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Original Article

New Isospora and Host Species in Brazilian Passerines

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■Keywords

Apicomplexa, *Gnorimopsar chopi*, *Isospora chopi*, *Isospora gnorimopsar*, *Paroaria dominicana*, *Isospora dominicana*, *Saltator similis*, *Isospora beagai*, *Isospora ferri*, *Schistochlamys ruficapillus*, *Isospora ruficapillus*.

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ABSTRACT

Normal passerines (n=216) were evaluated for oocysts of *Isospora* in feces at the Triage Center for Wild Animals (CETAS, IBAMA, Belo Horizonte; August 21 to September 21, 2012). The positive samples with oocysts represented 13.0% of Cardinalidae (n=23), 11.2% of Emberizidae (n=107), 50% of Icteridae (n=10) and 60.3% of Thraupidae (n=68). The probability of fecal oocysts attributable to the host in Thraupidae is higher than in Cardinalidae, Emberizidae, Fringillidae and Turdidae, but similar to Icteridae. No oocysts were found in Fringillidae and Turdidae. Within Thraupidae, *Isospora* was for the first time described in *Paroaria dominicana* and *Schistochlamys ruficapillus* and within Icteridae, in *Gnorimopsar chopi*. *Saltator similis* presented a higher risk, 66.9% greater than *Lanio pileatus* and *Sporophila caerulescens* and with a 27.9% greater probability than *Sporophila nigricolis*. The new coccidian species described were *Isospora dominicana* [ellipsoid oocysts, 25 (30-20) x 25 (28-20) µm] in *Paroaria dominicana*; *Isospora beagai* [ovoid oocysts, 28 (32-17) x 25 (29-16) µm] and *Isospora ferri* [ellipsoid oocysts, 20 (22-16) x 18 (22-15) µm] in *Saltator similis*; *Isospora ruficapillus* [spheric to subspherical oocysts, 25 (26–23) x 24 (25–21) µm] in *Schistochlamys ruficapillus*; and *Isospora chopi* [spherical to sub-spherical oocysts, 24.5 x 22 (30-20 x 25-20) µm] and *Isospora gnorimopsar* [sub-spherical to ovoid oocysts, 27 x 23 (32-22 x 28-20) µm] in *Gnorimopsar chopi*. The morphometry and features were compared with previously described *Isospora* in passerines. New coccidian species and new passerine hosts are described for *Isospora* and recommends for constant monitoring during rehabilitation, especially for the hosts of Thraupidae and Icteridae.

Coccidiosis in the order Passeriformes is caused mostly by the genus *Isospora* (Page & Haddad, 1995; Duszynski *et al.*, 2018; Freitas *et al.*, 2002; Marietto-Gonçalves *et al.*, 2009; Brown *et al.*, 2010; Costa *et al.*, 2010; Berto *et al.*, 2011a) and may result in important clinical impacts for passerines during captivity (Page and Haddad, 1995; Friend and Frason, 1999; Brown *et al.*, 2010; Berto *et al.*, 2011a). In fact, infection by *Isospora* represents the most relevant parasitic disease for captive birds (Vilela *et al.*, 2009; Costa *et al.*, 2010; Keeler *et al.*, 2011; Pereira *et al.*, 2011) and demands diagnostic surveillance and strategic or curative medication to reduce losses (Freitas *et al.*, 2002; Yabsley, 2008; Marietto-Gonçalves *et al.*, 2009). In contrast, subclinical infection (coccidiosis) is the most common form of infection in the wild, representing a minor health impact in free-living birds (Upton *et al.*, 1995). However, most species of coccidians, especially of wild birds, are yet to be described (Moore & Clayton, 1997; Lederberg, 1998; Freitas *et al.*, 2002; Wobeser, 2008). In captive birds, a fatal disease outbreak by *Isospora icterus* was reported in Brazil in a group of a native icterid passerine *Icterus jamacaii* (Campo oriole or Troupial) (Marques *et al.*, 2011).

Twenty-one South-American passerine species are described as hosts for the genus *Isospora*, however, only 19 out of the 1073 species of Brazilian passerines have been studied for the occurrence of *Isospora* or other coccidians (Sick, 1997; Berto *et al.*, 2011a; CBRO, 2014).

The Thraupidae and Icteridae member species are the most frequently sampled among those admitted at the wild animal triage centers in Brazil (Centros de Triagem de Animais Silvestres, CETAS) due to illegal trade (Ferreira & Glock, 2004; Borges *et al.*, 2006; Pagano *et al.*, 2009; Santos *et al.*, 2011; Vilela, 2012; CBRO, 2014) and also because most species are declining in population (IUCN, 2018). According to Vilela (2012), and considering the new classification of species (CBRO, 2014), 61% of all Brazilian passerines at the triage centers belong to Thraupidae. This study describes 5 new host species of *Isospora*, from Thraupidae: (*Paroaria dominicana, Schistoclamys ruficapillus and Sporophila nigricolis*), of Cardinalidae (*Cyanoloxia brisonii*) and of Icteridae (*Gnorimopsar chopi*), and 2 new species of *Isospora* in the previously known host *Saltator similis.*

We describe the occurrence of oocystis of *Isospora* in passerines of families Thraupidae, Cardinalidae, Emberizidae, Fringillidae and Turdidae, and evaluate new and previously described host species, with the characterization of oocysts by morphometry and structural features.

MATERIALS AND METHODS

Birds and sampling

Fecal samples (n = 216) of clinically healthy passerines of six taxonomic families were evaluated: Cardinalidae, Emberizidae, Fringillidae, Icteridae, Thraupidae, and Turdidae. The occurrence of coccidia was evaluated for all passerines at rehabilitation in the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012 (Table I).

The study was registered at the SISBIO (Sistema de Autorização e Informação em Biodiversidade (SISBIO) do Instituto Chico Mendes de Conservação da Biodiversidade) ~~at~~ under number 35825-1 and at the ethics committee on animal research (CETEA-UFMG) under number 126/2013.

All fecal samples were collected non-invasively from birds that were kept in individual cages throughout the study. Upon arrival, white paper sheets were left

Table I – Passeriformes evaluated and individuals with oocysts in feces.

Family	Scientific name	Common name	Positive	Negative	Total	% Positive
Cardinalidae			3	20		
	Cyanoloxia brisonii		3	20	23	13.0
Emberizidae			12	95	107	11.2
	Sicalis flaveola	Canário da terra verdadeiro	7	33	40	17.5
	Sporophila angolensis	Curió	0	3	3	0.0
	Sporophila caerulescens	Coleirinho	4	9	13	30.7
	Sporophila frontalis	Pixoxó	0	1	1	0,0
	Sporophila lineola	Bigodinho	0	4	4	0.0
	Sporophila maximiliani	Bicudo	0	3	3	0.0
	Sporophila nigricolis	Baiano	1	34	35	2.8
	Sporophila plumbea	Patativa	0	1	1	0.0
	Zonotrichia capensis	Tico tico	0	7	7	0.0
Fringillidae						
	Sporagra magellanica	Pintassilgo	0	4	4	0.0
Icteridae			5	5	10	50.0
	Gnorimopsar chopi	Graúna	5	4	9	55.5
	Icterus jamacaii	Corrupião	0	1	1	0.0
Thraupidae			41	27	68	60.3
	Lanio pileatus	Tico tico rei cinza	0	3	3	0.0
	Paroaria dominicana	Cardeal do nordeste	4	3	7	57.1
	Saltator similis	Trinca ferro verdadeiro	36	18	54	33.3
	Saltatriculla atricollis	Bico de pimenta	0	2	2	0.0
	Schistochlamys ruficapillus	Bico de veludo	1	1	2	50.0
Turdidae			0	4	4	0
	Turdus amaurochalinus	Sabiá poca	0	1	1	0.0
	Turdus rufiventris	Sabiá laranjeira	0	3	3	0.0
Total			61	155	216	28.24

overnight on the bottom of the cages to collect feces the following morning. Samples were immediately examined at microscopy and subjected to flotation in saturated NaCl for microscopy on a slide with coverslip (100, 400 and 1,000x). Oocyst positive samples were partially transferred to an aerated flask with 2.5% potassium dichromate solution (22 C) at 1:5 for sporulation (sporogony) for 1 week. Sporulated oocysts of each bird were subjected to morphologic and morphometric evaluation in a Zeiss Axioscop 40 microscope (Carl Zeiss Microscopy GmbH, Göttingen, Germany), equipped with digital imaging, according to the Duszynski & Wilber (1997) protocol. Images were captured using a Canon G10 digital camera (Canon S Tower 2-16-6, Konan MINATO-KU, Tokyo, Japan), a 52mm adaptor tube and Axiovision 4.8 software with a Sony Vaio VPCSB35FB (Sony Brasil, São Paulo, SP, Brazil). Only viable oocysts, showing the complete development of sporocysts and sporozoites were evaluated. The numerical data were evaluated for sampling normality and homogeneity (ANOVA). The morphological features and morphometrical values were evaluated in an entirely random design (ERD) (Mann-Whitney, ANOVA) and the specific correlations were verified for the data of each individual. For *Saltator similis,* data were further evaluated for distribution normality and homogeneity of sampling error (Mann-Whitney, ANOVA) and specific correlation to determine the 2 coccidian species (Sampaio, 2007).

RESULTS

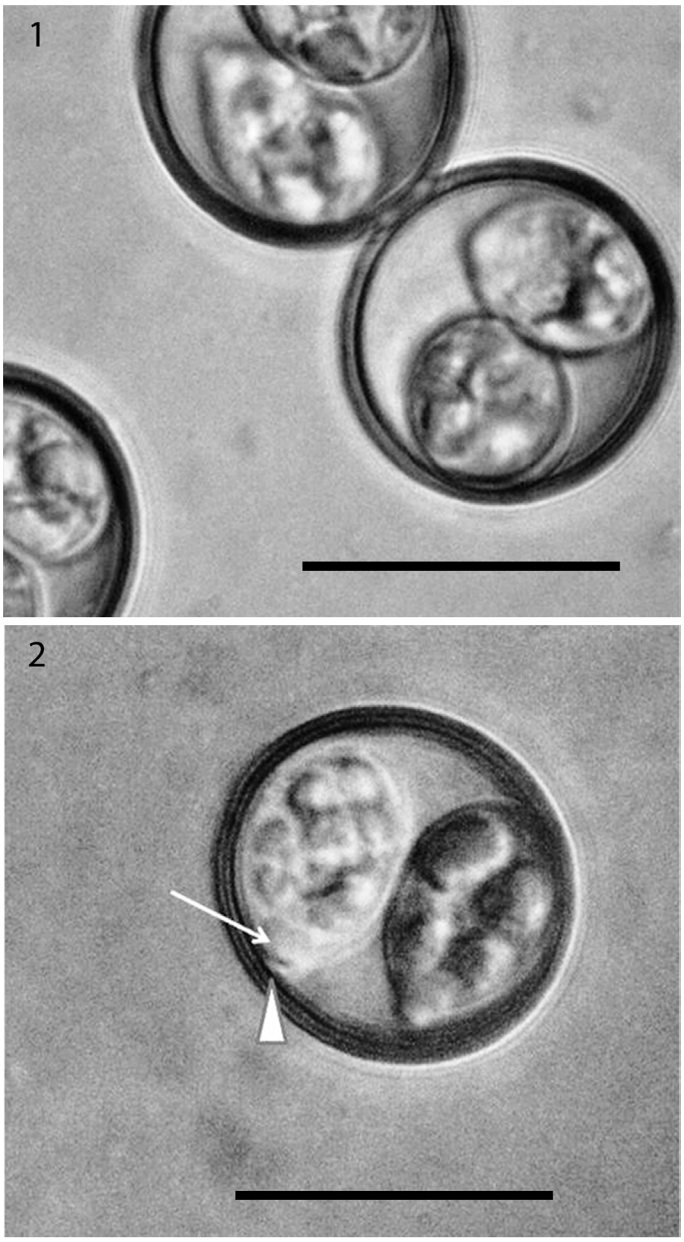
Fecal samples detected positive for oocysts were from *Cyanoloxia brisonii* (Cardinalidae), *Sicalis flaveola, Sporophila caerulescens* and *Sporophila nigricolis* (Emberizidae), *Gnorimopsar chopi* (Icteridae), and *Schistoclamys ruficapillus, Paroaria dominicana, Saltator similis,* and *Sporophila nigricolis* (Thraupidae). Samples from Fringillidae and Turdidae were negative (Table I). All sporulated oocysts obtained were typical of the *Isospora* and were further characterized.

DESCRIPTIONS

Isospora dominicana n. sp.

Description of the sporulated oocyst: spherical to subspherical oocysts, 25 x 25 µm (20-28 x 20-30 µm) (n=50); morphometric index (MI, length /width) 1.0 (1.0 – 1.2); smooth bilayered wall (1 µm in thickness); absences of micropyle, polar granule and sporocyst residuum (Table II).

Description of the sporocyst: Ellipsoidal sporocysts, 11 x 17 µm (9-13 x 15-18 µm), SI 1.5 (1.3-1.8), flattened Stieda body (1 µm in height by 2 µm in width) and prominent substieda body (2 µm in height by 3 µm in width) (Table II).



Figures 1, 2 – Oocysts of *Isospora dominicana* recovered from *Paroaria dominicana*. Note the spheric to subspheric oocyst, absence of polar granule and oocyst residuum, flat Stieda body (arrow) and prominent substieda (arrow head).

Taxonomy summary

Host: Paroaria dominicana (Aves: Passeriformes: Thraupidae).

Geographical location and date: Samples obtained at the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012.

Site of infection: Undetermined.

Table II – Comparative morphometry (µm) of oocysts and sporocysts, and morphological features of species of genus *Isospora* described in family Thraupidae (Aves: Passeriformes: Thraupidae).

Species	Host	Reference	Oocyst					Sporocyst					
			Shape	Polar granule	Diameter (µm) Major	Diameter (µm) Minor	Morpho metric index	Shape	Diameter (µm) Major	Diameter (µm) Minor	Morpho metric index	Stieda body Shape Length x width (µm)	Resíduum
Isospora vanriperorum	*Cardinalis cardinalis; Saltator similis*	Levine *et al.* (1980); Lopes *et al.* (2007)	Subspherical	Present	23,1 (26-22)	22,4 (25-20)	1,04	Ovoid	16,3 (17-15)	10		Button shaped	Compact
I. paroariae	*Paroaria coronate*	Upton *et al.* (1985)		Absent	22,3 (26-19)	21,4 (24-18)	1,1		15,2 (17-14)	10 (12-8)	1,53		
I. pityli	*Saltator grossus saturates*	McQuistion & Capparella (1992)	Subspherical	Absent	20,1 (21-20)	18,8 (20-17)	1,07	Ovoid	14,7 (17-12)	9,4 (11-8)	1,57	Mammilliform	Compact
I. formarum	*S. g. grossus; S.g. saturatus*	McQuistion & Capparella (1992)	Subspherical	Absent	24,6 (27-21)	23,5 (25-20)	1,1	Ovoid	15,7 (17-14)	11,3 (13-10)	1,4	Small, Mammilliform	Compact
I. saltatori	*S. similis*	Berto *et al.* (2008b)	Subspherical	Absent	18,3 (20-17)	17,9 (20-16)	1	Ovoid	13,4 (15-12)	8,9 (10-8)	1,5	Small, Mammilliform	Compact
I. trincaferri	*S. similis*	Berto *et al.* (2008b)	Subspherical	Present	26,2 (29-24)	23,6 (25-22)	1,1	Ovoid	17,5 (18-17)	11,5 (13-10)	1,5	Bubble shaped	Diffuse
I. thraupis	*Thraupis palmarum melanoptera*	Lainson (1994); Berto (2010)	Subspherical	Absent	19,9 (21-19)	19 (20-19)	1	Piriform	14,2 (16-14)	9,2 (10-9)	1,5	Delicate	Compact
I. andesensis	*Chlorospingus ophtalmicus*	Templar *et al.* (2004); Berto 2010)	Subspherical or ovoid	Present	22,6 (24-20)	18,7 (20-17)	1,2	Ovoid	14,1 (15-13)	8,5 (9-8)	1,7	Triangular, prominent	Diffuse
I. irisidornisi	*Irisidornis analis*	Metzelaars *et al.* (2005); Berto (2010)	Ovoid	Present	22,1 (25-20)	18,9 (23-16)	1,2	Ovoid	13,6 (17-9)	9 (11-8)	1,5	Bubble-shaped	Diffuse
I. tiesangui	*Ramphocelus bresilius dorsalis; T. palmarum; Dacnis cayana*	Berto *et al.* (2008a); Berto (2010)	Subspherical	Absent	24,2 (26-22)	23,4 (26-21)	1,03	Ovoid	17,7 (19-17)	11,5 (13-11)	1,54	Flat	Diffuse
I. marambaiensis	*R. b. dorsalis*	Berto *et al.* (2008a, 2010)	Subspherical	Absent	29,4 (31-27)	27,9 (29-26)	1	Ellipsoid	22,6 (24-21)	13 (14-12)		Flat	Diffuse
I. sepetibensis	R. b. dorsalis	Berto *et al.* (2008a, 2010)	Subspherical	Present 1 or 2	25,5 (29-24)	23,8 (26-22)	1,1	Ellipsoid	16,9 (18-16)	11 (12-10)		Button-shaped	Lateral
I. cadimi	*R. b. dorsalis*	Berto *et al.* (2009a, 2010)	Subspherical	Absent	24,2 (26-22)	22,9 (24-21)	1,1	Ovoid	16,9 (18-15)	11,6 (13-10)	1,5	Mammiliform	Diffuse
I. navarroi	*R. b. dorsalis*	Berto *et al.* (2009b, 2010)	Subspherical	Absent	21,4 (24-19)	20,6 (23-18)	1	Ellipsoid	16,1 (19-14)	10,2 (12-9)	1,6	Flat	Diffuse
I. ramphoceli	*R. b. dorsalis*	Berto et al (2010)	Subspherical	Absent	23,7 (26-22)	22,8 (24-21)	1,04	Ellipsoid or ovoid	16 (18-14)	11,4 (13-10)	1,41	Button-shaped	Diffuse
I. sanhaci	*Thraupis sayaca*	Berto *et al.* (2009c, 2010)	Subspherical	Absent	22,1 (24-19)	21 (23-17)	1	Ovoid	17 (19-15)	9,9 (11-9)	1,7	Mammilliform	Diffuse
I. silvasouzai	T. sayaca	Berto *et al.* (2009c, 2010)	Subspherical	Present	25,5 (28-22)	22,6 (25-19)	1,1	Piriform	17,6 (18-17)	10,5 (11-10)	1,7	Delicate	Compact
I. sayacae	*T. sayaca*	Berto *et al.* (2009c, 2010)	Subspherical	Absent	28,9 (30-28)	27,4 (29-24)	1,1	Bottle-shaped	23,4 (25-23)	11,8 (12-11)	2	Prominent	Diffuse
Isospora similisi	*S. similis*	Coelho *et al.* (2013)	Spheric to subspherical	Present	27,5 (29-26)	25,9 (28-24)	1,1	Ellipsoid or ovoid	17,4 (19-15)	12,2 (12-11)	1,4	Button-shaped	Diffuse
Isospora dominicana	*Paroaria dominicana*	Present study	Spheric to subspherical	Absent	25 (30-20)	25 (28-20)	1,04 (1,18-1)	Ellipsoid	17 (18-15)	11 (13-9)	1,5 (1,8-1,3)	Mammilliform 1 x 2	Absent
Isospora beagai	*Saltator similis*	Present study	Ovoid	Present	28 (32-17)	25 (29-16)	1,15 (1,5-1)	Ovoid	18 (23-12)	11 (15-9)	1,53 (2,2-1,23)	Prominent, Button-shaped 2 x 3	Compact
Isospora ferri	*Saltator similis*	Present study	Spheric to subspherical	Absent	20 (22-16)	18 (22-15)	1 (1,15-1)	Ellipsoid	14 (20-12)	8 (11-7)	1,6 (2,5-1,3)	Flat 1 x 2	Diffuse
Isospora ruficapillus	*Schistochlamys ruficapillus*	Present study	Spheric to subspherical	Absent	25 (26-23)	24 (25-21)	1,04 (1,09-1)	Ellipsoid	17 (18-16)	11 (11-10)	1,6 (1,63-1,45)	Flat, mammilliform 1 x 2	Diffuse

Sporulation: Exogenous.

Frequency of detection: In 4/7 (57%).

Collection material Id. Dominicana*:* Refrigerated (4 - 8 ºC) for analysis and subsequently frozen feces; oocysts photomicrographs deposited at the Avian Diseases Laboratory, Veterinary College, UFMG.

Etymology: The name given to this species was based on its host name: *Paroaria dominicana.*

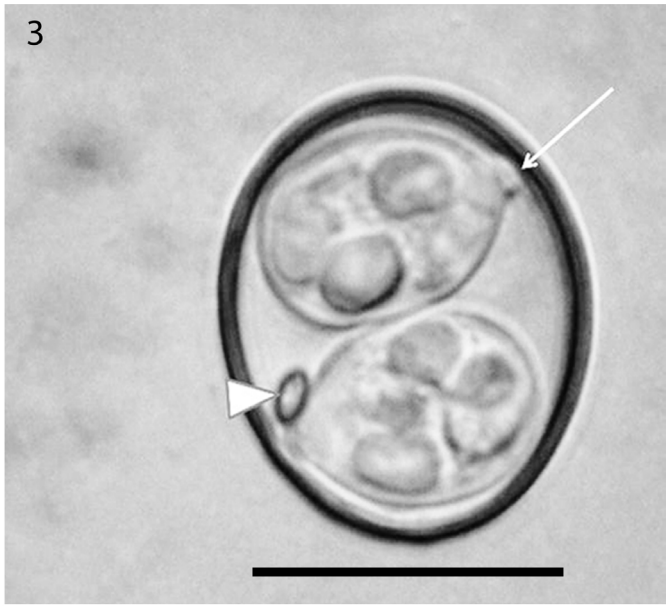
Remarks

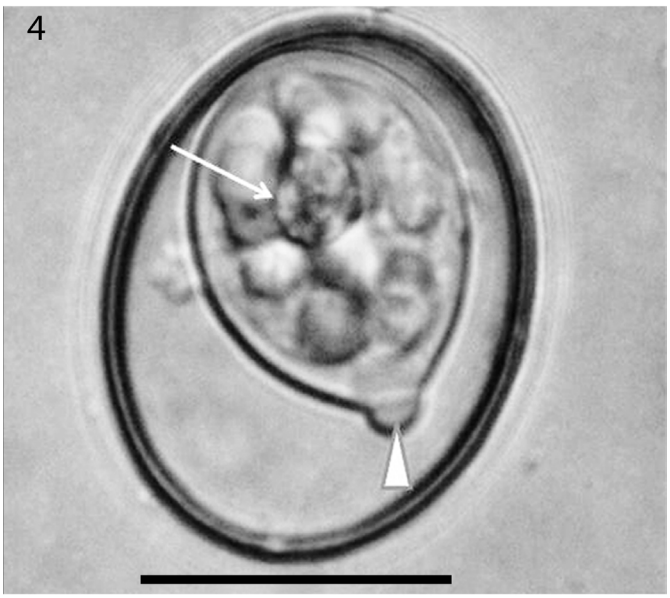
Considering the absence of a polar granule found in the coccidian species, this species was similar to 12 others previously described in publications on Thraupidae *Isospora marambaiensis, Isospora sepetibensis* and *Isospora tiesangui,* Berto *et al.* (2008a) and Berto (2010), *Isospora saltatori* Berto *et al.* (2008b), *Isospora cadimi* and *Isospora navarroi* Berto *et al.* (2009a, 2009b), *Isospora ramphoceli, Isospora sanhaci* and *Isospora sayacae* Berto *et al.* (2009c, 2010), *Isospora thraupis* Lainson (1994), *Isospora formarum* and *Isospora pityli* McQuistion and Capparella (1992), and *Isospora paroariae* Upton *et al.* (1985). Regarding the sporocyst residuum, it was absent for only the described species, in contrast to those compared with *Isospora* of Thraupidae (Table II). Despite such detail being considered sufficient for describing a new species (Duszynski & Wilber, 1997), further data were analyzed using a dichotomic key (Berto *et al.*, 2010). Results indicated a new species characterized by the absence of polar granule, larger than 25µm in length, flat Stieda body, large and easily visible substieda body and no sporocyst residuum (Table II). The absence of sporocyst residuum was not previously described for *Isospora* of Passeriformes. Considering these exclusive characteristics, the new species was thereby named *Isospora dominicana*.

Isospora beagai n. sp.

Description of the sporulated oocyst: Ovoidal oocysts, 25 x 28µm (16 -29 x 17-32µm) (n = 53), with morphometric index (MI, length/width) 1.1 (1..0 – 1.5), smooth bilayer wall approximately 1 µm in thickness. Absence of micropyle and the presence of polar granule (Table II).

Description of the sporocyst: The sporocysts are ovoidal of 11 x 18 µm (9-15 x 12 - 23 µm), SI 1.5 (1.2 – 2.2), prominent club-shaped Stieda body, of 2 µm in height by 3 µm in width and compact sporocysts residuum (Table II).





Figures 3, 4 – Oocysts of *Isospora beagai* recovered from *Saltator similis*. (3) Note the ovoidal oocyst, the presence of polar granule (arrowhead) and prominent Stieda body (arrow). (4) Note the ovoidal oocyst, the presence of prominent Stieda body (arrowhead) and diffused sporocyst residuum (arrow).

Taxonomy summary

Host: Saltator similis (Aves: Passeriformes: Thraupidae).

Geographical location and date: Samples obtained at the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012.

Site of infection: Undetermined. Samples were taken from feces.

Sporulation: Exogenous.

Frequency of detection: In 36/54 (68%).

Collection material Id. Beagai*:* Refrigerated (4-8 ºC) for analysis and subsequently frozen feces; oocycts

photomicrographs; stored at the Avian Diseases Laboratory, Veterinary College, UFMG.

Etymology: The name given to this species was based on the acronym of the geographical location in which it was found (BH, Belo Horizonte) (Brazil).

Remarks

Comparing the oocysts possessing a polar granule with previously described species (Table II), it was shown that, among the 23 known species, including the 4 described in this manuscript, only 8 *Isospora* species have been characterized by the presence of a polar granule. The species described here (Table III) (*Isospora beagai*) had a bubble-shaped polar granule similar to *Isospora vanriperorum, Isospora trincaferrri, Isospora iridornisi, Isospora sepetibensis* and *Isospora similis*. Considering the sporocyst residuum, a compact residuum similar to *I. vanriperorum* and *I. sepetibensis* was observed. In order to compare the species described here to the previously described *I. vanriperorum*, data in Table II along with descriptive images previously published, were employed (Lopes *et al.*, 2007; Berto *et al.*, 2011a; 2011b). Dissimilarities were found when compared to *I. vanriperorum*, such as a bilayered wall and a large and conspicuous substieda body. The sporocyst, although both ovoidal, also showed differences. Such characteristics are considered sufficient in determining this to be a different species (Duszynski & Wilber, 1997).

When considering *I. sepetibensis*, comparisons using dichotomic keys, descriptive drawings (Berto *et al.*, 2010; 2011a; 2011b), and data in Table II, show that sporocysts were described as ellipsoidal, in contrast to the ovoidal sporocysts found in the new *I. beagai* species found in this paper. The sporocyst residuum has been reported as compact, in contrast to the slightly larger and diffused sporocyst described here. Comparing the morphometric data of *I. beagai* with that of *I. sepetibensis*, a slight difference of oocyst and sporocyst measurements were revealed, being greater for the former.

The dichotomic key (Berto *et al.*, 2010) suggests this species be compared to *I. iridornisi*, which presents larger oocysts and sporocysts than *Isospora beagai* (p = 0.0001), a compact but not diffused sporocyst residuum in *I. beagai*, a larger substieda body, and not collar-shaped as seen in *I. beagai*. These individual features were considered sufficient in order to describe a new species (Duszynski & Wilber, 1997). In addition, the described host (*Irisidornis analis*) for *Isospora iridornisi* occcurs only in Colombia, Ecuador and Peru (northern South America), while *Saltator similis* occurs

Table III – Morphometric comparisons of Isospora species described in passerines of family Icteridae (Aves: Passeriformes, Icteridae).

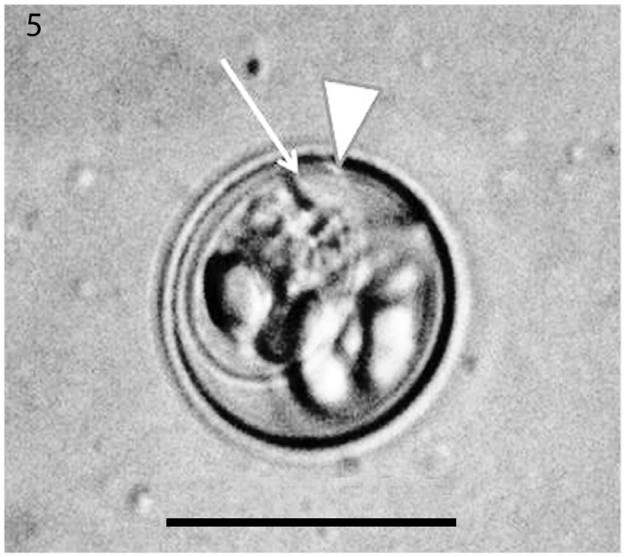
Species	Host	Reference	Oocyst					Sporocyst						
			Shape	Polar granule	Diameter (µm)		Morpho-metric Index	Shape	Diameter (µm)		Morphometric index	Stieda body	Residuum
					Length (L)	Width (W)			Length (L)	Width (W)		Shape height x width (µm)	
Isospora divitis	*Dives atroviolaceus*	Pellérdy (1967)	Sub-spheric	Absent	(30-22)	(28-20)	1.1		17	13	1.3	Conspicuous	Diffuse
Isospora cacici	*Cacicus cela cela*	Lainson (1994)	Sub-spheric	Present 1 or 2	26,5 (27,5-22,5)	23,7 (26,2-20)	1,1	Elongated	17,7 (18,75-17,5)	12,5 (13,75-11,25)	1,4	Prominent, cork shaped	Compact
Isospora belicosa	*Sturnella belicosa*	Upton *et al.*(1995)	Episoidal or ovoid	Present 1 or 2	29,4 (26,4-23,5)	23,5 (26,4-21)	1,2	Ellipsoidal	17,8 (18,6-16,8)	10,7 (11,2-10,2)	1,67	Large	Diffuse
Isospora icterus	*Icterus icterus*	Upton & Whitaker (2000)	Sub-spheric	Present	28,9 (32-27,2)	27,2 (30-25)	1,1	Ellipsoidal	17,8 (19,2-16,8)	12,8 (13,6-12)	1,39	Small, mammiliform	Diffuse
Isospora icterus	*Icterus jamacaii*	Marques *et al.* 2011	Sub-spheric	Present	30,1 (32,5-27,5)	28,5 (30-26,25)	1,1	Ellipsoidal1.3	17,6 (20-15)	12,9 (15-12,5)	1,4	Small, mammiliform	Diffuse
Isospora graceannae	*Icterus graceannae*	Upton & Whitaker (2000)	Sub-spheric	Present	23,9 (26,4-20)	22,3 (25-18,6)	1,1	Ellipsoidal	15,5 (16,2-14,2)	10,7 (11,4-10)	1,44	Robust	Diffuse
Isospora gnorimopsar	*Gnorimopsar chopi*	Present study	Sub-spheric to ovoid	Present 1 or 2	27 (32-22)	23 (28-20)	1,18 (1,33 -1)	Ellipsoidal	16 (19-14)	11 (12 - 9)	1,52 (1,72 - 1,33)	Flat 1 x 2	Absent
Isospora chopi	*Gnorimopsar chopi*	Present study	Sub-spheric to ovoid	Absent	24,5 (30-21)	22 (25-20)	1,08 (1,19 – 1)	Ellipsoidal	15 (16-13)	9,7 (10-8)	1,57 (1,66-1,3	Prominent 2 x 1	Present

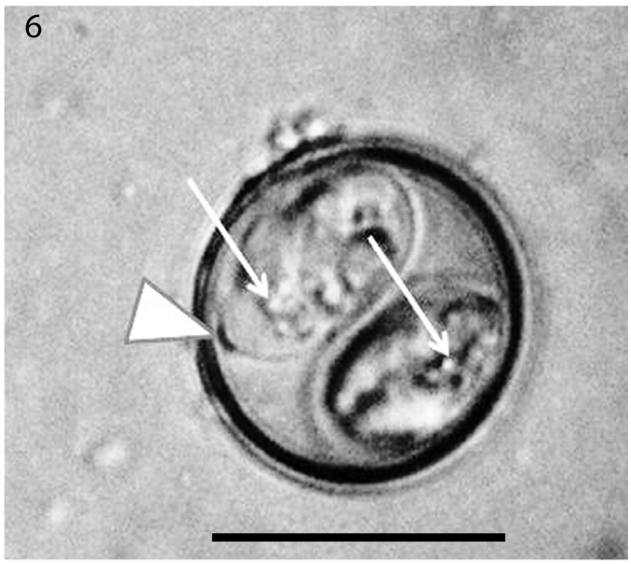
in southcentral South America, including Argentina, Bolivia, Brazil, Paraguay and Uruguay.

The morphologic and morphometric data and images were compared with descriptions in literature (Table II). The differences described for *I. beagai*, in comparison to *I. iridornisi*, include a diffused and ovoidal sporocyst for *I. beagai*, in contrast with a compact and ellipsoidal sporocyst for *I. iridornisi*.

Considering the morphometrical data of oocysts in *Saltator similis* (Tables II and III), two different set of data were obtained, and oocyst dimensions, the presence of polar granule, and compact sporocyst residuum, were considered sufficient reasons to describe a new species *Isospora beagai* (Duszynski & Wilber, 1997).

Isospora ferri n.sp.





Figures 5, 6 – Oocysts of *Isospora ferri* recovered from *Saltator similis*. (5) Note the spheric to subspheric oocyst, absence of polar granule, flat delicate Stieda body (arrowhead), large and conspicuous substieda (arrow), and round oocyst. (6) Note the absence of polar granule, flat and delicate Stieda body (arrowhead), and diffused sporocyst residuum (arrows).

Description of the sporulated oocyst: Spherical to subspherical oocysts, 18 x 20 µm (15-22 x 16-22) (n=59), MI 1.0 (1.0 x 1.2), presenting a smooth double layered wall of approximately 1 µm, and the absence of micropyle, polar granule and diffused sporocyst residuum (Table II).

Description of the sporocyst: Sporocysts are ellipsoidal, 8 x 14 µm (7 – 11 x 12 – 20) SI, 1,6 (1.3 – 2.5), with flat Stieda body 1 µm in height and 2 µm in width, prominent substieda body of approximately 2 µm in height and 3 µm in width (Table II).

Taxonomy summary

Host: *Saltator similis* (Aves: Passeriformes: Thraupidae).

Geographical location and date: samples obtained at the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012.

Site of infection: Undetermined. Samples were taken from feces.

Sporulation: Exogenous.

Frequency of detection: In 36/54 (68%).

Collection material Id. Ferri*:* Refrigerated (4-8 °C) for analysis and subsequently frozen feces; oocysts photomicrographs; stored at the Avian Diseases Laboratory, Veterinary College, UFMG.

Etymology: The name *I. ferri* was given based on the host's popular Portuguese name: trinca-ferro.

Remarks

In comparison to the coccidia previously found in feces of *S. similis* (Table II), the oocysts in this study were larger, thus reinforcing the need to introduce a separate species (Duszynski & Wilber, 1997).

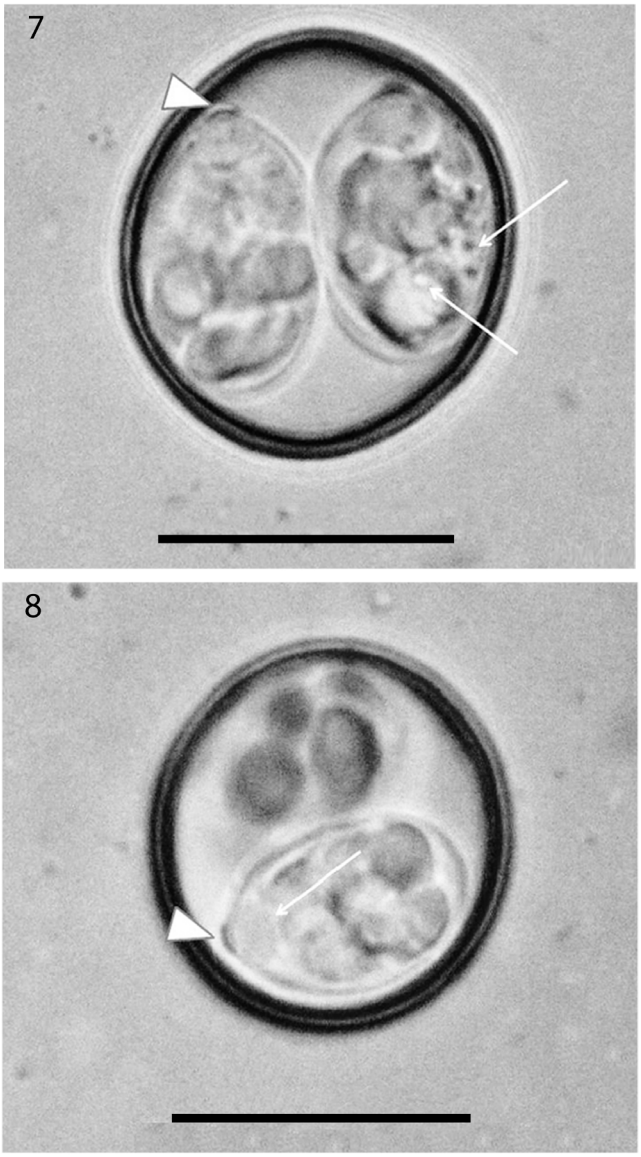
Oocysts of *Isospora*, which do not present polar granule of previously described species in *S. similis*, were compared to those of this new species, *I. ferri* (Table II). Out of the 20 known species, in addition to 4 described in this family (Thraupidae), 16 do not present a polar granule oocyst. The dichotomic key (Berto *et al.*, 2010) suggests this species be compared to *Isospora tiesangui* of the Brazilian tanager *Ramphocelus bresilius*. However, comparing the oocyst and sporocyst of these coccidians, *I. ferri* had a smaller dimension (Table II). The oocyst format was ovoidal for *I. ferri* but ellipsoidal for *I. tiesangui*; the Stieda body measured 0.5 x 3 µm in *I. tiesangui* in comparison to 1 x 2 µm in *I. ferri*; and the substieda body measured 2.5 x 4 µm in *I. tiesangui,* but 2 x 3 µm for *I. ferri*. Such differences are considered sufficient in determining

this to be a different species of *Isospora* in *Saltator similis* (Duszynski & Wilber, 1997).

The differences to *Isospora navarroi* were visible at the Stieda and substieda bodies (Berto *et al.*, 2011a, 2011b). The new species presented a larger flat Stieda and larger conspicuous substieda body. The sporocyst residuum was diffused and spread within the sporocyst, and not ring-shaped as in *I. navarroi*.

Considering the morphometrical data of oocysts in *Saltator similis* (Tables II and III), two different sets of data were obtained, and oocyst dimensions, the absence of polar granule, and diffuse sporocyst residuum, considered sufficient reasons enough to indicate *Isospora ferri* as a new species.

Isospora ruficapillus



Figures 7, 8 – Oocysts of *Isospora ruficapillus* recovered from *Schistochlamys ruficapillus*. (7) Note the mammilliform Stieda body (arrowhead) and the sporocyst diffused residuum (arrow). (8) Note the complex formed by the mammilliform Stieda body (arrowhead) and the prominent substieda (arrow).

Description of the sporulated oocyst: Spherical to subspherical oocysts, 24 x 25 µm (21-25 x 23-26) (n = 20), MI, 1.0 (1.0 – 1.1), presenting a double smooth wall, approximately 1 µm in thickness, the absence of micropyle and polar granule (Table II).

Description of the sporocyst: The ellipsoidal sporocysts, 11 x 17 µm (10 -11 x 16 x 18), with mammilliform Stieda body 1 µm in height per 2 µm in width, prominent substieda 2.5 x 3 µm (2.5 µm in height by 3µm in width), and the presence of a diffused sporocyst residuum (Table II).

Taxonomic summary

Host: Schistoclamys ruficapillus (Aves: Passeriformes: Thraupidae).

Geographical location and date: Samples obtained at the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012.

Site of infection: Undetermined. Samples were taken from feces.

Sporulation: Exogenous.

Frequency of detection: 1/2 (50%).

Collection material Id. Ruficapillus*:* Refrigerated (4-8 °C) for analysis and subsequently frozen feces; oocycsts photomicrographs stored at the Avian Diseases Laboratory, Veterinary College, UFMG.

Etymology: The name *I. Ruficapillus* was given based on the species' host *Schistoclamys ruficapillus*.

Remarks

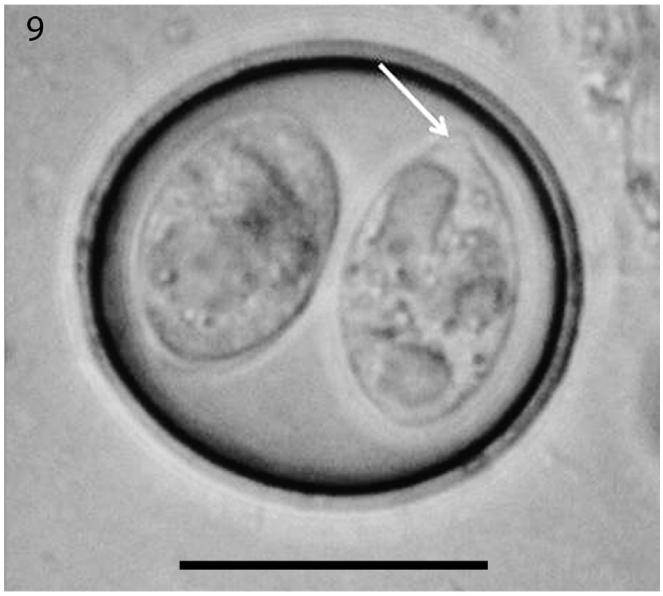
The morphometric and morphologic data obtained after sporulation were compared to data from the literature (Table II) and using a previously described dichotomic key (Berto *et al.*, 2010) which enabled the description of a new species: *Isospora ruficapillus.*

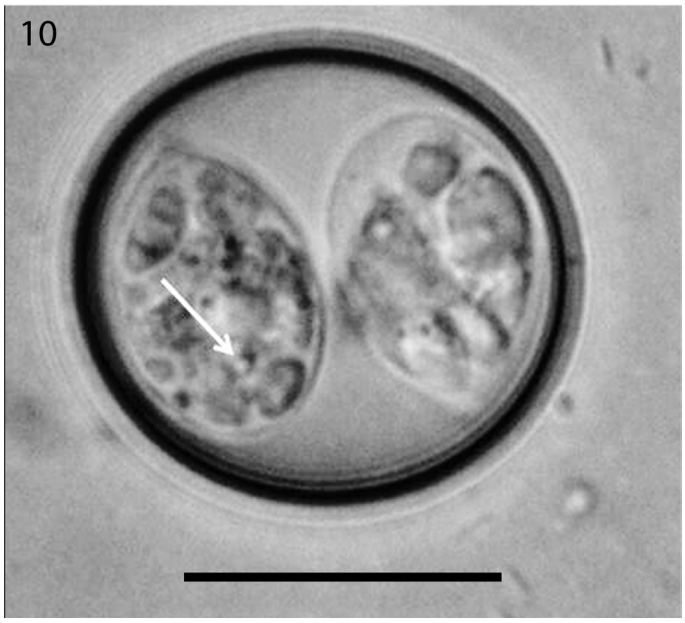
The closest species to *Isospora ruficapillus* was *Isospora sanhaci,* based on the dichotomic key (Berto *et al.*, 2010). *I. sanhaci* was described as having a roundish delicate substieda body, which differed from *I. ruficapillus* as observed in the present study, even though it presented similarities in other structures. The sporocyst shape of both species differed, being ellipsoidal for *I. ruficapillus* and ovoid for *I. sanhaci*. Considering the sporocyst residuum, the new described species presented a diffused structure.

Taking into account the absence of polar granule, the shape of the Stieda body and sporocyst residuum; the species found in *Schistochlamys ruficapillus* suggests this species be compared to *Isospora navarroi* and *Isospora marambaiensis* previously

described in *Ramphocelus bresilius dorsalis* (Berto *et al.*, 2008a; 2009b; 2010). *I. marambaiensis* presented larger oocysts and sporocyts, but the Stieda and substieda bodies were smaller and more delicate than in *I. ruficapillus* (Berto *et al.* 2011a, 2011b), and such differences were considered sufficient for describing a new coccidian species (Duszynski & Wilber, 1997).

Isospora chopi





Figures 9, 10 – Oocysts of *Isospora chopi* recovered from *Gnorimopsar chopi*. (9) Note the spheric to subspheric oocyst of *Isospora chopi* without polar granule, with prominent Stieda body (arrow) and diffused sporocyst residuum (arrowhead). (10) Note the spheric to subspheric *Isospora chopi* oocyst with sporocyst residuum (arrow), prominent Stieda body (arrowhead) and absence of polar granule.

Description of the sporulated oocyst: Spheric to subspheric oocysts (n = 48) of 22 x 24.5µm (20-25 x 20-30µm), MI of 1.2 (1.0 -1.2), with smooth double layered wall of approximately 1 µm in thickness, without micropyle or polar granule (Table IV).

Table IV – Morphometric comparisons of *Isospora* found in feces* of *Gnorimopsar chopi* (Aves, Passeriformes: Icteridae) in triage in the Wild Animals Triage Center (CETAS) of Belo Horizonte, Minas Gerais, Brazil.

Species	Mean	Standard deviation	Median	Maximum	Mínimum	Prob. (P=)
Oocyst length						
1	24,23	1,94	24,5	30,00	20,00	0,0001
2	26,95	2,32	27,00	32,00	22,00	
Oocyst width						
1	22,52	1,57	22,00	25,00	20,00	0,5635
2	22,81	1,84	23,00	28,00	20,00	
Oocyst morphometric index						
1	1,08	0,06	1,08	1,20	1,00	0,0001
2	1,19	0,11	1,18	1,52	1,00	
Sporocyst length						
1	15,05	0,95	15,00	16,00	13,00	0,0001
2	16,33	1,03	16,00	19,00	14,00	
Sporocyst width						
1	9,70	0,57	10,00	10,00	8,00	0,0001
2	10,69	0,64	11,00	12,00	9,00	
Sporocyst morphometric índex						
1	1,55	0,08	1,58	1,67	1,30	0,2028
2	1,53	0,10	1,52	1,73	1,33	

*Fecal samples were colected from August 21 to September 21, 2012.

Species 1: proposed name Isospora chopi; species 2: proposed name Isospora gnorimopsar.

Description of sporocyst: Ellipsoidal sporocysts of 10 x 15 µm (8-10 x 13-16 µm) with 2 µm in height and 1 µm in width prominent Stieda body and diffused sporocyst residuums (Table IV)

Host: Gnorimopsar chopi (Aves: Passeriformes: Icteridae).

Geographical location and date: Samples obtained at the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012.

Site of infection: Unknown. Samples were taken from feces.

Sporulation: Exogenous. *Frequency of detection*: In 5/ 9 (55%).

Collection material Id. Chopi*:* Refrigerated (4-8 °C) for analysis and subsequently frozen feces; oocysts photomicrographs stored at the Avian Diseases Laboratory, Veterinary College, UFMG.

Etymology: The name given to this species was based on its host name: *Gnorimopsar chopi*.

Remarks

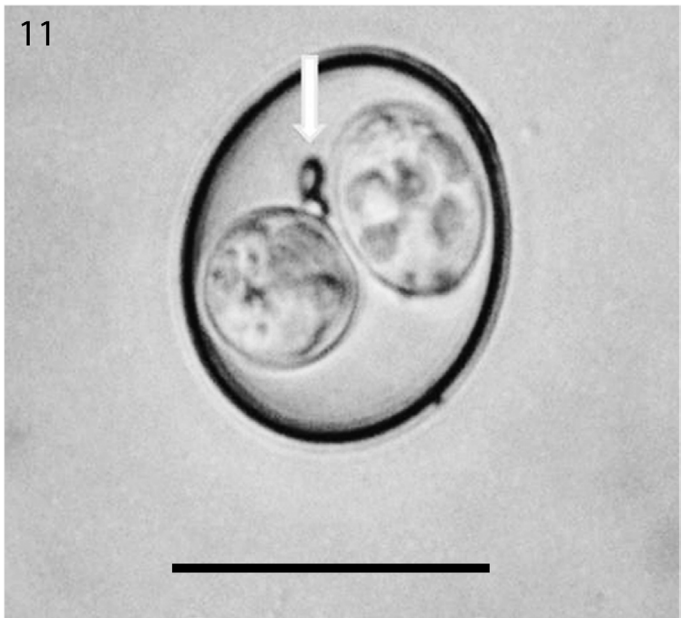
The morphometric and morphologic data (Table IV) obtained after sporulation were compared to data from the literature (Table V) for *Isospora* of Icteridae and using a previously described dichotomic key (Berto *et al.*, 2010) which enabled the description of a new species, *Isospora chopi*.

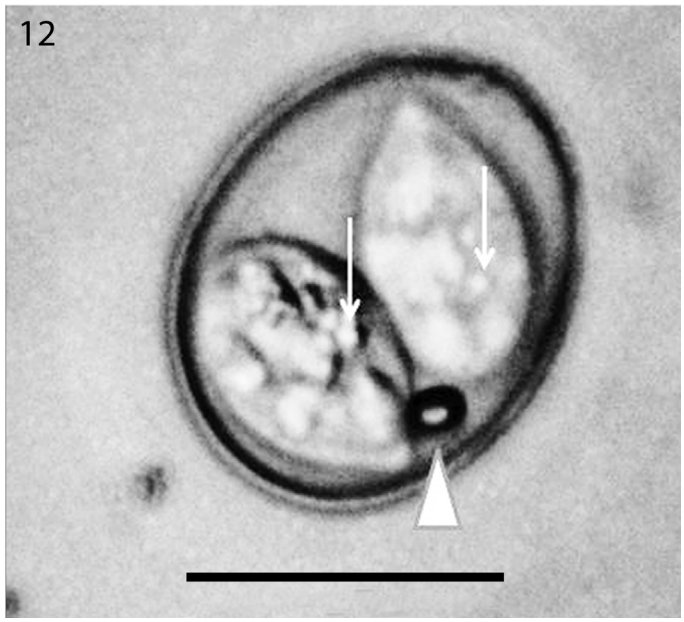
Analyzing the previously known *Isospora* of Icteridae, only *Isospora divitis* (Pellérdy, 1967) (Table V) shares common features to the new species (*I. chopi*), including the presence of sporocyst residuum, even though the morphometric measurements of the sporocyst differed. *I. divitis* was described in *Dives atroviolaceus* as an endemic icterid in Cuba. *D. atroviolaceus* and *G. chopi* never share the same environment; *G. chopi* occurs up to the southern borders of the Amazon forest in Brazil and *D. atroviolaceus* occurs only in Cuba.

Isospora gnorimopsar

Description of the sporulated oocyst: Subspheric to ovoid oocysts of 23 - 27 µm (20-28 x 22-32µm) (n = 59), with morphometric index (MI) 1.2 (1.0-1.4), with a smooth double layered wall of approximately 1 µm in thickness, absent micropyle and with 1 or 2 polar granules (Table IV).

Description of the sporocyst: Ellipsoidal sporocysts, 11-16 µm (9-12 x 14-19 µm), with SI 1.5 (1.3 x 1.), flat Stieda body (1 µm in thickness and 2 µm in width) and diffused sporocyst residuum (Table IV).





Figures 11, 12 – Oocysts of *Isospora gnorimopsar* recovered from *Gnorimopsar chopi*. (11) Note the ovoid to subspheric oocyst of *Isospora gnorimopsar* with two polar granules (arrow). (12) Note the ovoidal to subspheric oocyst of *Isospora gnorimopsar* with one polar granule (arrowhead) and sporocyst residuum (arrows).

Taxonomic summary

Host: *Gnorimopsar chopi* (Aves: Passeriformes: Icteridae).

Geographical location and date: Samples obtained at the Wild Animal Triage Center of Belo Horizonte (CETAS/BH), Brazil, from August 21st to September 21st, 2012.

Site of infection: Unknown. Samples were taken from feces.

Sporulation: Exogenous.

Frequency of detection: In 5/9 (55%).

Table V – Morphometric comparisons of Isospora species described in passerines of family Icteridae (Aves: Passeriformes, Icteridae).

Species	Host	Reference	Oocyst					Sporocyst					
			Shape	Polar granule	Diameter (µm)		Morpho-metric Index	Shape	Diameter (µm)		Morphometric index	Stieda body	Residuum
					Length (L)	Width (W)			Length (L)	Width (W)		Shape height x width (µm)	
Isospora divitis	*Dives atroviolaceus*	Pellérdy (1967)	Sub-spheric	Absent	(30-22)	(28-20)	1.1		17	13	1.3	Conspicuous	Diffuse
Isospora cacici	*Cacicus cela cela*	Lainson (1994)	Sub-spheric	Present 1 or 2	26,5 (27,5-22,5)	23,7 (26,2-20)	1,1	Elongated	17,7 (18,75-17,5)	12,5 (13,75-11,25)	1,4	Prominent, cork shaped	Compact
Isospora belicosa	*Sturnella belicosa*	Upton *et al.*(1995)	Episoidal or ovoid	Present 1 or 2	29,4 (26,4-23,5)	23,5 (26,4-21)	1,2	Ellipsoidal	17,8 (18,6-16,8)	10,7 (11,2-10,2)	1,67	Large	Diffuse
Isospora icterus	*Icterus icterus*	Upton & Whitaker (2000)	Sub-spheric	Present	28,9 (32-27,2)	27,2 (30-25)	1,1	Ellipsoidal	17,8 (19,2-16,8)	12,8 (13,6-12)	1,39	Small, mammiliform	Diffuse
Isospora icterus	*Icterus jamacaii*	Marques *et al.* 2011	Sub-spheric	Present	30,1 (32,5-27,5)	28,5 (30-26,25)	1,1	Ellipsoidal1.3	17,6 (20-15)	12,9 (15-12,5)	1,4	Small, mammiliform	Diffuse
Isospora graceannae	*Icterus graceannae*	Upton & Whitaker (2000)	Sub-spheric	Present	23,9 (26,4-20)	22,3 (25-18,6)	1,1	Ellipsoidal	15,5 (16,2-14,2)	10,7 (11,4-10)	1,44	Robust	Diffuse
Isospora gnorimopsar	*Gnorimopsar chopi*	Present study	Sub-spheric to ovoid	Present 1 or 2	27 (32-22)	23 (28-20)	1,18 (1,33 -1)	Ellipsoidal	16 (19-14)	11 (12 - 9)	1,52 (1,72 - 1,33)	Flat 1 x 2	Absent
Isospora chopi	*Gnorimopsar chopi*	Present study	Sub-spheric to ovoid	Absent	24,5 (30-21)	22 (25-20)	1,08 (1,19 – 1)	Ellipsoidal	15 (16-13)	9,7 (10-8)	1,57 (1,66-1,3	Prominent 2 x 1	Present

Collection material Id. Gnorimopsar*:* Refrigerated (4-8 °C) for analysis and subsequently frozen feces; oocysts photomicrographs stored at the Avian Diseases Laboratory, Veterinary College, UFMG.

Etymology: The name given to this species was based on the genus of the host, *Gnorimopsar chopi*.

Remarks

The morphometric and morphologic data obtained after sporulation were compared to data from literature (Table II) and using a previously described dichotomic key (Berto *et al.*, 2010) which enabled the description of a new species, *Isospora gnorimopsar.*

The presence of the polar granule in *I. gnorimopsar*, were compared to those of *I. cacici* (Lainson, 1994), *I. belicosa* (Upton *et al.*, 1995), *I. icterus* (Upton and Whitaker, 2000) and *I. graceannae* (Upton and Whitaker, 2000). However, the flattened shape of the Stieda body was distinct in *I. gnorimopsar*. Although *I. icterus* was described with a small Stieda body, the oocyst and sporocyst average dimensions were significantly different. In addition, no sporocyst residuum was found in *I. gnorimopsar*, in contrast to a diffused residuum in *I. icterus*. The analyses were performed based on descriptions by Berto *et al.* (2011a). Such differences are considered sufficient in determining this to be a new coccidian species (Duszynski & Wilber, 1997).

DISCUSSION

Out of the 216 fecal samples evaluated, 61 were positive for oocysts, which corresponded to 28% of this total, all being of the genus *Isospora*. Considering this occurrence, similar results had been previously found in birds by McQuistion (2000), Marietto-Gonçalves *et al.* (2009), Vilela *et al.* (2009) and Schoener *et al.* (2013). Considering passerines (Passeriformes), results are in agreement with previous reports by Pereira *et al.*, (2011) and Coelho *et al.* (2013), studying *Gubernatrix cristata* and *Saltator similis*, respectively, and found only *Isospora*.

Although the impact of coccidiosis in free-living passerines is unknown, the disease is highly significant in captive birds (Swayne *et al.*, 1991; Cork and Alley, 1999; Twentyman, 2001; Gill and Paperna, 2008; Marques *et al.*, 2011; Vasconcelos *et al.*, 2012). Results indicate that the triage birds evaluated, despite being temporarily in captivity, have undergone challenge, which could eventually have become clinically significant for susceptible birds, with the increasing concentration of oocysts in the housing environment. The adequate

cleaning and disinfection of the premises should be intensified using more efficient principles such as ammonium hydroxide (Kahrs, 1995). Considering the risk of coccidiosis for birds in triage, in agreement with monitoring recommendations, the authors suggest routine evaluations of feces to be performed weekly (Friend and Franson, 1999).

In this study, not all oocysts found were characterized. A few samples, although adequate for determining the genus, were not adequate for the description of species due to the lack of development, presentation or preservation of discernible features. New host species presenting *Isospora* in this study include *Cyanoloxia brisonii, Gnorimopsar chopi, Paroaria dominicana, Schistochlamys ruficapillus, Sicalis flaveola, Sporophila caerulescens* and *Sporophila nigricolis*. The coccidians found in the host species *Cyanoloxia brisonii, Sicalis flaveola, Sporophila caerulescens* and *Sporophila nigricolis* belong to the genus *Isospora*, and a detailed morphology of the oocysts was not evaluated.

The morphological comparisons were performed for characterizing *Isospora* species in the host family taxon. The careful analysis of oocysts included the determination of oocyst and sporocyst metrics (length and width), oocyst wall, including layers, projections, texture and thickness, and the presence and characteristics of structures (micropyle, polar granule, oocyst residuum, Stieda and substieda bodies, refractile bodies, nucleus, residuum, adherent membranes, sporodium and sutures) (Duszynski & Wilber, 1997). When comparing features, *Isospora gnorimopsar* differed from *Isospora cacici* (Lainson 1994), *Isospora belicosa* (Upton *et al.*, 1995), *Isospora icterus* and *Isospora graceannae* (Upton and Whitaker 2000). *Isospora chopi* was compared to *Isospora divitis* (Pellérdy 1967) and differed from this species.

Isospora dominicana, I. beagai, I. ferri and *I. ruficapillus*, which were found in the Thraupidae feces, were compared to and differed from *I. vanriperorum* (Levine *et al.*, 1980; Lopes *et al.*, 2007), *I. paroariae* (Upton *et al.*, 1985), *I. pityli* and *I. formarum* (McQuistion and Capparella, 1992), *I.* saltatori (Berto *et al.* 2008b), *I. trincaferri*, (Berto *et al.*, 2008b), *I. thraupis* (Lainson, 1994; Berto, 2010), *I. andesensis* (Templar *et al.*, 2004; Berto, 2010), *I. irisidornisi* (Metzelaars *et al.*, 2005; Berto, 2010), *I. tiesangui* (Berto *et al.*, 2008a; Berto, 2010), *I. marambaiensis* (Berto *et al.* 2008a; 2010), *I. sepetibensis* (Berto *et al.*, 2008a; 2010), *I. cadimi* (Berto *et al.*, 2009a; 2010), *I. navarroi* (Berto *et al.*, 2009b; 2010), *I. ramphoceli* (Berto et al, 2010), *I. sanhaci* (Berto *et al.*, 2009c; 2010), *I. silvasouzai* (Berto *et al.*, 2009c; 2010), *I. sayacae* (Berto *et al.*, 2009c; 2010) and *I. similisi* (Coelho *et al.*, 2013).

The morphometric and morphologic comparisons enabled the identification of new *Isospora* species in previously known and unknown passerine host species. However, more reliable and conclusive studies should be developed, including phylogenetic studies, in order to evaluate, compare and group genotypes, using molecular techniques.

In addition to previous studies, we have demonstrated the occurrence of new host species and new coccidian species in native avian host passerine species. The higher risk for the host species of Thraupidae became clear, as compared to Cardinalidae, Emberizidae, Fringillidae and Turdidae. Within Thraupidae, *Saltator similis* is the most frequently described host species. *Isospora* was unpublished in *Paroaria dominicana*, *Schistochlamys ruficapillus* and *Gnorimopsar chopi*. The new species of *Isospora* described were *Isospora dominicana*, *Isospora ferri*, *Isospora ruficapillus*, *Isospora chopi* and *Isospora gnorimopsar*. The new coccidian species and new passerine hosts add to the complexity of *Isospora* in passerines and indicates for frequent monitoring during rehabilitation.

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LITERATURE CITED

Berto BP, Balthazar LMC, Flausino W, Lopes CWG. New isosporoid coccidian parasites of sayaca tanager, *Thraupis sayaca*, from South America. Acta Parasitologica 2009b;54:90-94.

Berto BP, Balthazar LMC, Flausino W, Lopes CWG. Three new species of *Isospora* Schneider, 1881 (Apicomplexa: Eimeriidae) from the buffy-fronted seedeater *Sporophila frontalis* Verreaux, 1869 (Passeriformes: Emberizidae) from South America. Systematic Parasitology 2009a;73:65-69.

Berto BP, Balthazar LMC, Flausino W, Lopes CWG. Two new coccidian parasites of green-winged Saltator (*Saltator similis*) from South America. Acta Protozoologica 2008b;47:263-267.

Berto BP, Flausino W, Luz HR, Ferreira I, Lopes CWG. Three New Coccidian Parasites of Brazilian Tanager (*Ramphocelus bresilius dorsalis*) from South America. Acta Protozoologica 2008a;47:77–81.

Berto BP, Flausino W, Luz HR, Ferreira I, Lopes CWG.. Two new *Isospora* species from Brazilian tanager (*Ramphocelus bresilius dorsalis*) of South America. Parasitology Research 2009b;105:635-639.

Berto BP, Flausino W, McIntosh D, Teixeira-Filho WL, Lopes CWG. Coccidia of new world passerine birds (Aves: Passeriformes): a review of *Eimeria* Schneider, 1875 and *Isospora* Schneider, 1881 (Apicomplexa: Eimeriidae). Systematic Parasitology 2011a;80:159-204.

Berto BP, Luz HR, Ferreira I, Flausino W, Lopes CWG. A diagnostic tool to identify species of the genus *Isospora* Schneider, 1881(Apicomplexa: Eimeriidae) based on sporulated oocysts from Thaupidae family (Aves: Passeriformes): a dichotomous key. Revista Brasileira de Medicina Veterinária 2010;32:182-186.

Berto BP, Luz HR, Flausino W, Teixeira-Filho WL, Ferreira I, Lopes CWG. Isosporoid Coccidia (Apicomplexa: Eimeriidae) parasites of tanagers (Passeriformes: Thraupidae) from the Marambaia Island, Brazil. Pesquisa Veterinária Brasileira 2011;31:798-805.

Berto BP. Morfologia e sistemática de coccídios (Apicomplexa: Eimeriidae) parasitas de aves passeriformes da Ilha de Marambaia [thesis]. Rio de Janeiro (RJ): Universidade Federal Rural do Rio de Janeiro; 2010.

Borges RC, Oliveira A, Bernardo N, Costa RMMC. Diagnóstico da fauna silvestre apreendida e recolhida pela Polícia Militar de Meio Ambiente de Juiz de Fora, MG (1998 e 1999). Revista Brasileira de Zoologia 2006;8:23-33.

Brown MA, Ball SL, Snow KR. Coccidian parasites of British wild birds. Journal of Natural History 2010;44:2669-2691.

CBRO- Comitê Brasileiro de Registros ornitológicos. Listas das aves do Brasil [cited 2014 April 1]. Available from: http://www.cbro.org.br.

Coelho CD, Berto BP, Neves DM, Oliveira VM, Flausino W, Lopes CWG. Oocyst shedding by green-winged-saltator (*Saltator similis*) in the diagnosis of coccidiosis and *Isospora similis* n. sp. (Apicomplexa: Eimeriidae). Revista Brasileira de Parasitolologia Veterinária 2013;22:64-70.

Cork SC, Alley MR. Aspergillosis and other causes of mortality in the stitchbird in New Zealand. Journal of Wildlife Diseases 1999;35:481-48.

Costa IA, Coelho CD, Bueno C, Ferreira I, Freire RB. Ocorrência de parasitos gastrointestinais em aves silvestres no município de Seropédica, Rio de Janeiro, Brasil. Ciência Animal Brasileira 2010;11:914-922.

Duszynski DW, Upton SJ, Couch L. The Coccidia of the world [cited 2018 Apr 09]. Available from: http://biology.unm. edu/coccidia/home.html.

Duszynski DW, Wilber PG. A guideline for the preparation of species descriptions in the Eimeriidae. Journal of Parasitology 1997;83:333-336.

Ferreira CM, Glock L. Diagnóstico preliminar sobra a avifauna traficada no Rio Grande do Sul, Brasil. Biociências 2004;12:21-30.

Freitas MFL, Oliveira JB, Cavalcanti MDB, Leite AS, Magalhães VS, Oliveira RA, *et al.* Parasitos gastrointestinales de aves silvestres en cautiverio en el estado de Pernambuco, Brasil. Parasitologia Latinoamericana 2002;57:50-54.

Friend M, Franson JC, editors. Intestinal coccidiosis. *In*: Friend M, Franson JC. Field manual of wildlife diseases: general field and procedures and diseases of birds. Washington: United States Geological Survey, Biological Resources Division; 1999. p.207-213.

Gill H, Paperna I. Proliferative visceral *Isospora* (atoxoplasmose) with morbid impacto on the Israel sparrow *Passer domesticus biblicus* Hartert, 1904. Parasitology Research 2008;103:493-499.

IUCN. Red list of threatened species. Version 2013.2 [cited 2018 May 12]. Available from: www.iucnredlist.org.

Kahrs RF. General disinfection guidelines. Scientific and Technical Review of the Office International des Epizooties 1995;14:105-122.

Keeler SP, Yabsley MG, Fox JM, McGraw SN, Hernandez SM. *Isospora troglodytes* n. sp. (Apicomplexa:Eimeriidae), a new coccidian species from wrens of Costa Rica. Parasitology Research 2011;110:1723–1725.

Lainson R. Observations on some avian coccidia (Apicomplexa:Eimeriidae) in amazonian Brazil. Memórias do Instituto Oswaldo Cruz 1994;89:303-311.

Lederberg J. Emerging infections:an evolutionary perspective. Emerging Infection Diseases 1998;4:366-371.

Levine ND, Van-Riper S, Van-Riper C. Five new species of *Isospora* from Hawaiian birds. Journal of Protozoology 1980;27:258-259.

Lopes BB, Berto BP, Massad FV, Lopes CWG. *Isospora* vanriperorum Levine 1982 (Apicomplexa:Eimeriidae) in the green-winger Saltator, *Saltator similis* (Passeriformes:Cardinalidae) in the southeastern Brasil. Revista Brasileira de Parasitololgia Veterinária 2007;16:211-214.

Marietto-Gonçalves GA, Martins TF, Lima ET, Lopes RS, Filho RLA. Prevalência de endoparasitas em amostras fecais de aves silvestres e exóticas examinadas no laboratório de ornitopatologia e no laboratório de enfermidades parasitárias da FMVZ-UNESP/BOTUCATU, SP. Ciência Animal Brasileira 2009;10:349-354.

Marques MVR, Vilela DAR, Andrade EAG, Galvão GZ, Resende CZ, *et al.* Fatal coccidiosis by *Isospora icterus* (Upton & Whitaker 2000) in captive campo troupial (Icterus jamacaii) (Aves, Passeriformes, Icteridae) in Brazil. Journal of Zoo and Wildlife Medicine 2011;42:735-737.

McQuistion TE. The frequency of detection of coccidian parasites in passerine birds from South America. Transactions of the Illinois State Academy of Science 93:221-227.

McQuistion, TE, Capparella A. *Isospora sagittulae*, a new coccidian parasite (Apicomplexa:Eimeriidae) from the spotted antbird (*Hylophylax naevioides*). Transactions of the American Microscopical Society 1992;111:365-368.

Metzelaars HT, Spaargaren T, McQuistion TE, Capparella AP. *Isospora iridosornisi*, a new coccidian parasite (Apicomplexa, Eimeriidae) from the yellow-throated tanager, Iridosornis analis of South America. Acta Parasitologica 2005;50:191-193.

Moore J, Clayton DH. Conclusion: Evolution of host–parasite interactions. In: Clayton DH, More J, editors. Host–parasite evolution: general principles and avian models. New York: Oxford University Press; 1997. p.370–376.

Pagano ISA, Sousa AEB, Wagner PGC, Ramos RTC. Aves depositadas no Centro de Triagem de Animais Silvestres do IBAMA na Paraíba:uma amostra do tráfico de aves silvestres no estado. Ornithologia 2009;3:132-144.

Page CD, Haddad K. Coccidial infections in birds. Seminars in Avian and Exotic Pet Medicine 1995;4:138-144.

Pellérdy L. Three new coccidia parasitic in Cuban birds (Protozoa:Sporozoa). Acta Zoologica Academiae Scientiarum Hungaricae 1967;13:227-230.

Pereira LQ, Berto BP, Flausino W, Lovato M, Lopes CWG. *Isospora bocamontensis* n. sp. (Apicomplexa:Eimeriidae) from the yellow cardinal *Gubernatrix cristata* (Vieillot) (Passeriformes:Emberizidae) in South America. Systematic Parasitology 2011;78:73–80.

Sampaio IBM. Estatística aplicada à experimentação animal. Belo Horizonte: Fundação de Ensino E Pesquisa em Medicina Veterinária e Zootecnia; 2007. 265p.

Santos EAM, Bueno M, Araújo AS, Barros IFA, Paes NNG, Rodrigues SRW, *et al.* Aves do centro de triagem de animais silvestres do Estado do Amapá. Ornithologia 2001;4:86-90.

Schoener ER, Alley MR, Castro I. Coccidia species in endemic and native New Zealand passerines. Parasitology Research 2013;112:2027-2036.

Sick H. Ornitologia Brasileira. Rio de Janeiro: Nova Fronteira; 1997. 862 p.

Swayne DE; Getzy D, Slemons RD, Bocetti C, Kramer L. Coccidiosis as a cause of transmural lymphocytic enterits and mortality in captive Nashville warblers (*Vermivora ruficapilla*). Journal of Wildlife Diseases 1991;27:615-620.

Templar AC, McQuistion TE, Capparella AP. A new coccidian parasite, *Isospora andesensis*, from the common bush tanager *Chlorospingus ophthalmicus* of South America. Acta Protozoologica 2004;43:369–371.

Twentyman CM. A study of coccidial parasitis in the hihi (*Notionystis cincta*) [thesis]. Palmerston North (NZ): Massey University; 2001.

Upton SJ, Current W, Clubb S. Two new species of *Isospora* (Apicomplexa:Eimeriidae) from passeriform birds of South America. Systematic Parasitology 1985;7:227–229.

Upton SJ, Stamper MA, Whitaker BR. *Isospora bellicosa* sp. n. (Apicomplexa) from a Peruvian red-breasted meadowlark, *Sturnella bellicose* (Passeriformes:Icteridae). Archiv für Protistenkunde 1995;145:132-134.

Upton SJ, Whitaker B. New species of *Isospora* (Apicomplexa, Eimeriidae) from the troupial and white-edged oriole (Icterus spp.) (Aves, Passeriformes, Icteridae). Acta Parasitologica 2000;45:67-70.

Vasconcelos TCB, Longa CS, Campos SDE, Costa CHC, Bruno SF. Coccidiose em Sporophila maximilliani (Passeriformes:Emberizidae):relato de dois casos. Revista Brasileira de Medicina Veterinária 2012;34:261-264

Vilela DAR, Savernini THOPM, Mendes EJ, Campos SM, Andrade RA, Guimarães RC, *et al.* Ocorrência de coccídeos intestinais em passeriformes silvestres provenientes do tráfico e encaminhados para o Cetas do IBAMA em Belo Horizonte. Anais do 12º Congresso ABRAVAS; 2009; Águas de Lindóia, São Paulo. Brasil. p.56-57.

Vilela DAR. Diagnóstico da Avifauna Encaminhada para os Centros de Triagem de Animais Silvestres (CETAS) do Brasil e Ocorrência de Clamidiose Aviária no CETAS de Belo Horizonte, MG [thesis]. Belo Horizonte (MG): Universidade Federal de Minas Gerais; 2012.

Wobeser GA. Parasitism: costs and effects. In: Atkinson, CT, Thomas NJ, Hunter DB, editors. Parasitic diseases of wild birds. Oxford: Wiley-Blackwell, 2008. p.3-12.

Yabsley MJ. Eimeria. In: Atkinson, CT, Thomas NJ, Hunter DB, editors. Parasitic diseases of wild birds. Oxford: Wiley-Blackwell, 2008. p.162-180.