



## *Isospora brasilsatoae* n. sp. (Apicomplexa: Eimeriidae) from thrushes *Turdus* spp. (Passeriformes: Turdidae) from Brazil

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### Abstract

A new species of coccidia (Protozoa: Apicomplexa: Eimeriidae) found parasitizing the yellow-legged thrush *Turdus flavipes* (Vieillot, 1818), the pale-breasted thrush *Turdus leucomelas* Vieillot, 1818 and the creamy-bellied thrush *Turdus amaurochalinus* Cabanis, 1850 in Southeastern Brazil is described. *Isospora brasilsatoae* n. sp. has oocysts that are ovoidal to pyriform,  $26.8 \times 21.1 \mu\text{m}$ , with smooth, bilayered wall,  $\sim 1.6 \mu\text{m}$  thick. Micropyle present. Oocyst residuum absent, but one to three polar granules are present. Sporocysts are elongate ovoidal,  $18.1 \times 10.5 \mu\text{m}$ . Stieda body knob-like and sub-Stieda body trapezoidal. Sporocyst residuum is composed of granules that appear to be membrane-bounded. Sporozoites are vermiform with refractile bodies and striations. This is the ninth description of an *Isospora* sp. parasitizing a New World thrush.

**Key words:** taxonomy, morphology, coccidia, *Isospora*, oocysts, Passeriformes, Turdidae, Itatiaia National Park, Serra dos Órgãos National Park, Guapimirim, Cacaria, Rio de Janeiro, Brazil

### Introduction

Brazil has 14% of the biodiversity of the world. The explanation for this biological richness lies in the large number of endemic species, the enormous vegetation cover, the variety of biomes and the immense coastline (Lewinsohn & Prado 2005). Brazil occupies 47.8% of the Neotropical region, being known as the 'country of the birds' for having about a third of all species on the planet, representing almost 57% of the total resident birds of South America. In this sense, Brazil becomes one of the most important countries for investment in bird conservation in the world (Sick 1997; Lewinsohn & Prado 2005; Marini & Garcia 2005).

Among all families of Aves in Brazil, the Turdidae family comprises 20 genera and 180 species, of which 87 are classified in the genus *Turdus* Linnaeus, 1758. *Turdus* spp. are abundant in the Atlantic and Amazon forests, preferably inhabiting humid areas with higher trees on slopes, but also found near the soil feeding on small fruits and insects (Sick 1997; BirdLife International 2016).

Wild birds are hosts of endo- and ectoparasites; however, among all these, coccidian protozoa can be highlighted. Parasitism by coccidians should not affect the health of wild birds in preserved/conserved environments; however, in impacted environments, stress and consequent low immunity make wild birds more susceptible to coccidiosis (Berto & Lopes 2013).

In this context, the current study describes a new species of *Isospora* recovered from yellow-legged thrushes

*Turdus flavipes* (Vieillot, 1818), pale-breasted thrushes *Turdus leucomelas* Vieillot, 1818 and creamy-bellied thrushes *Turdus amaurochalinus* Cabanis, 1850 captured in different localities in Southeastern Brazil.

## Material and methods

A total of four expeditions were conducted in 3 different localities in southeastern Brazil: (1) Parque Nacional do Itatiaia (22°26'57"S, 44°36'25"W), a protected area located in the Serra da Mantiqueira on the border of the States of Rio de Janeiro, Minas Gerais and São Paulo (ICMBIO 2018a); (2) a fragmented area of Atlantic Forest in the Municipality of Guapimirim (22°31'10"S, 43°00'36"W), which is located around Parque Nacional da Serra dos Órgãos, another protected area located in the coastal mountain range (Serra do Mar) of the State of Rio de Janeiro (ICMBIO 2018b); and (3) Cacaria (22°42'51"S, 43°50'38"W) at the Municipality of Piraí in the State of the Rio de Janeiro. A total of five *T. flavipes* (four from Parque Nacional do Itatiaia and one from Cacaria), four *T. leucomelas* (two from Parque Nacional do Itatiaia and two from Guapimirim) and one *T. amaurochalinus* (from Cacaria) were captured with mist nets. The birds were kept in individual boxes with clean ground paper. After identification of the species (Sigrist 2014), the bird was photographed and released. A fresh droplet of feces from each individual bird was placed in an individually centrifuge tube with a potassium dichromate 2.5% (K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub>) solution. Field-collecting permits were issued to B.P. Berto by SISBIO/ICMBio (licenses 42798-1; 45200-1; 49605-1; 54951-1) and CEUA/UFRRJ (protocols IV-036/2014; ICBS-008/2015; IV-6606250616). Fecal samples were taken to the Laboratório de Biologia de Coccídios, Departamento de Biologia Animal, Instituto de Ciências Biológicas e da Saúde, Universidade Federal Rural do Rio de Janeiro (UFRRJ), where they were incubated at room temperature (20–25°C) for one week. Oocysts were recovered by flotation in Sheather's sugar solution (Specific gravity: 1.20) and examined microscopically using the technique described by Duszynski & Wilber (1997) and Berto et al. (2014). Morphological observations, line drawings, photomicrographs, and measurements were made with the use of an Olympus BX41 binocular microscope (Olympus Optical, Tokyo, Japan) coupled to a digital camera Eureka 5.0 (BEL Photonics, Monza, Italy) connected to a computer running the software BELView (Version 6.2.3.0, BEL Engineering, Monza, Italy). Line drawings were edited using two software applications from CorelDRAW® (Corel Draw Graphics Suite, Version 11.0, Corel Corporation, Canada), specifically Corel DRAW and Corel PHOTO-PAINT. All measurements are in micrometres and are given as the range followed by the mean in parentheses.

## Results

Two *T. flavipes* from the Parque Nacional do Itatiaia, one *T. leucomelas* from Guapimirim and the only *T. amaurochalinus* from Cacaria were positive for an *Isospora* sp. unrecorded in scientific literature.

### *Isospora brasilsatoae* Oliveira and Berto n. sp.

**Type host:** Yellow-legged thrush *Turdus flavipes* (Vieillot, 1818) (Aves: Passeriformes: Turdidae).

**Other hosts:** Pale-breasted thrush *Turdus leucomelas* Vieillot, 1818 (Aves: Passeriformes: Turdidae); creamy-bellied thrush *Turdus amaurochalinus* Cabanis, 1850 (Aves: Passeriformes: Turdidae).

**Type locality:** Parque Nacional do Itatiaia (22°26'57"S, 44°36'25"W), Southeastern Brazil.

**Other localities:** Cacaria (22°42'51"S, 43°50'38"W) and Guapimirim (22°31'10"S, 43°00'36"W), also from Southeastern Brazil.

**Type-material:** Photosyntypes, line drawing and oocysts recovered from *T. flavipes* in 2.5% K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> solution (Williams et al. 2010) are deposited at the Museu de Zoologia at the Universidade Federal Rural do Rio de Janeiro, Brazil, under accession number MZURPTZ2018007. Photomicrographs are also deposited and available (<http://r1.ufrrj.br/labicoc/colecao.html>) in the Parasitology Collection of the Laboratório de Biologia de Coccídios, at UFRRJ, under repository number P-90/2018. Photographs of the type-host specimen (symbiotype) are deposited in the same collection.

**ZooBank registration:** To comply with the regulations set out in article 8.5 of the amended 2012 version of the International Code of Zoological Nomenclature (ICZN, 2012), details of the new species have been submitted

to ZooBank. The Life Science Identifier (LSID) for *Isospora brasilsatoae* is urn:lsid:zoobank.org:act:6C3FEE82-FC9C-4A58-8C17-1713532F03F3.

**Site of infection:** Unknown.

**Prevalence:** Four of 10 (40%).

**Sporulation:** Exogenous. All oocysts were passed in the feces unsporulated and were fully sporulated by day 7 in  $K_2Cr_2O_7$  solution at room temperature (20–25°C).

**Etymology:** The specific name is derived from the family name of a Brazilian parasitologist Dr Marília de Carvalho Brasil Sato, given in her honor for her contribution to the study of taxonomy and ecology of parasites.

**Description** (Figs 1; 2A–C)

Oocyst (n = 15) ovoidal to pyriform, 25–30 × 19–23 (26.8 × 21.1); length/width (L/W) ratio 1.2–1.4 (1.27). Wall bi-layered, delicate, 1.4–1.8 (1.6) thick, outer layer smooth, c.2/3 of total thickness. Micropyle present, without micropyle cap, wrinkles or invagination of the in inner layer perceptible. Oocyst residuum absent, but 1 to 3 rounded polar granules are present. Sporocyst elongate ovoidal with tapered anterior end (where it is Stieda/sub-Stieda complex), 17–19 × 10–11 (18.1 × 10.5); L/W ratio 1.6–1.9 (1.72). Stieda body present, knob-like, 2.0 high × 2.0 wide. Sub-Stieda body present, trapezoidal, 1.5 high × 3.5 wide. Para-Stieda body absent. Sporocyst residuum present, as a distinctly sub-spherical body consisting of numerous small granules that appear to be membrane-bounded, 6–9 (7.5). Sporozoites vermiform, with anterior and posterior refractile bodies and striations.

**Remarks:** *Isospora brasilsatoae* is different from other coccidian species of Turdidae of the New World on several aspects (Table 1). It is the only one to have a pyriform shape of the oocysts. It has a micropyle, which is a characteristic present only in the oocysts of *Isospora albicollis* Lainson and Shaw, 1989, *Isospora sabiai* Pinho, Rodrigues, Silva, Lopes, Oliveira, Ferreira, Cardozo, Luz, Ferreira, Lopes and Berto, 2017 and *Isospora machadoae* Pinho, Silva, Rodrigues, Lopes, Oliveira, Luz, Ferreira, Lopes and Berto, 2018 (Lainson & Shaw 1989; Pinho et al. 2017a; 2017b; 2018). From these three, but also from the others, *I. brasilsatoae* can be easily differentiated by having up to three rounded polar granules, sporocysts elongate ovoidal (L/W ratio > 1.6), sub-Stieda body trapezoidal, and compact residuum.

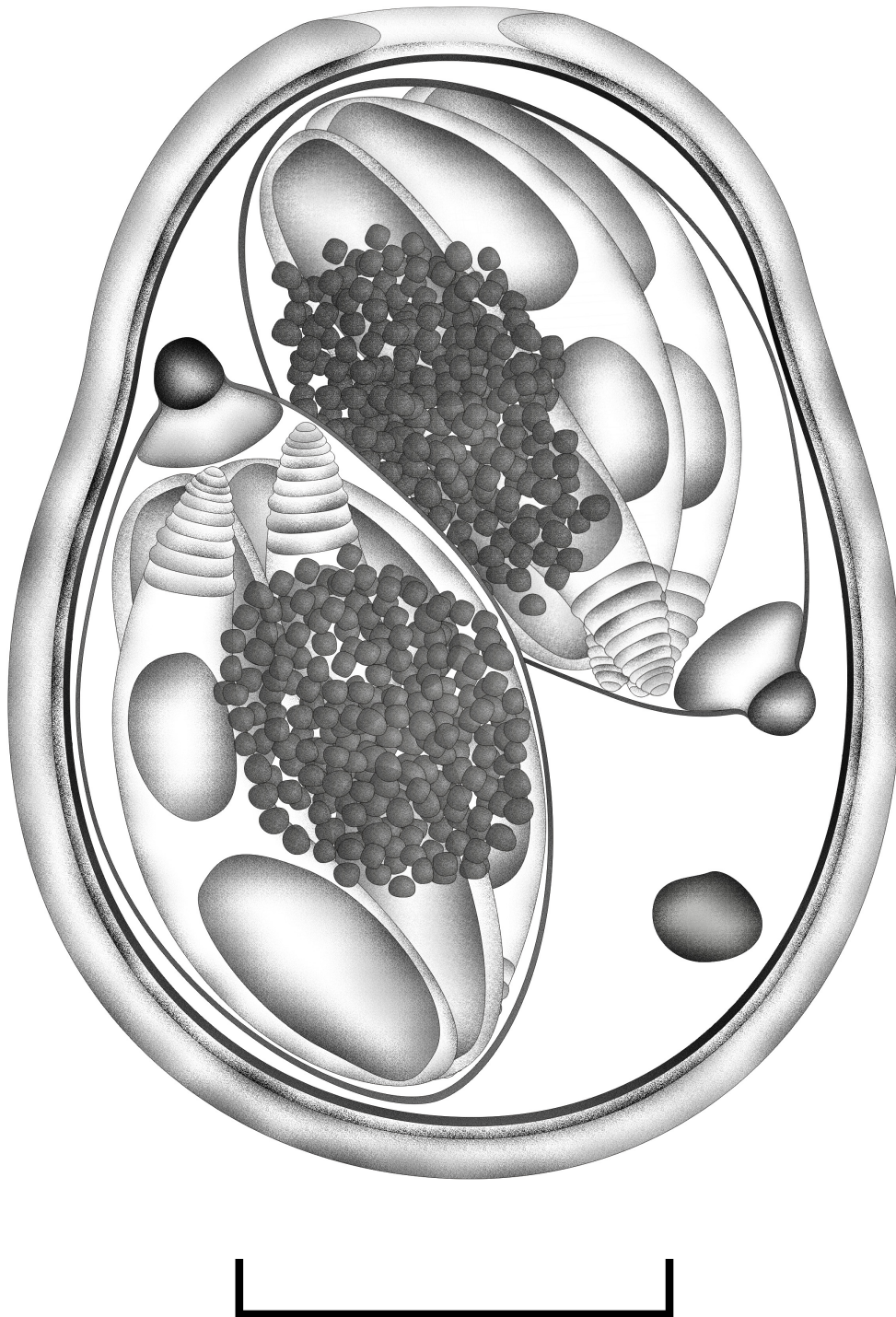
## Discussion

*Turdus* spp. captured in the current study belonged to forest species, which have similar feeding habits, such as eating invertebrates in moist soil and feeding on fruits and berries (Vogel et al. 2014). Thus, the thrushes in the anthropogenic environments may have altered their habits and they had a greater energy expenditure in the adaptation to the different environment, predisposing them to transmissions and infections (Giraudeau et al. 2014). In addition, studies such as de Souza et al. (1992) emphasize that forest environments present smaller birds with predominantly frugivorous feeding habits, which tend to have higher prevalence and densities of coccidia. Despite this, the fecal samples recovered from the thrushes of the current study were not excessively dense, and the birds were apparently healthy, demonstrating that these birds did not suffer from coccidiosis, even in anthropogenic environments.

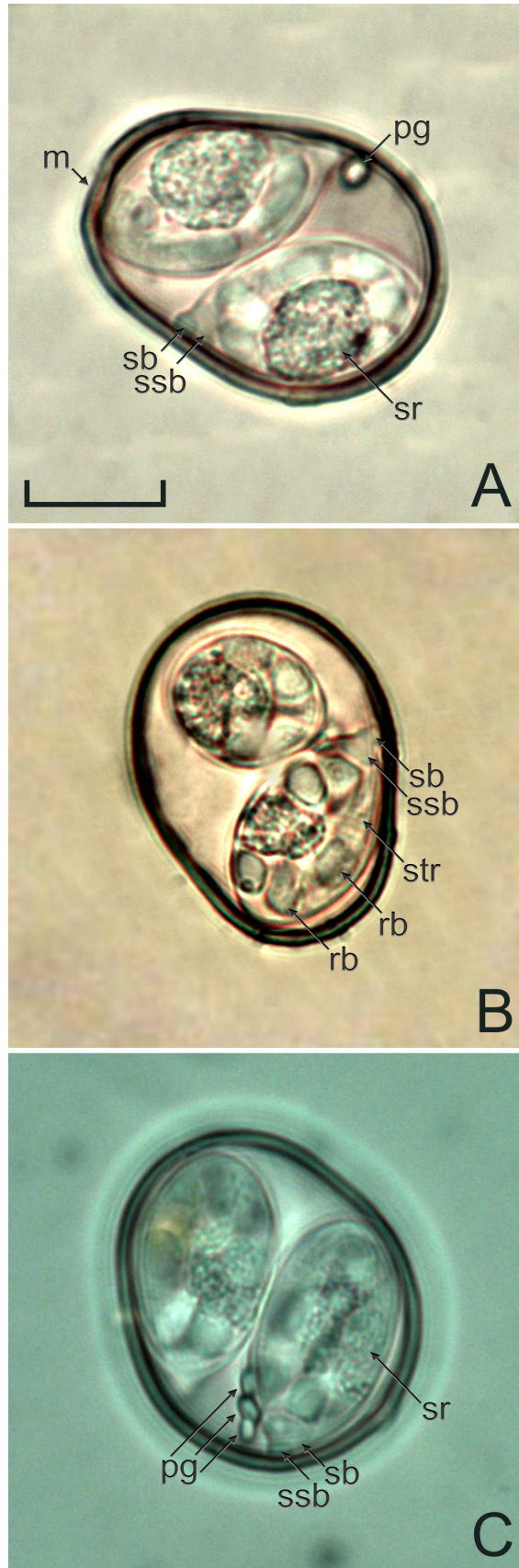
The coccidian parasites of the host family Turdidae in the New World integrate one of the few groups of coccidia to be well characterized and differentiated in the ‘World of Coccidia’. From the works of McQuiston & Holmes (1988) and Lainson & Shaw (1989) to the most recent works in the 21st century, coccidian species in this host family have been described accurately and in great detail. In this sense, species hardly identified as *I. sabiai*, which required many observations and morphometric evaluations for their characterization (Pinho et al. 2017b), even species with prominent characteristics such as *I. albicollis* and *I. machadoae* are well differentiated (Lainson & Shaw 1989; Pinho et al. 2018), as shown in Table 1.

*Isospora brasilsatoae* is an example of a coccidian species with very prominent characteristics, which considerably facilitate its identification. In addition to the large size, the pyriform shape that is observed in the great majority of its oocysts, added to the very elongated sporocyst with its tapered end (where it is Stieda/sub-Stieda complex), allow the identification of *I. brasilsatoae* with accuracy.

Finally, the comparison of *I. brasilsatoae* with *Isospora* spp. described from the host family Turdidae in the New World (Table 1) clearly supports the designation as a unique species. Therefore, *I. brasilsatoae* is considered as new to science, being the ninth description in a New World thrush.



**FIGURE 1.** Line drawing of the sporulated oocyst of *Isospora brasilsatoae* n. sp, a new coccidium species recovered from the yellow-legged thrush *Turdus flavipes*, the pale-breasted thrush *Turdus leucomelas* and the creamy-bellied thrush *Turdus amaurochalinus*. Scale-bar: 10 $\mu$ m.



**FIGURE 2.** Photomicrographs (A-C) of sporulated oocysts of *Isospora brasilsatoae* n. sp, a new coccidium species recovered from the yellow-legged thrush *Turdus flavipes* (A), the pale-breasted thrush *Turdus leucomelas* (B) and the creamy-bellied thrush *Turdus amaurochalinus* (C). Note the micropyle (m), polar granule (pg), Stieda body (sb), sub-Stieda body (ssb), sporocyst residuum (sr), striations (str) and the refractile body (rb). Scale-bar: 10µm.

TABLE 1. Comparative morphology of *Isospora* spp. recorded from Turdidae of the New World

Coccidia	Hosts	References	Oocysts					Substieda body	Residium						
			Shape	Length (µm)	Width (µm)	L/W ratio	Wall			Micropyle	Polar granule	Shape	Length (µm)	Width (µm)	L/W ratio
<i>Isospora phaeoformis</i> Levine, Van Riper and Van Riper, 1980	<i>Myadestes obscurus</i> (Gmelin, 1789)	Levine et al. (1980)	ellipsoidal	25–28 (27)	18–20 (19)	–	smooth	absent	present	ovoidal	15–18 (16)	10–11 (11)	–	present	compact
<i>Isospora robini</i> McQuiston and Holmes, 1988	<i>Turdus migratorius</i> Linnaeus, 1766	McQuiston & Holmes (1988)	ellipsoidal or ovoid	20–28 (23)	16–22 (20)	(1.2)	smooth	absent	present	ovoid	10–17 (13.8)	7–12 (9.0)	(1.5)	nipple-like	compact
<i>Isospora tacurituensis</i> Lainson and Shaw, 1989	<i>Turdus albicollis</i> Vieillot, 1818	Lainson & Shaw (1989)	sub-spherical	15–19 (17.3)	14–19 (17.1)	–	smooth	absent	present, single, ~3 × 2	ellipsoidal	10–13 (11.8)	7–10 (8.4)	–	nipple-like	diffuse or compact
<i>Isospora albicollis</i> Lainson and Shaw, 1989	<i>T. albicollis</i>	Lainson & Shaw (1989)	ovoidal	22–27 (24.5)	19–24 (20.3)	–	smooth	present	present, single, ~2.5 × 2	ellipsoidal	12–15 (16.0)	8–10 (11.2)	–	nipple-like to bubble-shaped	diffuse or compact
<i>I. albicollis</i>	<i>T. albicollis</i> ; <i>Turdus leucomelas</i> Vieillot, 1818	Pinho et al. (2017a)	ovoidal	23–26 (24.4)	18–22 (19.7)	1.2–1.4 (1.24)	smooth	present	present, single	ellipsoidal	14–17 (15.4)	9–11 (10.1)	1.5–1.6 (1.52)	knob-like to rounded, × 1.3	diffuse or compact
<i>Isospora zorali</i> Keeler, Yabsley, Gibbs, McGraw and Hernandez, 2012	<i>Catharus aurantirostris</i> (Hartlaub, 1850)	Keeler et al. (2012)	round to slightly ovoid	16–24 (19.7)	15–21 (18.6)	(1.1)	smooth	absent	present, 1 to 2	ovoidal	11–18 (14.5)	7–11 (8.5)	(1.7)	nipple-like	diffuse or compact
<i>Isospora massardi</i> Lopes, Berto, Luz, Galvão, Ferreira and Lopes, 2014	<i>T. albicollis</i>	Lopes et al. (2014)	sub-spherical	15–21 (18.6)	14–19 (17.7)	1.0–1.1 (1.1)	smooth	absent	present, 2 ellipsoidal granules, 1.5 × 0.5	ovoidal	13–16 (14.8)	8–11 (9.3)	1.4–1.8 (1.6)	knob-like to rounded, × 2	diffuse
<i>Isospora sabiei</i> Pinho, Rodrigues, Silva, Lopes, Oliveira, Ferreira, Cardoso, Luz, Ferreira, Lopes and Berto, 2017	<i>T. albicollis</i> ; <i>Turdus rufigiventris</i> Vieillot, 1818; <i>T. leucomelas</i> ; <i>Turdus flavipes</i> Vieillot, 1818	Pinho et al. (2017b)	sub-spherical to ellipsoidal	17–27 (20.9)	15–24 (18.6)	1.0–1.4 (1.12)	1.0–1.4 (1.12)	present, inconspicuous or imperceptible	present, splinter-like or comma-shaped granules	elongate ellipsoidal to reniform	14–22 (16.5)	7–12 (9.2)	1.5–2.1 (1.8)	present, knob-like, 0.5 × 2.0	compact
<i>Isospora machadoae</i> Pinho, Silva, Rodrigues, Lopes, Oliveira, Luz, Ferreira, Lopes and Berto, 2018	<i>T. albicollis</i>	Pinho et al. (2018)	sub-spherical	21–24 (22.2)	20–23 (21.2)	1.0–1.2 (1.1)	rough	present	present, 1 to 2, sub-spherical and robust	ellipsoidal	12–14 (13.3)	9–11 (9.7)	1.2–1.5 (1.4)	flattened to half-moon-shaped, × 1.5	diffuse
<i>Isospora brasilsataoe</i> Oliveira and Berto n. sp.	<i>T. flavipes</i> ; <i>T. leucomelas</i> ; <i>Turdus amaurochalinus</i> Cabanis, 1850	current work	ovoidal to piriform	25–30 (26.8)	19–23 (21.1)	1.2–1.4 (1.27)	smooth	present	present, 1 to 3, rounded	elongate ovoidal	17–19 (18.1)	10–11 (10.5)	1.6–1.9 (1.72)	knob-like, 2.0 × 2.0	compact

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## References

- Berto, B.P. & Lopes, C.W.G. (2013) Distribution and Dispersion of Coccidia in Wild Passerines of the Americas. *In: Ruiz, L. & Iglesias, F. (Eds.), Birds: Evolution and Behavior, Breeding Strategies, Migration and Spread of Disease*. Nova Science Publishers, New York, pp. 47–66.
- Berto, B.P., McIntosh, D. & Lopes, C.W.G. (2014) Studies on coccidian oocysts (Apicomplexa: Eucoccidiorida). *Revista Brasileira de Parasitologia Veterinária*, 23 (1), 1–15.  
<https://doi.org/10.1590/S1984-29612014001>
- BirdLife International (2016) Data Zone. Available from: <http://datazone.birdlife.org/> (accessed 25 September 2018)
- Duszynski, D.W. & Wilber, P. (1997) A guideline for the preparation of species descriptions in the Eimeridae. *Journal of parasitology*, 83 (2), 333–336.  
<https://doi.org/10.2307/3284470>
- Giraudeau, M., Mousel, M., Earl, S. & McGraw, K. (2014) Parasites in the city: degree of urbanization predicts poxvirus and coccidian infections in house finches (*Haemorhous mexicanus*). *PLoS ONE*, 9 (2), e86747.  
<https://doi.org/10.1371/journal.pone.0086747>
- ICMBIO (2018a) Parque Nacional do Itatiaia. Available from: <http://www.icmbio.gov.br/parnaitatiaia> (accessed 25 September 2018)
- ICMBIO (2018b) Parque Nacional Serra dos Órgãos. Available from: <http://www.icmbio.gov.br/parnaserradosorgaos> (accessed 25 September 2018)
- ICZN (2012) International Commission on Zoological Nomenclature: Amendment of articles 8, 9, 10, 21 and 78 of the International Code of Zoological Nomenclature to expand and refine methods of publication. *Zookeys*, 219, 1–10.  
<https://doi.org/10.3897/zookeys.219.3994>
- Keeler, S.P., Yabsley, M.J., Gibbs, S.E., McGraw, S.N. & Hernandez, S.M. (2012) A new *Isoospora* species of passerines in the family Turdidae from Costa Rica. *Journal of Parasitology*, 98 (1), 167–169.  
<https://doi.org/10.1645/GE-2721.1>
- Lainson, R. & Shaw, J.J. (1989) Two new species of *Eimeria* and three new species of *Isoospora* (Apicomplexa, Eimeriidae) from Brazilian mammals and birds. *Bulletin du Muséum National d'Histoire Naturelle*, 11 (2), 349–365.
- Lopes, B.B., Berto, B.P., Luz, H.R., Galvão, G.S., Ferreira, I. & Lopes, C.W.G. (2014) *Isoospora massardi* sp. nov. (Apicomplexa: Eimeriidae) from the white-necked thrush *Turdus albicollis* (Passeriformes: Turdidae) from Brazil. *Acta Parasitologica*, 59 (2), 272–275.  
<https://doi.org/10.2478/s11686-014-0240-4>
- Levine, N.D., Van Riper, S. & Van Riper, C. (1980) Five new species of *Isoospora* from Hawaiian Birds. *Journal of Protozoology*, 27 (3), 258–259.  
<https://doi.org/10.1111/j.1550-7408.1980.tb04250.x>
- Lewinsohn, T.M. & Prado, P.I. (2005) How many species are there in Brazil?. *Conservation Biology*, 19 (3), 619–624.  
<https://doi.org/10.1111/j.1523-1739.2005.00680.x>
- Marini, M.A. & Garcia, F.I. (2005) Conservação de aves no Brasil. *Megadiversidade*, 1 (1), 95–102.
- McQuiston, T.E. & Holmes, B.B. (1988) *Isoospora robini* sp. n., a new coccidian parasite (Apicomplexa: Eimeriidae) from the American robin (*Turdus migratorius*). *Proceedings of the Helminthological Society of Washington*, 55 (2), 324–325.
- Pinho, I.F.D., Silva, L.M.D., Rodrigues, M.B., Oliveira, M.D.S., Lopes, B.B., Luz, H.R., Ferreira, I., Lopes, C.W.G. & Berto, B.P. (2017a) *Isoospora albicollis* (Apicomplexa: Eimeriidae) in thrushes *Turdus* spp. (Passeriformes: Turdidae), in southeastern Brazil. *Revista Brasileira de Parasitologia Veterinária*, 26 (2), 231–234.  
<https://doi.org/10.1590/s1984-29612017006>
- Pinho, I.F., Rodrigues, M.B., Silva, L.M., Lopes, B.B., Oliveira, M.S., Ferreira, M.A., Cardozo, S.V., Luz, H.R., Ferreira, I., Lopes, C.W.G. & Berto, B.P. (2017b) Characterization and distribution of *Isoospora sabiai* n. sp. (Apicomplexa: Eimeriidae) from thrushes *Turdus* spp. (Passeriformes: Turdidae) from Brazil. *Journal of Parasitology*, 103 (3), 285–291.  
<https://doi.org/10.1645/16-152>
- Pinho, I.F.D., Silva, L.M.D., Rodrigues, M.B., Lopes, B.B., Oliveira, M.S., Luz, H.R., Ferreira, I., Lopes, C.W.G. & Berto, B.P. (2018) *Isoospora machadoae* sp. nov. (Protozoa: Apicomplexa: Eimeriidae), a new coccidian species from white-necked

- thrushes *Turdus albicollis* (Passeriformes: Turdidae) of South America. *Zoologia*, 35, e24570.  
<https://doi.org/10.3897/zoologia.35.e24570>
- Sick, H. (1997) *Ornitologia Brasileira*. Nova Fronteira, Rio de Janeiro, 862 pp.
- Sigrist, T. (2014) *Guia de Campo: Avifauna Brasileira*. Avis Brasilis, São Paulo, 608 pp.
- Souza, F.D., De Roma, J.C. & Guix, J.C. (1992) Consumption of *Didymopanax pachycarpum* unripe fruits by birds in southeastern Brazil. *Miscellanea Zoológica*, 16, 246–248.
- Vogel, H.F., Metri, R. & Zawadzki, C.H. (2014) Comunidade e partilha ecológica de turdídeos (Aves: Passeriformes) em um fragmento urbano de floresta com araucárias em Guarapuava no Sul do Brasil. *Arquivos de Ciências Veterinárias e Zoologia da UNIPAR*, 17 (2), 151–152.  
<https://doi.org/10.25110/arqvet.v17i2.2014.4934>
- Williams, R.B., Thebo, P., Marshall, R.N. & Marshall, J.A. (2010) Coccidian oöcysts as type-specimens: long-term storage in aqueous potassium dichromate solution preserves DNA. *Systematic Parasitology*, 76 (1), 69–76.  
<https://doi.org/10.1007/s11230-010-9234-2>