Identification of Indigenous Sheep Production Systems and Major Objective Traits of Sheep Producers at Anfillo and Sibu Sire Districts, Western Oromia, Ethiopia

Dinka Hora[1], Hasan Yusuf[2], Ayantu Mekonnen[2], Diriba Diba[2], and Gemeda Duguma[2]*

[1]Anfillo Agricultural Office, West Wallaga Zone, Dambi Dollo, Ethiopia
[2]Wallaga University, P.O. Box 395, Nekemte, Ethiopia

Abstract: The study was undertaken at Anfillo and Sibu Sire districts of Oromia Region, Ethiopia to identify sheep production systems, major objective traits and major production constraints. A total of 146 sheep producer households (73 from each district) who have at least three sheep were involved in the study. Semi-structured questionnaire, secondary data and personal observation were used to capture data. Most of household heads (82.90%) involved in the current study were males. The overall average sheep flock size and landholding per household obtained in the current study were 7.95±2.25 and 2.33±2.51ha, respectively. The primary objective of sheep rearing was income generation followed by meat production. The most common housing types in the study areas were separate houses purposively built for sheep, followed by sheds constructed attached to the family house. In addition, some of the respondents (17.8%) also indicated that sheep shared family house. Natural pasture and fallow land were the most important feed sources both in dry and wet seasons. Most common source of water (80.8%) in the study districts was river. The overall mean age at first service for male and female were 7.88±0.08 and 7.65±0.09 months, respectively. The mean age at first lambing, lambing interval and litter size/twinning rate obtained in the current study were 13.66±0.09 months, 7.85±0.07 months and 1.46±0.05, respectively. Appearance (I=0.32), mothering ability (I=0.26) and twining rate (I=0.19) were some of the most important attributes used for female selection; while appearance (I=0.33), growth rate (I=0.32) and tail size (I=0.21) were the most preferred traits for breeding male selection. Feed shortages (I=0.32) and diseases and parasites (I=0.25) were the major constraints that influence sheep production in both districts. The production and reproduction performances obtained from owners in the current study were encouraging provided that the constraints indicated in the current study are addressed.

Keywords: *Breeding objective, Production systems, Sheep, Traits*

Introduction

Indigenous sheep genetic resources have great role to the crop-livestock farming production systems in Ethiopia (Meseret, 2020). They have unique adaptive mechanisms, which enable them to fit in varied agro-ecologies and contribute to the livelihood of smallholder sheep producers in terms of income generation and meat production and other products. Indigenous sheep breeds are sources of income, meat, skin, manure, wool or fleece and serve as insurance against emergencies (Kosgey, 2004; Desalegn, 2019; Afras, 2021). Sheep production has more advantages compared to large ruminants due to their high fertility, short generation interval, higher survival rates, lower initial capital, their ability to produce under scarce feed resources, ease of management and faster growth rate (Matawork and Mitiku, 2017; Zeru *et al*., 2017). Despite all these advantages, sheep production and productivity is challenged by complex and interlinked technical, institutional and socioeconomic constraints (Solomon *et al*., 2010).

Livestock production systems in the country have evolved mainly as a result of the influence of the natural production environments and socio-economic conditions of farmers or pastoralists. That means, the country's livestock production is of subsistence in nature. Like all other livestock species in the country, sheep are kept under traditional extensive systems with no or minimal inputs as well as improved technologies that results in low production and productivity. Livestock production system is characterized based on the contribution of the livestock sector to the total household revenue, type and level of crop agriculture practiced, types of livestock species kept, mobility and duration of movement, type of agriculture practiced and degree of integration with crop production, level of input and intensity of production (Solomon *et al*., 2010). There are five major sheep production systems in Ethiopia. These are: highland sheep-barley system, highland crop (cereal)-livestock system, highland perennial crop system, lowland crop-livestock system, and pastoral/agro-pastoral system (Solomon *et al*., 2010; Hizkel, 2021).

Description of production system was undertaken for the indigenous Horro sheep breed by several authors both under on-station and on-farm managements (Solomon and Gemeda, 2000; Simegn *et al*., 2017; Kasahun *et al.,* 2022). Moreover, understanding the breeding objectives of livestock keepers is a prerequisite to design sound community-based breeding programs

*Corresponding Author. E-mail: gdjaallataa@yahoo.com

Published by Haramaya University, 2023

ISSN: 2616-8804 (Print); 2959-0531 (Online)

(CBBPs) that consider farmers' priorities and trait preferences that are tailored by specific production systems. However, information about on-farm production system characterization production performance and identifying breeding objective traits and their relative economic importance through participatory community approaches still scant in the study area of Horro Guduru Wallaga Zone. Despite the distribution of the sheep breeds to wider parts of western Oromia. According to Helen *et al.* (2015), knowing the production environment of indigenous sheep would allow a better comparative understanding of the adaptive fitness and performance of the breed. Therefore, consideration the wider production environments of the breed along with their production and reproduction performances, the major objectives of sheep producers and major sheep production constraints are crucial to design future development programs. Hence, this study was undertaken with the objective of characterization the existing sheep production systems, identify the major objective traits of sheep producers and to identify major sheep production constraints in in study area.

Materials and Methods

Description of the Study Areas

The study was carried out at Anfillo district of Qellem Wallaga Zone and Sibu Sire district of East Wallaga Zone of the Oromia Region, Ethiopia. The two districts were selected purposively based on sheep population. Anfillo district is located at about 694 km from Addis Ababa to the west direction. The district is situated at 8°29'N latitude and 34°39'E longitude. Altitude of the district ranges from 500 to 3470 meter above sea level (m.a.s.l.). The maximum and minimum annual air temperature of the district is 33 °C and 14 °C, respectively. Anfillo district experiences a uni-modal type of rainfall that extends from March to Mid-November; while the dry season lasts from Mid-November to February. The maximum and minimum annual rainfall is 1453 mm to 2074 mm. Coffee is one the dominant crops grown in Anfillo district. the total livestock population of the district was estimated to be about 371,373, of which about 16.61% are sheep Anfillo district agricultural office (ADAO, 2022).

Sibu Sire district is situated at a distance of about 278 km from Addis Ababa to the west direction on the main road to Nekemte, capital city of East Wallaga Zone. Altitude of the district ranges from 800 to 2750 m.a.s.l. Sibu Sire district is situated at 9°4'N latitude and 36°49'E longitude. The mean annual maximum and minimum air temperatures recorded for Sibu Sire were 26 °C and 20 °C, respectively. The mean annual rainfall of the district ranged from 1000 mm to 1200 mm that falls from around March to October. The rainfall pattern of the area is unimodal similar to Anfillo district. According to the reports of the Sibu Sire agricultural office (SSAO, 2022), Sibu Sire district has an estimated livestock population of about 625,040; of which sheep are about 45,895 (7.34%). Geographical description of the study districts is indicated in Figure 1.

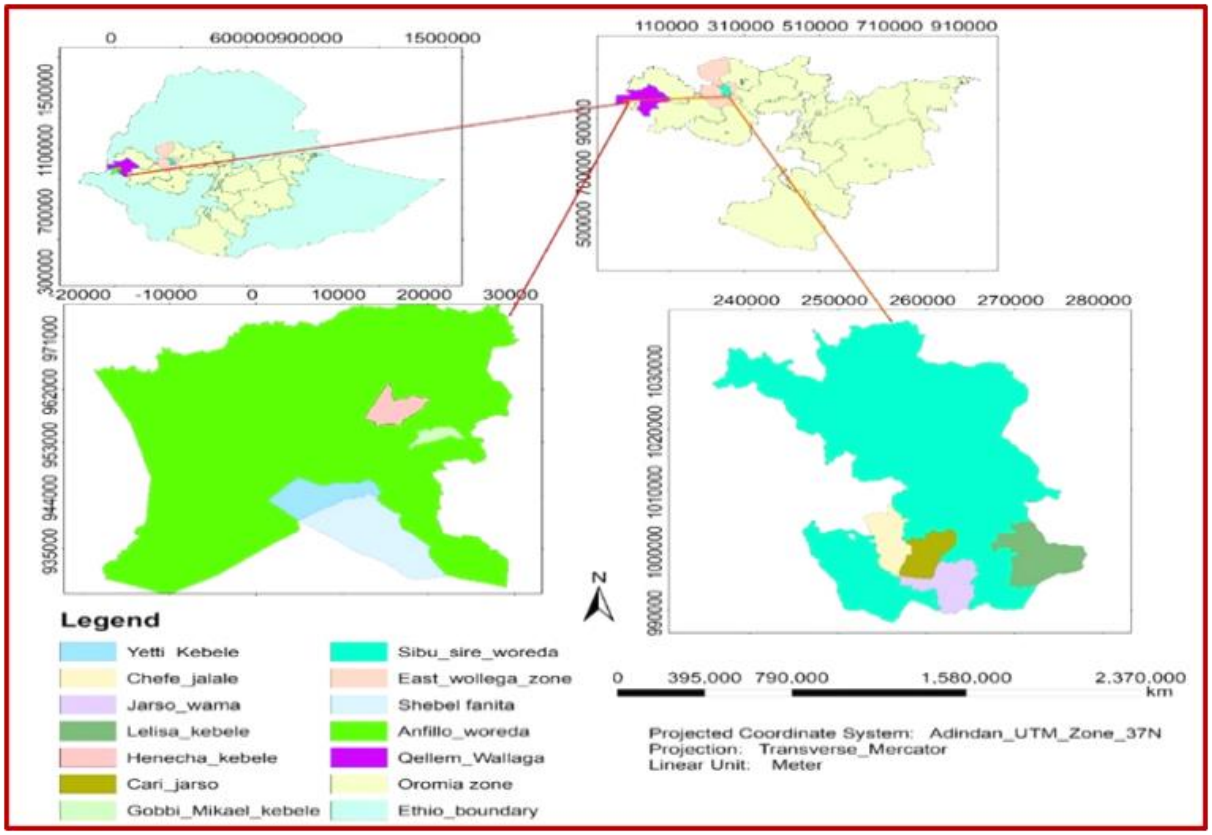

Figure 1. Map of the study areas.

Sampling Technique and Sample Size Determination

Before determining survey areas discussions were held with zonal and district experts, extension and development agents to identify study districts and peasant associations. Following the discussion, Anfillo and Sibu Sire districts were purposely selected. Based on the information gathered, in the selected districts, four peasant associations (the smallest administrative unit in Ethiopia), namely Gobbi Mikael, Shebel and Yetti peasant associations (PAs) were selected from Anfillo district and Chari Jarso, Chafe Jalale, Jarso Wama and Lalisa PAs from Sibu Sire district were selected purposively based on based on sheep production and population potential and willingness of the farmers to participate in the activities. The researchers tried to make the sample size taken from each PA proportional to the number of households in that PA after the total sample size was determined by using Yamane (1967) formula.

Finally, households who owned at least four adult goats with a minimum of one-year experience in sheep husbandry were identified to do so; the list of farmers was prepared in each selected. Hence, households were selected from the prepared list using systematic random sampling technique until the calculated sample size of each PA was maintained. The following formula was used to determine the sample size for this study:

$$n=\frac{N}{1+Ne^2}$$

where, n = minimum returned sample size, N = the population size, and e = the degree of accuracy expressed as a proportion = 0.05.

Based on the above sample size formula, a total of 146 sheep producers (73 households from each district) were involved.

Data Collection Methods

Description of the production system: Structured, semi-structured questionnaire interviews were conducted with individuals or selected groups of individuals to systematically generate data for describing the production system. Questionnaires was prepared in English and translated to Afan Oromo, pre-tested and administered. The semi-structured questionnaire was also designed to collect information on economically important reproductive performances, including age at puberty, age at first kidding, lamping interval, litter size, average productive life of ewes, and economically important trait preferences using the flock ranking index by setting selection criteria for ewe and rams. Focus group discussions were held with an average of 7 to 9 individuals and group members included animal health technician, elders, community leaders, women, development workers or an animal science expert, representative and individuals who have higher experiences on rearing of sheep. Discussions held with the focus groups were to verify/confirm information gathered using the questionnaire interview.

Breeding objective identification: Traits preferences of sheep producers are heterogeneous (Gemeda, 2010), and identification of breeding objectives is crucial. Accordingly, breeding objectives of sheep producers of the two districts were identified using survey questionnaire and focus groups discussions.

Data Analysis

Data collected during the study were coded and recorded and entered into the Microsoft Excel Sheet and imported to Statistical Package for Social Science (SPSS version 23). A one-way analysis of variance was done for quantitative data using districts as independent variable. Descriptive statistics were employed for the qualitative data that include mean and percentage values of various parameters and mean comparisons were carried out using the Chi-square ($\chi 2$) test. Additionally, Chi-square ($\chi 2$) test was used for the categorical variables like type of house and housing materials, herding practices, water sources, health services and health managements to assess the statistical significance between the two districts for the respective variables. Index was computed to rank major feed sources, purposes of keeping sheep, selection criteria and constraints of sheep production following Kosgey (2004). The farmer's trait preference rankings were summarized into an index using weighted averages. Index was computed as Index = sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular qualitative variables divided by sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all qualitative variables measured.

Results and Discussion

General Household Characteristics

The average family size obtained in the current study was 5.8±2.17 at Anfillo district and 5.2±1.78 at Sibu Sire district. The average family size obtained in the current study is slightly higher than the 4.6 national average household members reported (CSA, 2017). Large family size provides work force for agricultural activities. Thus, family size may have an effect on sheep production through provision of the labor required for sheep management and it could reduce the cost of labor hiring for the sheep management. The majority of the households targeted in the current study (82.9%) were male-headed. Only, about 17.1% of the respondents were female-headed households. According to CSA (2017), average number of households headed by women is one-quarter, which is a bit higher than the average households headed by women obtained in the current study. Bosenu *et al.* (2014) and Mebrate (2020) also reported higher proportion of male-headed households. The findings of the current study indicated that sheep flock sizes owned by male headed households were higher than flock size owned by women headed households. According to respondents, females are busy with household management, kitchen works (workload inside the house) and they may not have extra time for management of their sheep. This implies that, sheep owned by male-headed households might have also

better management as compared to female-headed households. Hence, this may need capacity building for female headed households to benefit from any farm activities in general and sheep production in particular.

The result revealed that about 22.6% only write and read, about 33.6% attended primary education and about 26.02% attended secondary high schools. Respondents in the Sibu Sire district were better with regard to level of education. Therefore, majority of the sheep producers in the current particular study areas could understand different extension services provided by the relevant development workers such as capacity building trainings concerning improved sheep production, breeding and prevention of diseases. In the present study, about 17.8% of respondents did not even attend any form of formal education in both districts.

Land Holding Per Household

The average land holding per household in the study areas are presented in Table 1. In the current study, land holding per household was significantly different ($p < 0.05$) between the districts, except fallow lands. More cultivated land was observed in Anfillo district as compared to the Sibu Sire district. However, most of the cultivated land in Anfillo district was covered by coffee; while that of Sibu Sire was covered with cereal crops mainly maize and sorghum that might have provides maintenance feeds in lean period. In Sibu Sire district, allocation of land for crops helps to provide crop residues for animals, which is particularly important during season of feed scarcity. Endeshaw (2007) also reported that allocating land for cropping could provide animals with much crop residues in the lean period. Although grazing land was the dominant feed source for sheep in the study areas, respondents indicated that grazing lands have been shrinking from time to time because of the encouragement of crop lands to the communal grazing lands in both districts. In the present study, landholding had positive relationship with sheep flock size. Households having higher grazing land had larger sheep flock size than those household having smaller grazing lands. Smaller grazing land may not allow rotational grazing thus, would lead to overgrazing and soil degradation and higher transmission of diseases.

Table 1. Average land holding (ha) per households.

Descriptor	Districts		Overall	Test	
	Anfillo	Sibu Sire			
	Mean ± SD	Mean ± SD		F-value	P-value
Total land (ha)	2.46 ± 2.74[a]	2.19±2.27[b]	2.33±2.51	14.92	0.004
Cultivated land(ha)	2.20± 2.14[a]	1.80± 1.73[b]	2.05±1.94	17.73	0.002
Fallow land (ha)	0.04± 0.06	0.03±0.00	0.035±0.03	3.89	0.530
Grazing land (ha)	0.19±0.71[a]	0.29± 0.84[b]	0.24± 0.77	4.68	0.032

Different superscripts indicate significant differences at P<0.05 among the two districts; ha= Hectares; SD= Standard deviation.

Purpose of Keeping Sheep

The major purposes of keeping sheep in the study areas are indicated in Table 2. The major reason for production of sheep is mainly associated with the farmers' breeding objectives. Thorough understanding of the major purposes of keeping sheep is important in defining the breeding goals (Jaitner *et al.*, 2001). In the present study, one of the major purposes of sheep production was income generation or cash with an index value of 0.44. This is in accordance with reports in the literature (Admasu *et al.*, 2017; Esubalew *et al.*, 2019; Kerga, 2021). The cash generated from the sale of sheep is mostly used to buy agricultural inputs such as improved seeds, fertilizer and different payments such as school fees, purchase of clothes and for different expenses. Household meat production and manure were ranked as second and third sheep production purposes being preceded by cash income with index values of 0.27 and 0.15, respectively.

Table 2. Ranked reasons of keeping sheep as indicated by sheep owners.

Reasons of keeping sheep	Districts								
	Anfillo				Sibu Sire				
	Rank			Index	Rank			Index	Overall index values
	1st	2nd	3rd		1st	2nd	3rd		
Meat	9	19	33	0.22	17	31	24	0.31	0.27
Cash	48	25	0	0.44	52	12	9	0.43	0.44
Manure	9	12	22	0.17	4	15	9	0.12	0.15
Saving	0	10	5	0.06	0	6	13	0.06	0.06
Wealth	7	0	6	0.06	0	4	10	0.04	0.05
Skin	0	7	7	0.05	0	5	8	0.04	0.05

Sheep Flock Size and Structure

Sheep flock size and structure of the study areas are indicated in Table 3. The overall mean sheep flock size of the study area was 7.95±2.25, with flock size ranged from 2 to 15 head of sheep. The mean sheep flock size reported in the current study is in close agreement with

the flock size reported for Horro sheep breed at Horro district (Zewdu, 2008). Breeding ewes were significantly ($p<0.01$) higher in Sibu Sire district than Anfillo district. This might be due to the shorter reproductive lifespan for breeding ewes in Anfillo district compared to the Sibu Sire district (Table 3). In the current study, breeding ewes (46.30%) had higher proportion followed by lambs of both sexes younger than 6 months (24.30%). In contrast to the higher proportion of breeding ewes obtained in the current study, Tadesse *et al.* (2018) reported a very low proportion (29.2%) of breeding ewes in Amhara Region. The higher proportion of breeding ewes (46.30 %) in a flock might be due to the fact that females were allowed to be retained in the flock until the end of their production life. The current study is in close agreement with the previous literature reports that ranged from 33.12% to 49.20% (Tesfaye, 2008; Gemeda, 2010; Hizkel, 2021). The proportion of breeding ewes (older than one year) reported in the current study is, however, below the 52.62% national average reported by the CSA (2021). Even sometimes, there are cases where older ewes which are generally past their most productive stage are kept in a flock for several reasons (Gemeda, 2010). The lower proportion of mature breeding rams and the remaining of aged unproductive ewes in flock/flocks warrants management intervention that favor the retention of large proportion of middle aged ewes and fair proportion of mature breeding males. On the other hand, the lower proportion of breeding males (7.80%) in the flock may indicate that males are either sold early or sold at earlier age before their mating service year ended for the purpose of immediate cash need. In line with this, Gemeda (2010) reported that the could not find 15 mature breeding rams in Bonga and Horro areas flocks for estimation of live weight for group ranking exper4iment. The proportion of castrated males was significantly ($p<0.01$) higher at Anfillo district than Sibu Sire. The likely reason for the difference may be their breeding objectives (e.g. fatty meat is preferred at Anfillo district compared to Sibu Sire), market demand and accessibility. Generally, the proportion of the different classes of sheep reflects the management decision of the owners which in turn is determined by their production objectives (Esubalew *et al*., 2019).

Table 3. Sheep flock size and flock structure in the study districts.

Classes of sheep	Anfillo district			Sibu Sire district			Overall			P value
	№	Mean ±SD	%	№	Mean ±SD	%	№	Mean ±SD	%	
Male lambs < 6 months	73	1.0±1.04	12.40	71	1.0± 0.73	12.46	144	1.0±0.89	12.40	0.854
Female lambs <6 months	69	1.0±1.03	11.70	74	1.0±0.81	13.00	143	1.0±0.92	12.30	0.655
Total lambs < 6 months	142	2.0±1.54	24.10	145	1.9± 1.12	25.44	287	1.9±1.34	24.74	0.951
Male lambs 6 to 12 months	40	0.6±0.71	6.80	31	0.4±0.67	5.44	71	0.5±0.69	6.12	0.280
Female lambs 6 to 12 months	77	1.1±1.03	13.10	64	0.9±0.97	11.23	141	1.0±1.00	12.20	0.283
Total lambs 6 to 12 months	117	1.6±1.26	20.50	95	1.3±1.22	16.67	212	1.5±1.23	18.30	0.144
Female >1year/breeding ewe	242	3.3±1.25	41.02	295	4.0±1.54	51.80	537	3.7±1.44	46.30	0.002
Male >1year/breeding ram	65	0.9±0.91	11.02	25	0.3±0.67	4.40	90	0.6±0.84	7.80	0.000
Male castrated	24	0.3±0.56	4.10	9	0.1±0.37	1.58	33	0.2±0.48	2.80	0.009

SD= Standard deviation; №= Number of sheep.

Production and Reproduction Performances of Sheep

Production and reproduction performances of indigenous sheep of both districts are summarized in Table 4. The overall mean for age at 1st service for male and female sheep are 7.9±0.08 and 7.7±0.09 months, respectively. Ulfina *et al.* (2003) also reported that Horro ram lambs reached age at 1st service at the age of 182 days (6.06 month) under on-station management with nutritional management of 300 g/head/day. The overall mean age at 1st lambing obtained in the current study was 13.7±0.09 months. There was no significant difference ($p>0.05$) in age at 1st service and age at 1st lambing between the districts considered in the current study.

The overall mean lambing interval (LI) obtained in the current study was 7.9±0.07 months. The lambing interval reported in the present study is nearly similar with the 7.8±2.40 months reported by Zewdu (2008) for Horro sheep breed managed under on-farm conditions in Horro district. There was significant difference between the two districts in lambing interval (LI). Lambing interval was longer at Anfillo than it was at Sibu Sire district (Table 4). This might be due to differences in flock management (Shashie and Mengistu, 2019) and location differences that may have impact on feed availability and other physical environments. However, it is shorter than the 8.5±1,60 month reported for Bonga sheep managed under on-farm condition (Metsafe, 2015). Zelalem (2016) who reviewed the reproductive performances of over 17 indigenous sheep eco-types from the different parts of Ethiopia reported laming interval (LI) ranging from 6.64 to 12.7 months. The current findings of lambing interval (LI) is, however, shorter than the 263 days (8.8 month) and 303 days (10.1 month) reported for Washera sheep breed under on-station and on-farm managements, respectively (Shigdaf *et al*., 2013). According to the authors, management system had significant effect on lambing interval.

Mean litter size obtained in the current study was 1.5±0.05 (Table 4); and it is higher than the 1.36 reported by Zewdu (2008) for Horro sheep flocks kept under on-farm management condition and the 1.34

reported by Solomon and Gemeda (2000) for Horro sheep flocks maintained at Bako Agricultural Research Center. The likely difference between the current findings and that of Zewdu (2008) may be due to differences of agro-ecology. The present study was conducted in mid-land altitude and that of Zewdu (2008) was in highland areas. In addition, Solomon and Gemeda (2000) analyzed data collected over two decades and their results may be more reliable than the current study results and that of Zewdu (2008), which were based on survey results. The value obtained for litter size in the current study is within the range of the 1.18 to 1.55 lambs/lambing reported by Solomon *et al.* (2002) and the 1.28 to 1.55 reported by Gizaw *et al.* (2013). Previous research studies (Mekuriaw *et al.*, 2013; Shashie and Mengistu, 2019) noted that management system, breed, level of nutrition, season and age of ewes are major sources of variations in litter size. This indicated that, improving the general management system and level of nutrition could be important factors to increase litter size so as to enhance the productivity of ewes.

Based on respondents, ewes in Sibu Sire district had significantly ($p<0.05$) longer reproductive lifetime than ewes in Anfillo district. The overall mean reproductive lifespan for ewes was 8.4±0.08 years and the average reproductive lifespan for ewes at Sibu Sire district was 8.7±0.12 years compared to the 8.1±0.09 years reported for ewes at Anfillo district. In the current study, reproductive lifespan was not associated with reproductive performances, thus difficult to conclude whether the shorter or the longer reproductive life span is better or not. Sometimes, producers keep aged ewes for different reasons other than reproduction performances. For instance, Gemeda (2010) reported that Afar pastoralists keep aged ewes with one or more pairs of erupted permanent incisors just for homestead recognition purposes. That means some elite ewes able to lead their respective flocks to their homestead or they save them from wandering away.

Table 4. Production and reproductive performances of sheep population.

Reproductive and productive parameters	Districts			P value
	Anfillo	Sibu Sire	Overall mean	
AAFS of female (months)	7.7±0.12	7.6 ±0.13	7.7±0.09	0.479
AAFS of male (months)	8.0±0.10	7.8±0.11	7.9±0.08	0.284
Age at first lambing (months)	13.7±0.12	13.6±0.13	13.7±0.09	0.428
Lambing interval (months)	8.0±0.10	7.7±0.08	7.9±0.07	0.006
Litter size	1.5±0.07	1.4±0.07	1.5±0.05	0.681
RLT of ewes (years)	8.1±0.09	8.7±0.12	8.4±0.08	0.001
Weaning age of lambs (months)	4.6±0.09	4.2±0.10	4.4±0.07	0.002
Marketing age of male (months)	9.2±0.18	8.8±0.16	9.0±0.12	0.022
Marketing age of female (months)	9.9±0.16	9.1±0.18	9.5±0.13	0.001

AAFS= Age at first service; RLT= Reproductive lifetime of ewes.

According to respondents, mean age at weaning was 4.4±0.07 months and significant difference ($p<0.05$) was observed between the districts in weaning age. Weaning age was slightly shorter at Sibu Sire district compared to that of Anfillo district. The possible reason, among others, for the shorter weaning age at Sibu Sire district may be the influence of Bako Agricultural Research Center, which is located at less than 25 km from the Sibu Sire district. The center provides extension services to farmers on improved crop and livestock production technologies. Marketing age for males and females was significantly different ($p<0.05$) between the districts. Both male and female sheep are marketed earlier at Sibu Sire district compared to that of Anfillo district. The likely difference in marketing age may be accessibility difference. Sibu Sire district is situated at about 278km from Addis Ababa as opposed to Anfillo which is located at about 694 from the capital city of the country.

Identification of Sheep Breeding Objectives of Smallholder Farmers

Major objective traits for breeding ewes: Major breeding objectives for breeding ewes are presented in Table 5. In Anfillo district, appearance (Index=0.40), mothering ability (Index=0.24) and twinning rate (Index=0.15) were the first three important objective traits for the selection of breeding ewes. However, in Sibu Sire district, mothering ability (Index=0.29), appearance (Index=0.23) and twinning rate (Index=0.15) were the first three most preferred attributes to select breeding ewes. The difference in traits preferences between the districts might be due to their differences in breeding objectives. In the Sibu Sire district, mothering ability was identified as the top-ranked attribute due to its significant role in achieving higher lamb production for the market. Conversely, in the Anfillo district, appearance emerged as the most preferred trait. Overall, when selecting breeding females, traits such as appearance (Index=0.32), mothering ability (Index=0.26), and twinning rate (Index=0.19) were consistently regarded as the most desirable. Specifically, mothering ability (Index=0.26) and twinning rate (Index=0.19) were ranked as the first, second, and third most important traits for the selection of breeding ewes, respectively. According to the focus group discussions (FGD) and individual interviews with sheep owners, both attributes are important to have large number of lambs for replacement and for marketing within short period. Gemeda *et al.* (2011) also indicated that sheep

producers from four different regions of Ethiopia were highly opted for good mothering ability of ewes, which is important for caring of lambs and better survival and growth of lambs at early stages.

Major objective traits for breeding rams: Most preferred traits for breeding rams selection are indicated in Table 5. The top three most preferred objective traits for the selection of breeding rams were appearance (Index=0.33), growth rate (Index=0.32) and tail size (Index=0.21) (Table 5). The higher preferences of farmers for body appearance, growth and tail size traits were also previously report of Demeke *et al.* (2015) and Esubalew *et al.* (2019). Growth rate is the primary trait considered in breeding rams selection at Sibu Sire district; while appearance was considered most at Anfillo district. This could practically mean that a breeding ram with fast growth rate and good tail size/shape and attractive appearance could fetch premium price at market and may also inherit its good appearance to its offspring. Appearance is a composite trait that encompasses size, coat color, body condition and tail. When owners put their sheep to the traditional market, the buyers first look at the tail and the overall appearance of the rams to select and fix their prices.

Table 5. Selection criteria for ewe and rum in the study area as ranked by owners.

Criteria	Districts								Overall index values
	Anfillo				Sibu Sire				
	Rank				Rank				
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	
Breeding ewe									
Mothering ability	15	17	25	0.24	25	21	11	0.29	0.26
Tail size	3	7	19	0.10	5	3	9	0.07	0.08
Lambing interval	7	8	0	0.08	0	1	22	0.05	0.07
Appearance	39	21	15	0.40	16	20	13	0.23	0.32
Twining rate	9	15	10	0.15	20	13	10	0.22	0.19
Growth rate	0	3	2	0.02	3	15	7	0.11	0.07
Color	0	2	2	0.01	4	0	1	0.03	0.02
Breeding ram									
Color	3	4	10	0.06	7	10	13	0.12	0.09
Appearance	33	19	16	0.35	27	14	21	0.30	0.33
Growth rate	18	24	19	0.28	28	25	20	0.35	0.32
Tail size/shape	19	22	12	0.26	8	18	11	0.16	0.21
Mating ability	0	4	16	0.05	3	6	8	0.07	0.06

Sheep Management System

Housing management: In the present study, majority of the respondents (46.6%) from both districts housed their sheep within fairly-constructed separate houses and about 17.8% of the respondents indicated that sheep share family houses during the night (Table 6). About 35.6% of sheep owners house their sheep in a shed/house that is constructed just attached to the main family house (*Gaadaa*). According to respondents, owners who are unable to afford to construct either a separate house or a shed attached to the main family house share their house with their sheep. Sheep which shares a family house are tethered on one corner of the house to restrain them from damaging house utensils. From human health perspective, sharing a house with any domestic animals including sheep may increase the probability of transmission of zoonotic diseases. The current result is in line with the report of Zewdu (2008) and Helen *et al.* (2015). The majority of respondents (73.3%) indicated that corrugated iron sheet was the major roofing materials used in the study areas followed by grass thatched roofing (17.1%) and plastic sheet roofing (9.6%). Plastic sheet roofing is less durable compared to the iron sheet and grass thatched roofing. In the current study, the different types of floor used in sheep houses were earthen floor, wooden floor and concrete floor. Majority of the respondents (61.6%) indicated that earthen floor was the most common flooring type used followed by wooden floor (28.1%). The former is used in a house separately constructed for sheep while the latter is commonly used in a sheep house constructed attached to the family house. Wooden floor is preferable for cleaning and fast drying as it allows passing urine and retaining feces.

Herding management: Majority of the respondents (61.60%) indicated that sheep are herded separately from other livestock species. On the other hand, about 17.8%, 13.7% and 6.8% of respondents reported that sheep are herded with goats, with calves and with cattle, respectively (Table 7). The present finding is similar with the finding of Guadie (2021). When asked about their preferences, about 53.4% and 58.9% of the respondents from Anfillo and Sibu Sire districts, respectively, opted to herd their own flock separately from others flocks. However, it may increase the chance of inbreeding and also limit selection due to the small flock size owned per household. Hizkel (2021) also reported that separate herding of each flock may increase the chance of inbreeding and may also reduce selection intensity as flock size is very small.

Table 6. Type of houses, roofing and flooring materials commonly used in the study areas.

Type of house and housing material	Districts						χ^2 value
	Anfillo		Sibu Sire		Overall		
	№	%	№	%	№	%	
Type of house							
Separate house for sheep	24	32.90	44	60.30	68	46.60	15.344**
In family house	12	16.40	14	19.20	26	17.80	
A shed attached to family house (*Gaadaa)*	37	50.70	15	20.50	52	35.60	
Roofing materials							
Iron sheet	44	60.30	63	86.30	107	73.30	12.705**
Grass	19	26	6	8.20	25	17.10	
Plastic sheet	10	13.70	4	5.50	14	9.60	
Flooring materials							
Earthen floor	43	58.90	47	64.80	90	61.60	28.983**
Wooden floor	30	41.10	11	15.10	41	28.10	
Concrete	0	0	15	20.50	15	10.30	
Wall construction material							
Wood	73	100	73	100	146	100	

*Superscripts: ** indicates P<0.01.*

Table 7. Herding practices of sheep reported by households.

Herding practices	Districts						χ^2 value
	Anfillo		Sibu Sire		Overall		
	№	%	№	%	№	%	
Sheep flock is herded							
Together with cattle	10	13.70	0	0	10	6.80	
Together with goats	7	9.60	13	17.80	20	13.70	11.998**
Sheep herded separately	44	60.30	46	63.00	90	61.60	
Together with calves	12	16.40	14	19.20	26	17.80	
Ways of herding							
Sheep of a HH run as a flock	39	53.40	43	58.90	82	56.20	0.445ns
Sheep of more than one HHs run as flock	34	46.60	30	41.10	64	43.80	

*Superscripts: ns indicates P=0.05 and ** indicates P<0.01; HH= Household.*

Diseases and health management: Diseases have numerous negative influences on productivity of herds i.e. death of animals, loss of weights, slow down growth, reduced fertility performance, reduction in physical power. There have been many ways of fighting against diseases and among these, vaccinations and treatments are the major ones (CSA, 2021). According to the focus group discussions, the most common sheep diseases in Anfillo district were bloats, "goat plague", brucellosis, pneumonic pasteurellosis, peste des petits ruminants, and ecto-parasites. On the other hand, fascioliasis, pasteurellosis, orf and external parasites were some of the predominant diseases reported from Sibu Sire district. According to the focus group discussions from Anfillo district, most sheep producers did not treat their animals regularly at government veterinary clinics mainly due to its less accessibility. In addition, sheep producers also do not have the capacity (inability to pay service charge) to use private veterinary clinics. Relatively better access to veterinary was observed in Sibu Sire district, because most sheep producers could have better access to veterinary services in nearby. Majority of the respondents (75.3%) from both districts indicated that sheep owners, usually tried to take their sheep, when they got sick, to the veterinary clinic. The current result is similar with the report of Helen *et al.* (2015) in Eastern Ethiopia. However, about 17.8% and 6.8% of the respondents indicated that sheep producers use traditional healing practices and both the veterinary clinic and the traditional healing practices, respectively. The most common traditional treatment practices used in the study areas were bleeding under the tongue of sheep, branding under the neck by hot iron and provision of "*sanafich*" to the sick sheep. Vaccination was provided, though not done on regular basis, to all livestock species including sheep, particularly if suspected for outbreak of diseases.

Major Feed and Water Sources of Sheep in the Study Areas

The major sources of feed for sheep in the study areas are presented in Table 8. Natural pasture was the most important feed source throughout the year in both districts. This is in agreement with the findings reported in the literature (Zewdu *et al.*, 2012; Hulunim, 2014; Yadeta, 2016). During dry season, natural pasture (Index=0.43) was the most common source of feed for sheep followed by fallow land (Index=0.31) and concentrates (Index=0.18) in Anfillo district. In this district, the sheep owners rarely used crop residues as the major crops grown is coffee rather than other crops that may provide crop residues for their sheep. In Sibu

Sire district, natural pasture (Index=0.39), concentrates (Index=0.20) and fallow lands (Index=0.19) were the three most important sources of feed for sheep during dry season. In contrast to Anfillo district, sheep producers at Sibu sire district use crop residues (0.15) as source of feed during dry season that may help to cope up the period of feed problem. Other feed sources like *atela* (local beverage by products), kitchen left over, backyard forages, backyard tree such as branch of avocado, *Sesbania sesban* and *Leucaena leucocephala*, roadside grass, purchased feeds, etc are also used in the study areas mainly to overcome problems of the scarcity of feed.

Rivers and springs were the main sources of water during the dry season in Sibu Sire district; whereas rivers and water wells were major sources of water in Anfillo district (Table 9). There were significant ($p<0.01$) difference among the districts with regard to source of water, distance of watering points, frequency of watering during both the dry and wet seasons. The current result reveled that there was seasonal variation in availability of water and watering frequency. Distance of watering points varied with season and it was longer during the dry season. Similar result was reported by Helen *et al.* (2015) and Hagos *et al.* (2017) in other parts of the country.

Table 8. Major feed resources of sheep in dry and rainy seasons in the study districts.

Feed sources by season	**Anfillo district**				**Sibu Sire district**				Overall index values
	Rank			Index values	Rank			Index values	
	1st	2nd	3rd		1st	2nd	3rd		
Dry Season									
Natural pasture	43	30	0	0.43	40	20	13	0.39	0.41
Concentrate	7	13	33	0.18	17	12	13	0.20	0.19
Crop residues	0	5	23	0.08	9	8	23	0.15	0.12
Crop aftermath					0	10	9	0.07	0.03
Fallow land	23	25	17	0.31	7	23	15	0.19	0.25
Rainy Season									
Natural pasture	55	18	0	0.46	35	38	0	0.41	0.44
Improved forages	0	32	41	0.24	22	0	51	0.26	0.25
Fallow land	18	23	32	0.30	16	35	22	0.32	0.31

Table 9. Major water sources for sheep in dry and rainy seasons.

Descriptors/variables	Districts			χ^2 value
	Anfillo	Sibu Sire	Overall	
	№ (%)	№ (%)	№ (%)	
Sources of water during dry season				
River	63 (86.3)	55 (75.3)	118 (80.8)	24.906**
Spring	-	17 (23.3)	17 (11.6)	
Water well	10 (13.7)	1 (1.4)	11(7.5)	
Sources of water during rainy season				
River	19 (26.0)	16 (21.9)	35 (24.0)	0.345ns
Spring	4 (5.5)	4 (5.5)	8 (5.5)	
Rain water	50 (68.5)	53 (72.6)	103 (70.5)	
Distance of water sources during dry season				
Watered at home	10 (13.7)	1 (1.4)	11 (7.5)	32.346**
Travel less than 1km	16 (21.9)	49 (67.1)	65 (44.5)	
Travel 1 to 5km	47 (64.4)	23 (31.5)	70 (47.9)	
Distance of water sources in rainy season				
Watered at home	51 (69.9)	53 (72.6)	104 (71.2)	0.134ns
Travel less than 1km	22 (30.1)	20 (27.4)	42 (28.8)	
Frequency of watering in dry season				
Once a day	61 (83.6)	49 (67.1)	110 (75.3)	5.309*
Twice a day	12 (16.4)	24 (32.9)	36 (24.7)	
Frequency of watering during rainy season				
Freely available	60 (82.2)	53 (72.6)	113 (77.4)	33.434**
Once a day	-	20 (27.4)	20 (13.4)	
Once in two days	13 (17.8)	-	**13 (8.9)**	

*Superscripts: ns indicates P=0.05; * indicates P<0.05; and ** indicates P<0.01.*

Major Sheep Production Constraints

Identification of constraints that affect sheep production and genetic improvement program should prioritize as the first step before implementation (Baker and Gray, 2004). Based on respondents, feed shortages, disease and parasites were the major constraints that influence

sheep productions with index value of 0.32 and 0.25, respectively (Table 10). There was variation in index intensity in prioritizing constraints between the districts. Discussions with focus groups also confirmed that seasonal feed shortage both in quality and quantity was the major problem in sheep production. Duration of feed shortage was longer in Anfillo district as compared to Sibu Sire district. According to the respondents, the scarcity of feed was mainly due to expansion of crop cultivation to grazing lands (especially coffee planting on grazing land in Anfillo district) and soil degradation. Likewise, several authors (Chiemela *et al*., 2018; Mebrate, 2020; Kerga, 2021) also reported seasonal feed shortage as a major and the first ranked constraint that influences sheep production and productivity in the country. The seasonal scarcity of feed in the country is due to expansion of crops (cultivation of grazing lands) that reduce grazing land and land for fodder production (Markos, 2006; Solomon *et al*., 2010). Market problems and labor shortages were also important constraints in Anfillo and Sibu Sire districts, respectively.

Table 10. Major sheep production constraints of the study areas.

Constraints	Anfillo district				Sibu Sire district				Overall index values
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	
Feed shortages	30	28	15	0.37	23	18	14	0.27	0.320
Disease and parasites	18	21	26	0.28	16	17	15	0.22	0.250
Lack of improved breeds	0	3	7	0.03	0	2	6	0.02	0.025
Water shortage	2	6	8	0.06	4	3	2	0.05	0.055
Low productivity of sheep	1	2	5	0.03	0	2	3	0.02	0.025
Market problem	15	4	6	0.13	2	9	12	0.08	0.110
Labor shortages	0	0	0	0	19	16	18	0.24	0.120
Predator	7	9	6	0.10	9	6	3	0.10	0.050

Conclusion

The overall average sheep flock size per household was 8.0±2.25. In the study districts, the sale of breeding rams at an earlier age leads to a smaller proportion of breeding males and fast-growing males are sold before they may pass on their 'best' genes to offspring. In that case mediocre males may remain in the flock and get chance to breed. This may maximize the chance of inbreeding as well as reduce the chance of selecting best breeding rams. The reproductive performances of sheep flocks at both districts were fair, but should be taken with caution as data used in the current study were collected through survey questionnaire and personal observation. Appearance, growth rate and tail size were most important attributes for breeding ram selection. Seasonal feed shortage in terms of both quality and quantity is the major constraints of sheep production. Feed shortages, disease prevalence and parasites were the major constraints that influence sheep productions in the study areas. Most of sheep owner prefer to herd own flock separately than mixing with sheep from other households and this may increase the chance of inbreeding and reduce selection intensity. This may also hinder community-based genetic improvement where village's flocks are considered as single flock and reduces chance of inbreeding and could increase selection intensity. The practice of hay making and urea treatment of crop residues was not commonly practiced. Moreover, infectious diseases should be prevented and controlled through the provision of strong extension services.

Acknowledgments

The Anfillo Agriculture Office is acknowledged for allowing the study leave for the major author. Sheep producers involved in the current study are also acknowledged for generously responding to the survey questions and their hospitality.

Conflict of Interests

The authors declare that they have no competing interests.

References

Hagos Abraham, Solomon Gizaw & Mengistu Urge (2017). Begait goat production systems and breeding practices in Western Tigray, north Ethiopia. *Open Journal of Animal Sciences*, 7:198-212.

ADAO (Anfillo district agricultural office) (2022). Anfillo District Agricultural Office report. (Unpublished government report)

Admasu Lakew, Aberra Melesse & Sandip Banerjee (2017). Traditional sheep production systems and breeding practice in Wolaita Zone of Southern Ethiopia. *African Journal of Agricultural Research*, 12 (20): 1689-1701.

Afras Abera (2021). Review on sheep and goat production system in Ethiopia. *Advances in Dairy Research*, 9 (9): 1-12.

Shashie Ayele & Mengistu Urge (2019). Productive and reproductive performances of indigenous sheep in Ethiopia: A review. *Open Journal of Animal Sciences*, 9: 97-120.

Baker, R.L. & Gray, G.D. (2004). Appropriate breeds and breeding schemes for sheep and goats in the tropics: The importance of characterization and utilizing disease resistance adaptation to tropical stress. In: R. Sani, G.D. Gray, R.L. Baker (Eds.), Worm control for small ruminant in tropical Asia,

Australian Center for International Agricultural Research (ACIAR).

Bosenu Abera, Kefelegn Kebede & Solomon Gizaw (2014). Indigenous breeding practices and selection criteria of sheep breed in Selale area, central Ethiopia. *International Journal of Livestock Research,* 4(7): 49-56.

Chiemela Peter Nwogwugwu, Seung-Hwan Lee, EgbuChidozie Freedom, Prabuddha Manjula & Jun Heon Lee (2018). Review on challenges, opportunities and genetic improvement of sheep and goat productivity in Ethiopia. *Journal of Animal Breeding and Genomics*, 2 (1): 001-008.

CSA (Central Statistical Agency of Ethiopia) (2021). Agricultural sample survey 2021, Volume II, report on livestock and livestock characteristics (private peasant holdings). *Statistical Bulletin* 589, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency) (2017). Ethiopia demographic and health survey key findings, Central Statistical Agency, Addis Ababa, Ethiopia, The DHS Program, ICF, Rockville, Maryland, USA.

Demeke Haile, Solomon Gizaw & Kefelegn Kebede (2015). Selection criteria and breeding practice of sheep in mixed crop livestock farming system of North Shoa, Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 5 (21): 168-174.

Desalegn, A. (2019). Economic value estimation of important traits and designing of breeding schemes for sheep breeds in northwestern Amhara, Ethiopia, MSc Thesis, University of Gondar, Gondar, Ethiopia.

Endeshaw, A. (2007). Assessment on production system and marketing of goats at Dale district (Sidama Zone), MSc Thesis, Hawassa University, Hawassa, Ethiopia.

Esubalew Adimasu, Kefyalew Almayehu & Tesfaye Getachew (2019). Breeding objective, breeding practices and selection criteria of indigenous sheep in western Amhara, Ethiopia. *International Journal of Sustainable Agricultural Research*, 6 (4): 172-182.

Gemeda Duguma (2010). Participatory definition of breeding objectives and implementation of community-based sheep breeding programs in Ethiopia, PhD Thesis, University of Natural Resources (BOKU), Vienna, Austria.

Gemeda Duguma, Tadele Mirkena, Aynalem Haile, Iñiguez, L., Okeyo, A.M. & Markos Tibbo (2011). Identification of smallholder farmers' and pastoralists' preferences for sheep breeding traits: Choice model approach. *Animal*, 5: 1984-1992.

Guadie, G. (2021). Phenotypic characterization of indigenous sheep populations and defining breeding objectives in selected districts of central and west Gondar Zone, Amhara Regional State, Ethiopia, MSc Thesis, Bahir Dar University, Ethiopia.

Helen Nigusie, Yoseph Mekasha, Solomon Abegaz, Kefelegn Kebede & Sanjoy Kumar Pal (2015). Indigenous sheep production system in eastern Ethiopia: Implications for genetic improvement and sustainable use. *American Scientific Research Journal for Engineering, Technology, and Sciences*, 11 (1): 136-152.

Hizkel Kenfo (2021). Review of indigenous sheep breeds production systems in Ethiopia. *International Journal of Innovative Science and Research Technology*, 6 (2): 669-675.

Hulunim, G. (2014). On-farm phenotypic characterization and performance evaluation of Bati, Borena and Short Eared Somali goat populations of Ethiopia, Msc Thesis, Haramaya University, Haramaya, Ethiopia.

Jaitner, J., Sowe, J., Secka-Njie, E. & Dempfle, L. (2001). Ownership pattern and management practices of small ruminants in the Gambia-Implications for a breeding programme. *Small Ruminant Research*, 40: 101-108. https://doi.org/10.1016/S0921-4488(00)00221-2.

Kasahun Bekana, Temesgen Jembere & Gemeda Duguma (2022). On-farm and on-station comparison of early growth and survival performances of Horro sheep in western Ethiopia. *Ethiopian Journal of Animal Production*, 22 (1): 1-10.

Kerga, T. (2021). Husbandry practices and phenotypic characterization of indigenous sheep types in Gurage Zone, southern Ethiopia. *International Journal of Livestock Production*, 12 (4): 154-167.

Kosgey, I.S. (2004). Breeding objectives and breeding strategies for small ruminant in the tropics, PhD Thesis, Wageningen University, the Netherlands.

Markos Tibbo (2006). Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopia highlands, PhD Dissertation, Swedish University of Agricultural Science (SLU), Uppsala, Sweden.

Matawork M. Gobena & Mitiku G. Tona (2017). A review on sheep production system, marketing and constraints in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 7 (19): 34-42.

Mebrate, G. (2020). On-station and on-farm performance evaluation of Awassi X Menz crossbred sheep in the central highlands of Ethiopia, Msc Thesis, Debre Berhan University, Debre Berhan, Ethiopia.

Mekuriaw, S., Mekuriaw, Z., Taye, M., Mazengia, H., Mekuriaw, G. & Haile, A. (2013). Reproductive performance and survival rate of Washera and Farta sheep breeds under traditional management system in Farta and Lay Gayint districts of Amhara Regional State, Ethiopia. *Ethiopian Journal of Animal Production*, 13 (1): 65-82.

Meseret Molla (2020). Conservation-based breeding program for indigenous sheep breeds in Ethiopia, the way forward. *Online Journal of Animal and Feed Research*, 10 (1): 17-24.

Metsafe Mamiru (2015). On-farm performance evaluation and community-based traditional selection methods of Bonga sheep in Adiyo Kaka *woreda*, southern Ethiopia, MSc Thesis, Hawassa University, Hawassa, Ethiopia.

Shigdaf Mekuriaw, Mengiste Taye, Zeleke Mekuriaw, Getinet Mekuriaw, H. Mazengia & Aynalem Haile

(2013). Evaluation of reproductive performances and survival rate of Washera sheep under farm and station management systems in Amhara Region, Ethiopia. *Agricultural Advances*, 2 (7): 206-215.

Simegn Alemayehu, Temesgen Jembere & Gemeda Duguma (2017). Study of early growth traits in Horro sheep using sizable records at Bako Agricultural Research Center, west Ethiopia. *Livestock Research for Rural Development*, 29 (2). http://www.lrrd.org/lrrd29/2/alem29026.htm.

Solomon Abegaz & Gemeda Duguma (2000). Genetic and phenotypic parameters of growth, reproduction and survival performance of Horro sheep at Bako Agricultural Research Center, Research Report. International Livestock Research Institute (ILRI), Addis Ababa, Ethiopia. p: 57.

Solomon Abegaz, Gemeda Duguma, Enyew Negusie, Girgo Ulfina Galmessa, Fekede Terefe & Edward Rege (2002). Factors affecting reproductive performance and estimates of genetic parameters of litter size in Horro sheep. *The Journal of Agricultural Science*, 139 (1):79–85.

Solomon Gizaw, Azage Tegegne, Berhanu Gebremedhin & Hoekstra, D. (2010). Sheep and goat production and marketing systems in Ethiopia: Characteristics and strategies for improvement. IPMS (improving productivity and market success) of Ethiopian farmer's project working paper 23. ILRI, Nairobi, Kenya. p: 58.

SSAO (Sibu Sire agricultural office) (2022). Sibu Sire agricultural office. (Unpublished government report).

Tadesse Amare, Gebeyehu Goshu & Berhan Tamir (2018). Flock composition, breeding strategies and farmers' traits of interest evaluation of Wollo highland sheep and their F1 crosses. *Journal of Animal Science and Technology*, (60): 14. https://doi.org/10.1186/s40781-018-0173-9.

Tesfaye Getachew (2008). Characterization of Menz and Afar indigenous sheep breeds of smallholders and pastoralists for designing community-based breeding strategies in Ethiopia, MSc Thesis, Haramaya University, Ethiopia.

Ulfina Galmessa, Gemeda Duguma, Solomon Abegaz, Solomon Gizaw & Raina, V.S. (2003). Effect of plane of nutrition on age and weight at sexual maturity in Horro ram lambs. *The Indian Journal of Animal Sciences*, 73 (9): 1069-1071.

Yadeta Neme (2016). Production and reproduction performances, producers' trait preferences and marketing system of small ruminants in Ada Barga and Ejere districts of West Shoa Zone, Ethiopia, MSc Thesis, Jimma University, Jimma, Ethiopia.

Yamane, T. (1967). Statstics, an introductory analysis, 2nd ed., Harper and Raw, New York.

Zelalem Abate (2016). Review of the reproductive performances of indigenous sheep in Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 6 (9): 117-126.

Zeru Assefa, Mengestie Abebaw & Melese Yenew (2017). A review on heath and production management of sheep in Ethiopia. *Report and Opinion*, 9 (8):42-63.

Zewdu Edea (2008). Characterization of Bonga and Horro indigenous sheep breeds of smallholders for designing community based breeding strategies in Ethiopia, MSc Thesis, Haramaya University, Ethiopia.

Zewdu Edea, Aynalem Haile, Markos Tibbo, Sharma, A. K., Sölkner, J. & Wurzinger, M. (2012). Sheep production systems and breeding practices of small holders in western and southwestern Ethiopia: Implications for designing community-based breeding strategies. *Livestock Research for Rural Development*, 24 (7). http://www.lrrd.org/lrrd24/7/edea24117.htm.