Sisay et., Ethiop. Vet. J., 2022, 26 (2), 1-17
DOI https://dx.doi.org/10.4314/evj.v26i2.1 *Ethiopian Veterinary Journal*

Effects of supplementation of different indigenous species of browses to Arsi-Bale yearling goats on feed intake, growth performance, and helminthes loads

Amsalu Sisay, Tegene Negesse and Ajebu Nurfeta*

School of Animal and Range Sciences, College of Agriculture, Hawassa University, Ethiopia

**Correspondence author: solianaa2008@gmail.com or amsals2001@yahoo.com*

Abstract

This study was conducted to evaluate the effects of browse tree leaves meals on growth performance and parasite load of naturally parasitized yearling goats. Thirty-six Arsi-Bale yearling bucks which were naturally parasitized with helminths were randomly allocated to one of the following feeding treatments; T1 = *Chloris gayana* grass hay ad lib + 100g concentrate, T2 = T1 + dried 100g of *Acacia tortilis* leaves, T3 = T1 + dried 100g of *Acacia seyal* leaves, T4 = T1 + dried 100g of *Acacia senegal* leaves, T5 = T1 + dried 100g of *Millettia ferruginea* leaves and T6 = T1 + dried 100g of *Vernonia amygadalina* leaves. Goats were fed on corresponding diets for 70 days. Fecal egg count and body weight changes were recorded every 14 days. Higher feed conversion efficiency was observed in goats supplemented with dried browse tree leaves of *Acacia seyal* (T3), *Millettia ferruginea* (T5), and *Vernonia amygadalina* (T6). All supplemented goats had significantly ($p<0.05$) lower fecal egg count (FEC) at day 70 and grew significantly ($p<0.05$) faster than the control group. Goats supplemented with dried browse tree leaves of *Acacia seyal*, *Millettia ferruginea,* and *Vernonia amygadalina* grew faster than goats supplemented with other dried browse tree leaves**.** A rapid and significant reduction of FEC was observed in goats supplemented with *Millettia ferruginea* starting from day 14 and the lowest ($p<0.05$) value was attained at day 70 after treatment. Similarly, goats supplemented with *Vernonia amygadalina* showed an accelerated reduction of FEC starting from day 28 and attained the lowest ($p<0.05$) value at day 70 after treatment. Goats supplemented with *Millettia ferruginea* (T5) and *Vernonia amygadalina* (T6) had the lowest ($p<0.05$) FEC at all times after supplementation and grew faster than the other groups. The rapid and accelerated reduction of FECs and fastest growth rate observed in goats supplemented with *Millettia ferruginea* and *Vernonia amygadalina* indicated that these

browse tree leaves could be effective to control helminths parasite and improve the growth performance of parasitized goats.

Keywords: Indigenous browses tree leaves; parasitized goats; initial parasite load; fecal egg count; average daily weight gain.

Introduction

Browse plants play a significant role in the nutrition of ruminants in tropical regions. Browse species, because of their resistance to heat, drought, salinity, alkalinity, and grazing, are the major feed resources during the dry season (Amsalu *et al.*, 2021). In addition, the major advantage of browse plants over herbaceous legumes and grasses is their higher crude protein content (Amsalu *et al.*, 2021). This advantage makes them a promising supplement to crop residues and poor-quality natural pasture-based diets. Tropical browse species have been also reported to reduce gastro-intestinal parasite (GIP) burden and increase parasitized animal performance (Tavendale *et al.,* 2005).

Gastrointestinal parasites are one of the factors that contribute to the low productivity of livestock in developing countries (Pathak, 2013). Synthetic anthelmintics have long been considered the most effective way of controlling parasitic infections. However, these drugs are expensive and sometimes unavailable to smallholder farmers and pastoralists in developing countries. There are also cases of increased resistance to anthelmintics worldwide in ruminants (Pathak, 2013). Similarly, other control options, such as rotational grazing, may not be readily practiced by many smallholder farmers due to limited land size, or by many pastoralists due to communal land ownership. It follows that a search for novel and more sustainable anthelmintics is the best approach to the control of helminthosis.

In developing nations, traditional methods of controlling nematodes, used by small farmers, remain largely dependent on medicinal plants. Because these plants potentially represent a sustainable alternative to conventional chemotherapy. Recent research results indicated that tannins-containing plants have reduced worm burden and increased animal performance (Athanasiadou *et al*., 2000; Molan *et al*., 2000a, b,). Feeding forage legumes such as Sulla (*Hedysarum oronarium*) and Lotus (*Lotus pedunculatus*) significantly increased the growth of parasitized lambs (Niezen *et al.,* 1998; Robertson *et al.,* 1995).

The vast majority of the *in vivo* and *in vitro* studies examining the effects of tannin-rich plants against gastrointestinal nematodes have been performed on temperate legume forages (Hoste *et al.*, 2006). Although woody browses are largely distributed in the tropics, especially in East Africa, only a limited number of *in vitro* studies have addressed the question of their potential direct anthelmintic properties (Papachristou *et al.*, 2005). Particularly, indigenous browses from the Rift Valley of Ethiopia are not studied for their potential to control gastrointestinal parasites (GIP) in the ruminants. Hence, the current study was conducted to evaluate the effects of five indigenous browse species of tree leaves from the Rift Valley of Ethiopia on feed intake, growth performance, and reduction capacity of parasite load of naturally parasitized yearling goats.

Materials and methods

Study area

The experiment was conducted at Adami Tulu Agricultural Research Center, which is located 167 km south of Addis Ababa at an altitude of 1650 meters above sea level in the mid-rift valley. The agro-ecological zone of the area is semi-arid and sub-humid with acacia woodland vegetation type. The mean annual rainfall is 760mm. The mean minimum and maximum temperatures are 12.6°C and 27°C, respectively. The soil type is fine, sandy loam with sand: silt: clay in the ratio of 34: 38: 18, respectively (Worku *et al.*, 2019).

Collection and preparation of browse leaves

Leaves of *Acacia seyal, Acacia senegal, Acacia tortilis, Millettia ferruginea,* and *Vernonia amygdalina* were collected at the end of the rainy season (September 2017) for subsequent animal supplementation studies. The plants were chosen based on a recent questionnaire survey in the southern Rift Valley of Ethiopia which indicated that they were frequently used by small-scale farmers against parasitic infections or used to treat associated clinical signs (Belete *et al.,* 2012). Leafy twigs were sampled and shed-dried within 24 hours and placed in polyethylene bags and kept in a cool, dry room pending the animal studies.

Experimental design

Growing Arsi-Bale goats were purchased from small-scale farmers in the vicinity. The goats had been grazed on communal grazing land in such a way that they had acquired a natural worm burden (1300 – 3000 EPG). Thirty-six intact bucks aged 12 to 14 months (age determined by dentation) with an average body weight of 14±1.4 kg were selected and allowed to acclimatize to the experimental environment and diet for two weeks. After conducting the initial fecal egg count, goats were blocked based on their fecal egg counts (500 EPG as low parasite load and 3000 EPG as high parasite load) and randomly allocated to one of the following feeding treatments; Treatment one (T1) = *Chloris gayana* grass hay ad lib + 100g concentrate mixture/head/day (75% wheat bran, 24% maize, and 1% mineral mix), treatment two (T2) = T1 + 100g of *Acacia tortilis* leaves hay, treatment three (T3) = T1 + 100g of *Acacia seyal* leaves hay, treatment four (T4) = T1 + 100g of *Acacia senegal* leaves hay, treatment five (T5) = T1 + 100g of *Millettia ferruginea* leaves hay and treatment six (T6) = T1 + 100g of *Vernonia amygadalina* leaves hay.

Data collection

The animals were housed in wooden pens with raised floors and fed individually with their respective experimental feeds for 10 weeks and had free access to clean water throughout the experimental periods. Any feed refusals were collected and weighed early in the morning before the daily feed allowance was offered. Daily feed intake was calculated by deference from daily feed offered and refused. The body weight of the animals was taken and fecal samples were collected from the rectum of the animals for FEC analysis every 14-days. Fecal egg counts were assessed using the McMaster method (Zajac and Conboy, 2012). The feed conversion efficiency was calculated as a ratio of body weight gain to DM intake in g/day (Gulten *et al*., 2000)

Chemical analysis of experimental diets

Feed samples were analyzed for dry matter (DM), ether extract (EE), and ash according to AOAC (2005). The neutral detergent fiber (NDF) was determined according to Van Soest *et al.* (1991). Acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to AOAC (1995). Nitrogen was determined by the Kjeldahl procedure and CP was calculated as N x 6.25.

Metabolizable energy (ME) of diets was estimated according to the equation proposed by Donker (1989).

Statistical analysis

Data were analyzed using the general linear model (GLM) of SAS, Version 9.2. The FEC were square-root transformed to normalize the data and then analyzed as a randomized complete block design using two-way analysis of variance (ANOVA) with initial parasite load as blocks.

The statistical model used was $Y_{ij} = \mu + B_i + L_j + B * L_{ij} + e_{ij.}$ Where: Y_{ij} is an observation, μ is the overall mean, B_i is the effect of browses, L_j is the effect of initial parasite load, $B*L_{ij}$ is the interaction between species and initial parasite load and e_{ij} is the experimental error. The means were separated by Duncan multiple range test. Differences between means were considered statistically significant if $p < 0.05$.

Ethical consideration

The goats used for this experiment were purchased from the local market. During the experimental period, they were housed on a well-protected, cleaned, wooden bedded floor. They were not artificially parasitized, but they were naturally parasitized while they were grazing in their locality before the experiment. We used the common palatable browse species as a supplement to the normal feed to treat the natural parasite load. The experimental diets were formulated to fulfill the animal maintenance feed requirements. No feed additives were used. We took only fecal samples, no blood or serum sample were taken. During the experimental periods all animals were gaining live weight, there was no morbidity or mortality at all. All the above information can be cross-checked with the scientific results of the experiment itself.

Results

Chemical composition of the feed

The chemical compositions of feed ingredients used in the experiment are given in Table 1. The result indicated that the average dry matter contents of all feed ingredients were ($p>0.05$) similar. All browses used in the current study had CP content above 13% DM. *Acacia senegal* had the highest ($p<0.05$) CP content while *Chloris gayana* hay had the lowest ($p<0.05$). The NDF of feed ingredients varied from 14 to 66% of DM. *Chloris gayana* hay had the highest (P<0.05) NDF concentration while *Acacia seyal* had the lowest (p<0.05). *Millettia ferruginea* had the highest (p<0.05) ADF concentration while *Acacia seyal* had the lowest (p<0.05). The highest (p<0.05) ash contents were observed in *Vernonia amygadalinan, Millettia ferruginea,* and *Acacia senegal,* and the lowest (p<0.05) was observed in maize grain.

Table 1. Chemical composition (%DM) and energy values (Mcal/Kg DM) of feed ingredients used in the study

	DM	Ash	CP	EE	NDF	ADF	ME
Chloris gayana hay	94.00	8.68[b]	5.30[d]	2.25[b]	65.99[a]	17.28[b]	2.47[g]
Wheat bran	91.00	2.83[c]	12.20[c]	3.21[ab]	47.44[c]	13.45[c]	2.54[e]
Maize grain	93.00	1.04[c]	5.30[d]	4.01[a]	**27.74[e]**	5.50[f]	2.67[a]
Acacia tortilis hay	94.00	7.22[b]	21.76[b]	3.09[ab]	19.48[f]	12.63[d]	2.55[d]
Acacia seyal hay	94.00	6.50[b]	13.00[c]	3.30[ab]	14.00[g]	9.40[e]	2.60[b]
Acacia Senegal hay	94.00	10.63[a]	28.80[a]	4.38[a]	22.00[e]	12.10[d]	2.56[c]
Millettia ferruginea hay	93.20	10.62[a]	22.46[b]	3.49[ab]	40.77[d]	22.42[a]	2.39[h]
Vernonia amygdalina hay	93.00	12.60[a]	22.50[b]	2.86[b]	22.10[e]	14.40[c]	2.52[f]
SE	0.51	0.50	0.25	0.29	0.31	0.29	0.01

Means in the same column with different superscripts differ significantly (p<0.05). DM = Dry Matter, EE = Ether Extract, CP = crud protein, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ME = metabolisable energy (Mcal/Kg DM).

Nutrient (% DM) and energy (Mcal/Kg DM) contents of experimental diets

The nutrient and energy contents of experimental diets are given in Table 2. The lowest (p<0.05) fiber (NDF and ADF) contents and highest ME value were observed in diet T3 and the highest fiber (NDF and ADF) and lowest ME in diet T1. Diet four (T4) had the highest (p<0.05) CP content while T1 had the lowest (p<0.05). The lowest (p<0.05) ash content was observed in T1 while the highest was in T6.

Table 2. Nutrient (% DM) and energy (Mcal/Kg DM) contents of experimental diets

Diets	DM	Ash	CP	EE	NDF	ADF	ME
T1	92.80	4.18^{e}	7.74^{e}	3.16^{d}	52.99^{a}	14.66^{a}	2.52^{d}
T2	93.00	4.94^{c}	11.14^{c}	3.14^{d}	47.66^{c}	12.22^{c}	2.56^{b}
T3	93.00	4.76^{d}	9.00^{d}	3.19^{c}	46.29^{d}	11.41^{d}	2.57^{a}
T4	93.00	5.80^{b}	12.90^{a}	3.46^{a}	48.29^{b}	12.10^{c}	2.56^{b}
T5	92.68	5.79^{b}	11.13^{c}	3.24^{b}	48.32^{b}	12.66^{b}	2.55^{c}
T6	92.75	6.29^{a}	11.33^{b}	3.08^{e}	48.32^{b}	12.66^{b}	2.55^{c}
SE	0.3	0.01	0.03	0.01	0.06	0.09	0.01

Means in the same column with different superscripts differ significantly (p<0.05). DM = Dry Matter, EE = Ether Extract, CP = Crude protein, NDF = Neutral detergent fiber, ADF = Acid detergent fiber, ME = metabolisable energy (Mcal/Kg DM), T1= Chloris gayana hay adlib + concentrate, T2 = T1 + Acacia tortilis, T3 = T1 + Acacia seyal, T4 = T1 + Acacia senegal, T5 = T1 + Millettia ferruginea, T6 = T1 + Vernonia amygadalina,

Feed and nutrient intake

The daily feed and nutrient intake of the experimental animals is presented in Table 3. The result indicated that all goats supplemented with browse species were significantly (p<0.05) higher in their total feed intake (TFI) and dry matter intake (DMI) than the control groups (T1). Total feed intake and DM intake were (p<0.05) the highest in goats supplemented with *Acacia tortilis* followed by goats supplemented with *Acacia seyal.* Among the supplemented groups, the lowest (p<0.05) TFI and DMI have been observed in goats supplemented with *Vernonia amygadalina* followed by goats supplemented with *Millettia ferruginea.* However, a higher feed conversion efficiency was observed in goats supplemented with *Vernonia amygadalina* and *Millettia ferruginea.* Crude protein intake was (p<0.05) the highest in goats supplemented with *Acacia senegal* followed by goats supplemented with *Acacia tortilis.* Goats supplemented with *Acacia tortilis* had the highest (p<0.05) NDFI while those supplemented with *Vernonia amygadalina* had the least. The intake of ADF was highest (p<0.05) in goats supplemented with *Acacia tortilis* and the control group.

Table 3. Average feed intake (g) of Arsi Bale goats fed *Chloris gayana* hay supplemented with different browse species.

	Intake (g/head/d)						
Diets	**TFI**	**DMI**	**CPI**	**NDFI**	**ADFI**	**ME**	**FCEf**
T 1	527.00^{e}	489.06^{e}	55.36^{d}	259.15^{c}	71.69^{a}	1.23^{f}	0.02
T 2	638.00^{a}	593.34^{a}	66.10^{b}	282.80^{a}	72.52^{a}	1.52^{a}	0.06
T 3	618.00^{b}	574.74^{b}	51.73^{e}	266.05^{b}	65.58^{b}	1.48^{b}	0.07
T 4	598.00^{c}	556.14^{c}	71.74^{a}	268.56^{b}	67.30^{b}	1.43^{c}	0.03
T 5	587.40^{c}	545.79^{c}	60.67^{c}	265.14^{d}	68.47^{b}	1.39^{d}	0.07
T 6	556.00^{d}	515.69^{d}	58.43^{c}	249.18^{e}	65.29^{b}	1.32^{e}	0.07
SE	0.41	2.2	0.4	1.3	0.6	0.01	0.01

Means in the same column with different superscripts differ significantly ($p<0.05$). TFI = Total feed intake, DMI = Dry matter intake, CPI = Crud protein intake, NDFI = Neutral detergent fiber intake, ADFI = Acid detergent fiber intake, ME = metabolisable energy (Mcal/d), T1= Chloris gayana hay adlib + concentrate, T2 = T1 + Acacia tortilis, T3 = T1 + Acacia seyal, T4 = T1 + Acacia senegal, T5 = T1 + Millettia ferruginea, T6 = T1 + Vernonia amygdalina, FCEf = Feed conversion efficiency (g gain/g intake)

Effects of browse supplementation on fecal egg count and average daily weight gain

Effects of browse supplementation on fecal egg count (FEC) and average daily weight gain (ADG) of Arsi Bale goats are presented in table 4. The result indicated that all supplemented goats gradually reduced their FEC with time attaining the lowest FEC at 70 days after treatment while the FEC in the control group (T1) progressively increased throughout the experimental period. Goats supplemented with *Acacia seyal*, *Millettia ferruginea,* and *Vernonia amygdalina* grew faster than goats supplemented with other browses. All supplemental goats had significantly ($p<0.05$) lower FCE and except for T4, grew significantly ($p<0.05$) faster than the control group. Goats in the control group had the highest ($p<0.05$) FEC and lowest ADG throughout the experimental period. Goats supplemented with *Millettia ferruginea* (T5) and *Vernonia amygdalina* (T6) had the lowest ($p<0.05$) FEC at all times after treatment and grew faster than the other groups. A rapid and significant reduction of FEC was observed in goats supplemented with *Millettia ferruginea* starting from day 14 and the lowest ($p<0.05$) value was attained at day 70 after treatment. Similarly, goats supplemented with *Vernonia amygdalina* showed an accelerated reduction of FEC starting from day 28 and attained the lowest ($p<0.05$) value at day 70 after treatment. Goats supplemented with *Millettia ferruginea* reduced their FEC by 57, 61, and 66% after 28, 42, and 56 days of treatment, respectively.

The FEC of goats supplemented with *Vernonia amygadalina* reduced by 40, 62, and 74% after 42, 56, and 70 days of treatment, respectively.

Table 4. Effects of browse supplementation on fecal egg count (eggs per gram feces) and ADG (g/d/h) of Arsi Bale goats

	Fecal egg count (eggs per gram feces)*						
Treatments	**Day 0**	**Day 14**	**Day 28**	**Day 42**	**Day 56**	**Day 70**	**ADG**
T 1	1550 (35.15)	3000 (54.68)^{a}	4000 (63.19)^{a}	3500 (59.09)^{a}	2966 (54.00)^{a}	3075 (55.00)^{a}	10.00^{b}
T 2	2262 (46.94)	2500 (49.87)^{ab}	3500 (59.09)^{a}	3000 (54.68)^{a}	2500 (49.87)^{ab}	1800 (42.40)^{b}	32.14^{a}
T 3	1550 (35.15)	2175 (43.44)^{ab}	2800 (49.73)^{ab}	1844 (40.23)^{b}	1500 (38.45)^{bc}	1500 (38.45)^{b}	39.29^{a}
T 4	2262 (46.94)	1944 (41.99)^{ab}	1625 (37.71)^{bc}	1406 (36.51)^{b}	1188 (32.68)^{cd}	1213 (32.83) ^{bc}	14.29 ^{ab}
T 5	1150 (30.15)	825 (27.66)^{c}	500 (21.92)^{c}	444 (20.95)^{c}	388 (18.56)^{d}	588 (23.95)^{c}	35.72^{a}
T 6	2675 (49.87)	2425 (40.64)^{ab}	2175 (34.36) ^{bc}	1600 (32.56)^{b}	1025 (25.44)^{cd}	688 (23.77)^{c}	35.72^{a}
SE	5.28	4.10	6.5	3.5	4.4	3.9	5.5

Means in the same column with different superscripts differ significantly (p<0.05). T1= *Chloris gayana* hay adlib + concentrate, T2 = T1 + *Acacia tortilis*, T3 = T1 + *Acacia seyal*, T4 = T1 + *Acacia senegal*, T5 = T1 + *Millettia ferruginea*, T6 = T1 + *Vernonia amygadalina*. *Data for FECs are shown as arithmetic means with the means of the square-root transformed FECs in parentheses. Statistical analysis was undertaken on square-root transformed data. S.E.S of FEC is for square-root transformed data

Effects of initial parasite load on FEC and ADG

Effects of initial parasite load on subsequent fecal egg counts and ADG of Arsi-Bale goats are indicated in Table 5. Initial parasite load had a significant (p<0.05) effect on subsequent fecal egg count and ADG of goats. Goats with a high initial parasite (HIP) load showed (p<0.05) higher FEC at all times until day 70, at which the effects become (p>0.05) non-significant. Goats with low initial parasite (LIP) load grew significantly (p<0.05) at a faster rate than the other groups.

Table 5. Effects of initial parasite load on subsequent fecal egg count (eggs per gram feces) and ADG (gm/d) of Arsi Bale goats.

	Fecal egg count (eggs per gram feces)*					
Initial load	Day 14	Day 28	Day 42	Day 56	Day 70	ADG (g/d)
HIP Load	3019 (53.54)[a]	3033 (50.59)[a]	2500 (47.87)[a]	2068 (43.45)[a]	1683 (39.05)	22.32
LIP Load	1271 (32.54)[b]	1833 (38.10)[b]	1431 (33.47)[b]	1121 (29.54)[b]	1271 (33.08)	33.39[a]
SE	2.4	3.8	2.0	2.5	2.2	3.1

Means in the same column with different superscripts differ significantly ($p<0.05$). *Data for FECs are shown as arithmetic means with the means of the square-root transformed FECs in parentheses. SE of FEC is for square-root transformed data. HIP = High initial parasite load (3000 EPG), LIP = Low initial parasite load (500 EPG)

Effects of initial parasite load and browse supplementation on FEC and ADG

The effects of initial parasite load and browse supplementation on fecal egg count and ADG is presented in table 6. Though not significant, goats with HIP load in all treatments had higher FEC than those with LIP load at all times after supplementation. The ADG of goats with LIP load in each of the supplemented treatments was higher than that of goats with the HIP load. The ADG of goats with LIP load was significantly higher ($p<0.05$) when supplemented with *Acacia seyal* than other browses. Goats with HIP load and supplemented with *Millettia ferruginea* and *Vernonia amygdalina* grew faster than goats with HIP load in other treatments. The effects of *Vernonia amygdalina* supplementation were significant and effective on goats with LIP loads. Fecal egg count of goats with LIP loads and supplemented with *Vernonia amygdalina* were ($p<0.05$) lowest of all other groups at all times after supplementation. The group of goats with HIP load and supplemented with *Millettia ferruginea* had the lowest ($p<0.05$) FEC at all times after supplementation as compared to all other groups of goats with HIP load in other treatments. *Vernonia amygdalina* supplementation reduced the FEC of goats with HIP load by 76% and that of goats with LIP load by 50% at day 70 after supplementation. *Millettia ferruginea* supplementation reduced the FEC of goats with HIP load by 68% and that of goats with LIP load by 51% at day 56 after supplementation.

Table 6. The interaction effects of parasite load and browse supplementation on fecal egg count (eggs per gram feces) and ADG (g/d/head) of Arsi Bale goats.

Treatments		Fecal egg count (eggs per gram feces)* Day 0	Day 14	Day 42	Day 56	Day 70	ADG
T 1	HIP	2675 (51.59)[a]	3250 (56.96)[a]	3750 (61.21)[a]	3506 (59.00)[a]	3625 (60.00)[a]	12.50[b]
	LIP	425 (18.69)[b]	2750 (52.378)[ab]	3250 (56.97)[a]	2426 (49.00)[ab]	2525 (50.00)[ab]	7.50[b]
T 2	HIP	2762 (52.34)[a]	2750 (52.38)[ab]	3250 (56.97)[a]	2750 (52.39)[a]	1900 (43.58)[ab]	21.43[ab]
	LIP	1762 (41.54)[ab]	2250 (47.36)[ab]	2750 (52.39)[ab]	2250 (47.36)[ab]	1700 (41.22)[ab]	42.86[ab]
T 3	HIP	2675 (51.59)[a]	3625 (60.10)[a]	2988 (54.04)[ab]	1750 (41.73)[ab]	1750 (41.733)[ab]	28.58[ab]
	LIP	425 (18.69)[b]	725 (26.82)[b]	700 (26.42)[bc]	1250 (35.18)[ab]	1250 (35.18)[bc]	50.00[a]
T 4	HIP	4375 (64.95)[a]	2675 (50.72)[ab]	1413 (37.45)[b]	1850 (43.01)[ab]	1025 (29.97)[bc]	14.29[b]
	LIP	150 (12.10)[b]	1213 (33.25)[b]	1400 (35.58)[b]	525 (22.35)[b]	1400 (35.70)[bc]	14.29[b]
T 5	HIP	1975 (42.61)[ab]	1175 (33.54)[b]	500 (22.36)[bc]	625 (24.88)[b]	600 (24.41)[bc]	28.57[ab]
	LIP	325 (17.67)[b]	475 (21.78)[b]	388 (19.55)[bc]	150 (12.25)[b]	575 (23.50)[bc]	42.86[ab]
T 6	HIP	5000 (70.45)[a]	4638 (67.60)[a]	3100 (55.21)[ab]	1925 (39.76)[ab]	1200 (34.64)[bc]	28.57[ab]
	LIP	350 (17.24)[b]	213 (13.68)[b]	100 (9.92)[c]	125 (11.13)[b]	175 (12.91)[c]	42.86[ab]
SE		7.4	5.7	4.9	6.2	5.4	7.8

Means in the same column with different superscripts differ significantly (p<0.05). T1= *Chloris gayana* hay adlib + concentrate, T2 = T1 + *Acacia tortilis*, T3 = T1 + *Acacia seyal*, T4 = T1 + *Acacia senegal*, T5 = T1 + *Millettia ferruginea*, T6 = T1 + *Vernonia amygadalina*. HIP = high initial parasite load, LIP = low initial parasite load. *Data for FECs are shown as arithmetic means with the means of the square-root transformed FECs in parentheses. Statistical analysis was undertaken on square-root transformed data. SE of FEC is for square-root transformed data

Discussion

Chemical composition of feed

The chemical composition of hay, wheat bran, and maize used in this experiment was comparable with the values reported by many workers (Awet, 2007; Sebsebe *et al.,* 2007; Tolera, 2008; Sisay *et al.*, 2015). The range of CP contents of the browses in the current study is in line with the findings of Njidda and Nasiru (2010) and Theart *et al.* (2015) who reported 14 to 21% and 13 to 25%, respectively. It has been indicated that most tropical browses are high in CP and can be used to supplement poor-quality roughages to increase the productivity of ruminant livestock in the tropics (Makkar and Becker, 1998; Njidda and Nasiru, 2010; Theart *et al.*, 2015) which is consistent with the results obtained in the current experiment. In this study, the NDF and ADF of browses varied from 14 to 41 and 9 to 22% DM, respectively, which is comparable with the findings of Fadel Elseed *et al.* (2002) and Kaitho *et al.* (1997). The low NDF and ADF contents in *Acacia seysal* and *Acacia tortilis* in this study indicate that these browses have better dry matter intake and high digestibility. Schroeder (2004) reported the negative correlation of NDF and ADF with dry matter intake and digestibility of browses.

Feed and nutrient intake

The TF and DM intakes of supplemented goats in the current study ranged from 556 to 638 gm and from 515 to 593 gm, respectively. The current findings are in line with the findings of Sisay *et al.* (2015) who reported a range of 556 to 638 gm for TF and 524 to 601 gm for DM intakes of Arsi Bale goats supplemented with *Millettia ferruginea.* The highest TF and DM intake observed in goats supplemented with *Acacia tortilis* and *Acacia seyal* could be attributed to the lowest NDF and ADF values of *Acacia tortilis* and *Acacia seyal* (Table 1). It is well accepted that forage intake and degradation are mainly affected by the NDF and ADF contents (Njidda and Nasiru 2010). Schroeder (2004) reported the negative correlation of NDF and ADF with dry matter intake and digestibility of browses. Theart *et al.* (2015) reported a negative correlation between NDF and ADF with *in vitro* digestibility. The higher feed conversion efficiency observed in goats supplemented with *Millettia ferruginea* and *Vernonia amygadalina* could be attributed to the significant reduction effects of those browses on FECs throughout the experimental periods (Table 3).

Fecal egg count and weight gain

This experiment demonstrated that both browse supplementation and levels of initial parasite load significantly affected daily weight gain and FECs of goats. All supplemented goats had significantly ($p<0.05$) lower FEC at day 70 and grew significantly ($p<0.05$) faster than the control group. These results were in line with the earlier studies (Osoro *et al.*, 2007a,b) which showed that grazing goats on a diet supplemented with tannin-containing *heather* had lower

FECs and better growth performance, in comparison with animals on non-supplemented diets. Similarly, Paolini *et al.* (2003) reported a reduction of FECs and improvement of ADG of naturally infected goats when supplemented with Sainfoin (*Onobrychis viciifoliae*) hay. Naturally, infected deer reduced FECs and increased ADG when supplemented with Chicory (*Cichorium intybus*) (Hoskin 2003). Significant reduction of FECs and improvement of ADG were observed on sheep supplemented with *Lotus pedunculatus* (Niezen *et al*., 1998) and on lambs grazed on Sulla (*Hedysarum coronarium*) pasture (Niezen *et al.,* 1995).

Goats with LIP loads grew faster than goats with HIP loads in all treatments and goats supplemented with *Acacia seyal*, *Millettia ferruginea* and *Vernonia amygadalina* grew faster than goats supplemented with other browses. Niezen *et al.* (1995) reported significantly higher ADG from all lambs with low initial parasite loads compared to those with high initial loads. The highest weight gain attained by goats supplemented with *Millettia ferruginea* and *Vernonia amygadalina* could be attributed to the significant reduction effects of those browses on FECs throughout the experimental periods (Table 3). The highest weight gain attained by goats supplemented with *Acacia seyal* could be attributed to the high nutritive values (lowest NDF and ADF) of *Acacia seyal* (Table 1). Although *Acacia seyal* had high nutritive values and the intake was adequate to ensure high ADG in goats with low initial parasite load, the ADG of goats with high initial load and supplemented by *Acacia seyal* was suffered by parasite load.

The significant and accelerated reduction of FECs obtained by supplementing *Vernonia amygadalina* in the current study agrees with the findings of Amsalu *et al.* (2021) who conducted an *in vitro* experiment and reported the highest larval migration inhibition rate and highest adult mortality rate of *H. Contortus* when treated with *Vernonia amygadalina* leaf extracts.

Conclusions

All browse species except *Acacia seyal,* used as a supplement had high CP contents, sufficient to be considered as high protein forage that can be used as supplements for low-quality roughages. The lowest NDF, ADF contents, and high DM intake of *Acacia seyal,* coupled with its high supplemental value, inducing a high growth rate of parasitized goats, would make the browse a potential supplement for parasitized goats. The lower FEC at the end of the experimental period and faster growth rate observed in all supplemented goats indicate that these browses species could have the potential to reduce parasite load and improve growth rates of goats if they are supplemented for longer periods. There was a rapid and accelerated reduction of FECs and the fastest growth rate in goats supplemented with *Millettia ferruginea* and *Vernonia amygadalina,* which indicated that these browses species could have the potential to control helminths parasite and improve the growth performance of parasitized goats even with short term supplementation. Further research should focus on the analysis of the concentrations of Total phenol, Total Tannin, and Condensed Tannin of these promising browses species and their effects on the GIP of livestock.

Acknowledgments

This research project was fully supported by the research fund granted by the Vice President for Research and Technology Transfer of the Hawassa University (HU) for which the authors are highly grateful. The great cooperation and support of Adami Tulu Research Center, especially the goat and dairy research teams, in providing experimental goats, feeding pens, Lab facilities, and guesthouses are highly acknowledged.

References

Amsalu, S., Tegene, N. and Ajebu, N., 2021. Anthelminthic effects of extracts of indigenous browses from mid rift valley of Ethiopia. *Ethiop. Vet. J.,* 25, 132-143.

Athanasiadou, S., Kyriazakis, I., Jackson, F. and Coop, R.L., 2000. Effect of short-term exposure to condensed tannins on adult *Trichostrongylus colubriformis*. *Vet. Rec.*, 146, 728–732.

Awet, E., 2007. Feed utilization, body weight, and carcass parameters of intact and castrated Afar sheep fed on urea-treated teff straw supplemented with wheat bran. An MSc. Thesis presented to the School of Graduate Studies of Haramaya University. 70p.

Belete, S., Hassen, A., Assafa, T., Amen, N. and Ebro, A., 2012. Identification and nutritive value of potential fodder trees and shrubs in the mid-Rift Valley of Ethiopia. *J. Anim. Plant Sci.,* 22, 1126-1132.

Donker, J. D., 1989. Improved energy prediction equations for dairy cattle rations. *.J. Dairy Sci.*, 72, 2942-2948.

Fagg, C. W. and Stewart, J. L., 1994. The value of *Acacia* and *Prosopis* in arid and semi-arid Environments. *J. Arid. Environ.,* 27, 3–25.

Fadel Elseed, A.M.A, Amin, A.E, Khadiga, A., Abdel Ati, J., Sekine, M., Hishinuma, M. and

Hamana, K., 2002. Nutritive evaluation of some fodder tree species during the dry season in central Sudan. *Asian-australas. J. Anim. Sci*., 15, 844-850.

Gulten, K., Rad, F. and kinder, M., 2000. Growth Performance and feed conversion efficiency of Siberian sturgeon juveniles (*Acipenser baeri*) reared in concrete raceways. *Turk. J. Vet. Anim. Sci.,* 24, 435-442.

Hoskin, S.O., 2003. Effect of withholding anthelmintic treatment on autumn growth and internal parasitism of weaner deer grazing perennial ryegrass-based pasture or chicory. *Proc. N. Z. Soc. An. Prod*. 63, 269–273.

Hoste, H., Frank, Spiridoula, J., Stig, A., Thamsborg, M., Simone and Hoskin, O., 2006. The effects of tannin-rich plants on parasitic nematodes in ruminants. *Trends Parasitol.*. 22, 256-261.

Kaitho, R. J., Umunna, N. N., Nsahlai, I. V., Tamminga, S., van Bruchem, J. and Hanson, J., 1997. Palatability of wilted and dried multipurpose tree species fed to sheep and goats. *Anim. Feed Sci. Technol*., 65, 151-163.

Makkar, H.P.S., and Becker,K., 1998. *Jatropha curcas* Toxicity: Identification of Toxic Principle(s). In: Toxic Plants and Other Natural Toxicants, Garland, T., A.C. Barr, J.M. Betz, J.C. Reagor and E.M. Bailey (Eds.). CAB International, New York, USA, pp: 554-558.

Molan, A.L., Waghorn, G.C., Min, B.R. and McNabb, W.C., 2000a: The effect of condensed tannins from seven herbages on *Trichostrongylus colubriformis* larval migration in vitro. *Folia Parasitol.,* 47, 39–44.

Molan, A.L., Hoskin, S.O., Barry, T. N. and McNabb, W.C., 2000b.The effect of condensed tannins extracted from four forages on deer lungworm and gastrointestinal nematode larval viability. *Vet. Rec.,* 147, 44–48.

Niezen, J.H., Robertson, H.A., Waghorn, G.C. and Charleston, W.A.G., 1998. Production, faecal egg counts, and worm burdens of ewe lambs which grazed six contrasting forages. *Vet. Parasitol.,* 80, 15–27.

Niezen, J.H., Waghorn, T.S., Charleston, W.A.G. and Waghorn, G.C., 1995. Growth and gastrointestinal nematode parasitism in lambs grazing either lucerne (*Medicago sativa*) or sulla (*Hedysarum coronarium*) which contains condensed tannins. *J. Agric. Sci.,* 125, 281–289.

Njidda, A .A. and Nasiru, A., 2010. In vitro gas production and dry matter digestibility of tannin-containing forages of the semi-arid region of North-eastern Nigeria. *Pak. J. Nutr.*, 9, 60-66.

Osoro, K., Benito-Peña, A., Frutos, P., García, U., Ortega-Mora, L.M., Celaya, R. and Ferre, I . 2007a. The effect of heather supplementation on gastrointestinal nematode infections and 23 Performance in Cashmere and local Celtiberic goats on pasture. *Small Rumin. Res.,* 67, 184-191.

Osoro, K., Mateos-Sanz, A., Frutos, P., García, U., Ortega-Mora, L.M., Ferreira, L.M.M., Celaya R. and Ferre, I., 2007b. Anthelmintic and nutritional effects of heather supplementation on Cashmere goats grazing perennial ryegrass-white clover pastures. *J. Anim. Sci.,* 85, 861-870.

Paolini,V., Dorchies, P.h. and Hoste, H. 2003. Effects of sainfoin hay on gastrointestinal infection with nematodes in goats. *Vet. Rec*., 152, 600–601.

Papachristou, T.G., Platis, P.D. and Nastis, A.S., 2005. Foraging behavior of cattle and goats in oak forest stands of varying coppicing age in Northern Greece. *Small Rumin. Res*., 59, 141-156

Pathak, A. K., 2013. Potential of using condensed tannins to control gastrointestinal nematodes and improve small ruminant performance. *Int. J. Mol. Vet. Res.,* 3, 36-50.

Robertson, H.A., Niezen, J.H., Waghorn, G.C., Charleston, W.A.G. and Jinlong, M., 1995. The effect of six herbages on live weight gain, wool growth, and faecal egg count of parasitized ewe lambs. *Proc. New Zealand Soc. Anim. Prod.,* 55, 99–201.

Schroeder, J.W., 2004. Forage Nutrition for Ruminants. North Dakota State University Cooperative Extension. Retrieved from http://www.ag.ndsu.edu/pubs/ansci/dairy/as1252w.html.

Sisay, T., Sandip, B., Ajebu, N. and Bangu, B., 2015. Studies on supplementation of graded levels of *Millitia Ferruginea* leaf meal on feed intake, growth performance, and carcass characters of Arsi Bale goats. *GJSFR D Agric. Vet.,* 15, 11-20

Tavendale, M.H., Meagher, L.P., Pacheco, D., Walker, N., Attwood, G.T. and Sivakumaran, S., 2005. Methane production from *in vitro* rumen incubations with *Lotus pedunculatus* and Medicago *sativa*, and effects of extractable condensed tannin fractions on methanogenesis. *Anim. Feed Sci. Technol.,* 124, 403–404.

Theart, J.J.F., Hassen, A., van Niekerk, W.A. and Gemeda, B.S., 2015. In vitro screening of Kalahari browse species for rumen methane mitigation. *Sci. Agric.* 72, 478-483.

Tolera, A., 2008. Feed resources and feeding management: A manual for feedlot operators and development workers. Ethiopian Sanitary and Phytosanitary Standards and Livestock and Meat Marketing Program (SPS-LMM), Addis Ababa, pp 43.

Worku, A., Alemu, T., Gurru, M., Gudeto, A., Messele, F., *et al.,* 2019. Evaluation of different feeding options on growth response and carcass characteristic of yearling Kereyu-Bulls to attain local/export market weight. *Int. J. Agric. Sci. Food Technol.*, 5(2), 050-053.

Zajac, A.M. and Conboy, G.A., 2012. Veterinary Clinical Parasitology. 8th ed. John Wiley and Sons UK, P40-87.