REVIEW ARTICLE

Antiparasitic treatment using herbs and spices: A review of the literature of the phytotherapy

Tratamento antiparasitário utilizando plantas condimentares e aromáticas: Uma revisão de literatura

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Adriane Leites Strothmann[1], Maria Elisabeth Aires Berne[2], Gabriela de Almeida Capella[3], Micaele Quintana de Moura[4], Wesley Douglas da Silva Terto[4], Caroline Maciel da Costa[5] & Natália Berne Pinheiro[6*]

[1] Undergraduate in Biological Sciences, Instituto de Biologia (IB), Universidade Federal de Pelotas (UFPel). *Campus* Capão do Leão, RS, Brazil.
[2] Veterinarian, DSc. Departamento de Microbiologia e Parasitologia (DMP), IB, UFPel, *Campus* Capão do Leão, RS, Brazil.
[3] Veterinarian, MSc. Programa de Pós-Graduação em Parasitologia (PPGPar), IB, UFPel, *Campus* Capão do Leão, RS, Brazil.
[4] Biologist, MSc. PPGPar, IB, UFPel, *Campus* Capão do Leão, RS, Brazil.
[5] Undergraduate in Zootechnics, Faculdade de Veterinária (FaVet), UFPel. *Campus* Capão do Leão, RS, Brazil.
[6] Veterinarian, MSc. PPGPar, IB, UFPel, *Campus* Capão do Leão, RS, Brazil.

Abstract

This study sought to make a literature review of the medicinal plants *Origanum majorana*, *Origanum vulgare* L., *Thymus vulgaris* L., *Cuminum cynimum* L., and *Rosmarinus officinalis L.* with antiparasitic potential. Articles and theses were selected from the LILACS, PubMed, and Google Scholar databases, which comprised the period from 2000 to 2021 (22 years). In all, 49 studies were selected, and the majority were with the plant *Origanum vulgare* L. (oregano), followed by *Thymus vulgaris* L. (thyme). Twenty-five genera of parasites were detected, which were described being tested with phytotherapic. The nematode *Haemonchus* spp. was the most evaluated in these studies, followed by the parasite genera *Leishmania*, *Trichostrongylus*, and *Toxocara*. All plants showed antiparasitic effects, with more or less action, therefore with the potential to continue research in the search for biomolecules to control these parasites.

Keywords: phytotherapy, endoparasites, alternative control.

Resumo

O presente trabalho faz uma revisão bibliográfica das plantas medicinais *Origanum majorana*, *Origanum vulgare* L., *Thymus vulgaris* L., *Cuminum cynimum* L. e *Rosmarinus officinalis* L. com potencial antiparasitário. Foram selecionados artigos e teses nos bancos de dados LILACS, PubMed e Google Acadêmico que compreendiam o período de publicação de 2000 a 2021 (22 anos). Ao todo, foram selecionados 49 estudos, sendo que na maioria constava a planta *Origanum vulgare* L. (orégano), seguido de *Thymus vulgaris* L. (tomilho). Foram detectados 25 gêneros de parasitos, os quais foram descritos sendo testados frente a algum fitoterápico. O nematoda *Haemonchus* spp. foi o mais avaliado nestes estudos, seguido dos gêneros dos parasitos *Leishmania*, *Trichostrongylus* e *Toxocara*. Todas as plantas apresentaram efeitos antiparasitários, com maior ou menos ação, portanto com potencial para dar continuidade aos estudos em buscas de biomoléculas para controle destes parasitos.

Palavras-chave: fitoterapia, endoparasitos, controle alternativo.

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***Correspondence**
Natália Berne Pinheiro
Departamento de Microbiologia e Parasitologia, Instituto de Ciências Biológicas, Universidade Federal de Pelotas – UFPel
Campus Universitário, s/n, Caixa Postal 354
CEP 96010-900, Pelotas (RS), Brazil
E-mail: nbernevet@gmail.com

Introduction

Man's relationship with natural resources to improve his living conditions and increase his chances of survival is ancient (Taufner et al., 2006). Medicines derived from plants (i.e., herbal medicines) present a wide spectrum of use, especially by groups of people in vulnerable situations and those concerned about consuming a more naturally produced food (Nery et al., 2009; Silva et al., 2017). When used correctly, these molecules present fewer side effects (Andrade et al., 2018). It is esteemed that at least 80% of the world population uses traditional medicine, and of these, 85% utilize medicinal plants (Barata, 2003; Fenalti et al., 2016; Gadelha et al., 2013).

In Brazil, phytotherapy was included as a practice in the public health network in 2006 (Brasil, 2006). In 2011, ANVISA created a manual with instructions for using medicinal plants with therapeutic potential, which had been described and scientifically accepted (Brasil, 2010). The intention was to guide the proper use, especially for users of the Unified Health System (SUS), because the population uses many plants without any guidance, which may bring risks since there are various toxic species (Giordani et al., 2016).

Diseases caused by parasites are a major public health problem (Estancial & Marini, 2014). Evidence has shown that roughly 300 helminth species and 70 protozoa species have already been diagnosed infecting humans, being the cause of death of about 200,000 people per year (Melo et al., 2017). Given that it affects the neediest population, since the mid-twentieth century, the pharmacopoeia used to control neglected tropical diseases remains unchanged (Hotez et al., 2006).

Only the use of drugs to treat diseases transmitted by parasites is not enough since the environment, water, and food are important sources of infection (Andrade et al., 2010). In addition, with the indiscriminate use of drugs, parasite resistance to available drugs emerges, especially among production animals (Fortes & Molento, 2013).

Thus, medicinal plants have been described with importance in research because they constitute an alternative treatment for parasitic diseases. Given this context, this study sought to perform a literature review of research that used the medicinal plants *Cuminum cynimum* (cumin), *Origanum vulgare* (oregano)*, Origanum majorana* (marjoram), *Rosmarinus officinalis* (rosemary), and *Thymus vulgaris* (thyme) and the evaluation of these molecules in parasites of medical and veterinary importance.

Methodology

This review selected papers in the LILACS, PubMed, and Google Scholar databases that comprised the publication period between 2000 and 2021. The descriptors chosen to find the selection of studies were "anti-helminthic medicinal plants," "*Rosmarinus officinalis* L.," "*Origanum majorana*," "*Origanum vulgare L.*," "*Thymus vulgaris L.*," and "*Cuminum cyminum* L." and their correspondents in English: "medicinal plants" and "anthelminthic," and in Spanish: "plantas medicinales" and "antihelmíntico" for the LILACS and PubMed databases. As for Google Scholar, the words used were "anti-helminthic medicinal plants" and the name of each species; in Portuguese, English and Spanish.

Results and discussion

Brazil has a plethora of different plant species (approximately 55,000 species). Among the species that compose the registered herbal medicines, 25% originate from South America, estimating that less than 15% of the species have been studied for medicinal purposes (Zago, 2018). Thus, research pointing to their biological proof is necessary as the population routinely uses some of these plants as medicine and because they may be important sources for discovering new therapeutic options (Marinho et al., 2007; Zago, 2018).

In this review, 49 papers were selected, in which *Rosmarinus officinalis L.*, *Origanum majorana*, *Origanum vulgare L.*, *Thymus vulgaris L.*, and *Cuminum cyminum L.* were tested against parasites of medical or veterinary importance. Of the 49 studies selected for review, 34 consisted of experimental work, and of these, 28 were only *in vitro* studies and 6 were *in vitro* and *in vivo* or just *in vivo* experimental studies.

Oregano was the most commonly studied plant (n = 15), followed by thyme (n = 14), rosemary (n = 7), marjoram (n = 4), and cumin (n = 2) (Figure 1). Six studies tested more than one plant: Santoro et al. (2007b) investigated oregano and thyme, Sanchez-Suarez et al. (2013) analyzed thyme, oregano, and rosemary, Castro (2018) used cumin and dill, and Štrbac et al. (2021) and Pensel et al. (2014) evaluated thyme and oregano.

The list of plants tested *in vitro* or *in vivo* and their effects on different parasite stages are listed in Tables 1–5. Some papers appear duplicated in the tables because the authors used two plants for the study or more than one parasite for the same plant.

Multiple biological activities have already been attributed to these plants in research. In a literature review of cumin by Al-Snafi (2016), the authors reported various activities, such as antimicrobial, insecticide, anti-inflammatory, analgesic, hypotensive, bronchodilator, antioxidant, anticancer, and antidiabetic activities, among others. Its anthelmintic activity seems to be little studied

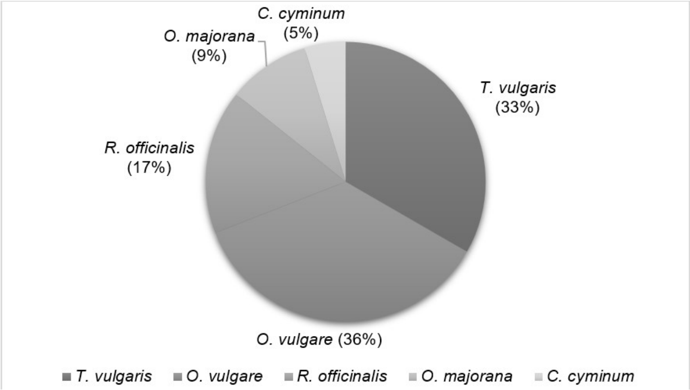

Figure 1. Percentage of studies using *Rosmarinus officinalis*, *Origanum majorana*, *Origanum vulgare*, *Thymus vulgaris*, *and Cuminum cyminum* from 2000 to 2021 for parasite control.

Table 1. Relationship of the plant *Cuminum cynimum* with parasites that have been studied in *in vitro* studies.

Parasite	Product	Concentration	Activity	Reference
Fasciola hepatica	Essential oil	2.06, 1.03, 0.51, 0.25, 0.13, 0.06, 0.03, 0.016 mg/mL;	Ovicidal action: 2.06 to 0.06 mg/mL: 100%; 0.03 mg/mL: 99%; 0.16 mg/mL: 98%;	Silva et al. (2020)
Haemonchus contortus	Essential oil	9.4, 4.7, 2.35, 1.17, 0.58 mg/mL;	Hatching inhibition: 9.4 to 0.58 mg/mL: 98.62 to 93.95%; Inhibition development: 9.4 to 2.35 mg/mL: 69.12 to 49.5%; Larval migration inhibition: 9.4 to 0.58 mg/mL: 23.45 to 10.8%;	Castro et al. (2021a); Castro et al. (2021b)

since few studies were found in this review. For marjoram, its biological activities documented by science include antioxidant, anxiolytic, anticonvulsant, antidiabetic, antidrop, antimutagenic activity, anti-ulcer, antibacterial, antifungal, and antiprotozoal activities (Prerna & Vasudeva, 2015). Documented properties of oregano include antimicrobial, antioxidant, hepatoprotective (Oniga et al., 2018), anticancer (Elshafie et al., 2017), and antiparasitic properties, as reported in this study. Rosemary has been reported to have antibacterial, antidiabetic, anti-inflammatory, antitumor, antioxidant, antinociceptive, and analgesic properties, among others. In contrast, thyme has antiseptic, antispasmodic, antitussive, antimicrobial, antifungal, antioxidant, antiviral, and antiparasitic properties (Dauqan & Abdullah, 2017).

In this review, a total of 25 genera of parasites were found that have been tested with these plants (Figure 2). Of the 25 genera found, 20 were classified at the species level. The species belonging to the genus *Haemonchus* were the most tested, followed by *Leishmania*, *Trichostrongylus*, *and Toxocara*. Most of the parasite species found in this review can infect humans.

The large number of studies observed is justified by the important role of medicinal plants in modern medicine, which is an economically viable alternative for the population. In addition, they have natural compounds that, with the advancement in research, present an easy method of

Table 2. Relationship of *Origanum majorana* with parasites that have already been studied in *in vitro* and/or *in vivo* tests.

Parasite	Product	Concentration	Activity	Reference
Toxoplasma gondii	Essential oil	50 μg/mL	Growth inhibition rate: 63.36 ± 6.66;	Elazab et al. (2021)
Toxocara spp.	Essential oil	6, 3, 1.5, 0.75, 0.37, 0.18 mg/mL;	Embryo inhibition: 0.18 to 6 mg/mL: 92.32% to 100%;	Capella (2017)
			Larvicidal activity: 1.5 to 6 mg/mL: 100%;	
Haemonchus contortus	Essential oil	Essential oil (eggs): 8, 4, 2, 1 mg/mL.	Hatching inhibition: 4 and 8 mg/mL: ±60 to 80%.	Abidi et al. (2020)
		Essential oil: (adult nematodes) 0.5, 0.25, 0.125 mg/mL	Adult nematode mortality: 0.5 mg/mL: 50% after 8 h	
Heligmosomoides polygyrus	Essential oil in mice diet	5000 and 4000 mg/kg	Total worm reduction: 76.33 to 62.59%.	Abidi et al. (2020)
			Reduction of the number of eggs in the feces: 5000 mg/kg: 74%.	

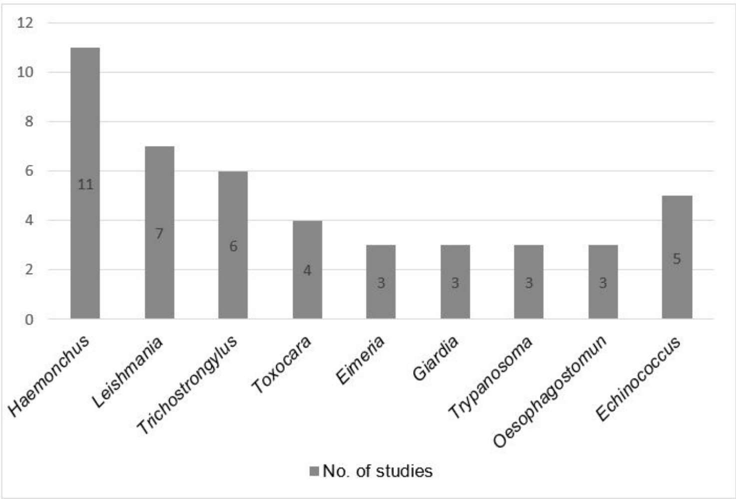

Figure 2. Genera of endoparasites most frequently found in *in vitro* and/or *in vitro* studies in the LILACS, PubMed, and Google Scholar databases from 2000 to 2021.

manipulation so that they are less toxic and more efficient and also because they have biological activities similar to allopathic medicines (Gadelha et al., 2013).

Table 3. Relationship of *Origanum vulgare* with parasites that have already been studied in *in vitro* and/or *in vivo* tests.

Parasite	Product	Concentration	Activity	Reference
Trypanosoma cruzi	Essential oil	For epimastigotes: 25 to 250 µg/mL	Inhibition of epimastigotes growth: 200 µg/mL: 50%.	Santoro et al. (2007a)
		For trypomastigotes: 25 to 400 µg/mL	Trypomastigote cell lysis: 200 µg/mL: ± 95%.	
Cryptosporidium parvum	Essential oil	60 µg/mL	*In vitro* growth reduction: 55.6 ± 10.4%	Gaur et al. (2018)
Eimeria spp.	Essential oil in chicken diets	500 ppm	Fewer intestinal lesions and more weight gain	Mohiti-Asli & Ghanaatparast-Rashti (2015)
Giardia lamblia	Hydroalcoholic extract	100 and 200 mg/mL per 120 min	Cyst viability: 100 mg/mL: 20% and 200 mg/mL: ± 5%.	Davoodi & Abbasi-Maleki (2018)
Leishmania major *Leishmania braziliensis* *Leishmanis panamensis*	Essential oil	640 to 10 µg/mL	Increased leishmanicidal effects on *L. panamensis*	Sanchez-Suarez et al. (2013)
Haemonchus spp.	Dye	80 to 0.62 mg/mL	Hatchability inhibition: tincture of 80 to 20 mg/mL: 100%.	Dias de Castro et al. (2013)
Trichostrongylus spp.	Hydroalcoholic extract (HAE)		HAE: 80 mg/mL: 96.7 ± 1.51% and 40 mg/mL: 80 ± 1.44%.	
Oesophagostomun	Aqueous extract (AQE)		AQE: 80 mg/mL: 49.8 ± 2.24%	
Toxocara spp.	Essential oil	6, 3, 1.5, 0.75, 0.37, 0.18 mg/mL	Embryo inhibition: 6 to 0.18 mg/mL: 100 to 88.15%.	
			Larvicidal activity: 6 to 0.37 mg/mL: 100%.	
Haemonchus spp. *Trichostrongylys* spp. *Teladorsagia* spp. *Chabertia* spp.	Essential oil	50, 12.5, 3.125, 0.195, 0.049 mg/mL	Embryo inhibition: 50 to 0.049 mg/mL: 100%.	Štrbac et al. (2021)
Echinococcus granulosus	Essential oil	10 µg/mL	Scholex viability: 22.3 ± 1.2% after 60 d	Pensel et al. (2014)
Eimeria spp.	Supplementation in sheep and lamb diet	4 g/day sheep 2 g/day lambs	Oocyst reduction and helps with weight gain	Dudko et al. (2018)
Ascaridia galli	Ethanolic extract	50 mg/mL	% infertile eggs from day 10 to day 21: 100 to 61%.	Villanueva et al. (2015)
Cooperia spp. *Trichostrongylus* spp. *Ostertagia* spp. *Oesophagostomun* spp. *Haemconchus* spp. *Bunostomum* spp. *Nematodirus* spp.	Essential oil	10000, 5000, 1000, 100, 10, and 1 ppm	Surviving larvae: 0% at 1000 ppm/day1 to 1.5 ± 1.3% at 1 ppm/day28	Galuppi et al. (2009)
Haemonchus contortus	Aqueous suspension in sheep diet	260 mg/kg	Reduction in parasite load: 64.9%.	Munguía-Xóchichua et al. (2013)
Giardia lamblia	Supplementation canine dog diet	100 g/animal/day	82.33% reduction in symptoms and parasite load	Mosquera Rodríguez (2016)
Echinococcus spp.	Macroemulsion (MAE) Microemulsion (MIE)	MAE: 10%. MIE: 0.6 to 1%.	Protoscoleces mortality rate: 100% after 15 min in all three concentrations.	Soleimani et al. (2021)

Table 4. Relationship of *Rosmarinus officinalis* with parasites that have already been studied in *in vitro* and/or *in vivo* tests.

Parasite	Product	Concentration	Activity	Reference
Trypanosoma cruzi	Essential oil (EO)	50 and 100 µl/mL	Epimastigote inviability: OE 50 µL/mL: 96.2% and 100 uL/mL: 100%.	Rojas et al. (2010)
Acanthamoeba poluphaga	Essential oil	1, 2, and 4 mg/mL	Cell death: 2 and 4 mg/mL: 100% in 144 h.	Anacarso et al. (2019)
			1 mg/mL: 86% after 144 h. Change in trophozoite morphology	
Leishmania major	Essential oil	0.875, 1.75, 2.5, 5, and 10 µg/mL	Cellular alteration causing infeasibility.	Bouyahya et al. (2017)
Leishmanis infantum				
Leishmania tropica				
Leishmanis major	Essential oil	OE and NE: 0.0625, 0.125, 0.25, 0.5, and 1 µg/mL	Mean macrophage infection rate: OE 0.125 µg/mL: 39.33 ± 6.02%.	Shokri et al. (2017)
	Nanoemulsion (NE)		NE 0.0625 µg/mL: 54.33 ± 7.02%	
Toxocara spp.	Essential oil	6, 3, 1.5, 0.75, 0.37, and 0.18 mg/mL	Embryo inhibition: 6 to 0.18 mg/mL:	
			70.52 to 68.45%.	
			Larvicidal activity: 6 to 3 mg/mL: 97.97 to 95.13%.	
Haemonchus spp.	Essential oil	227.5, 113.7, 56.8, 28.4, 14.2, and 7.1 mg/mL	Embryo inhibition: 227.5 to 7.1 mg/mL: 100 to 97.4%.	Pinto et al. (2019)
Ostertagia spp.			Inhibition of larval migration: 227.5 and 113.7 mg/mL: 74 and 70.1%.	
Trichostrongylus spp.			56.8 to 7.1 mg/mL: 55.3 to 20%.	
Echinococcus granulosus	Essential oil	10 µg/mL	Reduced cell viability: 71% on day 7	Albani et al. (2014)

Table 5. Relationship of *Thymus vulgaris* with parasites that have already been studied in *in vitro* and/or *in vivo* tests.

Parasite	Product	Concentration	Activity	Reference
Trypanosoma cruzi	Essential oil	For epimastigotes: 25 to 250 μg/mL	Growth inhibition: 200 μg/mL: 100%.	Santoro et al. (2007a)
		For trypomastigotes: 25 to 400 μg/mL	Cell lysis: 100 μg/mL: 100%.	
Trichinella spiralis	Alcoholic extract mice diet	500 and 1000 mg/kg	500 mg/kg: Decrease of adult worm in the intestine: 79.4%.	Attia et al. (2015)
			% of larvae in muscle: 1000 mg/kg: 71.3%	
Haemonchus contortus	Essential oil (EO)	EO (hatchability and motility): 50, 25, 12.5, 6.25, 3.125, 1.562, 0.781 mg/mL	Hatchability inhibition: 50 to 0.78 mg/mL: >94%.	Ferreira et al. (2016)
		EO (larval development): 1 to 0.0625 mg/mL	L3 larval motility inhibition: 50 to 0.78 mg/mL: >84%.	
			Larval development inhibition: 1 to 0.006 mg/mL: >99%.	
Caenorhabditis elegans	Essential oil	2, 3, and 4%	Dead adult nematodes: 2%: 80% in 48 h.	
			Larval hatching 2, 3, and 4%: >10%.	
			Decreased adult motility at the concentrations tested.	
Haemonchus contortus	Essential oil	9.4, 4.7, 2.35, 1.17, 0.58, and 0.29 mg/mL	Embryo inhibition: 9.4 to 0.29 mg/mL: 100 to 77.6%.	Castro et al. (2021a); Castro et al. (2021b)
			Developmental inhibition: 9.4 to 2.3 5 mg/mL: 100 to 65.68%.	
			Larval migration inhibition: 9.4 to 1.17 mg/mL: 95.3 to 69.6%.	
Haemonchus spp. *Trichostrongylys* spp. *Teladorsagia* spp. *Chabertia* spp.	Essential oil	50, 12.5, 3.125, 0.195, and 0.049 mg/mL	Embryo inhibition: 50 to 0.049 mg/mL: 100 to 98.5 ± 0.58%.	Štrbac et al. (2021)
Echinococcus granulosus	Essential oil	10 μg/mL	Scolex viability: 35.3 ± 2.8% after 60 d.	Pensel et al. (2014)
Blastocystis hominis	Ethanolic extract	4, 2, 1, and 0.5 mg/mL	*In vitro* growth inhibition: 24 h: 100 to 68%.	El-Sayed (2009)
			48 h: 100 to 73.8%;	
			72 h: 100 to 80.4%;	
			96 h: 100 to 84.8%.	
Echinococcus spp.	Alcoholic extract	2500, 1500, 1000, and 500 μg/mL	Scolex death: 2500 μg/mL: 100% after 6 days.	Yones et al. (2011)
			Other concentrations: 100% after 7days	
Toxocara vitulorum	Essential oil in rats' diet	42.5 mg/kg	Decreased number of larvae in the organs of infected rats	Amin & El-Kabany (2013)
Trichostrongylus spp. *Haemonchus* spp. *Osephagostonum spp.*	Diluted in water with nor in lambs' diets	0.3 g/kg	Decreased number of eggs in the feces of 37.5% of the animals on day 14	Cruz et al. (2017)
Eimeria stiedae	Essential oil in rabbits' diet	500 mg/kg	Decrease in stool oocysts: 0% day 34	Abu El Ezz et al. (2020)
Giardia lamblia	Methanolic extract	300 μg/mL	*In vitro* growth inhibition: 95.86%.	
Trichomonas vaginalis	Methanolic extract	300 μg/mL	*In vitro* growth inhibition: 96.42%.	

Conclusions

All the plants investigated in this review have antiparasitic activity against the endoparasites tested, with *Origanum vulgare* L. (oregano) and *Thymus vulgaris* L. (thyme) standing out as the plants that have been studied the most. *Cuminum cyminum* L. (cumin) was the plant with the least number of evaluations in studies regarding antiparasitic action. The endoparasite genera most studied were *Haemonchus*, *Leishmania*, *Trichostrongylus*, and *Toxocara*, respectively. The plants evaluated in the identified studies showed action at different stages of parasite development, indicating the potential of these molecules for their use as phytotherapy.

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Ethics statement

Not apply

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MEAB - none.

Conflict of interests

ALS, MEAB, GAC, MQM, WDST, CMC and NBP - No conflict of interest

Authors' contributions

ALS - Development of methodology; preparation and writing the initial draft. MEAB, GAC, MQM, WDST, CMC and NBP - Writing, Review and Editing manuscript.

Availability of complementary results

The study was carried out at Laboratório de Helmintologia, Departamento de Microbiologia e Parasitologia do Instituto de Ciências Biológicas, Universidade Federal de Pelotas - UFPel, Pelotas, RS, Brazil.

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