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Medicated *Prosopis spp* -based feed blocks- for antihelmintic efficacy and performance of weaner lambs

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Abstract

The aim of this study was to determine effects of supplementing medicated *Prosopis juliflora*-based feed blocks on feed intake, daily weight gains and antihelmintic control potential in sheep. Twelve red maasai weaner lambs, 4 months old, with an average initial live weight of 10 kg (±2.3) were used in the study which lasted for 42 days. The sheep were blocked by weight and within each block, randomly allocated to 3 treatments with 4 animals each. Each animal block received one of the following treatments; (i). *Cenchrus ciliaris* grass hay (basal diet) *ad libitum*, without supplementation (control), (ii) *C. ciliaris* grass hay (basal diet) *ad libitum*, supplemented with Non-medicated *P. juliflora* feed blocks (PJ) (iii) *C. ciliaris* grass hay (basal diet) *ad libitum*, supplemented with medicated *P. juliflora* blocks. Basal feeds and test supplements (two blocks per day) were offered individually at 0800 h and 1430 h daily. Fresh drinking water was available *ad libitum (PJM).*

The tested diets increased significantly total live weight gains for PJ (18.1) and PJM (20.5) as compared to control group (14.4). Significantly ($P<0.001$) higher daily average weight gains were reported in the treatment groups (431 and 488.1 g for non-medicated and medicated feed blocks respectively, than the control (342.9 g). Average dry matter intake ($kg^{-1}d$) varied among the treatment diets from 0.42, 0.67 to 0.89 for the control, non-medicated and medicated *P. juliflora* multi-nutrient blocks respectively. Higher feed conversion efficiency was reported in the animals on medicated prosopis blocks (1.82) than in the non-medicated treatment (1.56) and the control group (1.22). The mean EPG trends of control group progressively rose from day-zero to throughout the experimental period. Significantly higher ($P<0.05$) coccidial species egg output of the untreated controls had risen by 500% and 106% for strongyles spp respectively by end of the experiment. Non-medicated and medicated *P.juliflora* feed-blocks achieved a maximum percentage mean EPG output reduction of 39% and 91% respectively for Strongyles species by 42 days post treatment. 87% and 56% mean coccidial EPG output reduction was recorded for non-medicated and medicated feed blocks respectively. Therefore, according to the current results, *P. juliflora* based feed blocks fortified with a de-wormer such as Nilzan Plus at the rate of 5% per 100 kg of block ingredients would be a potential strategy to control gastro-intestinal parasites and improve livestock productivity in Kenya's rangelands, and additionally, minimize *P. juliflora* invasions in affected regions of Kenya, and other areas of the world with massive colonization with this invasive plant species.

Keywords: Gastrointestinal parasites, invasive plant species, livestock feed, value-addition

Introduction

Pastoralism being the main-stay of most rural communities in Baringo county, current aggressive invasion of *Prosopis* species on the main grazing areas and elimination of grasslands is becoming a big threat to their livelihoods. The invasive potential of *Prosopis spp.,* and the emerging trends of massive colonization of wetlands are already showing the indications of great disaster of national and international importance. The magnitude of the problem is easily understood in the contest that most infestations seen today are still relatively young stands and of moderate densities yet their negative impacts have already been felt by the pastoralists through elimination of treasured pasture lands. The full impact of their invasion is likely to be felt when the infestations will achieve high densities in the next 10-20 years if no intervention is introduced in good time. If un-checked, *Prosopis spp.,* has the potential to wipe out pastoralism in the near future (Aboud et al 2005). Watering points for both livestock and wild game is not accessible in some areas due to the impenetrable thickets of *Prosopis spp*. Reports by Harding and Bate (1991) revealed that, with good rainfall, the colonization rate of *Prosopis spp.,* increases three fold. In such flooded conditions exercabated by weather variability and climate change, the plant is able to form totally impenetrable thickets as seen in most dryland ecosystems of Kenya. Total eradication of *P. juliflora* would not be a solution owing to high overhead costs. Therefore, small-scale prosopis-based feed industry would be an important avenue that can convert weedy invasions into productive and profitable model (Pasiecznik et al 2001). The seeds are passed un-digested in the animal gut, and as a result, they are triggered to germinate even more readily under favourable conditions. By transforming Prosopis into a value-added livestock feed, crushing the seeds so they cannot re-germinate, value addition and processing technology has the potential to slow the invasion of Prosopis in crucial grazing lands and give animals a more balanced, nutritious diet. Efforts to address its control and management will therefore be a big relief to the affected communities. Seed harvesting coupled with value-addition and/or processing for animal feeding will reduce the rapid regeneration and colonization of *P. juliflora*, while improving the household incomes of vulnerable groups in pastoral areas. There are much voices requesting for an external support to manage the spread or eliminate it altogether and replace it with better plant species. However, *Prosopis spp.,* can provide many of the needs of populations living in drylands of the world, and have the potential to provide much more if knowledge on their utilization is expanded. For instance, feeding trial in India on livestock using rations containing up to 45% of *Prosopis spp.* components yielded a 1.5% of cattle body weight with acceptable live weight gains (Tewari et al 2000). Collection of prosopis pods is an important source of income, with earnings of up to US$ 50 per day with collection of about 150 kg per person per day. The purpose of the current study was to formulate, test and popularize prosopis-based feed supplements as management and control strategy of invasive prosopis plant species, while improving livestock productivity and livelihoods in dryland ecosystems. This will was achieved through establishment of a small-scale community-owned livestock feed industry, so that they can harvest prosopis pods, process and sell the value-added livestock feed products to the ready market within and outside the County of Baringo.

Materials and methods

Study area

The study was conducted between July to August, 2014 at the Kenya Agricultural and Livestock Research Organization (KALRO), Perkerra Research Station in Baringo County, Kenya. Baringo County was purpossively selected as a pilot study area due to its intense colonization by *Prosopis juliflora*, and where the invassive species problem has elicited mixed reactions by the community members. Baringo county is an arid area situated in the former Rift valley Province of Kenya, in Agro-ecological zone Zone IV and V (FAO 1996). Temperatures in this region ranges from a minimum of 10°C to a maximum of 35°C in different parts of the county. The average annual rainfall ranges from approximately 650 mm on the Njemps plains to over 1,300 mm at Kabarnet near the summit of Tugen hills. The rainfall is low, erratic and poorly distributed throughout the year.

Animals and management

Twelve red maasai weaner lambs, 4 months old, with an average initial live weight of 10 kg (+ 2.3) were used in a study comprising feed intake, growth and antihelminthic efficacy trials. The weaner lambs were purchased from pastoral farmers in the outskirts of Marigat sub-county of the greater Baringo county. During the 42 days long trial, animals were housed in individual metabolic cages indoors.

Experimental design and treatment diets

The sheep were blocked by weight and within each block, randomly allocated to 3 treatments with 4 animals each. Each animal block received one of the following treatments; (i). *Cenchrus ciliaris* grass hay (basal diet) *ad libitum*, without supplementation (control), (ii) *C. ciliaris* grass hay (basal diet) *ad libitum*, supplemented with Non-medicated *P. juliflora*-based feed blocks (iii) *C. ciliaris* grass hay (basal diet) *ad libitum*, supplemented with medicated *P. juliflora*-based feed blocks. Basal feeds and test supplements (two blocks per day) were offered individually at 0800h and 1430h daily. Fresh drinking water was available *ad libitum*.

Feed intake and Growth performance trial

To calculate daily feed intake, amounts of basal feeds and supplements offered to and refused by each individual animal were recorded daily. Samples of feed offered and refused were collected three times per week for DM determination at 60ºC for 48 hours. Sub-samples of feed offered were ground to pass through a 1-mm sieve and stored for laboratory analysis. The sheep were weighed every Friday at the start, up to the end of the trial for calculation of growth rates. Feed and water were removed about 15 h before weighing for data accuracy.

Chemical analysis

The samples were analyzed for DM, CP, CF and ash contents. Nitrogen in samples was determined by the Kjeldahl N method (AOAC 2000).

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (2000). Significant differences were detected at P<0.05. Significant differences among treatment means were separated using Least Significant Difference (LSD).

The chemical composition of the experimental diet is presented in Table 1. Least-cost feed formulation using feedsoft computer software program was used in the formulation of experimental prosopis feed blocks. Medicated and non-medicated prosopis blocks were prepared using two formulations as shown in Table 2.

Table 1. Dry matter (g/kg) and chemical composition ((g kg^{-1}DM) of basal diet and test supplements

Test feed	DM	CP	CF	Ash
Cenchrus ciliaris	900	73	350	40
Medicated *Prosopis* block	750	201	180	483
Non-medicated *Prosopis* block	750	200	180	485

Moulding and drying

One-kilogram cooking oil containers were improvised, and used in casting the *P. juliflora* multi-nutrient blocks. During casting, the insides of the moulds were lined with cooking oil to prevent the blocks from sticking to the walls of the moulds, and to allow for easy removal of the blocks from the moulds (Mugambi et al 2008).

Figure 1. Making of experimental prosopis feed blocks at KALRO-Perkerra

Moulding and storage of the blocks was done under a roofed building to allow proper curing of the blocks. The blocks were left to air-dry in the well-ventilated shed for a period of five days.

Table 2. Inclusion rates (% DM) and chemical composition of ingredients used for preparation of Prosopis feed blocks

Feed ingredient	Formulations		Chemical composition			
	1	2	DM	CP	CF	Ash
Prosopis pod meal	60	60	86.6	21.8	20.1	14.1
Wheat bran	10	10	88	13	18	13
Molasses	10	10	63	2.5	-	3.6
NaCl	5	5	-	-	-	-
Mineral premixes	5	5	-	-	-	-
Cement	10	10	-	-	-	-
Total	100	100				
Water	45	45				

Nilzan Plus (Dewormer)	5 L	-

In vivo anthelmintic activity trial

Prevailing common nematodes in the study area were characterized before experimentation by sampling the feces of all experimental animals, and cultured for larvae identification. The animals were ear-tagged for identification and de-wormed once before and after the experiment using Nilzan Plus at a rate of 25 to 50 ml per animal, depending on the live weight at the time. The active ingredient of this de-wormer (Nilzan) is 1.5% w/v levamisole hydrochloride B. P, 3.0% w/v Oxyclozanide B. P and 0.38% w/v Colbalt Sulphate. After 14 days, the animals were re-infected again with the identified common parasites in that region at the rate of 10µ (3000 larvae). Fecal egg count (FEC) was performed twice viz once immediately after challenge, and then six weeks post-challenge.

Collection of fecal material and quantification of egg output

The freshly passed feces were collected directly from the rectum per animal using rubber glove at the start of the sixth week (Figure 2). Each collection was put in a container labeled with the number of the animal and the date of collection. Thereafter, the fresh samples were kept in a refrigerator to avoid hatching till the counting exercise. The fecal samples were collected at day-zero and 42 days post treatment. Fecal egg counts were performed on individual fecal samples and expressed as eggs per gram feces (EPG). Modified McMaster egg counting technique was used for quantification of nematode eggs (MAFF 1986, Bondarenko et al 2009) from individual fecal samples.

Figure 2. Screening for nematodes during experimentation at KALRO Perkerra

Figure 3. Medicated Prosopis feed blocks

Culture for larvae identification

At the end of the monitoring period, the fecal samples were collected to culture for isolation of larvae and later their identification. On each sampling day, composite fecal cultures were made for each treatment group. Cultures were incubated for 14 days at 27°C. Third stage larvae were recovered from the cultures by the Baerman technique and identified according to Thienpont et al 1979, MAFF 1986 and Hansen and Perry 1990.

Statistical analysis

The anthelmintic efficacy was determined by comparing the parasites egg population means in treated groups and the control groups of animals and zero day fecal egg collection record. Data was subjected to analysis of variance (ANOVA) using GenStat version 14th edition. Significant differences were detected at $P<0.05$. Significant differences among treatment means were separated using Least Significant Difference (LSD).

Results

Effect of *P. juliflora*-based feed block supplementation on dry matter intake and growth performance

The results of live weight gains and dry matter intake of experimental diets are presented in Table 3. Results showed a significant ($P<0.001$) difference in growth rates among the treatment groups. The tested diets increased significantly total live weight gains (kg) for PJ (18) and PJM (21) as compared to control group (14). Higher daily average weight gains were also observed in the treatment groups (431 and 488 g for non-medicated and medicated feed blocks respectively, than the control (343 g). Average dry matter intake ($kg^{-1}d$) varied among the treatment diets from 0. 4, 0.7 and 0.9 for the control, non-medicated and medicated *P. juliflora* multi-nutrient blocks respectively (Table 3). Medicated prosopis blocks had better recorded feed conversion efficiency (1.8) than in the non-medicated treatment (1.6) and the control group (1.2).

Table 3. DM intake and growth performance of red masai weaner lambs supplemented with prosopis feed blocks

Parameters	***CC***	PJ	PJM	**$LSD_{(0.05)}$**	**P- value**
Growth rates					
Total average live weight gain (kg)	14^{c}	18^{b}	21^{a}	2.41	0.002
Average daily wt.gain, ($g^{-1}d$)	343	431	488		
DM intake					
Average DMI ($kg^{-1}d$)	0.4^{c}	0.7^{b}	0.9^{a}	0.17	0.003
Feed conversion efficiency (kg DMI/kg gain)	1.2	1.6	1.8		

^{a,b}*Values bearing different superscripts in row differ significantly ($P < 0.05$)*
PB= Prosopis spp. blocks

Antihelmintic efficacy determination of medicated *P. juliflora* multi-nutrient blocks

The mean EPG output of weaner lambs supplemented with medicated and non medicated *P. juliflora*-based feed blocks, and un-supplemented *C. ciliaris* as control are presented in Table 4.

Table 4. Mean fecal egg counts and percent count reduction of gastrointestinal nematodes after supplementation with medicated and non-medicated P. juliflora multi-nutrient blocks

	Fecal egg output Mean (numbers)		**% Fecal egg output**		**$LSD_{(0.05)}$**	**P-value**
Strongyle	**0 days**	**42 days**	**0 days**	**42 days**	876	0.002
C. ciliaris	3000^{a}	3167^{b}	100	106		
Non-medicated PB	3000^{a}	1833^{c}	100	61		
Medicated PB	3000^{a}	283^{d}	100	9		
Coccidia	**0 days**	**42 days**	**0 days**	**42 days**	11,211	0.05
C. ciliaris	3000^{a}	15000^{b}	100	500		
Non-medicated PB	3000^{a}	1333^{c}	100	44		
Medicated PB	3000^{a}	400^{d}	100	13		

^{a,b}*Values bearing different superscripts in rows and columns differ significantly ($P < 0.05$)*

The mean EPG trends of control group rose from day-zero to throughout the experimental period (Table 4). Significantly higher coccidial and strongyles species egg output of the untreated controls had risen by 500% and 106% respectively by end of the experiment (Table 4). Notably, non-medicated and medicated *P.juliflora* feed blocks achieved a maximum percentage mean EPG output reduction of 39% and 91% respectively for strongyles species by 42 days post treatment. 87% and 56% mean coccidial EPG output reduction was recorded for medicated and non-medicated feed blocks respectively.

Parasites isolated in the experimental animals

The culture results revealed presence of two nematode species, namely; *Haemonchus* species and *Trichostrongylus* species (Table 5).

Table 5. Gastrointestinal nematode species prevalent in the red maasai sheep in farms surrounding Marigat sub-county

Species of nematode	**Prevalence of species**	**% Prevalence**
Haemonchus	+++	331
Trichostrongylus	++	75

(++) fairly prevalent, (+++) highly prevalent

Discussion

P. juliflora-based feed block supplementation had a great effect on average daily weight gains, with or without medication in the block, as compared to the control groups on sole *C. ciliaris* as basal diet. The relatively higher dry matter intake (DMI ($kg^{-1}d$) of the basal diet of the animals on Prosopis block supplementation could be attributed to improvement in rumen environment due to higher crude protein (CP) content (22%) in the prosopis (Kyuma 2013). Microorganisms in the rumen requires nitrogen for their cell synthesis and multiplication. They in turn improve the degradability of ingested feeds in the rumen, as they also form part of the microbial proteins, a high value protein which is digested and absorbed in the lower gut. However, there was a significantly higher DMI in the medicated prosopis feed blocks as compared to the non-medicated. The relative higher DMI in the medicated blocks could be due to the boosted antihelmintic drug (Nilzan Plus at a rate of 25 to 50 ml per animal depending on their weights at that time). Generally, prosopis plants have natural antihelmintic effects against certain worms due to anti-nutritional factors, mainly tannins present in the pods, leaves and the bark (Koech et al 2011). Thus the variation between the two prosopis blocks (medicated and non-medicated) could be due to the boosted antihelmintic activity with Nilzan Plus.

Higher weight gains of weaner lambs due to supplementation of basal diets of *C. ciliaris* with prosopis feed blocks in the current work could be partly explained by high content of CP (22%) of prosopis pod meal, leading to high digestibility and high utilization efficiency in ruminants (Jones 1984). The prosopis pod has two main parts; the outer part, relatively with high sugar contents (13 MJ/kg) and the inner part, mainly the seed with high protein content of approximately 40% (Kyuma 2013). The animal only utilizes the outer part of the pod (with high sugars), and eliminates the high valued seed with high protein, which passes through the gut undigested. This passage through the gut undigested de-scalarizes the seed making it more aggressive and easy to grow after defaecation in the dung. The ingested sugars from the pods are responsible for decaying teeth in livestock (Kyoge et al 2002) which causes the animal to starve and later dies of malnutrition. Therefore value addition of prosopis pods by crushing and/or grinding has an added advantage of improved CP availability and utilization, a factor that is attributed to the enhanced feed intake and average daily weight gains of weaner lambs on *C. ciliaris* as basal diet.

The study revealed that fortifying prosopis feed blocks with a dewormer inhibited substantially production of eggs by gastro-intestinal nematode parasites. However, it was also evident from the study that non-fortified prosopis blocks also had positive effects in controlling the gut nematodes as compared to the control groups. A recent survey study (Syomiti, Unpublished data) revealed that greater percentage of pastoral farmers around Baringo County were not de-worming their livestock as a routine management. Instead, the animals dependent on indigenous knowledge of phytotheraphy, where certain tree species including prosopis plant were believed to have some anti-helmintic activity against some nematodes. This is evidenced by massive tree bark stripping of some tree species by livestock, in an attempt to de-worm themselves (Fig. 4).

Fig. 4 Bark stripping by livestock

This is confirmed in the current study where parasite egg output was substantially reduced by non-medicated prosopis feed blocks. In the current study, Nilzan Plus addition to feed blocks acted as a booster to the existing antihelmintic activity of prosopis pod meal, which is attributed to secondary plant metabolites such as tannins.

Conclusions

Results obtained in this study suggested that *P. juliflora* based feed blocks fortified with a de-wormer such as Nilzan Plus at the rate of 5% per 100 kg of block ingredients would be a potential strategy to control gastro-intestinal parasites and improve livestock productivity in Kenya's rangelands, and additionally, minimize *P. juliflora* invasions in affected regions of Kenya, and other areas of the world with massive colonizations.

Recommendations

The current study recommends *P. juliflora* management by exploitation as value-added livestock feed and a vial option for controlling the spread of this invasive tree species. Commercialization of value-added *P. juliflora* feed blocks could improve livestock productivity and rural livelihoods where prosopis invasion is a menace. In view of these findings, a further in vitro and in vivo studies on antihelmintic potential of different locally available plant species and natural soil-salt lick for inclusion in the feed blocks targeting specific parasite species and for cost reduction in feeds and feeding in dry lands in the wake of climate change.

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