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RESEARCH ARTICLE

AN EVALUATION OF THE ANTHELMINTIC EFFICACY OF FENBENDAZOLE AND IVERMECTIN AGAINST GASTROINTESTINAL NEMATODES IN CAPRINE HERDS ON SMALLHOLDER FARMS IN RUPANDEHI, NEPAL

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ABSTRACT

Gastrointestinal nematode (GIN) infections significantly impact goat productivity and livelihoods of smallholder farmers in Nepal. This study assessed the efficacy of fenbendazole and ivermectin against GIN in goats from Siyari Rural Municipality, Rupandehi. Thirty goats with fecal egg counts (FEC) exceeding 300 eggs per gram were randomly assigned to fenbendazole-treated, ivermectin-treated, or untreated control groups. Fecal samples were collected on days 0, 7, 14, and 21 post-treatment and analyzed using the McMaster technique. FECRT results demonstrated high efficacy for fenbendazole (99.08%) and ivermectin (99.57%) on day 21, with significant reductions in mean egg counts ($p < 0.0001$). No evidence of anthelmintic resistance was detected following WAAVP guidelines. The untreated control group showed a significant increase in egg counts, indicating active parasitic infection. These findings confirm the continued effectiveness of fenbendazole and ivermectin in controlling GIN in the region and underscore the importance of ongoing efficacy monitoring and integrated parasite management to sustain drug efficacy and prevent resistance in smallholder goat farming systems.

KEYWORDS

Fenbendazole, Ivermectin, Gastrointestinal nematodes, Goats, Anthelmintic efficacy, Anthelmintic resistance.

1. INTRODUCTION

Rearing small ruminants such as goat and sheep plays a crucial role in the livelihoods of households in developing countries, serving rural people as a source of food and financial security (Oluwatayo and Oluwatayo, 2018). Livestock farming has great potentialities in Nepal, fast returns on investment, and wide market potential, so it is reared in almost all parts of the country (Adhikari et al., 2017). Among the first domesticated ruminants, goats have been vital to mankind for longer than cattle or sheep (Haenlein, 2007). The goat population is around 14.5 million goats in Nepal, and about 75% of households in Nepal are engaged in goat farming (Ministry of Agriculture and Livestock Development, 2022; MoAC, 2017; Adhikari et al., 2017). Goats are commonly reared in arid, mountainous areas as well as in temperate, tropical, and sub-tropical zones. Goats are kept as supplementary animals by small farmers as a source of milk and meat (Adhikari et al., 2017).

Goat farming constitutes a major component of the livestock sector in Nepal, providing milk, meat, fiber, and manure, and is predominantly adopted by small and marginal farmers, whose primary and stable source of income is agriculture. The increasing trend of internal and international migration of young males in search of employment has shifted the responsibility of agriculture and livestock rearing to women. The goats can be easily handled and cared for by women and children because of their small body size (Maharjan et al., 2013). In Nepal, major indigenous breeds are Terai, Khari, Sinhal, and Chyangra. Common exotic breeds reared are Jamunapari, Barbari, Saanen, Beetal, and Boer, which are adapted to the diverse climatic conditions (Bhattarai et al., 2019).

The goat population in Nepal has increased by 3.94% in 2022/23 compared to the previous year, reflecting its growing importance (Ministry of Agriculture and Livestock Development, 2022). However, parasitic diseases, particularly gastrointestinal nematode (GIN) infections, represent a major challenge, which is responsible for 60–70% of livestock diseases and causing substantial economic losses through reduced productivity, impaired growth, and mortality (Strydom et al., 2023). The majority of goat farmers in Nepal live in tropical and subtropical climate zones. This makes Nepal vulnerable to a diverse range of parasites of veterinary importance. The common GIN species affecting goats in Nepal mainly include Haemonchus contortus, Trichostrongylus colubriformis, Teladorsagia circumcincta, Cooperia spp., Nematodirus spathiger, Oesophagostomum spp., Trichuris spp., Dictyocaulus filaria, and Strongyloides papillosus (Ghimire and Bhattarai, 2019). These GINs are mainly responsible for major production losses in quantity and quality, hindering the growth and productivity of goats. The effective therapeutic strategies are an utmost necessity in any small ruminant and are critical to operational profitability (Anim-Jnr et al., 2023).

The control of these parasites primarily relies on anthelmintic drugs such as benzimidazoles (e.g., Albendazole, fenbendazole) and macrocyclic lactones (e.g., ivermectin). However, the widespread and unregulated use of these drugs has led to the development of anthelmintic resistance (AR), especially against benzimidazoles, posing a serious threat to goat health and farm profitability (Fissiha and Kinde, 2021). The development of resistance to the available anthelmintic drugs is a seriously increasing

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problem. The occurrence of anthelmintic resistance is influenced by multiple factors, including host-related characteristics, parasite species, the type and usage patterns of anthelmintics, animal management practices, and prevailing climatic conditions, hindering the implementation of uniform preventive measures across production systems (Entrocasso et al., 2008; Mphahlele et al., 2019). Periodic monitoring of anthelmintic efficacy using methods like the fecal egg count reduction test (FECRT) is essential to detect resistance and inform effective deworming strategies (Cabaret and Berrag, 2004).

The resistance process can be slowed by the effective planning and deworming strategies incorporating the remaining effective anthelmintic, especially Macrocyclic Lactones (Shalaby, 2013). Therefore, addressing GIN infections through strategic deworming programs, regular monitoring of anthelmintic efficacy, and the prudent use of available drug classes is essential to ensure sustainable goat farming and safeguard the livelihoods of Nepal's smallholder farmers. This study aims to evaluate the efficacy of commonly used anthelmintics against gastrointestinal nematodes in goats raised by smallholder farmers in Siyari Rural Municipality, Rupandehi, Nepal.

2. Materials And Methods

2.1 Study area and time

The selection of goats for the experiment was made from the smallholder farmers in Siyari Rural Municipality, Rupandehi, Nepal. Lab work was conducted in the Institute of Agriculture and Animal Science (IAAS, TU). The research was conducted from September 10 to October 10, 2023.

2.2 Selection of animal

A total of seventy-five male goats from smallholder farmers at Siyari Rural Municipality, Rupandehi, Nepal, were screened for GIN infection by sedimentation (Soares et al., 2020) and flotation methods (Gnani Charitha et al., 2013). Out of which thirty-five goats with epg greater than 300 for nematodes found by fecal examination technique, and out of thirty-five goats, thirty goats of similar breed and age and reared under similar husbandry practice (Intensive) were selected for the study. The significance of egg count 21 days after treatment was analyzed using a paired t-test.

2.3 Treatment of animals

A total of thirty goats were selected for the study and were randomly divided into three groups, comprising ten goats in each group. 10 goats in each treatment group are sufficient to evaluate the anthelminthic efficacy (Table 1). The treatment of animals with drugs was carried out as per the dose recommended by the manufacturer.

Table 1: Experimental design for anthelmintic efficacy trial

Group	Number of Goats	Treatment	Dosage	Route of Administration
A	10	Fenbendazole (FENOVET-200)[a]	7.5 mg/kg body weight	Oral
B	10	Ivermectin (Kepromec®)[b]	0.2 mg/kg body weight	Subcutaneous
C	10	Untreated (Control)	-	-

a - A proprietary product of Nepal Pharmaceuticals Laboratory Pvt. Ltd. (NPL), Birgunj, Parsa, Nepal. Each tablet of FENOVET-200 consists 200 mg of fenbendazole.

b - A proprietary product of Kepro, Netherlands. Each ml consists 10 mg of ivermectin.

2.4 Sample collection

Fresh fecal samples were collected from the experimental animals on day 0 before treatment and on day 7, day 14, and day 21, respectively, after treatment. Using gloved fingers, 5-10 grams of feces were obtained from each goat by digital rectal extraction and then immediately placed in a zipped plastic bag. About 2-3 drops of 5-10% formalin were placed inside a zip-lock bag as preservative and mixed well with fecal samples. The bag was zipped as close to the feces as possible to keep out air. Each sample was carefully labeled.with tag number of the individual goat for identification. The samples were kept in formalin for a day and transported to the parasitology lab of IAAS, TU and kept in refrigerator until examination.

2.5 Fecal examination

2.5.1 Qualitative analysis

After collection of fecal samples, qualitative analysis was carried out by microscopic examination using sedimentation and floatation method for the detection of parasitic eggs.

2.5.2 Sedimentation method

About 3 g fecal mass was mixed with 40-50 ml of water in a beaker and strained through a tea strainer to remove coarse particles and debris. The filtrate was placed in a plastic cup, and subsequently, the cup was filled up to the rim. The fecal suspension was allowed to stand for twenty minutes. After twenty minutes, the supernatant was discarded to obtain 3-5 ml of sediment. Few drops of the sediment were then placed on the slide, covered with a cover slip, and examined under a microscope.

2.5.3 Floatation method

In this method, a saturated solution of sodium chloride was used to prepare the flotation solution in which fecal suspension was subsequently prepared. The fecal suspension was allowed to settle for twenty minutes. After this, 10-15 ml from the superficial layer of the suspension was collected in a graded test tube, and a coverslip was placed on top of it in such a way that the undersurface of the coverslip just touches the fecal suspension. The test tube was allowed to stand for ten minutes, after which the coverslip was lifted gently and placed on the glass slide to prepare a fecal smear. The smear was examined under a microscope.

2.5.4 Quantitative analysis

2.5.4.1 McMaster technique

The Mc Master counting technique is a quantitative technique to determine the number of parasitic eggs present per gram of feces (EPG). A flotation solution is applied to separate the eggs from the fecal material in a counting chamber (McMaster) with two slots/ compartments. The technique described below will detect 50 or more epg of feces (Noel et al., 2017).

2.5.4.2 Procedure

3 grams of feces were taken in a mortar and ground into finer particles using a pestle. 42 ml of clear distilled water was poured, and fecal suspension was prepared. The fecal suspension was poured into a plastic cup through a tea strainer. The filtrate was filled into a 15 ml calibrated centrifugation tube and centrifuged at 1000 rpm for 5 minutes. The supernatant was discarded, and saturated sodium chloride solution (NaCl, specific gravity = 1.2) diluted in a 1:15 ratio was added. Then, 0.5 ml aliquots were added to each of the two chambers of a McMaster slide. After 10 min, the nematode egg counts were performed under the two grids (volume = 0.3 ml) of the McMaster slide under a light microscope using a 100× magnification. The fecal egg count values, expressed as EPG of parasites, were obtained by multiplying the total number of eggs by 50.

2.6 Assessment of drug efficacy and anthelmintic resistance

Anthelmintic resistance status was evaluated by FECRT based on the method described by the World Association for the Advancement of Veterinary Parasitology (WAAVP) guidelines (Geurden et al., 2022). The FECRT has long been the gold standard and most widely recommended method for assessing anthelmintic resistance in field and research settings. FECRT assesses the anthelminthic resistance of a given compound by comparing worm egg counts from animals before and after treatment. All the individual in drug treatment group were subjected to epg at day 0 before treatment and day 7, day 14, day 21 respectively after treatment.

FECR (%) = {1-(T2/T1)(C1/C2)}*100% (McKenna, 2006). T1 and T2 represent the mean pre and post treatment FECs of the treated group, and C1 and C2 represent the mean pre and post treatment FECs of the untreated control group, respectively. According to established thresholds:

- Resistance is present when the percentage reduction in egg count is less than 95% (Coles et al., 2006).
- Anthelmintic drug is highly effective when percentage reduction in egg count is over 98% (Wood et al., 1995).

2.7 Statistical analysis

Fecal egg count expressed in epg is measured from all individual goat at day 0 before treatment, and treated with anthelmintic drugs and measured on day 7, day 14, and day 21, respectively, after the treatment. The data was entered in an MS Excel 2019 spreadsheet and was imported into GraphPad Prism version 8.0.1.244 for statistical significance. For analysis of drug efficacies, a paired t-test was done to compare efficacy within the treatment group on different days. A p-value of equal to or less than 0.05 was considered statistically significant. Finally, tables and graphs were used to present the results generated from Graph, and other tabular and graphical presentations were completed in MS Excel 2019.

3. Results

3.1 Fecal examination

A total of 75 male goats from smallholder farmers in Siyari Rural Municipality, Rupandehi, Nepal were screened for GIN infection using fecal examination. Among them, 35 goats with fecal egg counts (EPG) exceeding 300 were identified. Of these, 30 goats of similar breed, age, and husbandry practices were selected for the study. The results showed a marked reduction in fecal egg counts in both treatment groups. Group A (fenbendazole) decreased from 1750 ± 90.36 EPG on day 0 to 145 ± 41.29 on day 21, and Group B (ivermectin) from 1660 ± 78.81 to 20 ± 11.05. In contrast, the control group showed an increase from 550 ± 42.03 to 1535 ± 120.42 (Table 2). This indicates high efficacy of both drugs and progressive infection in untreated animals.

Table 2: Mean fecal egg count (EPG ± SE), along with minimum and maximum values, of goats in each treatment group (fenbendazole, ivermectin, and Control) before treatment (Day 0) and at subsequent intervals post-treatment (Day 7, Day 14, and Day 21).

Group	Day 0	Day 7	Day 14	Day 21
fenbendazole Group (A)				
Minimum EPG	1400	0	0	0
Maximum EPG	2200	600	400	350
Mean EPG ± S.E	1750 ± 90.36	315 ± 74.10	180 ± 47.25	145 ± 41.29
ivermectin Group (B)				
Minimum EPG	1300	0	0	0
Maximum EPG	2050	500	250	100
Mean EPG ± S.E	1660 ± 78.81	225 ± 62.47	85 ± 31.60	20 ± 11.05
Control Group (C)				
Minimum EPG	350	450	700	1000
Maximum EPG	750	1000	1500	2000
Mean EPG ± S.E	550 ± 42.03	655 ± 55.50	1120 ± 107.50	1535 ± 120.42

Group A goats were treated with fenbendazole (7.5 mg/kg orally), Group B with ivermectin (0.2 mg/kg subcutaneously), and Group C remained untreated as controls. Fecal egg counts were determined using the McMaster technique. Results show a progressive decline in EPG in treated groups and an increasing trend in the control group over the 21-day observation period.

There was significant difference as (p value ≤0.05) that is (p value <0.0001) in EPG count between day 0 and day 21 in fenbendazole treated group, indicating a marked decrease parasitic burden. This was only possible due to highly effective treatment, no chances of any external or biological factors influencing the reduction of EPG count. Similarly, the ivermectin treated group demonstrated a statistically significant reduction in EPG count (p value <0.0001) (Table 3). This data revealed the high efficacy of ivermectin in reducing parasitic load. Conversely, there was a statistically significant increase in EPG count in untreated control group (p value <0.0001).

Table 3: Paired t-test analysis comparing mean fecal egg counts (EPG) on Day 0 and Day 21 within fenbendazole-treated, ivermectin-treated, and control groups of goats.

Treatment Group	Mean EPG (Day 0)	Mean EPG (Day 21)	Difference	SE of Difference	t-ratio	p-value (adjusted)
fenbendazole	1750	145	1605	51.88	30.94	<0.0001
ivermectin	1660	20	1640	69.84	23.48	<0.0001
Control	540	1535	-995	82.48	12.06	<0.0001

Statistical comparison was performed using a paired t-test to evaluate the significance of change in mean EPG following treatment with fenbendazole and ivermectin. Both treatment groups exhibited highly significant reductions in EPG ($p < 0.0001$), indicating strong anthelmintic efficacy. In contrast, the untreated control group showed a statistically significant increase in EPG over the 21-day period, confirming ongoing parasitic infection in the absence of intervention. The test parameters included mean EPG on Day 0 and Day 21, mean difference, standard error of the difference, t-ratio, and adjusted p-value.

3.2 Fecal egg count reduction (FECR)

The FECR percentage was 99.08% and 99.57% on the 21st day of post-treatment in Group A and Group B, respectively. These FECR values were reduced significantly (p value ≤0.05), that is (p value <0.0001) on day 21st in comparison with day 0 (Table 4).

Table 4: Fecal egg count reduction (FECR%) at days 7, 14, and 21 post-treatment in fenbendazole- and ivermectin-treated goat groups.

Group	7 days	14 days	21 days
(A). fenbendazole	85.16%	95.04%	99.08%
(B). ivermectin	88.82%	97.53%	99.57%

Fecal egg count reduction percentage (FECR%) was calculated using the formula FECR (%) = 100 × [1 − (T2/T1) × (C1/C2)], where T1 and T2 represent the mean pre- and post-treatment fecal egg counts (EPG) of the treated group, and C1 and C2 represent those of the control group. Both fenbendazole and ivermectin showed progressively increasing efficacy over time, reaching 99.08% and 99.57% FECR respectively by day 21, indicating high anthelmintic effectiveness and absence of detectable resistance.

4. Discussion

The present study was conducted to evaluate the efficacy of two anthelmintic drugs, fenbendazole and ivermectin, against GIN in goats raised by smallholder farmers in Siyari Rural Municipality, Rupandehi, Nepal. The findings showed high efficacy for both drugs, with FECR exceeding 95% by day 21 post-treatment, eliciting effective parasite control and the absence of detectable anthelmintic resistance according to the threshold defined by (Coles et al., 2006).

In the fenbendazole-treated (group A), the FECR was 99.08 % on day 21, highlighting a significant drop in mean number of eggs per gram (EPG) count from 1750 ± 90.36 on day 0 to 145 ± 41.29 on day 21($p < 0.0001$), that aligns with the previous studies, (Aktaruzzaman et al., 2015; Garg et al., 2004; Kumar Halder et al., 2019; Tramboo et al., 2017). However, these results deviate from research conducted by who found developing resistance in some goat herds (Sharma et al., 2015). The maintained effectiveness observed in this study could be attributed to proper dosing, regular deworming practices, rotational grazing, and supplementary

feeding with plants possessing natural anthelmintic properties (Maqbool et al., 2017; Shalaby, 2013; Stull et al., 2007).

In the ivermectin-treated (group B), the FECR reached 99.57 % by day 21, with EPG declining from a mean of 1660 ± 78.81 on day 0 to 20 ± 11.05 on day 21 ($p < 0.0001$). These findings are consistent with studies, who reported similar levels of efficacy (Aktaruzzaman et al., 2015; Byaruhanga and Okwee-Acai, 2013; Njanja et al., 1987; Ram et al., 2007). This sustained high efficacy observed may be explained by ivermectin's extended duration of action, its favorable pharmacokinetic profile facilitating prolonged parasite suppression (Entrocasso et al., 2008).

In the present study, both fenbendazole (99.08 % FECR) and ivermectin (99.57% FECR) demonstrated highly effective anthelmintic activity, with a minimal difference of 0.49% in their fecal egg count reduction rates. There was a significant difference ($p < 0.0001$) between pre-treatment and post-treatment EPG counts in both treatment groups, confirming the reliability of both fenbendazole and ivermectin under field conditions. Crucially, no evidence of anthelmintic resistance was detected among GIN in smallholder goat populations within Siyari Rural Municipality, as both drugs achieved more than 95% FECR (Coles et al., 2006).

The control group (Group C) demonstrated a statistically significant ($p < 0.0001$) increase in EPG counts, rising from a mean of 550 ± 42.03 at day 0 to 1535 ± 120.42 at day 21. This indicates active progression of parasitic infection in the absence of treatment. This further highlights the importance of implementing regular deworming programs for maintaining herd health in smallholder goat farming systems(Silva et al., 2009). The variations in minimum and maximum EPG counts, coupled with differences in standard error among treatment groups, suggest some degree of heterogeneity in parasite burden among individual goats. This variation may result from factors like differences in host immunity, age, nutritional status, and farm management practices that influence the parasitic dynamics (Celi et al., 2017; Zvinorova et al., 2016). Therefore, strategic deworming practices along with integrated improved husbandry and pasture management, are essential to sustain the efficacy of existing anthelmintics and prevent the emergence of resistance in Nepal's smallholder goat production systems.

4.1 Limitation of the study

In the present study, sample size was confined to a single rural municipality, which limits the broader applicability of the findings. There were limited data available on anthelmintic efficacy against gastrointestinal nematodes in goats within this region, signifying the need for more comprehensive research. Furthermore, only two anthelmintics, fenbendazole and ivermectin, were evaluated, excluding other commonly used drugs that may have different efficacy profiles. Also, the study did not include molecular identification of nematode species or investigation of specific resistance mechanisms, which would provide deeper insights into parasite dynamics and the development of anthelmintic resistance.

5. Conclusions

The present findings suggest that both fenbendazole and ivermectin maintain high anthelmintic efficacy against GIN in goats within Siyari Rural Municipality. The observed absence of detectable anthelmintic resistance highlights the importance of maintaining good management practices and periodic monitoring of effectiveness to prevent the emergence of drug resistance. The significant increase in egg counts in the untreated control group highlights the critical need for regular and targeted anthelmintic interventions to mitigate parasite burden and associated production losses. Therefore, it is recommended to continue active surveillance through FECRT, along with adopting parasite management strategies such as pasture rotation, selective treatment, and nutritional supplementation.

Ethical Approval

This research was reviewed and approved by the Thesis Advisory Committee of the Institute of Agriculture and Animal science. All procedures involving animals were carried out following institutional norms for animal welfare, with verbal consent obtained from livestock owners prior to sample collection and data recording.

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Declaration Of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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