Journal of Agriculture and Environmental Sciences

Research Article

Selection criteria and breeding practices of farmers for indigenous goat populations in selected districts of Awi Zone, Amhara Region, Ethiopia

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Received: March 19, 2025; Received in revised form: June 13, 2025; Accepted: December 13, 2025

Abstract: *The study was carried out in three agro-ecological zones, namely Ankesha (highland), Dangila (midland) and Jawi (lowland) districts of Awi Zone that were selected purposively based on goat production potential and agro-ecology. The objective of the study was to identify the selection criteria and breeding practices of farmers that keep indigenous goat populations in Awi Zone, Amhara region, Ethiopia. A total of 180 households were selected randomly for the administration of a semi-structured questionnaire. Data were gathered through semi-structured questionnaires, focus group discussions and key informant interviews. Different types of statistical analysis were employed depending on the nature of the data. Data collected through questionnaire were analyzed by descriptive statistics using Statistical Package for Social Sciences (SPSS) and a T-test was applied when required to test the statistical significance. Indices were calculated to provide ranking of different variables. The result of the study showed that twining ability, appearance, age at sexual maturity and color were the main selection criteria for does whereas appearance and color were the main criteria for selection of breeding bucks. The mating practice was uncontrolled within the household's flock and between neighbouring flocks. The rate of inbreeding (ΔF) for goats in the Ankesha, Dangila and Jawi districts were 0.001, 0.0026 and 0.0030, respectively which is lower than the maximum acceptable level of 0.063 from literature. The result of this study highlighted the importance of designing breeding programs that take into account selection criteria and trait preferences of farmers for improving goat productivity in the study area.*

Keywords: Awi Zone; Breeding management, Indigenous goats, Trait preference
Citation: Mebratie, W., and Tekuar, S. (2025). Selection criteria and breeding practices of farmers for indigenous goat populations in selected districts of Awi Zone, Amhara Region, Ethiopia. J. Agric. Environ. Sci. 10(1): 19-31. https://doi.org/10.20372/jaes.v10i1.10861

1. Introduction

Ethiopia has the largest livestock population in Africa and a homeland of a large number of goat populations which are kept in various production systems and different agro-ecological zones of highlands, semi-arid and arid environments (IBC, 2004; Mekuriaw, 2016). Ethiopia holds huge and diverse goat populations that play an important role in the livelihood of resource-poor farmers. According to CSA, (2021/22), there are about 45. 7 million head of goats in Ethiopia. Out of these, 69% are females and the remaining 31% are males. Almost all the goats are indigenous breeds, which account for 99.9% of the total population (CSA, 2021/22).

The sale of goats and goat products (meat, skin, and milk) by farming communities is the major economic source for their subsistence (Wodajo et al., 2020). In

addition, goats are raised mostly to safeguard against crop failure and unfavorable crop prices in intensive cropping areas (Legesse *et al.,* 2005). Almost all goat population is managed by resource-poor smallholder farmers and pastoralists under traditional and extensive production systems (Abegaz, 2014). Goats in the highlands are widely distributed in the mixed crop-livestock production systems with very small flock sizes (Alemu, 2004).

Despite the wide distribution and large number of Ethiopian goat populations, the productivity per unit of animal and the contribution of this sector to the national economy is relatively low. Even though goats have valuable contributions to the livelihoods of farmers in rural areas, the sector has been given low development attention at global (Aziz, 2010) and national (Gizaw *et al*., 2013) levels. This is mainly due to inadequate recognition of the contributions of goats to the livelihoods of the poor, resulting in underutilization of the diverse goat genetic resources (Aziz, 2010).

Community-based breeding programs are considered a promising tool for livestock genetic improvement under smallholder tropical conditions (Mueller *et al*., 2015). Designing effective genetic improvement is one way to increase the productivity of the goat genetic resource in the country (Temesgen *et al*., 2019). However, identification, characterization and documentation of goat types in the environment in which they are kept, identifying selection criteria and trait preferences as well as breeding practices in those environments are the prerequisite for genetic improvement (Sadea Adem, 2018). Moreover, for designing a sustainable genetic improvement program, considering the compatibility of the genotypes with the farmers' breeding objectives, selection criteria and trait preferences is crucial (Tibbo, 2006). To design breeding programs necessary to specific systems and react properly to the growing domestic and foreign demand for live goats and goat products; identifying the selection criteria, trait preference of farmers and their breeding practices are critical (Tilahun *et al.,* 20l9) and can be used as input for designing a breeding program.

In the Amhara region, different researchers have identified the selection criteria, trait preference and breeding practices of farmers (Muluneh *et al*. 2016a, Tilahun *et al*., 2019). However, there is only limited information on the selection criteria and breeding practices of farmers for indigenous goats in the Awi zone except for the limited work done by FARM Africa (1996) and Hassen *et al*. (2012). Furthermore, updating the previous results is important since information about animal genetic resources is not static (Sölkner *et al*., 1998). The absence of adequate information on the selection criteria and breeding practices of farmers leads to wrong decisions about genetic resources (Wuletaw *et al.,* 2006). Therefore, the objective of this study was to identify the selection criteria and breeding practices of farmers and estimate the rate of inbreeding for the goat population in the study area.

2. Materials and Methods

2.1. Description of the study area

The study was conducted in Ankesha (highland), Dangila (midland) and Jawi (lowland) districts of Awi Zone, which is one of the 11 zones found in Amhara National Regional State (ANRS). Detailed information about the study districts is given in Table 1. It consists of eight districts namely Guangua, Ankesha, Banja, Dangila, Fageta Lekoma, Guagusa Shikudade, Jawi, Zegem and three administration towns namely, Chagnie, Injibara and Dangila towns. Awi Zone is located in the western parts of Amhara Region and it is bordered on the west by Benishangul-Gumuz Region, on the North by West Gondar Zone and the East by West Gojjam Zone. The Zone is located at a distance of 120 km from Bahir Dar and 475 km from Addis Ababa. The altitude of the Zone ranges from 500 to 3,200 meters above sea level, with an average altitude of about 2,300m and falls into three agro-ecological Zones. The two agro-ecological zones, *Dega* (>2300 *m.a.s.l.*), *Woyna-dega* (1500-2300 *m.a.s.l*) constitute the largest area coverage as compared to the *Kolla* which falls in the range of 500-1500 *m.a.s.l.*

Based on the 2007 census data conducted by the Central Statistical Agency (2016), Awi zone has a total population of 1,220,316, of whom 598,880 (49.1%) are men and 621,436 (50.9%) are women. It has 1,231,447 cattle, 676,509 sheep, 162,576 goats, 206035 equines (horse 96136, donkey 93052, mule

16667), 1,151708 poultry and 128906 beehives (CSA, 2021/22).

Table 1: Description of the study districts

Variables	Districts		
	Ankesha	Dangila	Jawi
Temperature	15–20 °C	16-27 °C	32- 40 °C
Rainfall (mm)	1000-2000	1500-2200	700-1569.4
Altitude (*m.a.s.l*)	1800 - 3200	1440 – 2380	650 – 1300
Longitude	36.59°E	36.8° E	36.8°"E
Latitude	10°31′ N	11.3°" N	9.3°"N
Total area (ha)	95,503	91,840	515,000
Human Population	106,680	40,930	71,357
Poultry population	12,1986	116,854	107,124
Cattle population	16,6821	182,383	169,574
Sheep population	63,965	52,654	42,876
Goat population	25,656	26,596	64,846
Equines	29,386	14,722	32,880

2.2. Sample Size Determination of the Households

The number of sampled households in the study area was determined using the formula described by Cochran (1977) as indicated in Formula 1 below.

$$n = \frac{z^2 * (p)(q)}{e^2} \quad [1]$$

Where:

n = the minimum required number of sample size within the range of acceptable error margin.

Z^2 = standard normal deviation (1.96 for 95% confidence level)

e^2 = is the margin of error at 95% confidence level.

The distribution of attributes in the population p is 0.136.

q = (1-p), accordingly q is 0.864.

Based on the above formula, a total of 180 households (HHs) were selected for interview.

2.3. Data collection

In each sampling site, farmers were briefed about the objective of the study before starting the data collection. The survey data was collected from primary and secondary data sources. Primary data was generated through a semi-structured questionnaire, focus group discussions and key informants' interviews. The questionnaire was prepared by using a standard description list developed by FAO (2012). Semi-structured questionnaires were translated into the local language and administered to collect information on livestock composition, flock structure, selection criteria, breeding management and practice as well as culling and marketing age in each of the selected flock owners. Thus, a total of 180 goat keepers were interviewed. Before conducting the actual survey, the enumerators were trained and the questionnaire was translated in to Amharic and pre-tested.

Focus group discussions with farmers were held in each peasant association (PA) to triangulate information gathered using questionnaire data on selection criteria and breeding practices of farmers for their goats. Nine focus group discussions (3 per PA) with an average of 8 to 10 members were conducted in the selected rural kebeles by including elders, community leaders, women, representative animal health technicians, development agents, individuals who are known to have better knowledge on the present and past social and economic status of the area was targeted. Three Key informant interviews were conducted, one in each district with development agents and model farmers involving 15 participants per district. General information and environmental conditions of the study areas such as climatic data (temperature and rainfall), geographical

location, and human and livestock demography were obtained through secondary data and informal interviews with zone agricultural experts from the offices of the respective district of Agricultural and Rural Development.

2.4. Data management and analysis

The collected data were coded and recorded in Microsoft Excel. Different types of statistical analysis were used depending on the nature of the data. Data collected through questionnaires were analyzed by descriptive statistics using Statistical Package for Social Sciences software and a T-test was applied when required to test the statistical significance.

For ranked variables, indices were calculated using the following formula; Index= Σ of [3× number of households ranked first + 2 × number of households ranked second + 1× number of households ranked third] given for particular qualitative variables divided by Σ of [3× number of households ranked first + 2 × number of households ranked second + 1× number of households ranked third] for all qualitative variables considered (Kosegy, 2004).

The coefficient of inbreeding (ΔF) was calculated from the effective number of breeding goats. Estimates of the average change in percentage inbreeding were made based on the formula given by Falconer and Mackey (1996). Accordingly, the effective goat population size in the study area was calculated as indicated below.

$$Ne = (4Nm * Nf) / (Nm + Nf) \quad [2]$$

Where,

Ne = effective population size, Nm = number of breeding males and Nf = number of breeding females. The rate of inbreeding coefficient (ΔF) was calculated from Ne as ΔF = 1/2Ne (Falconer and Mackay, 1996).

3. Results and Discussion

3.1. Livestock composition

The mean number of various livestock species composition per household in the study area is reported in Table 2. The major livestock species observed in the study area were goats, sheep, cattle, donkeys, chickens, horses, and mules in this order. The present study revealed that the average flock size per household of goats (12.62±0.44) is predominantly the highest of all other livestock species followed by chicken, cattle, sheep, donkey, horse, and mule, respectively.

These findings are in agreement with Muluneh *et al.* (2016b) who indicated that goat number (12.24±5.94) per household in the West Gojjam Zone is higher than other livestock species followed by chicken. Discussions with focal groups further indicated that the reasons for the increasing trend of goat rearing are that goats could serve as an immediate source of income, have short generation intervals and prolificacy, they require low initial capital, as well as their broad feeding habits and drought tolerance. The average flock size per household of goats in the Jawi (17.40±0.83) district was significantly higher than that of the Dangila (10.53±0.53) and Ankesha (9.95±0.44) districts, respectively, due to the abundance of browse plants that could favour goat keeping in the district.

The higher sheep holding in Dangila and Ankesha districts as compared with the Jawi district is due to the better adaptability of sheep in highland agro-ecology. Moreover, the higher goats and cattle holding in the Jawi district than Dangila and Ankesha districts is due to the presence of larger natural grazing land with relatively better coverage of bush and shrubs around the district. Cattle are the most important livestock species for cultivation, threshing, milk, and manure which make them more preferred than sheep in the study area.

Table 2: Livestock composition per household in the study districts

Livestock Species	Jawi	Dangila	Ankesha	Overall	Test
	Mean± SD	Mean± SD	Mean± SD	Mean± SD	P-value
Goat	17.40±6.46[a]	10.53±4.12[b]	9.95±3.40[c]	12.62 ±5.90	0.001**
Cattle	9.55±6.04[a]	5.47±2.62[b]	4.73±2.72 [c]	6.58±4.61	0.001**
Sheep	1.77±2.80[a]	3.55±3.37[b]	4.40±3.83[c]	3.23± 3.64	0.004**
Chicken	8.92±5.30[a]	6.77±4.61[b]	4.6±3.72[c]	6.76± 4.89	0.001**
Donkey	1.08±0.93[a]	0.73±0.80[b]	0.75±0.90[bc]	0.86± 0.88	0.049*
Horse	0.10±0.54[a]	1.03±0.78[b]	1.10±0.74[c]	0.74± 0.89	0.001**
Mule	0.22±0.42	0.50±0.72	0.20±0.46	0.31±0.56	0.12[ns]

Means followed with different superscripts in the same row are significantly different at p = 0.05, SD = Standard deviation, ns = non-significant at p = 0.05.

3.2. Goat flock structure by sex and age group

The proportion of the different classes of animals reflects the management decision of the producers which in turn is determined by their production objectives (Gizaw, 2010). The goat flock structure in the study area is indicated in Table 3. Breeding does make the major contribution in the flock (28.16 %) followed by young breeding females aged 6 months to 1 year (19.01%) in all the study districts. The mean (±SD) breeding does per household was 4.93±2.34, 2.87±1.11, and 2.55±0.94 in Jawi, Dangila and Ankesha districts, respectively. According to the respondents adult does were replaced by young females which might be a practice of replacing older adult females for breeding purpose.

The higher proportion of breeding females in the flock was in line with the report from the Siti Zone Somali region which is 30.23% (Gatew *et al.*, 2015). The lower proportion of young male kids (12.83%) as compared to young female kids (14.47%) in the study area was due to the selling of young male kids at an early age whenever cash is needed which needs systematic intervention to control negative selection. The percentage of castrated goats was 9.64%, 10.97% and 7.71% in in Jawi, Dangila and Ankesha districts, respectively. The percentage of castrates found in the districts was close to Muluneh *et al.* (2014) who reported 12.2 % castrated males in Gonji Kolela district of Western Gojjam. The relatively smaller proportion of castrates in Ankesha district indicated the low practice of buck castration in the area as compared with Dangila and Jawi districts where there is a high demand for intact males by exporters.

Table 3: Goat flock structure in the study districts

Flock structure	Jawi	Dangila	Ankesha	Overall	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
< 6-month male kids	2.15±1.10[a]	1.32±0.90[b]	1.25±0.80[c]	1.57 ± 1.03	*
Male 6 month to 1 year	0.97±0.80[a]	0.60±0.69[b]	0.68±0.75[bc]	0.73 ± 0.75	*
Female 6 month to 1 year	3.10±1.24[a]	1.98±1.00[b]	1.90±0.95[c]	2.33 ± 1.19	***
Male >1 year (buck)	1.58±0.74[a]	1.33±0.67[b]	0.97±0.66[c]	1.24 ± 0.73	*
Female >1 year (doe)	4.93±2.34[a]	2.87±1.11[b]	2.55±0.94[c]	3.45 ± 1.90	***
Castrated buck	1.63±1.36[a]	1.13±1.01[b]	0.72±0.70[c]	1.17 ± 1.13	*

Means followed with different superscripts on the same row are significantly different at P<0.05; N = Number of respondents; SD = Standard deviation; *** = P<0.001; ** = P<0.01; * = P<0.05

3.3. Breeding management

About 56.6% of the goat keepers in the study area had one breeding buck, 34.4% owned more than one breeding buck and the remaining (15%) had no breeding buck. This result contradicted the study of (Dawit, 2012) who reported that the number of farmers who did not have breeding buck was significantly higher than those who owned one and more than one breeding buck in the Eastern Harerghe zone, Ethiopia. Across the studied districts, the

respondents in Jawi (93.3%) had a higher proportion of breeding buck compared with Dangila (85%) and Ankesha (76.7%) districts. The result is in agreement with the finding of Solomon Abegaz (2014) who reported that the majority (86.67 %) of Abergele goat keepers had their own breeding buck. The overall mean (±SD) number of breeding buck per flock was (1.45±0.62) in Jawi, (1.13± 0.65) in Dangila and (1.0 ±0.68) in Ankesha districts, respectively that shows the existence of more than one breeding buck across the study districts. According to the respondents, the higher proportions (78.4%) of the source of breeding bucks were from their own (private) flock and the remaining source (19.7%) was obtained from the market through purchases, sharing from neighbouring bucks (1.9%) or random mating with neighbouring bucks available in the flocks during communal browsing and watering point.

The purpose of keeping breeding buck in the study area was for breeding and fattening (65.6%) followed by breeding and socio-cultural benefit (25.5%) and for only breeding purposes (8.9%) (Table 4). The majority (71.8%) of the goat keepers in the Jawi district were keeping bucks for breeding and fattening while the remaining (18.3 %) kept for breeding and socio-cultural benefit and 10% kept bucks for only breeding (mating) purposes. The majority of the respondents (93.4%) did not have special management for breeding bucks in the study area which should be improved since better management of bucks increases their reproductive performance. In line with this study, Muluneh *et al.* (2016a) reported the purpose of keeping breeding buck to be mating (68.9%), fattening (63.3%) and socio-cultural practice (14.4%) in West Gojjam zone.

Table 4: Breeding management in the study districts

Breeding Management	Jawi		Dangila		Ankesha		Overall	
Do you have a breeding buck	N	%	N	%	N	%	N	%
▪ Yes	56	93.3	51	85	46	76.7	153	85
▪ No	4	6.7	9	15	14	23.3	27	15
Buck ownership								
▪ Having no breeding buck	4	6.7	9	15	14	25.3	27	15
▪ Having one breeding buck	25	41.7	34	56.7	32	53.4	91	56.6
▪ Having > 1 buck	31	51.6	17	28.3	14	23.3	62	34.4
Sources of breeding buck								
▪ Own (private) flock	53	94.6	40	78.5	27	58.7	120	78.4
▪ Purchased/market	2	3.6	9	17.6	19	41.3	30	19.7
▪ Neighbouring	1	1.8	2	3.9	-	-	3	1.9
Purposes of keeping breeding buck								
▪ Mating	6	10	8	13.3	2	3.3	16	8.9
▪ Breeding and socio-cultural	11	18.3	15	25	20	33.3	46	25.5
▪ Breeding and fattening	43	71.7	37	61.7	38	68.3	118	65.6
Special management for breeding buck								
▪ Yes	3	5.4	2	3.9	5	10.9	10	6.6
▪ No	53	94.6	49	96.1	41	89.1	143	93.4

N = Number of respondents, % = percent

3.4. Breeding practices

The majority (97.7%) of the respondents in the study area entirely use natural uncontrolled mating within the household's flock and between neighbouring flocks (Table 5). This is in line with Muluneh *et al.* (2016b) who reported that natural mating or uncontrolled mating within the household's flock and between neighbouring flocks was the type of mating practiced in West Gojjam Zone.

The main reasons for uncontrolled mating was because flocks of different households graze/browse together in communal grazing areas (73.3%) followed by the insufficient number of bucks (17.8%) and a lack of awareness (6.9%) about the effect of

inbreeding as also revealed in focus group discussions and key informants' interviews. Similar to this study, Gatew *et al.* (2015) indicated that in the Borana Zone (98.48%) of the Oromia Regional State and Siti Zone (98.26%), Somali Regional State uncontrolled breeding surpassed due to the extensive communal production system in the study area.

According to Kosgey (2004), an advantage of natural uncontrolled mating is that it allows for all-year-round breeding. Since the mating system was naturally uncontrolled, almost (98.9%) all of the respondents in the study area were not controlling their bucks from mating does of another goat flock while only a few farmers did not allow serving their does by anyone else's buck from the mixed flock. Among the reasons for this, the goat owners did not wish a goat with a black coat color to mate with their does since the study community culturally distastes a black coat color and thus use it as a culling criterion. This is in line with Muluneh *et al.* (2016a) in which color was reported as the major criteria considered by the goat owners in allowing their does to be served by bucks from another flock in West Gojjam Zone.

Some goat keepers in the study area allow their selected buck to mate with his mother, daughter and sister; because they believe that the performance (growth and milk yield) of the newborn will be good due to cumulative effect (since both buck and doe come from the same pedigree as best animals) due to lack of awareness about inbreeding.

The majority of the goat keepers, 55% in Jawi, 61% in Dangila and 36.7% in Ankesha districts, could be able to identify the sire of newborn using phenotypic characteristics (coat color, body conformation, height, etc.). Phenotypic similarity of kids with the existing breeding male in the flock is used to identify the sire of the kid. In agreement with this study, Muluneh *et al.* (2016a) reported that 22.22% of the respondents in Bahirdar Zuria, 37.78% of Yilmana-Densa and 28.89% of Gonji-Kolela were able to identify the sire of new born kid mostly by looking at its color. Similarly, Dawit (2012) reported that the majority of respondents i.e. 26.8% in Meta, 12% in Babbile and 23.8% in Gurawa districts of Eastern Harerghe zone were able to identify the sire of a newborn kid.

Table 5: Type of mating practiced in the study districts

Breeding practices	Jawi		Dangila		Ankesha		Overall	
Mating practice	N	%	N	%	N	%	N	%
▪ Controlled	0	0.00	2	3.3	2	3.3	4	2.2
▪ Uncontrolled	60	100	58	96.7	58	96.7	176	97.7
Reason for uncontrolled mating								
▪ Communal grazing area	46	76.7	43	71.7	41	68.3	132	73.3
▪ Lack of awareness about inbreeding	8	13.3	6	10	3	5	16	6.9
▪ Insufficient number of bucks	6	10	11	18.3	16	26.7	32	17.8
Do you identify the sire of the kid?								
▪ Yes	33	55	37	61.7	22	36.7	92	51.1
▪ No	27	45	23	38.3	38	63.3	88	48.9
Do you allow your buck to serve others?								
▪ Yes	60	100	59	98.3	59	98.3	178	98.9
▪ No	-	-	1	1.7	1	1.7	2	1.1
Do you allow your does to be served by others?								
▪ Yes	58	96.7	55	91.7	60	100	172	96.1
▪ No	3	3.3	5	8.3	-	-	7	3.9

N = Number of respondents, % = percent

3.5. Culling and marketing age

The average market age and reasons for culling of goats in the study area is presented in Table 5. The mean (±SD) market age of female goats was 12.48±1.47, 12.58±1.7 and 12.92±1.29 months in Jawi, Dangila, and Ankesha districts, respectively,

whereas the market age of male goats was 11.22±1.62, 11.27±1.74 and 11.68±1.28 months in Jawi, Dangila and Ankesha districts, respectively. The overall mean (±SD) market age of female and male goats was (12.66±1.52) and (11.39±1.56 months), respectively. The average mean (± SD) market age of male and female goats obtained in the current study were lower than 15.32 and 16.11 months reported for males and 15.38 and 21.93 months for females in Gewane and Amibara districts, respectively (Seifemichael, 2013). In the study area, farmers mainly sell old bucks and does followed by castrated males and buck kids which were aged 6 months to 1 year as obtained using individual interviews and focus group discussions.

Culling is a practice to remove unproductive or undersized animals from the flock. In the study area, respondents were culling their bucks at an average age of 6.55±0.12, 6.08±0.17 and 6.23±0 .88 years in Jawi, Dangila and Ankesha districts, respectively whereas their female counterparts were culled at the age of 9.33±0.15, 9.12±0.18 and 8.67±0.15 years, in Jawi, Dangila and Ankesha districts, respectively. From the reproductive point of view, culling should be stringent and used as a means of improving the genetic quality and productivity of a flock. It is essential to intensively cull bucks after 6 years of age and use them for fattening instead of reproduction purposes hence the average productive life of bucks was less as compared to does. In the study area, the reasons for culling were age, sickness, reproductive problems, physical defects, and unwanted physical character. Out of this the most important reasons for culling goats were age and health problems followed by reproductive problems. Conversely, Dedacha *et al.* (2017) reported that health problem was the primary reason for the culling of goats in Odo Shakiso and Adola districts.

Table 6: Average market and culling age of goats in the study districts

Parameters	Jawi		Dangila		Ankesha		Overall	
Market age (months)	Mean±SD		Mean±SD		Mean±SD		Mean±SD	
▪ Male	11.22±1.62		11.27±1.74		11.68±1.28		11.39±1.56	
▪ Female	12.48±1.47		12.58±1.77		12.92±1.29		12.66±1.52	
Culling age (years)								
▪ Male	6.55±0.12		6.08 ± 0.17		6.23±0 .88		6.29±0.90	
▪ Female	9.33±0.15		9.12±0.18		8.67±0.15		9.03±0.09	
Reasons of culling	N	%	N	%	N	%	N	%
▪ Age	35	58.3	27	45	25	41.7	87	48.3
▪ Sickness	14	23.3	22	36.7	24	40	60	33.3
▪ Reproductive problem	8	13.3	9	15	5	8.3	22	12.2
▪ Physical defect	1	1.7	1	1.7	2	3.3	4	2.2
▪ Unwanted physical character	2	2.3	1	1.7	4	6.7	7	3.9

3.6. Selection criteria for breeding does and bucks

Participatory approaches for the identification of traits of the breeding objectives are crucial for the success of community-based breeding programs. The selection criteria of farmers to identify a breeding doe were different according to the production system and culture of the community in Ethiopia. The selection criteria for breeding does in the current study include twining ability, body size/appearance, and age at sexual maturity in this order (Table 7). In the study area, twining ability, body size/appearance, and age at sexual maturity were the best criteria for selecting breeding does with index values of 0.27, 026 and 0.17, respectively. In Jawi and Dangila districts, twining ability, body size/appearance, and age at sexual maturity were the top most criteria to select breeding does in this order. Whereas body size/appearance, twining ability and age at sexual maturity were the most important selection criteria in Ankesha district with index values of 0.28, 0.23 and 0.19, respectively (Table 7). Color, kidding interval, maternal history, and temperaments were also considered important in all of the study districts in selecting breeding does. Similar to this study, Dawit (2012) in Eastern

Hararghe Zone and Muluneh *et al.* (2016a) in Western Gojjam Zone reported that twining ability, appearance and age at sexual maturity were considered as the first three criteria for selection of does.

Selection criterion is linked to the demand in particular areas. In the case of the selection of breeding doe in the study area, milk yield is not important as there were no demand for goat milk in which drinking goat milk is considered taboo. This implies that the culture and the norms of the communities should be considered to improve goat traits and include them in the breeding objectives.

The choice of a good breeding buck is a fundamental factor in small ruminant production. It contributes 50% of the genetic makeup of kids born and determines the overall production and reproduction rate of the flock. Traits like body size/appearance, growth rate and coat color were considered the top three important traits in selection of breeding bucks in all the study districts and were given higher emphasis (Table 8).

The results revealed that Jawi and Dangila districts select their breeding bucks on the basis of body size which was the primary criteria with higher index values of 0.34 and 0.31, respectively. This is followed by coat color and kid growth with index values of 0.20 and 0.19, respectively.

The findings of the current study were in agreement with Abegaz (2014) who reported that body size followed by coat color as the most important selection criteria of breeding bucks. According to the author, body size and coat color recorded index values of 0.33 and 0.22, respectively, in Western lowland goats while 0.31 and 0.25 in Abergelle goats in the same order. These results were similar with the report of Ahmed *et al.* (2015) in Horro Guduru Western Ethiopia who reported that body size, coat color, and growth rate were the first, second and third most important selection criteria for breeding bucks. This implies that designing goat improvement strategy in the study area should primarily target meat production traits for bucks and reproductive performance for does.

Table 7: Selection criteria for breeding does in the study districts

Selection criteria	Jawi				Dangila				Ankesha				Overall index			
Breeding does	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Color	8	8	12	0.14	3	6	18	0.11	4	5	16	0.11	15	19	46	0.12
Body size/appearance	20	11	12	0.26	21	5	12	0.23	23	10	11	0.28	64	26	35	0.26
Maternal history	1	1	3	0.02	2	2	5	0.04	2	1	4	0.03	5	4	12	0.03
Age at sexual maturity	5	16	8	0.15	10	15	5	0.18	8	19	9	0.19	23	50	22	0.17
Kidding interval	7	7	12	0.13	4	9	12	0.12	5	10	9	0.12	16	26	33	0.12
Twining ability	19	17	13	0.29	18	22	8	0.29	17	13	6	0.23	54	52	27	0.27
Temperament	0	0	0	0.00	2	1	0	0.02	1	2	5	0.04	3	3	5	0.03
Milk yield	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00
Walking ability	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0	0	0.00

Index = sum of (3 No. of respondents for ranked 1st+2* No. of respondents for ranked 2nd+1* No. of respondents for ranked 3rd) for a particular trait divided by sum of [3* No. of respondents for ranked 1st+2* No. of respondents for ranked 2nd+1*No. of respondents for ranked 3rd] for all traits.*

Table 8: Selection criteria for breeding bucks in the study districts

Trait	Jawi				Dangila				Ankesha				Overall index			
Breeding bucks	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index	R1	R2	R3	Index
Color	11	20	23	0.27	9	19	18	0.23	10	15	18	0.22	30	44	69	0.24
Body size	26	18	7	0.34	25	16	6	0.31	26	21	5	0.35	77	55	18	0.33
Fertility	5	6	5	0.09	6	5	7	0.10	5	5	7	0.09	16	16	19	0.09
Libido	0	0	4	0.01	0	1	3	0.01	0	0	4	0.01	0	1	11	0.01
Growth rate	13	10	16	0.20	12	13	12	0.21	14	12	15	0.23	39	35	43	0.21
Adaptability	1	2	1	0.03	2	2	5	0.04	2	0	6	0.03	5	4	12	0.03
Walk ability	3	2	0	0.04	0	2	3	0.02	0	0	2	0.006	3	4	5	0.04
Character	1	1	1	0.02	5	1	2	0.05	3	6	0	0.05	9	8	3	0.05
Pedigree	0	1	2	0.01	1	1	4	0.03	0	1	3	0.01	1	3	7	0.02
Horned	0	0	1	0.003	0	0	0	0.00	0	0	0	0.00	0	0	1	0.003

Index = sum of (3 No. of respondents ranked 1st+2* No. of respondents ranked 2nd+1* No. of respondents ranked 3rd) for a particular trait divided by sum of [3* No. of respondents ranked 1st+2* No. of respondents ranked 2nd+1* No. of respondents ranked 3rd] for all traits.*

3.7. Effective population size and rate of inbreeding

The utilization of breeding buck/s born in the flock, uncontrolled breeding, and lack of knowledge about the impact of inbreeding and small flock size may lead to accumulations of inbreeding and declined genetic diversity (Falconer and MacKay, 1996; Kosgey, 2004). However, communal grazing/ practice by many goat keepers in extensive production systems allows breeding females to mix with males from neighbouring flocks and this can minimize the risk of inbreeding by increasing the effective population size (Jaitner *et al.,* 2001). The effective population size (Ne) and the rate of inbreeding (ΔF) calculated for the goats' population of Jawi, Dangila and Ankesha districts are presented in Table 9. When goat flocks of the households were mixed, the rate of inbreeding (ΔF) for goats in Jawi, Dangila and Ankesha districts were 0.001, 0.0026 and 0.0030, respectively. This was lower than the maximum acceptable level of 0.063 (Armstrong, 2006) which is attributed to the use of communal herding, early castration of undesired males and rotational use of breeding bucks suggesting that mixing goat flocks should be encouraged in the study area to further decrease the rate of inbreeding by increasing the effective population size.

Table 9: Effective population size and rate of inbreeding of goat flocks in the study districts.

Districts	Nm	Nf	Ne	ΔF
Jawi	95	296	575.34	0.001
Dangila	68	172	194.93	0.0026
Ankesha	58	153	168.23	0.0030

Nm = Number of males, Nf = Number of females, Ne = effective population size, ΔF = coefficient of inbreeding

4. Conclusion and Recommendations

The most important selection criteria for breeding does were twinning ability, appearance and age at sexual maturity in this order. For selection of breeding bucks the traits which were given high emphasis were body size, color and growth rate in all the study districts (Ankesha, Jawi and Dangila). The rate of inbreeding was lower than the maximum acceptable level however poor breeding practices in the study area such as uncontrolled mating should be addressed in the future researches in order to reduce the rate of inbreeding. An effort should be made to increase the proportion of breeding males in line with the selection and culling of genetically inferior bucks with controlled breeding. Besides, training of farmers about inbreeding and the effect of mixing flocks on the rate of inbreeding might be helpful to increase their awareness. Furthermore, farmers in the study

area select breeding does and bucks based on qualitative characteristics without recording performance data, which may lead to wrong selection decisions. Therefore, awareness should be created for farmers on performance data recording and objective selection of breeding does and bucks to improve flock productivity.

Data availability statement

Data will be made available on request.

Conflicts of interest

The authors declared that there is no conflict of interest.

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