



Revista Brasileira de Parasitologia
Veterinária

ISSN: 0103-846X

zacariascbpv@fcav.unesp.br

Colégio Brasileiro de Parasitologia
Veterinária
Brasil

Vasconcelos Meireles, Marcelo

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Revista Brasileira de Parasitologia Veterinária, vol. 19, núm. 4, outubro-diciembre, 2010,
pp. 197-204

Colégio Brasileiro de Parasitologia Veterinária
Jaboticabal, Brasil

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Cryptosporidium infection in Brazil: implications for veterinary medicine and public health

Infecção por *Cryptosporidium* no Brasil: implicações em medicina veterinária e em saúde pública

Marcelo Vasconcelos Meireles^{1*}

¹Curso de Medicina Veterinária, Universidade Estadual Paulista – UNESP

Received June 21, 2010

Accepted November 9, 2010

Abstract

The aim of this review paper is to report the results of cryptosporidiosis research in Brazil, mainly its occurrence in animals and implications for veterinary medicine and public health. An increasing number of papers related to *Cryptosporidium* spp. infection in Brazil are available at national and international literature. The main focus described in these papers is the occurrence of *Cryptosporidium* spp. in food, environmental samples, in humans and several animal species, particularly birds, cattle, dogs and cats. Using molecular biology techniques, most *Cryptosporidium* species and genotypes identified in other countries have been described in Brazil. In mammals, there are descriptions of infection by *C. bovis*, *C. canis*, *C. felis*, *C. meleagridis*, *C. parvum*, and the cervine genotype; in birds, the following species and genotypes have been described: *C. baileyi*, *C. galli*, *C. meleagridis*, *C. parvum* and the avian genotypes I, II and III. Several species have been described in humans, such as *C. parvum*, *C. hominis*, and some species adapted to animal hosts such as *C. canis*, *C. felis* and *C. meleagridis*.

Keywords: *Cryptosporidium* spp., animals, humans, Brazil.

Resumo

O objetivo deste trabalho foi relatar, por meio de revisão de literatura, os resultados de pesquisas sobre a criptosporidiose no Brasil, com ênfase em sua ocorrência em animais e suas implicações em medicina veterinária e em saúde pública. Um número crescente de trabalhos sobre a infecção por *Cryptosporidium* spp. no Brasil está disponível na literatura nacional e internacional. Nestes trabalhos, são abordados principalmente aspectos relacionados à ocorrência de *Cryptosporidium* spp. em alimentos, amostras ambientais, no homem e em diversas espécies animais, particularmente em aves, bovinos, cães e gatos. Por meio de técnicas de biologia molecular, a maioria das espécies e alguns genótipos identificados em outros países foram descritos no Brasil. Em mamíferos, houve identificação de *C. bovis*, *C. canis*, *C. felis*, *C. meleagridis*, *C. parvum* e o genótipo cervídeo; em diversas espécies de aves, foi descrita infecção por *C. baileyi*, *C. galli*, *C. meleagridis*, *C. parvum* e pelos genótipos I, II e III de aves. Várias espécies foram descritas no homem, como *C. parvum* e *C. hominis*, além de algumas espécies adaptadas a hospedeiros animais, como *C. canis*, *C. felis* e *C. meleagridis*.

Palavras-chave: *Cryptosporidium* spp., animais, homem, Brasil.

Introduction

Cryptosporidiosis is a parasitic disease that affects amphibians, birds, mammals, fish and reptiles, particularly in the gastrointestinal tract, causing clinical or subclinical infections (XIAO et al., 2004; FAYER, 2008). Although the first description of infection due to *Cryptosporidium* was made by Tyzzer, in 1907, it was only in the 1970s, after the first reports of infection in cattle (PANCIERA et al., 1971) and in humans (MEISEL et al., 1976; NIME et al., 1976),

that cryptosporidiosis aroused the attention of researchers because of its potential as an important cause of zoonotic and anthroponotic infections, and clinical or subclinical illnesses, in humans and animals. Until then, it had been considered to be a supposedly rare and opportunist infection (XIAO et al., 2004).

In Brazil, there has been an increasing amount of research and growing numbers of published papers relating to cryptosporidiosis, particularly in poultry, cattle, dogs, cats and humans, and to a lesser extent, in other species of domestic and wild mammals. Most of the published papers have dealt with occurrences of infection by the genus *Cryptosporidium* by means of microscopy, without species classification (Table 1). Studies aiming to classify

*Corresponding author: Marcelo Vasconcelos Meireles
Curso de Medicina Veterinária, Universidade Estadual Paulista – UNESP,
Rua Clóvis Pestana, 793, Bairro Dona Amélia,
CEP 16050-680, Araçatuba – SP, Brazil;
e-mail: marcelo@fmva.unesp.br

the species of this protozoon, using molecular techniques, remain scarce albeit growing in number (Table 2).

Articles in review form published in several countries have discussed a wide variety of aspects of cryptosporidiosis in humans and animals, but there is little information from studies developed in Brazil (RAMIREZ et al., 2004; XIAO et al., 2004; JEX et al., 2008; BOWMAN; FORSTER, 2010; RYAN, 2010). The aim of the present study was to report, through a review of the literature, the results from studies on cryptosporidiosis in Brazil, with emphasis on its occurrence in animals and its importance within veterinary medicine and public health.

Etiological Agent

The genus *Cryptosporidium* belongs to the phylum Apicomplexa, class Conoidasida, subclass Coccidiasina, order Eucoccidiorida, suborder Eimeriorina and family Cryptosporidiidae (ADL et al., 2005; FAYER, 2008). However, from molecular phylogenetic data, Carreno et al. (1999), Barta and Thompson (2006) and Kuo et al. (2008) suggested that this genus is genetically more closely related to the class Gregarinia. This theory was based on the existence of extracellular stages in the biological cycle of *Cryptosporidium andersoni*; on its multiplication in cell-free culture medium (HIJJAWI et al., 2002); and on the cross-reactivity of anti-*Cryptosporidium* monoclonal antibodies with sporocysts of the genus *Monocystis*, in the direct immunofluorescence reaction (BULL et al., 1998).

There is still no clear and definitive documentation regarding how many and which *Cryptosporidium* species infect amphibians, birds, mammals, fish and reptiles. Around 19 species have been described by means of morphological, biological and molecular data. Because of the absence of data relating to biological and morphological characteristics, several isolates have been classified as genotypes, without species definition (FAYER, 2010).

Occurrence of *Cryptosporidium* in Samples from the Environment, Food and Domestic and Wild Animals in Brazil

1. Samples from the environment and food

The presence of *Cryptosporidium* in samples from the environment and food is important in public health terms. For this reason, research has been conducted resulting in descriptions of *Cryptosporidium* sp. in water treatment works (NISHI et al., 2009a), samples from sewage and rivers (FRANCO et al., 2001; FARIAS et al., 2002; IACOVSKI et al., 2004; NISHI et al., 2009b; RAZZOLINI et al., 2010), from well water for human consumption and from ditches (GAMBA et al., 2000), from bivalve mollusks and oysters (GUIGUET LEAL et al., 2008) and from vegetables (SILVA et al., 2005).

2. Domestic poultry and wild birds kept in captivity

All the species and some genotypes of *Cryptosporidium* that have been reported in birds in other countries (RYAN, 2010) have been described in Brazil (Table 2). The prevalence of 4.86% (47/966) among birds reared in captivity (NAKAMURA et al.,

2009) is similar to what was described by Ng et al. (2006) in Australia (6.25%; 27/430).

There are reports of infection caused by *Cryptosporidium baileyi* in domestic chickens, quails and ducks (MEIRELES; FIGUEIREDO, 1992; CARDOZO et al., 2005; HUBER et al., 2007), including evaluations of the biological, zootechnical and pathogenetic aspects of infections due to this species, following experimental inoculation in domestic chickens (MEIRELES et al., 1999) and quails (CARDOZO et al., 2005). Two species with zoonotic potential have been described in Brazil: *Cryptosporidium meleagridis* in domestic chickens (HUBER et al., 2007; NAKAMURA et al., 2009) and *Cryptosporidium parvum* in cockatiels (*Nymphicus hollandicus*) (NAKAMURA et al., 2009).

A new genotype of *Cryptosporidium* that is present in ostriches and was described by Santos et al. (2005) and Meireles et al. (2006), and which has been correlated with the presence of prolapse of the cloaca and mortality, was subsequently classified as avian genotype II (NG et al., 2006). Oliveira et al. (2008) analyzed 77 samples of ostrich feces from five properties in the State of Rio de Janeiro, and found that 50 samples (44.4%) were positive for *Cryptosporidium* sp.

Passeriformes and Psittaciformes present chronic infection due to *Cryptosporidium galli*, characterized by intermittent shedding of oocysts, which in most cases is of subclinical nature (ANTUNES et al., 2008; SILVA et al., 2010).

There are also reports of infection by *Cryptosporidium* in broiler chickens (JACOBSEN et al., 2006) and in emus (*Rhea americana*) (LUDWIG; MARQUES, 2008), although without species classification.

3. Domestic mammals

The first report on *Cryptosporidium* infection in cattle, in Brazil, was made by Modolo et al. (1988), among dairy calves in the Botucatu region (SP). The prevalence of *Cryptosporidium* in dairy cattle in Brazil ranges from 0.6 to 72.13% (Table 1), with greatest occurrence in animals up to the age of two months (GARCIA; LIMA, 1994; SOUZA; LOPES, 1995; FEITOSA et al., 2004; LANGONI et al., 2004; CARDOSO et al., 2008).

In several Brazilian States, a correlation has been observed between the presence of clinical signs such as diarrhea and the presence of other etiological agents, with occurrences of infection due to *Cryptosporidium* in fecal samples from dairy cattle (GARCIA; LIMA, 1994; SOUZA; LOPES, 1995; LANGONI et al., 2004; CARDOSO et al., 2008; FEITOSA et al., 2008) or beef cattle (OLIVEIRA FILHO et al., 2007).

The epidemiological and clinical characteristics of most of the reports of infection in cattle suggest that the species described was *C. parvum*. *Cryptosporidium* species have been classified according to the morphological characteristics of the oocysts, as *C. parvum* (CARDOSO et al., 2008), *Cryptosporidium muris* (in cattle, currently classified as *Cryptosporidium andersoni*) (SOUZA; LOPES, 1995; PENA et al., 1997) or *C. andersoni* (CARDOSO et al., 2008). Molecular characterization of *Cryptosporidium* species was only done in two studies, with identification of *C. parvum* (HUBER et al., 2007; THOMAZ et al., 2007) and *Cryptosporidium bovis* (THOMAZ et al., 2007).

Table 1. Prevalence of *Cryptosporidium* spp. in fecal samples of bovines, dogs and cats submitted to different diagnostic techniques without species level identification.

Host	State	Nº of positive samples/Nº of samples (% of positive samples)	Diagnostic technique*	Reference
Bovines	Mato Grosso	30/130 (40.0)	AFS	Oliveira Filho et al. (2007)
	Minas Gerais	85/305 (27.87)	AFS	Garcia and Lima (1993)
	Minas Gerais	51/262 (19.5)	AFS	Garcia and Lima (1994)
	Paraná	6/849 (0.6)	CF-BF	Cardoso et al. (2008)
	Rio de Janeiro	36/59 (72.13)	CF-PC, SMB	Souza and Lopes (1995)
	São Paulo	53/308 (17.3)	CF-BF	Pena et al. (1997)
	São Paulo	79/203 (38.9)	AFS	Langoni et al. (2004)
	São Paulo	56/459 (12.4)	CF-PC, ELISA	Feitosa et al. (2004)
Dogs	Ceará	9/88 (10.3)	AFS	Newman et al. (1993)
	Minas Gerais	5/269 (1.85)	ELISA	Figueiredo et al. (2004)
	Minas Gerais	6/256 (2.3)	SMB	Mundin et al. (2007)
	São Paulo	43/1755 (2.4)	CF-BF	Funada et al. (2007)
	Rio de Janeiro	4/81 (4.9)	CF-BF	Pereira et al. (2010)
	Rio de Janeiro	131/500 (26.2)	SMB	Balassiano et al. (2009)
	São Paulo	43/450 (9.5)	AFS, PCR	Lallo and Bondan (2006)
	São Paulo	10/420 (2.4)	ELISA	Bresciani et al. (2008)
	São Paulo	8/240 (3.1)	AFS	Katagiri and Oliveira-Sequeira (2008)
Cats	Rio de Janeiro	6/48 (12.5)	CF-BF, SMB	Huber et al. (2002)
	São Paulo	27/187 (14.4)	CF-BF	Gennari et al. (1999)
	São Paulo	37/327 (11.3)	CF-BF	Funada et al. (2007)
	São Paulo	2/51 (3.9)	MG, ELISA	Coelho et al. (2009)

*AFS: acid-fast stain; SMB: safranin methylene blue; CF-BF: centrifugal-flotation using sucrose solution/bright field microscopy; CF-PC centrifugal-flotation using sucrose solution/phase contrast microscopy; PCR: polimerase chain reaction; ELISA: enzyme-linked immunosorbent assay; MG: malachite green negative strain.

The presence of *Cryptosporidium* oocysts in fecal samples from domestic buffalos was described by Ribeiro et al. (2000), in asymptomatic animals or in animals with symptoms characterized by diarrhea.

The prevalence of infection due to *Cryptosporidium* in dogs, in Brazil, ranges from 2.3% (MUNDIN et al., 2007) to 26.2% (BALASSIANO et al., 2009), according to epidemiological studies that aimed to detect oocysts or soluble antigens in fecal samples. In cats, the prevalence of *Cryptosporidium* ranges from 3.9% (COELHO et al., 2009) to 14.44% (GENNARI et al., 1999) (Table 1). The two *Cryptosporidium* species most commonly found in dogs and cats (*Cryptosporidium canis* and *Cryptosporidium felis*) were described by Huber et al. (2007) and Thomaz et al. (2007), respectively in dogs and cats (Table 2).

The first report of cryptosporidiosis in goats, in Brazil, was made by Vieira et al. (1997), at the Veterinary Hospital of the Federal University of Minas Gerais, among 22 goats aged one to two weeks that presented diarrhea and mortality. On six properties located in the State of Rio de Janeiro, out of a total of 105 fecal samples from goats (from 56 adult animals and 49 young animals) that were examined using the safranin-methylene blue technique, Bomfim et al. (2005) found five samples (4.8%) that were positive for *Cryptosporidium*, all from young animals.

In horses, cryptosporidiosis is generally of subclinical nature, with low prevalence, as demonstrated by Souza et al. (2009), who found a prevalence of 0.75% (3/396) in fecal samples in the State of Rio de Janeiro, which were examined by means of centrifugation-flotation in Sheather solution and the safranin-methylene blue technique.

Asymptomatic infection due to *Cryptosporidium*, in sheep, was observed by Green et al. (2004), in the State of São Paulo, with a prevalence of 55.5% (102/184) during the rainy season and 17.3% (31/179) during the dry season. In the municipality of Ibimirim (State of Pernambuco), the rate of positive findings in fecal samples examined using the Kinyoun technique was 3.7% (3/81), and two animals presented subclinical infection (TEMBUE et al., 2006). In another study, the rate of positive findings in fecal samples from sheep was 6.7% (31/460), which were found in 38.1% (8/21) of the properties investigated in the Araçatuba region (State of São Paulo). *C. parvum* and the cervid genotype were identified by means of nested PCR for amplification of fragments of the 18S subunit of rRNA gene and of the actin gene, with sequencing of amplified fragments (FÉRES et al. 2009).

The prevalence of infection in pigs in Brazil has been found to be 1.7% (2/114) in the State of Minas Gerais and 1.2% (2/174) to 7.6% (32/423) in the State of São Paulo (NISHI et al., 2000; CALDERARO et al., 2001). Clinical infection in piglets, with the presence of *Cryptosporidium* associated with *Escherichia coli*, rotavirus and picobirnavirus was reported by Alferi et al. (1994), in the State of Paraná.

4. Wild mammals and reptiles

In addition to the possibility of clinical illness, the presence of *Cryptosporidium* in wild animals, particularly mammals, represents a possibility for transmission of zoonotic species to humans, including

Table 2. *Cryptosporidium* species and genotypes identified in humans and animals in Brazil using molecular diagnostic techniques.

	Host	Species or genotype	Gene target	Diagnostic technique	Reference
Mammals	Bovine	<i>C. bovis</i> , <i>C. parvum</i>	18S rRNA	PCR/RFLP, PCR/sequencing	Huber et al. (2007); Thomaz et al. (2007)
	Capybara (<i>Hydrochoerus hydrochaeris</i>)	<i>C. parvum</i>	18S rRNA, gp60	PCR/sequencing	Meireles et al. (2006)
	Cat	<i>C. felis</i>	18S rRNA	PCR/RFLP, PCR/ sequencing	Huber et al. (2007); Thomaz et al. (2007)
	Dog	<i>C. canis</i>	18S rRNA	PCR/RFLP, PCR/ sequencing	Huber et al. (2007); Thomaz et al. (2007)
	Guinea pig	<i>Cryptosporidium</i> sp.	18S rRNA	PCR/RFLP, PCR/ sequencing	Huber et al. (2007)
	Human	<i>C. canis</i> , <i>C. felis</i> , <i>C. hominis</i> , <i>C. meleagridis</i> , <i>C. parvum</i>	18S rRNA, COWP, TRAP-C1, ML1	PCR/RFLP, PCR/ sequencing	Brantley et al. (2003); Gatei et al. (2003); Gonçalves et al. (2006); Bushen et al. (2007); Araújo et al. (2008); Lucca et al. (2009)
	Lamb	Cervine genotype, <i>C. parvum</i>	18S rRNA, actin	PCR/ sequencing	Féres et al. (2009)
Birds	Black vulture (<i>Coragyps atratus</i>)	<i>C. baileyi</i>	18S rRNA, actin	PCR/sequencing	Nakamura et al. (2009)
	Canary (<i>Serinus canaria</i>)	Avian genotype I; <i>C. galli</i>	18S rRNA, actin	PCR/sequencing	Antunes et al. (2008); Nakamura et al. (2009)
	Cockatiel (<i>Nymphicus hollandicus</i>)	<i>C. galli</i> , <i>C. parvum</i> , avian genotype III	18S rRNA, actin	PCR/sequencing	Antunes et al. (2008); Nakamura et al. (2009)
	Domestic chicken (<i>Gallus gallus domesticus</i>)	<i>C. baileyi</i> , <i>C. meleagridis</i>	18S rRNA	PCR/RFLP, PCR/ sequencing	Huber et al. (2007); Nakamura et al. (2009)
	Duck*	<i>C. baileyi</i>	18S rRNA	PCR/RFLP, PCR/ sequencing	Huber et al. (2007)
	Great-billed seedfinch (<i>Oryzoborus maximiliani</i>)	<i>C. galli</i>	18S rRNA	PCR/sequencing	Silva et al. (2010)
	Indian peafowl (<i>Pavo cristatus</i>)	Avian genotype I	18S rRNA, actin	PCR/sequencing	Nakamura et al. (2009)
	Lesser seed-finch (<i>Oryzoborus angolensis</i>)	<i>C. galli</i>	18S rRNA, actin	PCR/sequencing	Antunes et al. (2008); Nakamura et al. (2009)
	Ostrich (<i>Struthio camelus</i>)	Avian genotype II	18S rRNA, actin, hsp70	PCR/sequencing	Meireles et al. (2006); Nakamura et al. (2009)
	Quail*	<i>C. baileyi</i>	18S rRNA	PCR/RFLP, PCR/ sequencing	Huber et al. (2007)
	Rosy-faced Lovebird (<i>Agapornis roseicollis</i>)	Avian genotype III	18S rRNA, actin	PCR/sequencing	Nakamura et al. (2009)
	Rusty-collared seedeater (<i>Sporophila collaris</i>)	<i>C. galli</i>	18S rRNA	PCR/sequencing	Silva et al. (2010)
	Saffron finch (<i>Sicalis flaveola</i>)	<i>C. baileyi</i>	18S rRNA, actin	PCR/sequencing	Nakamura et al. (2009)
	Ultramarine grosbeak (<i>Cyanocompsa brissonii</i>)	<i>C. galli</i>	18S rRNA	PCR/sequencing	Silva et al. (2010)

* Avian species was not reported.

the cervid genotype. However, the importance of wild animals in the epidemiology of human cryptosporidiosis has still not been defined (SMITH et al., 2006; XIAO; FAYER, 2008; FENG, 2010).

Among the wild mammals investigated in Brazil, oocysts of *Cryptosporidium* sp. have been found in manatees (*Trichechus manatus*) (BORGES et al., 2009), in fecal samples from wild

mammals of the Atlantic forest (*Akodon serrensis* and *Oryzomys ratticeps*) in three mountainous areas in southeastern Brazil (DALL'OLIO; FRANCO, 2004) and in rodents (*Akodon montensis*, *Sciurus aestuans* and *Thaptomys nigrita*) in a deforested area in the State of São Paulo (LALLO et al., 2009). Meireles et al. (2007) found a zoonotic subtype of *C. parvum* in fecal samples from

capibaras (*Hydrochoerus hydrochaeris*) that were gathered in the city of Araçatuba (State of São Paulo).

In reptiles, there is only one report of the presence of oocysts of *Cryptosporidium* sp., in rattlesnakes housed at the Venomous Animal Study Center (CEVAP) of UNESP, in Botucatu (KARASAWA et al., 2002).

5. Public health

Infections in humans are commonly caused by *C. hominis*, a species that is almost exclusively found in human beings, or by *C. parvum*, which is the main etiologic agent of zoonotic infections, with many cases described in the literature. However, there are sporadic reports of infections in humans caused by other species or genotypes, including *C. canis*, *C. felis*, *C. meleagridis*, *C. muris*, *Cryptosporidium suis* and the rabbit, cervid, squirrel, horse, monkey and pig genotypes (XIAO, 2010).

In Brazil, some species and genotypes with zoonotic potential, such as *C. canis*, *C. felis*, *C. meleagridis*, *C. parvum* and the cervid genotype, have been identified in animals. In humans, there are reports of infection caused by *C. parvum*, *C. hominis* and species that are adapted to animal hosts, such as *C. canis*, *C. felis* and *C. meleagridis* (Table 2).

Concluding remarks

Although there are significant numbers of studies on cryptosporidiosis in Brazil, the molecular epidemiology of the parasite is still little explored. Viewing oocysts under the microscope is a valuable means for diagnosing and determining the intensity of the infection, and for making a morphometric and morphological evaluation on the oocysts, but it does not enable classification of the parasite species. In the Brazilian literature, because of the high cost of molecular techniques, methods based on microscopy are predominantly used for diagnosing cryptosporidiosis (Table 1).

One factor to be borne in mind is that oocysts and other evolutionary stages of the genus *Cryptosporidium* are very small and occasionally very similar, in their morphological and staining characteristics, to yeasts, fungal spores and other structures present in fecal samples. This may result in false-positive diagnoses from routine diagnostic techniques such as Kinyoun, modified Ziehl Neelsen or safranin-methylene blue, or from oocyst observation without staining, after concentration in saturated sucrose, sodium chloride or zinc sulfate solutions.

In the event that there are few oocysts in the fecal samples, or doubts regarding the diagnosis, it is recommended that the diagnosis should be confirmed through combining the techniques described above or, preferably, through using techniques that are more specific, such as immunofluorescence, staining with 4',6'-diamidino-2-phenylindole (DAPI), differential interference contrast microscopy or the polymerase chain reaction.

Although information on certain animal species remains scarce, the information that is available in Brazil demonstrates that cryptosporidiosis presents clinical and epidemiological characteristics that are similar to those found in other countries, particularly in relation to ruminants, horses, dogs and cats; the species and genotypes found in birds and mammals (including

humans) have already been described in other countries. Table 2 shows the *Cryptosporidium* species and genotypes that have been identified using molecular biology techniques in animals and humans in Brazil.

Because *Cryptosporidium* has multiple hosts and transmission cycles, along with genetic variation between species and between genotypes, it is of fundamental importance to undertake molecular characterization of the Brazilian isolates, whether of environmental, food, animal or human origin, in order to epidemiologically evaluate, prevent and control outbreaks of cryptosporidiosis in humans and animals.

References

- ADL, S. M. et al. The new higher level classification of eukaryotes with emphasis on the taxonomy of protists. **Journal of Eukaryotic Microbiology**, v. 52, n. 5, p. 399-451, 2005.
- ALFIERI, A. A. et al. Ocorrência de *Escherichia coli*, *Rotavirus*, *Picobirnavirus* e *Cryptosporidium parvum* em um foco de diarreia do pós-desmame em suínos. **Semina**, v. 15, n. 1, p. 5-7, 1994.
- ANTUNES, R. G. et al. Natural infection with *Cryptosporidium galli* in canaries (*Serinus canaria*), in a cockatiel (*Nymphicus hollandicus*) and in lesser seed-finches (*Oryzoborus angolensis*) from Brazil. **Avian Diseases**, v. 52, n. 4, p. 702-705, 2008.
- ARAÚJO, A. J. U. S. et al. Genotypic identification of *Cryptosporidium* spp. isolated from HIV-infected patients and immunocompetent children of São Paulo, Brazil. **Revista do Instituto de Medicina Tropical de São Paulo**, v. 50, n. 3, p. 139-143, 2008.
- BALASSIANO, B. C. C. et al. Factors associated with gastrointestinal parasite infection in dogs in Rio de Janeiro, Brazil. **Preventive Veterinary Medicine**, v. 91, n. 2-4, p. 234-240, 2009.
- BARTA, J. R.; THOMPSON, A. R. C. What is *Cryptosporidium*? Reappraising its biology and phylogenetic affinities. **Trends in Parasitology**, v. 22, n. 10, p. 463-468, 2006.
- BOMFIM, T. C. B. et al. Natural infection by *Giardia* sp. and *Cryptosporidium* sp. in dairy goats, associated with possible risk factors of the studied properties. **Veterinary Parasitology**, v. 134, n. 1-2, p. 9-13, 2005.
- BORGES, J. C. G. et al. Ocorrência de infecção por *Cryptosporidium* spp. em peixe-boi marinho (*Trichechus manatus*). **Revista Brasileira de Parasitologia Veterinária**, v. 18, n. 1, p. 60-61, 2009.
- BOWMAN, D. D.; FORSTER, A. L. Cryptosporidiosis and giardiasis in dogs and cats: veterinary and public health importance. **Experimental Parasitology**, v. 124, n. 1, p. 121-127, 2010.
- BRANTLEY, R. K. et al. AIDS-associated diarrhea and wasting in northeast Brazil is associated with subtherapeutic plasma levels of antiretroviral medications and with both bovine and human subtypes of *Cryptosporidium parvum*. **Brazilian Journal of Infectious Diseases**, v. 7, n. 1, p. 16-22, 2003.
- BRESCIANI, K. D. S. et al. Infecções por *Cryptosporidium* spp. em cães de Araçatuba, SP, Brasil. **Veterinária e Zootecnia**, v. 15, n. 3, p. 466-468, 2008.
- BULL, S. et al. Cross-reaction of an anti-*Cryptosporidium* monoclonal antibody with sporocysts of *Monocystis* species. **Veterinary Parasitology**, v. 77, n. 2-3, p. 195-197, 1998.

- BUSHEN, O. Y. et al. Heavy cryptosporidial infections in children in northeast Brazil: comparison of *Cryptosporidium hominis* and *Cryptosporidium parvum*. **Transactions of the Royal Society of Tropical Medicine and Hygiene**, v. 101, n. 4, p. 378-384, 2007.
- CALDERARO, F. F. et al. Frequência de agentes causadores de enterites em leitões lactentes provenientes de sistemas de produção de suínos do Estado de São Paulo. **Arquivos do Instituto Biológico**, v. 68, n. 1, p. 29-34, 2001.
- CARDOSO, J. M. S. et al. Ocorrência de *Cryptosporidium* spp. em um rebanho bovino leiteiro no município de Caçapava, estado de São Paulo, Brasil. **Revista Brasileira de Parasitologia Veterinária**, v. 17, p. 239-242, 2008. Suplemento 1.
- CARDOZO, S. V.; TEIXEIRA FILHO, W. L.; LOPES, C. W. G. Transmissão experimental de *Cryptosporidium baileyi* (Apicomplexa: Cryptosporidiidae) isolado de frango de corte à codorna japonesa (*Coturnix japonica*). **Revista Brasileira de Parasitologia Veterinária**, v. 14, n. 3, p. 119-124, 2005.
- CARRENO, R. A.; MARTIN, D. S.; BARTA, J. R. *Cryptosporidium* is more closely related to the gregarines than to coccidia as shown by phylogenetic analysis of apicomplexan parasites inferred using small-subunit ribosomal RNA gene sequences. **Parasitology Research**, v. 85, n. 11, p. 899-904, 1999.
- COELHO, W. M. D. et al. Ocorrência de parasitos gastrintestinais em amostras fecais de felinos do município de Andradina, São Paulo. **Revista Brasileira de Parasitologia Veterinária**, v. 18, n. 2, p. 46-49, 2009.
- DALL'OLIO, A. J.; FRANCO, R. M. B. Ocorrência de *Cryptosporidium* spp. em pequenos mamíferos silvestres de três áreas serranas do Sudeste brasileiro. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 56, n. 1, p. 25-31, 2004.
- FARIAS, E. W. C.; GAMBA, R. C.; PELLIZARI, V. H. Detection of *Cryptosporidium* spp. oocysts in raw sewage and creek water in the city of São Paulo, Brazil. **Brazilian Journal of Microbiology**, v. 33, n. 1, p. 41-43, 2002.
- FAYER, R. General biology. In: FAYER, R.; XIAO, L. ***Cryptosporidium and cryptosporidiosis***, Boca Raton: CRC, 2008. p. 1-42.
- FAYER, R. Taxonomy and species delimitation in *Cryptosporidium*. **Experimental Parasitology**, v. 124, n. 1, p. 90-97, 2010.
- FEITOSA, F. L. F. et al. Importância de *Cryptosporidium* spp. como causa de diarreia em bezerros. **Pesquisa Veterinária Brasileira**, v. 28, n. 10, p. 452-456, 2008.
- FEITOSA, F. L. F. et al. Prevalência de criptosporidiose em bezerros na região de Araçatuba, Estado de São Paulo. **Ciência Rural**, v. 34, n. 1, p. 189-193, 2004.
- FENG, Y. *Cryptosporidium* in wild placental mammals. **Experimental Parasitology**, v. 124, n. 1, p. 128-137, 2010.
- FÉRES, F. C. et al. Ocorrência e caracterização molecular de *Cryptosporidium* em cordeiros. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 61, n. 4, p. 1002-1005, 2009.
- FIGUEIREDO, H. C. P. et al. Excreção de oocistos de *Cryptosporidium parvum* em cães saudáveis das cidades de Lavras e Viçosa, Estado de Minas Gerais, Brasil. **Ciência Rural**, v. 34, n. 5, p. 1625-1627, 2004.
- FRANCO, R. M. B.; ROCHA-EBERHARDT, R.; CANTUSIO NETO, R. Occurrence of *Cryptosporidium* oocysts and *Giardia* cysts in raw water from the Atibaia river, Campinas, Brazil. **Revista do Instituto de Medicina Tropical de São Paulo**, v. 43, n. 2, p. 109-111, 2001.
- FUNADA, M. R. et al. Frequência de parasitos gastrintestinais em cães e gatos atendidos em hospital-escola veterinário da cidade de São Paulo. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 59, n. 5, p. 1338-1340, 2007.
- GAMBA, R. C. et al. Detection of *Cryptosporidium* sp. oocysts in groundwater for human consumption in Itaquaquecetuba city, S. Paulo-Brazil. **Brazilian Journal of Microbiology**, v. 31, n. 2, p. 151-153, 2000.
- GARCIA, A. M.; LIMA, J. D. Frequência do *Cryptosporidium* em bezerros lactentes de rebanhos leiteiros de Minas Gerais. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 45, n. 2, p. 193-198, 1993.
- GARCIA, A. M.; LIMA, J. D. Prevalência de *Cryptosporidium* spp. em rebanhos leiteiros de Pará de Minas (M.G.) e sua relação com práticas de manejo. **Revista Brasileira de Parasitologia Veterinária**, v. 3, n. 1, p. 23-28, 1994.
- GATEI, W. et al. Molecular analysis of the 18S rRNA gene of *Cryptosporidium* parasites from patients with or without human immunodeficiency virus infections living in Kenya, Malawi, Brazil, the United Kingdom, and Vietnam. **Journal of Clinical Microbiology**, v. 41, n. 4, p. 1458-1462, 2003.
- GENNARI, S. M. et al. Ocorrência de protozoários e helmintos em amostras de fezes de cães e gatos da cidade de São Paulo. **Brazilian Journal of Veterinary Research and Animal Science**, v. 36, n. 2, p. 87-91, 1999.
- GONÇALVES, E. M. N. et al. Multilocus genotyping of *Cryptosporidium hominis* associated with diarrhea outbreak in a day care unit in São Paulo. **Clinics**, v. 61, n. 2, p. 119-126, 2006.
- GREEN, R. E.; AMARANTE, A. F. T.; MASCARINI, L. M. The seasonal distribution of *Cryptosporidium* oocysts in sheep raised in the state of São Paulo. **Revista Brasileira de Parasitologia Veterinária**, v. 13, n. 3, p. 125-127, 2004.
- GUIGUET LEAL, D. A. et al. First report of *Cryptosporidium* spp. oocysts in oysters (*Crassostrea rhizophorae*) and cockles (*Tivela mactroides*) in Brazil. **Journal of Water Health**, v. 6, n. 4, p. 527-532, 2008.
- HIJJAWI, N. S. et al. Successful *in vitro* cultivation of *Cryptosporidium andersoni*: evidence for the existence of novel extracellular stages in the life cycle and implications for the classification of *Cryptosporidium*. **International Journal for Parasitology**, v. 32, n. 14, p. 1719-1726, 2002.
- HUBER, F. et al. Genotypic characterization and phylogenetic analysis of *Cryptosporidium* sp. from domestic animals in Brazil. **Veterinary Parasitology**, v. 150, n. 1-2, p. 65-74, 2007.
- HUBER, F.; BOMFIM, T. C.B.; GOMES, R. S. Comparação entre infecção por *Cryptosporidium* sp. e por *Giardia* sp. em gatos sob dois sistemas de criação. **Revista Brasileira de Parasitologia Veterinária**, v. 11, n. 1, p. 7-12, 2002.
- IACOVSKI, R. B.; BARARDI, C. R.; SIMÕES, C. M. Detection and enumeration of *Cryptosporidium* sp. oocysts in sewage sludge samples from the city of Florianópolis (Brazil) by using immunomagnetic separation combined with indirect immunofluorescence assay. **Waste Management & Research**, v. 22, n. 3, p. 171-176, 2004.
- JACOBSEN, G. et al. *Cryptosporidium* sp. em intestinos, bursa de Fabricius e traquéia de frangos (*Gallus gallus*). **Ciência Rural**, v. 36, n. 2, p. 682-684, 2006.
- JEX, A. R. et al. *Cryptosporidium*: biotechnological advances in the detection, diagnosis and analysis of genetic variation. **Biotechnology Advances**, v. 26, n. 4, p. 304-317, 2008.

- KARASAWA, A. S. M. et al. Occurrence of *Cryptosporidium* (Apicomplexa, Cryptosporidiidae) in *Crotalus durissus terrificus* (Serpentes, Viperidae) in Brazil. **Memórias do Instituto Oswaldo Cruz**, v. 97, n. 6, p. 779-781, 2002.
- KATAGIRI, S.; OLIVEIRA-SEQUEIRA, T. C. Prevalence of dog intestinal parasites and risk perception of zoonotic infection by dog owners in São Paulo State, Brazil. **Zoonoses and Public Health**, v. 55, n. 8-10, p. 406-413, 2008.
- KUO, C. H.; WARES, J. P.; KISSINGER, J. C. The apicomplexan whole-genome phylogeny: an analysis of incongruence among gene trees. **Molecular Biology and Evolution**, v. 25, n. 12, p. 2689-2698, 2008.
- LALLO, M. A. et al. Ocorrência de *Giardia*, *Cryptosporidium* e microsporídios em animais silvestres em área de desmatamento no Estado de São Paulo, Brasil. **Ciência Rural**, v. 39, n. 5, p. 1465-1470, 2009.
- LALLO, M. A.; BONDAN, E. F. Prevalência de *Cryptosporidium* sp. em cães de instituições da cidade de São Paulo. **Revista de Saúde Pública**, v. 40, n. 1, p. 120-125, 2006.
- LANGONI, H. et al. Contribuição ao estudo da etiologia das diarreias em bezerros de aptidão leiteira no Estado de São Paulo, Brasil. **Brazilian Journal of Veterinary Research and Animal Science**, v. 41, n. 5, p. 313-319, 2004.
- LUCCA, P. et al. Molecular characterization of *Cryptosporidium* spp. from HIV infected patients from an urban area of Brazil. **Revista do Instituto de Medicina Tropical de São Paulo**, v. 51, n. 6, p. 341-343, 2009.
- LUDWIG, R.; MARQUES, S. M. T. Primeiro relato de *Cryptosporidium* spp. em emas (*Rhea americana*) cativas de zoológico no Brasil. **Parasitologia Latinoamericana**, v. 63, n. 1-4, p. 76-80, 2008.
- MEIRELES, M. V. et al. Biological studies and molecular characterization of a *Cryptosporidium* isolate from ostriches (*Struthio camelus*). **Journal of Parasitology**, v. 92, n. 3, p. 623-626, 2006.
- MEIRELES, M. V. et al. Experimental infection with *Cryptosporidium baileyi* in floor-pen raised broilers. **Revista Brasileira de Ciência Avícola**, v. 1, n. 1, p. 37-42, 1999.
- MEIRELES, M. V. et al. Natural infection with zoonotic subtype of *Cryptosporidium parvum* in capybara (*Hydrochoerus hydrochaeris*) from Brazil. **Veterinary Parasitology**, v. 147, n. 1-2, p. 166-170, 2007.
- MEIRELES, M. V.; FIGUEIREDO, P. C. Isolamento e identificação de *Cryptosporidium baileyi* Current et al., 1986 (Apicomplexa: Cryptosporidiidae) em frangos de corte. **Revista Brasileira de Parasitologia Veterinária**, v. 1, n. 2, p. 125-130, 1992.
- MEISEL, J. L. et al. Overwhelming watery diarrhea associated with a *Cryptosporidium* in an immunosuppressed patient. **Gastroenterology**, v. 70, n. 6, p. 1156-1160, 1976.
- MODOLO, J. R.; GONÇALVES, R. C.; KUCHEMBUCK, M. R. G. Ocorrência de criptosporidiose em bezerros na região de Botucatu-SP. **Revista Brasileira de Medicina Veterinária**, v. 10, n. 1, p. 9-10, 1988.
- MUNDIN, M. J. S. et al. Prevalence of *Giardia duodenalis* and *Cryptosporidium* spp. in dogs from different living conditions in Uberlândia, Brazil. **Veterinary Parasitology**, v. 144, n. 3-4, p. 356-359, 2007.
- NAKAMURA, A. A. et al. Molecular characterization of *Cryptosporidium* spp. from fecal samples of birds kept in captivity in Brazil. **Veterinary Parasitology**, v. 166, n. 1-2, p. 47-51, 2009.
- NEWMAN, R. D. et al. Environmental sources of *Cryptosporidium* in an urban slum in northeastern Brazil. **American Journal of Tropical Medicine and Hygiene**, v. 49, n. 2, p. 270-275, 1993.
- NG, J.; PAVLASEK, I.; RYAN, U. Identification of novel *Cryptosporidium* genotypes from avian hosts. **Applied and Environmental Microbiology**, v. 72, n. 12, p. 7548-7553, 2006.
- NIME, F. A. et al. Acute enterocolitis in a human being infected with the protozoan *Cryptosporidium*. **Gastroenterology**, v. 70, n. 4, p. 592-598, 1976.
- NISHI, L. et al. Investigation of *Cryptosporidium* spp. and *Giardia* spp. in a public water-treatment system. **Zoonoses and Public Health**, v. 56, n. 5, p. 221-228, 2009a.
- NISHI, L. et al. *Giardia* spp. and *Cryptosporidium* spp. in the Ivaí Indigenous Land, Brazil. **Vector Borne and Zoonotic Diseases**, v. 9, n. 5, p. 543-547, 2009b.
- NISHI, S. M. et al. Parasitas intestinais em suínos confinados nos estados de São Paulo e Minas Gerais. **Arquivos do Instituto Biológico**, v. 67, n. 2, p. 199-203, 2000.
- OLIVEIRA FILHO, J. P. et al. Diarréia em bezerros da raça Nelore criados extensivamente: estudo clínico e etiológico. **Pesquisa Veterinária Brasileira**, v. 27, n. 10, p. 419-424, 2007.
- OLIVEIRA, F. C. R. et al. Ocorrência de oocistos de *Cryptosporidium* spp. (Apicomplexa, Cryptosporidiidae) em avestruzes, *Struthio camelus* L., 1758 (Aves, Struthionidae) criadas nas regiões norte e baixada litorânea do estado do Rio de Janeiro, Brasil. **Revista Brasileira de Parasitologia Veterinária**, v. 17, supl. 1, p. 322-325, 2008.
- PANCIERA, R. J.; THOMASSEN, R. W.; GARNER, F. M. Cryptosporidial infection in a calf. **Veterinary Pathology**, v. 8, n. 5-6, p. 479-484, 1971.
- PENA, H. F. J.; KASAI, N.; GENNARI, S. M. *Cryptosporidium muris* in dairy cattle in Brazil. **Veterinary Parasitology**, v. 73, n. 3-4, p. 353-355, 1997.
- PEREIRA, A. M. et al. Prevalence of parasites in soil and dog feces according to diagnostic tests. **Veterinary Parasitology**, v. 170, n. 1-2, p. 176-181, 2010.
- RAMIREZ, N. E.; WARD, L. A.; SREEVATSAN, S. A review of the biology and epidemiology of cryptosporidiosis in humans and animals. **Microbes and Infection**, v. 6, n. 8, p. 773-785, 2004.
- RAZZOLINI, M. T.; SANTOS, T. F. S.; BASTOS, V. K. Detection of *Giardia* and *Cryptosporidium* cysts/oocysts in watersheds and drinking water sources in Brazil urban areas. **Journal of Water and Health**, v. 8, n. 2, p. 399-404, 2010.
- Ribeiro, M. G. et al. Identification of enteropathogens from buffalo calves with and without diarrhoea in the Ribeira Valley, State of São Paulo, Brazil. **Brazilian Journal of Veterinary Research and Animal Science**, v. 37, n. 2, p. 159-165, 2000.
- RYAN, U. *Cryptosporidium* in birds, fish and amphibians. **Experimental Parasitology**, v. 124, n. 1, p. 113-120, 2010.
- SANTOS, M. M. A. B.; PEIRÓ, J. R.; MEIRELES, M. V. *Cryptosporidium* infection in ostriches (*Struthio camelus*) in Brazil: clinical, morphological and molecular studies. **Brazilian Journal of Poultry Science**, v. 7, n. 2, p. 113-117, 2005.
- SILVA, C. G. M.; ANDRADE, S. A. C.; STAMFORD, T. L. M. Ocorrência de *Cryptosporidium* spp. e outros parasitas em hortaliças consumidas *in natura*, no Recife. **Ciência & Saúde Coletiva**, v. 10, p. 63-69, 2005.

- SILVA, D. C. et al. Physical, epidemiological, and molecular evaluation of infection by *Cryptosporidium galli* in Passeriformes. **Parasitology Research**, v. 107, n. 2, p. 271-277, 2010.
- SMITH, H. V. et al. Tools for investigating the environmental transmission of *Cryptosporidium* and *Giardia* infections in humans. **Trends in Parasitology**, v. 22, n. 4, p. 160-167, 2006.
- SOUZA, J. C. P.; LOPES, C. W. G. Criptosporidiose em bezerros de rebanhos da bacia leiteira Sul-Fluminense, Estado do Rio de Janeiro. **Revista Brasileira de Parasitologia Veterinária**, v. 4, n. 1, p. 33-36, 1995.
- SOUZA, P. N. B. et al. Natural infection by *Cryptosporidium* sp., *Giardia* sp. and *Eimeria leuckarti* in three groups of equines with different handlings in Rio de Janeiro, Brazil. **Veterinary Parasitology**, v. 160, n. 3-4, p. 327-333, 2009.
- TEMBUE, A. A. M. et al. Ocorrência de *Cryptosporidium* spp. em ovinos no município de Ibimirim, estado de Pernambuco. **Ciência Veterinária nos Trópicos**, v. 9, n. 1, p. 41-43, 2006.
- THOMAZ, A. et al. Molecular identification of *Cryptosporidium* spp. from fecal samples of felines, canines and bovines in the state of São Paulo, Brazil. **Veterinary Parasitology**, v. 150, n. 4, p. 291-296, 2007.
- TYZZER, E. E. A sporozoan found in the peptic glands of the common mouse. **Proceedings of the Society for Experimental Biology and Medicine**, v. 5, p. 12-13, 1907.
- VIEIRA, L. S. et al. Outbreak of cryptosporidiosis in dairy goats in Brazil. **Veterinary Record**, v. 140, n. 16, p. 427-428, 1997.
- XIAO, L. et al. *Cryptosporidium* taxonomy: recent advances and implications for public health. **Clinical Microbiology Reviews**, v. 17, n. 1, p. 72-97, 2004.
- XIAO, L. Molecular epidemiology of cryptosporidiosis: an update. **Experimental Parasitology**, v. 124, n. 1, p. 80-89, 2010.
- XIAO, L.; FAYER, R. Molecular characterisation of species and genotypes of *Cryptosporidium* and *Giardia* and assessment of zoonotic transmission. **International Journal for Parasitology**, v. 38, n. 11, p. 1239-1255, 2008.