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Original Research

Characterization of Sheep Production System in Eastern Arsi Zone of Oromia Regional State, Ethiopia

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Abstract

The study was conducted in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts of the East Arsi zone of Oromia Regional State to undertake phenotypic characterization of indigenous sheep types, to characterise the production system, and to identify the production constraints and objectives of farmers' sheep production. Multistage purposive and random sampling techniques were employed to identify districts and animals. A detailed structured questionnaire, focus group discussions, field observations of animals, and secondary data collection were employed to produce the data. A total of 136 households were involved in the survey questionnaire. The average mean numbers of sheep per household were 10.31, 10.33, and 18.07in Lode Hetosa, Diksiis, and Lemmu Bilbilo districts, respectively. In all districts, sheep were primarily kept for income generation, with index values ranging from 0.32 to 0.35. The major available feeds for the wet and dry seasons were natural pasture and crop residues, respectively. Physical appearance and coat colour were ranked first and second selection criteria, respectively, for both breeding rams and ewes in all districts, except that tail was ranked as a second selection criterion in Diksiis district for breeding rams only. Disease was ranked as the first pertinent constraint for sheep production in all study districts. The overall mean age of males and females at first mating was 5.51±0.1 and 6.96±0.16 months, respectively. The overall mean age at first lambing of sheep in the study areas was found to be 13.1±0.15 months. The overall ewe life-time lamb production in the study areas was reported as 10.64±0.30. The mean lambing interval of sheep in the study areas was 7.87±0.08 months. The major production system in the area is a mixed crop-livestock system. Major sheep breeding objectives identified in the current study should be considered in the genetic improvement programme, and major constraints reported should also be addressed.

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INTRODUCTION

Sheep is the second most important livestock species in Ethiopia, estimated at 28.9 million heads (CSA, 2016). There are diverse breeds and sheep types distributed from the cool alpine climate of the mountains to the arid pastoral areas

of the lowlands (Gizaw, 2008). They are owned and managed by smallholder farmers as an integral part of the livestock sub-sector (Duguma et al., 2011). Sheep contribute substantial amounts of income, food (meat and milk), and non-food products such as manure, skins, and coarse wool. They also serve as a means of risk mitigation during crop failures, property security, monetary saving, and investment, in addition to many other socio-economic and cultural functions (Tibbo, 2006; Zewdu, 2008). Indigenous sheep breeds are highly adapted to low-input systems or are naturally selected for survival in suboptimal and disease-ridden environments (Tibbo et al., 2006). The annual meat production from small ruminants (sheep and goat) is estimated at 154,000 tonnes per year and is relatively small as compared to the large number of animals (50 million) (Mourad et al., 2015). The low level of productivity of the indigenous sheep breeds is due to several factors, such as genotype, institutional, environmental, and infrastructural constraints (Okeyo, 2007).

Genetic improvement is one way to increase the productivity of the sheep resources in the country. The essential procedure for genetic improvement of livestock involves the identification of available breeds or strains and the characterization of existing production systems or production environments in which they are kept. Moreover, descriptions of breed characteristics and their adaptation, as well as production potential in those environments, are crucial for designing genetic improvement programmes (Workneh and Rowlands, 2004). Detailed and up-to-date information on indigenous knowledge of livestock management, identification of important traits, and typical features with the full participation of farmers are important for effective and sustainable utilisation of typical sheep breeds (Kosgey et al., 2006). As a result of their wide range of habitat, behavioural, and reproductive adaptations, sheep have evolved into a large number of different geographically separate phenotypic forms or races varying in size, fleeces, conformation, muscling, and coat colour (Asefa et al., 2017).

According to Gizaw (2008), there are nine known sheep breeds in Ethiopia. Often, populations bear either the names of the communities that own them or the locations in which they are found. However, there is no clear phenotypic or genetic evidence to show whether these names and the differential adaptive characters are related to the distinct breed types (Zewdu, 2008). Most often, those locations are believed to be home tracts for those breeds or ecotypes (Mirkena et al., 2012). In order to make the best use of sheep keeping operations, it is important and a prerequisite to have a comprehensive understanding of the whole situation through assessing the production environment (climate, feed availability, and disease prevalence); the production system (production practise, preferences, socio-economic circumstances, and level of input use); and the productive and adaptive characteristics of the sheep breeds (Sisay, 2010). Characterizing the production systems is a first natural step in designing any genetic improvement programme (Dossa et al., 2009; FAO, 2010).

The information provided by production systems characterization studies is essential for planning the management of animal genetic resources at local, national, regional, and global levels. However, information is scarce or limited on the sheep production systems found in the Arsi zone. Thus, to fill this gap, the present characterization study was conducted in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts of the Arsi zone with the following objectives:

Objectives

1. To characterise sheep production systems in the study areas

2. To determine sheep producers' breeding practises and objectives

MATERIALS AND METHODS

Description of the Study Area

The present study was carried out in Lode Hetosa, Lemmu Bilbilo, and Diksis districts of the East Arsi zone, which is located in south-eastern Ethiopia at latitude and longitude of 7°44' N and 39°29' E, respectively. The elevation of the East Arsi zone ranges from 1500 to 4245 m.a.s.l. The administrative town of the zone is Asella. The total livestock population in the East Arsi Zone was estimated at 7.9 million. Out of this, about 2.5 million are cattle, 1.6 million are sheep, 1.1 million are goats, 0.24 million are horses, 0.024 million are mules, 0.46 million are donkeys, 0.062 million are camels, 1.8 million are chickens, and 0.095 million are beehives (CSA, 2016). The East Arsi zone was selected for morphological characterization of sheep types and their production systems because it is mainly dominated by sheep production next to cattle and poultry production. The map of the study area is shown in Figure 1.

The altitude and temperature of Lode Hetosa district was ranging from 1800 to 3200 m.a.s.l. and 10 °CC, respectively. The area receives an annual rainfall of 800-1400mm. Lode Hetosa district has three major agro-ecologies: lowland (5%), midland (41%), and highland (51%). The main rainy season of the district occurs between March and September, and the dry season lasts from October to February.

The altitude of Lemmu Bilbilo district ranged from 1500 to 4180 m.a.s.l. The district receives an average annual rainfall of about 1100mm and has an average annual temperature ranging from 60 °C to 26°C. About 3%, 17%, and 80% of Lemmo Bilbilo district are categorised as lowland, midland, and highland, respectively. The main rainy season in all districts occurs between March and September, and the dry season lasts from October to February.

The altitude of Diksiis district ranged from 2550 to 3600 m.a.s.l. The area receives an average annual rainfall range of 700mm to 1200mm and has an average annual temperature ranging from 100°C to 26°C. The main rainy season of the district occurs between March and September, and the dry season lasts from October to February. The district has only highland agro-ecology.

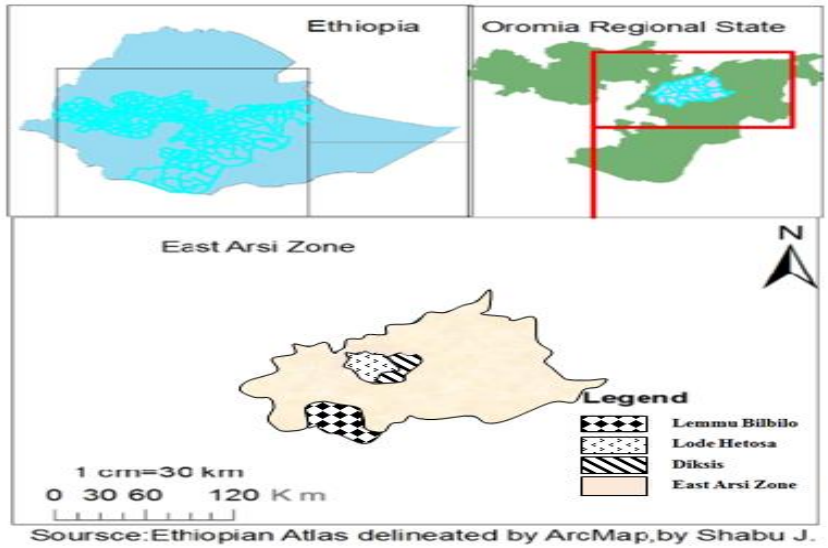

Figure 1 *Map of the study area*

Sampling Techniques and Sample Size

Multistage purposive sampling techniques were employed in the current study. In the first stage, districts known for having the highest sheep populations were selected. Accordingly, out of 24 districts in East Arsi Zone, three were selected purposefully based on their sheep population, ranked one up to three. In the second stage, three Gandas from each district were selected. At the third stage, households were selected purposefully, based on ownership of a minimum of two sheep, together with the respective district staff of livestock and fishery resources development offices and kebele administrators for characterization of the production practises. The total sample size was determined using the probability proportional to size sampling technique (Cochran, 1977).

The formula for sample size determination is:

$n = ((z^2\ pq)/d^2)/(1+1/N\ ((z^2\ pq)/d^2\ -1))$

Where:

n = the number of sample sizes when the population is less than 10,000.

z = z value (1.96 for 95% confidence level),

p = estimated value for the variability of the population,

q = 1-p,

N = Total number of population, and

d = margin of error or degree of accuracy desired

Using the above formula with the assumption of a 5% standard of error (d), a 95% confidence level (z = 1.96), and 10% variability assumed (p) for the population size (N) of 7439 households in the sampling frame provided a sample size of 136 households.

Methods of Data Collection

A structured and semi-structured questionnaire, group discussions (comprising of extension workers, DA's, model farmers, and knowledgeable sheep producers), visual observation, and measurements on animals were conducted to collect primary information. The questionnaires were pre-tested prior to the commencement of the interview, and necessary corrections were made before conducting the survey study. Information on the general socio-economic situation, including the composition of livestock species, productivity, reproductive performance (age at puberty, age at first lambing, lambing interval, life-time lamb crop, and productive life), culling practises, castration practises, selection criteria for mating, management practises, feed resource utilisation and availability, and major production constraints, was captured using the questionnaire. Group discussions were also carried out with professionals, knowledgeable sheep producers, and elders to gain better insight into the past and present social and economic status of the areas and strengthen the reliability of the survey questionnaires. In addition, secondary information was collected from the respective Livestock and Fishery Resources Development and Rural Land Management offices.

Data Management and Analysis

Data collected through a questionnaire was checked, coded, entered into a computer, and analysed using SPSS version 23. A chi-square test was employed to assess the statistical significance among the categorical variables. The index was calculated to provide an overall ranking of the reasons for keeping sheep, feed

resources in the study area, selection criteria, and constraints as follows:

Index = Σ {[5*proportion of respondents that ranked a trait as first + 4*proportion of respondents that ranked a trait as second + 3*proportion of respondents that ranked a trait as third + 2*proportion of respondents that ranked a trait as forth + 1*proportion of respondents that ranked a trait as fifth for a particular attribute] / [Sum of (5*proportion of respondents that ranked a trait as first + 4*proportion of respondents that ranked a trait as second + 3*proportion of respondents that ranked a trait as third + 2*proportion of respondents that ranked a trait as forth + 1*proportion of respondents that ranked a trait as fifth for a particular attribute) for all variables in question]}

RESULTS AND DISCUSSION

General household characteristics

The results on general household information are presented in Table 4. The differences among the three districts for all descriptors were statistically non-significant. The study showed that about 87% of the families were headed by males, whereas 13% of the families were headed by females. This was in agreement with results reported by Mesfin (2015) in the Wolaita zone and Tesfaye (2008) in the Menz area of the Amhara regional state. The age structure of the respondents showed that about 38.3%, 35.8%, 15.4%, and 10.5% of the respondents were between the age groups of 36–50, 20–35, 51–60, and >60 years, respectively. These results showed that about 74.1% (38.3 + 35.8%) of respondents fell in the age group of 20–50 years, indicating that the three districts under study had a higher proportion of households of productive age. The educational status of the respondents revealed that 41.3% had attended primary (1–8 grades) education. This was in agreement with earlier reports by Michael (2013) in Gozamen, Sinan, and Huleteju districts of the east Gojjam zone of the Amhara regional state. The study also showed that 27.8% of the respondents were able to read and write. Similarly, about 16% of respondents attended secondary (9–12 grades) education, whereas 14.8% of respondents were illiterate. The proportion of illiterates in the present study was lower than the report of Mesfin (2015) in the Wolaita zone. However, the proportion of primary and secondary education in the present study was lower than that reported by the same author. The current result indicates that the higher proportion of farmers having either a primary or elementary educational background would be an opportunity to utilise modern technologies in sheep production.

Socio-economic condition of the study area

The results on the socioeconomic conditions of the study area are presented in Table 1. The differences among the three districts for all three activities were statistically significant (0.00).The overall household income was generated from crop and livestock production (98.88%) jointly, whereas trading contributed about 1.2%.

Table 1

General household information in the study area

Descriptors	Districts						Overall	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
Sex of HH Head:								
Male	44	81.5	47	87	50	92.6	141	87
Female	10	18.5	7	13	4	7.4	21	13
Age structure (year):								
20-35	15	27.8	21	38.9	22	40.7	58	35.8
36-50	21	38.9	19	35.2	22	40.7	62	38.3
51-60.	10	18.5	8	14.8	7	13	25	15.4
>60	8	14.8	6	11.1	3	5.6	17	10.5
Marital status:								
Married	52	96.3	52	96.3	46	85.2	150	92.6
Divorced	0	00	0	00	1	1.9	1	0.6
Widowed	0	00	2	3.7	1	1.9	3	1.9
Not married	2	3.7	0	00	6	11.1	8	4.9
Educational status:								
Illiterate	5	9.3	8	14.8	11	20.4	24	14.8
Read and write	13	24.1	17	31.5	15	27.8	45	27.8
Primary education	22	40.7	23	42.6	22	40.7	67	41.3
Secondary education	14	25.9	6	11.1	6	11.1	26	16

N= number of respondent; NS= non-significant

Crop production was the major (72.8%) farming activity across all districts, and livestock production was the second major activity in the study areas. Crop-livestock mixed farming is the major mode of production in the study areas, and farmers focus mainly on crop production compared to livestock production. Probably, the contribution of livestock to the system was either overlooked or not considered properly.

Livestock holding in the study areas

The livestock composition of the study areas is presented in Table 2. The perusal of Table 2 shows that the number of sheep per household was the highest among all species of livestock in all three districts. The average number of sheep per household was 12.9. Sheep holding per household was highest in Lemmu Bilbilo district (18.07). The differences were statistically significant among all pairs of districts except the Lode Hetosa and Diksiis pairs. This may be due to the fact that the farmers in Lemmu Bilbilo district have better land for animal grazing than the other two districts. The present finding was lower than the 54.37, 25.89, and 27.14 sheep per household reported by Gizaw et al. (2008) for Blackhead Ogaden, Menz and Arsi-Bale sheep breeds, respectively. The results of the current study showed that the number of cattle per household was the second most numerous, followed by chickens, in all three districts. However, the number or household of other species (goat, donkey, mule, and horse) was small.

Table 2

Least Square Mean (± SE) livestock composition per households across the districts

Species	District			
	Lode Hetosa	Lemmu Bilbilo	Diksiis	Over all
	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Cattle	06.46±0.68[b]	11.11±0.68[a]	6.39±0.68[b]	07.99±0.68
Sheep	10.31±1.38[b]	18.07±1.38[a]	10.33±1.38[b]	12.91±1.38
Chicken	04.41±0.60[b]	06.9±0.60[a]	02.07±0.60[c]	04.46±0.60
Goat	00.61±0.29[a]	00.89±0.29[a]	00.11±0.29[a]	00.54±0.29
Donkey	01.8±0.18[a]	02.15±0.18[a]	01.16±0.18[b]	01.7±0.18
Mule	00±0.02[a]	00.02±0.02[a]	00.02±0.02[a]	00.01±0.02
Horse	00.37±0.20[c]	02.41±0.2[a]	01.39±0.20[b]	01.39±0.20

Sheep Flock structure

The flock size and structure of sheep (number or household) in the study area are presented in Table 3. The results of the table showed that the difference in the number of males and females per household in all age groups, except 6 months–1 year-old males, was statistically significant. Similarly, differences in the number of castrate sheep per household were non-significant. The number of female sheep and households in all age groups was higher than the number of male sheep and households in the corresponding age group in all three districts. Out of the three districts, Lemmu Bilbilo had the highest number of males per household in two age groups (3.18 and 0.94 for < 6 months and >1 year age groups, respectively) and the highest number of female sheep per household in all age groups (3.87, 1.6, and 7.33 for < 6 months, 6 months-1 year, and >1 year age groups, respectively). The possible explanation for this may be the highest number of sheep or households in Lemmu Bilbilo district in the present study.

Table 3

Flock size and structure in the study areas

Age (year)	District			
	Lode Hetosa	Lemmu Bilbilo	Diksiis	Over all
	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Male < 6 months	1.52±0.29[b]	3.19±0.29[a]	1.96±0.29[b]	2.22±0.29
Male 6 months-1yr	1.20±0.23[a]	1.15±0.23[a]	0.93±0.23[a]	1.09±0.23
Male > 1 yr	0.57±0.12[b]	0.94±0.12[a]	0.15±0.12[c]	0.56±0.12
Castrate	0.06±0.1[a]	0.20±0.1[a]	0.07±0.1[a]	0.11±0.1
Female < 6 months	1.68±0.3[b]	3.67±0.3[a]	2.48±0.3[b]	2.61±0.3
Female 6 m to 1 year	1.26±0.24[a]	1.59±0.24[a]	1.41±0.24[a]	1.42±0.24
Female >1yr	4.04±0.53[b]	7.33±0.53[a]	4.30±0.53[a]	5.22±0.53

LSM= Least Square Mean; SE= standard error

The current study results showed that male sheep less than six months of age were the highest in number per household, whereas male sheep greater than 1 year were the lowest in number per household. This may indicate that the requirement for males is less than that for females, and sheep producers generally dispose of males at an early age to generate income. This, however, affects badly the effective number of males, thereby resulting in higher inbreeding and a shortage of breeding rams. The number of female households was highest in the >1-year-old age group. The possible reason behind keeping a large number of breeding females is that farmers were interested in harvesting more lambs. The report by CSA (2016) showed that the number of female sheep is greater than the number of male sheep. Similarly, Fsahatsion et al. (2013) also reported that the average number of ewes was higher than breeding rams in Gamogofa Zone, Southern Ethiopia.

Farmers Objectives of Sheep Rearing

The farmers' objectives for sheep rearing in the study area are presented in Table 4. As reported by the respondents, sheep are primarily kept for generating income in all the districts, with index values of 0.35, 0.32, and 0.34 in Lode Hetosa, Lemmu Bilbilo, and Diksiis, respectively. Similar results were reported by earlier workers (Tesfaye, 2008; Zewdu, 2008; Michael, 2013; Fsahatsion et al., 2013). The results further showed that the second and third reasons for sheep rearing in the study areas were saving (as a live bank for households) and social prestige, with index values of 0.20 and 0.19 for Lode Hetosa, 0.25 and 0.16 for Lemmu Bilbilo, and 0.23 and 0.22 for Diksiis districts, respectively.

Table 4

Farmers Objectives of Sheep Rearing in the Study Area

Objective	Districts																	
	Lode Hetosa						Lemmu Bilbilo						Diksiis					
	1st	2nd	3rd	4th	5th	Index	1st	2nd	3rd	4th	5th	Index	1st	2nd	3rd	4th	5th	Index
For meat	1	3	19	17	6	0.14	0	2	15	23	12	0.14	0	4	6	12	17	0.1
Manure	0	0	11	21	16	0.12	0	3	8	20	18	0.12	0	0	5	28	14	0.11
Social prestige	0	23	15	5	10	0.19	0	11	18	11	4	0.16	0	15	36	3	0	0.22
Saving	4	24	8	7	4	0.20	10	28	13	0	3	0.25	9	26	7	3	2	0.23
Income	49	4	1	0	0	0.35	44	10	0	0	0	0.32	45	9	0	0	0	0.34

Feed Resources

The feed resources available during both wet and dry seasons in the study areas are presented in Table 5. The availability and types of feed resources vary among seasons and locations. The different feed resources reported in the areas were natural pasture, improved forage, crop aftermath, crop residues, fallow land and oat. A survey result by Alemayehu (2005) generalized that from the overall feed intake of animals in Ethiopia, natural pastures (including browse plants) and crop residues contributed 80-90 and 10-15 percent, respectively.

The main feed resources available during the wet season are natural pasture and oats, ranked number one and two with index values of 0.33, 0.40, and 0.53 for natural pasture and 0.32, 0.21, and 0.19 for oats in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts, respectively. Crop residue ranked as the third source of feed in Lode Hetosa and Diksiis districts (0.20 and 0.16, respectively), whereas grazing on uncultivated lands ranked as the third feed source in Lemmu Bilbilo district (0.20). The present result with respect to natural pasture being the number one feed source during the wet season was in agreement with literature reports (Zewdu, 2008; Michael, 2013; Yenesew *et al.*, 2013).

During the dry season, crop residues ranked as the first source in all districts under study, with index values of 0.50, 0.39, and 0.44 in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts, respectively. This was in agreement with the findings of Amelaml et al. (2015), who reported that the major feed resource commonly used in the dry season was crop residue in Tocha, Mareka, and Konta districts in Dawuro Zone and Konta Special Woreda of the South Region of Ethiopia. Crop aftermath and natural pasture were ranked number two and three as feed sources in Lode Hetosa (0.22 and 0.21, respectively) and Diksiis districts (0.27 and 0.235, respectively), whereas natural pasture and crop aftermath were ranked number two and three as feed sources in Lemmu Bilbilo (0.23 and 0.21, respectively) district. Herding, tethering, and free grazing were the major feeding management strategies in the study areas.

Table 5

Feed Resources during Wet and Dry season

District	Lode Hetosa					Lemmu Bilbilo					Diksiis				
Feed	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	index
Wet season															
Natural pasture	24	16	5	0	0.33	45	8	0	0	0.40	54	0	0	0	0.53
Improved forage	0	0	0	1	0.01	0	0	2	4	0.02	0	0	0	0	0.00
Crop aftermath	0	8	5	5	0.08	0	2	4	3	0.03	0	4	7	0	0.07
Crop residue	12	6	12	4	0.20	0	6	20	8	0.14	0	19	3	0	0.16
Oat	17	19	12	0	0.32	0	24	11	14	0.21	0	22	6	0	0.19
Grazing on uncultivated land	1	2	10	0	0.06	9	14	11	4	0.20	0	4	7	0	0.06
Dry season															
Natural pasture	5	6	24	5	0.21	13	4	17	19	0.23	5	6	40	3	0.25
Improved forage	0	0	0	1	0.01	0	0	2	4	0.15	0	0	0	0	0.00
Crop aftermath	0	30	2	0	0.22	0	25	15	1	0.21	0	41	4	0	0.27
Crop residue	48	6	0	0	0.50	37	17	0	0	0.39	49	5	0	0	0.44
Uncultivated land	1	0	9	3	0.06	4	8	13	14	0.16	0	2	5	4	0.04

Water Sources and Availability

The livestock water source, availability, and distance travelled by livestock to drink water in the study area are presented in Table 6. The main water sources in the study areas were rivers, springs, pipes, and ponds. However, the three districts showed variation in the number one source of water. Pipe water (61.1%), rivers (81.5%), and ponds (66.7%) were the main sources of water in Lode Hetosa,

Lemmu Bilbilo, and Diksiis, respectively. About 70.4%, 59.3%, and 72.3% of respondents in Lode Hetosa, Lemmu Bilbilo, and Diksiis, respectively, reported that water was sufficiently available for livestock. However, in Lemmu Bilbilo district, a lower number of respondents reported the availability of sufficient water compared to the other two districts. The possible reason may be that water discharge in the river, which was the main water source in this district, gets either reduced or completely dries during the dry season.

The results also showed that in Lode Hetosa, about 48.1% of respondents watered their animals at home. However, 20.4, 13.00, 9.3, and 9.3% of respondents trekked their animals to watering points located at different distances (Table 6).

Table 6

Livestock water sources, water availability and distance traveled to drink water (Km)

Source of water	District						Over all	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
River	20	37.1	44	81.5	18	33.3	82	50.6
Pond	0	00	5	9.3	36	66.7	41	25.3
Spring	1	1.9	2	3.7	0	00	3	1.9
Pipe	33	61.1	3	5.6	0	00	36	22.2
Availability								
Sufficient	138	70.4	32	59.3	39	72.3	109	67.3
In sufficient	16	29.6	22	40.7	15	27.7	53	32.7
Distance to get water								
At home	26	48.1	1	1.9	0	00	27	16.7
0-0.5 km	11	20.4	19	35.2	50	92.6	80	49.4
0.5-1 km	7	13	15	27.8	4	7.4	26	16
1-2 km	5	9.3	9	16.7	0	00	14	8.6
2-3 km	5	9.3	7	13	0	00	12	7.4
>3 km	0	00	3	5.6	0	00	3	1.9

N=Number of households

Watering frequency for sheep

The watering frequency for sheep in the study areas is presented in Table 7. During the dry season, water was provided once a day by 51.9, 88.9, and 96.3% of respondents in Lode Hetosa, Lemmu Bilbilo, and Diksiis, respectively. Similarly, during the wet season about 68.5% of respondents provided water once a day in Lode Hetosa district only. In Lemmu Bilbilo and Diksiis districts, about 74.1 and 68.5% of respondents, respectively, reported that no water is provided to sheep. The possible reason for this may be that, due to rain, sheep obtain water during surface grazing.

Table 7

Watering frequency for sheep in the study area

Watering frequency and watering points	District						Over all	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
Dry season:								
Once a day	28	51.9	48	88.9	52	96.3	128	79
Twice a day	24	44.5	6	11.1	2	3.7	31	19.1
Freely served	2	3.7	0	00	0	00	2	1.2
Wet season:								
Once a day	37	68.5	13	24.1	4	7.4	54	33.3
Twice a week	5	9.3	1	1.9	7	13	13	8
Within 3 day	1	1.9	0	00	6	11.1	7	4.3
No watering	9	16.7	40	74.1	37	68.5	86	53.1
Freely served	2	3.7	0	00	0	00	2	1.2

N=Number of households;

Housing of Sheep

The majority of respondents (63.0%) reported that they had separate houses for their sheep, and about 24.7% of respondents housed their sheep just adjacent to their houses, and 12.3% of respondents' house sheep were inside their own residential house (Table 8). This trend was followed in all three districts. The present finding was not in agreement with the reports of Mesfin (2015), who found that the majority (93.3%) of the households in Wolaita Zone keep sheep at night in the main family house, whereas only about 6.67% keep their animals in separate houses constructed specifically for sheep. The possible reason for housing sheep may be to protect animals from extreme climate (rains, wind), temperature (cold, excessive heat), predators, and theft. All of the farmers across the study districts house their sheep during the night.

Perusal of Table 8 also showed that 74.7% of respondents house their sheep separately from other livestock species, whereas 25.3% of respondents house their sheep with other livestock species, mostly calf and goat, in the three districts. The majority of respondents (93.2%) in the study districts house both male and female sheep together at night, while only about 6.8% of the farmers' house male and female sheep separately. The possible reason may be to avoid fighting, as male animals have generally aggressive behaviour.

Table 8

Housing practices of the sample population

Housing	District						Over all	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
Types of housing:								
Separated housing	35	64.8	34	63	33	61	102	63
Adjacent to human house	12	22.2	15	27.8	13	24.1	40	24.7
In home with human	7	13	5	9.3	8	14.8	20	12.3
Housing method:								
Housed with different animal	13	24.1	16	29.6	12	22.2	41	25.3
Sheep housed separately	41	75.9	38	70.4	42	77.8	121	74.7
Housing by sex								
Both sex separately	6	11.1	2	3.7	3	5.6	11	6.8
Both sex together	48	88.9	52	96.3	51	94.4	151	93.2

N=Number of households

Breeding Management

The results of ram possession, source of breeding ram, and purpose of keeping ram are presented in Table 9. About 66.0, 19.1, and 14.8% of respondents reported that they have no breeding rams, one breeding ram, and two or more breeding rams, respectively. The results also revealed that 70.4 and 88.9% of respondent farmers in Lode Hetosa and Diksiis districts did not own any breeding rams, respectively. However, the situation was comparatively better in Lemmu Bilbilo district, where only about 38.9% of respondents did not own breeding rams. That means ewes of farmers who do not own breeding rams are served by rams present in other flocks during either field grazing or watering. The advantages of having two or more mature breeding rams are that it minimises the rate of inbreeding compared to having a single ram in a flock, and it increases the productivity of females in view of the fact that they mate breeding rams on time. On the other hand, single-sire flocks run the risk of low conception rates or an extended lambing season if the ram has reduced fertility or libido.

Table *9*

Breeding Ram Possession and Purpose of keeping ram

Breeding ram	District						Over all	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
Possession of breeding ram:								
No breeding ram	38	70.4	21	38.9	48	88.9	107	66
One breeding ram	8	14.8	18	33.3	5	9.3	31	19.1
Two or more breeding ram	8	14.8	15	27.8	1	1.9	24	14.83
Purpose of keeping ram:								
Mating	3	5.6	3	5.6	4	7.4	10	6.2
Socio-cultural	-	-	-	-	1	1.9	1	0.6
Fattening	19	35.2	1	1.9	12	22.2	32	19.8
Mating and socio-economic	4	7.4	11	20.4	-	-	15	9.3
Mating and fattening	25	46.3	34	63	37	68.5	96	59.3
Socio-economic and fattening	-	-	3	5.6	-	-	3	1.9
For all purpose	3	5.6	2	3.7	-	-	5	3.1

N=Number of households;

Breeding practices

The major type of mating practise in the study areas was uncontrolled natural mating. About 90.7% of the respondents from all districts did not use controlled mating (Table 10). Only about 9.3% of the respondent farmers reported that they practised controlled mating in their ewes. The present finding is not in agreement with the report of Fekerte (2008), who found that 78% of farmers practised a partially controlled mating system in the Shinile and Erer districts of the Shinile Zone of the Somali Regional State. The predominance of uncontrolled mating in flocks would potentially increase the level of inbreeding, resulting in low productivity and survival.

The results also showed that about 14.2, 37.7, 30.9, and 16.0% (pooled 98.8%) of respondents used rams for 1-2, 2, 3, and > 3 years, respectively, for breeding purposes. The

present results were comparable to those of Zewdu (2008), who reported that, on average, a breeding ram was kept for two years (range of 1 to 4 years) for the Bonga breed. Extended breeding ram use of about 8 years was also reported by the same author in the Horro area for the Horro sheep breed. However, in both Bonga and Horro areas, a breeding ram use time was fixed to 2 years since the community-based sheep breeding programmes were established in 2009 for Horro and Bonga sheep breeds (Duguma, 2010).

In the study areas, about 21% (overall districts) of the respondents reported that they provide preferential management for breeding rams. According to the respondents, breeding rams were provided with home-grown grains, especially barley and oats. This result was in agreement with the results of Mesfin (2015) in Wolaita zone, who found that only about 25% of sheep producers in Wolaita zone offered breeding ram crop residues, household leftovers, and local brewery products.

Table 10

Breeding Practices in the Study Area

Breeding practices	District						Over all	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
Mating type:								
Controlled mating	3	5.6	5	9.3	7	13	34	9.3
Uncontrolled mating	51	94.4	49	90.7	47	87	121	90.7
Ram serving in flock:								
<1 year	0	0	0	0	2	3.7	2	1.2
1-2 year	15	27.8	4	7.4	4	7.4	23	14.2
2 year	22	40.7	21	38.9	18	33.3	61	37.7
3 year	8	14.8	21	38.9	21	38.9	50	30.9
>3 year	9	16.7	8	14.8	9	16.7	26	16.0

N=Number of households; ns= not significant

Selection of Breeding Rams and Ewes

Selection Practice

The selection of parents for the next generation in both rams and ewes was very common among the sampled farmers. Out of the interviewed respondents, 90.7%, 98.1%, and 88.9% of the farmers in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts, respectively, practise selection of breeding rams (Table 11). Similarly, 92.6%, 100%, and 96.3% of the respondents in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts, respectively, practise the selection of breeding ewes. This finding was comparable with

previous works by Michael (2013), who reported that about 97.8%, 96.7%, and 92.2% of farmers in Sinan, Gozamen, and Huleteju districts selected their ewes to be parents of the next generation. About 63.4% and 65.4% of respondents indicated that they select breeding males and females between the ages of 6 and 9 months. With regard to age at selection for male and female sheep, it was found that the overall selection age for breeding rams and ewes was 7.28 ± 0.27 and 7.56 ± 0.33 months, respectively. This result was also comparable with the report of Tesfaye (2008), who found that the average selection age of Afar ewes was about 7.9 months.

Table 11

Selection Practiced by Respondent Farmers in Study Area

	District						Over all	
	Lode Hetosa		Lemmu Bilbilo		Diksiis			
	N	%	N	%	N	%	N	%
Selection practice for breeding Males:								
Yes	49	90.7	53	98.1	48	88.9	150	92.6
No	5	9.3	1	1.9	6	11.1	12	7.4
Selection practice for breeding Females:								
Yes	50	92.6	54	100	52	96.3	156	96.3
No	4	7.4	00	00	2	3.7	6	3.7
Selection Age of Males:								
3-6 months	2	4	19	35.8	5	10.5	26	17.3
6-9 month	38	77.6	29	54.8	28	58.3	95	63.4
9-12 months	9	18.3	5	9.4	15	31.3	29	19.3
Selection Age of Females:								
3-6 months	4	8	18	33.4	4	7.7	26	16.7
6-9 month	35	70	31	57.4	36	69.2	102	65.4
9-12 months	0	0	3	5.6	9	17.3	12	7.7
>12 months	11	22	2	3.7	3	5.7	16	10.2

Selection Criteria for Breeding Rams and Ewes

The results of the ranking of selection criteria for breeding rams and ewes in the study areas are presented in Table 12. Physical appearance and coat colour were ranked first and second selection criteria, respectively, for both breeding rams and ewes in all three districts except Diksiis district, where tail ranked number two in rams only. Farmers in the research region may be more concerned with the physical characteristics of their rams and ewes because they think animals with good body conformation have offspring with good body conformation. The present result that physical appearance was the number one selection criteria for both males and females was in agreement with studies by Michael (2013), who reported that appearance of the animal was one of the best selection criteria in Gozamen, Sinan, and Huleteju districts in the East Gojjam zone of the Amhara regional state, and Fsahatsion *et al.* (2013), who reported that body conformation (appearance)

was the primary selection criteria in the Weyna-dega (56.5%) area in the Gamo Gofa zone of the Southern Nation and Nationalities regional state. Similarly, Dhaba *et al.* (2013) also reported that sheep producers in the Ilu Ababora zone of the Oromia region attributed about 57%, 25%, and 16.3% to body conformation, pedigree, and coat colour in selecting breeding sheep.

In the study areas, the mean marketing age ranges from 6.56 to 8.94 months. This is in agreement with Tesfaye (2008) for Afar sheep, wherein a market age of 6.7 and 8.4 months for male and female, respectively, was reported. However, the current marketing age was lower than the 11.3 and 11.9 months of marketing age, respectively, reported for male and female Menz sheep by the same author. The difference between the current study and that of Tesfaye (2008) on the marketing age of Menz sheep may be due to differences in rate of growth between Menz sheep and the sheep breed considered in the current study. Furthermore, Duguma (2010) reported that significant differences ($p<0.01$) were observed in live weight among adult ewes of different local breeds. According to the author, Bonga ewes were the heaviest, followed by Horro ewes, and Menz ewes were the lightest.

Major Constraints on Sheep Production

Table 12

Ranking of selection criteria for breeding rams and ewes

Criteria	District													
	Lode Hetosa					Lemmu Bilbilo					Diksiis			
	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	index
For male :															
Appearance	39	9	1	0	0.44	38	14	0	1	0.40	37	9	0	0	0.41
Coat color	6	32	10	2	0.34	11	26	13	2	0.31	6	15	18	0	0.25
Tail	1	4	11	3	0.09	1	9	38	3	0.22	5	18	19	0	0.26
Growth	3	4	9	0	0.1	3	4	0	3	0.05	0	1	0	0	0.01
Character	0	0	1	1	0.01	0	0	0	1	0.01	0	2	4	0	0.03
Horn	0	0	0	4	0.01	0	0	0	5	0.01	0	0	4	7	0.04
For female:															
Appearance	32	14	3	0	0.43	27	26	1	0	0.40	35	11	3	0	0.42
Coat color	8	25	12	2	0.33	13	11	28	0	0.30	8	25	11	0	0.29
Tail	1	3	4	0	0.05	0	1	0	6	0.02	2	4	6	0	0.08
Pedigree	0	1	5	2	0.04	9	14	10	1	0.22	6	9	10	0	0.17
Fertility	9	5	6	0	0.15	5	2	1	0	0.06	1	3	0	0	0.0

Identifying the constraints of sheep production is important to solve the problems facing sheep management and to improve sheep productivity. The major sheep production constraints reported by respondent sheep producers in the current study areas are presented in Table 13. The major constraints reported are diseases, feed shortages, predators, water shortages, and poor sheep genotypes. Disease was ranked as the first

important constraint in all study districts, with index values of 0.39, 0.40, and 0.40 in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts, respectively. Similarly, feed shortage was ranked as the number two constraint in sheep production across all districts (index values of 0.30, 0.35, and 0.39 in Lode Hetosa, Lemmu Bilbilo, and Diksiis districts, respectively). According to Michael (2013), the severity of the problem was observed in cases of disease with high index values in Gozamen and Sinan districts in the east Gojjam zone of the Amhara region. Similarly, Zewdu (2008) reported that diseases, feed shortages, predators, and labour shortages were the most pertinent constraints that significantly influence sheep production in Horro and Bonga. Solomon (2007) also identified disease as the first and most important production constraint for Gumuz sheep in the North Western Lowland area of the Amhara Regional State. The most widely reported diseases in the study areas included sheep pox, Pasteurolosis, Coenuruses cerebralis, cough (upper respiratory tract infection), and other parasitic disease.

Table 13

Sheep Production Constraint in the Study Area

Constraint	District														
	Lode Hetosa					Lemmu Bilbilo					Diksiis				
	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	Index	1st	2nd	3rd	4th	index
Disease	27	20	3	0	0.39	25	23	2	0	0.40	21	23	1	0	0.40
Feed shortage	18	16	6	2	0.30	15	20	13	1	0.35	29	11	2	1	0.39
Improved sheep	4	2	6	2	0.1	14	2	2	0	0.16	4	6	2	0	0.1
Water shortage	0	4	3	1	0.04	0	4	2	2	0.04	0	10	5	0	0.1
Predator	5	8	17	1	0.17	0	4	4	0	0.05	0	0	2	0	0.01

Reproductive Performances

Good reproductive performance is a prerequisite for any successful genetic improvement, and it determines production efficiencies (Zewdu, 2008). Reproductive performance depends on various factors, including age at first mating, age at first lambing (months), lifetime lamb crop production, lambing interval (months), and reproductive life span or longevity of ewes (years). The reproductive performances of the ewes in the current study are indicated in Table 14.

Age at First Mating in Male and Female Sheep

According to the respondents, the overall mean age of males and females at first mating was 5.51 ± 0.1 and 6.96 ± 0.16 months (overall), respectively. This result was in agreement with the report of Tsedeke (2007), who found an age at first mating of 6.9 months for the local Alaba ewe sheep. Similarly, Helen et al. (2015) reported that the average age at sexual maturity for males and females is 6.38 and 6.65 months, respectively, in the Eastern Hararghe zone of Oromia. However, the current study result is lower than the 11.05±1.6, 10.88±1.7, and 9.5±1.4 months of age at first mating for males and 11.13±2.7, 10.8±1.9, and 9.5±1.4 months of age at first mating for females reported by Amelmal et al. (2015) in Tocha, Mareka, and Konta, districts of Dawuro zone of the

Southern Nations and Nationalities People Regional State, respectively.

Age at First Lambing

Age at first lambing is a good indicator of sexual maturity in ewes. The overall mean age at first lambing of sheep in the study areas was found to be 13.1±0.15 months. This is in agreement with the 13.3±1.70 months reported by Zewdu (2008) for the Horro indigenous sheep breed and the 13.47 months reported by Belay and Haile (2009) for ewes under smallholders' management conditions in southwestern Ethiopia. Similarly, Helen et al. (2015) reported 12.7 months for the Eastern Hararghe zone sheep type. However, it is lower than the 14.9 ± 3.1 months reported for Bonga by Zewdu (2008) and the 16.4±0.3 months reported for Tigray sheep type reported by Zelealem et al. (2012). Nevertheless, it is higher than the 12.4 months reported for Gamo Goffa ewes by Fsahatsion et al. (2013).

Total lifetime lamb production

The lifetime lamb production is a very important trait to improve sheep productivity and profitability. The overall ewe life time lamb production in the study areas was reported as 10.64±0.30. This was in agreement with the 10.78±4.7 ewe lifetime lamb production reported by Amelmal et al. (2015) in Konta district of Dawuro zone. However, the current result was lower than the 12.2±1.80 and 15.3±4.3 lambs reported for ewe lifetime production for Bonga and Horro ewes (Zewdu, 2008) and the 13.47±1.76 lambs reported for ewe lifetime production for Gumuz sheep (Solomon, 2007) in Metema areas. This may be because of the differences in twining ability among the different sheep breeds. The overall reproductive life span for male and female sheep in the study areas, as per respondents, was 6.55±0.26 and 8.3±0.18 years, respectively.

Lambing interval

The lambing interval is the interval between two successive parturitions. The mean lambing interval of sheep in the study areas was 7.87±0.08 months. This result was in agreement with the results reported by Zewdu (2008) for Horro sheep, in which the mean lambing interval was reported as 7.8 months, and Fsahatsion et al. (2013) for the local Gamo Gofa sheep breed (7.34 months). However, the current result was shorter than the 9.03±0.12 month reported for the Washera sheep breed (Mengiste, 2008).

Table 14

Reproductive Performances of Sheep in Study Area

Characters	District			Overall
	Lode Hetosa	Lemmu Bilbilo	Diksiis	
	LSM±SE	LSM±SE	LSM±SE	LSM±SE
Age at first mating of male (months)	5.96 ±0.1[a]	5.54±0.1[a]	5.04±0.09[a]	5.51±0.1
Age at first mating of female (months)	7.33±0.16[a]	6.71±0.16[b]	6.84±0.15[b]	6.96±0.16
Age at first lambing (months)	13.44±0.15[a]	12.7±0.15[b]	13.09±0.14[ab]	13.08±0.15
Lamb in her lifetime	9.57±0.30[b]	12.12±0.30[a]	10.3±0.29[b]	10.64±0.30
Lambing interval (months)	7.87±0.08[a]	7.85±0.09[a]	7.91±0.08[a]	7.88±0.08
Reproductive lifetime of male (years)	6.4±0.34[a]	6.88±0.26[a]	6.42±0.19[a]	6.55±0.26
Reproductive lifetime of female (years)	8.1±0.19[b]	9.04±0.19[a]	7.88±0.17[b]	8.3±0.18

SE= Standard error

CONCLUSION AND RECOMMENDATION

The characterization of the sheep production system was carried out in the east Arsi zone in three districts (Lode Hetosa, Lemmu Bilbilo, and Diksiis). The study districts are characterised by a mixed-crop-livestock farming system. Crop production was the major farming activity in the study areas, followed by livestock production. The main objectives of keeping sheep are for income generation, followed by saving and social prestige, across all the districts studied. The main feed resources available during the wet season were natural pasture and oats, ranked numbers one and two. However, during the dry season, crop residues ranked first in all districts. Physical appearance and colour were ranked first and second selection criteria, respectively, for both breeding rams and ewes in all three districts, except Diksiis district, where tail ranked number two in rams only. The major constraints on sheep production in the study areas were disease, feed shortages, predators, water shortages, and poor genotype.

In the current study, reproductive performances considered were age at first mating, age at first lambing, ewe lifetime lamb production, and lambing interval. The overall mean age of males and females at first mating was 5.51±0.1 and 6.96±0.16 months, respectively. The overall mean age at first lambing of sheep in the study areas was found to be 13.1±0.15 months. The overall ewe life-time lamb production in the study areas was reported as 10.64±0.30. The mean lambing interval of sheep in the study areas was 7.87±0.08 months.

Since disease is the number one constraint in the study area, a location-specific vaccination schedule and dosing schedule need to be developed to minimise the losses of sheep by farmers due to diseases. A sustainable extension service needs to be organised on all aspects of sheep management, with more emphasis on feed improvement, breeding ram management, and ram selection.

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