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Original Article

Implication of the fecal egg count reduction test (FECRT) in sheep for better use of available drugs

Implicação do teste de redução da contagem de ovos nas fezes (TRCOF) em ovinos para melhor uso dos anti-helmínticos disponíveis

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Abstract

The aim here is to present data on the efficacy of anthelmintics in sheep flocks in Rio de Janeiro, Brazil, and to discuss the interpretation of the fecal egg count reduction test (FECRT) for each nematode genus. Fecal eggs counts and pre- and post-treatment coprocultures were performed, the former to evaluate the efficacy of and the latter to determine the overall parasite prevalence. An additional efficacy test was performed at Farm # 1 a year after the initial test. Severe anthelmintic resistance was found for the flocks, with no FECRT sensitivity at any of the 22 farms evaluated. However, an analysis of the infective larvae showed that some drugs were effective against certain parasitic genera; i.e., levamisole was more effective against *Haemonchus* spp. and moxidectin against *Trichostrongylus* spp. In the additional FECRT performed at Farm # 1, moxidectin and nitroxynil were ineffective separately, but when applied in combination they were highly effective due to their efficacy against *Haemonchus* (nitroxynil) and *Trichostrongylus* (moxidectin), respectively. The use of the FECRT targeting the parasitic nematode species prevalent on farms may make it possible to choose more effective anthelmintics.

Keywords: Anthelmintic resistance, EPG, FECRT, gastrointestinal nematodes, sheep.

Resumo

O objetivo deste trabalho foi apresentar dados sobre a eficácia de anti-helmínticos em rebanhos ovinos no Rio de Janeiro, Brasil, e discutir a interpretação do teste de redução da contagem de ovos nas fezes (TRCOF) para cada gênero de nematoide. A contagem de ovos fecais (OPG) e coprocultura pré e pós-tratamento foram realizadas para avaliar a eficácia e a prevalência geral do parasito, respectivamente. Um teste de eficácia adicional foi realizado na Fazenda # 1 após um ano do teste inicial. Resistência anti-helmíntica grave foi encontrada, não havendo sensibilidade no TRCOF em nenhuma das 22 fazendas avaliadas. No entanto, na análise das larvas infectantes observou-se que algumas drogas foram eficazes contra certos gêneros parasitários; por exemplo, o levamisol foi mais eficaz contra *Haemonchus* spp. e a moxidectina contra *Trichostrongylus* spp. No TRCOF adicional realizado na Fazenda 1, a moxidectina e o nitroxinil foram ineficazes separadamente, mas quando aplicados em combinação, foram altamente eficazes devido à sua eficácia contra *Haemonchus* spp. (nitroxinil) e *Trichostrongylus* spp. (moxidectina), respectivamente. O TRCOF visando às espécies de nematoides parasitas prevalentes nas fazendas pode possibilitar a escolha de anti-helmínticos mais eficazes.

Palavras-chave: Resistência anti-helmíntica, EPG, TRCOF, nematoides gastrintestinais, ovinos.

Introduction

The main health issue affecting sheep around the world is gastrointestinal nematode infection (CHARLIER et al., 2014). Production rates drop due to parasitic spoliation (SCOTT et al., 2017), reduced voluntary food intake (VALDERRÁBANO et al., 2002) and efficiency of food utilization (BLACKBURN et al., 2015), and due to the mobilization of immune system cells to fight parasitism (HOSTE et al., 2005). In the attempt to control these diseases, anthelmintics (AH) have been used indiscriminately, causing them to gradually lose their effectiveness (KAPLAN & VIDYASHANKAR, 2012). Today, the phenomenon of anthelmintic

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resistance (AHR) to the various classes of drugs in sheep is reported in several regions of the world (TORRES-ACOSTA et al., 2012; GEURDEN et al., 2014; SALGADO & SANTOS, 2016), including to those most recently launched on the market (SCOTT et al., 2013; CINTRA et al., 2016).

AHR is difficult to detect in herds because it is caused by an increase in the frequency of resistance alleles through the selection imposed by the repeated use of a given AH (FLEMING et al., 2006). Sheep are hosts to a wide variety of gastrointestinal nematodes that cause clinical symptoms depending on the prevalence of each species, which varies as a function of climate and herd management system (ROSE VINEER et al., 2016). The most prevalent nematodes in most of Brazil are *Haemonchus* spp., *Trichostrongylus* spp., *Cooperia* spp., *Oesophagostomum* spp. and, in subtropical regions, *Teladorsagia* spp. (AMARANTE, 2014). Identifying parasite populations in the herd has become increasingly important in monitoring the spread of AHR in target nematode species and to keep track of changes in parasite prevalence resulting from climate variations (ROEBER et al., 2017).

Thus, the control of gastrointestinal nematode infections requires an in-depth understanding of parasite epidemiology and of the production system, including characteristics inherent to the animal and environment (SALGADO et al., 2018). It is also of paramount importance to preserve the effectiveness of compounds (ALBUQUERQUE et al., 2017) by implementing more sustainable practices (EASTON et al., 2018). Constant research focuses on parasite management approaches aimed at lowering AHR, such as methods of selective control (CHAGAS et al., 2016), pasture management systems (BURKE et al., 2009), refuge management (MUCHIUT et al., 2018) and selection of parasite resistant animals (AGUERRE et al., 2018). Nevertheless, at some point, AH are inevitably needed for the effective control of parasitic gastroenteritis (HAMER et al., 2018).

In this scenario, how can the producer choose the most suitable anthelmintic? It is essential to test the active substances beforehand so as to use the most effective one possible, with greater than 95% efficacy (COLES et al., 2006). AH efficacy can be determined by several methods, but notwithstanding a few limitations, the phenotypic fecal egg count reduction test (FECRT) is still the one most widely used in the field (LEVECKE et al., 2018). This test consists of counting the fecal eggs of animals before and after AH treatment, and it is recommended to do a fecal culture test to determine the species or genus of nematode resistant or susceptible to the evaluated product (COLES & ROUSH, 1992), although this is not a common practice. Considering the parasitic diversity in sheep and the differences in pathogenicity and AHR, it is important that the interpretation of FECRT be increasingly specific (MCINTYRE et al., 2018). There is also growing interest in the use of combined anthelmintics to achieve a better efficacy index (KOTZE et al., 2018), but the choice of this combination must be based on greater diagnostic precision. In this context, the purpose of this paper is to present data on the efficacy of AH drugs in sheep flocks in the state of Rio de Janeiro, Brazil, addressing the interpretation of FECRT for each genus of nematode in the search for the better use of tested drugs.

Material and Methods

Data and farms

Data were collected in the state of Rio de Janeiro, southeastern Brazil. Twenty-two farms distributed all over the state, each having at least 60 sheep, participated in the AH efficacy test. Predominantly healthy Santa Ines ewes and crossbred sheep were tested on each farm.

Fecal Egg Count Reduction Test (FECRT)

Five drugs were evaluated: albendazole, levamisole, ivermectin, moxidectin and closantel. Efficacy levels were evaluated based on the FECRT, as described by Coles & Roush (1992) and Coles et al. (2006). The animals were divided randomly into groups of 10-15 per AH, weighed, and then treated subcutaneously with the dose recommended by the manufacturer: ivermectin (0.2 mg/kg of body weight (bw), moxidectin (0.2 mg/kg bw), albendazole (3.4 mg/kg bw), levamisole (6.2 mg/kg bw) and closantel (10 mg/kg bw). These drugs were the most frequently used AH in sheep flocks in the state of Rio de Janeiro. Fecal samples were collected directly from the recta of animals on day zero and 14 days after administration of the AH and refrigerated until examination. The number of Strongyle eggs per gram of feces (EPG) from each animal was counted following the modified technique proposed by Gordon & Whitlock (1939). Fecal cultures from each group of tested animals were performed pre-and post-treatment for each AH. Fecal cultures were performed as described by Bonadiman et al. (2006) to determine the genera of the predominant nematodes resistant to the AH treatments. Larvae were morphologically identified as described by Van Wyk & Mayhew (2013).

The drug efficacy against each genus was calculated based on the difference in EPGs and infective larvae on day zero and 14 days after treatment, and an AH was considered efficacious if it reduced the EPG by 95% (COLES et al., 2006).

Farm # 1 was reevaluated one year after the initial efficacy test. The last drugs used on the farm (closantel and levamisole), as well as nitroxynil (34 mg/kg BW,) were tested separately and in combination with moxidectin.

Statistical analysis

AH efficacy was estimated using an adapted version of the analytical software RESO FECRT, version 2.0 (WURSTHORN & MARTIN, 1990). A diagnosis of resistance was reached when: (i) the percentage reduction in egg count was less than 95%, and when (ii) the 95% confidence interval (lower and upper 95%) was less than 90%. If only one of the two criteria was met, resistance was suspected (low resistance), according to Coles & Roush (1992) and Coles et al. (2006). Efficacy data are presented in the form of box plots and descriptive figures.

Results

Table 1 lists the efficacy data, % reduction in FECRT, and EPG one day prior to treatment (D0) and 14 days post-treatment (D14) of the five AH tested at the 22 sheep farms in the state of Rio de Janeiro, Brazil. According to the criteria adopted, ≥95% and confidence interval (CI) lower and upper 95%, none of the tested drugs proved efficacious on any of the evaluated farms.

According to the result of the RESO analytical program, all the farms with ≥95% efficacy showed "Low Resistance" due to the CI.

Table 1. Efficacy (%), 95% confidence interval (CI), mean EPG pre (D0) and post (D14) treatment at 22 farms in the state of Rio de Janeiro, Brazil.

Flock	Ivermectin		Moxidectin		Levamisole		Closantel		Albendazole	
	Mean EPG (D0-D14)	Efficacy (CI)	Mean EPG (D0-D14)	Efficacy (CI)	Mean EPG (D0-D14)	Efficacy (CI)	Mean EPG (D0-D14)	Efficacy (CI)	Mean EPG (D0-D14)	Efficacy (CI)
1	967-1417	0 (0-29)	1269-462	65 (30-81)	1269-462	95 (86-98) LR	1150-525	54 (0-86)	783-158 (45-93)	80
2	975-1067	0 (0-60)	1292-1442	0 (0-63)	1292-1442	97 (84-99) LR	167-322	72 (29-89)	486-186 (19-82)	62
3	475-708	0 (0-34)	722-289	60 (0-92)	722-289	49 (0-82)	733-13	95 (81-99) LR	400-80 (0-98)	80
4	580-970	0 (0-41)	533-820	0 (0-61)	533-820	77 (26-96)	664-464	30 (0-63)	2508-383 (15-97)	85
5	986-1386	0 (0-56)	1888-688	64 (0-88)	1888-688	51 (0-88)	1640-1010	38 (0-77)	3000-2929 (0-87)	2
6	533-467	13 (0-82)	833-433	48 (0-95)	833-433	91 (60-98)	460-170	63 (0-89)	325-213 (0-86)	35
7	730-310	58 (0-88)	486-329	32 (0-83)	486-329	48 (0-87)	833-433	48 (0-76)	760-840 (0-74)	0
8	538-725	0 (0-58)	1067-422	60 (0-92)	1067-422	95 (79-99) LR	975-213	78 (7-95)	1625-238 (32-97)	85
9	600-156	74 (31-90)	1063-125	88 (49-97)	1063-125	93 (75-98)	1250-725	42 (0-79)	4067-1044 (0-96)	79
10	1086-414	62 (0-89)	300-833	0 (0-15)	300-833	95 (86-99) LR	800-850	0 (0-0)	650-470 (0-63)	28
11	1114-1129	0 (0-79)	1388-163	88 (36-98)	1388-163	62 (0-86)	986-229	77 (29-92)	2700-1671 (0-87)	38
12	4500-5767	0 (0-62)	617-717	0 (0-79)	617-717	73 (28-90)	1538-625	94 (0-91)	771-400 (0-86)	48
13	1967-633	68 (15-88)	1871-71	96 (74-99) LR	1871-71	92 (75-98)	2189-600	73 (26-90)	1438-663 (0-89)	54
14	570-840	0 (0-38)	988-638	35 (0-73)	988-638	57 (0-91)	443-157	65 (14-85)	700-640 (0-67)	9
15	1556-889	43 (0-86)	540-20	96 (84-99) LR	540-20	96 (86-99) LR	820-260	68 (42-83)	889-1167 (0-53)	0
16	590-540	8 (0-71)	283-383	0 (0-46)	283-383	0 (0-54)	333-200	40 (0-73)	638-338 (0-87)	47
17	4500-5767	0 (0-62)	3450-2813	21 (0-73)	3450-2813	0 (0-53)	2644-1111	58 (6-81)	2000-2657 (0-63)	0
18	4500-5467	0 (0-62)	571-1243	0 (0-48)	571-1243	0 (0-0)	1083-617	43 (0-76)	300-400 (0-49)	0
19	1775-1600	10 (0-55)	1100-117	89 (38-98)	1100-117	53 (0-87)	780-300	62 (0-93)	1650-1017 (0-89)	38
20	5680-5800	0 (0-72)	1100-117	89 (65-97)	1100-117	43 (0-71)	1457-557	62 (0-89)	583-583 (0-56)	0
21	880-380	57 (5-80)	380-40	89 (56-97)	380-40	68 (0-92)	340-20	94 (75-99)	1750-1450 (0-54)	17
22	233-300	0 (0-19)	200-517	0 (0-24)	200-517	89 (53-97)	425-150	65 (1-87)	457-357 (0-74)	22

LR: low resistance. The unmarked farms were resistant to the drugs tested.

This finding applied to Farm # 3 for Closantel, on Farms 13 and 15 for Moxidectin, and Farms 1, 2, 8, 10, and 15 for Levamisole. Resistance against Albendazole and Ivermectin was found at all the farms.

The parasite with the highest prevalence in the herds under study was *Haemonchus* spp. The average percentage of genera identified in the first fecal culture from the 22 farms was 75% *Haemonchus* spp., 20% *Trichostrongylus* spp., 3% *Cooperia* spp. and 2% *Oesophagostomum* spp. The genus *Strongyloides* was identified at 35% of the farms, but was not quantified in fecal cultures. *Trichostrongylus* was predominant only at Farms 1 and 6.

Figure 1 summarizes the specific efficacy, separated by nematode genus, of the five AH drugs employed at the 22 aforementioned farms. The most effective drugs against *Haemonchus* were levamisole (65% average and 79% median efficacy) and closantel (62% average and 65% median). Macrocyclic lactones (ivermectin and moxidectin) were more effective against *Trichostrongylus* spp., with an average of 68% and 73%, respectively, and a median of 86% and 97%, respectively. The least drug resistant nematodes were *Cooperia* spp. and *Oesophagostomum* spp. Only closantel presented low efficacy levels (61% and 64%, respectively), as expected of this anthelmintic due to its specific spectrum against hematophagous nematodes. However, the calculation of efficacy may have been impaired by the low prevalence rates of these nematodes.

Table 2 lists the number of farms (among the 22 under study) that showed Resistance (R), Low Resistance (LR) or Susceptibility (S) to the five drugs subjected to the FECRT by the prevalent parasites, namely, *Haemonchus* and *Trichostrongylus*, which were identified at all the farms. The efficacy status (R, S or LR) of all the drugs varied according to the parasite genus, and the number of farms with status (R) decreased in a specific calculation of each nematode genus.

Table 3 lists the farms where the FECRT and the fecal cultures produced different results. Although the FECRT showed no efficacy, the fecal cultures showed susceptibility (S) of *Trichostrongylus* at farms 2, 3, 4 and 15 and of *Haemonchus* at farms 9 and 15.

Figure 2 illustrates the results of the first evaluation of anthelmintic efficacy based on the FECRT and infective larvae at Farm # 1 and the results after one year of application of the most effective anthelmintic. In the first evaluation, the parasite population

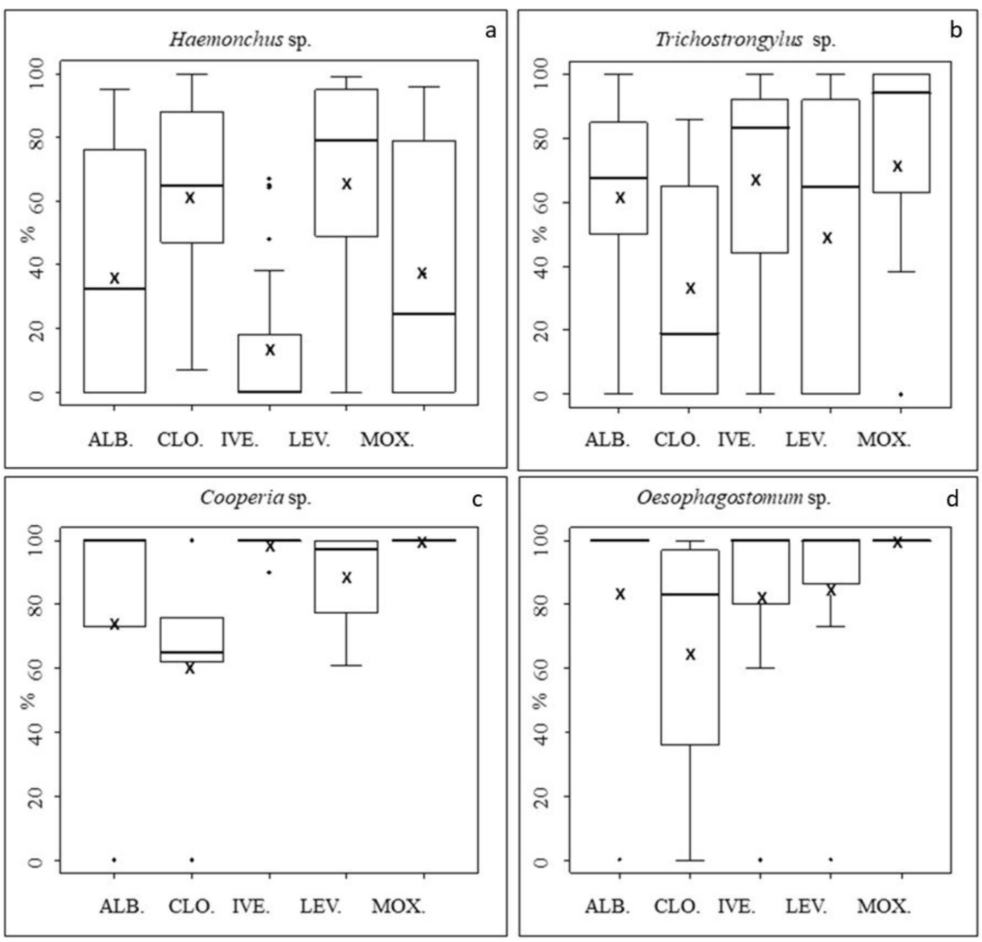

Figure 1. Distribution of anthelmintic efficacy against (a) *Haemonchus*, (b) *Trichostrongylus*, (c) *Cooperia* and (d) *Oesophagostomum* of the five drugs tested on 22 farms in the state of Rio de Janeiro, Brazil. The horizontal lines represent median values, the "x" represent arithmetic means, and the points represent outliers. Anthelmintics: IVE: ivermectin, MOX: moxidectin; LEV: levamisole; CLO: closantel; ALB: albendazole.

Table 2. Number of farms, of the 22 farms, where Resistance (R), Low Resistance (LR) or Susceptibility (S) to the five tested drugs was identified in the FECRT and by *Haemonchus* and *Trichostrongylus*.

Drugs	FECRT			*Haemonchus*			*Trichostrongylus*		
	R	LR	S	R	LR	S	R	LR	S
Ivermectin	22	0	0	22	0	0	20	1	2
Moxidectin	20	2	0	20	1	1	12	1	9
Levamisole	19	3	0	16	4	2	16	3	3
Closantel	21	1	0	19	1	2	22	0	0
Albendazole	22	0	0	21	1	0	19	0	3

Table 3. Efficacy (%) of the anthelmintics on the farms where differences were found in the FECRT and larval population.

FECRT(%)			Efficacy per nematode genus (%)				Larval population % (D0)			
Flock	Drug		*Hc.*	*Tric.*	*Coo.*	*Oes.*	*Hc.*	*Tric.*	*Coo.*	*Oes.*
2	Alb.	62 (R)	58 (R.)	100 (S.)	.	.	74	26	0	0
3	Lev.	49 (R)	47 (R.)	100 (S.)	.	.	85	15	0	0
4	Mox.	0 (R)	0 (R.)	100 (S.)	.	100 (LR.)	78	22	0	0
9	Clos.	42 (R)	100 (S.)	65 (R.)	0 (R.)	0%	59	31	8	2
15	Mox.	96 (LR)	96 (LR.)	100 (S.)	100 (LR.)	100 (LR.)	86	1	1	12
15	Lev.	96 (LR)	97 (S.)	20 (R.)	100 (LR.)	100 (LR.)	95	6	1	3

Drugs: Alb: albendazole, Lev: levamisole, Mox: moxidectin, Clos: closantel. D0: Population of nematode larvae on day zero of the anthelmintic test Nematodes genus: Hc.: *Haemonchus* sp., Tric.: *Trichostrongylus* sp., Coo.: *Cooperia* sp., Oes.: *Oesophagostomum* sp. Efficacy Status: R: resistant, S: susceptible and LR: Low resistance.

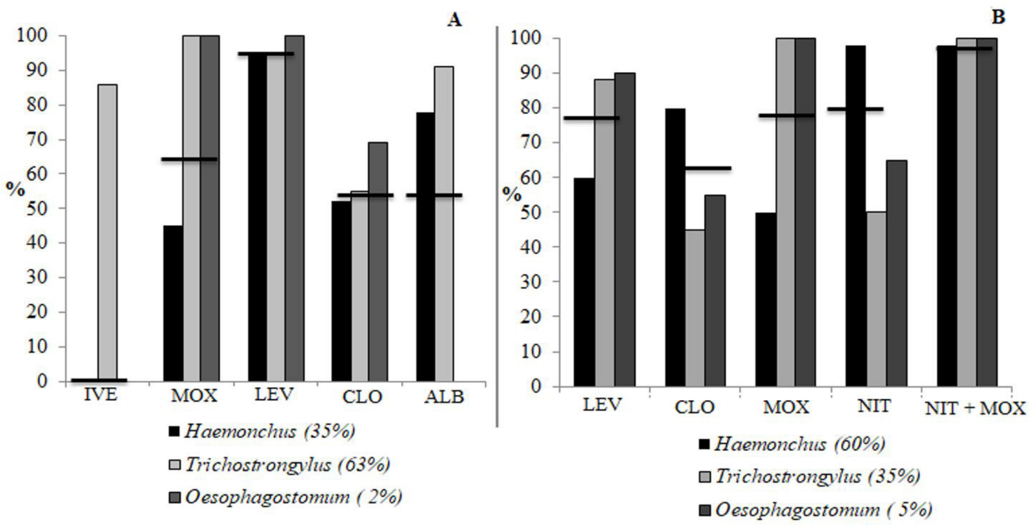

Figure 2. Anthelmintic efficacy in sheep at Farm # 1 in the first year of evaluation (A) and after one year of use of levamisole (B). The lines represent the effectiveness (measured by the FECRT). The percentage of prevalent parasite populations in each year is shown in parenthesis next to the names of parasite genera. Anthelmintics: IVE: ivermectin, MOX: moxidectin; LEV: levamisole; CLO: closantel; ALB: albendazole; NIT: nitroxynil.

consisted of 63% *Trichostrongylus*, 35% *Haemonchus* and 2% *Oesophagostomum*. The last drug used at this farm was closantel, and the most effective drug in the FECRT was levamisole (95% – Table 1 and Figure 2A). A year later, in the second evaluation, the parasite population consisted of 60% *Haemonchus* spp., 35% *Trichostrongylus* spp. and 5% *Oesophagostomum* spp. The efficacy of levamisole in the FECRT decreased in one year from 95% to 75%, and *Haemonchus* spp. was the most drug-resistant parasite (Figure 2B). Nitroxynil attained 78% efficacy in the FECRT and 98% efficacy against *Haemonchus*, but its spectrum of action did not include the other parasites. On the other hand, moxidectin showed 60% efficacy in the FECRT (similar to the preceding year), and was effective against *Trichostrongylus* and *Oesophagostomum* (100%). The combination of nitroxynil and moxidectin resulted in an overall efficacy of 98% and was highly effective against all the nematode genera identified at that time.

Discussion

Severe AHR was diagnosed at 22 sheep farms located in the state of Rio de Janeiro, Brazil. The findings of this study are consistent with those reported by Cruz et al. (2010), who diagnosed management failures and AHR in a herd in the north and northwest of the state. This study, which evaluated a larger number of sheep (1300) from flocks distributed throughout the state, represents the most extensive study involving the diagnosis of AHR in sheep in Rio de Janeiro.

The results confirm the serious situation of multiple AHR in Brazil. Salgado & Santos (2016) compiled 47 reports of failed efficacy (measured by the FECRT) in small ruminants in the country, of economic importance in the regions with the largest number of herds, such as the northeast (goats) and the south (sheep). There are numerous similar reports of AHR worldwide, with emphasis on the countries where sheep production is significant, such as Australia, the UK, New Zealand and Uruguay (FALZON et al., 2014). Resistance to active substances can be established rapidly, even after the introduction of new molecules, especially in the absence of alternative control programs (OLIVEIRA et al., 2017).

Therefore, considering that many AH do not reach the expected efficacy of at least 95% (COLES et al., 2006), the accurate diagnosis of parasitism and of the degree of effectiveness of AH is becoming increasingly necessary, as is the transmission of affordable control strategies to rural producers (LEARMOUNT et al., 2018). None of the AH available on the local market was effective (≥95% and CI≥90) at any of the farms where the FECRT test was applied in this study. In this situation, which is common in other regions of Brazil and around the world, and considering the difficulty of launching other classes of AH drugs, it is crucial for veterinarians to know how to work with whatever tools are available at the time, considering the epidemiology of these parasites. This was clearly shown by the efficacy tests aimed at the parasite population present in the group of tested animals, which revealed differentiated efficacy against the prevalent parasites, including susceptible genera.

Four genera of nematodes were prevalent in the analyzed herds, in descending order: *Haemonchus*, *Trichostrongylus*, *Cooperia* and *Oesophagostomum*, which are also prevalent in other regions of Brazil (AMARANTE et al., 2014). In this study, specific efficacy against *Haemonchus* influenced the FECRT results, due to its high prevalence. The AH that presented the highest overall reduction in FECRT was levamisole, given that it also presented higher efficacy against *Haemonchus*. This drug is widely used to control nematodes in ruminants, and was found to be the most effective in a study of 30 sheep flocks, also in the state of São Paulo, in southeastern Brazil (VERÍSSIMO et al., 2012).

Trichostrongylus was prevalent at Farms 1 and 6 of this study. Wilmsen et al. (2014) reported the prevalence of *Haemonchus* and *Trichostrongylus* in sheep in southeastern Brazil, with *Trichostrongylus* being the most prevalent due to its resistance to drought and low temperatures. This is an interesting fact, given that Farm # 1, for instance, is close to the other farms (3, 4, 5). Moreover, the data were collected in the same season; hence, the prevalence of *Trichostrongylus* was influenced not only by the climate. In an investigation of the AH drug management practices at this farm, the producer reported that closantel was the last drug used over a one year period, so the management of antiparasitics may have had a positive effect on *Trichostrongylus* populations, since closantel is recommended against hematophagous parasites (LANUSSE, 1996). Thus, parasite dynamics also changes as a result of AH drug management practices.

Overall, *Trichostrongylus* spp. were more sensitive to macrocyclic lactones, particularly moxidectin. Therefore, in the cases under study, these drugs showed a promising potential for use in situations where this parasite is highly prevalent, or in combination with another drug highly effective against the other parasites. However, previous testing is always necessary, as resistance of *Trichostrongylus* spp. has already been reported even to new drugs such as monepantel, for example (CINTRA et al., 2016; HAMER et al., 2018).

The monitoring of Farm # 1 for one year yielded important information about parasite dynamics regarding the evolution of drug efficacy. At the time of the first test, *Trichostrongylus* spp. was prevalent in the herd, and the most effective drug was levamisole (95%), whose use was therefore implemented. After one year, the tests were repeated based on the proportion of genera then present, when *Haemonchus* spp. was prevalent and levamisole showed 75% efficacy. Due to the decline in efficacy, drugs with potential efficacy were tested, such as nitroxynil (commercially available at the time of testing) and whose spectrum is aimed more at hematophages, and moxidectin, which had previously shown a good response against the other parasites. Thus, nitroxynil was effective (>95%) against *Haemonchus* spp. and moxidectin against *Trichostrongylus* spp. Since none of these drugs, alone, were more than 95% effective in the FECRT, a combination of nitroxynil + moxidectin was tested, resulting in 98% efficacy against the parasites identified at Farm # 1.

It should be noted that the aim here is not to encourage the indiscriminate use of combinations of drugs, but to suggest the possibility of effective treatment for livestock when none of the available drugs is effective separately. Given the difficulty of launching new drugs, there is growing interest in the combined use of drugs (KOTZE et al., 2018). However, the pharmacological interactions of these combinations must be considered (LANUSSE et al., 2018).

The efficacy of narrow spectrum drugs may be impaired in herds where there is a high percentage of other parasites, as was the case of nitroxynil at Farm # 1. For example, at Farm # 9 (Table 3), where closantel had never been used, it reduced 100% of the *Haemonchus* spp. population, but it was not effective overall because of the prevalence of other parasites that represented 41% of the parasite population at the time, and against which this drug was ineffective. Note that the results presented here are specific to each farm at the time of the tests and cannot be extrapolated to other herds.

In addition to specific diagnoses, constant parasitological monitoring of farms with adequate antiparasitic management is important to ensure better use of available drugs (MCINTYRE et al., 2018). Chagas et al. (2016) used levamisole on a herd for five consecutive years in a scheme based on selective treatment (EPG>4000, FAMACHA 4 or 5 and/or PCV<20%) of periparturient sheep and lambs after weaning, and found that effectiveness dropped from 100 to 70%. Thus, it is important to have trained professionals acting as advisors for rural producers to improve the practices of anti-parasite management (VANDE VELDE et al., 2015). It is also important that guidelines given to producers be clear and easy to understand, since they are a critical link in the dissemination of knowledge and promotion of diagnosis (EASTON et al., 2018).

Conclusions

The AH evaluation in 22 sheep flocks in the state of Rio de Janeiro, Brazil showed high levels of resistance and the efficacy based on egg count reduction differed from efficacy calculated by nematode genera. Thus, a more specific interpretation of efficacy tests increases the ability to choose drug combinations based on species differences in resistance levels.

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