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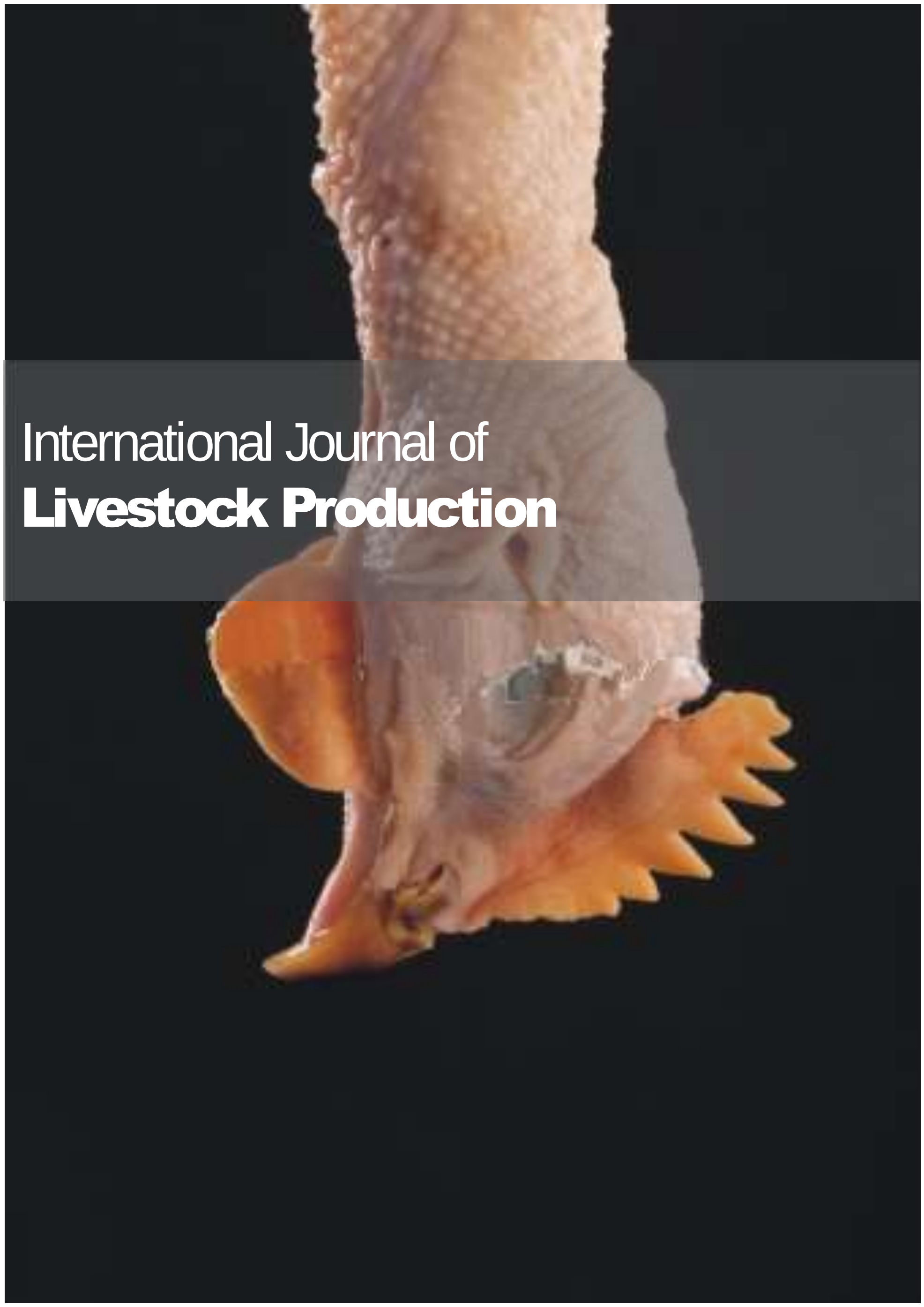

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Full Length Research Paper

The effect of using either soybean or groundnut straw as part of basal diet on body weight gain, and carcass characteristics of Gumuz Sheep

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The study was conducted to evaluate the effect of soybean or groundnut straw replacement for hay on live weight change and carcass characteristics of Gumuz sheep at Pawe Agricultural Research Centre. Thirty yearling male intact Gumuz sheep with initial body weight of 18.91 ± 2.6 kg (mean ± SD) were used in the experiment. The study consists of 90 days of feeding trial period after acclimatization of 15 days for the treatment feed, followed by evaluation of carcass characteristics at the end. The experimental design used was randomized complete block design. The experimental animals were grouped in to six blocks based on their initial body weight and each animal was randomly assigned to one of the five treatment diets; namely, Hay alone basal diet (control treatment; (T1), 50% Hay + 50% soybean straw (T2), 50% Hay + 50% groundnut straw (T3), 25% Hay + 75% groundnut straw (T4), and 25% Hay + 75% soybean straw (T5). Toasted soybean grain of 172 g and 5% molasses (of daily feed offered) were supplemented for each treatment group equally throughout the experiment period. Water and salt lick were available free choice. Natural pasture hay, soybean straw and groundnut straw contained 7.12, 4.39, and 8.08% CP, respectively. The daily body weight gains of T3 (91.48 g/d) was higher (P<0.01) than other treatment groups, whereas T2 (58.5) exhibited lower daily body weight gain. There was no difference in feed conversion efficiency (FCE) among treatments. The hot carcass weight of sheep in T3 and T4 were higher (P<0.01). The mixture of natural pasture hay with groundnut straw 50:50 or 25:75, respectively, resulted in heavier carcass yield showing the priority basal feed, but use of all combinations of the basal feed resulted in good performance of the Gumuz sheep breed.

Key words: Metekel, natural pasture hay, replacement.

INTRODUCTION

Ethiopia has diverse agro-ecologies and diverse livestock breeds/types which have different adaptations, productivity and utilization in the farming system. Sheep is kept across the agro-ecology and its population is

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estimated to be about 30.70 million. The sheep population is dominated by the indigenous breeds (99.72%) and only exotic breeds like Dorper and Awassi nowadays are used for crossbreeding of the indigenous breeds. The offtake rate of sheep in Ethiopia is about 35% and among the sheep flock two years and older (52.01% of the total sheep), 48.54% are kept for breeding; about 2.60% for mutton and less than one percent of them are kept for wool production (CSA, 2017). The short generation interval, ability to give multiple births and their small size make sheep adaptable to smallholder and mixed crop-livestock production system (FAO, 2000). There are about 17 breeds of sheep in Ethiopia and the Gumuz sheep is the one among these breeds.

Extensive sheep production under traditional communal grazing or browsing system is widely practiced. Sheep from this system provide large amount of domestic meat consumption and generate cash income from exports of mostly live animals and small proportion of meat, and skins. However, the productivity level of sheep is very low. The yield per animal slaughtered is estimated to be 10 kg of mutton (FAO, 2000). Although, there are various and complex constraints, which contributes to these reduced productivities of sheep, the most important limiting factor is feed scarcity.

Soybean [*Glycine max* (L.) Merrill] and Groundnut (*Arachis hypogaea* L.) are among the food /feed crops widely cultivated in the lowland areas of Ethiopia for various uses including raw materials for oil production, cash income, animal feed, increases soil fertility, serve as good intercrop (Geleta et al., 2007; Wijnands et al., 2009; Hailegiorgis, 2010; Jagwe and Owuor, 2014). Soybean production during the last 10 years has increased by 10 fold; while the total volume of production during the same period increased by 21 fold (Mekonnen and Kaleb, 2014). The nutritive value of soybean straw is higher than rice straw but lower than pod husk (Gupta et al., 1973; Krieder, 1979). In localities where these crops are dominant, the crop residues can be well used as alternative basal roughage for animals especially during the dry season. Treated residues have an advantage of efficient utilization of these resources as the quality specially the crude protein content is low as compared to the general roughages. This study therefore was initiated to evaluate the alternative use of soybean or groundnut straw with standard concentrate supplements on live weight change and carcass characteristics, of Gumuz sheep.

MATERIALS AND METHODS

Description of Study Site

The experiment was conducted at Pawe Agricultural Research Center, Metekel Zone of Benishangul Gumuz, Ethiopia. It is located at a distance of 572 km North West of Addis Ababa at a latitude/longitude of 11°19'N and 36°24'E. Pawe Agricultural Research Center is located at an elevation of 1100 masl with annual minimum and maximum temperature of 16.3 and 32.6°C, respectively. It receives an annual rainfall ranging from 900 to 1587 mm. It is characterized by hot to warm moist agro-ecological zone and it is known by soybean and groundnut production.

Feed production and management

Soybean and groundnut straw were collected from Pawe Agricultural Research Center (PARC) after harvesting of grain. The variety of soybean was Bellesa 95 and groundnut Manipiter. These varieties were produced as part of the centers seed multiplication activity with all the recommended production practice in which recommended (100 kg phosphorous) amount of fertilizer was applied at planting. Care was taken during harvesting the residues with leaves and pods. Soybean was trashed by tractor on the ground covered with plastic sheet and groundnut with hand picking. The crops were harvested at the grain maturity and threshed in few days period and the residues were collected and stored in a ventilated shade immediately after threshing. The natural pasture hay, which was dominated by *Cynodon dactylon* harvested manually with sickle from the natural pasture field in the research center at the stage of blooming of grasses (about 50% flowering). The harvested forage was dried for 3 to 4 days, transported to experimental sites and piled in a ventilated shade.

Experimental animals and their management

Thirty intact male yearling Gumuz sheep (with full milk teeth) and similar body conditions and sizes were purchased from a local market (Pawe, Gilgel Beless and Manbuk). Upon arrival to the research station, the animals were acclimatized to the environment and treatment feed for 15 days. During this period, the animals were grazing around the experiment station in day time and housed during the night in a group. Animals were ear tagged for identification purpose. At the end of the acclimatization, the animals were drenched with anthelminthic (Albendazole 300 mg bolus) and sprayed with Amitraz 12.5% at a dose of 1.6 ml per 1liter of water against internal and external parasites, respectively and vaccinated against common diseases of the area (Peste Des Petits Ruminants (PPR)) before the beginning of the experiment.

Hay and replacement soybean or groundnut straws were weighed and offered three times a day as basal diet after proper mixing. Basal diet was offered *ad libitum* at a rate of 20% refusal. All animals were supplemented with 5% of daily feed intake molasses and 172 g of toasted soybean grain on dry matter basis. The molasses was added to the straw and hay mixture weighed for each animal based on their *ad libitum* intake. The grain which considered as concentrate supplement was offered separately twice a day at 8:00 AM and 4:00 PM in equal proportions. The animals had free access to water and common salt lick throughout the experimental period. The refusal was measured daily in the morning before offering the daily ration.

Experimental design and dietary treatments

The design of the experiment used was randomized complete block design (RCBD). The experimental animals were grouped into six blocks each with five animals based on their initial body weight. The five experimental feed treatments were randomly assigned to animals in a block. The randomization was made using Microsoft excel 2013. The treatments of the experiment were: Hay alone (control treatment) (T1), 50% Hay + 50% soybean straw(T2), 50% Hay + 50% groundnut straw (T3), 25% Hay + 75% groundnut straw (T4), and 25% Hay + 75% soybean straw (T5). The animals were kept in individual pens furnished with feeding troughs and water buckets. Cleaning of the pens was done daily before placement of the morning ration. The feeding trial lasted for 90 days.

Measurements and analyses

Daily feed offered to the experimental animals and the corresponding refusals were recorded and measured during the experimentation period to determine daily feed intake in dry matter basis. This was determined by multiplying the average daily feed offered by the dry matter percentage of the feed and less the average daily feed refusal in dry matter basis. Samples of feed offered were taken from batches of feeds and refusals were collected from each animal across the experimental period for each animal and finally pooled for each treatment and sub-sampled. Feed conversion efficiency was calculated by dividing the average daily body weight gain to average daily feed intake. The partially dried samples of feeds were ground using laboratory mill to pass through a 1 mm sieve screen size and taken to Holotta Agricultural Research Centre nutrition laboratory for chemical analysis.

Data on live weight of sheep were measured at the beginning of the experiment and at every 15 days interval in the morning before provision of feed and water using suspended weighing scale with sensitivity of 100 g. Average daily body weight gain for each sheep was calculated as a difference between the final and initial body weight divided by the total number of actual feeding days. Carcass characteristics of experimental animals were evaluated by slaughtering all animals in the experiment after overnight fasting. Slaughter weight (SW) has been taken right before slaughter. The animals were slaughtered by severing the jugular vein and carotid artery with knife. The blood was drained into bucket and weighed. After the animals were killed, the skin was flayed carefully to avoid adherence of fat and muscle tissue to the skin. The skin was weighed and next the entire gastro intestinal tract without esophagus was removed and divided into two sections as stomach and intestine and were weighed with gut fill. During removal of gastro intestinal tract mesenteric fat and internal organs were separated carefully and weighed. The weight of hot carcass was taken after all the offal's were removed from the carcass. Edible and non-edible offals were identified and recorded. Total usable product was taken as the sum of hot carcass weight, skin and total edible offal component.

In order to measure rib eye-area of the carcass loin part was partitioned into fore and hind quarters between the 11^{th} and 12^{th} ribs. The cut ribs were chilled for 12 hours in deep refrigerator and the rib eye area (in cm^2) was measured after cutting at the 12^{th} and 13^{th} rib site. The cross- section of the rib eye muscle was traced first on transparency plastic paper and then the traced transparency paper was positioned on graph paper squares each having an area of 1 mm × 1 mm size. The number of squares included within the mark was counted for left and right sides and area was computed as the average of the two. The empty body weight was determined by deducting the gut fill from slaughter body weight and dressing percentage was calculated based on slaughter and empty body weights.

Chemical analysis

Dry matter, Organic Matter (OM) and ash were assayed on the offered and refused feeds and feces samples using the methods described by AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed according to the procedures of Van Soest and Robertson (1985). Hemicellulose and cellulose contents were calculated from the difference between NDF and ADF, and ADF and ADL, respectively. Analysis for Kjeldhal nitrogen was run according to AOAC (1990) procedures. The crude protein (CP) content was determined by multiplying nitrogen value by 6.25.

Statistical analysis

Collected data were subjected to the analysis of variance (ANOVA) using the GLM procedure of SAS (Version 9.0). Significant treatment means were separated using Tukey HSD (Tukey Honestly Significant Difference Test). The statistical model was:

$$Y_{ij} = \mu + T_i + \beta_j + \varepsilon_{ij}$$

Where: Y_{ij} = the response variable, μ = Overall mean, T_i = i^{th} treatment (test diets) effect, β_j = j^{th} block effect, ε_{ij} = the random error.

RESULTS AND DISCUSSION

Chemical composition of experimental feeds

The chemical composition of the treatment feed ingredients is given in Table 1. The roughages included to make the basal diets in this experiment; natural pasture hay, soybean straw and groundnut straw had different contents of crude protein which denotes their relative contribution as source of nutrients in the diet. The CP content of groundnut straw was 8.08%. This is a good indication that this oil crop straw could serve as a good source of roughage feed that can provide adequate CP content >7% for proper function of rumen microbes and to meet maintenance requirement of animals (Van Soest 1994), given other factors such as lignification does not limit feed digestibility and nutrient utilization. Soybean straw, however, contains lower CP (4.39%). The CP content of groundnut straw is lower than haricot bean haulms (9.1%) reported by Emebet (2008) but higher (6.8) than that reported by Dejene (2010). The value of CP content of groundnut straw in the current study is higher than that of widely used cereal crop residues such as maize stover (3.5%) reported by Dejene (2010).

The higher NDF content of soybean straw (86.37) and groundnut straw (70.70) categorize these roughage feed sources as low-quality feed, since roughage with NDF content greater than 65% is categorized as low-quality feed (Singh and Oosting, 1992). This might be due to the inherent characteristics of the species, the relative stage of maturity at harvest for the grain, the length of time stayed in the field after the grain matures, the residues management after harvest and threshing could remarkably affect the quality of the residues. As plants mature the cell wall constituent increase and therefore, the structural carbohydrates (cellulose and hemicelluloses) along with lignin increase and the percent of protein normally decrease (McDonald et al., 2002). Having high value of fiber component is the characteristics of most crop residues because of the high proportion of cell wall constituents and low level of proteins and rapidly degradable components. This

Table 1. Chemical composition (% on DM basis) of feed ingredients used for the feeding experiment.

Chemical composition	Feed ingredients			
	Natural pasture Hay	Soybean Straw	Groundnut. Straw	Toasted soybean grain
Dry Matter (DM)	93.99	93.34	93.39	95.57
Ash (DM)	9.77	8.46	5.33	6.69
Organic Matter (OM)	90.23	91.54	94.67	93.31
Crude Protein (CP)	7.12	4.39	8.08	41.27
Neutral Detergent Fiber (NDF)	79.53	86.37	70.70	43.67
Acid Detergent Fiber (ADF)	52.66	73.94	64.33	22.01
Acid detergent Lignin (ADL)	10.06	13.87	11.62	4.77

indicates poor nutritive value not capable of meeting microbial requirements in the rumen of animals (Van Soest, 1994).

Feed intake

The mean daily DM and nutrient intake of treatment diets is presented in Table 2. The mean total dry matter intake (TDMI) was higher (P<0.0008) in T3 than T2 and T5. This might be due to the higher CP content of the roughage feed in T3. Tegene et al (2001) confirmed an increase in total dry matter intake as the level of crude protein increases in the diet. The result of the DM intake in the current study was within the range of 2.5 to 3.9% of BW reported for various breeds of sheep and goats in the tropics (Devendra and Burns 1983), which was 2.93 to 3.69%. The higher and lower total DM intake in proportion to body weight (3.69%) and (2.93%) was recorded in T2 and T4, respectively. The higher intake in T2 is because of the low protein content of the soybean straw. Therefore, the sheep consumed the feed as much as the gut size could hold in an attempt to fulfill their nutrient requirements. Dry matter intake is considered as an important factor in the utilization of roughage by ruminant livestock and is a critical determinant of nutrient intake and performance in small ruminants (Devendra and Burns, 1983). The total roughage DM intake in the present study is higher than values reported for Arsi-Bale sheep fed with a basal diet of faba bean haulms (Ermiyas, 2008). The CP intake was significantly higher for T3 and T4. This is because of relatively higher level of CP content of groundnut straw as compared to other roughage feed. There was no significant difference between T1, T2 and T5.

Live weight change and feed conversion efficiency

Average initial body weight, final body weight and mean daily body weight gain are presented in Table 3. One to one ratio mixed natural pasture hay and ground nut basal diet (T3) showed improved (P<0.01) average daily body weight gain than when natural pasture hay mixed with soybean haulms in a similar ratio (T2). This may be due to the high DM and CP intake of the treatment group. There was, however, no statistically significant differences in final body eight between T1, T2, T4 and T5. Similarly, the FCE of the different treatment basal diets did not show differences (P<0.05).

In the current study the higher body weight gains in T3 than T2 and numerically higher gain in T4 compared to T1, T2 and T5 can be attributed to the basal diet consumed. This implies that the higher CP content of groundnut straw, digestibility and higher DM intake of this roughage feed resulted better daily gain than other treatment groups. The result indicates the best combination of natural pasture hay with groundnut straw as a basal diet could be one to one ratio. Mixing natural pasture hay with soybean straw in 50 and 75% proportion (T2 and T5) resulted in similar body weight as group consumed only hay basal diet. In general, body weight gain displayed by all treatment groups in the current study is similar to body weight gain reported for sheep consumed roughage basal diet and supplemented with different types of concentrate mixtures. Ermiyas (2008) found 55 to 87.8 g/day from Arsi-Bale sheep fed faba bean haulms and supplemented with linseed meal, barley bran and their mixtures. Similarly, Almaz (2008) found 51 to 63 g/day from local sheep fed finger millet supplemented with mixture of '*atella*' (by product of traditional brewery in Ethiopia) and noug seed cake in different proportions. The good body weight gain recorded for all treatments regardless of the difference that existed between groups consumed different types of basal diet could be related to the low level of supplemental soybean grain and molasses, which might have created favorable condition for rumen micro flora to grow both in population and types and degrade the fibrous feed efficiently. The type of microorganisms present in the rumen depends on the type of feed consumed, whereas the level of intake influences the number of microorganism present (Kellems and Church, 2002). Thus, higher intake will increase the population but lower intake declines their number, eventually affects digestibility of feeds and animal performance

Table 2. Daily dry matter and nutrient intakes of Gumuz sheep fed hay replaced with soybean or groundnut straw as a basal feed.

Parameter	Treatments						
	T1	T2	T3	T4	T5	SL	SEM
Feed DMI (g/day)							
TSG DMI	172.00	172.00	172.00	172.00	172.00	-	-
Roughage DMI	586.39[abc]	492.20[c]	744.44[a]	714.09[ab]	580.29[bc]	**	38.36
TDMI	758.39[abc]	664.20[c]	916.44[a]	886.09[ab]	752.29[bc]	**	38.34
TDMI (g/kg $W^{0.75}$)	67.32[ab]	60.35[b]	76.94[a]	77.18[a]	70.15[ab]	**	2.68
TDMI (%BW)	3.34[ab]	3.69[a]	2.98[b]	2.93[b]	3.23[ab]	**	0.14
Nutrient intake (g/day)							
CPI	104.84[b]	105.89[b]	127.69[a]	126.98[a]	98.07[b]	**	2.63
OMI	743.45[ab]	648.58[b]	890.84[a]	871.14[a]	751.19[ab]	**	37.51
NDFI	577.09[ab]	494.67[b]	688.96[a]	620.14[ab]	603.84[ab]	**	30.85
ADFI	370.35[b]	354.98[b]	513.36[a]	492.34[a]	479.34[a]	**	23.77
ADLI	75.77[c]	74.53[c]	108.25[a]	104.37[ab]	85.03[bc]	**	4.78

** significant at alpha 0.01; TGS: toasted soybean grain; TDMI: total dry matter intake; OMI: organic matter intake; CPI: crud protein intake; NDFI: neutral detergent fiber intake; ADFI: acid detergent fiber intake; ADLI: acid detergent lignin intake; SL: significance level; SEM: standard error of mean; T1: Natural pasture hay alone (control treatment); T2: 50% Natural pasture hay + 50% soybean straw; T3: 50% Natural pasture hay + 50% groundnut straw; T4: 25% Natural pasture hay + 75% groundnut straw;T5:25% Natural pasture hay + 75% soybean straw; BW: body weight. Figures with different superscripts with in a row are significantly different.

Table 3. Body weight change of Gumuz sheep fed natural pasture hay replaced with soybean or groundnut straw as a basal feed.

Body weight change	Treatments						
	T1	T2	T3	T4	T5	SL	SEM
Initial body weight (kg)	19.66[a]	19.30[ab]	19.00[abc]	18.23[c]	18.36[b]	**	0.24
Final body weight (kg)	25.23[ab]	24.57[ab]	27.23[a]	25.98[ab]	23.87[b]	**	0.73
ADG (g/day)	61.85[ab]	58.52[b]	91.48[a]	86.11[ab]	61.11[ab]	**	7.77
FCE (ADG/g DMI)	0.08	0.09	0.10	0.10	0.08	ns	0.008

** significant (p<0.01); ns: non-significant; ADG: average daily gain; FCE: feed conversion efficiency; SL: significance level; SEM: standard error of means; T1: Natural pasture hay alone (control treatment); T2: 50% Natural pasture hay + 50% soybean straw; T3: 50% Natural pasture hay + 50% groundnut straw; T4: 25% Natural pasture hay + 75% groundnut straw; T5:25% Natural pasture hay + 75% soybean straw. Figures with different superscripts with in a row are significantly different.

(McDonald et al., 2002).

Carcass characteristics

Slaughter weight, hot carcass and dressing percentage

Slaughter weight, hot carcass weight, and dressing percentage of the experimental animal are presented in Table 4. In this study there was a significant difference (p<0.005) in slaughter body weight among treatment groups. The higher slaughter body weight was recorded in T3 (26.5 kg) as compared to T2 and T5. This may be due to the higher DM and CP intake of the treatment group. The higher hot carcass weight was observed in T3 and T4. In this study no significance difference was observed in both slaughter and empty body weight basis.

Edible and non-edible carcass offals

The edible and non-edible offals content is presented in Table 5. In this study, there was significance difference (p<0.02) in total edible offal content (TEOC) between treatment groups, but there was no difference in total none edible offal contents (TNEOC).

SUMMARY AND CONCLUSION

A feeding study was conducted to evaluate the effect of replacing natural pasture hay with soybean or groundnut straw on feed intake, nutrient utilization, body weight change and carcass characteristics of Gumuz sheep at Pawe Agricultural Research Centre using thirty yearling intact male Gumuz sheep with initial BW of 18.91 ± 2.6 kg (mean ± SD). Toasted soybean grain (172 g DM) and

Table 4. Carcass characteristics of Gumuz sheep fed soybean or groundnut straw as a replacement for hay as a basal feed.

Variable	Treatments						
	T1	T2	T3	T4	T5	SL	SEM
Slaughter weight (kg)	24.75^{ab}	23.93^{b}	26.50^{a}	25.13^{ab}	22.93^{b}	**	0.59
Empty body weight (kg)	24.17^{ab}	23.47^{b}	25.95^{a}	24.66^{ab}	22.38^{b}	**	0.58
Hot carcass weight (kg)	9.72^{ab}	9.20^{ab}	10.30^{a}	10.23^{a}	8.57^{b}	**	0.33
Dressing percentage							
Slaughter weight base	39.10	38.41	38.83	40.69	37.30	ns	0.85
Empty body weight base	51.18	50.43	50.59	51.35	49.53	ns	0.87
Rib-eye area (cm^2)	7.33	7.65	7.23	8.22	6.90	ns	0.43

** Significant at p<0.01; ns: non-significant; SL: significance level; SEM: standard error of mean; T1: Natural pasture hay alone (control treatment); T2: 50% Natural pasture hay + 50% soybean straw; T3: 50% Natural pasture hay + 50% groundnut straw; T4: 25% Natural pasture hay + 75% groundnut straw; T5:25% Natural pasture hay + 75% soybean straw. Figures with different superscripts with in a row are significantly different.

Table 5. Carcass offals of Gumuz Sheep fed soybean or groundnut straw as a replacement for hay as a basal feed.

Traits	Treatments						
	T1	T2	T3	T4	T5	SL	SEM
Total edible offals (kg)	4.5^{ab}	4.0^{ab}	4.7^{a}	4.5^{ab}	3.9^{b}	*	0.2
Edible offal (% SBW)	17.9	16.9	17.7	18.0	16.9	ns	0.5
Total non-edible offal (kg)	10.6	10.7	11.5	10.3	10.5	ns	0.3
Total usable products (kg)	16.4^{abc}	15.5^{bc}	17.5^{a}	17.2^{ab}	14.6^{c}	**	0.5
Total usable products (%)	65.8^{ab}	64.7^{b}	66.2^{ab}	68.3^{a}	63.8^{b}	**	0.8

** significant at p<0.01; * significant at alpha 0.05; ns: non-significant; SBW: slaughter body weight; SL: significance level; SEM: standard error of mean; T1: Natural pasture hay alone (control treatment); T2: 50% Natural pasture hay + 50% soybean straw; T3: 50% Natural pasture hay + 50% groundnut straw; T4: 25% Natural pasture hay + 75% groundnut straw; T5:25% Natural pasture hay + 75% soybean straw. Figures with different superscripts with in a row are significantly different.

molasses (5% of daily feed offered) were given for all experimental animals. Randomized complete block design with five treatments consisting of six replications were used for the experiment. The experiment was conducted for ninety days after 15 days of acclimatization period. Data on feed quality, feed intake, growth performance were recorded. Animals were slaughtered at the end of experiments for carcass evaluation. The daily body weight gain of animals feed basal diets feed with 1:1 ratio mixed natural pasture hay and ground nut haulms (T3) (91.48 g/d) was the highest (p<0.014). Whereas T2 (58.5 g/d) exhibited lower daily body weight gain. There was no difference in FCE between treatments.

The hot carcass weight of sheep in T3 (10.30 kg) and T4 (10.23 kg) were higher (p<0.007) than sheep in the rest of the treatments. Dressing percentage expressed on slaughter weight and empty BW basis was not different (p>0.05) among treatments. There was no difference (p>0.05) in total non-edible offal components and rib eye area between treatments. Based on the results obtained mixture of natural pasture hay with groundnut straw in 1:1 and 1:3 ratio respectively, were found to be promising basal feeds in terms of body weight gain of Gumuz sheep under the situation of the current study.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Growth and carcass characteristics of Afar lambs at two concentrate levels supplementation and slaughter weights fed Tef Straw Basal Diet

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An experiment arranged in 2×2 factorial was carried out to evaluate the effect of concentrate levels, targeted live weights, and their interaction on live and carcass performance of Afar lambs. Forty yearling lambs were divided into 5 groups; one group was slaughtered at the beginning of the experiment and the other groups were randomly assigned to four treatments. Significantly (P≤0.05) higher dry matter intake DMI (740.38 g) was noted for lambs assigned to a higher (500 g) concentrate supplemented groups than 688.03 g recorded for lower (300 g) concentrate supplemented categories. Lambs finished for 30 kg live weight took longer (P≤0.001) feeding days (180) than the group targeted 30 kg slaughter body weight, which lapsed 91 days. Animals allotted to 500 g concentrate feed supplementation showed higher (P≤ 0.001) DWG (112.6 g) and FCE (0.15) than 300 g supplemented groups. The effect of concentrate levels and targeted body weights were significant on the majority parameters measured. It could be concluded that 500 g concentrate feed supplement and 30 kg target slaughter weight (T3) is the best strategy to finish yearling Afar lambs in 70 days of feeding for improved performance and economic of feeding.

Key words: Afar sheep, carcass, concentrate, slaughter weight, Tef straw.

INTRODUCTION

Sheep is an important farm animal in Ethiopia mainly as a source of income and food, varying with the socio-economic class of the people. There are 29.33 million sheep population in the country (CSA, 2014). However, sheep production in Ethiopia is mainly characterized by low input, and getting the production under the animal's genetic potential in terms of quantity and quality. Inadequate and poor quality feeds are among other constraints blamed to lower birth weight, weight gain, and slaughter weight of sheep and profitability of sheep farming in Ethiopia (Belete, 2009; Alemu, 2008).

The major available feed resources for sheep are crop residue, natural pasture grazing and hay, and industrial-by products which are either deficient in required nutrient or have lowest fibre that could not be enough for ruminant animals.

Tef is adapted to a large variety of environmental conditions and widely grown crop (Bereket et al., 2011). *Tef* straw is among crop residues available as feed resources for sheep production.

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However, dietary energy and protein content of Tef straw is not enough even for maintenance requirement of the animal. Most of the time Tef straw contains CP lower than 7%, which is the minimum requirement to support optimal microbial activity in the rumen (McDonald et al., 2002). There is a need to improve nutrient availability from Tef straw to maximize production from the animals. Afar sheep is one of the potential breeds for meat production for which improving utilization of easily accessible feed resources is imperative.

Concentrate feed supplementation is the one of the ways used to improve nutrient availability of Tef straw. Supplementation can be used to improve low quality and quantity feed resources by providing ideal environment for rumen microbes in order to improve fermentation, digestion and absorption (Olfaz et al., 2005). Small scale sheep fattening activities are being undertaken by concentrate supplementation on low quality feeds in different parts of Ethiopia targeting mainly seasonal domestic meat consumption or for export market.

Sheep fattening practices can be used to improve carcass yield and producers' income, and reduce the length of time needed to reach slaughter weight (Alemu, 2008). Moreover, according to McDonald et al. (2002), Olfaz et al. (2005) and Majdoub et al. (2013), nutritional levels are related to carcass yield, carcass quality and fat tissue development and composition. However, there is limited information on whether the growth and carcass characteristics of Afar sheep are differently influenced by concentrate feed level and body weight.

Therefore, it was worthwhile to evaluate growth performance and carcass characteristics of yearling Afar sheep finished at different target body weights and fed different concentrate levels supplementation on Tef straw basal diet.

The objectives of the study include evaluation of the growth performance, carcass characteristics and feed cost per unit gain of yearling afar sheep finished at 25 and 30 kg live weights and the determination of finishing duration and concentrate level supplementation for yearling afar sheep for the targeted market live weights.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at sheep research station of Debre Zeit Agricultural Research Centre, located at 45 km South East of Addis Ababa (08°44'N 38°,58'E; average altitude of 1900 m a.s.l), Ethiopia. The area is known for bimodal rainfall pattern with average annual rainfall of 845 mm and annual minimum and maximum temperature of 10 and 22°C, respectively. The area is characterized by mixed-crop livestock production system; with major crops grown include Tef (Eragrostis Tef), wheat, chick pea and lentil.

Experimental animals and diets

Forty yearling male Afar sheep were purchased from local market, ear tagged and de-wormed for parasite and vaccinated against sheep pox, Anthrax and Ovine pasteurellosis. Then, the animals were randomly assigned to 8 groups (block) of five animals based on their initial body weight, which was determined by two weighing average after overnight fasting at the end of the adaptation period of 15 days. The average initial body weight of experimental animals was 16.5 ± 0.26 kg (mean ± SD). One of the groups was slaughtered for initial carcass analysis and the others groups were kept and allotted to treatments in individual pens.

The concentrate feed was formulated from 39% wheat middling, 40% noug seed cake, 20% ground maize grain, and 1% common salt, on DM basis. The proportions of these concentrate feed ingredients were fixed based on practical preliminary observation to contain 22.7% CP, which resulted in better performance of sheep. Intact Tef straw was fed ad libitum to each animal, and also tap water was freely accessed.

Experimental treatments and design

Randomized complete block design (RCBD) with factorial arrangement of treatments was used to undertake feeding experiment. Four dietary treatments (two concentrate levels X slaughter weights) were arranged as: T1 = 300 g concentrate feed supplement and 25 kg target slaughter weight; T2 = 300 g concentrate feed supplement and 30 kg target slaughter weight; T3 = 500 g concentrate feed supplement and 25 kg target slaughter weight; T4 =500 g concentrate feed supplement and 30 kg target slaughter weight.

All animals were fed Tef straw ad libitum with 20% refusal and concentrate was given in equal quantity twice daily at 8 a.m. and 2 p.m according to plan.

Feed intake, live weight and feed conversion efficiency measurement

Once the feeding trial was commenced, data on feed offer and refusal were taken daily, the feed intake was calculated as the difference between feed offered and refused while live weight measurements were done at ten-day interval after overnight fasting, using a 100 kg movable weighing scale with a sensitivity of 0.5 kg. The average daily body weight gain was calculated as the difference between the initial and final live weight of the lambs divided by the number of experimental days. Feed conversion efficiency (FCE) of the lambs was determined as average daily body weight gain divided by average daily DM intake.

Carcass evaluation

When the animals reached about the target weight, feeding was stopped; animals were kept in fasting overnight then slaughtered for carcass evaluation. After slaughtering and flaying the skin the hot carcass weight and non-offal components were measured immediately. Hot carcass weight and non-offal components were measured immediately after slaughter. The carcass was chilled at 4°C for 24 h and weighed. It was then dissected, at median line into left and right half. The full reticulo-rumen was weighed using plastic buckets. The left carcass part of each animal was deboned using group of people and quantified as lean, fat and bone and multiplied by two to make whole carcass component.

Feed cost analysis

The feed cost per unit live weight gain was determined using the feed ingredients cost of each respective feed treatment divided by

Table 1. The DM intake of yearling Afar lambs as affected by concentrate levels and target live weights.

Factors	Measured variables			
	Straw DMI (g)	**Concentrate DMI (g)**	**Total DMI (g)**	**Feeding days**
Concentrate level effect				
300	404.6[a]	300[a]	704.6[a]	173[a]
500	274.7[b]	495.7[b]	770.4[b]	98[b]
Sig	***	***	*	***
Targeted weight effect				
25kg	321.9[a]	396.3[a]	718.3[a]	91[a]
30kg	357.3[a]	399.4[b]	756.7[a]	180[b]
Sig	NS	**	NS	***
Interaction effect				
T_1	377.6[a]	300[a]	677.6[a]	112[a]
T_2	431.6[a]	300[a]	731.6[a]	223[b]
T_3	266.3[a]	492.6[b]	759.0[a]	70[c]
T_4	283.0[a]	498.8[c]	781.7[a]	126[d]
Sig	NS	**	NS	***
CV	20.9	0.7	9.2	0

NS = non-significant (P≥ 0.05) *= significant (P≤0.05); **=significant (P≤0.01); *** = significant (P≤0.001); Sig=significance; CV= Coefficient of variance; [a,b,c,d] values with different superscripts within same row are significantly different.

live body weight for each respective treatment.

Data analysis

Data were analysed using SAS software program SAS (2002). Mean comparison was done using Duncan's multiple range test and significant differences between the treatment groups were declared at P≤ 0.05.

The model fitted to calculate the different parameters were:

Where, Yij = Response variables, μ = Over all mean, ai = ith effect of concentrate level, bj = jth effect of targeted body weight, (ai * bj) k = kth effect of concentrate level and target slaughter weight interaction if it was significant in the model and eijk = Effect of the ijkth random error.

RESULTS AND DISCUSSION

Feed and nutrient intake

The main and interaction effects of concentrate feed levels (CFL) and targeted market live body weights (LBW) on the average daily feed dry matter intake (DMI) are presented in Table 1. Concentrate feed levels affected the straw, concentrate (P≤0.001) and DMI intake (P≤0.01).

The effect of CFL was significant (P≤0.001) on feeding days which were the days waited for to attain the targeted body weight. The straw DMI of lambs was higher for lower (300 g) CFL supplemented groups than the higher (500 g) ones. The higher straw intake of animals was to fulfill the nutrient requirement from more straw eating. Higher total DMI was recorded for lambs were assigned for higher CFL supplemented groups.

Similar study has been reported that higher concentrate supplementation increased total DM intake in yearling sheep (Dessie et al., 2010). Formerly Getahun (2014) reported total DMI 710.6 g for Afar yearling sheep fed Tef straw, and 300 g concentrate feed supplement was partially similar to the present 731.6 g DMI. Contrary to the present result, DMI was reduced as the proportion of concentrate increased in the ration (Papi et al., 2011). In the present study the higher DMI of sheep at higher concentrate supplemented group was due to the fact that the palatability of concentrate was higher than the straw.

The lambs supplemented with lower concentrate level took longer days (173) to attain the required weight. This may be due to the limited nutrient intake. Target slaughter weight had no effect (P> 0.05) on straw and total DMI. The live body weight effect was significant on concentrate feed level DMI (P≤0.01) and days (P≤0.001) to reach the target body weight. The lambs reached market weight of 30 kg live body weight in 180 days of feeding than the 25 kg target slaughter body weight groups, which was attained in 91 days.

The Interaction effect of CFL and body weights was not significant (P≥ 0.05) on straw and total DMI. Concentrate intake and number of feeding days were influenced (P≤0.001) by concentrate levels and body weights interaction.

Feed intake trend of experimental animals is shown in Figure 1. Lambs registered high feed intake during the first 40 days, thereby decreased for 10 days and then,

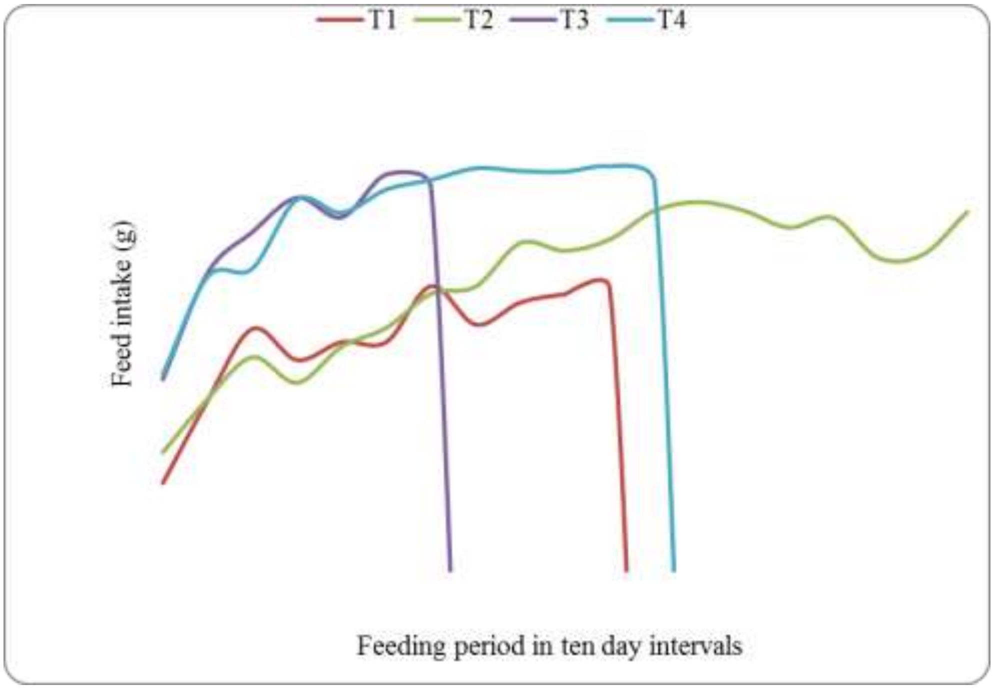

Figure 1. Trends of feed intake by experimental animals as affected by concentrate levels and target body weights.

increased up to the end of the feeding days; while this trend remained in the case of T2, and then increased inconsistently. Lambs fed on T3 showed higher feed intake during 50 days and thereafter increased inconsistently. However, the feed intake trend was similar in the case of T4 in first 50 days, but at lower rate thereafter.

The lowered feed intake rate for T1 in between could be due to environmental change, since the experiment started during dry season but terminated in wet season. The irregular feed intake trend of lambs in T2 also could be due to seasonal variability as the feeding experiment undertaken was in dry season and partly at the ending of rainy season. The lower feed intake trend at the end of experimental period in T3 and T4 could be because the animals got saturated energy density from high amount of concentrate feed.

Table 2 illustrates the main and interaction effects of concentrate level and target slaughter weights on energy, crude protein, calcium and phosphorous intake of yearling ram lambs. The CFL effect was significant ($P \leq 0.001$) on energy, crude protein (CP), calcium (Ca) and phosphorous (P) intake. Lambs that received 500 g concentrate level showed higher energy, CP and P intake. Calcium intake of experimental animals was lower for higher concentrate supplemented groups. Crude protein intake was higher ($P \leq 0.05$) in lambs slaughtered at 30 than at 25 kg live weight. Phosphorus intake was higher ($P \leq 0.05$) for higher slaughter weight categories as compared to the lower groups. There was no interaction effect ($P \geq 0.05$) on nutrient intake.

The higher energy, CP and P intake was due to higher amount of concentrate feed intake and higher concentration of these nutrients in the offered concentrate feeds. The higher Ca intake from lower concentrate feed supplemented groups was unjustifiable.

Live body weight change and feed conversion efficiency

The main and interaction effects of concentrate levels and target slaughter weights on body weight change and feed conversion efficiency (FCE) of yearling ram lambs is presented in Table 3. The initial, final and total body weight gains of the experimental animals were not statistically different ($P \geq 0.05$) between concentrate level groups. The main effect of concentrate level was significant ($P \leq 0.001$) on daily body weight gain and FCE. Animals allocated to 500 g supplemented group showed higher daily body weight gain and FCE than those in 300 g supplemented categories. This was because the experimental animals got higher amount of nutrients from more dry matter intake. In agreement with the present study, Eligy et al. (2014) reported higher body weight gain of sheep at higher level of concentrate supplement. The main target slaughter body weight effect was significant ($P \leq 0.001$) for final body weight, total body weight gain, daily body weight gain and FCE. The final body weight gain and total body weight gain of

Table 2. Energy, CP, Ca and P intake of lambs as affected by concentrate levels and slaughter weights.

Factor	Measured variables							
	Energy intake		CP intake		Ca intake		P intake	
	MJ	/kgDMI	g	%	g	%	g	%
Concentrate level effect								
300	6.5[a]	9.3[a]	85.4[a]	12.2[a]	1.8[a]	0.3[a]	1.2[a]	0.18[a]
500	8.2[b]	10.6[b]	1 25.1[b]	16.3[b]	1.4[b]	0.2[b]	1.9[b]	0.25[b]
Sig	***	***	***	***	***	***	***	***
Targeted weight effect								
25kg	7.2[a]	10.0[a]	104.2[a]	14.5[a]	1.5[a]	0.2[a]	1.6[a]	0.22[a]
30kg	7.5[a]	9.9[a]	106.3[b]	14.0[a]	1.7[a]	0.2[a]	1.6[b]	0.21[a]
Sig	NS	NS	*	NS	NS	NS	*	NS
Interaction effect								
Sig	NS	NS	NS	NS	NS	NS	NS	NS
CV	6.3	2.8	2.7	6.2	16	7.1	2.2	6.7

MJ= Megajule, ME= Metabilizable energy, CP=Crude protein, Ca= Calcium and P= Phosphorous, sig= significance; NS = non-significant (P≥ 0.05) *= significant (P≤0.05); *** = significant (P≤0.001); Sig=significance; CV= Coefficient of variance; [a,b,c,d] values with different superscripts within same row are significantly different.

Table 3. The body weight change of yearling Afar lambs as affected by concentrate feed levels and targeted body weights.

Factors	Measured variables				
	IBW (kg)	FW (kg)	TWG (kg)	DWG (g)	FCE
Concentrate levels effect					
300	16.50[a]	27.11[a]	10.61[a]	64.50[a]	0.09[a]
500	16.66[a]	27.29[a]	10.64[a]	112.60[b]	0.15[b]
Pr > F	0.7911	0.7745	0.9629	<.0001	<.0001
Sig.	NS	NS	NS	***	***
Targeted weights effect					
25kg	16.62[a]	25.11[a]	8.57[a]	100.33[a]	0.14[a]
30kg	16.53[a]	29.30[b]	12.67[b]	76.76[b]	0.10[b]
Pr > F	0.8737	<.0001	<.0001	<.0001	<.0001
Sig.	NS	***	***	***	***
Interaction effect					
Pr > F	0.5657	0.7191	0.2888	0.3071	0.4968
Sig.	NS	NS	NS	NS	NS
CV	10.1	6.6	14.1	14.7	13.7

experimental animals were higher at 30 kg target slaughter body weight than the 25 kg ones. Daily body weight gain (DWG) and FCE was higher for 25 kg targeted groups than the 30 kg market body weight categories. The interaction effect was not significant (P≥ 0.05) on all body weight change parameters. Higher DWG and FCE recorded for lower body weight experimental animals could be because for the younger and smaller sized animals the body weight gain rate was higher.

The body weight trend of experimental animals is shown in Figure 2. Those lambs assigned to T1 group had no increasing body weight during the first forty days; then it increased at the end of feeding days with a little

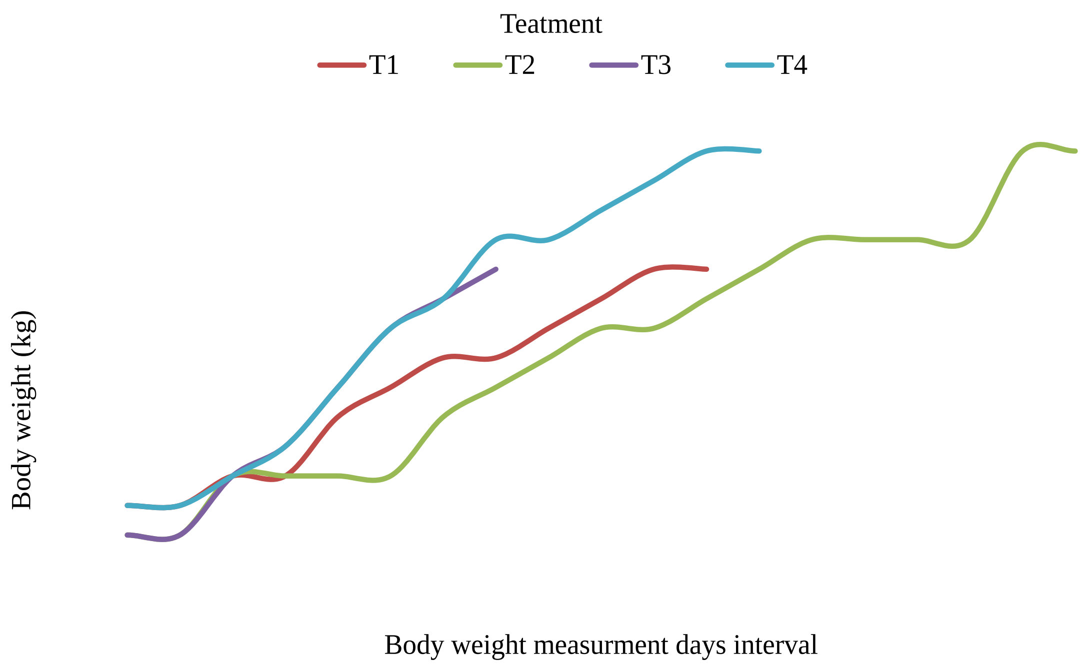

Figure 2. Trends of experimental animals' body weight change as affected by concentrate levels and target body weights.

bite up and down trend. In T2 the feed intake trend did not increase during the first 20 days and then, from onwards it increased with higher rate until the end of the experimental days. Lambs supplemented 500 g concentrate feed and targeted for 25kg market live body weight (T3) showed increasing body weight with higher rate except a little bit slower rate at the end of experiment. The body weight change trend in T4 increased all the time with down rate between 70 and 90 days and highest rate after that up to the end. From this body weight change trend one could say that higher body weight gain rate can be achieved within short feeding time by supplementing with higher amount of concentrate feed for growing yearling lambs.

Carcass yield and non-carcass components

Carcass yield parameters as affected by concentrate levels and targeted body weights and their interaction are show in Table 4. The concentrate level main effect was not significant (P≥0.05) on all carcass yield parameters except for trimmings. In disagreement with the present study Melese et al. (2017) reported that sheep consuming high level of concentrate supplement had significantly heavier carcass weight than supplemented in the low level. There are no similar responses of sheep for concentrate levels in terms of carcass yield between the present and previous study. This could be due to breed and environmental variation, and the concentrate level difference was not big enough to show considerable carcass yield differences. The slaughter weight, hot and cold carcass weight, dressing percentage (DP), carcass lean, fat and bone varied (P≤ 0.001) between targeted body weights. The yearling Afar lambs finished for 30 kg target slaughter body weight showed higher slaughter body weight, DP, carcass weight, carcass lean, fat and bone weight. The proportion of carcass lean and bone was similar (P≥0.05) between the two targeted body weights whereas, the carcass fat proportion was higher (P≤ 0.05) for lambs targeted for 30 kg body weight than the 25 kg body weight targeted lambs and initially slaughtered animals. This could be related with experimental animals got higher dietary energy from higher concentrate feed and stayed for longer time in feedlot. In line with the present report Majdoub et al. (2013) stated that higher lamb slaughtered weight resulted in more carcass yields.

Interaction effect was not significant (P≥0.05) on all carcass yield parameters except for carcass bone weight and carcass lean proportion. The carcass bone weight was higher (P≤ 0.01) for the 300 g concentrate feed supplemented and 30 kg target slaughter body weight interaction groups (T2). The carcass lean proportion was smaller (P≤ 0.01) for the interaction of 500 g concentrate feed supplement and waited for 25 kg target body weight (T3). The heavier bone recorded for T2 could be related with stayed longer time in feedlot with lower concentrate feed developing heaver bone.

Non-carcass components of finished Afar sheep as

Table 4. The carcass yield of lambs as affected by concentrate levels and body weights

Factors	Measured variables										
	SW (kg)	CW (kg)		DP	Trimming	Lean	Fat	Bone	Proportion (%)		
		Hot	Cold						Lean	Fat	Bone
Concentrate effect											
300g	26.8^{a}	12.3^{a}	10.4^{a}	39.6^{a}	279.9^{a}	5.8^{a}	1.7^{a}	2.4^{a}	55.8^{a}	16.2^{a}	22.6^{a}
500g	26.9^{a}	12.6^{a}	10.6^{a}	40.3^{a}	400.6^{b}	5.9^{a}	1.8^{a}	2.3^{a}	55.2^{a}	16.9^{a}	22.2^{a}
Sig	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
Target weight effect											
25kg	24.8^{a}	10.9^{a}	9.2^{a}	37.8^{a}	348.8^{a}	5.0^{a}	1.4^{a}	2.1^{a}	55.1^{a}	15.2^{a}	23.1^{a}
30kg	28.9^{b}	14.0^{b}	11.8^{b}	42.1^{b}	331.8^{a}	6.6^{b}	2.1^{b}	2.6^{b}	55.9^{a}	18.0^{b}	21.7^{a}
Sig	***	***	***	***	NS	***	***	***	NS	*	NS
Interaction											
Initial	16.0^{a}	5.6^{a}	5.5^{a}	34.9^{a}	278.1^{a}	3.2^{a}	0.2^{a}	1.7^{a}	57.8^{a}	3.8^{a}	31.4^{a}
T_1	24.6^{a}	9.1^{a}	8.9^{a}	36.9^{a}	256.2^{a}	5.1^{a}	1.4^{a}	1.9^{b}	57.5^{a}	15.7^{a}	22.4^{a}
T_2	28.9^{a}	12.3^{a}	12.0^{a}	42.4^{a}	303.8^{a}	6.5^{a}	2.0^{a}	2.7^{c}	54.2^{ab}	16.8^{a}	22.8^{a}
T_3	25.0^{a}	9.7^{a}	9.5^{a}	38.8^{a}	441.5^{a}	5.0^{a}	1.4^{a}	2.2^{d}	52.7^{b}	14.6^{a}	23.8^{a}
T_4	28.9^{a}	12.0^{a}	11.7^{a}	41.7^{a}	358.9^{a}	6.7^{a}	2.2^{a}	2.3^{d}	57.7^{a}	19.1^{a}	20.5^{a}
Sig	NS	NS	NS	NS	NS	NS	NS	**	**	NS	NS
CV	7.2	9.4	9.7	6.4	45.5	11.7	28.8	12.1	6.8	26	11.7

IBW= initial body weight; FW=final body weight; TWG= total weight gain; DWG=daily weight gain; FCE= feed conversion efficiency; Sig=significance; NS = non-significant (P≥ 0.05); *** = significant (P≤0.001); CV= Coefficient of variance; [a,b,c,d] values with different superscripts within same row are significantly different.

affected by concentrate levels and targeted body weights and their interaction are shown in Table 5.

The concentrate level main effect was not significant (P≥0.05) on all non carcass components except on kidney fat and liver weights. Except spleen, heart and testicles weight non- carcass components were affected significantly (P≤ 0.001) by targeted body weights. Interaction effect was not significant (P≥0.05) almost on all non-carcass components. The higher carcass yield recorded from heaver lambs is expected and again it could be related with higher nutrient intake. Except proportion of carcass lean all carcass and non-carcass parameters were lower for lambs slaughtered initially than the experimental lambs slaughtered after feedlot.

Feed cost analysis

The analysis of cost in feedlot as affected by concentrate levels and targeted body weights and their interaction are shown in Table 6. The effect of concentrate levels and targeted body weights main (P≤0.001) and their interaction (P≤0.05) were significant on feed cost per kg body weight gain. The feed cost per kg body weight gain for 300 g concentrate supplement was higher than for 500 g concentrate supplemented groups. The 30 kg targeted market body weight was required high feed cost per body weight gain than the 25 kg ones. Total feed cost was higher for 300 g concentrate feed level and 30 kg body weight interaction groups (T2) than T1 and T4 followed by T3 interaction categories. Lambs in T3 showed less feed cost per unit body weight gain as compared with the other groups. This was due to highest weight gain of lambs at higher concentrate supplementation (T3) groups within short feeding time.

Conclusion

Concentrate level and target slaughter weight main effects were significant on BWG and FCE, but the interaction effect was not significant on body weight change. Animals allocated to 500 g supplemented group showed higher BWG and FCE than 300 g supplemented categories. It could be concluded that 500 g concentrate feed supplement and 25 kg slaughter body weight (T3) is the best strategy for finishing of Afar sheep yearling lambs in 70 feeding days for better average DWG, FCE, carcass yield and less feed cost per weight gain.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

Table 5. The non-carcass components of lambs as affected by concentrate levels and body weights.

Factors	Measured variables											
	Full gut (kg)	**Empty gut (kg)**	**Kidney (g)**	**Kidney fat (g)**	**Spleen (g)**	**Lung(g)$^{\$}$**	**Heart(g)**	**Liver (g)**	**Skin (kg)**	**Head (kg)**	**Testicles(g)**	**Tail fat (kg)**
Concentrate effect												
300 g	6.9^{a}	2.0^{a}	138.7^{a}	105.7^{a}	64.7^{a}	376.8^{a}	103^{a}	310.6^{a}	2.7^{a}	1.5^{a}	423.8^{a}	1.6^{a}
500 g	6.8a	1.9^{a}	69^{b}	82.7^{a}	65.0^{a}	345.6^{a}	103^{a}	379.4^{a}	2.6^{a}	1.4^{a}	404.0^{a}	1.8^{a}
Sig	NS	NS	***	NS	NS	NS	NS	***	NS	NS	NS	NS
Target weight effect												
25 kg	6.4^{a}	1.7^{a}	65.3a	60.7^{a}	62a	326.9^{a}	97.8^{a}	330.6^{a}	2.4^{a}	1.3^{a}	394.5^{a}	1.5^{a}
30 kg	7.3^{b}	2.2^{b}	143.1^{b}	127.8^{b}	67.7^{a}	395.5^{b}	108.2^{b}	359.4^{b}	2.8^{a}	1.6^{b}	433.3^{a}	1.8^{a}
Sig	***	***	***	***	NS	***	***	***	NS	*	NS	NS
Interaction effect												
Initial	5.5^{a}	0.9^{a}	38.5^{a}	7.5^{a}	23.4^{a}	216.9^{a}	71.3^{a}	178.6^{a}	1.3^{a}	1.1^{a}	171.2^{a}	0.5^{a}
T_1	6.4^{b}	1.7^{b}	62.5^{a}	65.3^{b}	60.6^{b}	364.5^{b}	91.5^{b}	287.5^{b}	2.5^{b}	1.3^{b}	391.7^{b}	1.5^{b}
T_2	7.4^{b}	2.2^{b}	215.0^{b}	146.2^{b}	68.9^{b}	389.1^{c}	114.5^{b}	333.6^{b}	2.9^{b}	1.7^{c}	455.7^{b}	1.7^{c}
T_3	6.4^{b}	1.7^{b}	68.1^{a}	56.1^{b}	63.5^{b}	289.4^{c}	104.2^{b}	373.7^{b}	2.4^{b}	1.3^{b}	397.1^{b}	1.5^{bc}
T_4	7.2^{b}	2.1^{b}	71.2^{a}	109.2^{b}	66.6^{b}	401.8^{c}	101.8^{b}	385.2^{b}	2.8^{b}	1.5^{d}	410.9^{b}	2.0^{d}
Sig	NS	NS	***	NS	NS	*	NS	NS	NS	*	NS	*
CV	13.1	15.1	54.4	74.3	33.2	16.4	19.7	8.6	10.3	8.5	17.2	26.0

Sig= significance; NS = non-significant ($P \geq 0.05$) *= significant ($P \leq 0.05$); *** = significant ($P \leq 0.001$); \$= Lung with trachea.

Table 6. Feed cost analysis as affected by concentrate feed levels body weights.

Factors	Cost (Birr)					
	***Tef* straw**	**Wheat bran**	**Noug cake**	**Maize**	**Total feed**	**Feed cost/kg BW**
Concentrate level effect						
300	386.34^{a}	152.04^{a}	178.22^{a}	77.98^{a}	794.58^{a}	73.50^{a}
500	145.97^{b}	142.15^{b}	166.63^{b}	72.90^{b}	527.65^{b}	48.93^{b}
Sig	***	***	***	***	***	***
Targeted weight effect						
25kg	163.81^{a}	99.44^{a}	116.56^{a}	51.00^{a}	430.81^{a}	51.73^{a}
30kg	368.50^{b}	194.75^{b}	228.28^{b}	99.87^{b}	891.42^{b}	71.30^{b}

Table 6. Contd.

Sig	***	***	***	***	***	**
Interaction effect						
T_1	227.38[a]	98.15[a]	115.05[a]	50.33[a]	490.90[a]	60.49[a]
T_2	545.31[b]	205.94[b]	241.39[b]	105.61[b]	1098.25[b]	86.51[b]
T_3	100.23[c]	100.74[c]	118.10.52[c]	51.66[c]	370.71[c]	42.45[c]
T_4	191.70[a]	183.57[d]	215.18[d]	94.14[d]	684.59[d]	55.40[a]
Sig	***	***	***	***	***	*
CV	22.8	0.4	0.4	0.4	9.2	14.7

BW = Body weight; Sig = significance; * = significant (P≤0.05);** = significant (P≤0.01); *** = significant (P≤0.001); Sig=significance; CV= Coefficient of variance.

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The prevalence of foot related problems in working donkeys and its implication on the livelihood of donkey owners in Hawassa City, Southern Ethiopia

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A cross sectional study was conducted from April 2014 to April 2015 to assess foot related problems in working donkeys and their effects on the owners' livelihood in Hawassa City. The hoof problems in donkeys included hoof abnormality, apparent lameness or standing lameness. 369 owners owned 1 to 5 donkeys, 161 (43.35%) and 1(0.3%). 14(3.8%), 6(1.6%), 211(57.2%) and 138(37.4%) were illiterate, educated in religion, had elementary education and completed high school. The owners had 3 to 5 years' experience. 139(37.7%) donkeys had foot related problems. Hoof over-growth was the highest cause of foot problem (12.46% prevalence) followed by hoof abscess (9.2%). The owners' educational status and work experience were statistically and significantly associated with foot problem in donkeys (P=0.002) and (P=0.000). The number of days the donkeys work weekly and amount of weight they carry were also statistically and significantly associated with foot problems (P=0.044) and (P=0.008). The level of dependency of household on cart pulling donkey was not statistically and significantly associated with the foot problem. The age and body condition score of the donkeys were also significantly associated with the prevalence of lameness (P=0.013) and (P=0.011). The average annual financial earnings from a donkey with and without foot problem were 10,271.00 Ethiopia Birr (ETB) (513.55$) and 12,536.00 ETB (626.8$). The monetary loss from foot problems per a donkey yearly was 2469 ETB (123.45 US$) assuming the life expectancy of donkeys was calculated as a loss. Each donkey owner loses 45,614 ETB (2280.7US$) per donkey averagely due to culling of the donkey. The foot problems did not only affect donkeys, but also the living standard of the people depending on them. A systematic approach should be made to enhance donkeys' health and the livelihood of people engaged in it.

Key words: Cart pulling donkeys, financial loss, foot problems, Hawassa city, livelihood.

INTRODUCTION

Ethiopia possesses about 6.4 million donkeys (CSA, 2012), which is the largest in Africa. Despite this huge number of donkeys, its role in terms of economic contribution to the country and community is very limited due to various constraints. The common constraints include poor production and management system, poor

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development of the working condition, various types of diseases, and inadequate information on the epidemiology of donkey diseases (Ento, 2005). In Ethiopia, diseases are among the causes of high economic losses and leading to low productivity of donkeys (Jones, 2006). Hoof related problem is one of the problems that affect the welfare of donkey and livelihood of the owners, particularly, those depending on donkeys alone (Feseha et al., 2004; Aboud et al., 1998). Studies to elucidate the magnitude of this problem are lacking. Such information would be useful for designing strategies that would help to improve donkey health and welfare (Feseha et al., 2004).

In Ethiopia donkeys are used as a means of transporting a range of products; they help for rapid transportation of much quantity goods to the market than foot. Donkeys are reliable means of transportation as they provide a door to door transport service, where mechanized transportation cannot deliver due to poor infrastructure. Moreover, donkeys help to transport perishable products such as vegetables, milk and eggs safely with less damage than with other means of transport (Pearson et al., 2001).

Working donkeys play a central role in the livelihoods of many people across the world, and are often peripheral or invisible to others. For instance, in Ghana the main reason donkeys were kept was for transportation (91% of respondents) of household resources such as water, building materials, farm inputs and farm produce that might have otherwise been carried by women and children over long distances (Avornyo et al. 2015). According to Upjohn and Valette 2014, donkeys were used to bring in feed for the other livestock species and also carry sick animals to the veterinary clinic. Fielding and Krause (1998) remarked that pack donkeys alleviated the work of women farmers by carting farm produce over long distances; which clearly indicated the significant socio-economic contribution of this animal to the poor rural community. The role of donkeys varies from place to place, over time and between those who use them, even within the same household or small community. Working animals are the bases for the livelihood of households and they maintain or enhance other livelihood assets (Wade, 2014). According to Avornyo et al. (2015), having a donkey could earn the owner a mean annual income of US$110.06 from using the donkey for transport of various loads, and hiring out the donkeys to other people that could also earn a mean of US$70.56 for the household. In addition, manure from the donkey can be sold for a mean of US$28.27 in Ghana.

Despite donkeys' several contributions to the socio-economy in Ethiopia, their health and welfare problems are wide spread. According to Molla et al. (2017), the common health problems were skin problems, musculo-skeletal problem, wounds and behavioral abnormalities in Hawassa city that affect donkeys and livelihood of owners. These problems are not only affecting donkeys but also the livelihood bases of the households dependent on them. But there is no study in Ethiopia on the contribution of donkeys to the livelihood of their owners. Furthermore, no study estimates the loss due to their health problems in general and foot related problems, in particular. Therefore, the purpose of this study is to investigate the contribution of cart pulling donkeys to their owners and the impact of foot related problem on the livelihood of the owners in the study area.

MATERIALS AND METHODS

Study area and population

This study was conducted in Hawassa City from April 2014 to April 2015. Hawassa is located at an altitude of 1708 m above sea level; and with an average annual rain fall of 997.6 mm and mean annual temperature of 25°C. The study population was all cart pulling donkeys residing in all the 8 sub-cities of Hawassa. The study animals were selected by systematic random sampling technique from donkeys coming to veterinary clinics, gathered at market places waiting for working and resting places.

Sampling method and sample size determination

The sample size was calculated taking the 40.2% prevalence of lameness for donkeys reported by Teshome (2014), and then computed using the formula described by Thrustfield (2005). The study considered 95% confidence level and 5% desired absolute precision. Accordingly, a total of 369 donkeys and donkeys' owners were engaged for the study.

Data collection methods

Interview schedule

Structured questionnaire was administered to randomly selected donkey owners. The interview was based on the willingness of the owners to participate; informed verbal consent was obtained. The questionnaire covered various areas like awareness about foot health care and management, the daily earning and expenses for working on cart pulling donkeys and the types and duration of occurrence of foot related problems and costs for managing and treating foot related problems. The occurrence of foot related problems, costs associated with them and absenteeism from work due to foot related problems for the last one year (April 2014 to April 2015) were also included.

Observation and clinical examination of foot related problems

The donkeys were critically observed and clinical diagnosed both at rest and in locomotion for the occurrence of any foot related problems during the study period, April, 2014 to April, 2015. Both visualization and palpation of the musculoskeletal system were conducted in clinical examination. The visualization of the donkeys was conducted by visualizing the donkeys at side, in front and behind both at rest and in motion followed by friendly approach to the donkeys (Hodgson and Rose, 2000). The donkeys that showed any clearly impaired movement with uneven length and timing and those reluctant to bear weight on one or more limb were considered as having foot related problems. The skeleton and joint of the donkeys were palpated from distal to proximal, noting the presence of pain responses, swelling and wounds. Donkeys were handled as per ethical consideration of The Donkey Sanctuary, Ethiopia.

The contribution of donkeys and implication of lameness

The contribution of donkeys to the livelihood of the owners was assessed through what the owners are earning as incomes generated from the cart pulling donkeys business. Whereas, the financial loss due to foot related problems was determined through loss either by direct financial loss or absenteeism from work or additional costs incurred for managing and treating it. The financial loss due to culling of donkeys as a result of severe foot related problems were also taken into consideration in assessment of financial loss due to foot related problems. The computation was conducted taking into account the one year period, from April 2014 to April 2015.

Data management and analysis

All collected data were entered into Microsoft Excel spread sheet, and then summarized by using descriptive statistics like mean and percentage. Pearson's Chi-square (χ^2) test was used to test the association between variables. Benefit-cost ratio was used to analyze the monetary earning of non-lame cart pulling donkeys, and the actual (net) monetary benefit per year was also calculated. The net income/financial earning generated by the non-lame cart pulling donkey was calculated by subtracting the average gross annual money incurred by the owner (direct or indirect) to use for cart pulling from average gross annual income generated by the non-lame cart pulling donkey. The direct monetary loss due to lameness was calculated by multiplying the average frequency of lameness per year/ days of absenteeism from work due to lameness to obtain total days of absenteeism from work per year. This result was then multiplied by money earned per day for each donkey owner and treatment cost for lameness was added to it. Money loss due to culling as a result of foot related problems was calculated by considering the age of the donkey at culling, the life expectancy of the donkey and annual income generated by non-lame cart pulling donkey. The trend of cart pulling business was obtained by interviewing the owners.

RESULTS

Questionnaire introduced to the 369 donkey owners was fully responded to and submitted. Their cart pulling donkeys (n=369) were examined for lameness. From a total of 369 cart pulling donkeys examined, 139(37.7%) had foot related problems

Cart donkey owners' characteristics

All respondents of cart pulling donkey owners were males; and the age of 85.9% of the respondents were between 21 to 30 years. Among 369 respondents of cart donkeys owners, 161 (43.6%), 167 (45.3%) and 41 (11.1%) of them possessed one, two and three and more donkeys. About 345 (93.5%) of the respondents were fully dependent on their cart pulling donkeys for their households livelihood. The educational status of respondents included completed high school 138 (37.4%), completed elementary school 211 (57.2%) and illiterate 20 (5.4%). Working days and working hours of the respondents and cart pulling donkeys were more or less similar (Table 1).

The prevalence of foot related problems

From 369 cart pulling donkeys examined for foot related problems, 139 (37.7%) were found with one or more of foot related problems. The major types and causes of foot related problems and their proportion are shown in Table 1.

Risk factors associated with the occurrence of foot related problems

Among the various risk factors considered, the body condition score, weight carried at a time and the work experience of the owners were found to be statistically and significantly associated with the occurrence of foot related problems in donkeys. A detail of the results observed during this study is shown in Table 2.

The contribution of donkeys for the livelihood of the owners

The maximum and minimum working days of cart pulling donkeys were seven and five days per week, respectively. According to the respondents the average working hours was 8 h per day. The minimum and maximum income of the cart pulling donkey owners per hour was 4 and 45 Ethiopian Birr (ETB), respectively. Considering, a donkey working on average for eight hours daily, the minimum and maximum income of the owners was 32 and 360 ETB per day, respectively. The result from the respondents revealed that the average daily income was 124 ETB. The average working days/week was 5 days, and hence, the average working days/month was 20 days. Since, there are 12 months in a year; the average working days in a year were 240 days. The overall annual income of cart pulling donkey owners was computed to be 29,760 ETB (1488 US$) in Hawassa City during the study period (Table 3).

Average annual net contribution of the donkey to the owner was 12,536 ETB (626.8 US$). The benefit-cost ratio obtained by dividing annual earn from non-lame cart pulling donkey to the cost incurred by the owner for this business was 1.72. The ratio being greater than 1, cart pulling business has higher financial earning than cost incurred for the business. The benefit in this study indicates the financial earn, but not the actual benefit of the cart pulling business as there are other factors which affect the actual benefit to be earned. The exchange

Table 1. Major types and causes of foot related problems cart pulling donkeys in Hawassa, April, 2014 to April 2015.

Causes of lameness	No of lame donkeys	Prevalence (%)	95 % CI
Posture and gait abnormality	2	0.5	-0.2 - 1.3
Hoof over growth	46	11.7	8.4 - 14.9
Hoof abscess	34	9.2	6.2 - 12.2
Broken forward	1	0.3	-0.3 - 0.8
Arthritis	14	3.8	1.8 - 5.8
Dislocation	2	0.5	-0.2 - 1.3
Apparently lame	5	1.4	0.2 - 2.5
Fracture	1	0.3	-0.3 - 0.8
Muscular problem	20	5.4	3.1 - 7.7
Wound on the leg	14	3.3	1.4 - 5.1
Overall	139	37.7	32.7 - 42.6

Table 2. Risk factors associated with the occurrence of foot related problems of donkeys in Hawassa, April 2014 to April 2015.

Risk factor	Level of risk factor	No examined	Lameness number (%)	95% CI	$\chi 2$	P-Value
Age	< 6 years	65	17 (26.2)	15.4-37.0		
	6-10 years	269	105 (39.0)	33.2-44.9		
	> 10 years	35	17 (48.6)	31.7-65.4	5.66	0.059
BCS	2	26	11 (42.3)	22.9-61.7		
	3	238	101 (42.4)	36.1-48.8	8.93	0.011
	4	105	27 (25.7)	17.3-34.1		
Weight carried	≤ 100Kg	313	109 (34.8)	29.5-40.1		
	≥ 100 Kg	56	30 (53.6)	40.3-66.8	7.11	0.008
Working days^D	5 days	26*	7 (26.9)	9.4-44.4		
	6 days	330	124 (37.6)	32.3-42.8		
	7 days	13*	8 (61.5)	33.9-89.2		
Work hours per day^D	6 h	3*	1 (33.3)	-	-	-
	8 h	147	48 (32.7)	25.2-40.3		
	10 h	219	90 (41.1)	34.5-47.6	2.67	0.102
Work experience^O	3 year	175	92 (52.6)	45.1-60.0	32.56	0.000
	4 years	158	41 (25.9)	19.1-32.8		
	≥ 5 years	36	6 (16.7)	4.3-29.1		
No donkeys possessed^O	1	161	62 (38.5)	30.9-46.1	1.39	0.498
	2	167	65 (38.9)	31.5-46.4		
	≥ 3	41	12 (29.3)	15.1-43.4		

* Not analyzed due to smaller sample size (≤ 30); Superscript D=Donkey, and O=Owner.

rate of 20 ETB for 1US$ was considered.

Financial loss due to foot related problems

The foot related problems were leading to financial loss in two categories: one by absenteeism from work and another by treatment and management cost and culling of severely affected donkeys by foot related problems.

Financial loss due to absenteeism from work

The minimum and maximum days of absenteeism work from due to foot related problems during the study time period was 5 and 30 days, respectively. The average

Table 3. Mean monthly and annual financial income from cart pulling donkey to owners from non-lame donkeys in Hawassa from April, 2014 to April, 2015.

Average working hours/day	8 h
Maximum income/hour	45 ETB
Minimum income/hour	4 ETB
Maximum income/day	Maximum income/day*Maximum income/hours =360 ETB
Minimum income/day	Minimum income/day*Minimum income/hours =32 ETB
Average income/day	124 ETB
Annual average income/year	29,760 ETB(1488 US$)[by then exchange rate]
Average annual cost incurred by the donkey owner for cart pulling donkey	17,224 ETB (861.2 US$)
Average annual net income/year/donkey.	12,536 ETB (626.8 US$)
Cost benefit ratio of working on cart puling donkeys	1.72

[by then exchange rate] The exchange rate of 20 ETB for 1US$ was considered.

Table 4. Financial losses due to foot related problems in working donkeys in Hawassa, April 2014 to April, 2015.

Average days of work absenteeism per foot related problems	9 DAYS
Average frequency of foot related problems per year	2 TIMES
Total days of work absenteeism per year	18 DAYS
Average money earned per day	124 ETB
Average money lost due to work absenteeism/year	2232 ETB
Average annual treatment cost per donkey per year for foot related problems alone per donkey	33 ETB
Average financial loss due to culling (scenario 1=life time expectancy)	203.83*
Average financial loss due to culling (scenario 2= donkey market price estimation)	8.03**
Average annual financial loss due to foot related problem **=** Financial loss due to work absenteeism + financial loss due to treatment + financial loss due to culling	2469 ETB(123.45 US$)* 2273 ETB (113.65 US$)**
Financial income from a cart pulling donkeys without lameness/year (from Table 3)	12536 ETB (626.8 US$)
Average annual net benefit from lame donkey (average net annual contribution of non-lame cart pulling donkey (table 5)-average annual loss due to foot related problems)	10067 ETB (503.35 US$)

*scenario one was assumed to work in the study area.

absenteeism from work of donkeys due to foot related problems was 9 days. The average recurrence of foot related problem in a donkey per year was found to be 2 times. Multiplying average days of absenteeism from work by average recurrence of lameness per year gives the total days of absenteeism from work per year by a donkey due to foot related problem to be 18 days. Hence, this was multiplied by average daily income (124 ETB). Therefore, the owners lose on average 2,232 ETB annually due to foot related problem in a donkey (Table 4). The minimum and maximum days of absenteeism from work per year due to foot related problems in the donkey were 10 and 60 days, respectively. An owner with lame donkey lost a minimum of 1240 ETB annually and a maximum of 7740 ETB per donkey yearly (Table 4).

Financial loss due to treatment and management of foot problems and culling of donkeys

The average cost for treatment of a foot related problems in Hawassa city was 33 ETB per year for a donkey. In severe cases of foot related problems or when it is complicated, the owners were forced to cull the donkey. This was found to have significant impact on livelihood of the owners. The culling rate due to foot related problems was found to be 2(1.44%) donkeys per year during the study period. The financial loss incurred due to culling was computed based on the life expectancy and market value of the donkey.

Computation based on the life expectancy of the donkeys

This computation is based on the cumulative monetary value of the donkeys, that is, assuming the owner uses the donkey for its expected productive life time. The life expectancy of cart pulling donkey in Ethiopia is reported to be 10-25 years (W/Giorgis et al., 2013). For the purpose of this study the minimum life expectancy, 10 years, was used to compute the financial loss; and the age of the animal at culling time of 4 years for both culled donkeys forms the average age of the donkeys. The expected productive age was calculated by subtracting the age of the animal at culling from the expected life expectancy of the donkey. Therefore, the productive ages of the donkeys missed due to culling were 6 years. Then, by multiplying the remaining 6 years of expectancy life by average annual income from non-lame donkey resulted in 75,216 ETB (3760.8US$) per donkey owner due to culling. When bringing it to the individual donkeys, on average each owner is incurring costs of 203.83 ETB for culling of donkeys due to severe cases, when life time expectancy is considered (total costs for culling divided by the sample size; that is 75,216 ETB/369) (Table 4). The probable occurrence of lameness in culled donkeys in prospective years was ignored.

Computation based on the cost of the donkeys at public market

The minimum and maximum price of healthy donkey in Hawassa market in the year 2014-2015 was 2000 and 5000 ETB, respectively. The average price of healthy donkey was 2965 ETB. Hence, each of the two owners lost 2965 ETB on average. When bringing it to the individual donkeys, on average each owner is incurring costs of 8.03 ETB for culling of donkeys due to severe cases, when average market price of donkey is considered for financial loss estimation (by the above manner) (Table 4).

DISCUSSION

The current study revealed that the overall prevalence of cart pulling donkey foot related problems was 37.7% in Hawassa. This finding is higher than the report of Morgan (2007), who reported the prevalence of 3.1% in Debre-Zeit and Addis Ababa. But the prevalence observed in this study is lower than that reported by Reix et al. (2014) from Pakistan (89%). The variation in prevalence might be accounted to the differences in management systems prevailing in each study areas, difference in the working topography and load carried by donkeys. According to Mekuria et al. (2013), lameness is associated with continuous movement in various landscapes and on bumpy roads. It might also be due to variation in the type of work; the current study was on cart pulling donkeys whereas that of Debre-Zeit and Addis Ababa was donkeys used for pack purpose. The finding of current study is in line with report of Grave and Dyson (2014) who reported a lameness prevalence of 38.1% in horses, in United Kingdom.

Among the risk factors considered the body condition of the donkeys (χ^2=8.93, P< 0.05), weight carried by the donkeys (χ^2=7.11, P< 0.05) and working experience of the owners (χ^2=32.56, P< 0.05) were found to be statistically and significantly associated with the prevalence of foot related problems (Table 2). Highest prevalence of lameness observed in those donkeys with body condition score of 2 and 3; it is in agreement with Reix et al. (2014). Lameness by itself has indirect influence on the body condition of donkeys, perhaps through loss of appetite (Dobromylskyj et al., 2000; Almeida et al., 2008). high amount of weight carried by the donkeys increases the chance of lameness occurrences. This might be associated with the downward exerted pressure on the legs by the weight carried. Moreover, it might be related to the fact that owners did not load their donkeys based on the age of the donkeys.

The length of work experience of the owners and occurrence foot related problems in the study were inversely related. This might be due to the fact that owners with less work experience were also with weak management skill. Cart pulling donkey value for the owner and management skill can be developed gradually through time. The common causes of foot problem in cart pulling donkeys in this study were hoof over growth, hoof abscess, muscular problem and arthritis; a little bit different from the causes of lameness and associated risk factors in cart mules in Northern Ethiopia (Bazezew et al., 2014). They reported that age, rest within a day, load carried and educational status of the owner are not associated with lameness in mules. This difference may be due to the difference between socio-cultural and behavioural characteristics of the community in Hawassa and those in Northern Ethiopia as well as the time gap between the studies.

In the current study, 14.4% of donkeys work even they were lame and 64.24% donkeys stop working until recovery and the minimum and maximum working hour was 6 (0.8%) and 10(59.3%), respectively. This is an indication of the animals suffering, aggravated by beating, to make them carry loads beyond their capacity or work longer hours. Sick and injured animals put to work without adequate nutrition will have significant welfare consequences. This finding is in agreement with the report of Ramaswamy (1994): the state of health of draught animals is poor, as they are not fed adequately to replenish the energy required for work.

In the current study, there was no significant association between age of the donkey and weight carried by the donkey with the occurrence of foot related problems. This finding is consistent with Tadich et al. (2008), who reported that there was no association between the age of the donkey and the weight carried by it. The possible cause for this is that, all age groups ranging from ages less than 3 years to 15 years carry almost similar weights because the owners do not load their donkeys based on age or weight.

This study revealed that the average daily income of the cart pulling donkey owners was 124 ETB (6.2 US$)

and the average annual income was 12,536 ETB (626.8 US$). This finding is higher than the report of Pearson et al. (2001), who reported their contribution in terms of firewood trade to the family income is 156 to 1404 Ethiopian Birr annually in Tigray and the Rift Valley areas; in Ejersa, sand is transported in 20 litre containers fitted on the back of a donkey. Each day a donkey makes 80 shuttles from the river basin to the roadside transporting a volume of sand amounting to 4 m^3 and costing 90 Birr.

But Admasu and Shiferaw (2011) reported a lower annual return from donkey keeping, which is 4419 ETB (330USD) per annum in Lemo, Shashego and Mesikan Woredas of Hadiya and Gurage zones. This variation of income across the areas might be due to the difference in the area of donkey operation, the number of people interested in using donkeys for transportation, working hours of the donkey as well as the performance of the donkeys. Also it might be due to the difference in the level of dependency on donkey for livelihood between the areas. For example: in Hawassa 93.76% donkey owners were wholly dependent on cart pulling donkeys for their livelihood. Moreover, it might be due to the difference in wealth status of the customers to pay for the service of the cart pulling donkey.

The result of the current research showed that the cart pulling donkey business was found to generate promising cost benefit ratio, which is in agreement with the reports of Admasu and Shiferaw (2011). Trechter et al. (2008) reported equine industry directly generates $30 to $35 million in annual revenues and $735 to $862 million in expenses. This is higher than the current finding in Hawassa, because of the difference in the study area, the value and status given to the donkey and the activity done by the donkey in the study areas. The current study deals only with the income generated by cart pulling donkeys. But, the finding of Trechter included equines in general not only the income from the cart pulling donkeys.

On average the total loss incurred due to lameness that include: absenteeism, treatment cost and culling of donkeys were 2469 ETB(123.45 US$) per donkey yearly. This finding is very small compared with that of USDA (2001), that reported the total estimate ranges from $678 million to $1 billion for 1998 due to a range of estimates for the incidence of lameness in horses. This may be due to the difference in the value and status of donkey, treatment and other care costs in US and in Ethiopia, particularly in Hawassa. It can also be due to the difference in the considered factors in the calculation and species differences.

CONCLUSION AND RECOMENDATIONS

Cart pulling donkeys were one the means of livelihood for the owners and it is making valuable incomes that might be supporting the poor resource bases households in the area. But foot related problems in particular and other welfare problems were major challenges to the cart donkey owners aggravated by the poor service delivery level in the area. A wide prevalence of foot related problems and tendency of working on donkeys with foot problems signifies there is crucial welfare consequences on the donkeys in the area. The implication of lameness on the income of the owners was evidenced with absenteeism from work and culling of working donkeys. Moreover, lameness was one major constraint affecting the donkey welfare and income of the people who depend on donkeys for their livelihood; it warrants there should be much higher attention. The donkey cart business can be assumed as a low income based livelihood alternative to engage people considering the capacity development of people and giving animal welfare priority attention. Accordingly; awareness creation and training of the donkey owners on welfare and managing foot related problems should be emphasized to improve the welfare of donkeys and sustain their livelihood.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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