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Multiple anthelmintic resistance among Dorper sheep farms and its implications for sustainable helminth control in Laikipia County, Kenya

Nginyi J.M[1*], Mbuku S.M.[1], Wahome C[2], Ndungu D[1], Lumumba P.L.[1], Bor J.[1], Keshura R.[1] and Biwott G. C.[1]

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[1]Kenya Agriculture and Livestock Research Organization, Veterinary Research Institute, Muguga, P.O. Box 32-00902, Kikuyu, Kenya.
[2]State Department for Livestock, Ministry of Agriculture, Livestock, Fisheries and Cooperatives. P.O. Box 34188, Nairobi.

ABSTRACT

The study was carried out in Laikipia County, Kenya, in April 2021 to evaluate the possible resistance of commonly used anthelmintics among Dorper sheep. Sheep that had not been dewormed in the previous 28 days and with a faecal egg count of ≥150 eggs per gram of faeces were selected. Out of these, 64 sheep of varying ages, male and female were selected and randomly allocated to four treatment groups of 16 based on the faecal egg counts at Day 0. Faecal egg count reduction test was used to determine the efficacy of the three clasess, i.e. benzimidazoles, levamisoles and avermectins. Prior to the trial, a total of 181 farmers were interviewed to investigate existing helminth control strategies and other challenges faced by Dorper sheep farmers. Among the disease and pest challenges reported, pneumonia, worm infestation and diarrhoea were the three most important. Most of the farmers (90%) managed worm infestations through routine use of anthelmintics, with the majority (51%) using anthelmintics four times a year. The rest varied from once to six times a year. Ninety-eight percent of farmers indicated that anthelmintics were effective and on average, they had used them for the previous three years. FECRT, indicated *Haemonchus*, *Trichostrongylus*, *Oesophagostomumspp* had resistance to all the classes of anthelmintics with efficacies below the recommended 95%. It is recommended that an integrated approach to address multiple anthelmintic resistance be put in place to ensure sustainable Dorper sheep production in Kenya.

Keywords: Faecal egg counts, Dorper sheep, Anthelmintic resistance, Faecal egg count reduction test
*Corresponding author: email joseph.nginyi@kalro.org

INTRODUCTION

In Laikipia County, Dorper sheep and their crosses with local sheep are reared by most farmers as a breed of choice because they have higher production than indigenous sheep breeds. Dorper sheep farming is however faced by persistent challenges associated with unavailability of quality breeds, inadequate quality pasture especially for dry season feeding, diseases which limit its productivity and access to markets (Haile et al., 2017). Helminthosis is a major constraint to Dorper sheep productivity and it is associated with insidious economic losses by adversely affecting the animals' health, weight gain, feed conversion and reproduction efficiency (Urquhart et al., 1996, Obanda, et al., 2019). In some cases, mortality is reported especially among the young stock.

Dorper sheep are more susceptible to gastrointestinal nematodes compared to indigenous breeds, such as the Red Maasai (Chege, et al., 2004; Nganga et al., 2004). This is why it is important to control these parasites to have a sustainable sheep enterprise. As a contribution to enhancing Dorper sheep productivity, validation of an epidemiology-based strategic deworming was done. Prior to this, it was deemed necessary to establish the existing helminth challenges, and evaluate possible resistance of the commonly used anthelmintics.

MATERIALS AND METHODS

Study area

The study was carried out in Laikipia County amongst Dorper sheep keepers in Tigithi and Segera ward in Laikipia East sub-County. Liakipia County is located in a semi-arid area and on the leeward side of Mount Kenya in the former Rift Valley Province. It lies between latitudes 0° 18' South and 0°51'North and between longitudes 36°11' and 37° 24' East (Figure 1).

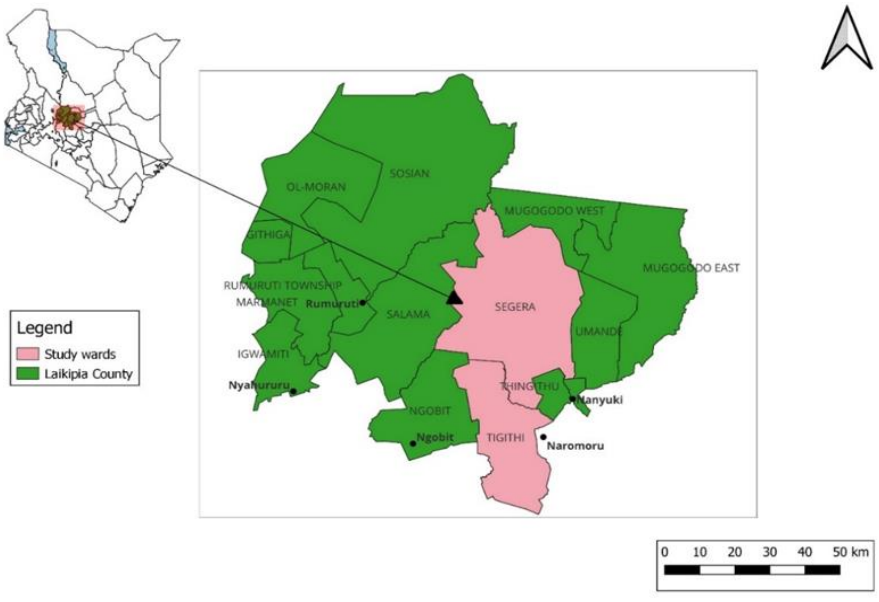

Figure 1: Map of Kenya showing Laikipia county and Tigithi and Segera wards where the study was carried out.

In addition to cultivating crops in high potential areas, Liakipia County is famous for livestock rearing. Sheep,goats, cattle and camels are some of the livestock kept under smallholder, pastoral and ranching systems. The research had three main components- an anthropogenic component undertaken through questionnaires, a field based experimental phase undertaken under farm conditions and a laboratory phase where samples collected from the experimental phase were analyzed.

Baseline survey

The farmers interviewed for the baseline data were randomly picked from a sampling frame based on records held by the county livestock department. A total of 181 farmers in Laikipia East were interviewed by trained enumerators using the Open Data Kit (ODK) data collection tool. The questionnaire interrogated various components of sheep rearing such as challenges (including feeds, water, disease and other management issues like marketing) faced by Dorper sheep farmers and helminth management. Once data entry was completed and questionnaire checked for completeness, the data were uploaded into the server every day. Analyses were carried out upon completion of the exercise.

Experimental sheep

The resistance evaluation was done using Dorper breed of sheep or Dorper crosses in 13 farms. Adult experimental sheep of both sexes were enrolled into the trial. Prior to the trial, a 30% proportion of the sheep in each of the 13 farms were ear tagged and sampled for faecal egg count (FEC). The rectal faecal samples were collected and put in well labelled sterile fecal sampling bottles and transported in ice packed cool box to a laboratory at the Nanyuki veterinary office for analysis.

Faecal egg count reduction test

The faecal samples collected on Day 0 were processed and examined for faecal egg counts using the modified McMaster egg counting technique (MAFF, 1986). Only the sheep that had not been dewormed in the last 28 days and had an egg count of ≥150 eggs per gram of faeces were included in the efficacy trial. From those that met the inclusion criteria, 64 were selected and randomly allocated to four treatment groups of 16 sheep each based on the faecal egg counts at Day 0. The groups and the mean faecal egg counts at Day 0 used for randomization are shown in Table 1.
The treatments for the three groups were administered as per manufacturers' recommendation on Day 0. Faecal egg counts for samples collected Day 14 post-treatment were used to calculate the percent faecal egg count reduction (FECR), thereby determining the efficacy of the anthelmintic as recommended by Geurden et al., 2022. Pooled samples per group were cultured to determine the genera of infective nematode larvae both on Day 0 and Day 14. Larval identification was based on morphological features as described in the Manual of Veterinary Laboratory Techniques (MAFF, 1986).

Data analysis

The data collected in the baseline survey were stored in Excel spreadsheets and exported to the Statistical Package for Social Scientists (SPSS) prior to analysis. The results that measured the farmers' responses were expressed as percentages or absolute numbers. The reduction in faecal egg counts post-treatment was calculated based on Day 14 faecal egg counts using the formula below:
FECR =100 X [1-(T2/C1)]
Where; T2 = post-treatment faecal egg counts of treated group, C1 = mean pre-treatment faecal egg count of untreated group.

Table 1: Experimental sheep allocated to four treatments and corresponding treatments administered.

Group	No. sheep /group	Mean EPG at day 0	Treatment	Anthelmintic brand	Active ingredient, concentration and route of administration
1	16	2175	BZ	Valbazen® 10%	10% Albendazole, (*per os)*
2	16	2206	LEV	Nilzan Super®	3.0 w/v Levamisole, 6.0 w/v Oxyclosanide, 0.764% Cobalt sulphate, (*per os)*
3	16	2175	IV	Supermec®	1%Ivermectin, (*subcutaneous)*
4	16	2137	Control		

Key: **BZ**= Benzimidazoles, **LEV**= Levamisole and **IV**= Ivermectin.

Table 2: The results of faecal egg count reduction test in Dorper sheep farms in Laikipia County.

Parameters	Group 1	Group 2	Group 3	Group 4
Sample Size	10	10	10	16
Mean FEC (D_0)	2175	2227	2175	2125
Mean FEC (D_{14})	371	787	513	2138
Percent reduction	83	63	76	0
95% LL CI	57	50	18	
95% UP CI	99	97	98	
Interpretation	R	R	R	

FECs=Faecal egg counts; **LL**=Lower limit of the 95% confidence interval and **UP**=Upper limit of the 95% confidence, **R**= Resistance.

RESULTS

Baseline survey

A total of 181 farmers spread across Tigithi and Segera ward in Laikipia County participated in the survey. Over two-thirds (68%) of the farmers kept Dorper sheep and reported preference for them because of their faster growth, higher market demand, high milk production and drought tolerance.

Extensive production was practiced by about two thirds (65%) of the respondents, where sheep were purely grazed on open grasslands without any form of feed supplementation. The remainder (33%) reared their sheep herds under semi-intensive production system, where sheep herds grazed on open grasslands and received minimal feed supplementation. A paltry (2%) of the respondents reared their sheep exclusively under zero-grazing system.

Pneumonia, worm infestations and diarrhoea were the three most important health challenges reported in Dorper sheep. Other disease conditions reported included heartwater, foot and mouth disease, mange and foot rot. Majority (90%) of the farmers managed worm infestations through routine use of anthelmintics, with the majority (51%) deworming their sheep four times a year. The rest used anthelmintics less frequently, with 24% deworming three times a year , 3% treating twice a year and 1% treating once a year. A smaller percentage of the farmers (3%) dewormed five times a year while 11% dewormed six times a year . Other than the routine use of anthelmintics, some farmers dewormed their sheep at the onset of rains (22%), during dry season (9%), while some (20%) practiced selective treatment where only sheep perceived to have helminthes were dewormed. Ninety-eight percent of the farmers indicated that the anthelmintics they were using were effective and on average, they had used them for the previous three years. According to the farmers, effectiveness was based mainly on improvement in body condition, cessation of diarrhea and changes in hair coat from rough to smooth and shiny among other observations.

About half (53%) of the respondents relied on advice from drug venders to decide which anthelmintic to use. Still a considerable number of the farmers (48%) relied on their past experience while selecting the anthelmintic brand for use on their sheep. Interestingly, a few based their choice on prices of the brand or availability in local outlets.

The farmers used different criteria to determine the dosage or quantity of the dewormer to give to the sheep. Sixty three percent of the respondents used animal live weights to guide the dose to be given while 34% read labels on drug containers and the other 32% relied on the advice from drug suppliers. The others used age of the sheep (28%) and advice from animal health service providers (21%). Some used a combination of these criteria. Calibrated equipment was used to administer the dewormers with about 79% using syringes and 30% using drenching guns. Only 4% used bottles to administer the dewormers with a few using a combination of the above. A majority of the farmers (94%) treated their animals in the morning before grazing with a few treating them in the evening and other times of the day.

Anthelmintic resistance evaluation trial

The results for resistance screening of the different anthelmintics tested are summarized in Table 2 below. The efficacy of the three broad-spectrum anthelmintics tested was 63%, 76% and 83% for Levamisole, Ivermectin and Benzimidazole-based drugs, respectively. This demonstrated existence of multiple anthelmintic resistance in the study area as all these figures were short of the 95% efficacy acceptable for drug efficacy.

Table 3: Nematode genera of infective larvae identified in pooled faecal samples before and after treatment with different broad-spectrum anthelmintics.

	Percentage of larvae on Day 0			Percentage of larvae on Day 14		
Nematode genera	*Group 1 (BZ)*	*Group 2 (LEV)*	*Group 3 (IV)*	*Group 1 (BZ)*	*Group 2 (LEV)*	*Group 3 (IV)*
Haemonchus	73.3	78	89	75	66.7	71.4
Strongyloides	6.7	0	0	5	6.7	5.7
Trichostrongylus	10	14	2.7	10	10	8.6
Oesophagostomum	6.7	4	4.1	10	13.3	11.4
Cooperia	3.3	4	4.1	0	3	2.9

Coproculture from pooled faecal samples per treatment group (Table 3) showed that *Haemonchusspp* was the most predominant nematode genera both before and after treatments.

Other genera encountered were T*richostrongylusspp*, *Oesophagostomumspp* and *Cooperia spp*. The results showed that all the above genera of nematodes were involved in the observed reduced efficacy of the three broad-spectrum anthelmintics.

DISCUSSIONS

Dorper sheep are known for their traits, such as faster growth, drought tolerance and high demand in markets among others (Anon, 2023). This makes the breed preferred by most small ruminant keepers. The sheep are reared mainly in an extensive system where they are grazed either in farmers' fields or sometimes in communal grazing areas.

Pneumonia and diarrhea are a common cause of death in small ruminants. It could be possible that majority of diarrhea cases encountered were because of gastrointestinal nematode infestations while pneumonia is caused by bacterial infection as a result of lowered immunity due to helminthosis. This means that it is possible that helminthosis accounts for a far greater role in the challenges faced by Dorper sheep farmers and causes significant losses directly and indirectly.

A majority of the farmers relied on professional advice given by drug venders and animal health service providers to determine the choice of brand, frequency, and dosage to use. This was reflected in the responses that indicated that a majority treated their sheep using the correct equipment, had acceptable frequency of use of four annual treatments and less and that the majority used anthlemintics in the morning before animals were let out for grazing. This practice is reported to improve the efficacy of anthelmintics (Patten et al., 2011; Nginyi, 2014), especially for drugs given orally. In addition, it improves drug availability as it is delivered when the rumen has little ingesta in it. The helminth control practices in the study area could possibly be associated with the response that indicated that the drugs used by the farmers were effective in the management of helminth infections. The farmers based their judgment on the positive changes observed in their sheep following the use of anthelmintics. The changes reported (changes in hair coat, cessation of diarrhea, resolution of bottle jaw and general improvement in body condition) were all consistent with use of anthelmintics with good efficacy (Urquhart et al., 1996).

Results of FECR indicated lowered efficacy with the best performing drug (benzimidazoles) at 83%. The lowest performing was Ivermectin at 63% while Levamisole had an efficacy of 76%. According to the guidelines given by the World Association for the Advancement of Veterinary Parasitology (WAAVP) on efficacy of anthelmintics of sheep nematodes (Geurden et al., 2022), drugs that indicated an efficacy below 95% reduction with a lower confidence limit of less than 90% are said to be resistant. In this study, this criterion was met, indicating that there was multiple resistance to all the broad-spectrum anthelmintics in the study area. Similar studies in Kenya (Wanyangu et al., 1994; Mungube et al., 2015; Gakuya et al., 2018, Nginyi et al., 2018; Morinket et al., 2021) indicated multiple anthelmintic resistance among the broad-spectrum drugs in sheep farms. This has serious implications in the sustainability of helminth control in sheep farms. One sequel is that many incidents of treatment failure will be reported in affected farms. This is likely to result in a higher frequency of treatments as the existing strategies used by farmers will no longer be ineffective in helminth control. In addition to the huge implication that this will have in the overall sheep productivity, this phenomenon will also impact animal welfare and food safety from increased drug use and subsequent drug residues in animal products.

It is recommended that the county veterinary authority institute implements measures to address this challenge to ensure sustainable Dorper sheep production in the study area and others where such a situation may be present. Also, the farmers should practice effective treatments by giving the correct dose based on heaviest animals in a cohort, using correct drugs, avoiding introduction of resistance by quarantine and treatment of newly bought animals, and avoiding unnecessary treatments including dry season treatments.

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