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Research Article

Efficacy of insecticides against chickpea pod borer (*Helicoverpa armigera*) at Sodo district Gurage Zone, Southern Ethiopia

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Abstract

Pod borer is a major insect pest constraining chickpea production in southern Ethiopia. This experiment was then conducted in the Sodo district with the objective to evaluate the efficacy of different insecticides for the control of pod borer of chickpeas. The experiment was conducted using one chickpea variety; Habru and five insecticides Diaznon (1.2l/ha), Diamethoate (1L/ha), Apron star (600g with 500l of water ha^{-1}), Endosulfan (250g/ha) and Karate (400ml/ha). The result revealed that all insecticides were effective against pod borer with differences in the percent of larval population reduction. The pod borer damage reduction by insecticide treatment ranged from 35.4% to 68.6 % and 39.5% to 76.7% compared to that in control. Diazinon and Karate resulted in a maximum seed yield of 1561.20 kg/ha and 1498.90 kg/ha, in 2017 and 1391.40kg/ha, 1421.29 kg/ha in 2019, respectively. The highest larval reduction was obtained from a plot treated with Diaznon followed by Karate 5% EC 68.6%, 64% during the 2017 cropping season respectively and in the 2019 cropping season highest larval reduction was obtained from a plot treated with insecticide Karate 5% EC 76.7% followed by Diaznon treated plot 67.2%. In both 2017 and 2019 experimental years better yield increment was recorded from Diaznon and Karate 5% EC treated plot. During the 2017 cropping season, the maximum yield increment was obtained from Diaznon treated plot at 27.3% followed by Karate at 24.2% while in the 2019 cropping season, Karate 5% EC treated plot yield increased by 32.6% followed by Diaznon treated plot 31.2%. Thus, chickpea growers in the area should prefer a mix of Karate and Diaznon 5% EC for better pod borer management.

Keywords: Chickpea; *Helicoverpa armigera*; Insecticides; Pod borer

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1. Introduction

Ethiopia is considered as secondary center of genetic diversity for chickpea and the wild relative of cultivated chickpea (*Cicer arietinum* L.). An average chickpea yield in Ethiopia on farmers field is usually below1t/ha although it's potential is more than 5t/ha (Melese, 2005). Chickpea is susceptible to a number of insect pests, which attack on roots, foliage and pods. Among insect pests, chickpea pod borer (*Helicoverpa armigera*. Hubner) is a major constraint for lower yield of chickpea in Ethiopia by feeding on all stages of the crop from seedling to maturity and generally cause 37- 50 % loss in grain yield (Iqbal et al., 2014; Ahmed & Awan, 2013). Chickpea pod borer successfully established as key insect pest of chickpea crop in spite of acid exudates on plant parts which deter insect foraging.

It is highly polyphagous insect feeding on many other crops such as cotton, tobacco, safflower, tomato, maize, cabbage, peanuts and pulses (Javed, 2013) Chickpea pod borer (*Helicoverpa armigera* Hubner) (*Lepidoptera:Noctuidae*) is a major field insect pest affecting pulses in several agro-ecological zones. Single larva can damage 40pods and selectively feeds up on growing points and reproductive parts of the host plant. The 1^{st}, 2^{nd}, and 3^{rd} instar larvae initially feed on the foliage (young leaves) of chickpeas and a few other legumes, but mostly on the flowers and flower buds of cotton, pigeon pea, etc. Larvae shift from foliar feeders to developing seeds and fruits as larval instar development progresses. Larger larvae bore into pods and consume the developing seeds inside the pod. It feeds on floral buds, flowers and young pods of the growing crop (Khan, 2009). Mostly, leaving out all other approaches of insect management insecticides application appears as an easy, popular and effective technique.

There is a high infestation of pod borer on chickpea, in chickpea growing districts of Gurage Zone (Damtew & Ojiewo, 2017). *H. armigera* control with insecticide on chickpea is not common in Ethiopia; rather the majority of the farmers follow a “do nothing” strategy. Ethiopian agriculture is fast transforming from subsistence to commercial farming system and use of pesticides is expected to increase rapidly as scales of production increase. The indiscriminate use of pesticides to tackle losses caused by *H. armigera* can increase cost of production, affect human health, biodiversity and the environment. Besides, several chemical control methods have been evaluated but the pest keeps developing resistance to synthetic chemicals (Lande & Sarode, 1995).

Therefore, judicious use of pesticides following established guidelines and in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment is recommended. However, the wise use of effective insecticides is important to avoid their drastic side effects on the environment, humans, animals and natural bio-control agents (Suhail, 2013). For effective insecticide chemicals for the management of this insect pest (pod borer) is required. Thus, to alleviate such limitation the experiment was initiated to evaluate the efficacy of five insecticides against chickpea pod borer (*Helicoverpa armigera* Hubner) under field conditions.

2. Materials and Methods

2.1. Description of study area

The experiment was done at the Sodo district during the 2017-2019 crop seasons. The location is suitable for the experiment because pod borer appears in the area every year under natural conditions. Specifically, the experiment was conducted at a location of $8^0$19'N latitude and $38^0$39'E longitude with an altitude of 1947 meter above sea level. According to meteorological data the average annual rainfall is 1050mm ranging between 800mm and 1200mm with average minimum and maximum temperature of 13^0C and 30^0C. Sodo is characterized by a verity ofsoil type.

The chickpea variety Habru was used as per standard agronomic practices during 2017-2019. The plot size was 1.8m × 2m (3.6m^2), keeping the spacing of 30×10 cm between rows and plants, respectively.

2.2. Treatments and experimental design

The experiment was conducted using one chickpea variety; Habru. Fiveinsecticides namely Diaznon (1.2l/ha with 100L of water ha^{-1}), Diamethoate (1L/ha with 150L of water ha^{-1}), Apron star (600g with 500ml of water ha^{-1}), Endosulfan (250g/ha with 1000ml of water ha^{-1}) and Karate (400ml/ha with 150-200L of water) were used in the experiment. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. There were six treatments including the control. All the treatments were administered in the field as the foliar spray applied manually with a knapsack sprayer. Insecticideswere sprayed at their recommended doses. A distance of 100 cm between the plots and 150 cm between the replications was maintained as the buffer zone.

2.3. Data collection

Observations were started after 30 days of sowing in one-meter length from each plot during the vegetative stage so to determine the economic threshold level (one larva per meter per row) of chickpea pod borers for timely application of chemicals. Five plants were selected at random from each treatment and the population of gram pod borer was observed to record the number of larvae plant^{-1} of chickpea.

The sprays of particular treatment were applied when the larval population was above the ETL to protect the crop from further heavy losses. Post treatment data on the percentage mortality of caterpillars of pod borers was taken after 7 days, for comparison with pretreatment observation (24 hours before spray). The data from the five sprays were pooled and the average percent mortality was calculated. The mean percent reduction of pod borer's population with respect to pre-treatment data was calculated by the formula given by Abbott et al. (1925). The reduction and yield increase percentage of the larvae was recorded by counting of the larval population over check (Eqs. 1-2).

$$\text{LR (\%)}= \frac{\text{Total larval population} - \text{Number of larval population after spray}}{\text{Total number of larval population}} \times 100 \quad (1)$$

$$\text{PYIC (\%)} = \frac{\text{Larval population of sprayed} - \text{Larval population ofunsprayed}}{\text{Larval population of sprayed}} \times 100 \quad (2)$$

Where, % LR = Percentage of larval reduction, PYIC = Percentage of yield increase over check

2.3.1. Pod Damage in percent (%)

On maturity of crop, the percent pod damage was determined by counting total number of pod and number of damaged pods from randomly selected five plants out of each treatment, using formula shown below. Percentages of pod damage (Eq. 3), relative yield loss (Eq. 4), and yield increase (Eq. 5) were calculated based on the equestions given here.

$$\text{Pod damage (\%)} = \frac{\text{Total pods produced per plant} - \text{Number of undamaged pods}}{\text{Total number of pods produced}} \times 100 \quad (3)$$

$$\text{RYL (\%)} = \frac{\text{Yield of maximum protected} - \text{Yield of other treatment}}{\text{Yield of maximum protected}} \times 100 \quad (4)$$

$$\text{YI (\%)}= \frac{\text{Grain yield of treated plot} - \text{yield of control plot}}{\text{Yield of control plot}} \times 100 \quad (5)$$

2.3.2. Grain yield

The yield of grains per plot was recorded at harvesting including control and this was converted into Kg/ha. Data on the larval population of Helicoverpa armigera caterpillars, pod damage and yield corresponding to each treatment was subjected to statistical analysis.

2.4. Statistical analysis

The data collected during experimentation was analyzed statistically by using analysis of variance (ANOVA) and means were separated by least significance difference (LSD) test at a 5% probability level using SAS version 2.0.

3. Result and Discussion

Data collected on the comparative efficacy of five insecticides tested for the management of pod borer on Chickpea was presented in tables.

3.1. Larval population

Five plants were randomly selected from each plot. The result revealed that insecticides were effective against pod borer even if they have different percent larval reductions in both years.

In 2017, according to the data in Table 1 the pest population of Helicoverpa armigera ranged from 2.83 to 3.53 larvae per plant before spray and 1.10 to 3.50 after spray during the season. It indicated that the pest was active during December. This period coincided with the flowering and pod formation stage of the crop. The pod borer damage reduction by different treatments ranged from 35.4% to 68.6 % compared to the control. The highest pod borer larval reduction 68.6 % was found in Diaznon sprayed plot followed by Karate5% EC 64 %

sprayed plot. The efficacy of these insecticides was supported with the result of Suneel Kumar & Sarada (2015) who recorded the lowest number of *Helicoverpa armigera* larva in plots treated with chlorantraniliprole 20% SC against an unsprayed control plot.

Table 1. Average larval populations of pod borer (*Helicoverpa armigera*) on chickpea before and after spray of insecticides in 2017 cropping season.

Insecticides	Mean larval population/Plant		Reduction % over check
	Before spray	After spray	
Control	2.83	3.50	_
Apron star	2.93	2.26	35.4
Endosulfan	3.50	1.35	61.4
Karate	3.46	1.26	64.0
Diaznon	3.53	1.10	68.6
Diamethoate	3.36	1.67	52.3

In 2019 the result revealed that Karate was effective against pod borer. The data summarized in Table 1 revealed that the pest population of Helicoverpa armigera ranged from 1.73 to 1.90 larvae per plant before spray and 0.60 to 2.58 after spray during the season. The pod borer damage reduction by different treatments ranged from 39.5 % to 76.7 % compared to control. The highest pod borer larval reduction 76.7% was found at Karate 5% EC sprayed plot followed by Diaznon 67 % sprayed plot. The present study was in agreement with the findingby Dagne et al. (2018) who reported that the highest pod borer larval reduction (90.63%) was found on Diaznon sprayed plot followed by Karate 5% EC (71.87%) treated plot.

Similar findings were reported by Chowdary et al. (2010), chlorantraniliprole was highly effective against *Helicoverpa armigera in okra.* The insecticide Apron star showed the least effective against chickpea pod borer which was in consistent with the work of Khanna et al. (2009) reported that NSKE 5% was the least effective against the pod borer of chickpea among the different insecticidal treatments during both experimental both years.

Table 2. Average larval populations of pod borer (*Helicoverpa armigera*) on chickpea before and after spray of insecticides in 2019 cropping season.

Insecticides	Mean larval population/Plant		Reduction % over check
	Before spray	After spray	
Control	1.81	2.58	-
Apron star	1.90	1.56	39.5
Endosulfan	1.73	0.98	62.0
Karate	1.90	0.60	76.7
Diaznon	1.82	0.85	67.0
Diamethoate	1.73	0.90	65.2

3.2. Yield of chickpea

The data of seed yields (kg/ha) and increased percent over check is presented in Table 2. From the result obtained at Sodo, Diaznon resulted maximum seed yield 1561.20 kg/ha, followed by Karate 5% EC1498.90 kg/ha, and where as the minimum seed yield 1135.58

kg/ha on unsprayed plot. Maximum percent of seed yield 27.3 % was increased over check by Diaznon. The second maximum percent of seed yield 24.2% was increased over check by Katare5% EC. The present finding is in agreement with work of Sreekanth et al. (2014) who reported the lowest pod damage and highest seed yield was obtained from plots treated with chlorantraniliprole.

Table 3. The grain yield of chickpea at Sodo 2017/18 cropping season

Treatment	GY(kg/ha)	Percent yield increase over check
Control	1135.58	-
Karate	1498.90	+24.2
Apron Star	1137.90	+0.2
Endosulfan	1466.70	+22.6
Diaznon	1561.20	+27.3
Diamethoate	1459.00	+22.2

GY=Grain Yield; kg=Kilogram; +=Iincrement

In 2019, Karate 5% EC resulted maximum seed yield 1421.29 kg/ha, followed by Diaznon 1391.40 kg/ha, and where as the minimum seed yield 957.67 kg/ha on unsprayed plot (Table 4). Maximum percent of seed yield 32.6% was increased over check by Karate 5%EC. The second maximum percent of seed yield 31.2% was increased over check by Diaznon. Similarly, Adsure and Mohite (2015) reported that Rynaxypyr treated plots had maximum yield and minimum pod damage by pod borer in comparison to indoxacarb and spinosad.

Table 4. The grain yield of chickpea at Sodo 2019/20 cropping season.

Treatment	GY (kg/ha)	Percent yield increased over check
Control	957.67	-
Karate	1421.29	+32.6
Apron Star	1134.60	+15.6
Endosulfan	1333.40	+28.2
Diaznon	1391.40	+31.2
Diamethoate	1389.00	+31.0

GY: Grain Yield; kg: kilogram; ha: hectare; +: increment

3.3. Economic analysis of insecticidal treatment

In 2017, the result showed that Diaznon sprayed plot provided the highest gross returns (ETB 62,440/ha) and the low gross return (ETB 45,400/ha) was computed from the untreated plot (Table 5). The plot sprayed with Diaznon gave the maximum net return ETB 61,890 /ha and the unsprayed plot gave a low net returns birr 45,400/ha (Table 5).

In 2019, Karate 5EC sprayed plot provided the highest gross returns (ETB 63,958/ha) and the lowest gross return ETB 43,095/ha was computed from untreated. The plots sprayed with karate 5EC gave the maximum net return ETB 63,005/ha. The unsprayed plot gave comparably low net returns ETB 43,095/ha (Table 6).

Table 5. Return and economic analysis of treatment for the control of Ppod borer in chickpea during the 2017/18 cropping season

Treatment	Yo (kg/ha)	Sale price (ETB/kg)	Fc and Ac (ETB/ha)	Gross return (Price x kg)	Net return ((GR- (Fc + Ac))
Control	1135.58	40	-	45,400	45,400
Karate	1498.90	40	840	59,920	59,080
Apron star	1137.90	40	300	45,480	45,180
Endosulfan	1466.70	40	600	58, 640	58,040
Diaznon	1561.20	40	550	62, 440	61,890
Diamethoate	1459.00	40	600	58, 360	57,760

Yo=Yield obtained Fc=Fungicide cost; Ac=Application cost; GR=Gross return; ETB=Ethiopian birr

Table 6. Return and of economic analysis treatment for the control of pod borer in chickpea during 2019/20 cropping season

Treatment	Yo (kg/ha)	Sale price (ETB/kg)	Fc & Ac (ETB/ha)	Gross return (Price x kg)	Net return ((GR- (Fc +Ac))
Control	957.67	45	-	43,095	43,095
Karate	1421.29	45	940	63,958	63,005
Apron star	1134.60	45	700	51,056	50,330
Endosulfan	1333.40	45	750	60,003	59,253
Diaznon	1391.40	45	650	62613	61,963
Diamethoate	1389.00	45	700	62505	61,805

Yo=Yield obtained; Fc=Fungicide cost; Ac=Application cost; GR=Gross return; ETB= Ethiopian birr

4. Conclusion

The result revealed that Diaznon and Karate5% EC were the most effective insecticides to give high mortality of pod borer on chickpea under field conditions. The most economical benefit for pod borer management was obtained from Diaznon sprayed plot and followed by Karate sprayed plots. It has been indicated from the present study that insecticides such as Diaznon and Karate were the most effective against the pod borer on chickpea resulting in the maximum reduction of the percentage of larval population even if they have a slight difference on efficacy at both years. Farmers should have used both insecticides for the management of pod borer in chickpea. One insecticide can be used in the absence of the other as an option/alternative to increase productivity and also quality of chickpea. Therefore, we suggested/recommended that these effective insecticides (Karate %EC and Diaznon) in mixed up at recommended rate were suggested to the growers for management of the pod borer population below economic threshold level under field conditions and to inhibit the resistance development of the pest.

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Conflict of the Interest

The authors declare that there is no conflict of interest

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Research Article

Availability, nutritional balance, and needs for dairy cattle feed resources in Derashe special district, Southern Ethiopia

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Abstract

The research was carried out in the Derashe District of Southern Ethiopia to assess livestock feed availability, utilisation practises, and nutrient balance. Data were gathered by field observations, key informant interviews, and a standardized questionnaire. With 149 responses, the district was divided into three agro-ecologies. Using a technique called probability proportional to size-sampling, the number of responders was calculated. Lowland, mid-altitude, and highland regions all had average land sizes of 1.67, 0.27, and 1.38 ha, respectively. The research district's entire livestock population was calculated to be 134,948.84 TLU. Cattle made up 83.23% of this, followed by goats 6.19%, donkeys 5.09%, sheep 3.51%, chickens 1.19%, mules 0.53%, horses 0.18%, and camels 0.002% of the district's total TLU of the animal population. There were 9.5 heads of local and crossbred cows in each household's average herd. Dairy cattle in the study locations primarily ate natural pasture, crop residues, crop aftershock grazing, standing hay, maize that had been thinned, and unconventional feeds (Cheka atella and Areke atella). Grazing land produced 97.75 tons of dry matter per year, crop leftovers 827.21 tons, conventional feeds 264.78 tons, fodder trees and shrubs 1.29 tons, crop aftermath grazing 110 tons, concentrates 0.5 tons, and forest land 30.54 tons. A total TLU value of 1693.5 was obtained by analyzing the overall feed balance in terms of DM yield annually. The present TLU units with a negative balance of 2513.16 tons demand about 3861.85 tons of DM annually. There was a deficit of 140 tons in the total CP produced and needed for the TLU, which came to 477.18 and 617.72 CP tons, respectively. Overall metabolizable energy (ME) produced and needed for the TLU were 25,739.3- and 73683.72-tons MJ, respectively, with a negative balance of 47,944.42 tons MJ of ME. Free grazing, stall feeding, and tethering were the three main feeding methods used in the research locations. Lack of feed, a lack of grazing pasture, subpar extension services, and a lack of water were the main obstacles and issues for the development of dairy cattle. Possibilities for increasing dairy feed output include favorable meteorological conditions, cereal crop productivity, and road access. The growth of forage, the collecting and storage of crop leftovers under sheds, the conservation of forage, particularly hay and silage, and the facilitation of feed selling mechanisms in local market areas could all help ease feed scarcity issues.

Keywords: Agroecologies; Dairy cattle; Derashe district; Feed; Feeding systems

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1. Introduction

The majority of animals in Africa are kept in Ethiopia (CSA, 2020). Although it is the second-largest contributor to the nation's foreign exchange, Alazar estimates that the livestock subsector in Ethiopia generates over 30% of the agricultural GDP and 16% of the entire GDP (2015). About 65 million cattle are thought to be in the nation's total cow population. Male cattle make up 44.10 percent of this total, while female cattle make up 55.9%. According to estimates, native breeds make up 97.79% of the nation's cattle. The other breeds are hybrids and exotics, which make up roughly 1.91% and 0.32% of the CSA%, respectively (CSA, 2020).

Diverse criteria are used to identify various dairy production systems in Ethiopia. Based on location, it can be broadly divided into systems for producing milk in metropolitan areas, peri-urban areas, and rural areas. The production system for dairy cattle can be divided into three categories: traditional small holders, privatized state farms, and urban and peri-urban systems Ketema (2008).

Ethiopia's primary sources of livestock feed are uncultivated pastures and grasslands, crop byproducts, improved pastures, forage crops, agro-industrial byproducts, and unconventional feeds (CSA 2020). Dairy farmers frequently use grazing land, hay, purchased succulent grass, maize stover, pseudo stems of enset and banana, mixed/balanced homemade concentrate feeds, plant weeds, and unconventional feeds like attella (a brewery by-product from locally produced beer and other alcoholic drinks), kitchen and fruit scraps, and leaves of other delectable agro-forest plants Sintayehu et al. (2008). Due to decreasing grazing field sizes, the importance of natural pasture grazing and stall feeding as important cattle feed resources and feeding systems occasionally declines (Yayneshet, 2010). Native hay has a restricted range of applications, but when used properly—that is, when it is cut in a timely manner and handled and stored properly—it has a higher feeding value than agricultural wastes. Because of the Highlands' limited grazing territory and inadequate management, fodder is insufficient to feed animals even during years with a favorable rainy season.

The Derashe district has not yet been described with regard to dairy cattle productivity and feed balance. Inferences for any type of management intervention must be based on research of the production system and feed balance. The first steps in creating a policy briefing and/or further development plan are to identify and prioritize the current management practices, breed identification, marketing milk and its products, performance parameters, opportunities, and restrictions. As a result, the current study is intended to examine the availability of feed resources and establish the balance between the nutritional needs of dairy cattle.

2. Materials and Methods

2.1. Description of the Study Area

The study was carried out in the district of Derashe in the Segen Area Peoples Zone, Southern Nations and Nationalities People's Region (SNNPR) (Figure 1). Derashe district is 500 kilometers (km) from Addis Abeba, 318 km from Hawassa, the regional seat, and 43 km from Segen, the zonal town. There are 18 kebeles in the Derashe district, one of the five districts in the Segen Area Peoples Zone (16 farmer administrations and 2 town administrations). The Derashe district's (AWANRO) office claimed that the district has 174 293 residents overall in 2016. (males: 85,034 and females: 89,259). About 25,202 households (24,062 men and 1140 women) are present (DWFEDO, 2016). The district is generally between 1500 and 2622 meters above sea level. The yearly temperature fluctuates between 15.10°C and 27.50°C, while the annual rainfall is between 600 and 1600 mm. The district's agro-ecologies are divided into three categories: highland (17.27%), midland (35%), and lowland (46.61%) (between 1500 and 2622 m.a.s.l).

A mixed-crop and animal production system is the most popular agricultural technique in the region. Wheat, sorghum, teff, and maize are the main crops that are grown in the study region. The majority of livestock production systems is traditional and geared toward subsistence and is characterized by modest management inputs in terms of production and breeding management, disease control, and nutrition. There are 134,056 cattle in the districts (61,868 males and 72,188 females), 47,404 sheep, 83,660 goats, 3 camels, 13740 donkeys, 297 horses, 1024 mules, and 544 chickens.

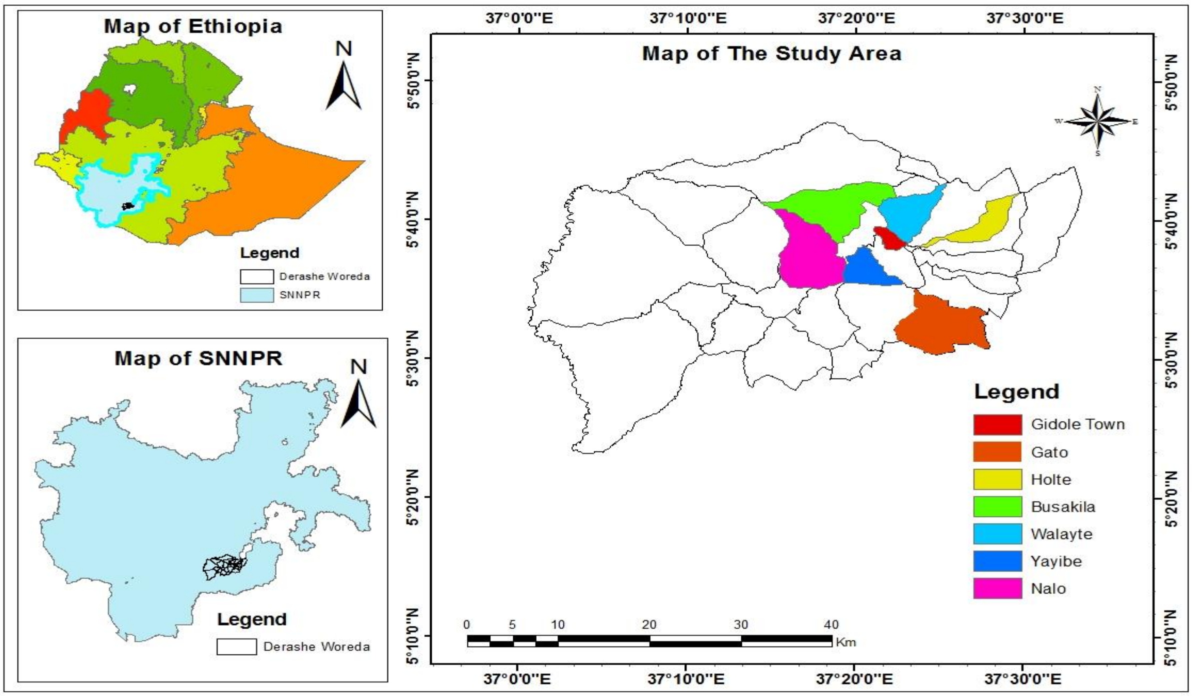

Figure 1. Map of the study area

2.2. Sample size and sampling techniques

Based on the potential for both local and crossbred dairy cattle, farmers' motivation and preferences to crossbreed local cows, and farmers' extensive experience keeping both local and crossbred dairy cattle among the five districts of the Segen area people's zone, the study site was chosen from the district. Agro-ecologies were chosen using a stratified sample technique, whereas the study's farmer associations were chosen using a basic random sampling technique. Using a systematic random sample technique, households with Jersey and HF crossbred cows as well as local cows were chosen for the study. Out all the districts, 149 households total were chosen. The agro-ecological of the districts is made up of 48.0% lowlands (below 1500 m.a.s.l.) and 17.27% highlands (between 230 and 2622 m.a.s.l.). Using a probability-proportional-to-sample-size determinant formula, the proportion of responses within each agro-ecology was determined. Five farmers from each agro-ecology participated in a pre-test of a standardized questionnaire that was used to interview the chosen farmers. Utilizing Cochran's probability proportional to sample size-sampling method, the total sample size for the household interview was calculated based on Eq. 1 (Cochran, 1977).

$$n = \frac{Z^2 * (p)(q)}{d^2} \rightarrow n1 = \frac{n0}{(1 + no/N)} \tag{1}$$

Where n_o= desired sample size according when population greater than 10,000; n_1 = finite population correction factors population less than10, 000; Z = standard normal deviation (1.96 for 95% confidence level); P = 0.11 (proportion of population to be included in sample i.e., 11%); q= 1-0.11 i.e. (0.89); and d = is degree of accuracy desired (0.05), 5% error term.

Based on the first formula, the total number of households were 149 from three agro-ecologies of the district i.e. (26 household highland (17.27%), 52 household mid-altitude (35%) and 71 household lowland (48.0%).

2.3. Quantity estimation of available feed resource

2.3.1. Dry matter yield of natural pasture

The average value of grazing land holdings and the per-hectare DM output of the natural pastures were multiplied to obtain the total quantity of DM available in natural pastures in the research area (FAO, 1987). For each total household and their associated TLU qualified to graze on this land unit, the total community grazing areas were multiplied by the quantity of DM acquired from communal grazing land.

2.3.2 Available crop residues and aftermath grazing

According to the FAO (1987) conversion factor for the Ethiopian condition, the amount of accessible crop leftovers (DM basis) was calculated from the overall crop yields of the households. For barley, wheat, teff, and oats, conversion factors are 1.5; for maize, they are 2; for pulse and oil crop straws, 1.2; and for sorghum, 2.5. Tolera & Said (1994), evaluated the amount of crop residue on the basis of DM available and those actually available for cattle consumption by subtracting 10% for loss. By dividing the amount of land available by the conversion factors of 1.8 for fallow land and 0.5 for aftermath grazing, calculated the quantities of DM available in fallow land and aftermath grazing (FAO, 1987).

2.3.3. Estimation of biomass yield of browses

The stem circumference was measuried in a tape applying the potential fodder yield of the selected shrubs and trees was calculated using Petmak (1983)equation. Thus, using the algometric equation log W = 2.24 log DT – 1.50, the leaf yield of fodder trees was calculated. W is the leaf yield expressed in kilograms of dry weight, and DT is the trunk diameter measured at a height of 130 cm. Likewise, trunk diameter (DT) can be calculated using the formula: DT = 0.636C, where C is the circumference in centimetres (cm). The algometric formula is log W = 2.62log DS -2.46 for a shrub's leaf yield. Where, DS represents the stem diameter at a height of 30 cm in centimeters.

2.3.4. Estimation of the balance between dry matter supply and requirement for dairy cattle

The yearly DM needs of the cattle population in the tested households were compared to the total amount of DM that was available throughout the main rainy season from natural pasture, crop residues, crop aftermath, tree legumes, and concentrates. During the study, interviews with household heads were performed to gather information on the livestock population in the sample houses. Using the ILCA's conversion factors, the quantity of livestock populations was transformed into tropical livestock units (TLU) for comparison (ILCA, 1990).

The daily DM requirements for maintaining 1 TLU were used to calculate the DM requirements for the livestock population. Kearl (1982), employed an 8.368 MJ ME/kg DM diet with a crude protein (CP) composition of 70 g/kg DM. Due to a lack of resources (time, money, and TLU conversion variables), as well as the researcher's and data enumerators' demands, neither the assessment of poultry feed availability or the requirement for poultry feed were included in this study.

2.4. Data and collection tools

Data on the socioeconomic traits of the respondents, household dairy cow holdings, dairy cattle feeds and feeding, health care and common diseases, breeding procedures and farmer's preferred trait combinations, housing, and routine farm management activities were gathered. Lactation length, lactation milk yield, and average daily milk yield were all gathered as milk production traits. The reproductive performances of cows were assessed using economically significant reproductive variables as age at first calving, calving interval, gestation duration, number of services per conception, and days open. A standardized questionnaire was also used to evaluate the benefits and drawbacks of dairy cattle rearing.

Data collection methods included the researchers' own observation, structured questionnaire interviews, focus group talks, and recording performance metrics. Along with performance records, recalled indicative data was also included. The researcher's own observations, a questionnaire survey that was administered, records on reproductive and productive performances, a focus group discussion with model or experienced farmers, and communication with livestock production experts at various levels were all used as data collection tools.

2.5. Data analysis

All of the survey data was examined using Statistical Package for Special Sciences (SPSS version 20). Significant differences were taken into account at P = 0.05 when testing statistical variations for categorical data using cross tabulations and chi-square tests, whereas one-way analysis of variance was used to analyze statistical variations for numerical data (one-way ANOVA). Turkey's honestly significant difference test was used to compare means, and levels of significance were also taken into account at P< 0.05. A table, numbers, percentages, means, and standard error of the means were used to present the analyzed data. The appropriate statistical model used for characterization of the dairy cattle production and feeding system is as follows (Eq. 2):

$$Y_{ijk} = \mu + \alpha_i + \Sigma_{ijk} \quad (2)$$

Where: *yijk* = total observation due to i^{th}, agro ecology effect; μ = is overall mean; α_i = location (agro-ecology); and e_{ijk} = random error.

3. Results and Discussion

3.1. Farm land size of dairy producers in the study area

The average size of the land in the study region was 1.10 hectares per household (Table 1). In the highland, mid-altitude, and lowland regions, the average land size was significantly different amongst the agro-ecologies (P< 0.001) and was 1.38, 0.27, and 1.67 ha, respectively. The research area's lowland region had the largest ownership, followed by the highland region.

The shrinking amount of land required in the study region, particularly in mid-altitude (urban) areas, to efficiently produce and improve forage crops or has access to communal grazing space, is one of the major issues. Similar findings were made by Sintayehu et al. (2008) for the southern Ethiopian regions of Shashemene and Dilla, where rural areas have 1.14 hectares per household. Due to relatively large average land sizes per household among farmers in highland and mid-altitude regions, the overall average values of the current study are greater than the finding of Yayeh et al. (2017) for rural areas of the Debremarkos district (0.98 ha per household). The research area's total average amount of community pastureland or grazing land was 0.32 hectares. In highland, mid-altitude, and lowland regions, the average community grazing was 0.20, 0.058, and 0.68 ha, respectively. This difference amongst agro-ecologies was significant (P< 0.001).

Table 1. Farm land size hectare (ha) of dairy producers in the study area

Land type	Agroecology			Overall (n=149)	*P*-value
	Highland (n=26)	Midland (n=52)	Lowland (n=71)		
Average farm land (ha)	1.38	0.27	1.67	1.10	**
Average communal grazing land (ha)	0.20	0.058	0.68	0.32	**

N= number of respondents; **= P <0.001.

3.2. Livestock population

As indicated in Table 2, the estimated total livestock population in Tropical Livestock Unit (TLU) in the Derashe distric was 134,948,84, which composed of 83.28% cattle, 6.19% goats, 5.09% donkeys, 3.51% sheep, 1.19% poultry, 0.53% mules, 0.18% horses, and 0.0022% camels. Cows made up 37.44% of the livestock, with oxen making up about 45.84%. The reason for the disparity in the number of male and female animals was that farmers in highland regions produced more dairy cattle for plowing purposes than those in mid-altitude and lowland regions.

Table 2. Livestock population in tropical livestock unit (TLU) in the Derashe district

Animals species	Population	TLU equivalent *	Total TLU
Cow	72,188	0.7	50,531.6
Oxen	61,868	1	61,868
Sheep	47,404	0.1	4,740.4
Goat	83,660	0.1	8,366
Donkey	13,740	0.5	6870
Horse	297	0.8	237.6
Mule	1024	0.7	716.8
Camel	3	1	3
Poultry	161,544	0.01	1615.44
Total			134,948.84

Endale s (2015)' findings for the Meta Robi district, West Shewa Zone, and Oromia regional state are supported by the current study. Although this is in line with the current study, under the country's highland production system, cattle made up 92% of the total TLU and approximately 37% of the cattle herd. Funte et al. (2010) In the research district, the average

TLU for cattle, goats, donkeys, sheep, poultry, mules, horses, and camels was 5.35, 0.33, 0.27, 0.19, 0.06, 0.02, 0.01, and 0.0001 correspondingly. Endale noted that, in contrast to the current study, the average TLU for cattle, sheep, goats, donkeys, horses, mules, and poultry in the Meta Robi district was 7.97, 0.74, 0.46, 0.78, 1.44, 0.8, and 0.07, respectively (2015). The sampled households' total number of tropical livestock units (TLU) varied between the three agro-ecologies (highland, mid-altitude, and lowland) and was roughly 182.65, 255.55, and 1254.55 TLU, respectively. When we compare agro-ecologies, lowland regions have more cattle populations than highland and mid-altitude regions.

3.3. Labor division and role of gender in the study area

Different agro-ecologies had different general labor divisions for dairy farming operations in the study locations. Husband, wife, both husband and wife, and the entire family (16.1, 19.5, 39.6, and 24.8%, respectively) were responsible for the feed collection and feeding methods (Table 3). The husband, wife, both of them, and the entire family (13, 4, 3, 1.5, and 51%) were responsible for watering practices, correspondingly. Despite the fact that husband and wife cleaned the dairy home, their combined contributions were 14.8, 7.4, 28.2, and 49.7%. Husbands, wives, and husband and wife worked together to care for dairy cattle 84.6, 1.3, and 14.1% of the time, respectively. Ultimately, 89.9, 9.4 and 0.7% of the practice milking was performed by the husband, the wife, and both the husband and wife. The current study differs from Azage et al. (2013) for the rural highland dairy systems of Fogera and Bure where husbands milk their wives 89.9% of the time, compared to 97.3% in Azage et al. (2013).

Table 3. The overall labor division in the study area as presented in percentage**;**

Types of activities	Husband	Wife	Both	Whole family	*P*-value
Feed collection and feeding	16.0	19.5	36.6	24.8	**
Watering practices	13.4	4.0	31.5	49.7	**
House cleaning	14.8	7.4	28.2	51.0	NS
Milking practices	89.9	9.4	0.7	0	**
Health care	84.6	1.3	14.1	0	**

**= P <0.001; NS=Not-significant

3.4. Feed resources availability in the study area

As shown in Table 14, the primary sources of feed for dairy cattle in the study area varied significantly across agro-ecologies (P< 0.001) and included natural pasture, crop residues (from teff, maize, sorghum, barley, and wheat), standing hay, enset, trees/shrubs, and most households also used non-conventional feed like liquid residues (from local areke, Tella, and Cheka) and common salt. The availability of feed resources varied across agro-ecologies, though; in lowland, more farmers use natural pasture and crop residues; in the mid-altitude region, 32 (61%) households feed their cattle purchased green grass, dry grass/standing hay, crop residues, and non-conventional feeds because there is a lack of grazing land; and 20 (39%) households use natural pastures, crop residues, and non-conventional feeds. In addition to using a little amount of modified forage (elephant grass), Highland farmers also employed natural pasture, crop wastes, enset, palatable fodder trees, and shrubs.

Table 3. Common dairy cow feed type in the study area according to utilization percentage

Feed type	Agro-ecology (%)			Total (n=149)	P-value
	Highland (n=26)	Mid-altitude (n=52)	Lowland (n=71)		
Natural pasture	100	40.4	100	79.2	**
Maize Stover	0	100	100	82.6	**
Sorghum Stover	100	100	0	52.3	**
Wheat straw	100	0	0	17.4	**
Barley straw	100	0	0	17.4	**
Standing hay/dry grass	100	100	0	52.3	**
Industrial by-product (wheat bran)	0	9.6	0	3.4	**
Non-conventional feeds					
Cheka atela/michicha	84.6	100	53.5	75.2	**
Areke atella	0	100	0	34.89	**

N=Number of the respondents, NS=Not-significant; **= $p<0.01$, *Cheka* is common local drink in study area, *michicha* is the residue of *cheka*

The current study, similar to Ketema (2014) for Kersa Malima woreda, Oromiya regional state, Abebe et al (2014).'s for Ezha district of the Gurage zone, southern Ethiopia, and Asrat et al. (2016) in and around Wolita town, reported that the major feed resources of dairy cattle were natural pastures, crop residues, standing hay, and non-conventional feeds. Natural pastures, crop remnants, and standing hay are the main sources of nutrition for dairy cattle, according to a study conducted by Abdirahin & Kefalew (2015) in Fafa, Eastern Ethiopia.

Dairy cattle feed sources included purchased grass, natural pasture, crop residues, agro-industrial byproducts, conserved hay, and non-conventional feeds, though the current study is in agreement with reports by Sintayehu et al. (2008) in the southern Ethiopian towns of Awassa, Yirgalem, and Dilla that the main sources of dairy cattle feed were enset, natural pasture, and crop residues. Asrat et al. (2013) discovered that the main dairy cattle feed resources in and around Boditti Wolaita, South Ethiopia, were natural pasture, crop leftovers, and non-conventional feeds; Haftu et al. (2014) discovered that the same sources were present in Ganta Afeshum woreda, Eastern Zone of Tigray.

According to Yayeh et al. (2017) in the Debremarkos District of the Amhara Regional State of Ethiopia, the main sources of feed for dairy cattle included natural pasture, crop residues, hay, concentrate, and alternative feeds. According to research by Belay & Janssens (2016), the primary sources of feed for dairy cattle in Jimma Town, Ethiopia, including hay, green feed, cereal grain, wheat bran, commercial concentrate, molasses, noug cake, brewery leftover grains, cotton seed cake, maize powder, and non-conventional feeds. Asrat et al. (2016) discovered that pasture, saved feed, purchased feed, and unconventional feed were the main sources of dairy cattle feed in and around Wolaita Sodo town, Southern Ethiopia.

The study also discovered that the primary sources of feed for cattle are mostly crops like maize that have been thinned. Most responders acknowledged that there was a noticeable lack of feed resources throughout both the dry and wet seasons. A paucity of feed supplies was noted in both highland and lowland regions during the dry season, whereas in mid-altitude regions, a shortfall was noted in both seasons due to a lack of grazing land. Teff, sorghum, and maize were the most common crop residues in highland, mid-altitude, and lowland regions, respectively. The close to towns, mid-altitude dairy producers were buying feed supplies from regional markets as well as highland and lowland farms. The study indicated that industrial by-products were not easily accessible.

3.5, Estimation of annual feed availability in study area

3.5.1. Crop residues dry matter production

Most of Ethiopia uses crop waste as a major source of animal feed, particularly in the dry months of the year. Based on the household total crop yields that were discovered through the questionnaire survey and used to estimate the amount of crop residues (DM) that were readily available. The total biomass of crop residues produced annually in the highland, mid-altitude, and lowland regions was, in accordance with the FAO conversion factor, 64.2, 165.16, and 780.44 tons, respectively.

This equates to 909.93 tons of dry matter annually. 10% of the crop residue loss is anticipated, according to Tolera & Said (1994), for a variety of reasons. Thus, the annual production of crop residues in the highland, mid-altitude, and lowland regions was 58.48, 150.15, and 618.58 tons, respectively (Table 4). This equates to an annual production of dry matter of 827.21 tons. In contrast, lowland farmers tend to have larger plots of land than farmers in highland and mid-altitude regions because they grow more cereal crops, which increases the bio-mass output of agricultural leftovers in these regions.

3.5.2. Natural pasture/grazing land dry matter production

It was determined that the annual production of dry matter from natural pasture was 22,564 (12,282 ha2 tons per ha). The respondents' pasture land holdings were used to determine how much natural pasture they generated.

The total number of respondents owned 5.25, 3.0625, and 48.875 ha of pasture land in highland, mid-altitude, and lowland regions, respectively. As a result, the annual production of pasture in the highlands, mid-altitudes, and lowlands was 10.5, 6.125, and 97.75 tons, respectively, for a total of 114.375 tons of dry matter. In contrast, lowland regions produced higher biomass yields than highland and mid-altitude regions.

Table 4. Dry matter feed resources category and their supply according to DM, CP and ME in three agro-ecologies of study area

Feed supply sources in tonne	Agro-ecology			Overall
	Highland	Mid-altitude	Lowland	
Natural pastures/grazing land	10.5	6.125	97.75	114.375
Crop residues	58.48	150.15	618.58	827.21
Non-conventional feed	48.6	156.6	59.58	264.78
Fodder trees and shrubs	0.42	0.34	0.53	1.29
Crop aftermath grazing	19.75	8.25	82	110
Concentrates	0	0.5	0	0.5
Forest land	6.58	1.62	22.34	30.54
Total	144.33	323.58	880.78	1348.69

3.5.3. Crop aftermath dry matter production

A total of 65,878.25 hectares of land were used for various annual crop kinds in the district's three agro-ecologies. Stubble grazing has a conversion factor of 0.5 FAO in terms of total dry matter production (1987). As a result, the district's annual feed production is 32,939.125 tons (65,878.25 ha * 0.5).

Although the amount of crop aftermath produced by the sampled households in the three agro-ecologies in the highland, mid-altitude, and lowland areas was 19.75 tons, 8.25 tons, and 82 tons, respectively, adding up to a total of 110 tons of feed obtained, a higher yield of crop aftermath (DM) was observed in the lowland areas than in the highland or mid-altitude areas due to the averagely large crop land size as compared to both.

3.5.4. Forest land dry matter production

About 5,455 acres of land were covered in forest throughout the district. To calculate the total dry matter production from forest land, a conversion factor of 0.7 FAO is employed (1987). Thus, 3,818.5 tons of dry matter in total were produced in the district. A total of 30.54 tons of dry matter were produced from forest land, with 6.58 tons occurring in highland areas, 1.62 tons in mid-altitude areas, and 22.34 tons occurring in lowland areas. This suggests that compared to the Highland and Mid-Altitude, the Lowland had a higher availability of forest land, which may serve as a source of feed for dairy cattle. This is because the study area's lowland was relatively wider than the rest.

3.5.5. Estimation of biomass yield of browses in the study area

The estimated total biomass yield of trees and bushes was 1.29 tons (1292 kg), which varied amongst agro-ecologies. They were around 0.42 tons (421 kg), 0.34 tons (344 lb), and 0.53 tons (527 kg), respectively, in highland, mid-altitude, and lowland regions. The pleasant and perennial Dashille, Grawa, shola, Nabinaba, shomboko, and kerkeha trees and bushes were found in highland and mid-altitude regions. In the end, animals in lowland areas were fed on wanza (*Cordia abyssinica*), woybeta (*Terminalia* spp.), and shifara (*Moringa* spp.) throughout the dry season. According to the responders, dashille trees are perennial and edible tree species that are used as a year-round feed source for cattle or dairy animals in highland and mid-altitude regions. In addition to the leaf portion, the young stem portion also serves as a source of food for livestock. Compared to mid-altitude areas, lowland areas had the highest biomass yield of trees and shrubs. Highland areas came in second.

3.5.6. Dry matter, protein and metabolizable energy availability

Grazing land, crop residues, non-traditional feeds, fodder trees and shrubs, crop aftermath grazing, concentrates, and forestland together produced 1,348.69 tons of dry matter (DM) in total. 3861.85 tons of DM per year were needed for the current TLU units based on the overall feed balance in terms of DM yield per annum to a total TLU value of 1693.05 (with the negative balance of 2513.16 tons). In comparison to the total dry matter (DM) needed annually, the number of total tropical livestock units (TLU) in highland, mid-altitude, and lowland environments was 182.65, 255.55, and 1254.85, respectively.

According to this finding, lowland areas require more total dry matter than mid- and highland regions do. This is because there are a lot of animals in lowland areas. In the highland, mid-altitude, and lowland regions, respectively, 144.33, 323.58, and 880.78 tons of dry matter (DM) were generated. The annual total feed balance in tons of DM for highland, mid-altitude, and lowland regions is negative in each case, at 272-, 259.21-, and 1981.53-tons DM. This outcome demonstrated that the annual dry matter production fell short of the annual requirements for animals. The results of the current study are in agreement with those from Endale (2015) in the Meta Robi district, West Shew Zone, Oromia regional state, Ethiopia, and Eba (2012) in the highlands of the Blue Nile basin, who both reported that the annual dry matter production was less than what was needed for annual livestock needs. With a negative balance of 140 CP tons, the total amount of CP generated and needed for the TLU were 477.18 and 617.72 tons, respectively.

Highland, mid-altitude, and lowland areas of the study area's three agro-ecologies produced and needed different amounts of crude protein (CP): 23.11, 51.79, and 140.92 tons of CP, respectively; 66.5, 93.26, and 457.97 tons of CP, respectively; and there was a negative balance of 43.39, 41.47, and 317.05 tons of CP, respectively. Lowland regions produce and use more CP than highland and mid-altitude regions do, in contrast. The total amount of metabolizable energy (ME) generated and used for the TLU was 25,739.3 tons of MJ and 73,683.72 tons of MJ, respectively. The significantly lower balance was 47,944.42 tons metabolizable energy. The amount of metabolizable energy (ME) produced and needed varied among the three agro-ecologies in highland, mid-altitude, and lowland regions. These amounts were 2756.29, 6176-, and 16807-tons MJ ME, respectively; 7949.12, 11121.73-, and 54612.87-tons MJ ME, respectively; and a negative balance was found in each case of 5,192.83, 4,945.73, and 37,805.

The amount of feed generated in the research area affected the differences in agroecology. In comparison to highland and mid-altitude regions, the production of dry matter (DM) from crop residue (618.58 tons year) and natural pastures and grazing land (97.75 tons annually) was greatest in lowland regions. Compared to the highlands and mid-altitude regions, the output of dry matter (880.78 tons), CP (140.92 tons), and ME (16807.8 tons) is often higher in the lowlands.

Table 5. Estimated yearly differences in feed resources availability required and balance in three agro-ecologies of the study area

Nutrients	Feed supply in tonne	Agro-ecology			Total
		Highland	Mid-altitude	Lowland	
Dry matter	Available, tons	144.33	323.58	880.78	1348.69
	Required, tons	416.62	582.9	2862.31	3861.85
	Balance, tons	-272	-259.21	-1981.53	-2513.16
Metabolizable energy	Available, MJ/t	2756.29	6176	16807	25739.3
	Required, MJ/t	7949.12	11121.73	54612.87	73683.72
	Balance, MJ/t	-5192.83	-4945.73	-37805.87	-47944.42
Crud protein	Available, tons	23.11	51.79	140.92	477.18
	Required, tons	66.5	93.26	457.97	617.72
	Balance, tons	-43.39	-41.47	-317.05	-140

The total amount of DM required for the socks annually in three agro-ecologies was 3861.85 tons DM (Table 5). However, only 1348.9 tons DM of feed were actually produced, leaving a negative balance of 2513.16 tons DM per year, or 34.92% of the annual requirement, which is only enough to sustain the current stocks for 4.19 months at the most. Although highland farmers required approximately 416.62 tons of DM annually, only 144.33 tons were actually produced, leaving a negative balance of 272.29 tons each year—just 34.64% of what was needed annually and enough to last the existing supplies for no more than 4.15 months. In the mid-altitude region, the required dry matter per year was 582.9 tons DM/year, but only 323.58 tons DM/year of feed was actually generated, leaving a negative balance of 259.32 tons DM/year, or only 55.5% of what is required to maintain the current reserves for no longer than 6.7 months. There for the overall estimated values for ME and CP availability can only support for 34.9% and 77.2% of energy and protein requirements for the total TLU units in three agro-ecologies of study area.

The shortage of feed supply was the major problems for dairy cattle production between agro-ecologies of study area. In three agro-ecologies, more farmers and dairy producers reported that a reduction in milk yield, lactation length, body condition/growth and reproductive performance of their dairy cattle was due to feed shortage.

As shown in Figure 2, dairy farmers in three agro-ecologies in the area buy feeds from outside suppliers to ease feed shortfalls from their own production. However, informal marketing is the dominating system across all of the study sites, and feed marketing is poorly structured. Green grass, standing hay, and crop residues from teff, maize, and sorghum are among the roughages that are sold informally in small quantities. Concentrates and industrial by-product feed sources weren't utilized at all research locations. Where dairy farmers lack access to land for the production of feed, feed marketing by 32 (61%) dairy producers is frequent in mid-altitude (town) areas.

The remaining 20 (39%) dairy producers used their own land and sold in small quantities at local markets. Therefore, the primary source of feed in communities at a medium height is commercial feed. During drought years, 35 (49% of farmers) in lowland areas buy crop remnants, whereas 36 (51% of farmers) use crop residues from their own cropland. 26 (100%) of the farmers in the highland region used grazing and crop land that they owned for feeding purposes. But in three agro-ecologies, alternative feeds and minerals were being sold clandestinely in the research sites. In the lowland and mid-highland agro-ecologies of the Borana Zone, Ethiopia, Takele et al. (2014) revealed findings that are consistent with the current findings.

Figure 2. Standing hay marketing system in mid-altitude(town) of the study area

3.5.7. Feed resources transporting systems in the study area

The agro-ecologies in the research area used various feed transport techniques. All of the respondents who lived in highland areas transported crop residues and other feed sources using people, particularly women, while dairy farmers in mid- and lowland areas transported feed sources using donkeys, women, and trucks. Depending on the distance to the sources of the crop residues, the truck's transportation cost averaged 720.00 ETB.

The current finding is consistent with research by Azage et al. (2013) from the International Livestock Research Institute (ILRI), Addis Abeba, Ethiopia.

3.5.8. Feed conservation/storage practices in the study area

One of the most crucial methods of managing feed to ensure feed availability is feed conservation. Conservation of agricultural leftovers for dairy cattle and animal feeds was a prevalent practice throughout the three agro-ecologies of the study areas (Figure 3). 61% of the crop residues at mid-altitude were stored in shade, while 39% were stacked in open areas. Farmers from both the highlands and the lowlands stack crop residues (100%) in a clear area.

(a) (b) (c)

Figure 3. Methods of storing different crop residues (a) Maize stover, (b) teff straw, (c) sorghum stover in the study areas

3.5.9. Feeding systems of dairy cattle in the study area

Dairy cattle were fed via stall feeding, free grazing on open pastures, and tethering at backyard and roadside locations. As indicated in Table 6, the overall feeding methods in the research regions were 56.41% free grazing, 20.51% stall feeding, and 23.07% tethering and limited stall feeding. The majority of the cattle that lowland dairy farmers feed graze freely on natural grass all year long in the same location. Participants in focus groups who discussed this issue noted that this type of feeding arrangement reduced the quantity and quality of natural pasture. In mid-altitude, 38.47% of stall feeding and tethering at backyard/roadside and 61.53% of stall feeding were observed.

Most highland farmers (around 69.24%) engage in free grazing, with the remaining farmers (30.76%) tethered on their own crop and grazing property. Lowland farmers supplemented their livestock with crop remains in the morning before letting them graze freely at home, but highland farmers supplemented their livestock with crop residues, enset, trees and shrubs, and non-traditional feeds in the morning and afternoon. Nearly all cattle owners in the study area were supplementing their herds with dry-season crop residues, trees and bushes, and non-traditional diets. Normal weight increase and milk production occur during the wet season, followed by fluctuating losses during the dry season depending on the demand placed on grazing land and the kind and amount of vegetation.

The current study is in agreement with research reports from Derese (2008) in the West Shewa Zone of the Oromia Region, Ethiopia, where the main dairy cattle feeding systems were free grazing, semi-grazing, and fulltime free grazing, and Yayeh et al. (2014) in the Debremarkos district of the Amhara regional state. Similar findings were made by Asrat et al. (2015) that dairy cattle feeding systems in Humbo woreda of Wolaita Zone, Southern Ethiopia, were free grazing, rotational grazing, and zero-grazing.

Table 6. Feeding systems in the study area

Types of feeding systems	Agro-ecology (%)			Overall (n=149)	P-value
	Highland (n=26)	Midland (n=52)	Lowland (n=71)		
Free grazing	69.24	0	100	56.41	**
Stall feeding	0	61.53	0	20.51	**
Tethering and limited stall feeding	30.76	38.47	0	23.07	**

**=P <0.001

According to Lijalem et al. (2015), the three main dairy cattle feeding techniques in southern Ethiopia's Sidama Zone were free grazing, rotational grazing, and zero-grazing. In and around Wolaita Sodo town, Southern Ethiopia, Asrat et al. (2016) discovered that the three main dairy cattle feeding strategies were free grazing, tethering, and cut-and-carry systems and Belay and Janssens (2016) in Jimma town, Ethiopia dairy cattle feeding systems were zero-grazing/stall feeding, Zero and partial grazing and fulltime grazing.

3.5.10. Form of feeding of crop residues in the study area

Asrat et al. (2015) reported similar results, stating that the free grazing, rotational grazing, and zero-grazing dairy cattle feeding regimes in Humbo woreda of Wolaita Zone, Southern Ethiopia. In the Aleta Chukka district of the Sidama Zone, southern Ethiopia, the availability of

Table 7. Form of feeding of crop residues in the study area

Parameters	Agroecology (%)			Overall (n=149)	P-value
	Highland (n=26)	Mid-altitude (n=52)	Lowland (n=71)		
Whole provided	84.65	5.3	97.2	68.9	**
Chopped provided	15.4	92.1	2.8	30.4	**
Mixed with other feeds	0.0	2.6	0.0	0.7	**
Total	100.0	100.0	100.0	100.0	

N=Number of respondents, **= P<0.001

communal grazing, private grazing, and stall feeding was evidenced. In the Sidama Zone of southern Ethiopia, free grazing, rotational grazing, and zero-grazing were the three main dairy cattle feeding methods, according to Lijalem et al. (2015). Asrat et al. (2016) identified three primary dairy cattle feeding practices in and around Wolaita Sodo town, Southern Ethiopia: free grazing, tethering, and cut-and-carry systems.

4. Conclusions

The majority of the dairy cattle feeding and availability systems in the Derashe district are subsistence production systems, with the exception of the mid-altitude (town) area. In the study areas, natural pastures, crop residues, after-harvest grazing, standing hay, maize that has been thinned, ensets, trees, shrubs, and unconventional feeds were the main sources of food for livestock. Grazing land, crop residues, conventional feeds, fodder trees and shrubs, crop aftermath grazing, concentrates, and forested lands were used to produce the majority of the dry matter. The negative balance was used to estimate the total DM yield per year that was produced and needed for the existing TLU units, as well as the amounts of CP and ME that were generated and needed. Stall feeding, free grazing on open pasture, tethering, and limited stall feeding were the feeding practices used in the research regions. The production of dairy cattle is restricted in the research region by a lack of grazing land, feed, and extension services. Despite the numerous issues and limitations that can hinder or slow down the growth of the production of dairy cattle feed in the research area, there were also favorable variables that could enhance feed production, such as climatic factors, agroecology, cereal crop production, and road access.

Based on the finding of the current study, the following recommendations are forwarded:

- All three agro-ecologies face dairy cattle feed shortages. Farmers should adopt conservation practices, such as hay and silage production during surplus periods, cultivate forages on cropland, collect and store crop residues under sheds, and build skills for sourcing feeds from local markets.
- The district lacks grazing land improvement, crop residue treatment, and water management. Stakeholders should deliver targeted extension services and training to innovative farmers to raise awareness and adoption.
- Improved forages contribute minimally due to limited access. Establish nursery sites in high-potential kebeles to promote dissemination and uptake.
- Dairy product marketing is underdeveloped, with highland/lowland farmers selling only butter and buttermilk due to cultural taboos on fresh milk, while mid-altitude producers sell milk informally. Form cooperatives for milk collection centers and market linkages to local/international buyers; extension staff should educate farmers to overcome taboos and expand fresh milk sales.

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Review Article

Trace minerals and their responses in dairy cattle: A review

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Abstract

The current dairy revolution demands more effective production in every aspect for which nutrition plays a great role in production and reproduction sustainability. For maintaining a good dairy enterprise and have steady income, it is essential to have the animals with good reproductive status with balanced nutrients in their diet. Most dairy research tends to focus on protein and energy needs, and trace minerals are often overlooked. Though, different forms of organic minerals differ in their solubility, availability and effect on animal performance and benefits appear to be more promising in the non-ruminants than in the ruminants, there is almost a consensus that organic trace minerals have higher bioavailability resulting in better animal performance, health, production immune response and stress alleviation than their inorganic salts. High yielding dairy cow requires quality feed with organic minerals and hence the bioavailability of these minerals form an essential component in the production system. Organic trace minerals consist of the same trace minerals being chelated, complexed or covalently bonded to amino acids, analogues, proteins or organic acids in a way that allows for increased absorption in the animal. In this context, organic (chelated) trace minerals can be a better solution compared to other feeding inventions.It is concluded that minerals from organic sources have higher bioavailability than inorganic sources. In dairy animals, majority of factors like nutrient intake, physiological status, manage mental and climatic conditions affect fertility of the animal. The main factor affecting the reproductive potential in different developing regions including Ethiopia is nutritional status of cows that too trace minerals. So further research with organic trace minerals is needed to: 1) better define conditions where performance or health responses may be expected, 2) define the optimal level of organic trace mineral(s) that should be added to the diet, 3) determine if responses observed are of a magnitude necessary to justify the cost, and 4) determine the mode of action whereby to improve the reproductive efficiency dairy cows.

Keywords: Dairy cows; Dietary requirements; Milk production; Organic trace mineral

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1. Introduction

Novel nutritional management and reproductive health qualifiers are major contributors to economic returns in modern dairy industry and small-scale enterprises. The modern dairy cow in such different levels needs a diet that supplies the sufficient nutrients needed to produce high quality and quantity of milk (Griffiths et al., 2007; Siciliano-Jones et al., 2008; Hackbart et al., 2010). Most dairy research tends to focus on protein and energy needs, and trace minerals are often overlooked. When trace minerals are formulated in whole diet basis, they function as structural, physiological, catalytic and regulatory (McDowell & Arthington, 2005; Suttle, 2010). Yet when we fail to consider the role of trace minerals, problems like, interferences or interactions with minerals in feed and water may arise (Overton & Yasui, 2014).

Trace minerals are also nutrients of variable forms in soils (Fletcher & Doyle, 1978; Williams, 1977; Mcdonald et al., 2010), in feedstuffs and animals in various levels and proportions in particular regions and agro-ecologies. Two broad categories of sources are available to supplement trace elements: inorganic and organic sources. After long term use of sulfates and oxides, organic trace minerals (second generation trace minerals (e.g. chelates, glycinates); it entered the market successfully as a high bioavailable and economically beneficial trace mineral source.

When referring to trace mineral source, the term “organic” is generic and encompasses numerous examples of trace elements (predominantly divalent Cu, Zn, and Mn) covalently bound to an organic ligand. The increased number of binding points results in greater stability for the molecule compared to unidentate molecules, and is known as the chelation effect (Vella, 1993). Though chelates can form four, five, six, or seven membered rings, five membered rings have been shown to have the greatest stability (Murphy, 2009). Though, different forms of organic minerals differ in their solubility, availability and effect on animal performance and benefits appear to be more promising in animals, they have higher bioavailability resulting in better animal performance, health, immune response and stress alleviation than their inorganic salts. This efficiency of its nutritional values has provoked the use of such mineral supplements better able to meet the animal's growing needs.

Mineral chelates are organic trace minerals designed to enhance gut absorption and improve bioavailability in dairy cows to have quality product. More recently, organic trace minerals are also being utilized to maximize animal productivity by elevating the cow’s genetic potential. There are several studies in different animal species with different sources of different mineral elements, which have revealed notable differences in the bioavailability of organic and inorganic minerals. Common organically bound trace minerals used in animal nutrition are iron, copper, zinc, manganese, chromium and selenium. Most of the organic minerals marketed are classified as complexes, chelates or proteinates.

Supplementation of organic mineral complexes is reported to improve dairy animal production to the recent dairy industry, especially in developed countries and least in developed countries like Ethiopia due to lack of sources (accessibility). There studies suggest that binding Cu, Zn, Fe and Mn with amino acids and peptides can enhance the bioavailability of these trace minerals, thereby leading to improved milk production, growth, reproduction and general health status in livestock. Many studies (Griffiths et al., 2007; Siciliano-jones et al., 2008; Hackbart et al., 2010) have shown a positive effect on milk yield by supplementing cows with organic trace minerals in place of inorganic minerals.

2. Trace Minerals in Dairy Cattle

2.1. Trace mineral contents of dairy cow feedstuffs

Trace minerals are present in forages and other feeds used in dairy cattle diets and with the exception of cobalt, meet the trace mineral requirements of rumen microbes (Table 1).

Table 1. Average trace mineral contents of feedstuffs (NRC, 2001; Chahal et al., 2008; Chiba 2009; Punz, 2010)

Feed stuffs	Trace mineral content mg/Kg DM of feed						
	Co	Cu	I	Fe	Mn	Se	Zn
Alfalfa fresh	0.35	12.44	-	315.43	92.68	-	36.08
Alfalfa hay	0.39	17.67	-	224.60	28.00	-	30.86
Barley grain	0.08	6.4	0.25	48	15	0.19	22
Barley straw	0.06	5.39	-	200.76	16.56	-	7.44
Bermuda grass hay	0.12	26.64	0.11	289.96	109.02	-	58.14
Brewers grain (dried)	-	14.9	-	195	57		104
Corn grain	0.14	4.17	0.30	35.20	6.22	0.13	21.63
Corn silage	0.08	7.0	0.06	196	42		32
Cotton seed cake	0.28	19.0	0.30	190	21	0.14	80
Dried skim milk	0.07	0.7	0.03	9	2.2		45
Fish meal	0.15	10.34	1.09	544.58	37.02	2.14	144.32
Grass silage, 1st cut	0.10	7.9	-	696	90		50
Rape seed extracted	-	7.1		190	76.2	-	78.9
Soya beans	0.10	17.0	0.20	125	31	0.48	58
Sunflower seed	-	28.5	-	177	33.5	2.29	79.1
Wheat grain	0.08	6.2	0.07	50	30	0.04	26
Wheat bran	0.80	11.0	0.09	90	119	0.08	95
Wheat straw	0.03	3.4	0.30	120	32	-	67

Therefore, supplementation of trace elements in animal diets of dairy cattle has long been practiced in order to ensure their rapid growth, boost reproductive performance and improve immune response (Overton & Yasui, 2014). Assessment of trace element status in the feedstuffs of animals identifies whether current mineral supplementation of livestock is adequate and whether improved productivity is likely to occur with changes in supplementation.

2.2. Trace mineral requirement in dairy cattle

Excellent nutritional management of dairy cows, particularly during the transition period from late pregnancy to early lactation, is critically important to meeting overall demands for milk yield while maintaining health and reproductive capacity (Roche et al., 2013). The pasture cattle eat, on the other hand, is frequently lacking in trace mineral concentrations. As a result, trace minerals must be added to the feed on a regular basis (Table 2).

Nutritional strategies also ensure that along with the proper energy, protein and amino acid requirements, the optimal amounts of trace minerals (TM) are supplied to the animals in tropics in order to improving body functions of production (Ward & Spears, 1997; Engle & Spears, 2000), reproduction, and immunity (Spears, 2000; Spears & Weiss, 2008).

Table 2. Requirements of trace minerals on lactating dairy cattle on dry matter basis (NRC, 2001)

Mineral	Unit	Recommended	Maximum
Cobalt	mg/ kg	0.11	10
Copper	mg/ kg	12-16	100
Iodine	mg/ kg	0.45-0.6	50
Iron	mg/ kg	50	1000
Manganese	mg/ kg	45-55	1000
Selenium	mg/ kg	0.3-0.5	2
Zinc	mg/ kg	45-60	500

Trace minerals have significant roles in physiological, biochemical, and immune, processes throughout the animal's body (Lei & Yang, 2005). Recent data indicate that micronutrient management will enhance the production of good quality milk (Table 3).

Table 3. Trace minerals requirement for per kg milk production of dairy cattle (ICAR, 2013)

Mineral	Unit	Requirem
Cobalt	mg/ kg	0.006
Copper	mg/ kg	3.75
Iodine	mg/ kg	5-50
Iron	mg/ kg	2.25
Manganese	mg/ kg	3.0
Zinc	mg/ kg	26.67

The keratin lining of the teat canal has been described as a physical and chemical barrier for protection of the mammary gland from bacterial attack and prevent entry. Because the mammary gland is a skin gland, it is highly likely that zinc will have a positive role in its protection.

Concentrations of TM in soils vary widely across the world, with some areas being high in Fe, Mo, or S, while others are deficient in Se and Zn (Suttle, 2010). Trace mineral status changes depending on several factors, including lactation, health, growth, feed quality, gestation progression, and pregnancy status (Table 4).

Deficiencies of TM (Figure 1) occur either as primary deficiency (inadequate intake or amount in the diet), or more commonly as secondary deficiency because of antagonistic interactions with other TM (Smart et al., 1981; Graham, 1991; Suttle, 2010).

Table 4. Summarization of trace minerals in Dairy rations (De Ondarza & Mary Beth, 1996; Linn et al., 1996; Kumar, 2003; Chaudhary & Singh, 2004)

Trace mineral	Function	Feed sources for dairy cattle
Cobalt	Part of vitamin B12, needed for growth of rumen microorganisms	Trace mineralized salt and commercial supplements
Copper	Needed for manufacture of haemoglobin, coenzyme	Trace mineralized salt and commercial supplements
Iodine	Synthesis of thyroxin	Iodized salt, trace mineralized salt and commercial supplements
Iron	Part of haemoglobin, part of many enzyme systems	Forages, grains, trace mineralized salt, ethylene diamine dihydroiodine
Manganese	Growth, bone formation, enzyme activator	Trace mineralized salt and commercial supplements
Molybdenum	Part of the enzyme xanthine oxidase	Widely distributed in feeds, deficiency rarely problem
Selenium	Functions with certain enzymes, , associated with vitamin E, immune system	Oil meals, alfalfa, wheat, oats, corn, commercial supplements
Zinc	Enzyme activator, wound healing	Forages, trace mineralized salt, zinc methionine

Antagonistic interactions between TM can result from the formation of insoluble complexes that limit its absorption in the gut, competition for binding sites, carrier proteins, or similar metabolic pathways, and induction of non-specific metal-binding proteins (Suttle, 2010).

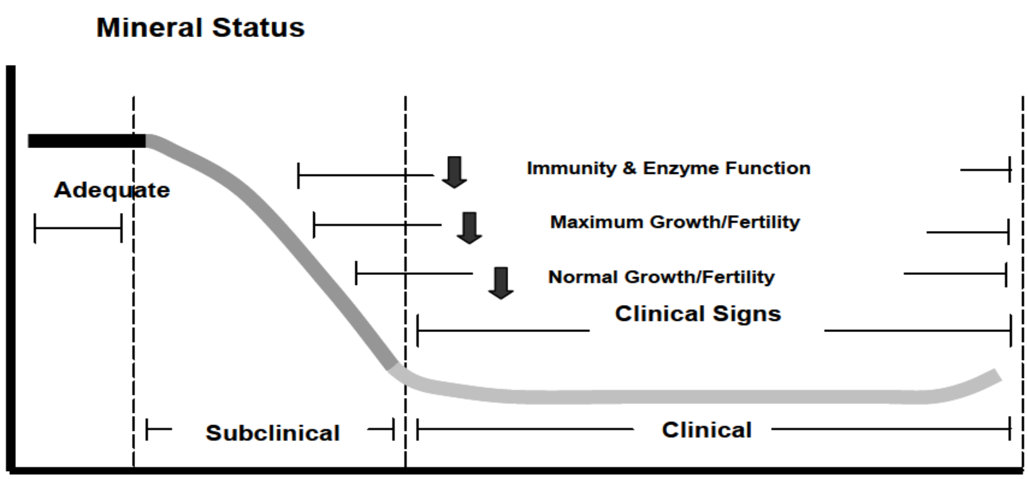

Figure 1. Declining trace mineral status on animal performance (Fraker, 1983; Wikse, 1992)

2.3. Trace mineral sources

Forages and feedstuffs commonly used in dairy rations that were from TM depleted soil are often deficient in zinc, manganese, copper and cobalt which in turn are responsible for low productivity problems among growing cattle in the tropics. Trace minerals such as Cu, Mn, and Zn have important roles (Miller et al., 1988), and have been typically offered to cattle either in inorganic or organic forms. Most research conducted using these various forms has focused on either partial or full replacement of either sulfates or oxides with one of the other forms with potentially greater bioavailability (Spears & Weiss, 2008).

2.3.1. Inorganic supplements

Micro-minerals that are not bound to carbon (C) but arranged with oxygen, chloride or other non-carbon-based compounds are inorganic trace minerals (carbonates, chlorides, sulfates, oxides, etc.) (Taylor & Field, 1998). Inorganic has been the primary option for feed grade TM supplementation for decades due to their affordability (cost) and high rumen solubility (Cunningham et al., 1953; Ammerman & Goodrich, 1983; Greene, 2000). Although inorganic trace minerals are often used in ruminant supplements, these mineral sources often have lesser biological availability and stability when compared to other organic mineral sources.

Inorganic TM dissociates in the reticulo-rumen, omasum, and abomasum, and can form compounds with plant polyphenols (McDonald et al., 1996) or with other TM that may have precipitated out of the digesta (Spears & Weiss, 2008). These complexes are insoluble and cannot be absorbed in the small intestine, which decreases the availability of the inorganic form to the host (Wright et al., 2008).

2.3.2. Organic supplements

The American Association of Feed Control Officials (Gayathri & Panda, 2018) define organic trace minerals as seven different complexes (a soluble metal salt and at least one amino acid); including metal (specific amino acid) complexes, metal amino acid complexes, metal amino acid chelates, metal proteinates, metal polysaccharide complexes, metal propionates, and yeast derivative complexes. Organic is considered to be chelated or complexed as a result of the metal ion (mineral) bound to a ligand via two or more donor atoms to form a heterocyclic ring(s) that contain the metal atom (Power & Horgan, 2000; Andrieu, 2008).

According to Miles & Henry (1999), the perceived benefits of organic trace minerals are: 1) protects the mineral from unwanted chemical reactions in the gastrointestinal tract by the ring structure; 2) chelates can pass easily intact through the intestinal wall into the blood stream; 3) reducing interactions between the mineral and other nutrients because of increased passive absorption; 4) the mineral is delivered in a form similar to that found in the body; 5) chelates are absorbed by different routes than inorganic minerals; 6) each mineral in the chelate facilitates the absorption of other minerals in the chelate; 7) chelates carry a negative charge so they are absorbed and metabolized more efficiently; 8) chelation increases solubility and movement through cell membranes; 9) chelation increases passive absorption by increasing water and lipid solubility of the mineral; 10) chelation increases stability at low pH; and 11) chelates can be absorbed by the amino acid transport system.

2.3.3. Hydroxy chloride trace minerals

Hydroxy trace minerals are relatively insoluble in water but become soluble under acidic conditions typical of those found in the abomasum of ruminants. These mineral sources have low water solubility (Spears & Weiss, 2008; Caldera et al., 2019) and in forage-fed ruminants, hydroxy chloride sources of Cu and Zn are less soluble in the rumen and bind less tightly with solid digestion than sulfate sources of the same metals (Jalali et al., 2020). The low solubility in water results in hydroxy trace minerals being non hygroscopic and less reactive in feeds and premixes than sulfates, resulting in improved vitamin stability (Lu et al., 2010) and less oxidation of lipids (Miles & Henry, 1999). These ruminal characteristics may explain, at least partially, the alleged increase in Cu bioavailability of hydroxy chloride vs. sulfate sources (Caldera et al., 2019) and by-pass the rumen, thus minimizing interactions that normally occur in the rumen.

2.4. Types of organic trace minerals supplements

Organic trace mineral supplements vary in regard to the type of ligand or ligands used to form the metal complex or chelate. In order for an organic mineral to be effective, four criteria should be met: higher water solubility, remain stable throughout the digestion process, enhance absorption and produce an economically beneficial response in the animal of trial.

Different types of organic trace elements are available on the market. For some of them, short-chain peptides and amino acids derived from hydrolysed soy proteins are used as ligands, and others use pure amino acids. Studies have shown that animals absorb, digest and use organic mineral sources better than inorganic ones, resulting in a greater bioavailability. According to the Association of American Feed Control Officials (AAFCO, 1998), various types of organic mineral products are shown in the Table 5. Deficiencies of TM (Figure 1) occur either as primary deficiency (inadequate intake or amount in the diet), or more commonly as secondary deficiency because of antagonistic interactions with other TM (Smart et al., 1981; Graham, 1991; Suttle, 2010).

Table 5. Classification of organic minerals as defined by American Feed Control Officials

Ligand type	Description
Metal (specific AA) complexes	These are the products resulting from complexing a soluble metal salt with a specific amino acid. E.g, zinc methionine is produced by combining zinc sulfate and amino acid (AA) methionine or copper lysine and manganese methionine.
Metal amino acid complexes	These are characterized by a metal atom (zinc for instance) complexed with several single amino acids. Each individual molecule is still one metal ion and one amino acid but has a variety of amino acids in the blend. For instance for a zinc complex in this category, the blend would include zinc methionine, zinc lysine, zinc leucine, zinc cystine, etc.
Metal amino acid chelates	These are formed from the reaction of a metal ion from a soluble metal salt with amino acids having a mole ratio of one mole of metal to one to three (preferably two) moles of amino acids to form coordinate-covalent bonds. The average weight of the hydrolyzed amino acids must be approximately 150 Da, and the final molecular weight of the chelate must not exceed 800 Da. Metal amino acid chelates are available for Co, Cu, Fe, Mn, and Zn.
Metal proteinates	These result from chelation of soluble mineral salt with AA and/or hydrolyzed protein. Final product may contain single amino acids, dipeptides, tripeptides or other protein derivatives.
Metal polysaccharide complexes	These are generally prepared by coating the metal with polysaccharide molecules. These are larger molecules based on chains of simple sugars that are highly soluble in digestive tract.
Metal propionates	These result on combining soluble metals and soluble organic acids such as propionic acid. The resultant products are highly soluble and generally disassociate in solution.
Yeast derivative Complexes	Other sources of organic trace elements that show promise are mineral enriched yeast. Presently the most common is selenium yeast with selenium complexed with a methionine molecule (selenomethionine). Chromium enriched yeast also has gained popularity for improving animal production (Rao et al., 2012).

2.5. Products of organic trace minerals and their effects

In tropical areas, poor grasslands remain the primary bottleneck for optimal cattle production (McDowell & Arthington, 2005) and several environmental characteristics (e.g. parent material, heavy rainfall) increase the risk for trace element imbalances in dairy cattle (Dudal, 1980). In recent years, there has been considerable interest in the use of organic trace minerals (OTM) in ruminant diets in many parts of tropical areas in order to support the overall health, performance and reproduction.

Researches investigating the impacts of organic trace minerals on grazing production systems have been highly variable. This happens due to the impacts that the rumen microbial population and fiber fractions in forage-based diets (Marques et al., 2016) exert on mineral x mineral interactions (e.g., formation of mineral complexes). However, recently organic mineral sources have begun to gain popularity because of a number of perceived benefits to their use (Miles & Henry, 1999).

Studies have confirmed that feeding amino acid complexes of Zn, Mn, and Cu, (Miller et al., 1988) and cobalt glucoheptonate improves performance of dairy cattle. The benefits include preventing mastitis, improving fertility, and reducing the incidence of foot lesions (Nocek et al., 2000; Uchida et al., 2001; Ballantine et al., 2002; Kellogg et al., 2004). According to the work of Krebs (1998), feeding organic sources of Zn, Cu and Selenium to dairy cows reduced the number of subclinical mastitis cases, but did not alter the concentrations of serum super oxide dismutase (SOD), glutathione peroxidase and ceruloplasmin. Through performance increases in milk yield and reproduction, decreased SCC and improved hoof health, the predicted results include a return on investment that tops 2 to 1.

The study of Nocek et al. (2006) was influential with selected organic trace minerals on milk production in that milk production increased (Kinal et al., 2005) due to their inclusion with basal diet in whole diet basis. Availa-4 and 4-Plex (Zinpro Corp., Eden Prairie, MN) are 2 products containing combination of organic Zn, Cu, Mn, and Co. The Zn, Cu, and Mn found in these products are complexed with single AA ligands, whereas the Co is complexed with glucoheptonate. Organic trace minerals significantly increased milk production by 0.93 kg/day, milk fat yield by 0.04 kg/d, and milk protein yield by 0.03 kg/d (Rabiee et al., 2010).

Table 6. Effect of complexed trace minerals on cow performance

Organic mineral	Observations	Refernces
Cu, Zn, Mn	Similar milk yield and composition Similar body weight No effect on uterine health Similar plasma variables	Yasui et al., 2014
Zn-amino acid complex	Decreased postpartum DMI Increased (20%) colostrum IgG concentration Feed efficiency increased Decreased service preconception Decreased milk fat concentration	Nayeri et al., 2014
Cu, Zn, Mn-polysaccahride complex	Reduced no. of days in open Increased conception rate No change in milk yield and composition	Chester-Jones et al., 2013
Cu, Zn, Mn	Increased colostrum immunoglobulins Increased milk fat No change in milk yield, protein and SCC Lower calf mortality Increased service perconception	Formigoni et al., 2011

Benefits of organic trace minerals include improvements in growth, milk production, reproduction, and somatic cell score (Andrieu, 2008; Spears and Weiss, 2008). Improvements in animal production despite measured differences in bioavailability suggest that current measures of bioavailability are either not sensitive enough to detect differences or do not reflect actual pools of minerals available to support animal physiology.

Bioavailability of Organic Trace Mineral

The proposed benefit to feeding organic trace minerals is that they should undergo less dissociation in the reticulo-rumen, omasum, and abomasum than their inorganic counterparts. Bioavailability of trace minerals can be defined as the proportion of an ingested mineral that is absorbed, transported to its site of action, and converted to the physiologically active species (O'Dell, 1983). Bioavailability can be affected by a number of factors such as animal species (breed and genetic variations of TM absorption and metabolism/physiological state), pH of the rumen and abomasum, antagonistic interactions with other TM, previous nutrition of the animal, interactions with dietary nutrients and ingredients, choice of response criteria, choice of standard source, and chemical form and solubility of the mineral element (Ashmead, 1993; Suttle, 2010).

The TM source, as either inorganic or organic is theorized to affect their bioavailability to the animal; with organic TM proposed to be more bioavailable (Gallaher et al., 1999) than their inorganic counter parts (Spears, 2000). Use of a standard source allows expression of bioavailability in terms of relative biological availability (Miller, 1983). Previous researches investigating the effects of metal complexes of methionine and lysine have shown that both mineral sources have greater bioavailability compared to inorganic salts (Wedekind et al., 1992; Nockels et al., 1993).

Amino acid complexes of trace minerals are more bioavailable (Wedekind et al., 1992; Paripatananont & Lovell, 1995) and are better retained by the body (Nockels et al., 1993) than inorganic sources of trace minerals. However, association of minerals with fiber fractions in feedstuffs (Whitehead, 1985) and/ or binding of minerals to undigested fiber constituents in the gastrointestinal tract may alter bioavailability of some trace minerals in ruminants (Kabaija & Smith, 1988). In general, most commonly reported positive responses to feeding in more bioavailable (OTM) forms to dairy cattle include increased milk yield, improved reproductive performance, decreased SCC, decreased lameness and improved foot health, and decreased disease incidence.

2.6. Organic trace mineral on nutrient utilization

Mineral intake is influenced by a variety of parameters, including animal needs, soil features, forage type and availability, water quality, protein and energy supplements, mineral supplement palatability, mineral freshness, mineral access and mineral supplement source and physical form (Tait & Fisher, 1996). The predominant forms of trace minerals available for supplementation typically are categorized as either inorganic or organic, with primary reference to their chemical structure. Metals are chelated, complexed, or covalently linked to AA, AA analogues, proteins, or organic acids, among other organic compounds, in various forms of organic trace minerals.

The majority of research involving these various forms has focused on replacing sulfates or oxides with one of the other forms with potentially improved bioavailability (Spears, 2000). Although some research has been done using these various forms as single sources (as described previously in the discussion for individual trace minerals), a significant amount of research has been done, including several recent studies, in which supplementation of blends of Zn, Cu, and Mn was evaluated in dairy cows during the transition period and(or) early lactation.

Dietary Mo and Cu consumption is influenced by Zn, Fe, and Mo intakes (McDowell & Arthington, 2005) can inhibit cu absorption and utilization. Organic trace minerals consist of the same trace minerals being chelated, complexed or covalently bonded to amino acids, analogues, proteins or organic acids in a way that allows for increased absorption in the animal (Figure 1) and to “do more with less” through lower inclusion levels. Research demonstrates that providing a more stable and predictable source of trace minerals, like hydroxychloride trace minerals; improves the precision of diets while supporting cow growth, digestive health, and milk production.

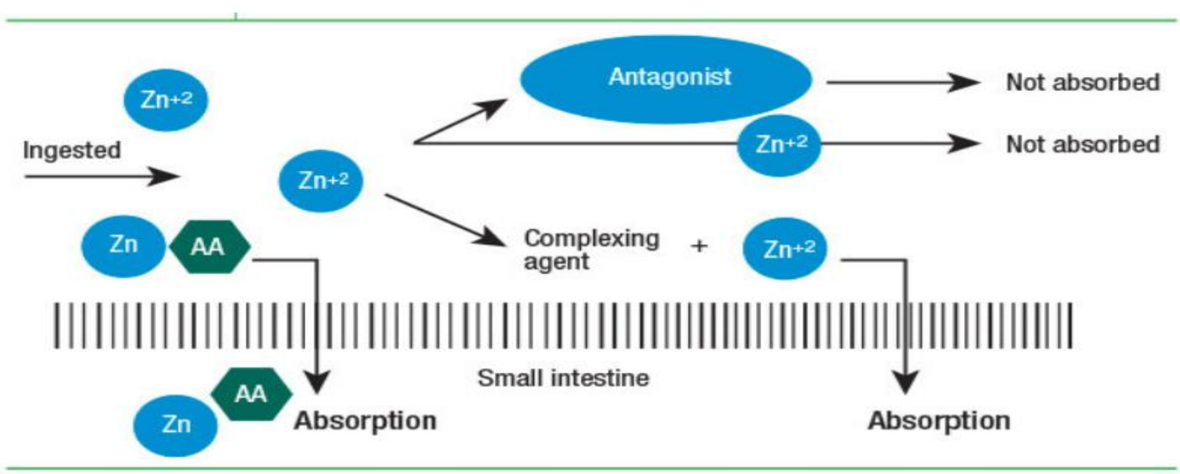

Figure 2. Mineral absorption in the gut

2.7. Organic trace mineral on lactation and reproductive performance

Functions of lactation and reproductive performance of dairy cattle are critical to the profitability of dairy operations (Table 7). From the perspective of trace mineral nutrition, among organic parts play very precious role in maintaining production, reproductive function and health of a dairy herd. As level of milk production has progressively increased, there has been considerable interest in the use of organic trace minerals in rations for ruminants. Organic forms of Cu, Mn, and Zn including metal amino acid chelates, metal complexes, metal methionine hydroxy-analog chelates, metal proteinates, and metal propionates have been shown to increase intestinal absorption and mineral bioavailability (Predieri et al., 2005; Wright et al., 2008).

Rabiee *et al*. (2010) performed a meta-analysis of production and reproductive results from 24 studies in which cows were supplemented with AA-complexes of Zn, Cu, and Mn, as well as Co-glucoheptonate from the same business. Although findings were significantly diverse, supplementing with these kinds of trace minerals enhanced milk output by a weighted mean difference of 0.93 kg/d. Kellogg et al. (2004) reviewed 12 studies that looked at the effects of feeding Zn-methionine complex on lactation performance and udder health, and found that supplementing with Zn-methionine complex decreased somatic cell count (SCC), and increase milk output.

Table 7. Effect of complexed Zn, Mn, Cu and Co on milk yield and milk components, milk composition and cases of mastitis of intensively grazed, lactating dairy cows (Cope et al., 2009)

	Treatment		S.E.[a]	P
	Control	CTM		
Milk production (kg/day)	16.6	17.5	0.31	0.04
Milk energy output (MJ/day) (kg/day)	55.3	58.6	0.93	0.01
Fat yield (kg/day)	0.73	0.78	0.014	0.02
Crude protein yield (kg/day)	0.58	0.62	0.010	0.01
Solids yield (kg/day)	1.31	1.39	0.023	0.01
Fat (g/kg)	44.4	44.9	0.67	0.11
Crude protein (g/kg)	35.1	35.5	0.31	0.37
Solids (g/kg)	79.4	80.3	0.93	0.50
Mastitis (cases/100 cows)	29.9	23.8	–[b]	0.08
Somatic cell count ($\times 10^3$ mL^{-1})	126	110	9.5	0.22

2.8. Effect of organic trace mineral nutrition on the environment

Factors that complicate trace mineral nutrition at the farm level include the existence of a large number of antagonisms affecting bioavailability of individual trace minerals and uncertainty in terms of requirements under all physiological and management conditions; thus, determining the optimum level and source of trace minerals under each specific situation continues to be a challenge. Soil type, elevation and plant group appeared to be the major determining factors for trace element supply.

Environment and certain grazing strategies were intimately related, and might provide both explanation and solution for hampered trace element supply. Targeted use of trace minerals also may limit the release of non-absorbed minerals in waste, supporting environmental sustainability efforts. Organic minerals were designed to reduce antagonistic relationships within the gastrointestinal tract and thus increase the bioavailability of trace elements. The organic part of trace minerals has tremendous quality over inorganic counterpart in that, the former increased bioavailability, reduction in their excretion and thereby reduction in the environmental pollution in different dairy cow enterprises.

2.9. Supplementation strategies of trace minerals

Cattle producers have a variety of methods for providing supplementary trace minerals to their animals in organic or inorganic form based on their chemical structure. Each method's applicability is determined by the animal's demands, the mineral concentrations in the feedstuffs consumed by the cattle, and the ability to offer trace mineral supplementation.

2.9.1. Free-Choice, salt-based supplements

The most common method for providing supplemental trace minerals to grazing cattle involves the formulation and blending of supplemental trace minerals with common salt, offered free choice. The success of the free choice, salt-based supplementation system is based on the concept that cattle are naturally seeking salt; therefore, it is essential that supplemental trace minerals be mixed directly in the salt carrier, not separate. In study, Manzano *et al*. (2021) reported a range in variation in free-choice mineral intake (reported as CV) of 77.5 to 108.4% among individual steers grazing cool season forages.

These researchers also observed differences in the pattern of mineral feeder visits throughout the day, whereas in the autumn period steers concentrated their visits during the mid-day hours compared to a uniform pattern of visits throughout the day in the spring period. The authors suggest that the steers targeted their visits to the mineral feeder during the daylight hours, fewer of which were available in the autumn period. When attempting to determine the optimal salt inclusion level of a free-choice, trace mineral-fortified supplement, the average intake of the herd over a 1- to 2-week period should be the target.

The level of increased salt inclusion will reduce visits to the mineral feeder and overall supplement intake (Braghieri et al., 2011). Mineral blocks (i.e., salt blocks) offer management conveniences related to labor because they often require less frequent replacement due to reduced intake by cattle. Block intake can be as much as 10% less than the consumption of supplements in loose form, potentially creating a gap between mineral consumption and cattle requirements (McDowell & Arthington, 2005).

2.9.2. Fortification of energy/protein supplements

The best method of insuring intake of supplemental trace minerals is through the fortification of energy and protein supplements. Although variation in voluntary intake among cattle that are provided with energy and protein supplements is expected, it is less than the variation observed with loose, mineral mix supplements (Bowman et al., 1997). Careful examination of the nutrient profile, matched to targeted intake, can determine if additional trace mineral supplementation is needed. If properly formulated, free-choice, salt-based supplementation could be replaced by energy and protein supplements during specific seasons of the year. Attention to animal dominance, adequate bunk space, feeding methods, and targeted intakes are essential (Bohman *et al*,. 1984). When properly managed, this supplementation strategy can significantly affect the overall economics of nutrient supplementation of the grazing cowherd.

2.9.3. Trace mineral injections

More recently, injectable multielement trace mineral products containing a combination of EDTA-bound Cu, Zn, and Mn with Na selenite have become more commonly used in grazing cattle. Injectable trace minerals have also been shown to improve reproductive performance among grazing beef cattle. In the example of Cu, they have not been favorably adopted due to the propensity to create injection site reactions (Boila et al., 1984) which were sometimes severe depending on the preparation (Pogge et al., 2012). Indeed, it is not surprising to conclude that trace mineral status of the cow or heifer at the time of injectable trace mineral administration would impact subsequent performance responses, such as reproduction. Additionally, injectable trace minerals may serve as a complement to traditional oral supplementation strategies, particularly in production systems having trouble managing routine delivery and/or intake of free-choice supplements.

2.9.4. Biofortification

Biofortification of forages is a noteworthy advancement in field of trace mineral supplementation of grazing cattle, particularly for Se. This methodology is based on the application of trace minerals as fertilizers to plants or amendments to soil. In the case of Se, biofortification of agronomic crops in Finland has been responsible for improving the Se status of the livestock and human population (Ranches et al., 2017).

Research with forage crops has shown substantial increases in forage Se concentrations in Se-biofortified warm season grasses (Valle et al., 1993; Filley et al., 2007), cool-season grasses (Hall et al., 2013) and legume forages (Hall et al., 2011). Selenium from Se-biofortified forage appears to be more available than inorganic Se at similar levels of intake when consumption is limited (<3 mg/d) (Valle et al., 1993). Additionally, short-term access to Se-biofortified forages improves Se stores that may support cattle through subsequent periods of Se inadequacy (Wallace et al., 2017).

2.9.5. Boluses and drenches

Boluses and drenches are considered direct methods of supplementing trace minerals. Long-acting trace mineral boluses (including Cu, Se, and Co) that can last up to six months are beneficial for cattle on wide difficult topography areas where free-choice mineral supplementation may be limited. Jackson et al. AAFCO, (1998) evaluated several single-use, pulse-dose trace mineral products (injectable, drench, paste, and bolus) and found that injectable trace minerals were effective at rapidly increasing trace mineral concentrations in plasma and liver, whereas long-acting boluses may be useful if a gradual increase in liver trace mineral concentrations is desired.

2.10. Challenges of organic trace mineral supplementation

Factors that complicate trace mineral nutrition at the farm level include the existence of a large number of antagonisms affecting bioavailability of individual trace minerals and uncertainty in terms of requirements under all physiological and management conditions; thus, determining the optimum level and source of trace minerals under each specific situation continues to be a challenge. The absorption antagonisms for many trace minerals are well-known (Spears, 2000), but are going to vary from farm to farm based upon variations in other feedstuffs and their composition and the micronutrient content of water.

The higher bio-availability of organic trace minerals can answer the new challenges arising from the legislation in favor of reducing the input and output of minerals while supporting animal health and welfare issues. Thus, the relevance of organic trace minerals is increasing from day to day in the situations where the pressure exerted by legislation and consumers is growing. These additives positively support sustainability along the production chain by providing safety to workers handling the product; maximizing return on investment by reducing the cost of supplements and improving performance through lower supplementation. Finally, their bio-availability reduces the environmental impact by lowering the mineral output that leads to soil pollution and a long-term toxicity risk. Lowering the level of trace element supplementation is key to extending this timescale and minimizing the environmental impact. They also enable better quality products in line with public health regulations to be produced for the end consumer.

Even if organic mineral sources are more bioavailable than inorganic sources, cost of these sources will be a major factor in the decision on whether or not to use them. One approach to this problem would be to supply only a portion of the supplemental minerals in the organic form. Deficient soils and forage TM content necessitate TM supplementation of animals in most tropical areas to ensure they have the adequate stores required for growth, production, and immune function. Additionally, if soils or pastures are containing high concentrations of minerals such as sulfur, molybdenum, and iron, the absorption of other TM can be adversely affected (McDowell & Arthington, 2005; Suttle, 2010).

Seasonal variations in forage trace element concentrations largely depend on the geographical and climate conditions. For example, the Se content of plants is lower in areas with high rainfall and its uptake by plants is largely determined by the temperature (higher rate at temperatures >20°C), whereas Fe concentration in pasture shows seasonal fluctuations, with peaks in spring and autumn (Kabata-Pendias, 2011). Trace element concentrations are also influenced by the stage of plant development: higher contents of Fe, Zn and Cu were detected in alfalfa leaves in the first stage of plant development (Markovic et al., 2009), and concentrations of Mo and Zn are also known to vary with plant development stage (Kabata- Pendias, 2011).

Preservation of forage also affects the trace element content, and for example the process of fermentation of silage appears to increase the Fe bioavailability (Hansen & Spears, 2009). Various factors affect TM bioavailability and include the amount of TM in the diet, pH of the rumen and abomasum, antagonistic interactions with other TM, and breed and genetic variations in TM absorption and metabolism (Ashmead, 1993; McDowell & Arthington, 2005; Suttle, 2010).

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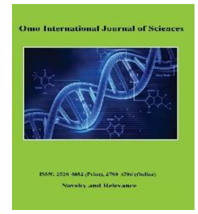

Research Article

Sheep breeding practices and reproductive performances in Arba Minch Zuria district of Gamo zone, Southern Ethiopia

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Abstract

The study was carried to characterize sheep breeding practices and reproductive performances in Arba Minch Zuria Woreda of Gamo zone, Southern Ethiopia. The district was selected based on its potential for sheep production and distribution of different sheep breeds in the most of villages of the district. It was stratified in to three distinctive agro-ecologies; highland, midland and lowland. A total of 138 households were interviewed using structured questionnaire and probability proportional to size sampling technique was used to select respondents. Data were analyzed using statistical procedures for social science version 20. The overall purpose of sheep rearing across all AEZs was source of income, saving, meat production, sharing the risk and manure production which were ranked first to fifth in the given order. Observed sheep breeding system was generally uncontrolled and no planned selection of breeding stock is practicing. Rams are herding together with ewes. Body size, coat color and long and fatty tail type (from Bonga/Dawuro and Doyagana/Wolaita) were the most frequently reported traits in selecting breeding rams; whereas size, color, tail size and twining rate were mentioned as traits given due emphasis in choosing future breeding ewes. The overall age at first lambing was 12.81±0.14 months, lambing interval was 7.52±.08 months and litter size were 1.50±.08 lamb per sheep ($P<0.05$). A high lambing month was extended from April to May. As per the current findings, the reproductive performance the sheep of the study area could be categorized as medium level of productivity. Therefore; further confirmatory study is recommended to identify and select the superior breeding animals based on well documented information for economically important traits.

Keywords: Arba Minch Zuria district, Breeding practice, Reproductive performance, Sheep

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1. Introduction

Ethiopia is believed to have the largest sheep population in Africa, which is estimated to be 30,697,942 million heads (CSA, 2017). Sheep are highly adaptable to a broad range of environments owned by smallholder farmers as an integral part of the livestock sub-sector (Zelalem, 2016). Approximately 75% of the sheep are kept in smallholder mixed farms in the highland areas, which cover areas of over 1500 altitude and receive over 700 mm of annual rainfall, while the remaining 25% are found in the lowlands. Sheep are traditionally kept in smallholdings and are associated with the small-scale resource poor livestock keepers (Zewdu, 2008).

Indigenous sheep in Ethiopia have a multipurpose role for smallholder farmers as sources of income, meat, milk, skin, manure and coarse wool or long hairy fleece. They are also a means of risk avoidance during crop failure. Thus, increasing the current level of productivity of sheep is essential to meet the demands of the ever-increasing human population (Mengesha & Tsega, 2012). Sheep serve as living bank for their owners and serve as source of immediate cash need and insurance against crop failure especially where land productivity is low and unreliable due to erratic rainfall, severe erosion, frost, and water logging problems. According to Zewdu (2008), sheep also play an important role in cultural, social livelihoods and religious values for large and diverse human population.

Based on research finding of (Kassahun, 2000; Edea, 2012), adaptive traits such as tolerance to diseases and feed shortage were given low emphasis in selecting replacement stocks in highland sheep breeds. Disease, feed and grazing land shortage identified several constraints such as early disposal of breeding stocks, small flock sizes with only a few breeding males, uncontrolled mating, communal grazing in wet season and free roaming during dry season that make controlled breeding or mating very difficult.

Traditional breeding practices such as sharing of breeding rams should be further strengthened. This in turn requires the full participation and long-term commitment of sheep keepers and other livestock development actors. To realize full benefits of a breeding strategy; approaches should be holistic with concurrent improvement in the non-genetic factors (disease resistance and feed efficiency) as well. The productivity of indigenous breeds is low compared to temperate breeds, but their ability to survive and produce in the harsh and mostly unpredicted tropical environment is remarkable. Reproductive performances are important early indicators of adaptability and management adequacy (Abegaz et al., 2002; Getahun, 2008).

The most important components of reproductive performance in sheep are age at first service, age at first lambing, lambing interval, litter size, slaughter age, ewe productive life and ewe life time lamb crop. Puberty in the ewe lamb is the point in which she first exhibits estrus. From the point of farmers view, puberty is the age at first service. Studies revealed that age at first mating for both sexes is not fixed and sheep are left to nature to reproduce (Zewdu, 2008).

Characterizing the current production systems, breeding practices, and productivity level of the breed/ type in their habitat are prerequisites to set up an improved management program at the smallholder and pastoral levels (Kosgey et al., 2004). Since, availing basic information is important to improve the small ruminant sector in general and sheep production system in particular with the focuses of improved breeding management practices, it is important to carry out research in this regard to filling the information gap in the study area. Therefore, the present study is planned with the following specific objectives: to assess the existing breeding management practice and breed/trait preferences and reproductive performances of different sheep types/breeds in the study area.

2. Materials and Methods

2.1. Description of the study area

The study was conducted in Arba Minch zuria woreda of Gamo zone, Ethiopia. The woreda is selected based on its high sheep production potential, large sheep population, pioneer in introducing of well productive Bonga, Dawuro and Doyogena local sheep breeds and have suitable agro-ecology. Arba Minch zuria woreda is characterized here under in the Table 1.

Table 1. The brief description of the study area

Climatic conditions	Arba Minch *Zuria woreda,* Gamo Zone
Major agroecological zones based on elevati on of meter above sea level (m)	Below 1500 (27.6%) (Low land), 1500- 2300 (41.4%) (Mid land) and 2300 – 3300 (31%) (highland)
Mean annual temperature (^{0}C)	16.3-30.6
Mean annual rainfall (mm)	800 – 1600
Sheep farming system	Mixed with crop production

2.2. Sampling technique and sample size

Multi-stage sampling procedures were followed at three different stages. In the first stage, three distinctive agro-ecologies that are potential for sheep farming were purposive selected. These three strata are low lands (<1500 m.a.s.l.), midlands (1500-2300 m.a.s.l.) and high lands (>2300 m.a.s.l.) (MoA, 2000).

In the second stage, based on reconnaissance survey and participatory rural appraisal (PRA) information; one representative farmer’s administrations (*kebeles)* from each stratum, three from the *woreda*, were selected following stratified random sampling technique. In the third stage, individual household heads having sheep of any breed and size and/or adopted improved sheep farming practices were identified and selected using systematic random sampling technique.

A list of households in each survey site was identified with the help of the chief of *kebeles* and agricultural development agents. The identified household heads were questioned using a pretested structured questionnaire. The total sample size for household interview was determined using probability proportionate (Eq. 1) to size-sampling technique Cochran (1977).

$$n = \frac{Z^2 * (p)(q)}{d^2} \tag{1}$$

Where, n= Desired sample size when population (household, HH) greater than 10,000; Z= Standa rd normal deviation (1.96 for 95% confidence level); P = 0.1 (proportion of population to be incl uded in sample i.e., 10%); q = is 1-P i.e. (0.9); d =is degree of accuracy desired (0.05) or 5% erro r term. The sample size was 138; which included 43 HHs from highland, 57 midland and low lan d 38 HHs were selected.

2.3. Data sources and data collection tools

A focus group discussion consisting of 12 famers were conducted in each agro-ecology. The focus group included model and well experienced sheep farmers, women, development agents and kebele governor at each agro-ecology. Discussion was made to complement the interview information and consists the objective of sheep keeping, breeding practices, selection criteria and trait preferences, and reproductive performances like age at first lambing and lambing interval, life span lambing, litter size, parturition length and puberty age, general management and breeding practices, productivity and adaptation ability.

In addition, the researcher's own observation to production system and breeding practices was made besides group discussion, questionnaire interview and communication with concerning livestock experts at different levels, farmers trait/breed preferences of sheep in the studied areas were collected using a pretested structured questionnaire.

2.4. Statistical analysis

Data (both qualitative and quantitative) was cleaned and entered into Microsoft office Excel every day after administering questionnaire to prevent loss of data. All the surveyed data was analyzed using statistical procedures for social science (SPSS) version 20. The indices were calculated for purpose of keeping sheep and trait preferences as follows:

Index = Sum of (3 × number of households ranked first + 2 × number of households ranked second + 1 × number of households ranked third) given for an individual reason, criteria or preference divided by the sum of (3 × number of households ranked first + 2 × number of households ranked second + 1 × number of household ranked third) for overall reasons, criteria or preferences.

3. Results and Discussion

3.1. Purposes of keeping sheep

The overall purposes of sheep production in the study areas were ranked as 0.32, 0.23, 0.17, 0.14, 0.13, and 0.01 for sale (income generation), saving, meat, share risks with other animals, manure and social functions (sacrifices or ritual), respectively. In the study area, sheep were kept for sale (income generation), meat, manure, saving, share risks with other animals and social functions (sacrifices or ritual) in highland with the index value of 0.31, 0.16 ,0.20, 0.20, 0.12 and 0.01, respectively and in the mid altitude 0.30, 0.19, 0.16, 0.12, 0.15 and 0.01, respectively. In the low land the index value of 0.40, 0.13, 0.32 and 0.16 for sale (income generation), meat, saving, and share risks with other animals, respectively (Tables 2).

The primary reason of sheep keeping by the farmers was for source of income generations through the sale of live animals with an index value of 0.31, 0.30, and 0.4 in highland, midland and lowland AEZs, respectively. During the focus group discussion, it was described that from the sales of live animals they generate cash that might be used to buy clothing and food items, pay taxes, to purchase additional fertilizers and household supplies (children's schools). These findings were in agreement with reports of earlier research works of (Arse et al., 2013; Yadeta, 2016; Hundie & Geleta, 2015). The second main reason of sheep keeping was for saving sheep as a pocket money being a live bank for the farmers that they use it at any time where the need for cash arises according to the focused group discussion. The rank of the index value was 0.20, 0.21 and 3.2 in the highland, midland and lowland respectively. Thirdly, meat production for the sheep keepers during festivals, family birth and wedding and personal consumptions was another purpose with index value of 0.17 overall AEZs which indicated in Table 2.

The fourth purpose was to distribute risk and benefit which was insurance for the sheep keepers during unexpected problems. When they face crop loss, they go for sales of the sheep for the large animals were not easily sold and their long replacement period does not help the farmer to solve his immediate problems so that they prefer to save those large animals. Its index value of this purpose was 0.12, 0.15 and 0.14 in the highland, midland and lowland respectively. Lastly, the manure production was the final purpose of keeping sheep mostly in the high land and midland farmers; manure is used as an organic fertilizer for increasing their soil fertility.

Table 2. Purpose of keeping sheep

Purpose of sheep production	Agroecological Zones												OI	Rank
	Highland				Midland				Lowland					
	R_1	R_2	R_3	I	R1	R2	R3	I	R1	R2	R3	I		
Sale	22	18	3	0.31	29	21	7	0.3	18	13	7	0.4	0.32	1
Meat	16	4	2	0.16	20	16	-	0.19	4	5	4	0.13	0.17	3
Manure	19	6	2	0.20	23	3	4	0.16	-	-	-	-	0.13	5
Saving	11	16	-	0.2	25	15	-	0.21	20	10	1	0.32	0.23	2
Share risks	6	11	-	0.12	21	6	2	0.15	11	4	-	0.16	0.14	4
Scarification	1	-	-	0.01	-	1	-	0.01	-	-	-	-	0.01	6

R_1= First rank, R_2 = Second rank, R_3 = Third rank, I = index, OI= Overall index

3.2. Sheep breeding practices

There was often no selective mating policy in the study area. Ram run with flock throughout the year, some select the breeding ram from the flock and neighbor's with 29.7% and 70.3% of overall altitudes. Only 29.7% of overall respondents that owned sheep had breeding ram. The majority of breeding rams originated from the same or other villages. In dry season, immediately after crop harvest, ram from different flocks while roam freely mates females within the same village or from other villages and some were using market rams or use neighbors' ram. Two possible breeding seasons of the flocks were identified.

Sheep owners (78.26%) indicated that the major breeding time of the flocks was between Octobers to January. Until crops were harvested, flocks usually tethered and maintained under nutritional stress. Between October and January, immediately after crops harvested the flocks freely graze on crop stubbles and aftermaths. Thus, adequate nutrition for reproductive process and access to breeding males creates favorable situation to the flock breeding during this period. About 65.22% of the sheep keepers indicated that the second minor breeding season was between April to June in the different agro-ecologies. As in main season, this was also attributed to improved feed supply from grasses and browses grown immediately after the belg shower rains.

Lambing of the flocks mated in major breeding season occur in an entry to wet season from April to May whereas births of the minor breeding season occur in dry season from October to December. This finding was in agreement with (Dhaba et al., 2013) who reported high lambing/kidding rate during April to June and (Yadeta, 2016). It was observed that there was no deliberate practice of making selective breeding to avoid risks of the inbreeding depression in the flocks. This has of more concern that almost all breeding rams originated from their respective flocks that might imply that the relationship of animals within a flock and even within a village was narrow and inbreeding was widespread and increasing.

3.3. Lamb rearing and selection of castration/culling

In cases of loss of their dams, young lambs were offered with cow's milk and household leftover foods until they start grazing and browsing. About 13.95% of the highland respondents practiced early weaning (preventing suckling by herding separately or tethering, until 4 months) of young lambs to maintain body condition of mothers for the subsequent reproduction, that was earlier than (Tsedeke, 2007) reported 4.6 months. These kinds of practices were not recorded in agro-ecologies. Dams were self-weaned their lamb (dams mated and prevent suckling, lamb grow and stop suckling).37.2% in the highland, 24.6% in the midland and 27% in the lowland of respondents were castrating their male animals, which was not significantly different in the AEZs.

In the highland, midland and lowland 34.9%, 33.3% and 26.8% of the households respectively used traditional methods of castration (use wood or stone to crash vas deference of the testicle), and2.3%, 3.5% and 21.1% households in the highland, mid altitude and lowland respectively use modern methods (using Burdizzo) at the kebeles DAs office. According to 95% of the total respondents the major reason of castration, was to fatten the sheep and sale them, the difference in this practice experienced in the agro ecology was closely related i.e., 93.8%, 100% and 90% in the high land, mid altitude and low land, respectively (Table 3). This was in agreement with (Yilikal, 2015; Sisay & Kefyalew, 2015), reported closer castration practices of sheep in Chencha and Mirab and Eastern Ethiopia.

About 2.5% of the total flock owners in all AEs castrate males with undesirable physical characteristics like black coat color and small body size at early age to avoid breeding. Several intact males in a household make noises and become restless and difficult to handle thus 2.5% in all AEZs of the respondent castrate their animals to tame, in high land it was 6.2% but, in the midland, and lowland there was no more rams tamed in the flock. The average age of castration was one year for sheep. This is attributed to the households' interest to castrate and fatten sheep as early as possible to take advantage of the higher demand and prices at the present market. No one of the sheep owned respondents practice docking the tail of female sheep to facilitate mating and sanitary purpose.

About 31.2% of respondents of overall altitudes sheep owners indicated that coat color was some of the good traits. White, light brown and mixture coat colors have a preference in that order in sheep, 78.9% of the respondents prefer these most important traits in the low land. The presence of medium size and up-ward orientation of horns add high aesthetic value as it was elaborated during the focused group discussion. The width, length and fatness of the tail were vitally important in sheep in the overall altitudes so that 2.9% of the respondents look intently for these traits.

This study identified that body conformation (height and length) and physical characteristics (coat color, horn, tail) were the major criteria that household consider selecting sheep for castration and fattening. Coat color (like red, red mixed with black) and horn (medium and twisted) and fat and long tail in sheep were also very important traits farmers preferences. This clearly depicts body conformation and certain physical traits (tail, coat color, horn) were foremost criteria that producers, traders and consumers critically consider and accordingly breeding efforts needs to assimilate the stakeholder preferences.

Table 3. Household management practices (%) of young, breeding and fattening flocks

Particulars	Agroecology			overall
	Highland	Midland	Lowland	
Castration of sheep	37.2	24.6	27	29.2
Castrating by local methods	34.9	33.3	7.9	26.8
Castrating by modern (burdizo)	2.3	3.5	21.1	8
Castration to fatten and sale	93.8	100	90	95
Castration to control unwanted breed	-	-	10	2.55
Castration to tame	6.2	-	-	2.5
Selection of physical characteristics color	14	12.3	78.9	31.2
Selection of physical characteristics horn	-	7	-	2.9
Selection of physical characteristics tail	34.9	43.9	78.9	50.7
Selection of physical characteristics body length	23.3	36.8	78.9	44.2

3.4. Breed types and preference to sheep

Types of sheep observed in the study AEZs were of short and thin-tailed, fat and long tailed and fat-tailed coarse hair type. Local sheep types, Dawro/Bonga breed and lowland sheep type Wolyta/Doyogena breed are found in the study area. According to (Solomon, 2008) phenotypically, Bonga sheep breed are fatty and long tail. As observed in the current study Doyogena sheep types are also fatty and long tail with course hair. In the highland and mid altitude, local (in area usually found) sheep type was dominant and characterized by thin and long tailed. In the study area, for the last few years GO and NGOs introduced sheep from Dawro into the highland and midland. In the low land, Doyogena sheep breed was dominantly distributed. Farmers from three AEZs mentioned, about 60.9, 54.7, 51.8, 51.4, 29.7 and 21.9% prefer sheep for immediate return, easy to manage keeping/raring, high market demand, distribute loss and benefits, market incentive price and appropriate for slaughter and home consumption, respectively. Immediate return due to high reproduction efficiency was comparably appreciated by respondents as compared to large animals like cattle Table 4.

Table 4. Household preferences to sheep

Characteristics	Agro-Ecology %			overall
	Highland	Midland	Lowland	
High market demand	64.3	36.8	60.5	51.8
Incentive market price	27.9	28.1	34.2	29.7
Easy to manage	66.7	42.1	60.5	54.7
Immediate return	65.1	57.9	60.5	60.9
Distribute loss and benefits	69.8	35.1	55.3	51.4
Appropriate for slaughter and home consumption	18.6	17.9	31.6	21.9

3.5. Reproductive performances of sheep

The results on reproductive performance of all agro-ecological zones Age at First Lambing, slaughter age, age of sexual maturity, Lambing Interval, Litter Size, and reproductive life span of the sheep had significant difference between AEZs as it is presented in Table 5.

3.5.1. Age at puberty

Age at puberty for highland local sheep male and female were 7.34±0.123 months and 7.95±0.136 months respectively, Dawuro/Bonga sheep breed/type was 7.00±0.555 months and 7.50±0.614 months for male and female respectively which was not significant differ. The sexual maturity of the breed types closely related but there was significantly different with in the agro-ecological zone ($p<0.05$). In the highland puberty age of male and female local sheep were 7.34±0.123 months 7.95±0.136 months and for midland local it was 7.74±0.120 months and 8.02±.132 months respectively. The case of Dawuro/Bonga sheep breed/type in the highland male and female was 7.00±0.555 months and 7.50±0.614 months and in the mid altitude male and female was 7.79±0.120 months and 8.14±0.232 months, respectively. In the highland Dawuro/Bonga Breeds/types and local sheep types had earlier puberty age than the midland sheep types/breeds in the study area.

During the focused group discussion, it was explained that due to feed shortage and the grazing land shortage, sheep keepers in the mid land mostly keep their sheep tethered. And in the low land it was found that the sheep breed was Woliata/Doyogena, average age at first mate male and female was 6.32±0.127 months and 7.42±0.141 months respectively. In both sexes, it was earlier than that of the highland and midland sheep breeds/types. The overall age at puberty 7.23±0.14 for males and 7.24±0.11 months for female of all sheep types, respectively; was longer than that of (Yilikal, 2015), 6.9 months in Chencha and 6.4 months in Mirab Abaya, but closer with (Helen et al., 2015) that was reported, 7.63±.14 for male and 7.24±.14 for female in indigenous sheep production system in eastern Ethiopia in her study on the implications for genetic improvement and sustainable use.

On other hand; the current finding is lower than result of (Amelmal, 2011) age at sexual maturity (puberty) was 11.05±1.6, 10.88±1.7 and 9.5±1.4 months for males and 11.13±2.7, 10.8±1.9 and 9.5±1.4 months for females in Tocha, Mareka and Konta, respectively. This indicates that the sexual maturity of sheep in Ethiopia Showed great variation among breeds / types, locations and differences or variation allowing for the selection of suitable breeds for a given environment.

3.5.2. Age at first parturition

Mean age at first parturition was 12.95±0.138 months for local sheep type and 12.50±0.626 months for Dawuro sheep type/breed in the highland and 13.02±0.135 months for local sheep type/breed and 13.14±0.237 months Dawuro sheep type/breed in the mid altitude. In the highland and midland for local sheep 12.95±0.138 and 13.02±0.135 months and 12.50±0.626 13.14±0.237 months in the highland and midland months Dawuro sheep types/breed, respectively represents the age at first parturition. Woliata/Doyogena sheep found only in the lowland and their age at first parturition was earlier than that of high and midland and the same is true for local and Dawuro sheep types.

Average age at first parturition observed in this study was 12.808±.142 months for parturition over the three agro-ecologies. In the mid altitude average age at first parturition was 13.02±0.135 month which was higher than the high land and low land. This finding is in agreement with (Deribe, 2009; Fsahatsion et al., 2013) in their study on farm performance evaluation of indigenous sheep (12.40) in Alaba, traditional sheep production and breeding practice (12.4±0.28) in Gamo Zone.

3.5.3. Parturition interval

Local highland sheep breed/type parturition interval was 7.76±0.75 and for midland it was 7.60±0.75 months but Dawuro breed/type has 7.50±0.339 and 7.29±0.128 months in the highland and mid land respectively. Doyogena/Wolyta sheep type parturition interval was closer to the Dawuro sheep type as indicated in Table 5. Parturition interval was significantly different between AEZs ($p<0.05$) with 7.519±0.077 months overall agro-ecologies of the system. Lambing interval was closer with (Fsahatsion et al., 2013) traditional sheep production and breeding practice (7.34±0.28) in Gamo zone and (Yilikal, 2015) small ruminant production and marketing: constraints and opportunities in Chencha and Mirab Abaya woredas, Southern Ethiopia.

Table 5. Reproductive parameters of sheep flock

Performance measurements	Agroecology (mean ± SE months)			Overall	p-value
	Highland	Midland	Lowland		
Local sheep type					
Age at first mate male	7.34±0.12^{a}	7.74±0.12^{a}	-	7.24±0.13	0.000
Age at first mate female	7.95±0.14^{a}	8.02±0.13^{a}	-	7.81±0.14	0.002
Age at first parturition	12.95±0.14^{a}	13.02±0.13^{b}	-	12.81±0.14	0.003
Parturition interval	7.76±0.08^{a}	7.60±0.08^{a}	-	7.52±0.o8	0.017
Litter size	1.29±0.08^{a}	1.21±0.08^{b}	-	1.50±0.08	0.000
Slaughtering age of male	7.73±0.22^{b}	9.09±0.22^{a}	-	7.80±0.20	0.000
Slaughtering age of female	8.00±0.22^{b}	9.16±0.21^{a}	-	7.95±0.22	0.000
Dawro/Bonga sheep type					
Age at first mate male	7.00±0.56^{b}	7.79±0.210^{a}	-	7.24±0.13	0.000
Age at first mate female	7.50±0.61^{b}	8.14±0.232^{a}	-	7.81±0.14	0.002
Age at first parturition	12.50±0.6^{b}	13.14±0.24^{a}	-	12.81±0.14	0.003
Parturition interval	7.50±0.34^{a}	7.29±0.128^{b}	-	7.52±0.o8	0.017
Litter size	1.50±0.36^{a}	1.50±0.136^{a}	-	1.5±0.08	0.000
Slaughtering age of male	7.00±1.00^{b}	8.64±0.38^{a}	-	7.78±0.23	0.000
Slaughtering age of female	7.50±0.38^{b}	8.64±0.37^{a}	-	7.95±0.22	0.000
Wolyta/Doyogena sheep					
Age at first mate male	-	-	6.32±0.13^{a}	7.24±0.13	0.000
Age at first mate female	-	-	7.42±0.14^{a}	7.81±0.14	0.002
Age at first parturition	-	-	12.4±0.14^{a}	12.81±0.14	0.003
Parturition interval	-	-	7.45±0.08^{a}	7.52±0.08	0.017
Litter size	-	-	1.97±0.08^{a}	1.5±0.08	0.000
Slaughtering age of male	-	-	6.42±0.23^{a}	7.78±0.23	0.000
Slaughtering age of female	-	-	6.42±0.23^{a}	6.42±0.64	0.000
Average life span in year	10.5±0 .44^{a}	9.5±0.19^{b}	9.3 ±0.09^{b}	9.8 ±0.16	0.016
Average lamb crop of life time of sheep in number	10.25±0.4^{b}	9.7±.36^{c}	15±0.37^{a}	11.7±0.30	0.000

Means in the same row with different superscript ($^{a, b, c}$) are significant at $P<0.05$

3.5.4. Litter size

Litter size of the local sheep type in the highland and mid land was lower than that of the Dawuro sheep in the highland and midland as well as Doyogena sheep closer to the Dawuro sheep type as presented in the Table 5. The average litter size or prolificacy as obtained in the present study was 1.495±0.082 lambs per head in the overall agro-ecologies significant (P<0.001) of the study area. The average litter size was in agreement with (Deribe, 2009) on farm performance evaluation of indigenous sheep (1.51) in Alaba.

The current results were within the range (1.08 - 1.75) as reported by (Girma, 2008), for tropical breeds. But the current liter size was higher than those reported by (Yadeta, 2016), 1.21, 1.18 and 1.16 in high, mid and lowland, respectively, for Ada Barga and Ejere districts sheep of West Shoa Zone, (Tadele, 2010) for Menz and Afar sheep breeds (close to one lamb per lambing), Bonga sheep (1.13) and Washera sheep (1.11) reported by (Solomon et al., 2010).

3.5.5. Slaughter age

Average slaughter age of sheep was 7.78±0.226 and 7.945±0.224 months for male and female in the overall AEs. Female slaughter age was higher than that of the male in the study area and highly significantly different in the AEZs (P<0.001). In Arba Minch zuria district there was consumption tradition of young lambs that might lead to culling of future breeding stock. That there was a belief on this practice to contribute to building the body and health of sick family better specially for mothers and this could attribute to the observed early slaughter ages of the sheep.

The current finding is lower than the results reported by Assen & Aklilu, (2012) who reported Age at Sexual Maturity of 8.42 and 8.8 months in HL and ML of Tigray region respectively. This finding was higher than that of Yadeta, (2016), finding but it was in agreement for the low land sheep.

3.5.6. Average life span and average lamb crop of the sheep

The variation in the reproductive life span of female sheep was significant due to AEZs (P<0.05) (Table 5). The reproductive life spans of sheep were 10.5, 9.5 and 9.3 years in the highland, midland and lowland respectively. This finding was closer to Yadeta (2016) reported. The mean lamb crops of sheep on its life span were 10.25, 9.7 and 15 lambs in the highland, midland and lowland respectively of agro-ecological zones (p<0.001).

4. Conclusion

The major purpose of this study was to generate baseline information on breeding practices and reproductive performances of available sheep types of Arba Minch Zuria district, Gamo zone, Ethiopia. Information was obtained from 138 sample sheep holders. The existing breeding practices and trait preferences, purpose of sheep keeping and reproductive performances of different sheep types were well summarized. As result, Sheep in Arba Minch Zuria woreda have appreciable reproductive performances such as: early maturity ($P<0.001$), short lambing interval ($P<0.01$) as compared to published reports of many other sheep breeds in Ethiopia. The local sheep breeds come from Bonga and Doyagena areas showed higher reproductive performances than the local sheep breeds inhibited in the study areas. Therefore, the current finding clued that introducing well productive local breeds to other areas is promising option for low resourceful smallholder farmers under tropical condition than introducing exotic breeds to traditionally managing systems. Therefore, GOs and NGO should introduce well-known local breeds like Bonga and Horro in Ethiopia for their better reproduction and production performances to other areas where agro- ecological conditions are matching with their natural habitat.

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Conflict of Interest

There is no any conflict of interest.

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Research Article

Evaluation of livestock feed resources and feed balance in selected districts of Gamo zone, Southern Ethiopia

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Abstract

The study was conducted in Bonke, Mirab Abaya and Dita districts of Gamo Zone, Southern Ethiopia with the objectives to assess available, opportunity, constraints and copying strategy of livestock feed production and to estimate feed balance. Primary and secondary data sources and field observations, key informant interview, focus group discussions and individual interview was employed to generate data. The survey data was stratified into districts, coded and analyzed using the Statistical Package for Social Sciences (SPSS version 20) windows 10 and general linear model procedure were used to analyze data. Statistical variation of categorical data (perception data) was tested by means of cross tabulation. In study districts, the palatable and perennial fodder trees were Erythrina brucei, Arundinaria alpine, Ficus sur, Dombya torrida and Hagenia abyssinica were supported major feeds for livestock. The major opportunity related to livestock feed production in study districts was presence of different feed resource types, distinctive agro-ecologies and accessible of crop residues, but the major constraints related to livestock feed production were land scarcity, shortage of dry season forages and land degradation due to erosion. Minimize livestock number, conserving optional feeds and purchasing optional feeds were major copying strategies of feed resources in study districts. The overall mean of feed supply in terms of DM yield per year to TLU was found to be 5.782tons of DM /Hh/ annual with negative feed balance of 5.47tons. Based on the findings of the present study, low productivity of livestock in Bonke, Dita and Mirab Abaya districts is clearly associated with the meager availability of feed resources. Hence, in order to alleviate these problems, alternative feed production technologies should be undertaken, such as, farmers should practice forage development on their own crop land and collect crop residues during crop harvesting times and conserve it under shed, the nutritive value of different types of fodder trees and shrubs should be further determined in the future, feed storage methods, particularly hay and silage during an excess of feed resources available should be practiced.

Keywords: Districts; Feed balance, Feed resources

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1. Introduction

Despite the largest livestock population in Africa (Hunduma, 2012), the productivity is comparatively low in Ethiopia. The low output is principally due to many constraints (Getahun, 2012; Belay & Janssens, 2016). Among these constraints, inadequate quantity and quality feed ingredients were identified as a major warning factor to the development of livestock production in Ethiopia (Belay et al., 2011; Alemayehu et al. 2017).

Moreover, (Alemayehu, 2006; Adugna et al., 2012; Yisehak et al., 2016; Kechero & Janssens, 2014), reported that feed supply shortage were major bottle necks of farmers for livestock production in Ethiopia. From types of feed resources, natural pasture and crop residues are contributing the largest feed type (Adugna et al., 2012). Among these, in Ethiopia 95% of livestock feed is from crop residues (FAO, 2018) like teff, barley and wheat. The contribution of feed resources, however, depends upon the agro-ecology, the types of crops produced, accessibility and production system (Thornton, 2010). According to Zewdie (2010), assessment of the quantity and quality of available feed resources in relation to livestock requirement has not been yet well addressed in most livestock production areas of the country. In Ethiopia, the annual DM production could satisfy only two-third of the total DM requirements of the livestock, as result during the dry season animals drop their condition which is an indicator of feed shortage and suggests that livestock production and productivity are constrained by feed scarcity (Funte et al., 2010; Sefa, 2017).

In this regard, dry matter (DM), crude protein (CP) and metabolisable energy (ME) supplied of different feed resources were bellowed the annual requirements of the total tropical livestock unit (TLU) with negative balance (Kechero & Janssens, 2014). Hence, both energy and protein are the main limiting influences for livestock productivity (McDonald et al., 2010). A preliminary feed supply-demand assessment in Ethiopia showed that the feed deficit was 10% when expressed as DM, but it was 45 and 42% when expressed as metabolizable energy (ME) and crude protein (CP), respectively (FAO, 2018). This data highpoints the need for more forage conservation to guarantee availability and quality across seasons and regions.

The crude protein (CP) content of pastures is lower than the value of forage crude protein content of (7%), which would cover the maintenance requirements of ruminants (McDonald et al., 2010). Due to the high number of human populations across the regions in Ethiopia increasing demand for cropping land to yield food for humans diminishes the amount of land available for natural grazing and forage production (Alemayehu, 2005; Adugna et al., 2012). As result, the role of natural pasture grazing land size diminishing and shrinking (Yayneshet, 2010). In case of Bonke, Dita and Mirab Abaya Districts, as related other densely populated Zones of Ethiopia, production of major feed resources is declining throughout the year. That is, of course, linked to the meager availability of feed resources. Hence, assessment of feed resources helps to guide the development of effective intervention strategies to improve quality of feeds, feed use efficiency and livestock productivity. Thus, this study was carried out to assess the opportunities, constraints, and coping strategies of livestock feed resources and estimate the balance between total dry matter, crude protein and energy supply and the requirements of the nutrients of livestock in Bonke, Dita and Mirab Abaya districts of Gamo Zone of Southern Ethiopia.

2. Materials and Methods

2.1. Description of the study area

The study was conducted at Bonke, Dita and Mirab Abaya districts, which are located in Gamo Zone of the Southern Ethiopia. Bonke district is located at 9°00'N latitude, 38°30'E longitude at an altitude of 600-4200 meter above sea level. The human population in district is 205,739 and livestock population is 558,759. In this district, the widely cultivated crops are barley, wheat, enset, maize, teff, beans and potatoes. The vegetation types in area are forest, woodland, bush and shrubs. Whereas Dita district is located at 7°16'N latitude, 37°18'E longitude at an altitude of 1,744 meter above sea level. The human population in district is 83,987 and livestock population is 319,878. In this district, the widely cultivated crops are barley, wheat, enset, maize, teff, beans and potatoes. The vegetation types in area are forest, woodland, bush and shrubs. Whereas Mirab Abaya district is located at 5°57'N latitude, 37°32'E longitude at an altitude of 1170 – 2700 meter above sea level.

The range annual rainfall of 900-1000mm and mean annual temperature of 23℃. The human population in district is 95,837 and livestock population is 368,270. In district, the widely cultivated crops are barley, wheat, enset, maize, teff, beans and potatoes. The vegetation types in area are forest, woodland, bush and shrubs. Land use in three districts almost similar that is Crop cultivation, livestock grazing, woods or forest and residential use.

2.2. Study design

Both primary and secondary data were collected following qualitative and quantitative research methodologies involving structured questionnaire, field measurement, individual interview and group discussion. Primary data on household, household herd, land holding, major feed resources, opportunity, constraints and copying strategies of feed resources were collected. Secondary sources of data focused on climate, topography, agro-ecology, human population and livestock population was collected from the office of districts and other documents. The group discussions were involved one group in each *kebele* and the researchers were facilitated the discussions at all sites.

For this study, multistage sampling techniques were followed. In the 1ststage, the purposively sampling technique was applied to select districts based on livestock potential. In the 2ndstage, 3 *kebeles* were selected from each district by using stratified sampling technique based on altitudes range. In the 3rd stage, a list of households in each *kebeles* was selected random sampling techniques and taken by the chief of *kebeles* and estimated by using probability proportional (Eq. 1) to sample size technique (Cochran, 1977).

$$no = \frac{Z^2 * (p)(q)}{d^2} \qquad (1)$$

Where, no = Desired sample size according when population greater than 10,000, Z =1.96 for 95% confidence level, P = 0.1 for 10% proportion of the population, q= 1-0.1, d =degree of accuracy desired at 5% error term. A total of 162 (54 households from each) from three districts were interviewed.

2.3. Livestock population data

In order to estimate the feed balance of the study districts, the livestock population data was collected through questionnaire as well as from secondary data sources (in the office of wereda) and converted in to total tropical livestock unit (TLU) using (FAO, 1987; Gryseels, 1988; FAO, 2002) methodology.

Total available DMs from natural pasture, crop residues, crop aftermath and fallow land, fodder tree and shrubs, improved forages and non-convectional feed stuffs were compared to the annual DM requirements of the livestock populations in the study area. Data of livestock population were obtained from the questionnaire of household heads during the survey. To compare the number of livestock populations in the area with the DM requirements of the livestock population according to the daily DM requirements for maintenance of 1 TLU (Kearl, 1982) where the daily DM requirement for maintenance of 1 TLU (250 kg livestock) which consumes 2.5% of its body weight is 6.25 kg DM/d or 2281 kg DM per year and a crude protein (CP) content of 160 g/kg DM and 32.1 MJ ME/kg DM diet is used, (MAFF, 1975; Jahnke, 1982).

2.4. Estimation the quantity of available feed resources

The quantity of feed resource in three districts of study area was estimated using the information on crop residues, grazing lands, fodder trees and shrubs, improved forages, and non-convectional feed stuffs collected from the respondents during survey. The amount of crop residues, used as source of livestock feed was estimated using established conversion factors developed by different investigators. The conversion factors developed for wheat, barley and teff straw is 1.5 per unit weight grain yield, while the factor for maize and haricot bean are, 2.0 and 1.2, respectively (FAO, 1987).

The dry matter (DM) output of grazing pasture was estimated based on FAO (1987) multiplier factor, which is 2.0 tons/ha. Crop aftermath grazing potential was estimated by using a mean of 0.5 tons/ha, while improved forages, fallow grazin land was 8 and 0.7 tons/ha/yr respectively (FAO, 1987; Alemayehu, 2002).

Quantity of other non-convectional feed stuffs which haven't clear conversion factors also can increase the quantity of DM for livestock based on respondents information. The quantity of potentially available DM from leaf and leaf midribs of enset (*E. ventricosum*) used for animal consumption was estimated by considering a mean of 8 tons/ha of enset growing land.

The biomass yield of shrubs and trees' potential fodder yield was estimated by measuring stem circumference using measuring tape and using the equation of Petmak (1983). Accordingly, leaf yield of fodder trees was estimated by the allometric equation of $\log W = 2.24 \log DT - 1.50$. Where, W = leaf yield in kilograms of dry weight and DT is trunk diameter (cm) at 130 cm height. Similarly, trunk diameter (DT) was obtained from: $DT = 0.636C$; where the C = circumference in centimetre (cm). For the leaf yield of a shrub the allometric equation is $\log W = 2.62 \log DS - 2.46$. Where DS is stem diameter in cm at 30 cm height.

2.5. Data analysis

All perceived and measured data were analyzed using the Statistical Package for Social Sciences (SPSS) version 20. Statistical variation of categorical data (perception data) was tested by means of cross tabulation (chi-square procedure), assuming significant differences when $P < 0.05$; while the descriptive statistics for the numerical data were compared by employing to the general linear model (GLM) procedure of SPSS, whereas post hoc multiple mean comparisons was employed to analysis feed balance by using Tukey procedure and assuming significant differences when $P < 0.05$. Descriptive statistics, such as means, percentages and standard error of the means were used to present the results of perceptions and measurements. The appropriate statistical model for assessment (Eq. 2) of livestock feed resources and feed balance is:

$$Yij = \mu + \alpha i + \varepsilon ij \quad (2)$$

Where, Y_{ij}= Total feed DM, CP and ME yield from three districts; μ = overall mean; $\boldsymbol{\alpha}_i$ = the effect of i^{th} locations (1-3) and $\boldsymbol{\varepsilon}_{ij}$ = random error

For parameters required ranking, indices were calculated by using Microsoft office Excel 2007 to provide ranking of opportunities, constraints and coping strategy for the livestock feed resources produced in the study districts. Index was computed (Eq. 3) with the principle of weighted average according to the following formula as employed by (Musa et al., 2006):

$$Index = Rn*C1+Rn-1*C2+\ldots.+R1*Cn/\sum Rn*C1+ Rn-1*C2\ldots.R1*Cn \quad (3)$$

Where; Rn = Value given for the least ranked level (example if the least rank is 5^{th} rank, then Rn=5, Rn-1=4 and … R1= 1). Cn = Counts of the least ranked level (in the above example, the count of the 5th rank = Cn, and the counts of the 1st rank = C1).

3. Results and Discussion

3.1. Household characteristics of respondents

The overall mean of family householding size in the present study districts was about 5.72 headed (Table 1). The average family size of each district was significantly different (P<0.05). Generally, in the study districts, the average family size of the respondents was higher than the national average family size of rural areas (4.9) per household (CSA, 2011) and closely related to Emana et al. (2017) who reported that the average family size of 5.37 in the Abol district of the Gambella Region, Ethiopia.

There was a significant difference (P<0.05) in the educational status of respondents among districts. Accordingly, the highest level of illiteracy was recorded in Dita district (79.6 %) and the lower level of illiteracy was observed in Mirab Abaya district (53.7 %). These illiteracy levels of the society are the challenges on modernization of livestock feed production that requires a continuous training to enable the livestock productivity to move forward. Similar finding was reported by Yisehak et al. (2013) in three districts of Jimma zone, Southwest Ethiopia.

3.2. Livestock holding in tropical livestock unit (TLU) of sampled households

In the current study, the overall mean of livestock in the sampled households was 4.934 TLU per households as indicated in Table 2. The mean of livestock in TLU in Bonke district

(5.672) was higher than Dita (4.809) and Mirab Abaya (4.319). The high mean value of livestock in Bonke district might be due to relatively higher grazing land resources holding size and also rearing of the high number of livestock as a social value rather than production purpose. The overall means of current result was lower than a research result reported by Sisay (2006) in Debark (5.10), and Layarmachiho (5.60). However, larger than Mergia et al. (2014) (3.3) in Baresa watershed and Mengistu et al. (2016) which was (3.05 ± 0.15). The effects of districts were significant (*P*<0.05) on sheep, horse, local oxen and cross bull numbers. This may be due to the nutritional factors, such as grazing land, feed types, availability of feed and the production purpose of farmers.

Table 1. Household characteristics of the respondents in the study districts

Characteristics		Study districts			Overall	*P*- value
		Bonke	Dita	M/Abaya		
Sex of the household (%)	Male	66.7	44.4	48.1	53.1	0.04
	Female	33.3	55.6	51.9	46.9	0.04
Age (years)	15-30	27.8	44.4	31.5	34.6	0.40
	31-50	57.4	40.7	51.9	50.0	0.40
	>50	14.8	14.8	16.7	15.4	0.40
Mean of family holding size	Mean	5.39^{a}	5.54^{b}	6.24^{c}	5.72	0.01
Educational status (%)	Literate	35.2	20.4	46.3	34.0	0.02
	Illiterate	64.8	79.6	53.7	66.0	0.02

^{abc}Means with different superscript in the same row of altitude are significantly different (P <0.05)

This overall result of sheep and horse was greater than the findings of Mohammed *et al.* (2016) in which sheep (0.10±0.01), horses (0.05±0.02) and mules (0.06±0.03). The result of current study was lower than Teshager et al. (2013) who reported relatively the smaller TLU values of livestock species in Bacho, Algie-Sachi and Chewaka districts.

3.3. The opportunity, constraint and copying strategy of feed resources

The major livestock feed resources opportunity and constraints are presented in Table 3. In the study districts, accessibility of different feed resource types such as crop residues, natural pasture, fodder trees and shrubs, industrial by products and forages were major opportunity in the study area. The index score of presence of different feed stuffs for livestock was ranked first in study districts. Next to presence of different feed stuffs, having different agro ecology and presence of different forage varieties were ranked second and third respectively. Even though, many opportunities that enhance livestock feed resources production in the study area, there are also a couple of constraints to hinder the productivity of feed resources.

Table 2. The mean livestock holding size in tropical livestock unit of the sample households

Livestock in TLU	Districts (mean)			Overall	*P*-value
	Bonke	Dita	M/Abaya		
Sheep	0.624	0.507	0.189	0.440	0.01
Goat	0.141	0.15	0.144	0.145	0.98
Donkey	0.037	0.074	0.139	0.083	0.07
Mule	0.130	0.117	0.052	0.099	0.30
Poultry	0.071	0.089	0.066	0.075	0.47
Horse	0.785	0.474	0.074	0.444	0.00
Local cow	0.563	0.593	0.563	0.573	0.93
Cross cow	1.500	1.133	1.033	1.222	0.13
Local heifer	0.111	0.125	0.166	0.134	0.58
Cross heifer	0.111	0.125	0.166	0.304	0.30
Local oxen	0.244	0.265	0.509	0.340	0.01
Cross oxen	0.422	0.317	0.176	0.305	0.21
Local bull	0.143	0.081	0.224	0.149	0.17
Cross bull	0.141	0.176	0.457	0.258	0.02
Local calf	0.078	0.189	0.111	0.127	0.00
Cross calf	0.078	0.189	0.111	0.235	0.00
Total livestock	5.672	4.809	4.319	4.934	0.01

The major constraints for livestock production ranked by respondents in the study districts were land scarcity due to high human population, shortage of dry season forages and land degradation due to erosion. This is similar to Belay et al. 2011) and Azage et al. (2013) who reported that shortage of land was the most limiting factor to livestock production. As responses of respondents in the study districts, minimize livestock number, conserving optional feeds and purchasing optional feeds were major copying strategies of feed resources in study districts ranked from first to third respectively.

Table 3. Livestock feed resources opportunity, constraints and copying strategy (n=12)

Opportunity/constraint/strategies	Districts						Overall	Rank
	Bonke		Dita		M/Abaya			
	Index	Rank	Index	Rank	Index	Rank		
Opportunity								
Agro ecology	0.264	2	0.264	1	0.333	2	0.287	2
Presence of d/t forage varieties	0.208	3	0.333	2	0.222	3	0.253	3
Presence of d/t feed stuffs	0.528	1	0.403	3	0.444	1	0.458	1
Constraints								
Land scarcity	0.486	1	0.403	1	0.375	2	0.421	1
Shortage of dry season forages	0.278	2	0.319	2	0.388	1	0.328	2
Land degradation due to erosion	0.236	3	0.278	3	0.236	3	0.250	3
Copying strategies								
Minimize livestock number	0.444	1	0.444	1	0.430	1	0.439	1
Conserving optional feeds	0.333	2	0.361	2	0.347	2	0.347	2
Purchasing optional feeds	0.222	3	0.194	3	0.222	3	0.213	3

3.4. Dry matter production of different feed resources

3.4.1. *Dry matter yield of natural pasture*

Table 4 shows that the effect of districts was no significant (*P*>0.05) on the mean of DM production utilization of communal and private grazing lands in the study areas. Accordingly mean of DM in tons obtained from communal grazing land through the survey was 0.314, 0.504 and 0.407 tons of DM per year of Bonke, Dita and Mirab Abaya districts, respectively.

The overall mean of DM produced from communal grazing land in the study areas was 0.409 tons DM/year. There was a no significant difference (*P*>0.05) on the mean of DM production of private grazing land utilization across districts in the study areas. The mean of DM produced from private grazing land at Bonke, Dita and Mirab Abaya was 0.146, 0.221 and 0.258 tons per year, respectively. The result of private grazing land obtained in this study is lower than the report of Sisay (2006) 1.15 tons for Layarmachiho *Woreda* and the same finding was 0.68 tons per household for Debark *Woreda*. The finding of the current study was also lower than the report of Zewdie & Yoseph, (2014) (3.7) for Adami Tullu Jidokombolcha.

3.4.2. Dry matter yield of crop residues

The overall mean of dry matter of crop residues produced per year by sampling households of different crop types in Table 4 was 1.217 tons DM/year. The effect of districts was significant (*P*<0.05) on the crop residues of barley in the study area. The mean yield of crop residue of barley was higher in Dita (0.569) than the Bonke (0.481) and Mirab Abaya (0.222). This difference may be due to genetic variety and environmental factors that affect the yield of barley.

Table 4. The crop residues yield of dairy cattle in sampled households (tons)

Crop residues	Districts				
	Bonke	Dita	M/Abaya	Overall	*P- value*
Barely	0.481[a]	0.569[a]	0.222[b]	0.431	0.020
Wheat	0.375[b]	0.639[a]	0.278[b]	0.428	0.016
Teff	0.057[a]	0.000[c]	0.197[b]	0.084	0.011
Sorghum	0.002[c]	0.021[b]	0.164[a]	0.013	0.020
Pulse and oil	0.192[b]	0.306[a]	0.283[b]	0.261	0.003
Total	1.107[b]	1.535[a]	1.144[b]	1.217	0.032

Means with different superscript in the same row of districts ([a, b, c]) are significantly different (P<0.05)

The majority of farmers in highland area were cultivated barley crop than midland. This may be due to environmental factors. The effect of districts was also significant (*P*<0.05) on the crop residues of wheat, teff, sorghum pulse and oil crops in the study areas. Therefore, these crop types that yield different production across the districts was consequently varies the crop residues in the areas. This result was in agreement with Berihu et al. (2014) who reported that crop residues from wheat, Maize, barley, bean, and peas are important feed sources in Ganta Afeshum woreda Eastern zone of Tigray especially during the dry season when availability of pasture is low.

3.4.3. Dry matter yield of crop aftermath grazing land

After harvesting the crops, livestock are allowed to graze the stubble of different crops such as Maize, teff, sorghum, wheat, barely, bean, pea etc. The conversion factor of 0.5 was used for stubble gazing (aftermath) into total dry matter yields (FAO, 1987). Therefore, the overall mean of 0.083 tons of DM feed were obtained per year from crop aftermath in the study districts.

The effect of district variation was significant ($P<0.05$) on the amount of stubble grazing land utilization Table 5 in the current study. This may be due to differences in landholding size of respondents. Based on survey information, 0.158, 0.048 and 0.042 tons of DM per year for crop aftermath were produced in the Bonke, Dita and Mirab Abaya districts, respectively. This crop aftermath was mainly obtained from left of wheat, barley, bean and pea straw in the highland altitudes whereas, at mid altitude from *teff*, wheat, maize and sorghum Stover. The findings of the present study were found to be lower than the study conducted in Meta Robi District (Endale, 2015).

3.4.4 Dry matter yield of fallow land

The quantities of available DM of fallow land were determined by multiplying the available land by the conversion factors of 1.8 for fallow land grazing (FAO, 1987). The effect of variation of districts was significant ($P<0.05$) on fallow grazing land dry matter production. Based on household survey data, the mean of fallow grazing land DM yield Bonke, Dita and Mirab Abaya districts was 0.383, 0.024 and 0.102 tons per year, respectively. This may be due to the farmers production purpose and allocation of land for cultivation for crops for livestock may be varies. The overall mean of fallow land DM production, all districts was 0.169 tons per year.

3.4.5 Dry matter yield of woodland/forestland

The conversion factor used to get total dry matter production from forest land is 0.7 (FAO, 1987). Therefore, overall mean of 0.075 tons of feed dry matter was produced in the districts per year. The effect district vary was significant ($P<0.05$) on dry matter production from forestland. According to the survey result, the mean of dry matter production from forest land was 0.003, 0.045 and 0.179 tons in Bonke, Dita and Mirab Abaya districts, respectively. The high production of DM at Mirab Abaya districts was due to high landholding as compared to other districts. In the other study reported by Endale (2015) in the Meta Robi District, west Shewa zone, Oromia regional state indicated that the total dry matter production from forest land was 10.29 tons and 2.62 tons higher than current study.

3.4.6. Biomass yield of fodder trees and shrubs in mean leaf weight (in tons)

The fodder trees and shrubs were potential to support livestock in the study districts through the year, especially during dry season. The overall mean of the estimated biomass yield of trees and shrubs presented in Table 6 was 1.851tons DM per year. In sampled households the mean estimated biomass yield of trees and shrubs were produced 1.967, 1.571 and 2. 017 tons DM per year in Bonke, Dita and Mirab Abaya districts respectively. In the Bonke district of current study, the palatable and perennial trees were *Erythrina brucei* and *Ficus sur* supported feed for livestock whereas Dita district *Ficus sur and Arundinaria alpina* were dominant fodders. However, the potential of fodders supported livestock in Mirab Abaya district was *Ficus sur*, especially during dry season. Some fodder trees and shrubs were found all districts, some are found both districts. The effect of districts was significant (*P*<0.05) on the *Moringa, Arundinaria alpina, and Erythrina brucei* types of trees in the study area. This type of trees and shrubs were more obtained and support livestock in areas. This may be due to adaptation case of species. *Ficus* species contributes a higher proportion than other types of trees and shrubs at both Bonke Dita districts. This may be due to adaptation of *Ficus* species specially *ficus sur* which are mostly found both in highland and midland of the study area and contains high canopy leaf weight.

Table 5. Biomass yield of trees and shrub in mean leaf weight (in tons) across districts

Scientific name	Browses	Districts			Overall	*P*- value
		Bonke	Dita	M/Abaya		
Erythrinabrucei	Trees	0.609	0.117	0.085	0.27	0.000
Ficus sur	Trees	0.676	0.935	1.15	0.921	0.112
Arundinaria alpine	Trees	0.333	0.243	0.033	0.203	0.000
Dombeya torrid	Trees	0.114	0.072	0.063	0.083	0.050
Hygenia abyssinica	Trees	0.195	0.193	0.144	0.177	0.085
Moring	Trees	0.001	0.005	0.534	0.179	0.000
Oxytenanther abysca	shrubs	0.002	0.004	0.004	0.003	0.144
Total		1.967	1.570	2.017	1.851	0.821

3.4.7 *Dry matter of non- conventional feeds*

According to the face-to-face interview of respondents in the study districts, non-conventional feed resources were among the important livestock feeds which presented in Table 6. In the current study, it is not possible to get a clear conversion factor, but measuring real data from households' response that consumption of non-conventional feeds to their livestock. As result, utilization of non-conventional feeds like *enset* stem, residues of *areke, tela and kitchen* left over were supporting livestock feed requirements. Accordingly, the result of survey data, the overall mean of 0.078 tons of feed dry matter was produced in surveying households of districts per year. The effect of districts was significant (P<0.05) on dry matter production from forestland. According to survey result, the mean of dry matter production from non-conventional was 0.002, 0.021 and 0.213 tons in Bonke, Dita and Mirab Abaya districts, respectively.

Table 6. Different feed resources available

Feed supply	Districts			Overall	P-Value
	Bonke	Dita	M/Abaya		
Improved forages	0.118	0.078	0.064	0.087	0.207
Enset leaves	0.151[b]	0.226[a]	0.063[c]	0.147	0.001
Crope resudues	1.294	1.514	1.314	1.374	0.750
Private grazing lands	0.146	0.221	0.258	0.208	0.572
Fodder trees& shrubs	1.967	1.570	2.017	1.851	0.821
Aftermath grazing	0.158[a]	0.048[b]	0.042[b]	0.083	0.000
Forestland	0.003[b]	0.045[b]	0.179[a]	0.075	0.000
Fallow land	0.383[a]	0.024[b]	0.102[b]	0.169	0.000
Communal grazing	0.314	0.504	0.407	0.409	0.515
Non convetional feed	0.002[c]	0.021[b]	0.213[a]	0.078	0.021
Total	5.635	5.846	5.861	5.782	0.724

Means with the different superscript ([a, b, c]) in the same row of districts are significantly (P<0.05) different

3.4.8 Nutrient supply, requirements and estimated balance of livestock

According to the daily DM requirements for maintenance of 1 TLU (250 kg livestock) which consumes 2.5% of its body weight is 6.25 kg DM/d and a crude protein (CP) content of 58 g/kg DM and 5.2 MJ ME/kg DM diet is used (Kearl, 1982), whereas 1 LSU (450 kg livestock) which consumes 10 kg DM/day/animal and crude protein content of 70 g/kg DM and 8.368 MJ ME/kg DM diet for maintenance is used (Winrock, 1992). So, in the current study dry matter, crude protein, and metabolizable energy availability, requirements and estimated balance of feeds of livestock were presented in Table 7.

The overall mean of dry matter supply of feed from natural pasture grazing, crop residues, crop aftermath grazing, fallow land, woodland grazing, fodder trees and shrubs was

5.635, 5.846 and 5.86 tons /year in three districts. The overall mean of annual DM, CP and ME requirement of livestock was 11.255tons, 10.422tons and 69.074tons, respectively. But the overall mean of annual DM, CP and ME supply of livestock feed was 5.782tons, 0.925tons and 36.429tons, respectively. The overall mean dry matter of feed supply in the study districts for livestock was below the requirements which indicated that 51% livestock were not satisfied in the study area. So, the requirements of livestock were not balanced with the yield from different feed resources in study districts. The effect of districts was significant (*P*<0.05) on the mean of DM, ME and CP requirement and balance in the study areas. This may be due to the chemical composition of feed types. However, it was not significant (*P*>0.05) on the mean of DM, ME and CP supply of livestock. In agreement with current study, Bedasa (2012) also indicated that the annual dry matter production was below annual livestock requirements of the Blue Nile basin in Ethiopia.

Table 7. Nutrient availability, requirements & estimated balance of feeds of livestock

Estimated nutrients (ton)	Districts			Overall	P Value
	Bonke	Dita	M/Abaya		
DM supply	5.635	5.846	5.86	5.782	0.965
DM required	12.939^{a}	10.972^{ac}	9.85^{c}	11.255	0.002
DM balance	-7.29^{a}	-5.126^{b}	-3.99^{c}	-5.47	0.044
DP supply	0.902	0.935	0.93	0.925	0.965
DP required	13.482^{a}	9.760^{bc}	8.02^{c}	10.422	0.002
DP balance	-12.58^{a}	-8.83^{bc}	-7.08^{c}	-9.497	0.002
ME supply	35.506	36.832	36.950	36.429	0.965
ME required	95.182^{a}	61.492^{bc}	50.547^{c}	69.074	0.002
ME balance	-59.677^{a}	-24.66^{bc}	-13.507^{c}	-32.644	0.006

Means with the different superscript ($^{a, b, c}$) in the same row of districts are significantly different

4. Conclusion

The fodder trees and shrubs were a potential to support livestock in the study districts throughout the year, especially during dry season. The overall mean and standard error of the estimated biomass yield of trees and shrubs was 1.369±0.108 tons DM/HH/year. In highland area, the palatable and perennial fodder trees were *Erythrina brucci, Ficus sur Arundinar alpina, Ficus sure, Dombeya torrida* and *Hagenia abyysinica* supported feed for livestock. The overall mean of DM, ME, and the CP requirement of livestock was higher than the actual feed produced, hence negative balance was recorded in all study districts. The overall mean of livestock population of 4.934 TLU of sampled households was needed 11.255 tons of dry matter feed per year for maintenance requirement alone, but the current production was only 5.782 tons that support livestock only. The existing feed supply can satisfy only 51 % of the annual maintenance

DM requirement of livestock units in study districts. Therefore, to overcome these feed shortages during the critical time of the year, the respondents were undertaking destocking, conserving crop residues and purchasing other feed types from local farmers as solution of the feed shortage problem in the study districts. Feed shortage is critical and it exists throughout the year in the study area. The existing feed supply cannot satisfy the optimum livestock. Since feed conserving practices, feed quality improvement strategies and development of indigenous and improved forage production should be taken, further research and development works should be designed to increase the development of indigenous and improved forage production should be taken. The contribution of improved forage in livestock feed was low in the current study may be due to land shortage, lack of awareness, lack of forage seeds and lack of interest. To alleviate this problem, nursery sites should be established in potential *kebeles* of the districts and to share knowledge as well as to disseminate these feeds among farmers. The most respondents were using different types of fodder trees and shrubs for their livestock feeding, but the nutritive value of such feeds not known so its quality should be further determined in the future.

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