

Breeding Practices and Reproductive Performances of Indigenous Sheep Breed in Mixed Crop Livestock System of Arsi Zone Oromia, Ethiopia

Kebede Tilahun^{1*}, Tesfaye Getachew², Elias Bayou³

¹Department of Animal Science, College of Agriculture Kebridehar University, ETHIOPIA

²International Center for Agricultural Research in Dry Area (ICARDA), Addis Ababa, ETHIOPIA

³Department Animal science, College of Agriculture, Mizan Tepi University, Mizan Teferi, ETHIOPIA

*Corresponding Author: keedetilahun2000@gmail.com

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Abstract

The study was conducted in the Arsi zone to generate comprehensive information on the breeding practices and reproductive performance of local sheep under farmers' management conditions. The information on these traits is important to develop a sustainable genetic improvement program. Lack of knowledge about reproductive performance and breeding practices leads to the setting up of unrealistic breeding goals, which in turn leads to improper utilization and conservation of animal genetic resources. Study districts were selected purposively based on the potential of sheep population distribution. Data were collected through questionnaires, focal group discussion, and secondary data. A total of 240 households were randomly selected and interviewed. Descriptive statistics and a ranking index were used to present the findings. Sheep were multi-purpose animals and kept to fulfill both tangible and non-tangible benefits. The main reasons for keeping sheep were income generation and as a means of saving and wealth status. Selection of breeding animals is practiced by farmers to become parents of the next generation using different criteria. The main preferred traits for selecting breeding males were appearance and coat colors. While breeding females were mainly selected based on age at first sexual maturity and lambing intervals. Uncontrolled mating was dominantly practiced in which mating takes place between closely related animals because sheep flocks graze together on communal grazing areas and watering points, lack of awareness, and lack of a breeding ram in the flocks. The age at first lambing and lambing interval were 15.5 and 9.3 months, respectively. The level of inbreeding is higher than the maximum acceptable level. Generally, the breeding practices and reproductive performance of sheep require intervention to improve the potential of sheep in this particular area.

Keywords: Arsi Zone, Breeding Practice, Selection Criteria, Sheep, Reproductive Traits.

Introduction

Small ruminants (sheep and goats) production is an important farming activity in the country and considered a major component of the livestock sector, especially for small holder resource poor farmers. This is due to they require small capital investment to start and run the sector, they have short generation interval, fast growth rate, their prolificacy, they are adapted to unfavorable tropical climate conditions and their ability to utilize wide varieties of feeds which is difficult to utilize by large ruminants (Notter, 2012; Nigussie *et al.*, 2013; Melesse *et al.*, 2022). Across a wide range of production systems and production environments small ruminants play a multipurpose roles including source of income, food, to build capital, source of wealth, means of asiving, meat, milk, skin, manure, as means of risk mitigation during crop failure and unfavourable crop prices, and their social and cultural roles for the communities rearing sheep and the country as a whole (Abraham *et al.*, 2017; Dagnew *et al.*, 2017; Gatew *et al.*, 2017; Gebre *et al.*, 2020).

Ethiopia is endowed with the largest sheep population. The country's sheep population is estimated to be 39.89 million heads (CSA, 2020), which have adapted and distributed in various agro-ecologies of the country that ranges from the cool alpine climate to the desert and arid pastoral areas. Almost all sheep (99.56%) in Ethiopia are local breeds and a few portions, 0.28% and 0.16% account for hybrid and exotic breeds, respectively (CSA, 2020). They can survive and reproduce under harsh environmental conditions such as feed scarcity, disease challenges, and poor management (Tibbo, 2006). They are raised for multipurpose roles, including cash income, and skin manure. Moreover, they have social, cultural and religious values for diversified communities (Tibbo, 2006; Zewdu, 2008; Admasu *et al.*, 2017; Bekele *et al.*, 2021).

Despite their multiple functions, the productivity of sheep in the country is very low and below the potential, which in turn affects the national economy at large and the livelihoods of smallholder resource-poor farmers in particular. The poor productivity of sheep is attributed to feed shortages, prevalence of diseases, lack of infrastructure, lack of technical capacity, lack of information, absence of planned and organized breeding programs, and lack of health services and polices (Tibbo, 2006; Gizaw *et al.*, 2013). This implies that there is a need to improve the sheep's genetic resources to increase their productivity through appropriate breeding programs and selection. The productivity can be improved by improving the management (Gobena and Tona, 2017) as well as improving the reproductive potential by selecting the best performing breeding animals for future parents. The genetic improvement also requires identification of the breed, the production environment in which the animals are reared, description of the production systems, their adaptation potential in their native environment in which they are reared for a century (Workineh *et al.*, 2004).

Reproductive traits are difficult to measure but are highly influenced by management systems (Nootter, 2000) and reproductive rates can affect selection intensity and the rate of genetic change for the traits under selection. Selection of breeding animals was practiced using various criteria, both qualitative and quantitative traits. The qualitative traits such as toggle, horn, color, and appearance appeared to select breeding males and females and need attention (Taye *et al.*, 2016). Designing, therefore, evaluation of the production systems, assessing the breeding practices, indigenous knowledge, of selection, and managing the breed, is a prerequisite to designing a genetic improvement program (Kosgey & Okeyo, 2007).

The Arsi zone is known for its population of livestock, and sheep are one of the most distributed animals across various agro-ecologies of the zone. Despite its large population of sheep, there is a paucity of information on reproductive performance, selection criteria, and breeding practices of sheep in the zone and particularly the current studded areas. There is no clearly defined performance evaluation, and the breeds of sheep are kept under a subsistence production system, and the indigenous knowledge of the sheep-keeping community is not exploited. Therefore, this study aimed to evaluate the reproductive performance, breeding practices, and selection criteria of the sheep and this information will be used in devising strategies to improve productivity and sustainable utilization as well as conservation of the sheep population.

Materials and Methods

Description of the Study Area

The study was conducted in the Arsi zone, Oromia National Regional State. It is located in the central part of

Oromia. It's bordered by the Bale zone in the south, the West Arsi zone in the southwest, the Shoa zone in the northwest, the Afar region in the north, and the West Hararghe zone in the east. The zone astronomically lies between 6° 45' N to 8° 58' N and 38° 32' E to 40° 50' E longitude. The mean annual temperature of the zone is found between 20-25°C in the lowland and 10-15°C in the highland areas. The main annual rainfall for most of the area is the rainy season, which starts in March and extends to October with the highest concentration in June, July, and August. In general, the mean annual rainfall of the zone is 633.7 mm to 1059.3 mm. There are great altitudinal differences; 805-4195 meters above sea level. Mixed-crop livestock production is the mainstay of the communities in the zone.

Sampling Method and Data Collection Procedure

For this study, a multistage purposive sampling technique was employed to select the districts based on the potential of sheep population distribution, agro-ecology, and suitability of the area for sheep production. In the first stage, two districts were purposively selected based on sheep population distribution. In the second stage, three kebeles from each district and a total of 6 kebeles were sampled purposively based on their sheep population size. In the third stage, the households in the kebeles were selected randomly by considering the minimum possession of 3 mature sheep of both sexes. Accordingly, from the two districts, a total of 240 households were sampled and interviewed. Semi-structured questionnaires were developed by adopting the general information list of FAO (2012) which was pre-tested and translated into the local language before being administered. Focused group discussions encompassed 6-10 households each were organized in each kebele and group discussions were conducted with key informants, local agricultural extension staff, elderly farmers, and village leaders who are known for better knowledge of the present and past social and economic status of the area to strength the reliability of survey questionnaires.

Statistical Data Analysis

The categorical data collected through questionnaire were subjected to cross-tabulation procedure in SPSS to assess association among different categorical variables. Cross tabulation could be used to uncover variables or multiple variables that affect a specific result or can aid in improving a specific outcome. Moreover, cross tabulation is advantageous for Error reduction, it makes the data set more manageable by dividing it into its representative sub-groups. It looks at the relationships between one or more categorical variables to uncover more granular insights, which is unnoticed with the standard approach, and allows you to compare the relationship between data sets. Chi-square (X^2) was carried out to test the presence of significance among categorical and numerical variables, respectively. The chi-square test is used to determine whether or not two variables are independent and used to test the variation between them is significant or not. An index was calculated for the questionnaire data collected using ranking to provide an overall ranking for qualitative data. For example, ranking constraints of sheep production, purpose of keeping sheep, selection criteria of females and male sheep were calculated by using the formula: Index = Σ of [3 × rank 1 + 2 × rank 2 + 1 × rank 3] given for particular qualitative variables divided by Σ of [3 × rank 1 + 2 × rank 2 + 1 × rank 3] given for all qualitative variables considered. This is valuable to rank different traits considered based on their importance.

Results and Discussions

Purposes of Breeding Sheep

The purposes of keeping sheep in the study area are presented in Table 1. Understanding the purpose of sheep rearing is important to formulate a sustainable breeding program which incorporates the breeding objectives of farmers. Identifying the primary objectives and the preferred traits will pave the way for policy makers and stakeholders to understand the needs of the population. Small ruminants are kept for multiple purposes with different priorities. They are primarily kept to both tangible (meat milk, manure, skin) and non-tangible (saving, socio-cultural) benefits (Feyissa *et al.*, 2018). The results of the present study indicate that sheep were kept as multi-functional animals to fulfill various needs. However, sheep were mainly kept to generate income (0.38) across the studied districts, which was utilized for buying seeds fertilizer, school fees, and to meet cash requirements during emergencies. Sheep were also reared and kept as a means of saving (0.23), which they considered as a living bank and a means of wealth. This finding was in line with (Admasu *et al.*, 2017; Feyissa *et al.*, 2018; Melak *et al.*, 2021), who reported that sheep were reared for various purposes and income generation was prioritized and ranked

first. Moreover, sheep are also reared by the communities for meat consumption for households, manure production, which is used as fertilizer for crops, and other backyard fruits and vegetables production, and skin, which can be used as household material and sold to generate income, with a lower ranking. Keeping sheep for a source of food and as a wealth status with high ranking was also reported by (Dagneu *et al.*, 2017) in the Amahara region, Mettema and Quara districts.

Table 1: Ranking of the purposes of breeding sheep as indicated by index values

Purposes	Districts											
	Aseko				Jeju				Overall			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Meat	7	4	9	0.06	3	12	7	0.06	10	16	16	0.06
Breeding	5	24	7	0.11	1	31	27	0.14	6	55	34	0.13
Wealth status	15	12	14	0.13	7	15	21	0.11	22	27	35	0.12
Manure	1	23	9	0.09	0	13	7	0.05	1	36	16	0.07
Saving	19	10	21	0.16	50	14	14	0.29	69	24	35	0.23
Income	73	11	19	0.42	59	18	13	0.34	132	29	32	0.38
Skin	0	0	7	0.01	0	0	7	0.01	0	0	17	0.01

Index = sum of (3×number of household ranked first + 2×number of household ranked second + 1×number of household ranked third) given for individual purpose divided by (3×number of household ranked first + 2×number of household ranked second + 1×number of household ranked third) given for all purpose.

Selection Criteria of Breeding Ewe

The selection criteria for breeding females are presented in Table 2. Farmers select the best-performing animals from their flock, which become parents of the next generation using their criteria. The criteria may vary with the knowledge of livestock owners and production systems (Tilahun *et al.*, 2023). Farmers consider both the appearance and production characteristics of sheep to be parents of the next generation. The primary criteria that farmers in both districts considered for selecting their breeding females were age at sexual maturity with an index of 0.27 followed by a lambing interval of 0.24 and twinning ability of 0.2. These traits increase the lamb crop of the ewe. The animal starts ovulation at an early age, has the chance to produce more lambs as it increases its productive lifetime. Similarly, the lambing interval (the time between consecutive lambing) increases the chance of producing more lamb crops. The shortest lambing interval indicates the animals are highly fertile and can produce more offspring through their productive age as compared with those animals having long lambing intervals. Along with these, the twinning ability promises productivity and some offspring per ewe/birth and throughout her lifetime. Increasing the lamb crop leads to an increase in the sheep flock size, and turn increases the selection intensity. Selection by farmers implies that the best animal can be selected, but the selected males and females are not necessarily mated due to sheep flocks roaming and grazing together, which makes uncontrolled mating (Asefa *et al.*, 2017). The present study suggests that farmers consider objective criteria that increase the productivity of sheep. On the contrary, Abebe *et al.* (2020) reported that farmers in northwest Ethiopia mainly considered body size and coat color when choosing their breeding females to become parents of the next generation. Different authors reported various criteria considered to select breeding females in different parts of the country. For instance, appearance and mothering ability were reported to be the primary selection criteria for breeding ewes in the east Gojjam zone (Abera *et al.*, 2017). While Genotype, body conformation, and twinning ability were reported to be the first and most preferred traits for selecting breeding ewes in southern Ethiopia (Tezera and Engidashet., 2022). Appearance, coat color, and longevity are the main criteria considered and ranked first to select breeding females (Alemayehu *et al.*, 2015).

While pastoralists in the Borena area mainly consider coat color to select their breeding females (Feyissa *et al.*, 2018). These variations in preferable traits for the selection of breeding females in various production areas suggest that selection practices depend on the needs and interests of farmers rearing animals. This further suggests that implementing any sustainable genetic improvement and selection programs could be based on the assessment of the preferred traits by the farmers in different production areas and systems.

Table 2: Ranking of selection criteria of breeding ewe as indicated by index values

Selection criteria for Breeding ewe	Districts											
	Aseko				Jeju				Overall			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Size/appearance	5	33	16	0.13	1	11	26	0.08	6	42	42	0.10
Color	1	3	3	0.02	1	3	4	0.04	2	6	7	0.02
Mothering character	2	9	10	0.05	2	5	5	0.02	4	14	15	0.04
Lambing survival	0	21	12	0.08	2	13	9	0.08	2	34	21	0.07
Lamb growth	0	7	11	0.03	1	16	9	0.07	1	23	20	0.05
Age at first sexual maturity	54	6	17	0.27	49	12	26	0.23	103	18	43	0.27
Lambing interval	40	27	16	0.26	18	46	15	0.26	58	73	31	0.24
Twining ability	18	14	35	0.16	46	14	26	0.23	64	28	61	0.21

$R1=rank1$, $R2=rank2$, $R3=rank3$, $Index=(3 \times \text{number of household ranked first} + 2 \times \text{number of household ranked second} + 1 \times \text{number of household ranked third})$ given for individual criteria divided by $(3 \times \text{number of household} + 2 \times \text{number of household ranked second} + 1 \times \text{number of household ranked third})$ given for all criteria.

Selection Criteria of Breeding Ram

Selection criteria for breeding rams are presented in Table 3. The existing sheep breeds resulted from long-term natural and artificial selection (Adimasu *et al.*, 2019). Farmers practice the selection of breeding rams from their flock, and the selected one will remain in the stock and be allowed to mate with their animals, and also their neighbors and villages. Farmers in the study area paid more attention to appearance (0.35), and coat color (0.32) when selecting breeding rams. Similar to this finding, Asefa *et al.* (2017) reported that appearance is the first criterion for selecting breeding rams in the Bale zone. Appearance and coat color were also reported as the major emphasis of farmers in selecting breeding rams in the western Amahara region (Adimasu *et al.*, 2019). The most preferred colors were white and red, while black colors were not preferred due to black sheep being less required and fetching low prices in the market as compared to others. In line with the current report, Feyissa *et al.* (2018) reported that black head with white body, brown head with white body, and pure white was the preferred coat color of the ram in the Borana zone, while black color was unwanted by farmers. Growth performance of the lamb and tail length was also considered to select breeding ram with lower ranking with an index value of (0.11) and (0.10), respectively. On the contrary, Tezera and Engidashet (2022) reported that the growth performance of lamb was the main priority of the criterion for selecting a breeding ram along with good genotype and appearance or size. On the other hand, little attention was given to libido and adaptability traits and, in agreement with Abebe *et al.* (2020), reported that libido and adaptation were less considered for selecting breeding rams in the northwest highlands of Ethiopia.

Table 3: Ranking of selection criteria of breeding ram as indicated by index values

Selection criteria for ram	Districts											
	Aseko				Jeju				Overall			
	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Appearance	62	41	7	0.382	67	7	11	0.314	129	48	18	0.35
Color	47	36	6	0.304	53	40	5	0.339	100	76	11	0.32
Horns	0	2	5	0.058	0	15	3	0.046	0	17	8	0.05
Character	0	7	6	0.028	0	20	5	0.063	0	27	11	0.05
Adaptability	0	6	2	0.019	0	1	0	0.003	0	7	2	0.01
Genotype	0	3	1	0.010	0	2	1	0.007	0	5	2	0.01
Growth	0	24	45	0.129	0	14	40	0.094	0	38	38	0.11
Libido	0	1	2	0.006	0	1	1	0.004	0	2	3	0.01
Tail length	11	0	46	0.064	0	20	54	0.131	11	20	100	0.10

$R1=rank1$, $R2=rank2$, $R3=rank3$, $Index=(3 \times \text{number of household ranked first} + 2 \times \text{number of household ranked second} + 1 \times \text{number of household ranked third})$ given for individual criteria divided by $(3 \times \text{number of household ranked first} + 2 \times \text{number of household ranked second} + 1 \times \text{number of household ranked third})$ given for all criteria considered.

Breeding Practice and Mating System

Breeding practices and mating systems of sheep are presented in Table 4. Natural and uncontrolled mating is the mating system that is dominantly practiced by sheep farming communities. Uncontrolled natural mating is also reported in different parts of the country by different authors. For instance, in Borena zone (Feyissa *et al.*, 2018), Bale zone Sewana and Dawekechan districts (Asefa *et al.*, 2017), in North Shoa (Haile *et al.*, 2015) and in Gamogofa zone (Hailemariam *et al.*, 2013). Female animals are randomly mated with any intact male, either within the same flock or neighboring flocks. In the study area, most of the respondents' farmers (56.2%) reported that mating took place throughout the year and was not restricted based on seasons. However, 43.8% of farmers reported the concentration of mating and lambing observed in some seasons. Thirty-nine (39.6%) of farmers reported that there was a situation of concentration of lamb especially in dry seasons. The occurrence of more births during the dry season in the present study may be due to mating taking place in wet seasons, especially during July and August. During this time, most of the belg crops were harvested in highland areas and there is a chance of mixing different flocks besides those mixed in communal grazing land and watering areas. This could result in the occurrence of mating, which leads to the concentration of births during the dry season (January and February). However, shortage of feed was one of the problems in dry seasons and ewes would not be able to provide sufficient milk for suckling lamb. This might result in pre-weaning mortality and stunted growth. Uncontrolled mating is dominantly practiced in this area for different reasons. The main reasons for uncontrolled mating were sheep flocks grazing together on common grazing land and at watering points, lack of awareness, and lack of sufficient breeding rams in the flock.

Table 4: Breeding practice and mating systems of sheep in Arsi zone

Mating system	Districts				Overall		Test
	Aseko		Jeju		N	%	p value
	N	%	N	%			
Is mating seasonally restricted							0.242
Yes	57	47.5	48	40	105	43.8	
No	63	52.5	72	60	135	56.2	
Lambing take place							0.587
Main rainy season	1	0.8	2	1.7	3	1.2	
Short rainy season	4	3.3	3	2.5	7	2.9	
Dry season	52	43.3	72	60	95	39.6	
Year round	63	52.5	72	60	135	56.2	
Reason of mating uncontrolled							0.001

N=number of households, %=percentage<0.05=significant, *P*>0.05=non-significant

Reproductive Performances of Sheep

The reproductive performances of sheep in the study area are presented in Table 5. Any successful and sustainable livestock production program is a result of good reproductive performance of animals. To obtain different animal products such as meat, milk, fiber, and skin, the existence of birth and survival is crucial, which is possible when reproductive performance is improved. Age at first service is the age at which the female and male reproductive organs become matured and capable of breeding. Age at first mating can determine the reproductive ability of sheep. The shorter age at first service in animals leads to the shorter age at first lambing, which in turn increases the reproductive life span of an animal. The overall age at first mating of male and female sheep in the study area were 8.7±1.16 and 8.7±1.37 months, respectively. This result was comparable with Taye *et al.* (2016), who reported the age at first mating of Doyogena sheep was 8.06 and 8.0 months for females and males, respectively. However, the present result was relatively larger than those (Melka *et al.*, 2021) who reported the average sexual maturity of Tigray sheep were 7.86 and 6.76 months for females and males, respectively. The delay in age at first service in the present study may be due to shortage feed and management and breed difference with those sheep in Tigray.

Age at first lambing is the age at which the female sheep gives birth for the first time in her life. It's determined by the age at first mating and the occurrence of fertilization and also successful completeness of the conceived embryo or zygote. The age at first lambing of sheep in the study districts was 15.5±1.87 months, which was comparable with 16.04 and 15.57 months reported by (Demeke *et al.*, 2020) in North Wollo zone Meket and Gidan districts, respectively. This result is larger than (13.2) months reported by Taye *et al.* (2016) for Doyogena sheep, (12.4)

months reported by Hailemariam *et al.* (2013), for sheep in Gamo Gofa zone and (12.09) months reported by Melak *et al.* (2021) for Tigray sheep. The delay in age at first lambing in the present study may be due to the direct influence of delayed age at first service or sexual maturity and the effect of feeding and seasons of birth along with genotype. According to Melak *et al.* (2021) the age at first lambing is delayed due to different factors such as feed shortage, prevalence of diseases, year of lambing, season of birth and the type of birth. Lambing interval is the interval between two successive parturitions. The average lambing interval was 9.3 ± 1.70 months and comparable with 8.73, 8.83 and 9.56 reported by Yadeta (2016) for sheep in highland, mid altitude and lowland areas of the west Shewa zone. The result was larger than the 7.21 months reported by Melak *et al.* (2021) for Tigray sheep in Tahaty Machew district. The lambing interval obtained indicates the sheep population under traditional production systems cannot give birth three times in two years. This is disagreed with Melak *et al.* (2021) who reported that under provision of good nutrition and management, Tigray sheep were able to give birth three times in two years.

The lifetime lamb crop is the number of lambs an ewe gives throughout its reproductive period. The average lifetime lamb crop of 10.2 ± 1.94 was comparable with 9.77 reported by Demeke *et al.* (2020) for northern Wollo sheep and 10.5 reported by Nigussie *et al.* (2015) in eastern Ethiopia. The breeding male is culled at the age of 3.6 years by a means of castration and fattening. Culling of unwanted animals is practiced by farmers for both females and males at various ages. Male sheep were culled at a maximum age of 3.6 years. While female animals stayed until 9.3 years. The main reasons for culling were poor productive performance, disease, and poor growth rates. Selling, slaughtering, and fattening are the main ways of culling unwanted animals.

Table 5: Mean \pm SE of reproductive performance of sheep

Characters	Districts			
	Aseko	Jeju	Overall	Test
	Mean \pm SE	Mean \pm SE	Mean \pm SE	P value
Age at first mating for female (M)	9.0 \pm 0.14	8.5 \pm 1.25	8.7 \pm 1.37	0.003
Age at first mating for male (M)	8.9 \pm 1.27	8.4 \pm 0.99	8.7 \pm 1.16	0.003
Age at first lambing (month)	15.7 \pm 1.94	15.2 \pm 1.77	15.5 \pm 1.87	0.053
Lambing interval (month)	9.4 \pm 0.16	9.1 \pm 1.84	9.3 \pm 1.70	0.290
Life time lamb crop of ewe (N)	9.8 \pm 1.98	10.7 \pm 1.82	10.2 \pm 1.94	0.001
Reproductive life time of ewe (Y)	9.1 \pm 1.20	9.5 \pm 1.27	9.3 \pm 1.28	0.005
Reproductive life time of ram (Y)	3.4 \pm 0.55	3.6 \pm 0.52	3.5 \pm 0.54	0.024
Culling age of breeding ram (Y)	3.6 \pm 0.52	3.6 \pm 0.52	3.6 \pm 0.52	0.621
Culling age of breeding ewe(Y)	9.1 \pm 1.20	9.6 \pm 1.82	9.3 \pm 1.31	0.001
Twining rate (percent)	40.8%	60%	50.4%	0.003

SE= standard Error, $p < 0.05$ =significant, $p > 0.05$ =non-significant, Y=year, M= months, N=number

Effective Population Size and Level of Inbreeding

Inbreeding is the mating of animals that are more closely related than the average of the population or those concerned about mating. The rate of inbreeding was relatively higher in a small population. It increases the deleterious genes and results in inbreeding depression, which in turn leads to reduced growth, production and productivity of animals. According to Asefa *et al.* (2017), homogenous sheep were the result of inbreeding and decreased genetic diversity. It is the result of a small population, the utilization of rams born in the flock, random mating and lack of awareness about the negative consequences of inbreeding. The effective population size and level of inbreeding are presented in Table 6. The number of breeding rams in the flocks was small in relation to the breeding ewes. This resulted in one ram serving for large numbers of ewes and increases the level of inbreeding. The ratio of breeding males to breeding females was 1:8.28 in Aseko district and 1:5.17 in Jeju district. This implies that one ram can serve for 8 and 5 females in Aseko and in Jeju districts, respectively. This is enough when considering the ability of a ram to mate. But using a ram born in the flock increased the rate of inbreeding because, in uncontrolled natural mating systems, there was the occurrence of mating between closely related animals, even dams with sons and sires with daughters.

The rate of inbreeding coefficient (Δf) for Aseko and Jeju districts when the populations are at random mating and sheep flocks of households run as flocks were (0.102 and 0.088), respectively. This suggests that when sheep of households run as a flock, the risk of inbreeding is larger due to the small number of effective population size. This

value was larger than the maximum acceptable level of inbreeding coefficient, 0.063 (Armstrong, 2006). The present result was lower compared with (Shibabaw, 2012), who reported that inbreeding coefficients of (0.36), (0.40) and (0.13) for Meta, Gorogutu and Deder districts of the eastern Hararghe zone. Based on the results obtained in herding practice, on average, 3.4 and 3.3 households were mixed, in Aseko and Jeju districts, respectively. On the other hand, when flocks mixed, the rate of inbreeding coefficients (ΔF) was reduced by 70.6% and 66% in Aseko and Jeju districts, respectively, and by Demeke *et al.* (2020) who reported that the when sheep, flock were mixed coefficient of inbreeding was reduced by 85% and 87.2% for Meket and Gidan districts, respectively. The results suggest that the genetic diversity in the population has decreased and leads to population homogeneity. Genetic variation is the main source of selection for genetic improvement. If there is no genetic variation in the population, the best animal is not better than the worst animal. This makes genetic improvement through selection difficult. Genetic variation is the key to any sustainable livestock production, utilization and conservation.

Table 6: Effective population size and level of inbreeding when populations are not mixed and when populations are mixed

Districts When sheep flock were not mixed				When the flock is mixed				
	Nm	Nf	Ne	ΔF	Nm	Nf	Ne	ΔF
Aseko	1.50	6.57	4.88	0.102	5.1	22.3	16.60	0.03
Jeju	1.82	6.47	5.68	0.088	6.0	21.4	18.72	0.03

Nm=Number of breeding male, Nf= Number of breeding female, Ne=Effective population size, ΔF , Inbreeding coefficient.

Conclusions

Sheep are a multi-purpose animal and reared to fulfill various functions in the community. The main reasons for keeping sheep were income generation, saving, breeding purposes, to obtain meat for household consumption, as well as for market, skin, and manure production, which is utilized for backyard crop production, especially by smallholder highland farmers. Farmers practice selection of breeding animals, both male and female, using different criteria. The selection criteria considered were varied, accordingly to the knowledge of farmers and preferred traits in some particular area. Uncontrolled natural mating was the dominantly practiced mating system, which includes mating of closely related animals. The main reasons for uncontrolled mating were sheep flocks grazing together on communal grazing land, lack of a sufficient number of breeding rams, and lack of awareness of the consequences of inbreeding. In general, improvement of the sheep population requires intervention in terms of breeding practices and utilization of rams, as well as designing mating systems, which enable that mating of unrelated animals should be in place.

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Contribution by Authors

The first author design methodology, collect the data, and analyzed. While, writing the paper, correcting and discussing was performed by all authors equally.

Conflict of Interests

There is no conflict of interest.

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