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Production System and Breeding Practices of Indigenous Sheep Populations in Qellam Wallaga Zone, Oromia, Ethiopia

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Abstract

The study was conducted to characterize the sheep production system and breeding practices. Semi-structured questionnaire, secondary data, and focus group discussions were used to capture the necessary information. With an average landholding of nearly 2.8±0.02 ha per household, a mixed crop-livestock system is the predominant mode of production. The mean flock size per household was 8.9±0.02, with breeding ewes older than a year comprising about 40.4% of the flocks. The average age at first sexual maturity was 8.3±0.10 months for males and 8.7±0.60 months for females. The average reproductive life time span, lambing interval, and age at first lambing were found to be 9.4±0.11 years, 7.8±0.10 months, and 13.4±0.07 months, respectively. When selecting breeding rams, appearance, tail type, and coat color are the most crucial characteristics. The comparable characteristics used in the breeding ewe selection were mothering ability, survival, and appearance. Own flock, purchasing, and neighboring flocks are the primary sources of breeding rams. Lambing seasons are nearly year-round. The findings indicated that even if village flocks mingle in communal grazing lands, each household's flock is herded separately. Generally, important to leverage the mixing flocks of sheep from villages in shared grazing areas to promote genetic improvement within the community.

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INTRODUCTION

Sheep is one of the most economically important animal species in Ethiopia. They are vital to the livelihood of pastoralists and farmers who lack resources. There are 42.9 million sheep in this country, with 70% of them being female and 30% male. In Ethiopia, indigenous sheep make up 99.5% of the population, with hybrid and exotic genotypes/breeds accounting for the remaining 0.41% and 0.08%, respectively (CSA, 2021). There are numerous indigenous sheep breeds in Ethiopia. According to Gizaw et al. (2008), there are at least nine breeds and fourteen

traditional sheep populations spread among various environments, production systems, and communities. Ayele & Urge (2019) reported that agro-pastoral and pastoral production systems account for 25% of the country's sheep population, with mixed crop-livestock systems accounting for the remaining 75%.

Despite their abundance and widespread distribution across the country's different agro-ecologies, the production and productivity of indigenous sheep are below potential. Ethiopia's traditional sheep production system is constrained by a lack of feed, the prevalence of disease and parasites, a lack of technical competence and market knowledge, and a lack of planned breeding plans and policies (Kocho, 2007; Gizaw et al., 2010). Generally, Ethiopian sheep farming is typically described as extensive meaning that sheep are raised year-round on natural pastures and crop residues/aftermath with very little, if any, concentrate supplementation. Nevertheless, there exists an intimate relationship between the circumstances of animal feed and the different stages of production and the rearing system and technologies used in the production process. According to Makkar (2016), availability in a sustained manner of the desired type and quantity of animal feed and its feeding is the foundation of livestock production system. For this very purpose, comprehensive data on husbandry practices and production systems can be the cornerstone for long-term improvement and evaluating reproductive success both within and across breeds (Gizaw et al., 2010; Tesfaye, 2021). There are also variations in the performance of different breeds of sheep in Ethiopia (Matawork & Mitiku, 2017). The lack of up-to-date and location specific information on production and marketing systems is often a major limitation to productivity and production improvement endeavors in sheep in Ethiopia (Solomon et al., 2003). Even though, a thorough understanding of the entire situation is necessary to make the most out of the sheep-keeping operation; there haven't been any in-depth research done on sheep production system in the Qellam Wallaga zone Oromia Regional State in general and the three districts of the Qellam Wallaga zone targeted in the current study. The main objective of the current study, therefore, was to evaluate the sheep production systems in Dale Wabara, Sadi Chanqa and Dale Sadi districts of the Qellam Wallaga zone.

MATERIALS AND METHODS

Description of the Study Area

The current study was carried out in Ethiopia's Qellam Wallaga Zone, Oromia Regional State. Three of the Qellam Wallaga Zone's 12 districts—Dale Wabara, Sadi Chanqa, and Dale Sadi—were chosen for this investigation. The districts were purposefully selected for the current study based on their high indigenous sheep populations. Figure 1 shows the map of the districts used in the investigation. The boundaries of Qellam Wallaga Zone are as follows: West Wallaga Zone to the north and east; Benishangul Gumuz Regional State to the north and west; Ilu Ababora Zone to the south and south-east; Gambella Regional State to the west and south-west; and the Sudan to the west. The geographical coordinates of the zone extended from 8°10' to 9°21' N latitude and 34°07' to

35°26’ E longitude. The altitude of the zone ranges from 500 to 3,335 m a.s.l. With regard to agro-ecological zones, about 0.2% of the zone area is categorized as highland, 20.35% as midland, and 79.45% as lowland. Qellam Wallaga zone has a total livestock population of 2,284,582; of which about 995,367 are cattle, 543,415 sheep, and 302,563 goats.

Dale Wabera is one of the eleven districts that make up the Oromia Regional State's Qellam Wallaga Zone. It was divided from the previous Gawo Dale district, and Kake serves as its administrative hub. Dale Wabara district is bounded to the east by Dale Sadi district, to the west by Yemalogi Walal district, to the north by Gawo Qebe district, and by the Ayira district of the West Wallaga zone, to the south by the Birbir River and the Illu Ababora zone. In the Dale Wabara district, there are roughly 51,105 head of goats, 72,123 sheep, and 195,631 cattle.

The Qellam Wallaga Zone, Oromia Regional State, Ethiopia is home to the Sadi Chanka District. The district is situated in the west, 572 kilometers from Addis Ababa. Surrounding Sadi Chanqa district, which has a total area of 493.51 km2, are the districts of Dale Sadi in the east, Hawa Galan in the west, Dale Wabara in the south, and Ilu Ababora zone (Darimu and Chawaka districts) in the north. There are approximately 494,798 livestock populations in the district overall, of which about 85,209, 53,841, and 29,543 are cattle, sheep, and goats, respectively.

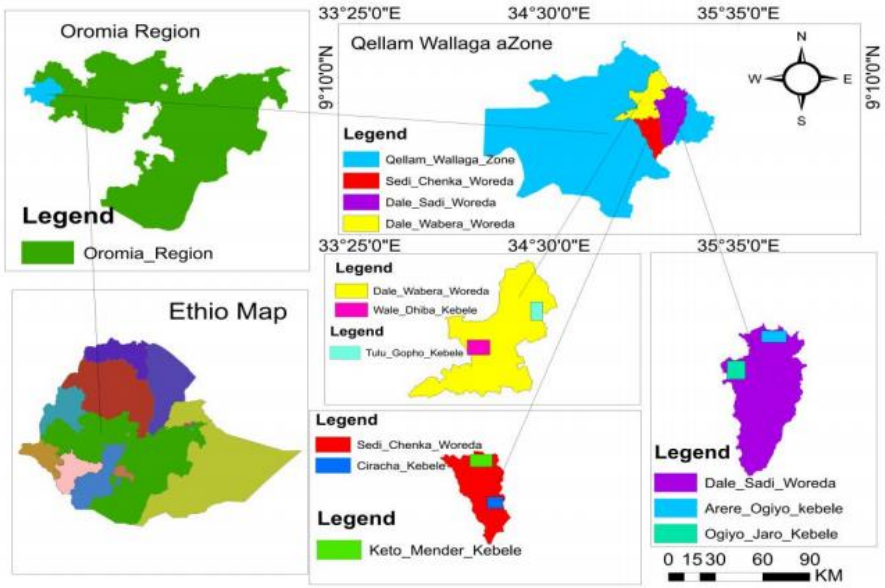

Figure 1. *Map of Study Area*

Dale Sadi District is one of the districts in Qellam Wallaga zone of the Oromia Regional State, Ethiopia. The district lies between 8°43' and 9°07 N latitude and 35°06' and 35°11' E longitude. Its boundaries are as follows: Lalo Qile District to the north, Ayira District to the east, Ilu Aba Bora Zone to the south, Sadi Chanqa District to the southwest, and Dale Wabara District to the west. Out of the approximately 88,635 overall population of

the district, males make up 46.64% and females 53.36%. The study district's average temperature is 25 °C. Generally, Dale Sadi is separated into two agro climatic zones: 40% is lowland and 60% is midland. The elevation of the districts varies from 1200 to 2200 meters above sea level (m.a.s.l.), and the average annual rainfall is between 1200 and 2350 millimeters (mm). Mixed-crop livestock farming is the major production system of the Dale Sadi district (Gurmu et al., 2021). There are roughly 529,809 animals in the district overall, of which 131,541, 63,962, and 25,302 are cattle, sheep, and goats, respectively.

Sampling method

Field assessments and through discussions were held with the subject matter specialists of the Qellam Wallaga Zone Agricultural and Natural Resource Office to decide on the potential districts involved in the study. Based on the outcome of the field assessments and discussions made with the subject matter specialists, three districts (Dale Wabara, Sadi Chanqa and Dale Sadi) were identified. The three districts were identified based on their potential for sheep production. Following identification of the districts, three peasant associations (PAs) from each district (i.e a total of six peasant associations) were purposefully selected for the study. Finally, 57 households from Dale Wabara, 52 from Sadi Chanqa and 47 from Dale Sadi districts (a total of 156 households (HHs) were identified) were selected following Yamane (1967). Households (HHs) having at least two and above adult sheep with a minimum of two years of experience in sheep husbandry practices were considered in current study. The formula used for the participating households' size determination was:

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

Where: n = sample size, N = total number of households.1 = probability the event occurring, and e = maximum variability or margin of error.

Methods of Data Collection

A semi-structured questionnaire, field observation, focus group discussions, key informants interview, and secondary data sources were all employed to capture data. The specific method for gathering data was determined by the sources of information and the type of data that was required. Identification of available opportunities, constraints, and sheep production system were basically the study's principal components. Focus group discussions, key informants interview, and field observations were used to verify the information obtained from the interview questions.

Data Management and Analysis

Data collected via the semi-structured survey were coded and entered into an Excel spread sheet, where after it was imported to the Statistical Analysis System (SAS, 2008) for further processing. Both the categorical and quantitative data were analyzed as deemed necessary. Ranking indices were employed to calculate sheep producers' preferences for various sheep attributes and for ranking of the major obstacles for sheep production in the study districts following (Kosgey, 2004). The ranking index formula fitted was:

$$\text{Index} = \frac{\sum[(3 \text{ x rank1}) + (2 \text{ x rank2}) + (1 \text{ x rank3})] \text{ individual attributes}}{\sum[(3 \text{ x rank1}) + (2 \text{ x Rank2}) + (1 \text{ x Rank3})] \text{ overall attributes}}$$

RESULTS AND DISCUSSION

Landholding/household in the Study Areas

The primary method of production in the research areas is mixed-crop livestock. In the current study, the average land holding size per household was 2.8±0.02 ha. Sadi Chanqa district has the second-highest mean land holding size per household, after Dale Wabara. At Dale Sadi, the landholding size per household was the lowest (Table 1). The average size of landholding per household in Ethiopia varies depending on regions, agricultural practices and economic conditions. The average landholding size per household indicated in this study is larger than the 1.13 ha average landholding size reported by the Central Statistics Agency (CSA, 2022). The average land holding size per household reported in this study is also larger than the 2.15ha reported by Mekasha et al. (2015).

Table 1

Least square mean (LSM±SE) landholding (ha) per household in the study areas

Type of land	Districts			
	Dale Wabara	Sadi Chanqa	Dale Sadi	Over all
Mean Landhoding	5.6±0.54	5.4±1.15	5.1±0.35	5.4±0.10
Land size (ha)	2.9±0.18[a]	2.8±0.15[a]	2.7±0.18[b]	2.8±0.02
Grazing land (ha)	0.3±0.02[a]	0.3±0.01[a]	0.3±0.02[a]	0.3±0.01
Cultivated (ha)	2.4±10.36[a]	2.3±0.99[b]	2.1±0.15[c]	2.3±0.07

SE= standard error; ha=Hectare; a row with different superscripts indicates significance

Sheep flock size per Household

In the research areas, the average number of sheep kept per household was 8.9±4.20. In Dale Wabara, Sadi Chanqa, and Dale Sadi districts, the average sheep flock size per household was 10.3±3.70, 8.5±2.50, and 7.7±6.50, respectively. Dale Wabara district had the largest sheep flock size, followed by Sadi Chanqa district. The mean flock size reported in the current study is comparable with the 8.5 mean flock size reported by Duguma et al. (2011). Compared to the 31.6 head of sheep per household reported for the Menz sheep breed (Getachew et al., 2010), and the 22.6 head of sheep per household reported by Amare et al. (2018), the overall mean number of sheep per household reported in the current study (8.9) is significantly lower. The mean sheep flock size per household obtained in the current study is less than the 12.5 reported in the north Wollo zone by Mohammed et al. (2014), the 16.9 reported in the Nuer zone (Jikawo and Lare districts) (Gezahegn et al., 2015), and the mean flock size ranges from 13.5 to 19.8 reported by Duguma (2010) for different indigenous sheep breeds. The likely causes of the discrepancy between the outcomes of the current study and the earlier ones could be differences in methodologies applied, agro-ecologies, management, and reluctance of some households to reveal their accurate flock sizes due to cultural beliefs and other

concerns. For instance, Duguma (2010) reported that sheep producers in Afar and Bonga areas were reluctant to reveal their actual flock sizes due to beliefs and fear of ear tag application on their animals.

Management of Sheep in the Study Areas

Feeding Management of sheep

In the current study, almost 42.9% of the respondents reported that children are heavily involved in sheep herding, whereas men are responsible for 28.2% of the sheep herding. According to 26.9%, 22.4%, and 19.9% of those who participated in the current survey, sheep of all classes are herded together, with goats, and with calves, respectively. The results of the current study were inconsistent with those of Hailemariam et al. (2013), who found that most respondents (63%) kept sheep apart from other livestock species. Herding and grazing practices during the dry and rainy seasons are indicated in Tables 2 and 3, respectively.

Table 2

Herding system and ways of herding described in number and proportion (№ (%))

Sheep herding management	Districts			Over all Mean
	Dale Wabara № (%)	Sadi Chanqa № (%)	Dale Sadi № (%)	№ (%)
Responsibility in herding				
Men	14 (24.6)	12 (23.1)	18 (38.5)	39 (28.2)
Women	15 (26.3)	8 (15.4)	6 (12.8)	29 (18.6)
Children	24 (42.1)	26 (50.0)	16 (34.1)	66 (42.9)
Relatives	4 (14.0)	6 (11.4)	7 (14.9)	17 (10.9)
Herding Methods				
All classes together	13 (22.8)	16 (30.8)	13 (27.3)	42 (26.9)
Together with goat	12 (21.1)	10 (19.2)	13 (27.7)	35 (22.4)
Together with calves	11 (19.3)	12 (23.1)	8 (17.0)	31 (19.9)
Lambs separated	15 (26.3)	3 (5.8)	9 (19.1)	27 (17.3)
Together with equines	6 (10.5)	11 (21.2)	4 (8.5)	21 (13.5)
Ways of herding sheep in the study area				
Own flock's herded separate	43 (75.4)	34 (65.4)	32 (68.1)	109 (69.9)
Neighbors flocks run together	14 (24.6)	18 (31.9)	15 (34.1)	47 (30.1)
Lamb's management				
Kept at backyard	39 (68.4)	31 (59.6)	27 (57.4)	97 (62.2)
Graze with neighbors' lambs	18 (31.6)	21 (40.7)	20 (40.5)	58 (37.8)

**** = significantly differences, NS = not significantly differences, chi/x2= chisquare, >= greater than HH=house holds*

Since communal grazing lands are the primary source of feed and all community members of the area have the right to access, herding is the primary method of sheep management used in the current study. In contrast to this, about 70.1% of the respondents in Gamogofa zone of the Southern Ethiopia, use tethering grazing system on own plot of land (Hailemariam et al., 2013). While residents of a particular area

tend to utilize whatever grazing pasture that is available, around 69.9% of respondents herded their own flock independently, keeping it distinct from other flocks. For instance, more than 75.4% of Dale Wabara respondents, 65.4% Sadi Chanqa respondents, and 68.1% Dale Sadi respondents stated that their flocks are kept separate and do not interact with other flocks. Nigussie et al. (2016) discovered, in contrast to this study, that about 70% of pastoral sheep producers and 45.5% of agro-pastoral sheep producers herded their flocks mixing with other flocks. However, over 31% of the interviewees in this study—24.6% from Dale Wabara, 31.9% from Sadi Chanqa, and 34.1% from Dale Sadi—indicated that flocks consisting of two or more households graze together on common grazing lands. Duguma et al. (2012) also reported that households alternately care their sheep, bringing together two or more neighboring households' flocks.

In the study, about 62.2% of those interviewed sheep owners keep young lambs apart in their backyard, whereas 37.8% reported that young lambs are free to run alongside their dams. The current report and that of Debele et al. (2013). There was a statistically significant difference ($p<0.05$) in sheep herding and management between the districts. This could be because of herding labor, management, theft concern, and production goals.

Grazing Practices of Sheep in the Study Areas

In all three districts, most sheep farmers let their sheep for free grazing during the dry season. Approximately 63.4%, 25%, and 11.1% of those involved in the study reported that, free grazing, herding, and tethering are carried out throughout the dry season, respectively. During the wet season, roughly 61.5%, 28.2%, and 10.2% of sheep producers, respectively, herded, tethered and let their animals to graze freely. In actuality, free-grazing is rarely practiced since animals can damage crops that are on fields. The results of this investigation agree with those published by Kenfo (2021).

Table 3

Grazing methods of sheep in the study districts during dry and wet season

	Districts							
Grazing methods	Dale Wabra		Sadi Chanqa		Dale Sadi		Over all	
In dry season	№	%	№	%	№	%	№	%
Free grazing	37	64.9	31	59.6	31	65.9	99	63.4
Herded	13	22.8	15	28.0	11	23.4	39	25.0
Tethered system	7	12.2	6	11.5	5	10.6	18	11.1
In wet season								
Free grazing	5	8.0	5	9.0	6	12.7	25	10.2
Herded	31	54.4	36	69.2	29	61.7	96	61.5
Tethered System	21	36.8	11	21.1	12	25.5	44	28.2

Herding and tethering are particularly essential in keeping sheep from becoming lost in the forest and being devoured by wild animals in the case of the study areas, which are coffee-producing regions with an abundance of agro-forestry trees that are used as shedes

for coffee plants. According to Duguma et al. (2012), sheep are herded from planting to harvesting to protect them from damaging crops and left for free to roam around in the dry season.

Feed Resources and Feeding System

Natural pasture, fallow land, and crop residues were the primary feed sources in all districts (Table 4). They were ranked first, second, and third, respectively, in both wet and dry seasons. In all three districts, atella is frequently utilized as supplementary feeds during the rainy season, with similar index values (I = 0.12). Dale Wabara has a higher potential of natural pasture than the other two districts. In Dale Wabara, Sadi Chanqa, and Dale Sadi districts, natural pasture was classified as the most important feed source, followed by fallow land and crop residues, with index values of 0.26, 0.23, and 0.21 during the dry season, respectively. The current result was analogous to that of Neme (2016), who conducted a survey study in highland, midland and lowland agro ecologies of West Shewa Zone, where small ruminants mostly obtained their feeds from natural pasture in both the rainy and dry seasons. Crop residues and atella constitute significant supplementary feed sources for sheep and other livestock species in the current study, especially during the dry season in agreement with several reports from different regions of Ethiopia(Kenfo et al., 2017; Habtegiorgis et al., 2020).

Table 4

Major feed resources for sheep in wet and dry season

	Districts													
Feed sources	Dale Wabara				Sadi Chanqa				Dale Sadi					
Wet season	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	Over all	rank
Natural pasture	16	15	16	0.27	13	16	11	0.26	18	8	12	0.29	0.27	1
Fallow lands	10	9	11	0.20	13	10	9	0.21	7	12	10	0.19	0.19	2
Left over	9	10	8	0.18	8	10	8	0.17	6	6	9	0.14	0.16	4
Atella	6	5	12	0.12	5	8	9	0.12	5	8	6	0.12	0.12	5
Crop residues	11	12	8	0.17	9	8	9	0.15	8	8	7	0.16	0.17	3
Peel of trees	5	6	2	0.08	4	0	61	0.05	3	5	3	0.07	0.06	6
Dry season														
Natural pasture	19	14	14	0.28	14	10	11	0.24	14	11	10	0.26	0.26	1
Atella	7	11	9	0.15	10	9	14	0.18	8	6	9	0.16	0.16	4
Crop residues	12	13	11	0.22	14	12	6	0.22	8	9	15	0.20	0.21	3
Kitchen left over	3	7	10	0.09	4	10	12	0.14	8	8	5	0.16	0.13	5
Fallow lands	16	12	13	0.25	10	11	9	0.22	9	13	8	0.22	0.23	2

Many researchers (Edea et al., 2009; Hailemariam et al., 2013) from various parts of Ethiopia, such as the Bonga area, Kafa zone of the Southern region, and Horro areas, Horro Guduru-Wallaga zone of the Oromia region, have also reported on the significance of natural pasture and crop residues. About 42.3%, 27.1%, 19.8%, and 16.0% of respondents in the currentstudy reported that some of the main supplementary feeds during the dry season in all districts include atella/kitchen leftovers, crop residues, and flour by-products, respectively.

Water sources and frequency of watering in the study areas

Major sources of water during dry and wet seasons, and watering frequencies of the study areas are depicted in Table 5. During both rainy and dry seasons, rivers serve as the primary supply of water. Regarding the season, almost 59.6% of the respondents stated that rivers are the primary source of water during the dry season, with water wells coming in second with 34.0%. However, during the rainy season, rivers accounted for the majority of the water sources in the study areas (44.2%), with springs coming in second (30.1%). The current outcome was consistent with the findings reported by Assefa (2020), Kenfo et al. (2017), and Admasu et al. (2017). In the current study, about 70.0% and 30.0% of the respondents reported that sheep drank once or twice a day during the dry season, respectively. On the other hand, almost 40.4% and 59.6% of respondents, respectively, reported that they freely water their sheep and once a day during the wet season. Sime (2022) reported that sheep in Eastern Tigray drink once a day throughout the dry season. In the highland and mid-altitude of the Bensa district, Sidama Regiion, sheep owners water their livestock once a day in both seasons (Kenfo et al., 2017).

Distance to drinking water in wet and dry seasons

In the study area about 35.2% and 37.2% of the respondents reported that the distance to drinking points is less than 1 km, both in wet and dry seasons. However, around 25.6% and 26.3% of the respondents said that, during both the wet and dry seasons, the distance to drinking point's ranges from1-2 km. The above result was consistent with the current findings of Gobena (2018). According to the author, the majority of respondents in West Shewa and Horro Guduru Wallaga sheep travel less than 1.5 km during the dry and wet seasons to drink their animals.

Table 5

Sources of water during dry and wet seasons and watering frequencies

	Districts			
	Dale Wabara № (%)	Sadi Chanqa № (%)	Dale Sadi № (%)	Overall Mean № (%)
Source of Water (Dry season)				
River water	30 (52.7)	40 (76.9)	23 (48.9)	93 (59.6)
Hand Well	24 (42.1)	9 (17.3)	20 (42.6)	53 (34.0)
Spring/stream	3 (5.3)	3 (5.8)	4 (8.5)	10 (6.4)
Source of Water (Wet season)				
River water	23 (40.3)	21(40.3)	25 (53.1)	69 (44.2)
Spring/stream	19 (33.3)	18 (34.6)	10 (21.2)	47 (30.1)
Rain water	5 (8.0)	4 (7.6)	3 (6.3)	12 (7.6)
Hand dug Well	10 (17.6)	9 (17.3)	9 (19.1)	28 (18.0)
Watering Frequency (Dry Season)				
Once in a day	41 (71.9)	35(67.4)	33 (70.2)	109 (70.0)
Twice in a day	16 (28.1)	17 (32.7)	14 (29.8)	47 (30.0)
Watering Frequency (Wet Season)				
Once in a day	35 (61.4)	32 (61.5)	26 (55.3)	93 (59.6)
Free access	22 (38.5)	20 (38.4)	21 (44.6)	63 (40.3)

Sheep Flock structure

Significant differences (at least at $p<0.05$) were observed among the different classes of sheep, except castrates, in the study districts (Table 6).

Table 6

Least Squares Mean (LSM±SE) of sheep flock structure of the study areas

Sheep flock structure	District			Over all Mean	P-Level
	Dale Wabra	Sadi Chanqa	Dale Sadi		
Male lambs < 1year	1.4 ±0.07[a]	1.3±0.06[c]	1.1±0.05[b]	1.3±0.03	0.027
Female lambs < 1year	1.5±0.08[a]	1.3±0.07[b]	1.2±0.06[c]	1.4±0.04	0.008
Males > 1year	3.4±012[a]	3.0±0.11[b]	2.7±0.10 [c]	3.1±0.71	0.000
Breeding Ewes >1 year	3.7±0.01[a]	3.4±0.10[b]	2.8±0.01[c]	3.4.±0.06	0.000
Castrates	1.1±0.04	1.0±0.02	1.2±0.04	1.2±0.02	0.672

SE=Standard Error; superscripts on a row indicate significance levels

In the present study there were about 33.3% (3.7±0.01), 34.0% (3.4±0.10) and 31.1% (2.8±0.01) breeding ewes older than a year in Dale Wabara district, Sadi Chanqa and Dale Sadi district, respectively. The corresponding proportions of males older than a year were 30.6% (3.4±012) in Dale Wabara district, 30.0% (3.0±0.11) in Sadi Chanqa district, and 30.0% (2.7±0.10) in Dale Sadi. In the total populations, there were 29.5% (3.1±0.71) of breeding males and 32.4% (3.4.±0.06) of breeding females with ages older than one year. In the current study, females olGder than a year relatively constituted the majority of flocks in comparison to the other groups (Table 6). The current findings with regard to breeding females are lower than findings reported by Duguma, (2010). The percentages of breeding ewes reported by the author in the Afar, Bonga, Horro, and Menz sheep breeds that reached one year of age or beyond varied from 47.0 to 57.4%. The present study, however, notes a fairly high percentage of males older than one year (total mean 29.5%), indicating that there may be a large number of males in the flocks in the present study areas. The current study's mean population of breeding ewes is lower than the mean population of ewes for the East Gojam zone that was previously reported (Michael et al., 2016). The Goncha Siso Enesie District's breeding male-to-breeding female ratio is lower than the findings of the current study (Getie et al, 2017). The authors reported a breeding male-to-breeding female ratio of 1:5; where breeding females constituted about 50.9% of the total flocks. In sheep breeding, the appropriate breeding ram-to-breeding ewe ratio is around breeding ram to 20-25 breeding ewes under controlled breeding schemes. Maintaining an appropriate breeding male-to-breeding female ratio is crucial for successful breeding and population management.

Purpose of Sheep Rearing in the Study Areas

Major purposes of keeping sheep in the study areas are indicated in Table 7. The primary

purposes for breeding sheep are income generation, saving and meat production, in that order. The present study's findings are in line with the findings of various other studies carried out around the nation (Hailemariam et al., 2013). With index values of 0.39I, 0.26I, and 0.21I, the foremost objectives for sheep keeping in Dale Wabara were income, followed by the production of meat and wealth. In contrast, the primary purpose of raising sheep in Sadi Chanqa and Dale Sadi was for revenue, followed by the production of meat and wealth with index values of 0.40I, 0.30I, and 0.20I and 0.38I, 0.28I, and 0.28I, respectively. Farmers raise small ruminants for a variety of purposes, including meat, religion and cultural purposes, revenue generation and saving, hides and skins.

Table 7

Major purpose of keeping sheep in the study areas

Purpose of keeping Sheep	Districts												
	Dale Wabara				Sadi Chanqa				Dale Sadi				Over all
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	
Income	31	16	10	0.39	22	18	10	0.40	21	20	5	0.38	0.39
Saving	15	13	19	0.26	15	13	21	0.30	12	11	20	0.28	0.28
Meat	8	18	13	0.21	7	12	9	0.20	6	6	11	0.15	0.19
Wealth	3	5	8	0.08	5	9	7	0.12	5	4	7	0.11	0.10
Socio-cultural	0	5	7	0.05	3	0	5	0.04	3	6	4	0.09	0.06

Marketing of Sheep in the study areas

About 51.3%, 36.5%, and 12.2% of sheep farmers in the study areas sell animals at the farm gate, village market, and district market, respectively. Sheep marketing involves collecting, transporting, and delivering sheep to their ultimate consumer or markets. According to Duguma et al. (2012), live sheep are gathered from sheep farms and delivered to neighboring marketplaces, and some may move on until terminal markets at Addis Ababa. Depending on the condition of the market under investigation, there are a wide range of sheep buyers and sellers in different quantities and types. Aleguma, Haroji Adano, Haroji Wobo, Bellam, Lello, and Sichawo are some of the few examples of minor markets, whilst some of the major markets in the study areas are found at Qaqe, Harosabu, Sadi Chanqa, Machara, and Dambi Dollo towns. Sheep producers supply their sheep to the nearby markets, which are subsequently transferred to the next market nearby (Duguma et al., 2012)). Similar to Gutu et al. (2019), the present findings indicate that about 66% of sheep farmers in the studied areas sell their animals at the livestock market nearest to them, 7% sell their animals within the community/at their respective villages, and 7% sell their animals at distant markets. There was fluctuation about the price of sheep in the study areas. Sheep rise in demand and are more expensive in April, September, and

December. These are the months of religious and social festivities. For example, Ethiopians celebrate Easter, Christmas, and New Year's in April, December, and September, respectively. Furthermore, farmers need money for school fees and school clothes' purchase at September. In the current study, about 32.1%, 29.5%, and 21.1% of respondents indicated that April (Ester), New Year's Day (September), and December (X-Mass) were the greatest selling months in the studied locations. According to Duguma et al., (2012), producers typically are unable to wait for these periods because of urgent financial needs at various times of the year, which results in strong market demand and the associated sheep price during the various social and religious festivals. Sheep became more in demand at September when the school year started, and at May, June, and July when agricultural supplies were bought. The last three months are period when there is an abundant supply of sheep but a decrease in sheep demand (Duguma et al., 2012).

Sheep Breeding Objectives in the Study Areas

Breeding Objectives for breeding rams

Table 8 shows the preferred characteristics for breeding ram selection in the research areas. Sheep breeding aims to achieve tangible and intangible benefits (Duguma, 2010). One of the most crucial decisions made on any breeding farm is selecting a breeding ram, as they make up half of the flock.

Table 8

Preferred attributes for breeding ram selection in the study areas

Attributes	Districts												Overall Mean	
	Dale Wabara				Sadi Chanqa				Dale Sadi					
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	Index	Rank
Table.8 continues..														
Appearance	25	14	12	0.34	18	22	7	0.34	15	20	7	0.32	0.33	1
Coat color	14	10	23	0.25	15	12	16	0.27	12	13	19	0.29	0.27	2
Tail types	8	12	17	0.19	10	8	9	0.18	8	10	12	0.20	0.19	3
Age	10	5	0	0.12	5	3	17	0.12	8	4	4	0.13	0.12	4
Pedigree	0	4	0	0.02	2	5	0	0.05	4	0	5	0.06	0.04	5
Adaptation	0	12	5	0.08	2	2	3	0.04	0	0	0	0.0	0.04	6

An outstanding, sound, and highly confirmed breeding ram that excels in both production and reproductive traits is necessary for a successful breeding program (Rather et al., 2021). With overall mean index values of 0.33I, 0.27I, and 0.19I, respectively, appearance, tail types, and coat color were among the most important traits in the current study areas that were ranked 1st, 2nd, and 3rd for breeding ram selection. Even if each district's ranking of coat color, tail type, and look varied, they are still the most significant factors when selecting a breeding ram. This outcome agreed with Edea (2008) research on breeding ram selection of the Horro and Bonga sheep breeds. Body size was found to be the most significant factor in the Basona Werena and Angolelatera districts of the

North Shewa zone in breeding ram selection (Haile et al., 2015). According to study findings by Wurzinger et al. (2006), and Duguma (2010) the two most important characteristics when selecting breeding rams were appearance and coat color, and their findings agreed with the findings of the current study.

Breeding objectives for breeding ewes

Table 9 displays the preferred characteristics for breeding ram selection in the research areas. The first, second, and third criteria ranked attributes for the selection of breeding ewes in all the districts were twinning ability, mothering ability, survival, and appearance, with index values of 0.27, 0.18, and 0.17 at Dale Wabara, 0.34, 0.23, and 0.18 at Sadi Chanqa, and 0.34, 0.33, and 0.24 at Dale Sadi districts, respectively. Good mothers, such as those that give birth to larger lambs with better pre-weaning survival rates and those who protect their lambs from predators without depriving them, are given the attention they deserve by small-holder sheep producers.

Table 9

Preferred attributes for breeding ewe selection in the study areas

Attributes	Districts												Overall	
	Dale Wabara				Sadi Chanqa				Dale Sadi					
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	Index	Rank
Mothering ability	17	13	15	0.27	20	16	15	0.34	20	13	9	0.34	0.32	1
Survival	11	10	10	0.18	13	10	14	0.23	13	19	17	0.33	0.25	2
Appearance	9	11	10	0.17	8	11	10	0.18	11	12	10	0.24	0.20	3
Tail type/size	8	6	5	0.12	4	6	11	0.11	0	3	6	0.04	0.10	4
Coat hair color	3	4	0	0.05	3	5	2	0.07	0	0	3	0.01	0.04	6
Disease resistance	0	5	7	0.05	0	0	0	0.0	0	0	0	0.0	0.02	8
Age at maturity	6	4	10	0.11	4	0	0	0.04	3	0	0	0.03	0.06	5
Pedigree	3	4	0	0.05	0	4	0	0.03	0	0	2	0.01	0.03	7

Sources of Breeding Stock and Mode of Exit

Understanding the processes involved in acquiring and disposing of breeding stocks is essential in order to evaluate the breeding stock used by sheep farmers (Kenfo et al., 2018). Source of breeding sheep and mode of entry and exit in the study areas are indicated in Table 10.

Table 10

Source of the breeding sheep and mode of entry and exit in the study areas

Source of sheep	Districts			Overall
	DaleWabara	Sadi Chanqa	Dale Sadi	
Source of Breeding Ram	№ (%)	№ (%)	№ (%)	№ (%)
Born in flock	26 (45.6)	23 (44.3)	21(44.7)	70 (44.8)
Purchased	18 (31.6)	16 (30.7)	14 (29.8)	48 (30.7)
Neighbor	13 (22.8)	13 (25.0)	12 (25.5)	38 (24.3)
Routes of Entry				
Home born	26 (45.6)	16 (30.8)	25(53.2)	67 (42.9)
Purchase	13 (22.9)	22 (42.3)	15(1.9)	50 (32.0)
Share/ribbi	12 (21.1)	11(1.2)	6 (12.0)	29 (18.6)
Gift	6 (10.5)	3 (5.8)	1 (2.1)	10 (6.4)
Routes of Exit				
Sale	14 (24.6)	19 (36.5)	20 (42.6)	53(34.0)
Slaughter	16 (28.1)	7 (13.5)	5 (10.6)	28 (17.9)
Mortality	11(19.3)	8 (15.4)	4 (8.5)	23 (14.7)
Predators	6 (10.5)	7 (13.5)	9 (19.1)	22 (14.1)
Gift	4 (7.0)	4 (7.7)	3 (6.4)	11 (7.1)
Theft	2 (3.5)	4 (7.7)	4 (8.5)	10 (6.4)
Lost	4 (7.0)	3 (5.8)	2 (4.3)	(5.8)

About 44.8%, 30.7%, and 24.3% of the respondents indicated that rams born in their own flocks, purchased rams, and rams from neighboring flocks are their primary sources of breeding rams. Purchase (32.2%), home-born (42.9%), and "Ribbi" or lamb crop sharing arrangements (18.6%) were some of the breeding stocks acquiring options in the current study areas. (Kocho, 2007) revealed that the first sources of foundation stock in Southern Ethiopia were own flocks or home-born, purchases, gifts from neighbors, and 'Ribbi', with relative percentages of 54.9%, 18.5%, 14.2%, and 12.4%. According to Edea (2008), birth or the initial stock inherited from parents, was the predominant means of indigenous sheep flock acquiring method in the Horro Guduru Wallaga zone of Oromia regional state and the Adiyo Kaka district of Keffa zone, southern Ethiopia. In the current study areas, sales (34%), slaughter (17.9%), mortality (14.7%), and predators (14.1%) were the primary means of sheep exit from flocks. Similar to the current outcome, Kenfo et al. (2017) and Kenfo et al., (2018) reports showed that sales accounted for about 70.9% of exits. According to Gemiyu (2009), sales account for 69.4% of sheep exit flocks. In the present study about 28.8% of sheep were lost due to mortality and predators. The mortality rate (14.7%) obtained in the present study is greater than the 6.86% reported in the Gewata district of the Kaffa zone in southwest Ethiopia by Fesseha et al. (2023). It was, however, far less than the 32.5% reported by Hadgu et al. (2021) for lambs from the Jamma

district of the South Wollo zone. Agro-ecological, managerial, and breed variances are possible causes of the discrepancies.

The current study found that sales (34%), slaughter (17.9%), mortality (14.7%), and predators (14.1%) were the major means of sheep exit from flocks. Gemiyu (2009) also reported that sales accounted for 69.4% of all flock exits. According to Kenfo et al. (2017), sales accounted for the majority of sheep exit (70.8%), followed by exchange (10%) and mortality (11.9%).

Mating System and Lambing Periods

Mating System

The majority of respondents (83.3%) reported that the most common mating system in the study areas was uncontrolled natural mating. Sheep breeding was found to be natural or uncontrolled in roughly 82.4%, 84.6%, and 82.9% of the recent studies from Dale Wabara, Sadi Chanqa, and Dale Sadi, respectively. Merely 6.7% of those involved in the study mentioned that controlled mating was carried out in the areas.

Additionally, Edea (2008) reported that uncontrolled mating was the most commo n practice in the Adiyo Kaka district of the Kafa zone, southern Ethiopia, and the Horro district of the Horro Guduru Wallaga zone, Oromia. Duguma et al. (2009) and Demeke et al. (2020) indicated that the main causes of unrestricted natural mating at village level include common watering points, free grazing (i.e., communal grazing areas), and the absence of breeding rams.

Peak Lambing Seasons

Table 11 shows major mating system, peak mating and lambing seasons of sheep in study areas. In the current study areas, the common mating system is natural mating (83.3%). Overall about 38.5%, 26.3%, and 20.5% of re spondents autumn, winter, and summer are the peak lambing seasons in their order of importance. At district level autumn, winter and summer are the 1st, 2nd and 3rd peak lambing seasons at Sadi Chanqa and Dale Sadi districts, respectively. However, the 3rd peak lambing season for Dale Wabara district was spring. Dale Wabara district experiences substantial soil degradation, which has an impact on feed crops and livestock productivity (Negasa, 2022), that may be the reason for the district's divergence from the other two districts in the third-ranked peak lambing season. Hayelom (2014) also reported that autumn (November and December) was the peak lambing season for lambing. This could be because feeds including crop aftermath are readily available during that time.

Table 11

Mating system, lambing and mating seasons of sheep in study areas

Effects	Districts			Over all
	Dale Wabara	Sadi Chanqa	Dale Sadi	
Mating system	№ (%)	№ (%)	№ (%)	№ (%)
Natural mating	57 (100)	52 (100)	47 (100)	156 (100)
Lambing season				
Autumn	24 (42.1)	20 (38.5)	16 (34.0)	60 (38.5)

Table. 11 Continues.

Winter	16 (28.1)	16 (30.8)	9 (19.1)	41 (26.3)
Summer	6 (10.5)	11 (21.2)	15 (31.9)	32 (20.5)
Spring	11 (19.3)	5 (9.6)	7 (14.9)	23 (14.7)
Effects	Districts			Over all
	Dale Wabara	Sadi Chanqa	Dale Sadi	
Mating system	№ (%)	№ (%)	№ (%)	№ (%)
Natural mating	57 (100)	52 (100)	47 (100)	156 (100)
Lambing season				
Autumn	24 (42.1)	20 (38.5)	16 (34.0)	60 (38.5)
Winter	16 (28.1)	16 (30.8)	9 (19.1)	41 (26.3)
Summer	6 (10.5)	11 (21.2)	15 (31.9)	32 (20.5)
Spring	11 (19.3)	5 (9.6)	7 (14.9)	23 (14.7)

Reproductive Performances of Sheep in the Study Areas

Farm animals' reproductive characteristics are impacted by both genetic and non-genetic factors. These elements are divided into intrinsic and extrinsic (Ajafar et al., 2022). While the animal's genotype corresponds to intrinsic factors, the animal's environment is related to extrinsic variables. The current study evaluates the reproductive performances of ewes and rams using a variety of reproductive traits, including age at sexual maturity (ASM) for both sexes, age at first lambing (AFL), lambing interval (LI), lambing rate (LR), and reproductive life span of ewes.

Age at Sexual Maturity of Sheep Populations in the Study Areas

The average age of first sexual maturity for males in the districts of Dale Wabara, Sadi Chanqa, and Dale Sadi was 8.0±0.10 months, 7.9±0.10 months, and 8.0±0.11 months, respectively. The corresponding mean ages at first sexual maturity for females were 8.9±0.09 months, 8.6±0.10 months, and 8.8±0.11 months in the districts of Dale Wabara, Sadi Chanqa, and Dale Sadi, respectively. The mean ages at sexual maturity for both males and females in this study were consistent with those reported by Edea et al. (2012) for males and females, which were 8.0±2.5 months and 8.5± 2.40 months, respectively. Nonetheless, the study's average age at sexual maturity was higher than the 7.12±0.12 months and 7.15±0.22 months, as well as the 7.68±0.23 months and 7.8±0.12 months recorded in the high and mid-altitude areas of Bensa district for males and females, respectively (Kenfo et al., 2018). The current study and previous study results indicate that males reach sexual maturity earlier than females. According to Sowande & Sobola (2008), this implies that ewes grow more slowly than males and they reach sexual maturity earlier than females. The authors' also indicated that ewes grow more slowly than males and reach maturity at a smaller size than males because of the effect of estrogen, which limits the growth of the long bones of the body.

Age at first lambing (AFL)

Age at first lambing is an important reproductive trait because it enables sheep to give birth to their first offspring sooner rather than later, which accelerates the spread of genes and increases population turnover.

According to Ayele & Urge (2019), females who mature early are known to have a comparatively lengthy and productive reproductive life. For Dale Wabara, Sadi Chanqa, and Dale Sadi, the mean ages at first lambing was 13.5±0.13 months, 13.4±0.10 months, and 13.3± 0.14 months, respectively. Regarding age at first lambing, there was no statistically significant difference ($p > 0.05$) between the districts. The current study's mean ages at first lambing was marginally shorter than the 13.8 months for sheep flocks in eastern Ethiopia reported by Nigussie et al. (2016).

Lambing interval (LI)

The lambing interval (LI) is the number of days that between two consecutive parturitions. The study's mean lambing intervals (LI) at Dale Wabara, Sadi Chanqa, and Dale Sadi were 7.8±0.10 month, 7.8±0.10 month, and 7.9±0.10 month, respectively. The lambing interval between districts did not significantly differ ($P > 0.05$) amongst districts. A mean lambing interval (LI) of 7.8 months reported in the current study is consistent with (Kocho, 2007). Nevertheless, it is shorter than the 8.2 and 8.6 months that were documented by Nigussie et al. (2015) and Tesfaye (2021). Additionally, the LI obtained in this study was marginally smaller than the 8-month LI interval reported by Edea (2008) for Bonga sheep breeds. According to Ayele & Urge (2019) comprehensive research review, which covered practically all indigenous sheep breeds in Ethiopia, lambing interval varies from 7.3 months to 11.2 months. A number of variables, including breed, production system, environment, and management methods, can be attributed for the variability in lambing intervals (LI), all of which raise the likelihood of conception after parturition.

Reproductive Life Span of Ewes (LSE)

The respondents reported that the reproductive life span of sheep in Dale Wabara, Sadi Chanqa, and Dale Sadi were 9.5±0.18, 9.4±0.19, and 9.3±0.18, respectively. The average reproductive lifespan of the ewes was 9.4±0.17 years. The present life span of ewes was longer than the 7.9±3.10 years reported by Edea (2008) for Horro sheep and the 7.6±015 years reported by Welday et al. (2019) for the sheep flocks in the Enderta district of the Tigray regional state. In the research locations, farmers usually sell young males instead of females, which they keep for breeding.

Table 12

Least square means (LSM±SE) average reproductive performances of sheep in the study areas

Characters/Attributes	` Districts			Over all	P-Value
	Dale Wabara	Sadi Chanqa	Dale Sadi		
AFB for male (month)	8.0±0.10	7.9±0.11	8.0±0.11	8.3±0.10	0.88
AFB for female (month)	8.9±0.09	8.6±0.10	8.8±0.11	8.7±0.60	0.24

Table 12. continues.

Age at 1st lambing (month)	13.5±0.13	13.4±0.10	13.3±0.14	13.4±0.07	0.77
Lambing interval (month)	7.8±0.10	7.8±0.10	7.9±0.10	7.8±0.10	0.65
Life span of ewe (year)	9.5±0.18	9.4±0.19	9.3±0.18	9.4±0.11	0.85

AFB= age at first breeding; SE= Standard Error

Litter Size (LS)

According to Ayele & Urge (2019), litter size is one of the most crucial reproductive factors that influences dam productivity and, in turn, farm profitability. The size of the litter is determined by the quantity of fertilized oocytes and ovulation rate. Another significant factor influencing litter size variance is the management strategy. Occurrence and proportion of single/multiple births in the study areas are indicated in Table 13. The overall mean twining rate in the current investigation was 32.7%. Dale Wabara district has the second-highest twining rate (33.3%), behind Dale Sadi district (34.0%). The twining rate found in this study is less than that found in studies on the Horro and Bonga sheep breeds by Edea et al. (2012), which are 39.9% and 36.0%, respectively. The selection of ewes and their treatment during breeding and agro-ecology may be the main factors contributing to the discrepancy

Table 13

Occurrence and proportion of single/multiple births in the study areas

Prolificacy	Districts			
	Dale Wabara	Sadi Chanqa	Dale Sadi	Overall
Single	38 (66.7)	36 (69.2)	31 (66.0)	105 (67.3)
Multiples	19 (33.3)	16 (30.8)	16 (34.0)	51 (32.7)

Sheep Production Constraints in the Study Areas

The production of sheep in the study areas is challenged by both technical and non-technical problems as indicated in Table 14. The most urgent issue impacting sheep production, according to respondents in every research district, is a lack of feed, which is followed by diseases and the market, with index values of 0.37, 0.29, and 0.22, respectively. In Dale Wabara district, 0.39, 0.26, and 0.23; in Sadi Chanqa district, 0.34, 0.31, and 0.20; and in Dale Sadi district, 0.38, 0.29, and 0.22 were the index values for these difficulties in their respective orders (Table 14). The current finding was consistent with reports by Haile et al. (2015). The primary challenges in the North Shewa areas' Basona Warana and Angolelatera districts were disease and a lack of feed. Duguma et al. (2017) argued that the low literacy and technical expertise of local sheep producers

may make it difficult for local communities to undertake sustainable livestock genetic improvement initiatives or improved sheep production activities.

Table 14

Some of the major sheep production constraints in the study areas

Constraints	Districts												Over all	
	Dale Wabara				Sadi Changa				Dale Sadi					
	1st	2nd	3rd	Index	1st	2nd	3rd	Index	1st	2nd	3rd	Index	Index	Rank
Feeds	29	18	10	0.39	20	18	9	0.34	19	23	5	0.38	0.37	1
Diseases	15	13	18	0.26	17	14	19	0.31	16	10	14	0.29	0.29	2
Market	10	14	21	0.23	11	11	8	0.20	9	12	11	0.22	0.22	3
Predators	3	5	0	0.06	4	9	7	0.12	3	2	6	0.07	0.08	4
Improved breed	0	5	0	0.03	0	0	0	0.0	0	0	5	0.02	0.02	5
Labour	0	2	4	0.02	0	0	5	0.02	0	0	6	0.02	0.02	6
Theft	0	0	3	0.01	0	0	4	0.01	0	0	0	0.0	0.001	7

CONCLUSION

A mixed crop-livestock system was the primary method of production in all three research districts, with an average landholding per household of almost 2.8±0.02 ha—a little bit more than the 1.13 ha reported by the Central Statistics Agency (CSA, 2022). In the current study areas, the average size of sheep flocks per household was 8.9±0.02, with around 40.4% of the flocks consisting of breeding ewes older than a year. Children are extremely involved in sheep herding, according to about 42.9% of respondents, followed by men (28.2%). The main source of feed is communal grazing areas, to which all members of the community have the right of access. The majority of respondents (63%) stated that while village flocks mingle in common grazing areas, each household's flocks are herded separately. Natural pasture, fallow lands and crop residues are the major feed sources and river water is the main water source in the study districts.

Creating income, saving money, and producing meat are the three main goals of sheep breeding, in that order. Smallholder sheep breeders sell their animals at farm gates, according to the majority of respondents (51.3%). For breeding ram selection, the most crucial characteristics are appearance (I=0.33), tail type (I=0.27), and cot color (I=0.19). Mothering ability (I = 0.32), survival (I = 0.25), and appearance (I = 0.20) were the corresponding traits used in the selection of breeding ewes. The main sources of breeding rams are own flocks, markets (purchases), and neighboring flocks. Lambing seasons are virtually year-round due to unrestricted mating. Nonetheless, autumn saw the highest percentage of lambing (38.5%),

followed by winter (26.3%) and summer (20.5%).

The mean age at first sexual maturity was 8.3±0.10 months for males and 8.7±0.60 months for females. The ewes' average age at first lambing, lambing interval, and reproductive life span were 13.4±0.07 months, 7.8±0.10 months, and 9.4±0.11 years, respectively. Approximately 32.7% of the ewes in the current study were reported to be multiple bearers. Seasonal feed shortages, diseases, and market conditions were some of the main obstacles to sheep production in the study areas

Recommendations

Shortages of fodder during certain seasons were the greatest obstacle to sheep production in the research areas. This is mainly because the main source of feed, community grazing lands, are open to all residents and provide unimpeded access to them without any kind of improvement or safeguard. Thus, safeguarding and improvement of communal grazing lands are crucial.

The flocks of each household are herded separately, yet most of the community flocks gather together in communal grazing lands. By taking into account flocks mixed together on the same grazing pastures as a single flock and giving farmers minimal awareness-raising training, this would facilitate community-based genetic improvement initiatives.

In the districts, the majority of smallholder sheep producers sell their animals at farm gates, making the marketing situation one of the major issues facing sheep production in the areas. In order to identify potential markets where producers could profit more, a tailored value chain study of sheep may be necessary.

A number of important characteristics were found to be crucial for selecting breeding rams and ewes, and any development program must take these into account.

In the current study, own flocks are the main supply of breeding rams, which could lead to inbreeding if precautions are not taken. For example, considering community-based sheep breeding initiatives may be one of the best solutions to avoid inbreeding.

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DECLARATION

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

Data will be made available on request

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