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Efficacy of Commercially Available Anthelmintics in Controlling Gastrointestinal Nematodes in Goats Managed Under Natural Conditions in the South Western Highlands of Uganda

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Abstract: Goat production is of great importance especially to the rural farmers in Uganda, serving a number of socio-economic functions. Among the limitations of goat production in Uganda are Gastro Intestinal Nematodes (GINs). These are usually controlled using commercial Anthelmintic compounds. Due to continual improper usage of these drugs by the farmers, evolution of resistant strains has resulted thus affecting their effectiveness in controlling the GINs. The aim of this study was to determine the efficacy of four commercially available anthelmintics used for controlling Gastro Intestinal Nematodes (GINs) in goats on natural pastures in the south western highlands of Uganda. A mini survey was conducted prior to the current study to get information about the most commonly used anthelmintics in the study area. Initially, 240 goats were enrolled into the study and, 210 were used in the final analysis. The goats were randomly allocated to 5 different treatment groups at district level namely; untreated controls (CTRL), Albendazole 10% (ABZ), Ivermectin (IVE), Levamisole (LEV) and Closantel (CL). Faecal and blood samples were collected from each animal at 0, 14, 28 and 42 days post-treatment respectively and analysed for faecal egg counts (FEC) using the modified McMaster method. The percentage reduction, FECR % was calculated from the arithmetic mean and difference in FEC between breeds, district and age were assessed by univariate analysis of variance in SPSS. Results at day zero indicated that age and district had significant effect on FEC (P-value= 0.001 and 0.035respectively) while breed had no significant effect (P-value=0.465). At 14 days post-treatment, district, breed and treatment had significant effects on FEC (P-value=0.00, 0.02 and 0.05 respectively) while age was not (P=0.931). Albendazole and Levamizol were the most used drugs in the study area while Closantel and Ivermectin were the least used. Drug efficacy varied between districts, with the highest mean Fecal Egg Count Reduction (FECR) achieved with Closantel (FECR%=100%), while the lowest mean FECR observed with Albendazole (FECR%=49%) in Rukungiri and Kisoro districts respectively. Ivermectin was effective in all the four districts (FECRT% > 95%). Our study confirmed presence of Anthelmintic resistance (AR) by GIN in goats in the south western highlands of Uganda. Closantel is highly effective against GINs, but albendazole is not due to its wide spread usage. Further research is necessary to find and validate alternative strategies for the control of GINs in goats.

Keywords: Gastro Intestinal Nematodes, Anthelmintics, Goats, Efficacy, Fecal Egg Count Reduction Test (FECRT), Uganda

1. Introduction

Goats as in other tropical parts of the world are among the most important livestock species in Uganda [10]. They are mostly kept by smallholders and the rural poor, including women headed households. They contribute substantially to the livelihoods of smallholder households as a source of income, food (meat and milk), and non-food products like manure and skins. They also serve as a means of risk mitigation during crop failures, property security, monetary saving and investment in addition to many other socio-economic and cultural functions. At the farm level, goats contribute significantly to the net cash income derived from livestock production in the crop–livestock production systems.

Uganda has over 13.2 million goats [13]. Nevertheless, the annual meat production from goats is relatively small compared to the number of heads [19]. Gastrointestinal nematodes (GINs) are a major contributor to this low productivity causing enormous production and financial losses [6, 14, 15, 22]. In Uganda, like many other tropical countries Gastro Intestinal Nematodes (GINs) cause considerable losses in production and also through control efforts [10]. Among all the GINs, *Haemonchus contortus* is the most prevalent in goat herds in Uganda [15].

Control strategies have mainly employed use of prophylactic anthelmintics (Chemicals used in treatment) alongside good management options [6]. However, the frequent use of anthelmintics in Uganda as it is in other endemic countries, has resulted in selection of parasites with single or multiple anthelmintic resistance (AR), which jeopardizes the treatment and control of GIN infections [1, 15]. Anthelmintic resistance has been reported in small ruminants in several countries globally and; in African countries including South Africa [21, 22], Ethiopia [18] and most recently in Uganda [3, 15].

Although a number of studies have been conducted in several areas in Uganda [3, 15, 16] little or no work has been done to assess the worm prevalence and Anthelmintic efficacy in the South western highlands of Uganda where a significant number of farmers are involved in goat production [9].

Therefore, our study was aimed at assessing the Efficacy of four commercially available anthelmintics namely; Albendazole, Ivermectin, Levamisole and Closantel to Gastro Intestinal Nematodes (GINs) in goats on natural pastures in the south western highlands of Uganda.

2. Materials and Methods

2.1. Study Area

The study was undertaken in four districts that make up the south western highlands of Uganda namely; Kabale, Kisoro, Kanungu and Rukungiri. These areas are characterized by highlands with undulating terrain ranging from about 800m to beyond 2400m above sea level [9]. A bimodal rainfall pattern with a mean annual rainfall ranging from 501 – 2250mm and temperature ranging between 15°C to 20°C has also been reported. Major production constraints revolve around limited land holding and degradation which greatly affect productivity in the zone.

Table 1. *Farms that Participated in the Study per District.*

District	Farm	No. of animals sampled and analysed (n)	History of Anthelmintic use	Goat Management system
Kabale	Nyakibande	22	Based on need	Semi-intensive/ Tethering
	Karweru	35	Not at all	Tethering (the goats were managed in small herds by different farmers
Rukungiri	Katonya	22	Based on need	Semi-intensive system
	Bwanga District Farm	29	Regular use	Semi-intensive
Kanungu	Comboni College farm	24	Regular use	Semi-intensive
	Ihunga ranch	28	Twice per annum	Semi-intensive
Kisoro	Rusave	21	Based on need	Semi-intensive
	Busanza	29	Twice a year	Semi-intensive

2.2. Anthelmintic Usage in the Zone

Prior to the current study a mini survey was conducted targeting mainly agro-input dealers due to their involvement in the sale of veterinary drugs to farmers to assess the level at which different anthelmintics were being used in the study area. Extension workers were also targeted due to their role in the management of clinical cases as well as training of farmers in animal health management. Semi structured questionnaires were administered and among other things the respondents were asked about the most commonly used dewormers in their respective areas, storage practices, how farmers got information about the drugs they bought from the shops, turnover rate and feedback from farmers on the response of animals to the treatments administered.

2.3. Goat Samples

Two farms were selected from each of these districts based on the willingness by the farmers to participate. A total of 240 goats were selected for the study having passed the 200 eggs per gram (epg) mark although only 210 were used in the final analysis. The 30 goats were either slaughtered or sold off by farmers during the course of the study. In all these farms, a semi-intensive type of management was practiced wherein goats were grazed or tethered for at least 4 - 6 hours per day on natural pasture and shrubs and housed overnight in raised slatted floor or mud floor pens and for small scale farmers, tied on wooden posts around the homestead.

2.4. Experimental Design

In each farm, the farmers were asked not to deworm their goats prior to the commencement of the study which commenced 10 weeks later as recommended by [4]. This was done to achieve a sufficient level of GIN infections enough to perform the study. This was also done to indicate the overall nematode population in the individual farm unbiased by previous treatments. There was no alteration in the routine management of the farms in order to maintain a true picture of what exactly transpires on the farms on a day to day basis to avoid bias. At the onset of the study, the goats were randomly allocated to 5 different treatment groups of 10 – 15 goats each taking into consideration of other variables such as Breed, age and Fecal Egg Count (FEC) at selection stage. A control (untreated) group was used at each of the participating farms. The control group was included to allow for monitoring of natural changes in egg counts during the test period and also act as an out group to be compared with. The animals were identified using ear tags for easy follow-up during the subsequent visits.

2.5. Treatment

Goats were assigned to one of five treatment groups at district level namely; untreated controls (CTRL), Albendazole 10% (ABZ) (1ml/20kg live body weight orally once), Ivermectin (IVE) (1ml/25kg live body weight, Subcutaneously, once), Levamisole (LEV) (1ml/5kg live body weight orally, once), and Closantel (CL) (1ml/25kg live body weight, Subcutaneously, once). Each of these compounds represented an Anthelmintic class as shown in table 2.

Table 2. *Classical Antihelmintic Compounds used in the Study.*

Class of Anthelmintic	Active ingredient	Dosage rate	Route of administration
Macrocyclic lactones	Ivermectin	1ml/25kg	Subcutaneous in the Axilla of the goat
Salicyclanilids	Closantel	1ml/25kg	Subcutaneous in the Axilla of the goat
Imidazothiazoles	Levamisole	1ml/5kg	Per os using a hypodermic syringe
Benzimidazole	Albendazole	1ml/20kg	Per os using a hypodermic syringe
Control	Nil	0	Nil

2.6. Sampling Procedures

For pre-screening of animals for sufficient egg counts, a minimum of 5 g (10 to 15 pellets) of feces was collected from each animal per rectum and were placed in individually sealed air tight plastic containers kept in a cool box. Blood samples for assessing Packed Cell Volume (PCV) were collected from the left jugular vein into 4 ml EDTA evacuated tubes (BDH, Plymouth, UK). All the samples were carried to the livestock laboratory at KAZARDI for faecal egg counts and haematocrit analysis. The same procedure for collection of fecal and blood samples was followed at 0, 14, 28 and 42 days post-treatment respectively. Live body weight for each goat under study was taken during sample collection using a spring scale. This assisted in the calculation of dosages according to manufacturers' instructions.

2.7. Processing of Samples

For faecal egg counts (FECs), modified McMaster method was used [5]. It was chosen to be used because it is an efficient, effective, easy to perform, affordable and convenient method of assessing faecal egg counts based on the principle of floatation.

2.8. Analysis and Interpretation of Data

Using the arithmetic mean, the percentage reduction, FECR % was calculated using the formula $100(1\text{-}X_t/X_c)$ [4] Where; X is the arithmetic mean, t is the egg count of the treated groups at day 14 and c the control group egg count at day 14. A computer program, RESO [4], was used in the calculation of resistance at 95% confidence interval and resistance was considered to be present when the percentage reduction in egg counts was less than 95% [4].

2.9. Statistical Analysis

Differences between breeds, district and age in terms of Fecal Egg Counts (FEC) were assessed by Univariate analysis of variance (ANOVA) using SPSS program. The data were analysed to find possible effects of breed, district and age group of the animals on the total nematode Fecal Egg Count at day zero. At day 14 the interaction between these parameters and treatment were added to the analysis. For the ANOVA analysis FEC were log10 (FEC + 50) transformed to attain normality of the data. However, non-transformed FEC values were used to calculate Anthelmintic efficacy. The trend line graphs and Bar charts were drawn using R statistical software.

3. Results

3.1. Fecal Egg Count Results

Table 3. *ANOVA table showing the effect of breed, district and age on FEC at day zero.*

Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.056	7	0.579	3.635	0.001
Intercept	2233.498	1	2233.498	14008.759	0.000
breed	0.243	2	0.121	0.762	0.468
Age	1.090	2	0.545	3.418	0.035
District	2.701	3	0.900	5.648	0.001

Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Error	32.206	202	0.159		
Total	2269.760	210			
Corrected Total	36.262	209			

Analysis of variance (ANOVA) on the initial effect of area of sampling (district), breed and Age group on FEC in the zone before treatment of the selected goats showed that some of these factors had effects while others did not, as shown in table 3. District and Age had significant effects (P-value=0.001 and 0.035 respectively) on FEC at day zero. However, breed showed no significant effect on FEC at day zero (P-value=0.468). A t-test was performed for pairwise comparison of the mean differences of the FEC for the four districts. This showed no significant difference in the occurrence of worm infection between Kabale, Kisoro and Rukungiri (P-value>0.05). However, all the three districts had FECs that were significantly lower than that of Kanungu (P-values<0.05). A similar t-test was done for mean FEC differences between the 3 age groups namely; Kids (4 – 6 months of age), Nannies (6 – 15 months of age) and Adults (15+ months of age). Nannies and Adults showed no significant difference between each other in terms of mean FEC (P-value=0.147). However, kids had significantly higher mean FEC than adults (P-value=0.019) and not significantly different from nannies (P-value=0.456).

Table 4. *Pair wise Comparison of Faecal Egg Count Means at Day Zero between Districts.*

(I) District	(J) District	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kabale	Kisoro	0.022785566	0.0773681864	0.769	-0.129767275	0.175338406
	Rukungiri	-0.066606342	0.0769630588	0.388	-0.218360361	0.085147676
	Kanungu	-0.265653679	0.0765714916	0.001	-0.416635614	-0.114671743
Kisoro	Kabale	-0.022785566	0.0773681864	0.769	-0.175338406	0.129767275
	Rukungiri	-0.089391908	0.0794664028	0.262	-0.246081964	0.067298148
	Kanungu	-0.288439244	0.0790872309	0.000	-0.444381658	-0.132496831
Rukungiri	Kisoro	0.066606342	0.0769630588	0.388	-0.085147676	0.218360361
	Kisoro	0.089391908	0.0794664028	0.262	-0.067298148	0.246081964
	Kanungu	-0.199047337	0.0786909540	0.012	-0.354208380	-0.043886293
Kanungu	Kabale	0.265653679	0.0765714916	0.001	0.114671743	0.416635614
	Kisoro	0.288439244	0.0790872309	0.000	0.132496831	0.444381658
	Rukungiri	0.199047337*	0.0786909540	0.012	0.043886293	0.354208380

Table 5. *ANOVA table showing the effect of breed, district, treatment and age on FEC at day fourteen.*

Source	Type II Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	51.442	35	1.470	11.847	0.000
Intercept	1041.652	1	1041.652	8395.905	0.000
Breed	1.299	2	0.649	5.233	0.006
District	1.253	3	0.418	3.368	0.020
Age	0.411	2	0.206	1.658	0.193
Treatment	29.359	4	7.340	59.159	0.000
District * Treatment	10.599	12	0.883	7.119	0.000
Age * Treatment	0.375	8	0.047	0.378	0.931
breed * Treatment	0.750	4	0.188	1.512	0.201
Error	21.588	174	0.124		
Total	1114.682	210			
Corrected Total	73.030	209			

A univariate analysis of variance (ANOVA) was done on FEC measured at day fourteen to determine the possible effect of district, Breed, Treatment, and Age group. From Table 5, results revealed that breed and district had a significant effect on FEC (P-value=0.006 and 0.02 respectively), treatment had a highly significant effect (P-value<<0.05). However, Age had no significant effect on FEC (P-value=0.193), irrespective of having a significant effect on FEC at day zero. Furthermore, there was a significant interaction between treatment and district (P-value<<0.05), while the interaction between Age and treatment was insignificant (P-value=0.931). As much as breed effect and treatment as main effect had significant effects, their interaction was not significant (P-value=0.201).

Additionally, pair-wise t-test comparisons of the mean differences were performed to compare general differences between treatments at day 14 post treatment.

Pair-wise comparison in Table 6, showed that all the four treatments were highly significantly different from the control treatment (P-values>>0.05). Albendazole produced a significantly different FEC reduction from that of Closantel (P-value<<0.05) and Ivermectin (P-value<<0.05) but not Levamisole (P-value=0.793). Closantel was highly significantly different from all the other treatments (P-value<<0.05) except Ivermectin (P-value=0.65).

3.2. Anthelmintic Usage in the Zone

From Figure 1, results of the survey revealed that at least all the four classical anthelmintics used in our study (Albendazole, Levamisole, Ivermectin and Closantel) were in use by farmers. The usage was recorded at different levels including district variation. From the graph (Figure 1), it can be noted that Albendazole was the most widely used anthelmintics in Kisoro, Rukungiri and Kabale closely followed by levamisole. In Kanungu District however, levamisole was the most used drug followed by Albendazole. There was a general low usage of ivermectin and closantel with Kanungu and Rukungiri districts reporting no usage of closantel at all.

Table 6. *Pairwise comparison of FEC means at day fourteen between districts.*

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
ABZ	CL	0.454614269	0.0751153134	0.000	0.306359818	0.602868720
	IVE	0.421676698	0.0732571260	0.000	0.277089735	0.566263660
	LEV	0.019583769	0.0743302734	0.793	-0.127121256	0.166288793
	CTRL	-0.849993024	0.0885886037	0.000	-1.024839593	-0.675146455
CL	ABZ	-0.454614269	0.0751153134	0.000	-0.602868720	-0.306359818
	IVE	-0.032937571	0.0723765997	0.650	-0.175786647	0.109911504
	LEV	-0.435030501	0.0734626111	0.000	-0.580023027	-0.290037974
	CTRL	-1.304607293	0.0878618597	0.000	-1.478019494	-1.131195093
IVE	ABZ	-0.421676698	0.0732571260	0.000	-0.566263660	-0.277089735
	CL	0.032937571	0.0723765997	0.650	-0.109911504	0.175786647
	LEV	-0.402092929	0.0715615219	0.000	-0.543333293	-0.260852566
	CTRL	-1.271669722	0.0862786334	0.000	-1.441957122	-1.101382322
LEV	ABZ	-0.019583769	0.0743302734	0.793	-0.166288793	0.127121256
	CL	0.435030501	0.0734626111	0.000	0.290037974	0.580023027
	IVE	0.402092929	0.0715615219	0.000	0.260852566	0.543333293
	CTRL	-0.869576793	0.0871916603	0.000	-1.041666226	-0.697487359
CTRL	ABZ	0.849993024	0.0885886037	0.000	0.675146455	1.024839593
	CL	1.304607293	0.0878618597	0.000	1.131195093	1.478019494
	IVE	1.271669722	0.0862786334	0.000	1.101382322	1.441957122
	LEV	.869576793	0.0871916603	0.000	0.697487359	1.041666226

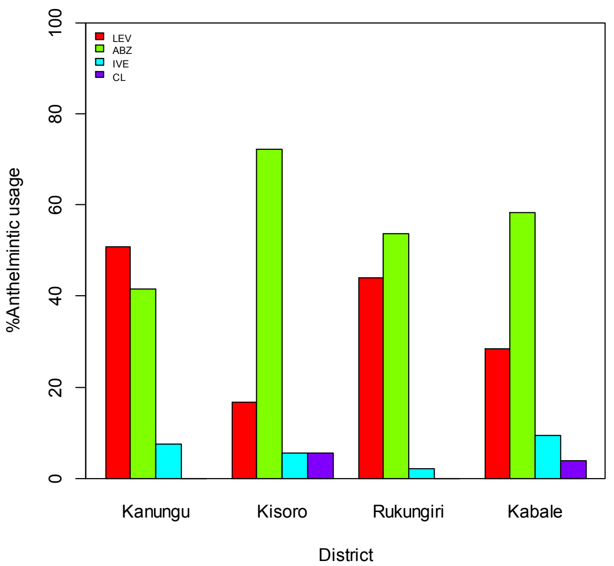

Figure 1. *Graphical summary of anthelmintic use in the districts under study.*

3.3. Efficacy of Anthelmintics

Generally the efficacy of each of the drugs used in the study varied between districts, with some of the drugs being effective or highly effective in some districts while being ineffective in others. For instance; in Kabale district albendazole (ABZ) and closantel were ineffective or were resisted by the GINs (FECR%<95%), while levamisole (LEV) and ivermectin (IVE) were effective (GINs were susceptible) (FECR%≥95%). In Kisoro district, levamisole and albendazole were ineffective (resisted by GINs), whereas Ivermectin and Closantel (CL) were effective. Ivermectin and closantel were effective in Rukungiri district, while levamisole and albendazole were resisted by the GINs. In Kanungu district, three Anthelmintics were effective (Ivermectin, Closantel and Abendazole) and only one (levamisole) was ineffective.

The highest mean FECR was achieved with Closantel (CL) in Rukungiri district which reduced the mean fecal egg count from 2681 – 4 eggs per gram (FECR%=100%). While the lowest mean FECR was observed with Albendazole (ABZ) in Kisoro district where it was only able to reduce the mean FEC from 1259 – 1250 eggs per gram (FECR%=49%).

Only Ivermectin (IVE) was effective in all the four districts, levamisole (LEV) was only effective in Kabale and ineffective in Kisoro, Rukungiri and Kanungu districts. However, in Rukungiri district, the gastro intestinal nematodes (GINs) were slightly resistant to levamisole (LEV) (FECR%=91%). It is in Kanungu where the resistance against LEV was marked (FECR%=72%). Albendazole (ABZ) was only effective in Kanungu (FECR%=98%) and ineffective in the other three districts. Kisoro exhibited the lowest level of albendazole (ABZ) effectiveness (FECR% = 49%). Closantel exhibited a very high efficacy in Kanungu, Kisoro and Rukungiri (FECR% of 98%, 99% and 100% respectively). Albeit, it was not effective in Kabale district (FECR%=91%).

***Table 7.** Summary of RESO results indicating the efficacy of the four anthelmintic compounds.*

District	Treatments	Arithmetic Mean of epg at day zero (Mean ± SEM)	Mean epg at day 14 (Mean±SEM)	%FECR	AR status
Kabale	LEV	2050.00±624.90	89.29±129.34	96	Susceptible
	ABZ	2627.78±779.39	261.11±161.31	87	Resistant
	IVE	1292.86±624.90	60.71±129.34	97	Susceptible
	CL	3204.55±704.99	186.36±145.91	91	Resistant
	CTR	2016.67±779.39	1800.00±161.31	-	
Kisoro	LEV	2866.67±674.97	358.33±139.70	85	Resistant
	ABZ	1259.09±704.97	1250.00±145.91	49	Resistant
	IVE	2533.33±674.97	70.83±139.70	97	Susceptible
	CL	1390.00±739.40	30.00±153.03	99	Susceptible
	CTR	2460.00±1045.66	1690.00±216.42	-	
Rukungiri	LEV	2444.44±779.39	150.00±161.31	91	Resistant
	ABZ	2718.18±704.97	309.09±145.91	81	Resistant
	IVE	2269.23±648.49	80.77±134.22	95	Susceptible
	CL	2680.77±648.49	3.85±134.22	100	Susceptible
	CTR	1650.00±1045.66	2790.00±216.42	-	
Kanungu	LEV	6437.50±674.97	883.33±139.70	72	Resistant
	ABZ	3037.50±674.97	25.00±139.70	99	Susceptible
	IVE	3450.00±704.97	27.27±145.91	99	Susceptible
	CL	2613.64±704.99	59.09±145.91	98	Susceptible
	CTR	3100.00±954.56	1375.00±197.56	-	

3.4. Anthelmintic Effect on FEC from Treatment Up to Day Forty Two

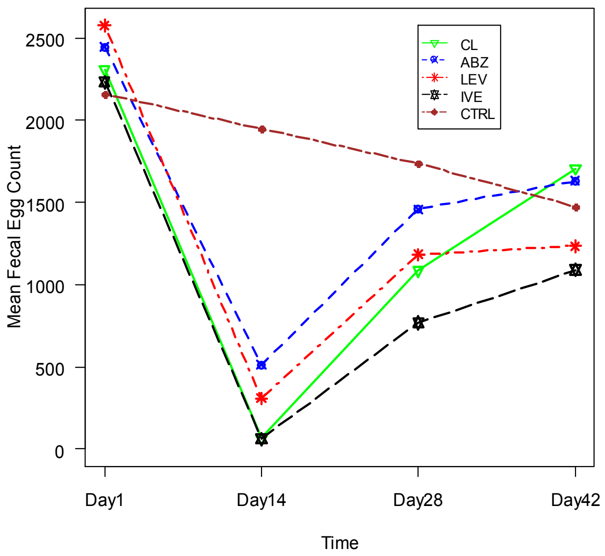

***Figure 2.** Graph indicating the trend of anthelmintic effect on FEC from treatment to day forty two.*

As observed from the Figure 2, there was dramatic decline in mean FEC between the treatment day (Day1) and the fourteenth day (Day14) after treatment of the goats with each of the anthelmintic except for the control that showed a slow decline. Ivermectin and Closental showed the lowest mean feacal egg count at Day14 (nearing to zero), followed by Levamizole and then Albendazole. Untreated animals had the highest mean FEC at day 14 even though these animals had the lowest FEC at the start of the experiment.

After the 14^{th} day to the 28^{th} day, mean feacal egg count for the goats increased dramatically for all the goats treated with each of the 4 drugs. Even with a gradual decrease in mean FEC, at Day28 the control group had the highest mean FEC, then Albendazole, followed by Levamizole, then Closental, while ivermectin had the lowest mean FEC. For control, mean FEC continued decreasing gradually.

After Day28 to Day42 there was a gradually slowed increase in mean FEC for all the drug treatments except Closantel, whose decrease in steep increase was not pronounced. At Day42 goats treated with CL had the highest mean FEC, followed by ABZ, CTRL, and then LEV respectively while IVE had the lowest.

4. Discussion of Results

4.1. Effect of Breed, Age Group and District on Fecal Egg Count

Our results indicated that breed of the goats had no significant effect on FEC at day zero. This implied a uniform distribution of worm infestations across the different breeds under study.

Age of goats had a significant effect on the level of worm infestation of the animal with adults and kids showing marked differences, where older animals had a sizably less egg count than the young animals. This is clearly understandable, since the immune system of the young goats is still poorly developed as compared to the mature or adult animals. This exposes young animals to high numbers of worm infections than the adult animals. This phenomenon was also observed by [2]. This implies that young animals need a more stringent management regime against these GINs compared to adults.

The significant difference in Fecal Egg Counts (FEC) between districts is clearly explained from the deworming history of the sampled farms in districts in the study. Farms sampled from Rukungiri, Kabale and Kisoro districts reported irregular deworming or no deworming at all, while the farms that participated in this study in Kanungu district reported regular deworming regimes. The practice of irregular deworming has also been reported in other parts of Uganda by [15]. This further highlights the importance of having a proper farm level Anthelmintic regime for effective control of GIT nematodes.

Statistical analysis results at day fourteen indicated that FEC of the goats did not vary significantly between districts, age groups and breeds. This means that all the four breeds responded similarly to treatment in any of the four districts. Also this indicated a uniform reduction in FEC between age groups of the animals; hence there was no need for selective treatment for different breeds, age groups and location (district). The uniform reduction in FEC fourteen days after treatment across the age groups tested in the study was probably expected since the drugs were administered according to manufacturers' instructions based on the live body weight of the animals.

At day fourteen post treatment the interaction between breed and treatment had no significant effect on the FEC. This may imply a lack of genetic variability between the breeds under study in responding to the used Anthelmintics. This report differs from that of [3] who reported that some Anthelmintics were more effective in certain breeds and less effective in others.

A significant interaction between districts and treatment could be as a result of the varying regimes of Anthelmintic usage in the four different districts under study. For instance a mini survey preceding this study on Anthelmintic usage in the four districts showed that in Kanungu, the most frequently used Anthelmintic was levamisole, followed by albendazole, yet in Kisoro, Rukungiri and Kabale, the mostly used was albendazole followed by levamisole. Also closantel was found to be in use in Kabale and Kisoro but not in Kanungu and Rukungiri. These could possibly cause Anthelmintic resistance due to frequent use.

4.2. Anthelmintic Efficacy

The effective dose rate of anthelmintic in the market was intended to kill more than 95% of more susceptible parasite species [12]. Therefore the failure of the drugs to reduce FEC to a level of 95% or more could probably be attributed to resistance of parasites to that drug. Frequent treatments of the animals using the same drug and under-dosing have been identified as major causes of antihelmintic resistence [12]. These allow for genetic selection and emergence of new resistant strains that possess the mutations for resistance against the drugs [8].

As observed from our results, albendazole is ineffective in reducing GINs in goats in Kabale, Kisoro and Rukungiri districts. Resistance of GINs to albendazole in these districts could be attributed to the already reported frequent use of albendazoles in the country [15].

However this was not the case in Kanungu district where albendazole was able to reduce the GINs by a high percentage (98%). This was rather unexpected given the high albendazole usage as reported in the mini survey. However, it should be noted that albendazole was the highest used Anthelmintic in all the other districts under study except in Kanungu where it came second after levamisole. Levamisole was ineffective in Kisoro, Kanungu and Rukungiri districts. This is probably due to possible resistance resulting from wide spread usage of these drugs in those districts as indicated by our mini survey. However, much as there was a high usage of levamisole in Kabale district, the drug was greatly effective according to this study (FECR = 98%). This could probably be due to the fact that one of the sampled farms with 35 animals had reported never to have used Anthelmintics to control worms. Therefore, levamisole was a new drug to this farm thus raising the general efficacy of the drug in the district.

Ivermectin was effective in all the goats across the districts. This attests to the fact that ivermectin is an injectable drug administered subcutaneously and so is rarely used by farmers due to difficulties in administration. However, these results strongly disagree with [15] who reported highest levels of Anthelmintic Resistance with Ivermectin and highest efficacy with Albendazole despite the fact that Ivermectin is among the least used dewormers in their study. This difference stems from the fact that they sampled institutional farms with a history of using ivermectin to control a number of ecto and endo parasites. The same can be said of closantel which is a relatively new compound on the market. During the mini survey, it was not available for farmers in Kanungu district and very rare in Rukungiri district.

4.3. Trends of Anthelmintic Effects Up to Day 42 Post Treatment

The dramatic decline in mean FEC up to day 14, and then a sharp rise thereafter is an indication of quick but non-persistent Anthelmintic treatment effects. The quick rise in mean FEC could be due to the fact that after treatment animals continued to feed on already contaminated pastures that could have led to the rapid re-infestation of the animals. This therefore calls for the need to use both Anthelmintic and other non-conventional measures [18] to control gastrointestinal nematodes in goats. It can be observed that ivermectin on top of producing the lowest mean FEC at day 14, it also kept the mean FEC largely lower than the other treatments for a longer period of time. This is due to the fact that ivermectin is by far a rarely used drug in the study area.

There was a slow decline in mean FEC over time for the control group. This owes to the fact that some parasites have natural intermittent shedding pattern of eggs. Therefore, the absence of eggs is not necessarily an indication of lack of parasites. This thinking is augmented by the fact that immature stages of parasites don't shed eggs. Therefore, a system that takes advantage of assessing the anaemia status of the goat such as Packed Cell Volume (PCV) and FAMACHA [20] can come in handy to supplement regular faecal egg count surveillance on farms.

4.4. Recommendations

The problem of Anthelmintic resistance as detected in the current study is possibly the reality at most of the goat farms in the zone and Uganda or even beyond. Therefore, Worm control strategies that are less dependent on commercial Anthelmintic usage should be encouraged if there is going to be meaningful control of gastrointestinal nematode infections in goats in Uganda.

Various methods aimed at restoring Anthelmintic efficacy such as, exploitation of refugia [18] and monitoring FECs and FAMACHA and treating only those individual animals with acceptable scores have been proposed. Some authors have even gone ahead to advise against empirical dosing of all flocks at certain times / intervals of the year [22]. There is need to tailor the recommendations to the small holder farmer situation if meaningful results are to be realised.

Some of the non Anthelmintic usage control options proposed by [6] include 1) Limiting contact between the host (goats) and infective larvae in the field through grazing management methods. 2) Improving the host response against gastrointestinal nematode infections relying on the genetic selection between or within breeds of goats and 3) Controlling the gastrointestinal nematodes based on non-conventional Anthelmintic materials such as plants and mineral compounds. These are able to eliminate worms or affect the biology of the gastrointestinal nematodes such that they don't apply their disastrous effects on the goats. These options ought to be packaged in a simplified manner for the farmers to get the message suitable for their production environment. This is important especially in rural Africa, where goat production is usually in the hands of the resource poor.

Since majority of the participants to this study fell in the category of resource poor small holder farmers, we therefore recommend a number of practical measures which when followed may contribute to a downward trend in the losses associated with gastrointestinal nematodes and Anthelmintic resistance.

Judicious use of Anthelmintics; whereby farmers are encouraged to treat only those animals that show clinical signs. This practice helps in aiding decision making when it comes to culling off of non productive animals in the flock. The goat that has received the highest number of treatments that year will join the list of goats to be culled off. This, on top of managing Anthelmintic resistance will go a long way in minimising on the costs incurred by the farmers during worm control activities.

Farmers need to be encouraged to use their indigenous technical knowledge. This calls for standardisation of these techniques before they become extinct. This presents a critical area for research in most rural economies in Africa because resource poor farmers have always devised means of managing health issues in their livestock. Their knowledge though not well documented cannot continue to be ignored.

Farmers can also use FAMACHA to assess the level of anaemia as a result of worm infestation. However, there is need to have this system validated in Ugandan goats before it is recommended for use by farmers [20]. With this system, only those goats with acceptable scores can be treated hence reducing on the amount of Anthelmintics used in the flock.

There is also a need for continued training of farmers and animal health workers on proper management of diseases. Peacock [17] proposed a model in which farmers can be trained within their localities to work as community based goat health workers. They are given disease diagnosis and management skills and are supported with start-up kits for practice.

For farmers keeping larger goat flocks it is advised that they use drug combinations [11] to achieve reasonable effectiveness. This should be done cautiously as it may lead to development of multiple Anthelmintic resistances to these drugs. It should also be done in combination with other non-Anthelmintic strategies to slow the progression of resistance of gastrointestinal nematodes to these commercial Anthelmintics.

For farmers with access to graze-able land, it is advisable that proper grazing management options such as rotational grazing are practiced as these will lead to control of worms without necessarily using a lot of commercial Anthelmintics. Farmers are also advised to keep shrubs in their farms as some of these are known to contain some level of condensed tannins which are believed to posses some Anthelmintic properties [7]. These plants need to be studied to establish their chemical composition and their toxic levels to gastro intestinal nematodes.

There is no doubt that Anthelmintics will remain an important part of management of gastrointestinal nematode infections. So since Anthelmintic resistance has been highlighted as a serious constraint to goat production in rural Africa, there is need for concerted effort by both governments and the private sector to encourage the sustainable use of the commercial Anthelmintics alongside other management options for sustainable goat farming.

It should also be noted that resistance to Anthelmintics is more or less irreversible once it has established. There is therefore great need to delay the development of Anthelmintic resistance or much better prevent it completely from occurring by judicious use of Anthelmintics. It is hoped that this study and many more that will be conducted in other parts of the world will be useful for goat farmers and animal health workers to promote practices that are aimed at preserving Anthelmintic effectiveness.

5. Conclusion

In conclusion therefore, gastrointestinal nematode parasites in South Western Highland Agro Ecological Zone of Uganda were generally highly resistant to commercial anthelmintics. However, of the tested compounds, Closantel and Ivermectin were found to be more effective on nematode populations at on farm sites. Further research is necessary to find and validate alternative strategies for the control of nematode parasites including those proposed in this paper.

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