enzymes in two species of marine *Cinclodes* (Passeiriformes: Furnariidae). *Condor,* 105(4): 830-833. DOI

Sabat, P. & Martínez Del Rio, C. 2002. Inter- and intraspecific variation in the use of marine food resources by tree *Cinclodes* (Furnariidae, Aves) species: carbon isotopes and osmoregulatory physiology. *Zoology,* 105(3): 247-256. DOI

Sabat, P. & Martínez Del Rio, C. 2005. Seasonal changes in the use of marine food resources by *Cinclodes nigrofumosus* (Furnariidae, Aves): carbon isotopes and osmoregulatory physiology. *Revista Chilena de Historia Natural,* 78(2): 253-260. DOI

Sabat, P.; Farina, J.M. & Soto-Gamboa, M. 2003. Terrestrial birds living on marine environments: does dietary composition of *Cinclodes nigrofumosus* (Passeiriformes: Furnariidae) predict their osmotic load? *Revista Chilena de Historia Natural,* 76(2): 335-343. DOI

Sabat, P.; Maldonado, K.; Canals, M. & Martinez Del Rio, C. 2006a. Osmoregulation and adaptive radiation in the ovenbird genus *Cinclodes* (Passeriformes: Furnariidae). *Functional Ecology,* 20(5): 799-805. DOI

Sabat, P.; Maldonado, K.; Fariña, J.M. & Martinez Del Rio, C. 2006b. Osmoregulatory capacity and the ability to use marine food sources in two coastal songbirds (*Cinclodes:* Furnariidae) along a latitudinal gradient. *Oecologia,* 148(2): 250-257. DOI

Sabat, P.; Maldonado, K.; Rivera-Hutinel, A. & Farfan, G. 2004a. Coping with salt without salt glands: osmoregulatory plasticity in three species of coastal songbirds (ovenbirds) of the genus *Cinclodes* (Passeriformes: Furnariidae). *Journal of Comparative Physiology B,* 174(5): 415-420. DOI

Sabat, P.; Nespolo, R. & Bozinovic, F. 2004b. Water economy of *Cinclodes* (Furnariidae) inhabiting marine and freshwater ecosystems. *Revista Chilena de Historia Natural,* 77(2): 219-225. DOI

Salvador, S.A. & Salvador, L.A. 2012. Reproducción de aves en Pampa de Achala, Córdoba, Argentina. *Historia Natural,* 2(2): 119-145.

Sanín, C.; Cadena, C.D.; Maley, J.M.; Lijtmaer, D.A.; Tubaro, P.L. & Chesser, R.T. 2009. Paraphyly of *Cinclodes fuscus* (Aves: Passeriformes: Furnariidae): implications for taxonomy and biogeography. *Molecular Phylogenetics and Evolution,* 53(2): 547-555. DOI

Short, L.L. 1972. Systematics and behavior of South American flickers (Aves, *Colaptes*). *Bulletin of the American Museum of Natural History,* 149: 1-110. Available: http://hdl.handle.net/2246/1198. Access: 26/08/2019.

Sick, H. 1969. Über einige Töpfervögel (Furnariidae) aus Rio Grande do Sul, Brasilien, mit Beschhreibung eines neuem *Cinclodes. Beitrage zur Neotropischen Fauna,* 6(2): 63-79. DOI

Sick, H. 1973. Nova contribuição ao conhecimento de *Cinclodes pabsti* Sick, 1969 (Furnariidae, Aves). *Revista Brasileira de Biologia,* 33(1): 109-117.

Sick, H. 1997. *Ornitologia brasileira.* Rio de Janeiro, Nova Fronteira.

Simon, J.E. & Pacheco, S. 2005. On the standardization of nest descriptions of neotropical birds. *Revista Brasileira de Ornitologia,* 13(2): 143-154.

Smalley, I.; Blake-Smalley, R.; O'Hara-Dhand, K.; Jary, Z. & Svircev, Z. 2013. Sand martins favour loess: How the properties of loess ground facilitate the nesting of sand martins/bank swallows/uferschwalben (*Riparia riparia* Linnaeus 1758). *Quaternary International,* 296, 216-219. DOI

Staude, I.; Vélez-Martin, E.; Andrade, B.O.; Podgaiski, L.; Boldrini, I.I.; Mendonça-Jr., M.; Pillar, V.D.P. & Overbeck, G.E. 2018. Local biodiversity erosion in south Brazilian grasslands under moderate levels of landscape habitat loss. *Journal of Applied Ecology,* 55(3): 1241-1251. DOI

Sturges, H.A. 1926. The choice of a class interval. *Journal of the American Statistical Association,* 21(153): 65-66. DOI

Styrsky, J.N. 2005. Influence of predation on nest-site reuse by an open-cup nesting neotropical passerine. *Condor,* 107(1): 133-137. DOI

Tobolka, M.; Kuzniak, S.; Zolnierowicz, K.M.; Sparks, T.H. & Tryjanowski, P. 2013. New is not always better: low breeding success and different occupancy patterns in newly built nests of a long-lived species, the White Stork *Ciconia ciconia. Bird Study,* 60(3): 399-403. DOI

United States Department of Agriculture (USDA). 2014. *Keys to Soil Taxonomy.* USDA – Natural Resources Conservation Service. Available: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580. Access: 26/08/2019.

Vaurie, C. 1980. Taxonomy and geographical distribution of the Furnariidae (aves, Passeiriformes). *Bulletin of the American Museum of Natural History,* 166: 1-357. Available: http://hdl.handle.net/2246/1040. Access: 18/08/2019.

Vergara, P.; Gordo, O. & Aguirre, J.I. 2010. Nest size, nest building behavior and breeding success in a species with nest reuse: the White Stork *Ciconia ciconia. Annales Zoologici Fennici,* 47(3): 184-194. DOI

Vieira, V.F. & Dortzbach, D. 2017. *Caracterização ambiental e delimitação geográfica dos Campos de Cima da Serra.* EPAGRI, Florianópolis. Available: https://www.epagri.sc.gov.br/index.php/solucoes/publicacoes/livros. Access: 20/08/2019.

Vizcarra, J.K. 2007. Un registro inusual de *Cinclodes fuscus fuscus* em Tacna, Perú. *Boletín Sociedad Antioqueña de Ornitologia,* 17(1): 50-52. Available: http://www.sao.org.co/publicaciones/boletinsao/XVII.htm. Access: 22/08/2019.

Vizcarra, J.K. 2010. Nuevos registros ornitológicos en los humedales de Ite y alrededores, Tacna, Peru. *The Biologist,* Lima, 8(1): 1-20.

Vizcarra, J.K.; Medrano, F.; Aguirre, J. & Araya, K. 2018. Observations on the presence and nesting of *Cinclodes taczanowskii* and *Sicalis raimondii* at a site on the southern coast of Peru. *The Biologist,* Lima, 16(1): 51-63.

Wiebe, K.L. 2011. Nest sites as limiting resources for cavity-nesting birds in mature forest ecosystems: a review of the evidence. *Journal of Field Ornithology,* 82(3): 239-248. DOI

Wiebe, K.L.; Koenig, W.D. & Martin, K. 2006. Evolution of clutch size in cavity-excavating birds: the nest site limitation hypothesis revisited. *The American Naturalist,* 167(3): 343-353. DOI

Zocche, J.J.; Zocche, N.M.; Carvalho, F.; Mendonça, R.A.; Ceron, K.; Peres, P.B. & Cruz-Neto, A.P. 2017. *Philodryas patagoniensis* (Patagonian Green Racer). Diet. *Herpetological Review,* 48(1): 217-218.

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