http://dx.doi.org/10.5935/1981-2965.20130021. *Artigo Cientifico*
http://www.higieneanimal.ufc.br

Use of herbal medicines in control of gastrointestinal nematodes of small ruminants: efficacies and prospects

Uso de fitoterápicos no controle de nematódeos gastrintestinais de pequenos ruminantes: eficácias e perspectivas

Zuliete Aliona Araújo de Souza Fonseca[1*], Wesley Adson Costa Coelho[1], Weibson Paz Pinheiro Andre[2], Wesley Lyeverton Correia Ribeiro[3], Ericka Natália Bessa[2], Victor Reis Galindo[4], Josivania Soares Pereira[1], Sílvia Maria Mendes Ahid[1,2]

[1]- Programa de Pós-Graduação em Ciência Animal, Universidade Federal Rural do Semi-Árido, Morroró, Rio Grande do Norte, Brazil.
[2]- Departamento de Medicina Veterinária, Universidade Federal Rural do Semi-Árido, Mossoró, Rio Grande do Norte, Brazil.
[3]- Programa de Pós-Graduação em Ciências Veterinárias, Universidade Estadual do Ceará, Fortaleza, Ceará, Brazil.
[4] – Faculdade de Veterinária, Universidade Estadual do Ceará, Fortaleza, Ceará, Brazil.
*Autor para correspondência: Email: alionahta@hotmail.com

Abstract: It is mainly due to the resistance to conventional anthelmintics representing a barrier, being a constant challenge to search for new bases in the control of these parasites. Thus the use of phytotherapics becomes viable alternative in the fight against gastrointestinal nematodes, beyond promoting slow development of the resistance, it is biodegradable and does not cause environmental contamination. Thereby, the review aims to address the main results obtained in research on herbal drugs effective in the control of gastrointestinal nematodes of small ruminants.

Key words: anthelmintics, medicinal plants, gastrointestinal nematodes, small ruminants

Resumo: o desenvolvimento de resistência a anti-helmínticos representa um dos principais entraves para o controle das endoparasitoses em pequenos ruminantes, sendo justificada a busca de novas alternativas no controle de helmintos. Dessa forma, o uso de

fitoterápicos torna-se alternativa viável no combate aos nematódeos gastrintestinais por promover um desenvolvimento lento da resistência, ser biodegradável e não causar contaminação ambiental. Desse modo, esta revisão visa abordar os principais resultados obtidos em pesquisas com fitoterápicos no controle de nematódeos gastrintestinais de pequenos ruminantes.

Palavras-chave: anti-helmínticos; plantas medicinais; nematódeos gastrintestinais; pequenos ruminantes.

---

*Autor para correspondência: Email: alionahta@hotmail.com
Recebido em 20.3.2013. Aceito em 26.3.2013

Introduction

The caprine and ovine culture is a socioeconomic activity very explored in Brazil, mainly in the Northeast region, representing an important source of money income for the population, however the gastrointestinal nematodes has been a public health concern to the productive chain, being one of the major causes of subclinical diseases, and production and economical loss (MOLENTO et al., 2011; VERÍSSIMO et al., 2012). This problem is more evident on the developing countries, where nutricional sources are frequently insuficient to the small ruminants and, as a result, there is a imunity decrease of the animal, leading to low productivity and high mortality due to parasitism (KNOX et al., 2006).

The control of the endoparasites is essencial to the succes within the production of small ruminants.

Recently, this control is done, mainly with synthetical antihelminthics that aims to reduce the animal level of infection,

however, the high cost, the inappropriated usage, and the development of resistent populations, associated with the risk of contamination of animal products and the enviroment due to residues of these compounds has been stimulating the search for control alternatives. (TORRES-ACOSTA; HOSTE, 2008; VIEIRA, 2008; ATHANASIADOU et al., 2008;).

Among the alternative ways, there is the phytotherapy, that uses bioactive plants rich in compounds that resembles antihelminthics (MAX et al., 2009) and because it has a important role when mixed with another methods, promoving a sustentable control of the nematode infections (CAMURÇA-VASCONCELOS et al., 2008).

The conventional paradigm of the parasites through the usage of a chemical basis must be replaced or associated with the search for alternative aproachs that offer a perspective which reduces the chemoprophylaxis and contributes to keep the antihelminthics efficiency of the recent drugs. (CEZAR et al., 2008; VIEIRA, 2008; FRED-JAIYESIMI et al., 2011). Within this scenario, it is necessary to develop studies that aims complementary alternatives instead of the tradicional methods of control (ADEMOLA; ELOFF, 2010).

Thus, this work is adressed to approach the main results obtained in ressearchs with phytotherapics that are proved to be effective in the control of small ruminant nematodes.

Development

Efficacy of phytotherapics in the control of small ruminant helminths

With the goal of contributing to the alternative control of nematodes in small ruminants, several researchs has speacially focused on the etnoveterinary medicine, by using plants of the popular medicine, evaluating its priniciples, efficacy and safety level (MONTEIRO et al., 2011).

Bioactive components of plants may act on different life stages of nematodes, acting since the egg hatching

until the parasite fecundity (HOSTE et al., 2006), motility, development and larval unsheathing, resulting with decrease of small ruminant infection, proven by the reduction of eggs per gram of faeces (EPG) and/or decrease of the graze contamination (MONTEIRO et al., 2011; MUPEYO et al., 2011; MARTÍNEZ-ORTÍZ-DE-MONTELLANO et al., 2010; HERNÁNDEZ-VILLEGAS et al., 2012).

Two approaches have been used to evaluate the antihelminthic effect of the phytotherapics: preparation of products (extracts, essential oils or isolated substances) to *in vitro* and *in vivo* evaluation and the administration of plants *in natura* to the animals with experimental and natural infeccion (ATHANASIADOU et al., 2007). Thus, studies have been conducted to validate the efficacy of medicinal plants, and the *in vitro* tests are the best to the initial evaluation and triage of products to verify the antihelminthic activity of new vegetal compounds (ASASE et al., 2005).

According to the *World Association for the Advancement of Veterinary Parasitology* (W.A.A.V.P.) reccomendations the phytotherapics can be classified by its effects of action, such as highly effective with 98% of efficiency, effective (90-98%), moderately effective (80-89%), or poorly active with less then 80% (WOOD et al., 1995).

The differences on the products efficacy is due to the chemical compositions of the phytotherapic (AL-ROFAAI et al., 2012).

Thus, the Table 1 show some phytotherapics that are described as owner of antihelminthic action, as well as the realized tests, and its respective efficacy.

Tabela 1. Herbal medicines proven effective *in vitro* and *in vivo* tests used to control gastrointestinal nematodes in small ruminants.

HERBAL	AVALUATION	TEST*	ANIMAL	EFFECT (%)	MAIN CONSTITUENTS	REFERENCE
Cocos nucifera	IT	EHT	SH	100	Taninos	OLIVEIRA et al. (2009)
		LDT		99,77		
Plectranthus punctatus	IT	EHT and LDT	SH	100	Saponinas	TADESSE et al. (2009)
Maesa lanceolata					Benzofenol	
Eucalyptus globulus	IT	EHT	SH	99,3	Monoterpeno 1,8-cineol	MACEDO et al. (2009)
		LDT		98,7		
Musa spp.	IT	LDT	SH	96,9	Taninos	OLIVEIRA et al. (2010)
Eucalyptus staigeriana	IV	EPG	SH	76,5	Limoneno	MACEDO et al. (2010)
			SH	60,7		MESQUITA et al. 2013)
Emulsão de óleo de laranja	IV	EPG	SH	97,4	Terpenos	SQUIRES et al. (2010)
Eucalyptus citriodora	IT	EHT	GT	98,8	beta-citronellal	MACEDO et al. (2011)
		LDT		99,7		
		EPG		66,2		
Senna occidentalis	IT	LDT	SH	99,3	-	EGUALE et al. (2011)
Leonotis ocymifolia				100	-	
Leucas martinicensis				99	-	
Albizia schimperiana				85	-	
Myracrodruon urundeuva	IT	EHT	SH	97,73	Taninos	OLIVEIRA et al. (2011a)
		LDT		100		
Anadenanthera colubrine	IT	LDT	SH	100	Taninos	OLIVEIRA et al. (2011b)
Leucaena leucocephala						
Mimosa tenuiflora						
Mentha piperita	IT	EHT	SH	99	Menthol	KATIKI et al. (2011)
Cymbopogon martini		LDT			Geraniol	
Cymbopogon schoenanthus		LDT			Geraniol	
Alpinia zerumbet	IT	EHT	SH	97,5	Taninos	MACEDO et al. (2012)
Tagetes minuta				96,8		
Mentha villosa				97,6		
Artemisia lancea	IT	EHT	SH	99	1,8-cineole (34.56%)	ZHU et al. (2013)
		LDT		93,6		
		TML		77		
Annona muricata	IT	EHT	SH	84,91	Compostos Felólicos	FERREIRA et al. (2013)
		LMT		89,08		

* Egg hatching test (EHT) and larval development test (LDT); EPG: eggs per gram of faeces; LMT: larval motility test; IT: *in vitro*, IV: *in vivo*, SH: Sheep, GT: goat.

In Brazil, studies shows the existence of different part of the vegetables that can be used as alternative on the antihelminthic control, such as aqueous extracts of leafs and pseudostem, essential oils and decoctions (OLIVEIRA et al., 2010; MACEDO et al. 2012; RIBEIRO et al., 2013).

Recent studies quoted the use of plants rich in secondary metabolites, several of those with high quantity of polyphenols, in special the tannins (HOSTE et al., 2012). Diverse biological actions are assigned to these substances that acts on the different parasite stages and the free live (MUPEYO et al., 2011).

Considering the use of tanniferous plants a promising alternative on the control of small ruminant nematodes, OLIVEIRA et al. (2011a) described the leaf extract and stem efficacy from *Myracrodruon urundeuva* on *H. contortus*, evaluating the ovicidal effect and the action of the extracts on the unsheathing of the third stage larvae (L3). The extracts demonstrated dose dependent ovicidal effect, however the leaf extract has been more effective inhibiting 97.73% of the egg hatching on the concentration of 1,25 $mg.mL^{-1}$, while the stem inhibited 83,56% of the eclosion on the concentration of 5 $mg.mL^{-1}$. The action of tannin involved on the antihelminthic activity was also evaluated by the use of polyvinylpolypyrrolidone, responsiblefor the inhibition of tannins, confirming the role of these secondary metabolites on the exsheathment of L3. A similar study was developed by OLIVEIRA et al. (2011b), aiming evaluate the role of tannins found on extract of tanniferous plants *Anadenanthera colubrina*, *Leucaena leucocephala* e *Mimosa tenuiflora* on the process of L3 from *H. contortus*.

Promising results were also described after incubation of nematodes with vegetable extracts rich in tannins, affecting the egg hatching, development

and larvae motility of *H. contortus* (BARRAU et al., 2005; BRUNET et al., 2007; AKKARI et al., 2008; MOLAN et al., 2010), as well as the reduction of egg removal on faeces (LANGE et al., 2006; HECKENDORN et al., 2007; MAX et al., 2009; JOSHI et al., 2011). There are some reports of reduction on parasite load of caprine and ovine nematodes fed with tanniferous plants (MINHO et al., 2008; MINHO et al., 2010).

MACEDO et al. (2012) evaluated the effect of decoctions rich in tannins derived from *Lantana camara* (Lc), *Alpinia zerumbet* (Az), *Tagetes minuta* (Tm) and *Mentha villosa* (Mv) on the inhibition of egg hatch from *H. contortus*. In the concentration of 2,5 $mg.ml^{-1}$, Tm and Mv demonstred efficacy of 96,8 and 97,6%, respectively, and did not differed statistically of the positive control, thiabendazole. In the same study, the authors related that Lc presented no effect on the egg hatching of *H. contortus.* FERREIRA et al. (2013) evaluated the acqous extract from the leaf of *Annona muricata,* popularly known as soursop fruit and it demonstred ovicidal effect on *H. contortus*, with 84,91% of efficacy, while diluted on the concentration of 50%. The test of larval motility had an inhibition of 89,08% on 12% dose. When tested in adults, there was a complete inhibition of motility on the first 6-8 hours of observation.

OLIVEIRA et al. (2009) evaluates the extract of ethyl acetate obtained on the liquid of the *Cocos nucifera* shell in egg hatchability and larvae development of *H. contortus*, atributing its action to the presence of tannins that promoted the infeasibility from tested eggs and with inhibition of 99,77% in larvae development on the concentrations of 5 $mg.mL^{-1}$ and 80 $mg.mL^{-1}$, respectively, and had no statistical difference when compared to negative controls, thiabendazole (0.025 $mg.ml^{-1}$) for egg hatching and ivermectin (0.008 $mg.ml^{-1}$) for larvae development.

The use of essential oils represents other option of phytotherapic approach and are between the vegetable substance classes that reported antiparasitic activity (ANTHONY et al., 2005). MACEDO et al. (2011) evaluated the *in vitro* and *in vivo* activity of the essential oil from *Eucalyptus citriodora*, in caprine naturally infected. Results showed reduction of 98.8% on egg hatch and 99.71% on larvae development in *H. contortus*, on 5,3 $mg.mL^{-1}$ and 10,6 $mg.mL^{-1}$ doses, respectively. On fecal egg count reduction test (FERCT), the mean efficacy was 66.25% being inferior when compared to ivermectin that showed 79.16% of antihelminthic action in caprine on the 8th day after treatment.

Elevated efficacy was also described to the essential oil of *Eucalyptus globulus* presenting the maximun action of 99,3% on the egg hatching tests and 98,7% on larvae development of *H. contortus*, on the concentration of 21,75 $mg.mL^{-1}$ and 43,5 $mg.mL^{-1}$, respectively (MACEDO et al., 2009). These results leads to the potential antihelminthic action of the oil of *E. citriodora* and *E. globulu* on the control of ovine and caprine nematodes.

KATIKI et al. (2011) tested the essential oil activity from *Mentha piperita, Cymbopogon martinii* and *Cymbopogon schoenanthus in vitro*, performing Egg hatching test (EHT), larval development test (LDT), larval exsheathment test (LET) and larval feeding inhibition test (LFIT) in different dilutions. From all the tests the LD50 and LD99 were tested. The *C. Schoenanthus* essential oil demonstred better activity against ovine trichostrongylids with LD_{50} and LD_{99} of 0,04 and 0,27 $mg.mL^{-1}$ for EHT, 0,06 and 0,27 $mg.mL^{-1}$ for LET, 24,66 and 5,23 $mg.mL^{-1}$ for LDT, and finally 0,009 and 24.66 $mg.mL^{-1}$ for LFIT respectively. The confirmation of the capacity of larvae development *in* vitro, becomes important over the control of nematodes enviromental cicle, decreasing the pasture contamination and consequently

modulating the risk of parasite infection (MAX, 2010).

In a study using *Eucalyptus staigeriana* oil on a dose of 500 $mg.kg^{-1}$ administering during three days in caprine infected by *H. contortus*, demonstred EPG reduction ranging from 61,4 to 76,57% on days 8 and 15 after treatment. On the same period the ivermectin efficacy ranged from 85,59 to 67,34% (MACEDO et al., 2010). However, the volatility and insolubility of the *Eucalyptus* spp. oil has limited its use on nematodes control (BATISH et al., 2008). Therefore, more recently, the preparation of chitosan pharmaceutical formulas based on the utilization of matrices for encapsulation of volatile compounds, it has been proposed to promote a higher protection of the drug and maximize the biological effect of essential oils (MESQUITA et al. 2013; RIBEIRO et al., 2013), moreover, it grants a higher solubility in. Thus, the nanotecnology consists of a adequated approach to implement the phytotherapics, once the possibility of optimizing the efficacy of these products exists (IRACHE et al., 2011).

In the attempt to validade vegetable products, Squires et al. (2010) tested in gerbils experimentally infected with *H. contortus* a emulsion of orange oil, and verified on the eighth day after infection a parasite reduction of 62.6% and 87.8% on the concentrations of 600 and 1200 $mg.kg^{-1}$, respectively, in a single dose. A dose of 600 $mg.kg^{-1}$ was tested in ovine, reducing 97.4% of the egg counted on faeces, when administered in a single dose and 94,9% when administered by three days in a row. Though the authors described promising results for the tested product, these must be interpreted with caution due to high doses and the number of administrations to obtain the wanted antihelminthic effected.

ZHU et al. (2013) after used the essential oil from *Artemisia lancea* described satisfatory results to EHT, LDT and LFIT over *H. contortus*. On EHT, the efficacy was 99,4% when used the dose of

10 mg.mL^{-1} and its major component, 1,8-Cineole, evidenciated moderated ovicidal activity (74,8%) with LD_{50} of 4,64 mg.mL^{-1}. On LDT, the essential oil of *A. lancea* and 1,8-Cineole, inhibited 93,6 and 65,2% on the dose of 10 mg.mL^{-1}, with LD_{50} 1,66 and 5,07 mg.mL^{-1}, respectively. And on LFIT there was a inhibition of 79,6 and 60,3% respectively, being all results dose dependent.

TADESSE et al. (2009) evaluated the action of acqueous extracts and hydro-alcoholic from *Maesa lanceolata* and *Plectranthus punctatus* over the egg hatching and larvae development of *H. contortus.* All the extracts tested demonstred efficacy above 98,9% on EHT, na dose de 0,5 mg.mL^{-1}. When evaluated at 1 mg.mL^{-1}, happened the complete inhibition of hatchability in all tested samples. The extracts were also able to inhibit the larvae development, with the best DL_{50} registered to the hydro-alcoholic extracts of leafs from *M. lanceolata*.

Similar tests were realized by EGUALE et al. (2011), to evaluate *Senna occidentalis, Leonotis ocymifolia, Leucas martinicensis, Rumex abyssinicus,* and *Albizia schimperiana* on the egg hatchability test and larvae demonstrating complete inhibition of egg hatching in concentrations below 1 mg.mL^{-1} to the acqueous and hydro-alcoholic extract of *L. martinicensis, L. ocymifolia* and acqueous extract of *S. occidentalis* and *A. schimperiana.* On LDT, the aqueous extract of *L. ocymifolia, L. martinicensis, A. schimperiana* and *S. occidentalis* presented efficacy of 100, 99, 85, and 99,3%, respectively. While the hydro-alcoholic extract of *A. Schimperiana* inhibited 99,09% on the maximun concentration tested (50 mg.mL^{-1}), the extract of *S. occidentalis* (9%) and *L. ocymifolia* (37%) demonstred low inhibition on the same concentration.

In vitro tests with different extracts (acqueous, methanolic and

dichloromethane) from parts (leaves, fruit and stem) of *Tabernaemontana citrifolia*, a plant commonly used as antihelminthic in small ruminants in Guadalupe, France, demonstred efficacy, depending on the parasite stage of *H. contortus*. The major effect found was on LDT, with reduction of 99.8% for extracts from the fruit, 83.8% from roots and 85% to the leaves. On EHT and on the larvae motility test, the results revealed efficacy of 22.7% and 56%, respectively to the extract from roots. To the larvae migraton test the higher efficacy was of 49.4% to the leaves extracts (MARIE-MAGDELEINE et al., 2010).

The alternative of utilization of plants can be a useful tool associated to other methods of smalls ruminant nematodes control, having its use justified even with a efficacy inferior to 95% in situations where synthetic antihelminthics are not recomended, as in the organic livestock, dairy production, or when the cost is not compensatory (CAMURÇA-VASCONCELOS et al., 2008).

Thus, plants with moredated antihelminthic activity must be considered, because they can allow a integrated approach, specifically designed to reach a sustainable control of parasites on the ruminant systems of production. (GITHIORI et al., 2006).

Final Considerations

The research for new phytotherapic on the field of Veterinary Parasitology is important to the control of small ruminant nematodes. The study of new substances to the verification of antihelminthic activity, becomes justifiable by the necessity of a sustainable control, through the use of biodegradable and self sustainable material.

Therefore, studies with phytherapics can contribute to expand the knowledge about antihelminthic actions of plants, allowing a better understanding of the fundamental aspects of its biological activities, as well as its constituents, which may constitute in a useful tool on the control of small ruminant parasites.

References

ADEMOLA, I.O.; ELOFF, J.N. *In vitro* anthelmintic activity of *Combretum molle* (R. Br. ex G. Don) (Combretaceae) against *Haemonchus contortus* ova and larvae. **Veterinary Parasitology**. v. 169, n. 1-2, p. 198-203, 2010.

AKKARI, H. et al. Feeding *Acacia cyanophylla* Lindl. foliage to Barbarine lambs with or without PEG: Effect on excretion of gastrointestinal nematode eggs. **Animal Feed Science and Technology**. v. 147, p. 182-192, 2008.

AL-ROFAAI, A. et al. *In vitro* ovicidal and larvicidal activity of methanolic leaf extract of *Manihot esculenta* (cassava) on susceptible and resistant strains of *Trichostrongylus colubriformis*. **Veterinary Parasitology**. v. 190, p. 127-135, 2012.

ANTHONY, J.P. Plant active components – a resource for antiparasitic agents. **Trends Parasitology**. v. 2, p. 462-468, 2005.

ASASE, A. et al. Ethnobotanical study of some Ghanaian anti-malarial plants. **Journal of Ethnopharmacology**. v. 99, p. 273–279, 2005.

ATHANASIADOU, S. et al. Medicinal plants for helminth parasite control: facts and fiction. **Animal**. v. 1, n. 9, p. 1392-1400, 2007.

ATHANASIADOU, S. et. al. Exploiting synergisms and interactions in the nutritional approaches to parasite control in sheep production systems. **Small Ruminant Research**. v. 76, n.4 9, p. 2-11, 2008.

BATISH, D.R. et al. Eucalyptus essential oil as a natural pesticide. **Forest Ecology and Management**. v. 256, p. 2166–2174, 2008.

BARRAU, E. et al. Efect of bioactive compounds from Sainfoin (*Onobrychis viciifolia* Scop.) on the *in vitro* larval migration of *Haemonchus contortus*: role of tannins and flavonol glycosides. **Parasitology**. v. 131, p. 531-538, 2005.

BRUNET, S. et al. The kinetics of exsheathment of infective nematode larvae is disturbed in the presence of a tannin-rich plant extract (sainfoin) both *in vitro* and *in vivo*. **Parasitology**. v. 34, n. 9, p. 1257-1262, 2007.

CAMURÇA-VASCONCELOS, A. L. F et al. Anthelmintic activity of *Lippia sidoides* essential oil on sheep gastrointestinal nematodes. **Veterinary Parasitology**. v. 154, p. 167-170, 2008.

CEZAR, A. S.; BIANCHIN, J. B. C. Controle alternativo de nematódeos gastrintestinais dos ruminantes: atualidade e perspectivas. **Ciência Rural**. v.38, n.7, p. 2083-2091, 2008.

EGUALE, T. et al. *In vitro* anthelmintic activity of crude extracts of five medicinal plants against egg-hatching and larval development of *Haemonchus contortus*. **Journal of Ethnopharmacology.** v. 137, p. 108-113, 2011.

FERREIRA L. E.. et al. In vitro anthelmintic activity of aqueous leaf extract of *Annona muricata* L. (Annonaceae) against *Haemonchus contortus* from sheep. **Experimental Parasitology**. v. 134, n.3, p. 327-332, 2013.

FRED-JAIYESIMI, A. A. et al. Anthelmintic activities of chloroform and methanol extracts of *Buchholzia coriacea* Engler seed. **Parasitology Reseach**. v. 109, n. 2, p. 441–444, 2011.

GITHIORI, J. B. et al. Use of plants in novel approaches for control of gastrointestinal helminths in livestock with emphasis on small ruminants. **Veterinary Parasitology**. v. 139, n.4, p. 308-320, 2006.

HECKENDORN, F. et al. Individual administration of three tanniferous forage plants to lambs artificially infected with *Haemonchus contortus* and *Cooperia curticei*. **Veterinary Parasitology**. v. 146, n. 1-2, p. 123-134, 2007.

HERNÁNDEZ-VILLEGAS, M.M. et al. *In vivo* anthelmintic activity of *Phytolacca icosandra* against *Haemonchus contortus*

in goats. **Veteriray Parasitology**. v. 189, n. 2-4, p. 284-290, 2012.

HOSTE, H. et al. The effects of tannin-rich plants on parasitic nematodes in ruminants. **Trends in Parasitology**. v. 22, n. 6, p. 253- 261, 2006.

HOSTE, H. et al. Direct and indirect effects of bioactive tannin-richtropical and temperate legumes against nematode infections. **Veterinary Parasitology**. v. 186, n. 1-2, p. 18-27, 2012.

IRACHE, J.M. et al. Nanomedicine: Novel approaches in human and veterinary therapeutics. **Veterinary Parasitology**. v. 180, n. 1-2, p. 47-71, 2011.

JOSHI, B.R. et al. Effect of feeding *Sericea lespedeza* leaf meal in goats experimentally infected with *Haemonchus contortus*. **Veterinary Parasitology**. v. 178, n. 1-2, p. 192-197, 2011.

KATIKI, L. M. et al.Anthelmintic activity of *Cymbopogon martinii, Cymbopogon schoenanthus* and *Mentha piperita* essential oils evaluated in four different in vitro tests. **Veterinary Parasitology**. v. 183, p. 103-108, 2011.

KNOX, M. R. et al. Exploiting the effect of dietary supplementation of small ruminants on resilience and resistance against gastrointestinal nematodes. **Veterinary Parasitology**. v. 139, n. 4, p. 385-393, 2006.

LANGE, K.C. et al. Effect of *Sericea lespedeza* (*Lespedeza cuneata*) fed as hay, on natural and experimental *Haemonchus contortus* infections in lambs. **Veterinary Parasitology**. v. 141, n. 3-4, p.273-278, 2006.

MACEDO, I. T. F. Atividade ovicida e larvicida *in vitro* do óleo essencial de *Eucalyptus globules* sobre *Haemonchus contortus*. **Revista Brasileira de Parasitologia Veterinária**. v. 18, n. 3, p. 62-66, 2009.

MACEDO, I. T. F. et al. Anthelmintic effect of *Eucalyptus staigeriana* essential oil against goat gastrointestinal nematodes. **Veterinary Parasitology**. v. 173, n. 1-2, p. 93-98, 2010.

MACEDO, I. T. F. et al. Evaluation of *Eucalyptus citriodora* essential oil on goat gastrointestinal nematodes. **Revistra Brasileira de Parasitology Veterinary**. v. 20, n. 3, p. 223-227, 2011.

MACEDO, I. T. F. et al. *In vitro* activity of *Lantana camara, Alpinia zerumbet, Mentha villosa* and *Tagetes minuta* decoctions on *Haemonchus contortus* eggs and larvae. **Veterinary Parasitology**. v. 190, n. 3-4, p. 504-509, 2012.

MARIE-MAGDELEINE, C. *In vitro* effects of Tabernaemontana citrifolia extracts on Haemonchus contortus. **Research in Veterinary Science**. v. 89, n. 1, p. 88-92, 2010.

MAX, R. A. Effect of repeated wattle tannin drenches on worm burdens, faecal egg counts and egg hatchability during naturally acquired nematode infections in sheep and goats. **Veterinary Parasitology**. v. 169, n. 1-2, p. 138-143, 2010.

MAX, R. A. et. al. The effect of wattle tannin drenches on gastrointestinal nematodes of tropical sheep and goats during experimental and natural infections. **Journal of Agricultural Science**. v. 147, p. 211-218, 2009.

MARTÍNEZ-ORTÍZ-DE-MONTELLANO, C. et al. Effect of a tropical tannin-rich plant *Lysiloma latisiliquum* on adult populations of *Haemonchus contortus* in sheep. **Veterinary Parasitology**. v. 172, n. 3-4, p. 283-290, 2010.

MESQUITA, M.A. et al. Anthelmintic activity of *Eucalyptus staigeriana* encapsulated oil on sheep gastrointestinal nematodes. **Parasitology research.** v. 112, p. 3161 – 3165, 2013.

MINHO, A.P. et al. Effect of *Acacia molissima* tannin extract on the control of gastrointestinal parasites in sheep. **Animal Feed Science and Technology**. v. 147, n. 1-3, p. 172-181, 2008.

MINHO, A.P. et al. Efficacy of condensed tannin presents in acacia extract on the control of *Trichostrongylus colubriformis* in sheep. **Ciência Rural**. v. 40, n. 6, p. 1360-1365, 2010.

MONTEIRO, M.V.B et al. Anthelmintic activity of *Jatropha curcas* L. seeds on *Haemonchus contortus*. **Veterinary Parasitology**, v. 182, p. 259-263, 2011.

MUPEYO, B.; B. et al. Effects of feeding willow (***Salix*** spp.) upon death of established parasites and parasite fecundity. **Animal Feed Science and Technology**. v. 164, n. 1-2, p. 8-20, 2011.

MOLAN, A. L.; FARAJ, A. M. The effects of condensed tannins extracted from different plant species on egg hatching and larval development of *Teladorsagia circumcincta* (Nematoda: Trichostrongylidae). **Folia Parasitologica**. v. 57, n. 1, p. 62-68, 2010.

MOLENTO M.B. et al. Challenges of nematode control in ruminants: Focus on Latin America. **Veterinary Parasitology**. v. 180, p. 126-132, 2011.

OLIVEIRA, L. M. B. et al. Anthelmintic activity of *Cocos nucifera* L. against sheep gastrointestinal nematodes. **Veterinary Parasitology**. v. 159, n. 1, p. 55-59, 2009.

OLIVEIRA, L. N. et al. Efficacy of banana crop residues on the inhibition of larval development in *Haemonchus* spp. from sheep. **Ciência Rural**. v. 40, n. 2, p. 488-490, 2010.

OLIVEIRA, L.M.B. et al. Effects of *Myracrodruon urundeuva* extracts on egg hatching and larval exsheathment of *Haemonchus contortus*. **Parasitology Research**. v. 109, n. 3, p. 893-898, 2011a.

OLIVEIRA, L.M.B. et al. Effect of six tropical tanniferous plant extracts on larval exsheathment of *Haemonchus contortus.* **Revista Brasileira Parasitologia Veterinária**. v. 20, n. 2, p. 155-160, 2011b.

RIBEIRO, W.L.C. et al. Activity of chitosan-encapsulated *Eucalyptus staigeriana* essential oil on *Haemonchus contortus*. **Experimental parasitology.** v. 135, p. 24-29, 2013.

SQUIRES, J. M. et al. Efficacy of an orange oil emulsion as an anthelmintic against *Haemonchus contortus* in gerbils (*Meriones unguiculatus*) and in sheep.

Veterinary Parasitology. v. 172, n. 1-2, p. 95-99, 2010.

TADESSE, D. et al. Ovicidal and larvicidal activity of crude extracts of *Maesa lanceolata* and *Plectranthus punctatus* against *Haemonchus contortus.* **Journal of Ethnopharmacology**. v. 122, n. 2, p. 240–244, 2009.

TORRES-ACOSTA, J. F. J.; HOSTE, H. Alternative or improved methods to limit gastrointestinal parasitism in grazing sheep and goats. **Small Ruminant Research**. v. 77, n. 2-3, p. 159-173, 2008.

WOOD, I.B. et al. World Association for the Advancement of Veterinary Parasitology (WAAVP) second edition of guidelines for evaluating the efficacy of anthelmintics in ruminants (bovine, ovine, caprine). **Veterinary Parasitology**. v. 58, n. 3, p. 181-213, 1995.

VERÍSSIMO; C. J. et al. Multidrug and multispecies resistence in sheep flocks from São Paulo state. **Brazilian Journal of Veterinary Parasitology**. v. 187, n. 1–2, p. 209-216, 2012.

VIEIRA, L. S., 2008. Métodos alternativos de controle de nematódeos gastrintestinais em caprinos e ovinos. **Tecnologia & Ciência Agropecuária.** v. 2, n. 2, p. 49-56, 2008.

ZHU, L. et al. *In vitro* ovicidal and larvicidal activity of the essential oil of *Artemisia lancea* against *Haemonchus contortus* (Strongylida). Veterinary Parasitology. v. 195, n. 1-2, p. 112-117, 2013.