



# A new species of *Cinclodes* from the Espinhaço Range, southeastern Brazil: insights into the biogeographical history of the South American highlands

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We describe *Cinclodes espinhacensis* (Furnariidae), a new species discovered at high elevation in the southern portion of the Espinhaço Range, in the state of Minas Gerais, southeastern Brazil. This new taxon is closely related to the Long-tailed Cinclodes *Cinclodes pabsti*, endemic to Serra Geral, southern Brazil. We present diagnostic morphological, genetic and vocal characters that support the rank of species for this allopatric taxon. It is readily distinguishable from *C. pabsti* by its much darker back, chest and flanks, lower body mass, shorter tarsus-length, lower frequency of vocalizations, and longer duration of calls. DNA sequence data estimate that the divergence time between this new species and *Cinclodes pabsti* occurred *c.* 220 000 years ago, during the late Pleistocene. This discovery illustrates remarkable biogeographical connections among the cold regions of South America. The new species has a restricted range and we suggest it meets the criteria of the IUCN Red List category of Endangered.

**Keywords:** allopatry, campos rupestres, *Cinclodes espinhacensis*, Furnariidae, phylogeny, Pleistocene, Serra do Cipó.

The genus *Cinclodes* Gray, 1840 (Furnariidae) comprises 15 species (Renssen *et al.* 2011) that are widely distributed throughout the cold regions of southern and western South America (Renssen 2003, Fig. 1). Although the genus forms a well-defined monophyletic group (Chesser 2004), the species limits have been difficult to determine (Renssen 2003, Chesser 2004, Sanín *et al.* 2009). This difficulty reflects the fairly recent radiation of this genus relative to other avian genera with similar species richness, as demonstrated by the low degree of genetic differentiation among *Cinclodes* taxa (Chesser 2004). The species can be grouped into three major lineages: (1) those of Patagonia and the highlands of central Argentina; (2) those of the north-central Andean and Pacific coastline;

and (3) the basal taxon, Long-tailed Cinclodes *Cinclodes pabsti* Sick 1969, which is endemic to the Serra Geral Mountains, Rio Grande do Sul and Santa Catarina states, southern Brazil (Chesser 2004). *Cinclodes pabsti* is a relict taxon that is currently isolated from all other *Cinclodes* species (Sick 1985).

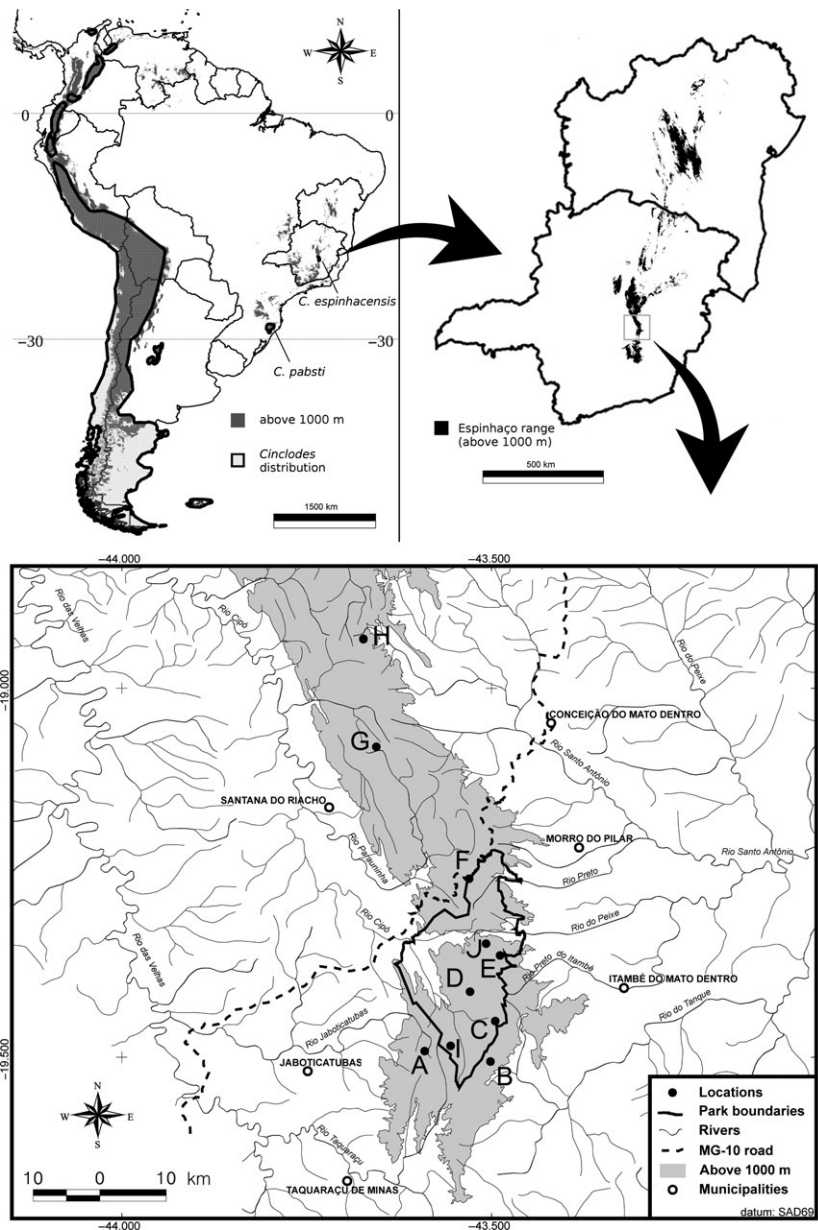
Two new locality records of *C. pabsti* were recently reported for Parque Nacional Serra do Cipó (hereafter P.N.S. Cipó), Minas Gerais, southeastern Brazil, more than 1000 km north of the known range limit of this species (Freitas *et al.* 2008): (1) 'Barraco de Tábua', Itambé do Mato Dentro municipality, where two individuals were seen and one was collected; and (2) at the 'Alto do Palácio' lodge, Morro do Pilar municipality, where one individual was observed in January and February 2007 (Fig. 1).

The Serra do Cipó region lies in the southern portion of the Espinhaço Range, which is one of Brazil's orogenic complexes that cross the Minas

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Unpublished for the purposes of zoological nomenclature (Art. 8.2, ICZN)



**Figure 1.** Upper left, geographical distribution of the genus *Cinclodes* (adapted from Vaurie 1980 and Remsen 2003, excluding the winter range of *Cinclodes fuscus fuscus*). The restricted distributions of *Cinclodes pabsti* and *Cinclodes espinhacensis* in south and southeastern Brazil are indicated. Upper right, the Espinhaço Range limits inside the Minas Gerais and Bahia states of Brazil. Below, *C. espinhacensis* localities mentioned in the text: (A) Serra da Lagoa Dourada, (B) Serra da Pedra Redonda, (C) Casa dos Currais, (D) Serra da Farofa, (E) Barraco de Tábua, (F) Alto do Palácio, (G) Serra do Breu, (H) Serra do Abreu, (I) Serra da Mutuca, (J) Travessão.

Gerai and Bahia states (Fig. 1). The Espinhaço Range supports a unique habitat above 900 m called ‘campos rupestres’, which is characterized primarily by quartzite rocky outcrops but also contains other habitats, including open fields and woodlands (Giulietti *et al.* 1997, Benites *et al.*

2003, Alves & Kolbek 2010). This habitat contains a large number of endemic plants and animals (Eterovick & Sazima 2004, Rapini *et al.* 2008, Vasconcelos *et al.* 2008b), many of which have biogeographical affinities to taxa in other mountains and cold environments in South America,

particularly the Andean and Patagonian biotas (Sick 1985, Vielliard 1990a, Harley 1995, Vasconcelos & Rodrigues 2010). Avian examples include Cipo Canastero *Asthenes luizae* (Furnariidae) and Hyacinth Visorbearer *Augastes scutatus*/ Hooded Visorbearer *Augastes lumachella* (Trochilidae), whose closest relatives are found in the Andes or Andean–Chacoan–Patagonian region (Silva 1995, Schuchmann 1999, Vasconcelos & Rodrigues 2010). *Asthenes luizae* and *Augastes scutatus* are the only birds recognized as endemic to the southern portion of the Espinhaço Range (Minas Gerais); the other three endemics are restricted to the northern portion (Bahia): Sincora Antwren *Formicivora grantsau* (Thamnophilidae), *A. lumachella* and Diamantina Tapaculo *Scytalopus diamantinensis* (Rhinocryptidae) (Bornschein *et al.* 2007, Vasconcelos *et al.* 2008b).

Understanding of Espinhaço birds has increased greatly in recent years (Melo-Júnior *et al.* 2001, Vasconcelos *et al.* 2008b, Vasconcelos & Rodrigues 2010). Many remarkable records have been made in the region (Costa *et al.* 2008, Mesquita *et al.* 2008, Vasconcelos *et al.* 2008a, Vasconcelos & Rodrigues 2010, Rodrigues *et al.* 2011), including the relatively recent discovery of three endemic bird species (Vielliard 1990b, Bornschein *et al.* 2007, Gonzaga *et al.* 2007). These recent discoveries indicate that poorly surveyed areas still remain in the region that might provide additional surprises.

The identification of *C. pabsti* in the Espinhaço Range initially provoked two hypotheses: (1) some *C. pabsti* individuals had recently dispersed there, which would also explain the absence of previous records in P.N.S. Cipó, one of the best surveyed areas in the Espinhaço; or (2) the individuals were members of an established allopatric population, which might represent a distinct taxon and not *C. pabsti*.

To investigate these hypotheses, we organized 10 expeditions to search for *Cinclodes* in the Serra do Cipó region and adjacent mountains from 2006 to 2011, where we found several individuals comprising a resident population. We collected data that provided morphometric, vocal and genetic evidence supporting the distinctiveness of the Espinhaço Range *Cinclodes* populations. Here we assess and discuss the taxonomic rank of this population under various species concepts currently in practice, since closely related allopatric taxa are difficult to delimit. We argue that our data support ranking the Espinhaço *Cinclodes* as a new species, which we formally describe and name.

## METHODS

We recorded over 30 *Cinclodes* individuals, including some in breeding pairs, at 10 localities in the Serra do Cipó region (Fig. 1). We collected 10 individuals and audio-recorded calls and songs. This material was compared with *C. pabsti* museum skins, DNA samples and audio recordings. For institutional acronyms see Appendix S1.

## Morphology

Colour names and codes are taken from direct comparison with the Munsell (2000) soil colour charts. External topographic anatomy nomenclature follows Proctor and Lynch (1993). Measurements were made following Baldwin *et al.* (1931), and were taken by G.H.S.F. with callipers and rounded to the nearest 0.1 mm. Body mass was measured either in the field before preparation using a Pesola spring scale and rounded to the nearest 0.1 g or, when available, on labels of *C. pabsti* specimens. Two birds that were captured with mist-nets and ringed were measured in the field.

The *C. pabsti* skins that were examined comprised: three males and three females, São Joaquim, Santa Catarina, Brazil (MNRJ 31114–31119); a male, São Francisco de Paula, Rio Grande do Sul, Brazil (MNRJ 32217); a female, Tainhas, Rio Grande do Sul (MNRJ 30325, holotype); a male and a female, Bom Jesus, Rio Grande do Sul (MZUSP 62539, 62540); a female, Bom Jesus, Rio Grande do Sul, (MHNCI 6273); a male, São José dos Ausentes, Rio Grande do Sul (MHNCI 6272). The following specimens were inspected from photographs provided by the curators of museums: sex unknown, Canela, Rio Grande do Sul (MCNRS 1306); two males, São Francisco de Paula, Rio Grande do Sul (MCNRS 1307, 2461); two males and a female, Bom Jesus, Rio Grande do Sul (MCNRS 2460, 2462, 2463); a male and a female, São José dos Ausentes, Rio Grande do Sul (MPEG 64821, 64823).

## Recordings and analyses of vocalizations

Vocalizations were recorded in the field by G.H.S.F., L.M.C., A.V.C. and L. C. Ribeiro using a Fostex FR-2LE or a Sony HI-MD MZ-RH910 field recorder with a Sennheiser ME-66 microphone and were

made at 44.1 kHz, 16 bits. The recordings were deposited at ASEC (16041–16073) and examples can be found in the Audio S1, S2 and S3. Recordings were obtained from at least 12 individual *Cinclodes* at the following localities in Minas Gerais: 'Casa dos Currais', Serra da Farofa, Serra da Mutuca, Serra da Lagoa Dourada (Jaboticatubas), Serra do Breu (Santana do Riacho), and Serra da Pedra Redonda (also known as 'Campo do Boi') (Itabira).

The *C. pabsti* vocalizations that were examined came from the following locations: Morro da Igreja, Urubici, Santa Catarina, Brazil (ASEC 12920–12932); Parque Nacional Aparados da Serra (BLSA 40048); Rio Grande do Sul (MLNS 34019, 43293); Urubici, Santa Catarina, three personal archives of V. Q. Piacentini; São Joaquim, Santa Catarina, one personal archive of V. Q. Piacentini; São Francisco de Paula, Rio Grande do Sul, one personal archive of E. Endrigo; São Joaquim, Santa Catarina, one personal archive of E. Endrigo. These recordings represent at least eight different individuals.

Spectrograms were generated, examined and measured using the RAVEN PRO v.1.4 software for LINUX (Cornell Laboratory of Ornithology, Bioacoustics Research Program, Ithaca, NY, USA), with a Blackman window type, a 256-sample size, a 3-dB filter and a 283-Hz bandwidth. We analysed both calls (i.e. single note vocalizations) and loudsongs (i.e. a series of notes). For the Minas Gerais populations, we measured 475 calls from 12 individuals and 26 loudsongs from four individuals. We also measured 225 calls from eight individuals and 30 loudsongs from at least four *C. pabsti* individuals. The parameters analysed for all the vocalizations included (from Charif *et al.* 2010) total duration (s), time max energy (s; the first time point in the vocalization at which the maximum energy, dB, occurs), peak frequency (Hz; the frequency at which the maximum energy first occurs), lowest frequency (Hz), highest frequency (Hz) and frequency range (Hz; highest minus lowest frequency). The parameters analysed only for the loudsongs were pace (number of notes per second), number of notes, and the duration, peak frequency and frequency range of the first, middle and last notes.

### Molecular data collection and analyses

We investigated DNA sequences from the nine *Cinclodes* sp. nov. specimens and the two mist-netted (not collected) birds. DNA was stored at BD-LBEM, and gene sequences were deposited in

GenBank (Appendix S2). *Cinclodes pabsti* tissues were obtained on loan from MPEG. DNA was also extracted from the metatarsal pad tissue of MHNCI specimens and from small pieces of thigh skin from MZUSP specimens. All other *Cinclodes* spp. sequences were retrieved from GenBank. For details of DNA extraction, see Chaves *et al.* (2008).

We compared the *Cinclodes* sp. nov. and *C. pabsti* sequences generated in the present study with previously published sequences of four mtDNA markers from other *Cinclodes* spp. (Chesser 2004, Fjeldså *et al.* 2004, Gonzalez & Wink 2008, Irestedt *et al.* 2009, Kerr *et al.* 2009, Sanín *et al.* 2009) to establish the relationships of the new species with other members of the genus. We made use of sequences of the COI, COII, ND3 and Cyt-*b* mtDNA genes. PCR, sequencing reactions and purification of amplified products were performed according to Chaves *et al.* (2008) and protocols were modified from Sanín *et al.* (2009) (see also the methods detailed in Appendix S3).

The alignments of the consensus sequences for all individuals and species were built using the CLUSTAL W algorithm available in the MEGA 4 software (Tamura *et al.* 2007). MEGA 4 was also used to estimate the number of intraspecific polymorphisms and the divergence between different haplotypes using the Kimura two-parameter (K2P) model of nucleotide substitution. We used the median-joining algorithm implemented in the software NETWORK v. 4.6 (Bandelt *et al.* 1999) to generate a network of haplotypes for the four concatenated mitochondrial genes.

We obtained 615 bp of COI, 684 bp of COII, 351 bp of ND3 and 878 bp of Cyt-*b* for all individuals, totalling 2528 bp of concatenated mtDNA sequences. The high-quality consensus sequences contained no insertions, deletions, stop codons or ambiguities that could suggest the presence of numts (Sorenson & Quinn 1998).

For phylogenetic reconstruction, we used the maximum parsimony (MP) and maximum likelihood (ML) approaches following Chesser (2004) and Sanín *et al.* (2009), implemented in PAUP\* (Swofford 1998) and PHYML v. 3.0 (Guindon & Gascuel 2003). Both analyses were conducted with 1000 bootstrap pseudo-replicates. The software BEAST v. 1.5.2 (Drummond & Rambaut 2007) was used to estimate the time of divergence among clades and to conduct a comparative Bayesian analysis of the tree topologies produced by

other methods. Both the ML and Bayesian analyses were run under the GTR+I+ $\Gamma$  model, which was selected as the best model according to the Akaike's information criterion (AIC) in MODELTEST v. 3.7 (Posada & Crandall 1998). We assumed a molecular clock calibration for mtDNA of 2.1% per million years, estimated for all orders of birds (Weir & Schluter 2008). As a calibration point of divergence time, we used the separation time between Scaly-throated Earthcreeper *Upucerthia dumetaria* and *Cinclodes* (mean 7.87 sd  $\pm$  1 million years ago, Mya) estimated by Irestedt *et al.* (2009). This divergence point is based on the basal separation of the *Acanthisitta* spp. lineage from the remaining passerines, and the split between New Zealand and Antarctica dated between 85 and 65 Mya. We used a normally distributed tree prior and a Yule Process speciation model with an uncorrelated log-normal distribution under a relaxed-clock model. The chains were run with the GTR+I+ $\Gamma$  model for 20 million generations with a random starting tree, and trees were sampled every 1000 generations.

## RESULTS

We propose to name this new *Cinclodes*

*Cinclodes espinhacensis* sp. nov.

Cipo *Cinclodes*

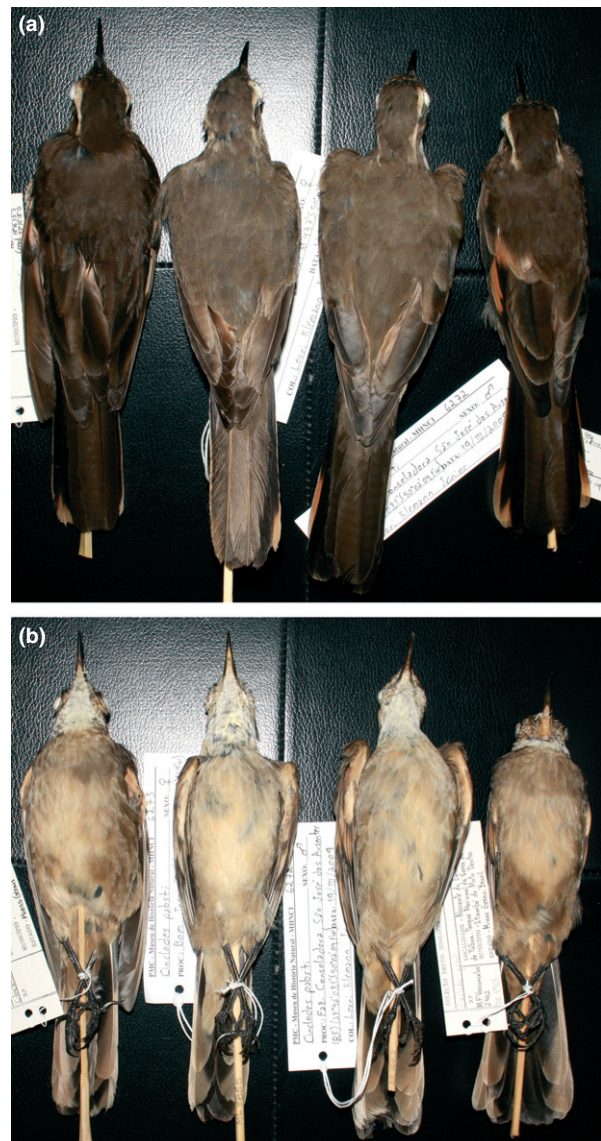
Pedreiro-do-Espinhaço (Portuguese)

### Holotype

DZUFMG 5763; adult male (skull 100% pneumatized); from Barraco de Tábuas, headwater of the Estancado stream (tributary of Rio Preto do Itambé), P.N.S. Cipó, Itambé do Mato Dentro, 19°21'S, 43°29'W, elevation c. 1495 m, southern portion of Espinhaço Range, Minas Gerais; collected on 27 February 2008 by G.H.S.F. and J. D. Ferreira, prepared by M. F. Vasconcelos; tissue sample BD-LBEM B3665.

### Diagnosis

Similar in plumage and shape to *C. pabsti*, except that it is much darker in coloration, particularly on the back (Fig. 2), and has a lower body mass. In *C. espinhacensis*, the forehead, crown, nape and auriculars appear very dark brown to black (10YR 2/1.5) compared with dark brown (10YR 3/3) in



**Figure 2.** Views (from left to right) of *Cinclodes espinhacensis* (DZUFMG 6357), *Cinclodes pabsti* (MHNCI 6273), *C. pabsti* (MHNCI 6272) and the holotype of *C. espinhacensis* (DZUFMG 5763): (a) dorsal view; (b) ventral view.

*C. pabsti*; the back, scapulars, rump, upper tail-coverts and the two central rectrices are very dark brown (10YR 2/2) compared with dark brown (7.5YR 3/4) in *C. pabsti*; the breast, side, flank, thigh feathers and crissum are yellowish brown (10YR 5/5) compared with light yellowish brown (2.5Y 6/3) in *C. pabsti*.

*Cinclodes espinhacensis* has a significantly lower body mass (mean 45.6 g, sd  $\pm$  2.23;  $n$  = 8) than *C. pabsti* (mean 53.56 g, sd  $\pm$  3.58;  $n$  = 13)

( $t$ -test = 5.60,  $P < 0.0001$ ; non-overlapping). It also has a significantly shorter tarsus-length (mean 29.4 mm,  $sd \pm 0.9$ ;  $n = 10$ ) than *C. pabsti* (mean 30.4 mm,  $sd \pm 0.8$ ;  $n = 12$ ) ( $t$ -test = 2.61,  $P = 0.017$ ; some overlap). Other morphological measurements did not differ significantly between the species (Table 1). The vocalizations differed significantly ( $P < 0.05$ ) between species in 11 acoustic metrics, including temporal and spectral measures (Table 2). The new species is also readily diagnosable by the DNA sequences of the COI, COII, Cyt-*b* and ND3 mtDNA genes (see below).

### Etymology

The specific epithet is a Latinized adjectival form of the name Espinhaço, in recognition of the great biological importance of this mountain chain ('Cadeia do Espinhaço'), where the new *Cinclodes* was discovered and to which it is apparently restricted. The term was first introduced by Eschwege (1822) from the German 'Rückenknöchengebirge' ('spinal bone mountains') and later geographically defined by Derby (1906). The Portuguese name also refers to their location of occurrence, whereas the English name refers to the region of the new species' type locality, the Serra do Cipó.

### Description of holotype

See Plate 1 and Figure 2: forehead, crown and nape colour midway between black and very dark

brown (10YR 2/1.5); back, scapulars, rump and upper tail-coverts very dark brown (10YR 2/2). A conspicuous very pale brown (10YR 8/4) superciliary stripe extends from the lores to the nape (c. 26 mm long and 3.5 mm wide). Malar stripe feathers very pale brown (10YR 8/4) with very dark brown (10YR 2/2) tips. Auriculars between black and very dark brown (10YR 2/1.5); the longer feathers' central areas very pale brown (10YR 8/4). Eye-ring very pale brown (10YR 8/4), although slightly interrupted antero-posteriorly. Anterior chin very pale brown (10YR 8/4); posterior chin and throat white (10YR 8/1) with traces of very dark brown (10YR 2/2) at the tip of some feathers, chiefly those at the sides of the throat and also at the tips of most of the posterior feathers of the throat, forming a collar. Breast brown (10YR 5/3); feather shafts on the upper breast very pale brown (10YR 8/4), and the most anterior feathers very pale brown (10YR 8/4) with brown (10YR 5/3) tips. Shoulder area very dark greyish brown (10YR 3/2). Abdomen very pale brown (10YR 7/4). Sides, flanks, thighs and under tail-coverts yellowish brown (10YR 5/5) and crissum white (10YR 8/1). Marginal and lesser secondary remige coverts very dark brown (10YR 2/2). Median and greater secondary coverts between black and very dark brown (10YR 2/1.5) with light yellowish brown (10YR 6/4) feather tips. Greater primary coverts black (10YR 2/1); the five outer coverts have a strong brown (7.5YR 5/8) spot (c. 14 mm long) on the outer vane. Leading

**Table 1.** Body mass (g) and morphological measurements (mm) of *Cinclodes pabsti* and *Cinclodes espinhacensis*. The values are the mean  $\pm$  sd, with the range and sample size in parentheses. Fledglings DZUFMG 6361 and 6362 are not included; two *C. espinhacensis* that were banded at the Serra do Breu locality on November 2009 are included. The body masses of *C. pabsti* were taken when available from the specimen labels.

Body mass	Culmen	Bill from nostril	Tarsus	Wing	Tail
<i>Cinclodes pabsti</i> (M)					
52.9 $\pm$ 2.4 (50.0–56.0; 7)	22.8 $\pm$ 0.7 (21.8–23.7; 6)	15.2 $\pm$ 1.2 (13.0–16.2; 6)	30.2 $\pm$ 1.1 (28.6–31.4; 6)	109.1 $\pm$ 3.2 (105.7–113.6; 6)	92.5 $\pm$ 1.7 (90.2–94.9; 6)
<i>Cinclodes pabsti</i> (F)					
55.1 $\pm$ 4.8 (49.0–62.0; 5)	23.6 $\pm$ 1.3 (22.2–25.2; 6)	15.5 $\pm$ 0.7 (14.6–16.4; 6)	30.5 $\pm$ 0.6 (29.9–31.3; 6)	107.2 $\pm$ 2.4 (103.9–110.4; 6)	89.2 $\pm$ 3.5 (84.5–94.2; 6)
<i>Cinclodes espinhacensis</i> (M)					
46.9 (46.9; 1)	23.0 $\pm$ 0.7 (22.2–23.4; 3)	15.0 $\pm$ 0.8 (14.2–15.8; 3)	29.9 $\pm$ 0.4 (29.4–30.2; 3)	106.9 $\pm$ 1.8 (104.9–108.5; 3)	90.8 $\pm$ 3.2 (88.9–94.5; 3)
<i>Cinclodes espinhacensis</i> (F)					
45.4 $\pm$ 2.3 (43.0–48.2; 7)	23.3 $\pm$ 0.7 (21.8–23.9; 7)	14.6 $\pm$ 0.4 (14.0–15.3; 7)	29.1 $\pm$ 0.9 (27.5–30.2; 7)	105.5 $\pm$ 4.3 (101.1–111.3; 7)	88.4 $\pm$ 2.4 (85.2–91.9; 7)
$P$ value of $t$ -test between species					
<0.0001	0.9230	0.0631	0.0167	0.1318	0.1950

**Table 2.** Measurements of selected parameters of calls and loudsongs of *Cinclodes espinhacensis* and *Cinclodes pabsti*: duration and time max energy (s), frequency (freq.) (kHz), pace (notes/s). The values are the mean  $\pm$  sd, with the range in parentheses.

	<i>Cinclodes espinhacensis</i>	<i>Cinclodes pabsti</i>	<i>P</i> value of <i>t</i> -test
		Call	
<i>n</i>	475	224	
Total duration	0.60 $\pm$ 0.10 (0.34–1.06)	0.44 $\pm$ 0.08 (0.13–0.61)	< 0.001*
Time max energy	0.03 $\pm$ 0.02 (0.00–0.27)	0.03 $\pm$ 0.04 (0.01–0.20)	0.204
Peak freq.	3.81 $\pm$ 0.38 (2.41–5.51)	4.11 $\pm$ 0.58 (2.58–6.55)	< 0.001*
Lower freq.	1.01 $\pm$ 1.46 (0.66–1.60)	1.10 $\pm$ 1.73 (0.74–1.95)	< 0.001*
Higher freq.	5.73 $\pm$ 0.93 (4.15–10.01)	5.81 $\pm$ 0.85 (4.13–9.20)	0.312
Range freq.	4.73 $\pm$ 0.93 (2.92–8.77)	4.71 $\pm$ 0.83 (3.00–8.03)	0.824
		Loudsong	
<i>n</i>	26	30	
No. of notes	36.65 $\pm$ 23.30 (12–135)	44.63 $\pm$ 15.13 (15–91)	0.130
Pace	14.24 $\pm$ 1.60 (10.50–16.85)	14.69 $\pm$ 1.27 (12.41–18.47)	0.246
Time max. energy	1.06 $\pm$ 0.24 (0.65–1.56)	1.44 $\pm$ 0.64 (0.32–2.80)	0.006*
Total duration	2.42 $\pm$ 1.28 (0.92–7.88)	2.96 $\pm$ 0.86 (1.15–4.89)	0.068
Peak freq.	4.18 $\pm$ 0.23 (3.79–4.65)	4.38 $\pm$ 0.36 (3.38–5.25)	0.016*
Lower freq.	1.45 $\pm$ 0.45 (0.77–2.68)	1.47 $\pm$ 0.32 (0.60–2.18)	0.859
Higher freq.	5.67 $\pm$ 0.38 (5.01–6.29)	6.18 $\pm$ 5.12 (4.78–7.00)	< 0.001*
Range freq.	4.22 $\pm$ 0.73 (2.38–5.33)	4.71 $\pm$ 0.58 (3.32–5.78)	0.007*
First note duration	0.02 $\pm$ 0.01 (0.01–0.03)	0.02 $\pm$ 0.01 (0.01–0.04)	0.030*
First note peak freq.	3.29 $\pm$ 0.28 (2.76–3.79)	3.60 $\pm$ 0.66 (2.44–5.06)	0.038*
First note range freq.	1.46 $\pm$ 0.44 (0.77–2.64)	2.01 $\pm$ 0.53 (0.94–3.30)	< 0.001*
Middle note duration	0.05 $\pm$ 0.08 (0.02–0.43)	0.04 $\pm$ 0.01 (0.01–0.06)	0.249
Middle note peak freq.	4.18 $\pm$ 0.301 (3.62–4.82)	4.32 $\pm$ 0.41 (3.00–5.06)	0.181
Middle note range freq.	3.33 $\pm$ 0.69 (1.93–4.30)	3.59 $\pm$ 0.64 (2.20–5.19)	0.163
Last note duration	0.03 $\pm$ 0.05 (0.01–0.26)	0.02 $\pm$ 0.01 (0.01–0.03)	0.349
Last note peak freq.	3.17 $\pm$ 0.75 (1.38–4.48)	3.42 $\pm$ 0.52 (2.07–4.13)	0.150
Last note range freq.	1.94 $\pm$ 0.53 (0.67–2.89)	2.48 $\pm$ 0.63 (1.39–4.46)	0.002*

\*Significant differences ( $P < 0.05$ ).

edge very pale brown (10YR 8/4), alula very dark brown (10YR 2/2), axillary region yellow (10YR 7/8), wing lining dark greyish brown (10YR 4/2). Primaries and secondaries black (10YR 2/1) with two transverse bars; anterior bar most conspicuous, beginning slightly on the inner vane of P8 with a strong brown tone (7.5YR 4/6), pronounced in P7 (c. 34 mm long) but also restricted to the inner vane with a strong brown tone (7.5YR 5/8), forming a strong brown (7.5YR 5/8) transversal stripe (c. 18 mm wide) from P6 to the secondaries; posterior bar strong brown (7.5YR 5/6), imbuing the margin of the outer vane (c. 16 mm) of P4, and extends over all secondaries. Tertiaries very dark brown (10YR 2/2), outer vane black (10YR 2/1) with outer edge grading to light grey (10YR 7/2). Central rectrices very dark brown (10YR 2/2), and other rectrices black (10YR 2/1); the three outer pairs have a strong brown (7.5YR 5/8) apical spot on the dorsal side of tail, and very pale brown (10YR 7/4) on the ventral side. This spot is c. 45.2 mm long in the sixth rectrix and c. 11 mm

long in the third. Soft parts in life: iris very dark brown; bill black, and lower mandible base greyish; tarsus and feet black.

### Measurements of holotype

Total culmen length 22.2 mm; length of bill from nostril 14.9 mm; height of bill at nostrils 4.8 mm; length of closed wing 104.9 mm; tail-length 88.9 mm; tarsus-length 29.4 mm; left testis 5.3  $\times$  3.0 mm.

### Paratypes

In addition to the holotype, there are nine paratypes of *C. espinhacensis*. One adult male (DZUFMG 6357), skull 100% pneumatized, was collected on 2 September 2009 at 'Casa dos Currais', P.N.S. Cipó, Jaboticatubas, Minas Gerais, 1465 m by G.H.S.F. and A.V.C.; the specimen was prepared by G.H.S.F. and its vocalization was recorded with digital copies deposited at the



**Plate 1.** *Cinclodes espinhacensis* sp. nov. holotype (upper left) with paratype fledgling. Watercolour by Belkiss Alméri.

ASEC (ASEC 16041–16048). On 16 and 17 November 2009, G.H.S.F., L.M.C. and M. F. Vasconcelos collected six individuals (prepared by M.F. Vasconcelos) on Serra do Breu, Santana do Riacho, Minas Gerais, 1430–1520 m: DZUFMG 6363, adult female, skull 100% pneumatized, reticulated ovary (8 × 5 mm), ova 1 mm; DZUFMG 6364, adult female, skull 100% pneumatized, reticulated ovary (9.1 × 3.6 mm), ova 1.2 mm; DZUFMG 6365, adult female, skull 100% pneumatized, reticulated ovary (8.6 × 4.1 mm), ova 1.6 mm; DZUFMG 6361, fledgling male, 51.2 g, skull 10% pneumatized, testes 1.2 × 1 mm; DZUFMG 6362, fledgling female, 52.2 g, skull 10% pneumatized, smooth ovary 5.8 × 2.6 mm; DZUFMG 6366, juvenile female, skull 30% pneumatized, smooth ovary 2.0 × 1.3 mm. On 23 February 2010, G.H.S.F. and L. C. Ribeiro collected an individual at Serra da Lagoa Dourada, Jaboticatubas, 1584 m: MZUSP 90449, subadult female, skull 90% pneumatized, smooth ovary 4.2 × 2.5 mm; its voice was recorded, and digital copies were deposited at ASEC (16069, 16070). On 5 March 2011, G.H.S.F. and L.M.C. collected an individual at Travessão, headwaters of Rio do Peixe, P.N.S. Cipó, Itambé do Mato Dentro, 1350 m: MNRJ 48171,

subadult female, skull 80% pneumatized, smooth ovary 4.0 × 2.0 mm.

### Variation within the type series

The specimens DZUFMG 6363 and 6365, and MZUSP 90449 have a pale brown (10YR 6/3) breast, not contrasting with the white throat, and a very pale brown (10YR 7/3) abdomen. These specimens, along with DZUFMG 6357 and 6364, have a white edge on the outer vanes of P6, P5 and the greater primary coverts.

The two paratype fledglings (DZUFMG 6361, 6362) are similar in plumage to the holotype (see Plate 1), with the following exceptions: the forehead, crown and nape are very dark grey (10YR 3/1), and the back, scapulars, rump and upper tail-coverts are very dark greyish brown (10YR 3/2). The breast feathers are pale brown (10YR 8/4) with dark greyish brown (10YR 4/2) tips and a light rachis that gives a scaled appearance. Some of the feathers on the abdomen and sides have dark tips. The posterior nuchal region feathers have dark tips. There are neossoptiles that remain as tufts at the tips of some feathers, mainly on the dorsal region. The gape is yellow.



The juvenile of the type series (DZUFMG 6366), whose skull was 30% pneumatized, was collected in the breeding season; it was foraging with at least four other individuals, two of which were adult females (DZUFMG 6365 and 6364). It has worn plumage with broken feather tips, particularly on the rectrices and remiges. The plumage (and behaviour) was like that of an adult, except that the feathers of the breast were similar to the fledglings described above and the superciliary stripe was white, not pale brown. Sick (1973) reported this juvenile breast pattern in *C. pabsti*, probably referring to the specimen MNRJ 31114, but no data pertaining to the skull are available on the specimen label. The specimens MZUSP 90449 and MNRJ 48171 do not have completely pneumatized skulls (80–90%) but their plumage is indistinguishable from that of the adults.

### Vocalizations

*Cinclodes espinhacensis* has two general categories of vocalization (Fig. 3), with some minor variation. The loudsong (following Willis 1967) is a series of notes that gradually increase in duration, energy, frequency and frequency range from the beginning to the middle of the sequence, and then decrease in the same parameters until the end (Fig. 3e). The peak frequency (*c.* 4.18 kHz) occurs *c.* 1.06 s after song onset, when the notes are approximately twice as long (*c.* 0.05 s) as the first (*c.* 0.02 s) and last (*c.* 0.03 s) notes. The pace of the song (mean 18.11 notes/s, range = 9.8–23.04, *sd* = ± 3.48) increases towards the end. Some sequences of subsequent but spliced songs are very long, and this pattern of increase and decrease of note duration, frequency and energy is continuously repeated (Audio S3). It is possible to distinguish three overtones of the fundamental notes. We recorded one sequence showing high modulation of the first notes, which is also found in *C. pabsti*.

The call of *C. espinhacensis* is typically of one note (Fig. 3a) with frequency modulation. The interval between call emissions has an average duration of 4.72 s (range = 0.61–32.78 s, *sd* = ± 4.48, *n* = 172). The maximum energy is usually in the fundamental frequency (87.2% of calls), with a ‘peak frequency’ of *c.* 3.81 kHz and a ‘time max energy’ *c.* 0.03 s from the beginning. In some cases, the maximum energy occurs in the first overtone (12.8% of calls) and can occur at the beginning of the call (‘time max energy’

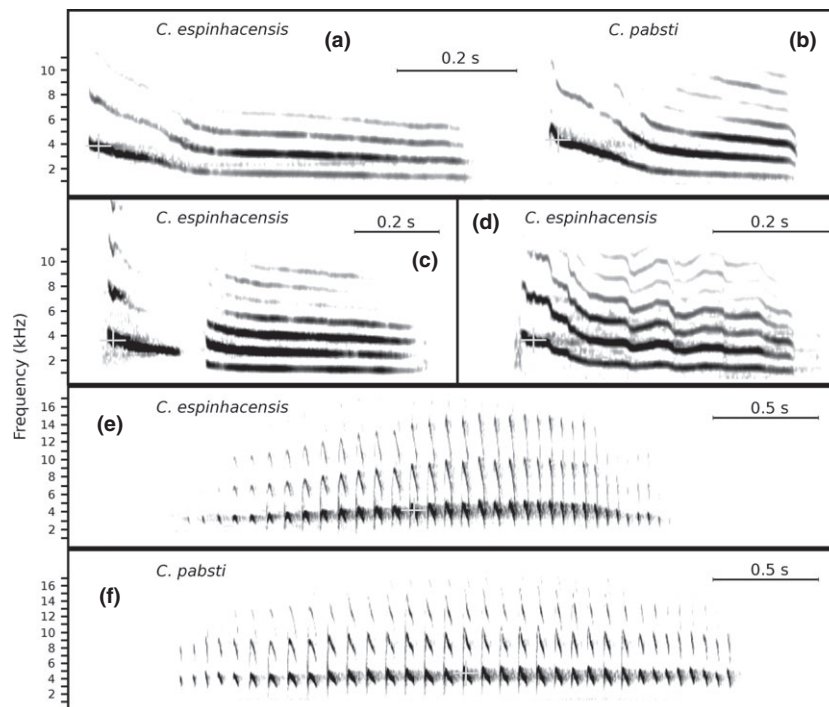
at *c.* 0.03 s) with a ‘peak frequency’ of *c.* 4.73 kHz (72.1% of those cases), or in the middle of the call (‘time max energy’ at *c.* 0.28 s) with a ‘peak frequency’ of *c.* 3.56 kHz. Infrequently (7.37% of calls), we recorded a two-note call (Fig. 3c, Audio S2) with the same structure as the normal call but with a gap between the notes averaging 0.15 s (range = 0.01–0.7, *sd* = ± 0.2). Another infrequent variation (0.6% of calls) was a highly modulated call (Fig. 3d).

Although the vocalizations of *C. pabsti* and *C. espinhacensis* are similar (Fig. 3), 11 acoustic measurements were significantly differentiated between them (Table 2). The calls of the new species are longer and have a lower ‘peak frequency’ and a lower ‘lower frequency’ (Fig. 3a vs. 3b). The loudsongs of *C. espinhacensis* have lower ‘time max energy’, ‘peak frequency’, ‘higher frequency’ and ‘frequency range’ values (Fig. 3e vs. 3f). The first note of the loudsongs of *C. espinhacensis* is shorter, with a lower ‘peak frequency’ and ‘frequency range’, and the last note also has lower ‘range frequency’.

### Geographical distribution

*Cinclodes espinhacensis* is restricted to the southern Espinhaço Range (Serra do Espinhaço Meridional), occurring from Serra da Pedra Redonda (Jaboticatubas) to Serra do Abreu (Congonhas do Norte) (Fig. 1). Its southernmost locality is *c.* 1140 km from the northernmost locality of *C. pabsti*, at Paineira, Santa Catarina (Sick 1973). Although the species can occur at altitudes of 1100 m (e.g. on the western base of Serra do Breu), it is recorded only in association with the highest mountains, *c.* 1500 m altitude, where the moist air mass from the Atlantic ocean is trapped, forming frequent misty conditions, termed the ‘nebular belt’ (Ribeiro *et al.* 2009). In these restricted areas of Serra do Cipó, a very rare and endemic ‘arborescent herb’, *Vellozia gigantea*, also occurs (Velloziaceae; see Fig. 4a; Ribeiro *et al.* 2009, Lousada *et al.* 2011).

Considering that the southernmost location of *C. espinhacensis* is only 50 km from the city of Belo Horizonte, it is surprising that it remained undiscovered for so long. The difficulty of accessing the region may have made its discovery challenging. *Cinclodes espinhacensis* is found high on mountaintops, far from roads and habitation, and surveys have traditionally been undertaken close to the only paved road that crosses the region (MG-10 road; Madeira *et al.* 2008).



**Figure 3.** Sound spectrograms of the principal vocalizations of Brazilian *Cinclodes*: (a) *Cinclodes espinhacensis* call, Audio S1; (b) *Cinclodes pabsti* call, ASEC 12920; (c) *C. espinhacensis* infrequent variant of call with a gap cutting in two notes, ASEC 16054; (d) *Cinclodes espinhacensis* infrequent variant of the call with modulation, ASEC 16045; (e) *Cinclodes espinhacensis* loudsong, ASEC 16042; (f) *Cinclodes pabsti* loudsong, ASEC 12931. Grey crosses indicate the time max energy and the peak frequency.

### Habitat and behaviour

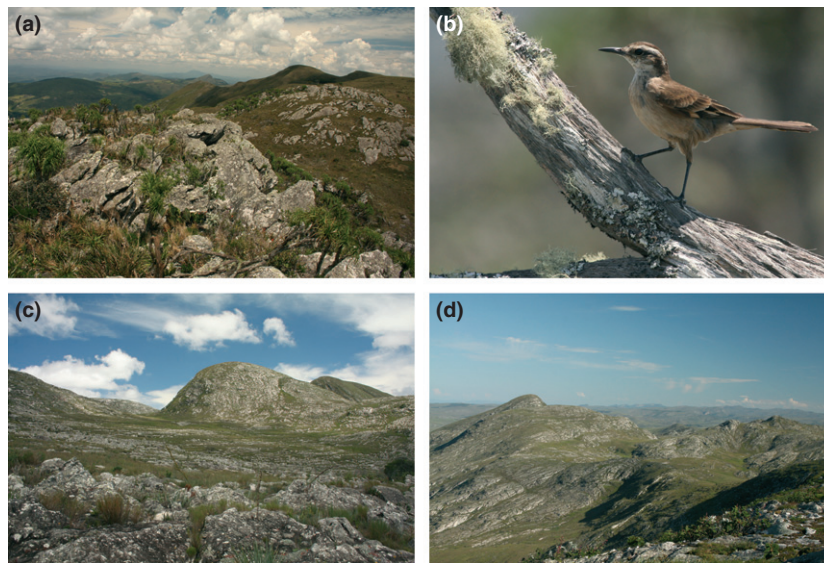
*Cinclodes espinhacensis* occurs in campos rupestres habitats on the highest hilltops, which are covered by rocky outcrops and surrounded by open fields typically composed of Velloziaceae, Eriocaulaceae and Xyridaceae plants (Fig. 4a,c,d; Giulietti *et al.* 1997). Although some similarities exist (Almeida *et al.* 2004), the campos rupestres habitat differs from that where *C. pabsti* occurs in Serra Geral, a subtropical grassland called 'campos', by having more complex plant communities and a greater predominance of rocky outcrops (Alves & Kolbek 2010, Overbeck *et al.* 2007).

*Cinclodes espinhacensis* forages on quartzite outcrops, as with the syntopic *Asthenes luizae*, and also through open fields, gleaning arthropods from crevices, lichens, mosses or grasses (Video S1). We observed nest burrows in the peat bogs that were found among the rocky outcrops. Other bird species that typically occurred in these campos rupestres included Grey-breasted Sabrewing *Campylopterus largipennis* (Trochilidae), *Augastes scutatus* (Trochilidae), Rock Tapaculo *Scytalopus*

*petrophilus* (Rhinocryptidae), *Asthenes luizae* (Furnariidae), Grey-backed Tachuri *Polystictus superciliaris* (Tyrannidae) and Serra Finch *Embernagra longicauda* (Emberizidae).

The general behaviour of *C. espinhacensis* is similar to that reported for its congeners (Vaurie 1980, Remsen 2003). We observed some individuals close to houses, a behaviour commonly reported for *C. pabsti* (Sick 1973) and Buff-winged *Cinclodes fuscus* (Vaurie 1980). However, we only observed isolated individuals near houses that are located far from rocky outcrops, where the core of the populations occurs: these houses, at Barraco de Tábuia and Casa dos Currais, were not permanently occupied by humans. We also recorded one individual inhabiting the area surrounding the lodge of Alto do Palácio for a few days (Freitas *et al.* 2008, Rodrigues *et al.* 2011). Due the absence of any *C. espinhacensis* population near this lodge and the bird's brief stay there, we considered the individual to be a possible vagrant.

When excited, *C. espinhacensis* sings non-stop and sometimes slightly erects the crown feathers. It often sings while perched on *Vellozia* spp. or



**Figure 4.** Habitat of *Cinclodes espinhacensis* in Serra do Cipó, Minas Gerais, Brazil: (a) Serra da Pedra Redonda, showing rocky outcrops with *Vellozia gigantea* upon which a subadult is perched (b); (c) Serra do Breu, view of the rocky outcrops that occur on the hilltops; (d) 'Pico do Breu', the highest peak of the region, reaching 1687 m (Photos: G. H. S. Freitas).

rocks (Fig. 4b; Video S1); sometimes it sings in flight. While emitting the loudsong, it sometimes lowers and vibrates the wings.

### Molecular analyses

We found two mtDNA haplotypes exclusive to *C. pabsti* and two exclusive to *C. espinhacensis* (Fig. 5). Among all of the concatenated mtDNA genes, we identified 11 substitutions at 11 polymorphic sites, of which eight were parsimony-informative. The K2P genetic distances between *C. pabsti* and *C. espinhacensis* estimated for the COI, COII, ND3 and Cyt-*b* genes were 0.0024, 0.0017, 0.0059 and 0.0047, respectively. Similarly, small genetic distances were also observed between other pairs of *Cinclodes* species: Peruvian Seaside *Cinclodes* *taczanowskii*/Chilean Seaside *Cinclodes* *nigrofumosus*, Royal *Cinclodes* *aricomae*/Stout-billed *Cinclodes* *excelsior* and Grey-flanked *Cinclodes* *oustaletii*/Olog's *Cinclodes* *obrogi* (Table 3).

The trees obtained from the ML, MP and Bayesian analyses exhibited different degrees of resolution and were not topologically congruent for the species of Clade 1 (Fig. 6). As in Sanín *et al.* (2009), support for most branches in Clade 1 was poor, and the internodes were short.

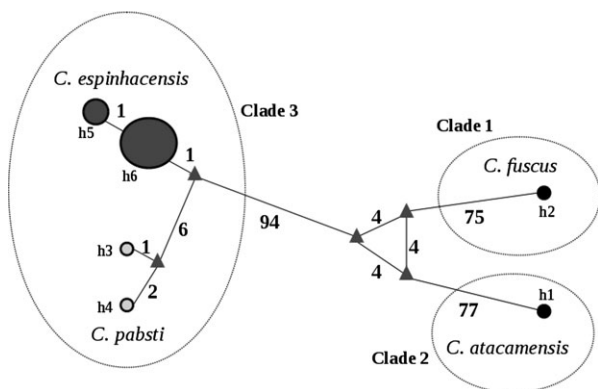
All of the tested phylogenetic reconstruction methods place *C. espinhacensis* as the sister species

to *C. pabsti*. The separation of those two species is estimated at *c.* 220 000 years ago (100–460 kya), during the 'Ionian' and Late Pleistocene (Fig. 6). The origin of the genus *Cinclodes* is dated at *c.* 7.34 Mya, during the Late Miocene. The Early Pliocene marks the separation of the Andean–Patagonian lineages (Clade 1 + 2) from the Brazilian highlands lineage (Clade 3) *c.* 4.25 Mya. The diversification of the genus occurred mainly during the Pleistocene, with all extant species being derived from lineages diverging between 2.5 Mya and 87 kya. Our estimates indicate that the most recent speciation event is the split of the sister species *C. nigrofumosus* and *C. taczanowskii*, which may have diverged as recently as *c.* 87 kya.

## DISCUSSION

### Systematics and biogeography

Our *Cinclodes* phylogeny has a similar topology to that of Chesser (2004), but with *C. espinhacensis* sister to *C. pabsti* on the basal branch (forming clade 3), and in turn these two taxa are sister to all of the other *Cinclodes* species (clades 1 and 2). The Brazilian species differ from the others in that they have longer tails and tertials (Sick 1969), which may represent apomorphies, although a careful analysis of all *Cinclodes* species should be undertaken.



**Figure 5.** Haplotype network showing relationships among *Cinclodes espinhacensis* and *C. pabsti* mtDNA sequences. The number of mutations is proportional to the connector length between haplotypes. The size of the circle is proportional to the number of individuals for each haplotype. Triangles represent median vectors.

*Cinclodes pabsti* and *C. espinhacensis* probably diverged in the Late Pleistocene, one of the most recent allopatric speciation events within the genus. Climatic changes during the Pleistocene are thought to have been important in shaping the

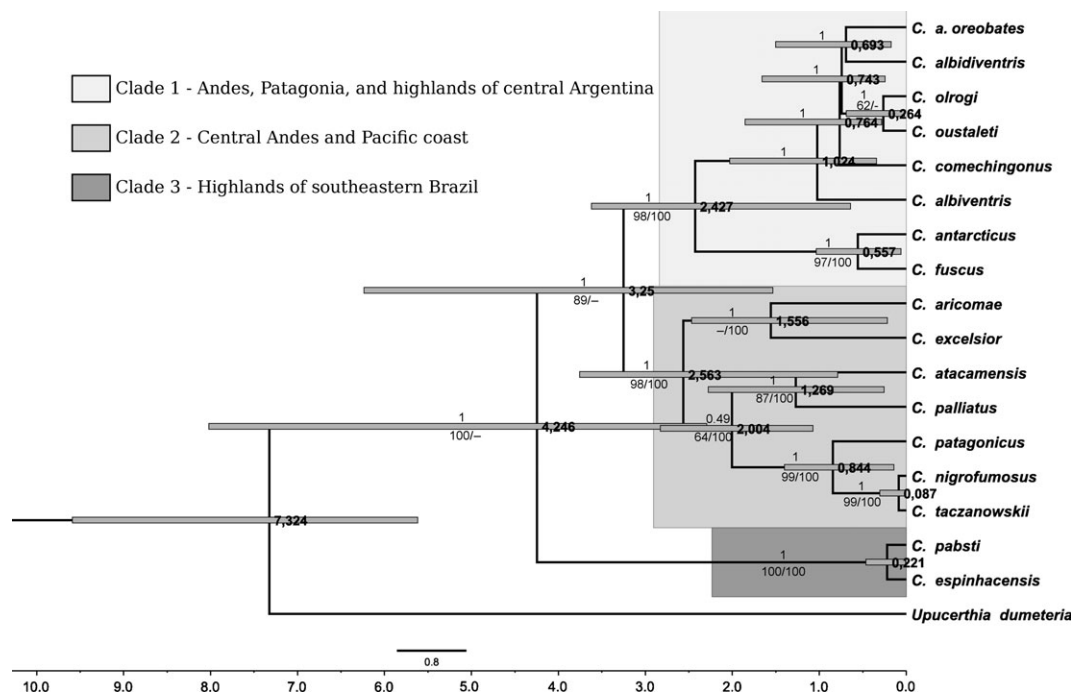
composition of the modern fauna and flora of the Brazilian mountains (Vuilleumier 1971, Simpson 1979, Silva 1997) and the recent divergence of some bird taxa, such as Spinetails *Cranioleuca* (García-Moreno *et al.* 1999) and Ground Tyrants *Muscisaxicola* (Chesser 2000). The two Brazilian *Cinclodes* species are a rare case of two allopatric and related species that are endemic to distinct Brazilian mountains, as has also been observed for *Augastes scutatus* and *A. lumachella*, and for *Scytalopus* spp. (Mata *et al.* 2009). In other cases, isolation created disjunct distributions within species, such as in *Polystictus superciliaris* and *Embernagra longicauda*, which are patchily distributed among the various mountains chains in southeastern Brazil (Silva 1995, Vasconcelos *et al.* 2008b).

*Cinclodes espinhacensis* is the third bird recognized as restricted to the southern Espinhaço Range, supporting this region's designation as an endemic bird area (Vasconcelos *et al.* 2008b). The other two endemic taxa have a similar relictual distribution, with their relatives occurring in the Andean (*Augastes scutatus*) or Andean–Patagonian regions (*Asthenes luizae*) (Silva 1995, Vasconcelos *et al.* 2008b), and *C. espinhacensis* reinforces this recurrent biogeographical pattern.

Disjunct distributions between the southeastern Brazilian highlands and the Andean region occur in many groups of organisms, particularly plants (Harley 1995, Safford 1999, Fiaschi & Pirani 2009) but also birds (Sick 1985, Silva 1995). Other taxa also show discontinuities between the mountains of southeastern Brazil and the subtropical region of southern South America. These taxa include some plants of Serra da Mantiqueira (between Espinhaço and Serra Geral) and Serra Geral (Safford 1999, Almeida *et al.* 2004); bees in the highlands of southeastern Brazil and lowlands or highlands of southern Brazil (Silveira & Cure 1993); the anuran pairs *Scinax pinima*/*Scinax uruguayus* and *Bokermannohyla martins*/*Bokermannohyla langi*, with the former member of each pair restricted to southern Espinhaço and the latter member distributed in southern Brazil (*B. langi*) or also in Argentina and Uruguay (*S. uruguayus*) (Leite *et al.* 2008); mammals of the genus *Akodon* in Serra da Mantiqueira and southern Brazil and Argentina (Gonçalves *et al.* 2007); and the lizard *Placosoma cipoense*, which is restricted to Serra do Cipó, and related species distributed in Santa Catarina, São Paulo and Rio de Janeiro (Uzzell 1959, Rodrigues 2008). In addition, there are species

**Table 3.** Kimura two-parameter mitochondrial DNA distances between *Cinclodes* species.

Species pairs		Distance K2P	
Species 1	Species 2	COII	ND3
<i>C. taczanowskii</i>	<i>C. nigrofumosus</i>	0.0015	0.0029
<i>C. pabsti</i>	<i>C. espinhacensis</i>	0.0017	0.0059
<i>C. oustaleti</i>	<i>C. olrogi</i>	0.0048	0.0049
<i>C. albiventris/tucumanus</i>	<i>C. oustaleti</i>	0.0077	0.0041
<i>C. albiventris/tucumanus</i>	<i>C. olrogi</i>	0.0074	0.0055
<i>C. antarcticus</i>	<i>C. fuscus</i>	0.0119	0.0097
<i>C. patagonicus</i>	<i>C. nigrofumosus</i>	0.0078	0.0029
<i>C. patagonicus</i>	<i>C. taczanowskii</i>	0.0094	0.0322
<i>C. albiventris/tucumanus</i>	<i>C. albidiventris oreobates</i>	0.0375	0.0048
<i>C. aricomae</i>	<i>C. excelsior</i>	0.0259	0.0322
<i>C. comechingonus</i>	<i>C. olrogi</i>	0.0282	0.0441
<i>C. albidiventris</i>	<i>C. albidiventris oreobates</i>	0.0396	0.0280
<i>C. comechingonus</i>	<i>C. oustaleti</i>	0.0342	0.0428
<i>C. albiventris/tucumanus</i>	<i>C. comechingonus</i>	0.0363	0.0431
<i>C. atacamensis</i>	<i>C. palliatus</i>	0.0485	0.0289
<i>C. albiventris/tucumanus</i>	<i>C. fuscus</i>	0.0400	0.0510



**Figure 6.** Bayesian Tree with divergence time and phylogenetic relationships within the genus *Cinclodes*. The grey bar represents the divergence time with the 95% HPD confidence interval. Posterior probabilities are listed above the branches, and bootstrap support values for parsimony and maximum likelihood analyses are listed beneath the branches (MP/ML). Bootstrap support from ML and MP were omitted when they were not consistent with the Bayesian tree topology presented here.

with disjunct populations, such as the birds Marsh Tapaculo *Scytalopus iraiensis* and Lesser Grass Finch *Emberizoides ypiranganus*, which occur in the southern Espinhaço Range and southward from southern Minas Gerais (Costa *et al.* 2008, Vasconcelos *et al.* 2008a). The vicariant pair *C. espinhacensis* and *C. pabsti* suggests that there is another important biogeographical connection between Serra Geral and Espinhaço Range that has not yet been studied in detail. It is surprising that both taxa are absent from the Serra da Mantiqueira and Serra do Mar, higher mountain ranges (> 2000 m) that are floristically similar to Serra Geral (Safford 2007).

*Cinclodes pabsti* was previously viewed as a Pleistocene ice-age relict (Sick 1973, 1985); however, the DNA sequence data indicates that the separation of the Brazilian clade occurred much earlier, probably in late Miocene-Pliocene (see also Derryberry *et al.* 2011). Although there was a large error associated with our estimate of divergence time, it is similar to that reported by Derryberry *et al.* (2011). The major diversification of the South American vertebrate fauna (Garda &

Cannatella 2007), including birds (Tambussi 2011), occurred during this period. The isolation (in the Espinhaço Range) of *A. luizae* from other Andean–Patagonian sister taxa could also have occurred during the Late Miocene (see fig. 1 in Derryberry *et al.* 2011).

During the Late Miocene–Pliocene, many geological and climatic changes occurred in South America that may have acted as vicariant barriers (Ortiz-Jaureguizar & Cladera 2006). During the Middle–Late Miocene, successive marine transgressions separated the Brazilian Shield from the Andean chain and from the Guayana Shield (Räsänen *et al.* 1995, Hernández *et al.* 2005). Severe drought-like conditions marked the Late Miocene–Pliocene, forming an arid corridor and enabling colonization of the highlands of southeastern Brazil and the Andean region, which at that time harboured more suitable, moister climates and thereby provided refuges for the ancestors of the extant mountain flora (Safford 1999). Faunistic interchanges within southern South America were also influenced by numerous glaciation events during the Late Miocene–Pliocene (Rabassa *et al.*

2005). Although the vicariant barrier hypothesis is plausible, given the strong flight capabilities of *Cinclodes* (Remsen 2003), an alternative hypothesis of early dispersal should also be considered.

### Species status

*Cinclodes espinhacensis* differs markedly from *C. pabsti* in its plumage colour tones. The plumage coloration differences that we documented are reliable, as we sampled specimens of both juveniles and adults throughout the year (*C. pabsti*: November–April and July; *C. espinhacensis*: February, May, September and December) and included fresh skins of *C. pabsti*. Furthermore, Gloger's rule (Zink & Remsen 1986) cannot explain the darkness of *C. espinhacensis* because southern Brazil is wetter than the Espinhaço Range in Minas Gerais (IBGE 2002).

Genetically, these two sister taxa are reciprocally monophyletic. In addition, they differ subtly in their vocalizations and habitat use. Their unequivocal allopatric distribution inhibits current gene flow. Therefore, *C. espinhacensis* is recognizable as a full species under the Phylogenetic Species Concept (Cracraft 1997) and the General Lineage Species Concept (de Queiroz 2005, 2007).

To assess the taxonomic rank of allopatric taxa under the Biological Species Concept, comparisons of the degree of differences among related species are often used (Isler *et al.* 1998, Helbig *et al.* 2002, Remsen 2010, Tobias *et al.* 2010). The genetic differences between *C. espinhacensis* and *C. pabsti* are small, but the overall maximum intrageneric sequence divergence is also relatively low, including the divergence among other taxa ranked as species (Chesser 2004, Sanín *et al.* 2009). The genetic distance between the Brazilian pair is greater than that observed between some *Cinclodes* taxa treated as species, including the sympatric pairs Dark-bellied *Cinclodes* *C. patagonicus*/*C. nigrofumosus* and Grey-flanked *Cinclodes* *C. oustaleti*/Cream-winged *Cinclodes* *Cinclodes albiventris* (Table 3). The differences in plumage between the two taxa in the Brazilian clade are comparable to those observed between other closely related species of *Cinclodes*, e.g. *C. nigrofumosus*/*C. taczanowskii*, *C. olrogi*/*C. oustaleti*, and *C. excelsior*/*C. aricomae* (Remsen 2003), as well as between species formerly treated as subspecies of *C. fuscus* (Sanín *et al.* 2009).

The sister taxa *C. nigrofumosus*/*C. taczanowskii* have low species rank support but were considered to be distinct species in the absence of conclusive data (Chesser 2004, Remsen *et al.* 2011). The genus *Cinclodes* underwent a very early diversification, as is apparent from the many similarities in morphological (Vaurie 1980, Jaramillo 2003), genetic (Chesser 2004, Sanín *et al.* 2009) and vocal traits (Jaramillo 2003) observed among many species. Here, we presented data that support the species status of two similar species occupying the Brazilian highlands and reinforce the importance of detailed investigation, especially with respect to morphological and vocal traits, for taxonomy.

### Conservation

The new species occurs in the southern portion of the Espinhaço Range, a region with unique fauna and flora that is threatened by rapid growth of tourism, land conversion, mining activity, burning for livestock grazing and other activities (Drummond *et al.* 2005, Jacobi *et al.* 2007, Martinelli 2007, Ribeiro & Freitas 2010). Many of the sites where the new taxon was observed outside the P.N.S. Cipó are located on livestock farms that follow the traditional management practice of an annual fire at the peak of the dry season; these fires sometimes reach the interior of the P.N.S. Cipó (França & Ribeiro 2008). All these activities can substantially affect the soil, and the diversity and structure of vegetation (Giulietti *et al.* 1997), thereby changing the campos rupestres habitat. Moreover, the endemic taxa of campos rupestres are among the most vulnerable to global climate change in Brazil due to their higher altitudes and relatively lower temperature (e.g. *A. luizae*; BirdLife International 2011, Şekercioğlu *et al.* 2012).

The range of *C. espinhacensis* is estimated at approximately 490 km<sup>2</sup> (by the Minimum Convex Polygon method), considering the known localities. It probably occupies a much smaller area, given the species' habitat requirements (rocky outcrops and open fields located at the highest hilltops). This distributional range is much narrower than those of other birds restricted to the campos rupestres (e.g. 4190 km<sup>2</sup> for *A. luizae*; BirdLife International 2011).

The nine locations where populations of *C. espinhacensis* were recorded (Fig. 1, excluding point F, where a single bird was reported for a brief period) can be grouped into four main localities: inside P.

N.S. Cipó (points C, D, I, J), the vicinity of P.N. S. Cipó (A, B), Serra do Breu (G) and Serra do Abreu (H). This grouping scheme takes into account the greater protection of the Conservation Unit, the relative protection of the surrounding area, and the isolation of the other two localities (following definitions of IUCN 2001).

Considering the small number of known locations for this species and the potential for habitat reduction or alteration, we suspect that *C. espinhacensis* is currently threatened with extinction. We provisionally suggest listing this new taxon as Endangered, following the International Union for Conservation of Nature criteria EN B1ab(iii)+2ab(iii) (i.e. its extent of occurrence and area of occupancy are estimated to be less than 5000 and 500 km<sup>2</sup>, respectively; it is known to exist at no more than five locations; and its area, extent and/or quality of habitat are projected to continuously decline) (IUCN 2001). Further research on areas of occurrence, population size and detailed habitat requirements are needed to improve the conservation status assessment of *C. espinhacensis*.

We are deeply indebted to L. C. Ribeiro and M. F. Vasconcelos for their help with the fieldwork and specimen preparation. L. E. Lopes helped with plumage analysis. L. F. Silveira (MZUSP), M. A. Raposo (MNRJ) and P. Scherer-Neto (MHNCI) kindly allowed examination of specimens in collections under their care. G. A. Bencke (MCNRS) and A. L. P. Aleixo (MPEG) provided photographs of *C. pabsti* specimens in the collections under their care. L. P. Gonzaga (ASEC), E. Endrigo, V. Q. Piacentini and M. Repenning kindly shared with the first author some of their own recordings of *C. pabsti*. This study was supported by 'Fundação O Boticário de Proteção à Natureza', FAPEMIG (PPM 0434-5.03/07, PPM-00161-10, PRONEX 2009, FAPEMIG/Vale 2010, Universal 2010), CNPq (473428/2004-0; 303558/2009-1; 473809/2008-7), and the U.S. Fish and Wildlife services. G.H.S.F. received a studentship from CNPq, L.M.C. from CAPES, and A.V.C. from FAPEMIG and CNPq. M.R. and F.R.S were supported by CNPq and M.R. was also supported by FAPEMIG (PPM). We thank the staff of the Brazilian Environmental Agency (ICMBio and CEMAVE) for logistical support. For helpful comments on the manuscript, we thank A. L. P. Aleixo, D. R. Lacerda, J. V. Remsen, P. C. A. Garcia, P. F. Donald and R. C. K. Bowie.

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Received 18 July 2011;  
revision accepted 9 July 2012.  
Associate Editor: Martin Collinson.

## SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article:

**Appendix S1.** Institutional acronyms cited in this manuscript.

**Appendix S2.** Samples of *Cinclodes* spp. used in the molecular analyses with voucher and GenBank accession numbers.

**Appendix S3.** Detailed methods for PCR-amplification and DNA sequencing.

**Video S1.** *Cinclodes espinhacensis* video, Serra do Abreu, Brazil, November 2011. Recording by G.H.S.F., L.M.C., and Leonardo A. S. Freitas.

**Audio S1.** *Cinclodes espinhacensis* call, Serra do Breu, Brazil, November 2009. Recording by G.H.S.F.

**Audio S2.** *Cinclodes espinhacensis* call variation, Serra do Breu, Brazil, November 2009. Recording by G.H.S.F.

**Audio S3.** *Cinclodes espinhacensis* loudsong, Casa dos Currais, Brazil, March 2009. Recording by G.H.S.F.

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