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Trait Preference and Performance Evaluation of Indigenous Goat Keepers of Borana Pastoralists in Ethiopia

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Abstract: The objectives of this study were to assess the growth and reproductive performance of goats in a pastoral and agropastoral area and Borana-Pastoralists' preferences for the traits of the indigenous goats. A total of 97 households were interviewed and a total of 194 goats were tracked for six months to collect data. The collected data were analysed using SAS's GLM and descriptive statistics. The results indicated that pastoralists in the study areas were practicing extensive production systems. The ratio of males to females aged less than six months was proportional. However, females over six months of age outnumbered males proportionally. The overall mean body weight (kg) in the pastoral study area at 0, 90, and 180 days of age were 2.37, 10.5, and 13.8, respectively. Similarly, in agro-pastoral study areas, the result was 2.41, 10.6, and 14.01 kg. The effect of birth type affected the growth of goats with a similar trend and consistently up to weaning was significant (P<0.05). Similarly, the results of the kidding numbers on the growth rate of kids were significantly different (P<0.05). The reproductive performance of goats, age at sexual maturity, age at first kidding, average kidding interval, and duration of reproductive life for the pastoralists' systems were studied. Accordingly, for the agropastoral area, the corresponding values were 9.70, 10.39, 15.88, 8.27 months, and 8.6 years, respectively, and 9.42, 10.12, 15.78, 8.20, months, and 10.52 years, respectively. The parity effect was significantly different (P<0.05) at 91-180 days of the age of kids on daily weight gain in the study areas. The most preferred traits in both areas were body size, milk yield, and coat color for females as well as body size, coat color, and growth rate for males. Hence, designing goat improvement strategies primarily targets traits towards meet the interest of indigenous goat keepers.

Key words: Pastoral, agropastoral, trait, performance evaluation, live weight.

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In Ethiopia, pastoralist groups rely heavily on goat husbandry for their subsistence needs. A recent molecular study on Ethiopian goats identified seven distinct breeds (Getnet, 2016). Even with their excellent genetic adaptability to arid settings, the nation's goat productivity is still below average.

Creating and executing appropriate breeding and management plans that are adapted to the regional environment could greatly improve the living conditions of Indigenous goat keepers.

Currently, an estimated 52.5 million goats are raised in various agroecological zones under a complex production system in Ethiopia (CSA, 2021). In Africa, goats are raised in large herds under various management techniques and in a range of agroecological zones. They are also found in small herds on mixed farms throughout the continent, ranging from the humid coastal zones of West Africa to the highlands of Ethiopia (Peacock, 2005). In the dry and semi-arid lowlands that are typical of pastoral and agropastoral agricultural systems, goats are primarily found in huge herds. The reason for the presence of indigenous goat genetic resources in the tropics is because of their resilience to extreme weather, their capacity to make good use of little feed, and their resistance to illnesses (Kosgey and Okeyo, 2007).

Goat populations of the Borana breed are adapted to semi-arid and arid environments and can be found in the south and southeast of Ethiopia. They grow swiftly, can generate a greater amount of meat, and have huge bodies. Nonetheless, without considering the preferences of the farmers or the state of agricultural practices, goat development efforts in Ethiopia were predicated on the notion of boosting meat and milk yield through the crossing of native goat breeds with exotic enhanced goat breeds.

Description of the production system and environment, knowledge of the breed management, and characterization of the morphological characters and productivity levels of the breeds in their habitat is the first step towards developing a sustainable improvement and conservation program of farm animal genetic resources (Sölkner *et al*., 1998; Duguma *et al*., 2010; FAO, 2010; Gizaw *et al*., 2011). In addition, performance monitoring, and periodic population dynamics monitoring as well as breed structures are useful techniques for determining a breeding policy for a specific area (FAO, 2007).

Many studies focus on station/experimental research where usually the conditions differ from the ones in the traditional production systems. Therefore, these works may not offer much to our understanding of animal adaptation to farmer's settings (Abegaz *et al*., 2002). On-farm performance evaluation, on the other hand, covers all aspects of the farm environment and identifies issues that limit productivity within the system. Knowledge of the adapted goat genetic resource's performance is a prerequisite for designing appropriate breeding and utilization programs. Morphological characterization is also one of the crucial means for describing goat breeds and is essential for gene conservation (Huson *et al*., 2014). Body measurements in addition to weight estimates describe the individual or population of small ruminants (Salako, 2006). Hence, it is necessary to carry out a strategic post-survey recording and documentation of the animals' performance in their natural habitat under goat keepers' conditions. Despite research on Indigenous goat breed trait preferences and on-farm performance evaluation conducted at the community-based in various agroecological zones and research stations in Ethiopia, there is a lack of information on the growth and reproductive performance of goats and keepers' preferences for the traits of the Indigenous goats of the Borana Pastoralist.

Materials and Methods

Description of the study area

The current study was conducted in the Yabello district of Borena Zone. It is located in the southern part of Ethiopia in the Oromia Regional state about 570 km away from Addis Ababa (Zewdie *et al*., 2018). The district is subdivided into 7 pastoral, 3 agropastoral, and 3 urban kebeles (CARE, 2009). The location of the study area is shown in Fig. 1 (Zewdie *et al*., 2018).

Research site selection and goat breed sampling techniques

The study area was purposefully selected based on the potential of the Indigenous goat population and stratified into pastoral (nomadic groups who rely on herds of domestic animals for food) and agropastoral (communities that integrate crop and livestock production) systems to choose kebeles (research sites) and households. Accordingly, three pastoral and one agropastoral kebeles were

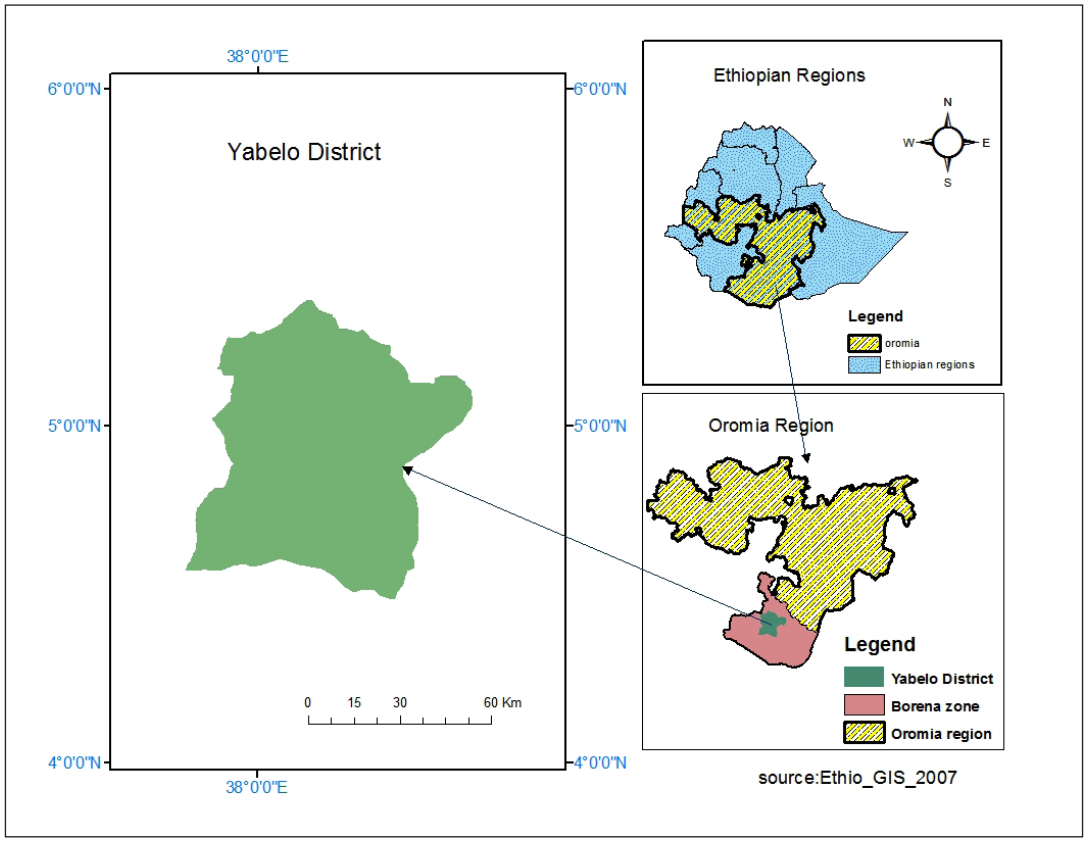

Fig. 1. Map and location of the study area.

randomly selected based on the availability of goat population, goat production practice, infrastructures, and logistics. The households selected according to the formula given by Bowley (1926) were interviewed. Accordingly, a total of 97 households (73 for pastoral and 24 for agropastoral) households were selected for data collection.

The formula given by Bowley (1926) was:

$n_i = nNi/N$

where i= 1, 2, 3; ni represents a sample size of i^{th} strata; n represents the total sample size; Ni represents the population size of the i^{th} strata and N represents the total population size.

The goat population was selected from households that own at least two mature goats, willingness of goat owners to participate in the study, and have at least one year of goat husbandry experience. Thus, a total of 194 goats were selected and monitored for quantitative data collection in both pastoral and agropastoral study areas, with only two goat kids sampled per household based on their age.

Data types and methods of data collection

The data were gathered from both secondary (published articles, books, and unpublished magazines) and primary sources (indigenous goat keepers, extension workers, and experts through questionnaires as well as field observation and focus group discussion). A focus group discussion per kebele with a group size of 8-10 households from various social sectors (youth, women, village leaders, development agents (DAs), experts, and socially respected elders who are known to have a better experience on the past and present social and economic benefit of indigenous goat keeping) were selected to obtain the primary source of data. Secondary data such as climatic data on temperature and rainfall, geographical location, and human and livestock demography data was collected from the Zone administrative office; the district office of Agriculture and Rural Development and other written and published documents were included. The focus group discussion focused on indigenous knowledge related to reproductive performance evaluation practices, the history of goat breeds and breeding, age at first service, household

responsibilities, purposes for keeping goats, and flock structures.

The questionnaire was prepared by adopting the Food and Agriculture Organization (FAO, 2012) and ILRI-OADB (Oromia Agricultural Development Bureau) questionnaire for the survey of livestock breeds in the Oromia Region (Workneh and Rowlands, 2004). The questionnaire was pre-tested (basic quantitative surveys as feedback forms, assessment, baseline, etc.) before administration and some re-arrangements were made based on the study objectives to address the criteria used for goat husbandry practice, on-farm performance evaluation, purpose of keeping the goat, and other types of livestock kept. The participatory definition of the trait was used since it allows respondents to mention as many reasons as possible for their preferences without being limited to a predetermined list.

On-farm performance monitoring

Data were generated in the prepared format adopted from the standard description list developed by FAO (2012) and the ILRI-OADB breed descriptor list (Workneh and Rowlands, 2004). Selected goat kids were monitored (January-June, 2021) for six months to generate growth performance data. Body weight data were collected early morning for six months per 15 days before the animal went for feeding and watering to avoid the effect of feeding and watering on the animal's body weight (FAO, 2012).

The sex and identification number of each animal were recorded. During the monitoring period, recruited enumerators recorded the sex, birth date, type of birth (single or twin), live weight (at 0, 90, and 180 days) of kids, and dam parity under the predominant management system. Birth date, birth weight (every 15 days using the spring balance scale (25 kg)), type of birth, sex of the kid, and parity of dam were recorded within 24 hours of the new birth. Growth rate, measured as average daily weight gain (ADWG), was calculated as follows: 90-day ADWG (grams) = weight gain between birth and 90 days, and 180-day ADWG (grams) = weight gain between 91 and 180 days.

ADWG = End weight - Start weight

Goat flock keepers were asked to rank (first, second, and third) the traits they preferred to select the best male and female goats for breeding purposes. Accordingly, four trait categories such as body size and growth, reproduction traits (like frequent kidding, early age kidding, and litter size), milk yield, and morphological characteristics were collected from goat keepers through a questionnaire and recorded.

Data management and analysis

Data collected through a questionnaire (survey) were analysed using descriptive statistics of the IBM SPSS Statistics Software (SPSS 20.0). Inferential statistics that include tables of means, percentages, averages, and ANOVA were obtained. The Chi-square test was used to assess the statistically significant variation among variables at the 5% probability level. A General Linear Model (GLM) procedure of Statistical Analysis Software (SAS) was used to analyse the growth performance traits of kids. Trait preferences data were analysed using the ranking index method.

Rn*C1+Rn-1*C2+,….+R1*Cn/Σ Rn*C1+ Rn-1*C2,….R1*Cn;

Rn = Value given for the least ranked level (for example if the least rank is 5^{th} rank, then Rn=5, Rn-1=4, and … R1= 1).

Cn = Counts of the least ranked level (in the above example, the count of the 5^{th} rank = Cn, and the counts of the 1^{st} rank = C1).

The model was used to analyse growth traits independently in both study areas.

$Y_{ijkl} = \mu + S_i + P_j + T_k + \varepsilon_{ijkl}$

where: Y_{ijkl} = observed live weight and weight gain (Y_{ijkl}^{th} individual); μ = Overall mean; S_i= effect due to i^{th} sex (I = 1, 2); P_j = effect due to j^{th} parity number (j = 1, 2, 3, 4, ≥5); T_k= effect due to k^{th} type of birth (k = single, twin); ε_{ijkl} = random residual error associated with Y_{ijkl}^{th} observation.

Results and Discussion

General household characteristics

A total of 97 goat keepers were interviewed for the household survey. The gender, household head, educational background, and age of the respondents were recorded (Table 1). In the pastoral study area, the percentage of male-headed households was 74% while the

Table 1. Households, gender, age categories, and level of education in the study areas

Descriptor	Pastoral	Agropastoral	Overall	P-Value
	(N= 73)	(N= 24)	%	
Sex of respondent				
Male	74.0%	79.2%	75.3	NS
Female	26.0%	20.8%	24.7	
Age group (years)				
< 20	2.7%	4.2%	3.1	
20 – 30	15.1%	16.7%	15.5	
31 – 40	30.1%	33.3%	30.9	NS
41- 50	16.4%	20.8%	17.5	
50– 60	21.9%	12.5%	79.2	
>60	13.7%	12.5%	13.4	
Education Level				
Illiterate	79.45%	62.5%	75.25	
Primary school	16.45%	20.83%	17.53	NS
Secondary school	4.10%	16.67%	7.22	

N = Number of HH; X^2 = Pearson chi-square; NS = non-significant

percentage of female-headed households was 26%. As for the agro-pastoral study area, the percentages of male-headed and female-headed households were 79.2% and 20.8%, respectively. Socio-culturally ascribed roles determine women's and men's responsibilities within Borana society. Women's and men's division of labour as well as roles at the community level and within the household are well defined although not rigid. Women take full responsibility for managing small animals, producing dairy products, and fetching water. Similarly, men take responsibility for land preparation, ploughing, and management/sale of cattle. In the current research, in the pastoral area under consideration, the female household heads have a role in decision-making when they are widows. In all other cases, men are the main actors in decision-making regarding livestock management. However, both women and men have decision-making roles in the use of benefits from live animal sales in both study areas (SOS Sahel, 2007). The current finding was in agreement with Tesfaye (2009) in Bale Zone, Oromia region reported that majority of goat owners were unable to read and write. Further, women's participation in decision-making at the household level is limited to the areas socially assigned to them. It is common for both men and women to make decisions to sell livestock together. However, men increasingly are making decisions alone to buy *khat* (leaves of *Catha Edulis* that are chewed to produce a mild 'high') or alcohol (SOS Sahel, 2007). At the community level, women's participation in decision-making processes that affect their lives and their families is often taken without their participation (SOS Sahel, 2007). Although women cannot hold any public positions (stage leader, vice leader, etc.), they have unofficial ways (food preparation and huts/house construction) of influencing decisions or actions (Watson, 2001).

Another result worth noting in the pastoralist area is high illiteracy in the pastoralist area particularly for women. This is due to the lack of family resources (boys tend to get priority in education this is changing as opportunities for women's unemployment increase), the distance from houses to schools, and the fact that traditionally girls have not attended. Moreover, illiteracy was high among the Maasai pastoralists of the Resettlement Action Plan (RAP) land village as the majority of the respondents (54%) had never been to school. This is commonly observed among households' mobile pastoral communities (Abraham *et al.*, 2022).

Livestock composition and holding pattern

The households' goat flocks in pastoral and agropastoral study areas are shown in Table 2. Accordingly, in the pastoral study area, 15.76% were male kids less than six months and 16.15% were female kids less

Table 2. Number of each of the goat classes in the selected households of study areas

Goat Class by age and sex	Pastoral		Agropastoral		Overall Mean ±SD
	N	%	N	%	
Males<6 month	242	15.76%	85	16.03%	3.6±8.63
Female<6month	248	16.15%	81	15.30%	3.87±8.40
Males 6 months - 1 year	174	11.34%	75	14.16%	6.23±8.90
Females 6 months - 1 year	215	14%	70	13.20%	6.86±10.41
Males > 1 year	111	7.23%	36	6.80%	3.12±7.22
Females > 1 year	513	33.39%	175	33.01%	10.21±11.2
Castrate	33	2.13%	8	1.5%	0.58±1.93

N= Number of the goat population

than six months. Moreover, 11.34% and 14% were males and females between six months to one year, respectively. Further, males and females greater than one year recorded 7.23% and 33.39%, respectively. Similarly, in the agropastoral study area, 16.03% and 15.30% were male and female kids less than six months, respectively. Further, 14.16 % were males between six months to one year 13.20% were females between six months to one year as well as 6.80% were males greater than one year and 33.01 % were females greater than one year. The proportion of the different classes of animals reflects the management decision of the goat keepers which in turn is determined by their production objectives (Solomon *et al.,* 2010). The higher number of adult females in the study areas indicates the keeping of female goats for breeding purposes.

The ratio of males to females aged less than six months was proportional. However, females over six months of age outnumbered males proportionally. This might be due to male goats older than one year being frequently sold for high prices whenever the family needed money. The males and females older than one year were 1:4.6 and 1:3.36 in the pastoral and agropastoral study areas, respectively. Gatew *et al.* (2017) reported that the breeding buck ratio in east Ethiopian pastoralists' flocks was 1:3. In the current study high proportion of kids within a flock might be an opportunity to increase the selection intensity which in turn increases the production and productivity within a short period.

The Livestock species that constitute the largest share in the value of livestock assets of a household are defined as the principal animals in northern Ethiopia (Fredu *et al.,* 2009). The same livestock species like sheep, cattle, camel as well as donkeys were kept in both research Locations but with different average numbers per family. This could illustrate how important those animal species are in specific locations. Goats were the most common livestock species in both pastoral and agropastoral areas (48.5% in pastoral and 43.6% in agropastoral study areas). The study area's high goat population may be related to the goat's ability to survive in arid environments better than other animals. Goat, cattle, sheep, and camel populations per household (Mean±SD) in pastoral area and agropastoral area were 22.36±1.40 and 19.77±0.92, 11.82±0.74 and 9.46±1.10, 5.8± 0.47 and 7.56±0.46, 2.82±0.40 and 1.21±0.07, respectively.

Preferences for goat production trait

Goat keepers were asked about the most preferred production traits for the selection of male and female goats. The respondents have ranked four traits with higher index values. Accordingly, body size and growth, reproduction (rate of birth, early age kidding, and litter size), milk yield, and morphological characteristics (coat color) were preferred for female goat selection. Body size, growth rate, body conformation, and coat colors were traits preferred for male goat selection. In addition, the survival rate of kids was graded based on the information gathered from the households. Survival traits are masked by other traits like fast growth and good milk yield of the dam (Oseni and Bebe, 2010; Dossa *et al.,* 2007).

In the current study, body size was the most preferred and frequently ranked trait in both study areas. Coat color was the Second-ranked trait. The growth rate was ranked third followed by milk yield in both study areas (Table 3).

Table 3. Ranking of goat trait preference by goat keepers in the study areas

Trait	Pastoral				Agropastoral			
	R1	R2	R3	Index	R1	R2	R3	Index
Coat Color	13	18	25	0.21	14	14	28	0.20
Body Size	37	16	11	0.24	42	16	20	0.27
Milk Yield	10	11	15	0.11	12	8	17	0.13
Growth Rate	16	35	14	0.16	29	17	9	0.15
Reproductive rate	5	7	10	0.06	13	10	5	0.10
Disease resistance	11	8	12	0.10	7	12	10	0.08
Drought resistance	15	10	18	0.13	10	5	15	0.08

Table 4. List of preferred traits and their corresponding rating for does in the study areas

Trait	Pastoral				Agropastoral			
	R1	R2	R3	Index	R1	R2	R3	Index
Milk yield	12	50	26	0.24	11	13	25	0.24
Body size/Conformation	51	22	16	0.32	56	8	6	0.42
Kid survival	15	33	28	0.21	10	38	7	0.25
Kidding interval	2	0	0	0.01	4	3	1	0.04
Paternal history	3	0	1	0.01	0	0	0	0
Maternal history	11	8	20	0.10	6	3	1	0.06
Coat color	13	9	12	0.10	3	8	1	0.16
Litter size	4	0	0	0.02	3	1	0	0.02
Age at sexual maturity	1	0	0	0.00	1	2	0	0.01

R3= households ranked first; R2= households ranked second, R1= households ranked third given for each selection criteria divided by the sum of R3, R2, and R1 for all selection criteria in a study site; R= Rank.

Coat color preference was also reported based on the study in three villages of Ilu Abba Bora districts of Ethiopia *Urgessa et al.,* 2013, where 0 to 28% of the owners considered coat color during buck selection. Feki (2013) reported that milk yield was the first and most highly valued trait in both pastoral and agropastoral villages of Afar.

Breeding doe selection criteria

Body size/conformation (index = 0.32) was ranked first in female goat selection for breeding in the pastoral study area followed by milk yield (index = 0.24), kid survival (index = 0.21), and coat color (index = 0.10). Similarly, in the agropastoral study area body size (index = 0.42) ranked first followed by kid survival (index = 0.25), milk yield (index=0.24), and coat color (index = 0.16) indicating that kid survival was more preferred than milk yield trait in the agropastoral area (Table 4). Feki (2013) reported that milk yield, fertility, and adaptive traits were frequently mentioned to define the best female in both production systems in the Afar area. Tegegne (2012) also reported that twinning ability (index = 0.31), kid growth (0.21), mothering character (index = 0.13), and body size (index = 0.13) were the most highly rated traits for selecting female goats from their flocks in the southern Ethiopia Bench Maji zone.

Breeding buck selection criteria

The availability of rams in the system considerably affects all biological and financial performances of the flock (Galal, 2005). The selection of a suitable breeding buck is a critical aspect of goat production. In both pastoral and agropastoral study areas, males with large body sizes and good conformation (tall, upright stance, straight back profile, etc.) were regarded as the best buck. In the current study, goat keepers ranked body conformation of breeding buck first (index = 0.50), coat color second (index = 0.30), and growth rate third (index = 0.20) in both pastoral and agropastoral areas (Table 5). Feki (2013) reported that the most preferred traits were body size (I = 0.35), as well as coat color (I = 0.20); they were favored

Table 5. Ranking goat keepers' selection criteria for breeding buck in the study areas

Selection Criteria	Pastoral				Agropastoral			
	R1	R2	R3	Index	R1	R2	R3	Index
Growth rate	12	32	40	0.24	10	25	38	0.20
Body conformation	53	18	20	0.36	60	21	26	0.46
Paternal history	0	1	1	0.01	0	0	2	0.01
Maternal history	2	5	8	0.04	4	2	1	0.03
Libido/active	5	8	2	0.06	6	2	5	0.05
Coat color	21	40	35	0.30	24	37	29	0.30

R3= households ranked first; R2= households ranked second, R1= households ranked third given for each selection criteria divided by the sum of R3, R2, and R1 for all selection criteria in a study site; R= Rank.

for males in the Afar region around the Asayta district.

The association between ranking for traits and study areas was not significantly different for survival, morphological, and behavioural traits. The relatively lower index value was observed in the pastoral study area for age at sexual maturity trait compared with the agropastoral study area.

Goat reproductive performances in the study areas

The age at sexual maturity of male goats was 9.70±0.03 months in the pastoral study areas and 9.42±0.02 months in the agropastoral study areas. Female goats were mated first at the age of 10.39±0.03 months and 10.12±0.02 months in the pastoral and agropastoral study areas, respectively (Table 6). Age at puberty was significantly influenced by season of birth. The female kids born in the wet season exhibited early oestrus compared with dry season born. This is due to the quality and quantity of feeds available during the wet season, which confirms that puberty depends on body weight rather than age (Zeshmarani *et al*., 2007; Bushara and Abu, 2012). Robinson *et al*., (2006) reported that puberty occurred with inadequate nutrition during the growing periods retards growth and delays puberty in the young doe.

The age at first kidding was averaged at 15.88±0.12 months in the pastoral study area and 15.78±0.22 months in the agropastoral one. Hulunim, (2014) reported that age at first kidding for Bati, Borena, and Siti area goats averaged 14.98±0.24, 15.86±0.22, and 20.15±0.12 months old, respectively. However, the current study's result was lower than the one indicated by Belete (2009) who reported younger age at first kidding for Arsi-Bale (12 months) goat types. These variations might be due to environmental factors, genetic differences, and feed availability. Alexander *et al*. (1999) reported that different factors, such as an individual's genetic composition, physical environment, nutrition, and time of birth affect reproductive traits, including age at first kidding.

The same factors could explain the difference in the age at first parturition between the current findings and the age reported by Belete (2009), for goats in western Ethiopia, of 12.46 months. On the other hand, Samuel (2005) reported age at first kidding of 13.18 for goats in the Yerer watershed of Ada'a Woreda. Dry season was associated with delayed age at first kidding, which signifies that the dams had an

Table 6. Reproductive performances of goats in both study areas

Reproductive trait	Pastoral	Agropastoral	
	MS±SE	MS±SE	Range
Age at 1st mating males (months)	9.70±0.03	9.42±0.03	6 - 16
Age at 1st mating females (months)	10.39±0.05	10.12±0.04	6 - 17
Age at 1st kidding (months)	15.88±0.34	15.78±0.22	12 - 24
Kidding interval (months)	8.27±0.22	8.20±0.14	7 - 12
Average years of service of buck	4.79±0.18	4.13±0.25	2 - 8
Number of kidding/ lifespan /does	10.15±0.33	10.52±0.28	6 - 15

SE= Standard error, MS= Mean square.

Table 7. Least squares mean (±SE) of kids' birth weight

Factor	Pastoral KBW (kg)			Agro-pastoral KBW (kg)		
	N	LSM±SE		N	LSM±SE	
Overall	146	2.37±0.02		48	2.41±0.01	
Sex			**			**
Male	68	2.71±0.01[a]		28	2.74±0.04[a]	
Female	78	2.35±0.01[b]		20	2.32±0.04[b]	
Parity of dam			*			*
1	18	2.31±0.112[b]		8	2.34±0.01[b]	
2	36	2.43±0.221[a]		10	2.46±0.03[a]	
3	42	2.58±0.11[a]		18	2.60±0.04[a]	
4	29	2.67±0.12[a]		7	2.70±0.01[a]	
≥5	21	2.41±0.11[a]		5	2.44±0.21[a]	
Type of Birth			*			*
Single	87	2.49±0.06[a]		35	2.53±0.03[a]	
Twin	29	2.20±0.08[b]		13	2.25±0.01[b]	

[a, b, c] means in the same column with the different superscript letters are significantly different; ** P<0.01, * P<0.05; LSM = least-square means, SE = standard errors, N = number of observations, KBW= Kid Birth Weight

opportunity to develop to full body size before first kidding (Warui *et al.,* 2007).

The average kidding interval of breeding in the current study was 8.27±0.22 months in the pastoral region and 8.20±0.14 months in the agropastoral study area. The kidding interval is a valuable indicator of reproductive efficiency in a flock (Belete, 2009). Webb and Mamabolo (2004) reported average kidding intervals of 8.6 months for indigenous goats of Mpumalanga, South Africa, which was higher than the current findings. These breeds have better reproduction performance than goats in the Borena area which might be attributed to either genetic and/or management variation.

Regarding the reproductive lifespan of males and females, it was 8.6 years in agropastoral and pastoralist study areas. This research finding was higher than the finding of Mahilet (2012) 7.45 years conducted at Hararghae highland goat. In the current study, the average offspring per doe is about 10.15 per lifespan in the pastoral study area and 10.52 in the agropastoral study area. This was lower as compared with the report of Markos (2000) where the kidding interval of goat ranges between 9-12 months. The average weaning age for both male and female goats was indeterminate in the current study. Weaning is determined more by growth rate than by age. As a result, dams with good mothering abilities dry out faster than those with poor mothering abilities. The average litter size of goats was 1.37 in the study area. This was lower as compared to the average litter size of 1.6 reported by Hailu *et al.* (2006) for Arsi Bale goats; as well as the average litter size of 1.7 reported by Webb and Mamabolo (2004) for indigenous Nigerian goats. The low litter size of goats in the study area suggests that the pastoralists do not prefer multiple births.

On-farm goat growth performance evaluation and monitoring

Growth performance

Birth weight is strongly influenced by breed (genotype), sex of the kid, birth type, age of doe, feeding conditions, season of birth, and production system. The effect of non-genetic factors (population and/or production environment, sex of kid, parity of dam, and type of birth) on the growth performance of kids, and weights at different ages of goat (birth, 90, and 180 days) at the study areas were recorded.

Average birth weight

The overall live weight at birth was 2.37±0.02 kg in the pastoral study areas and 2.41±0.01 kg in the agropastoral ones (Table 7). The current research result was lower than the result of the birth weight in Abergele goats recorded (2.6 kg) in the intensive management system reported by Berhane and Eirk (2006). The result showed that there is no significant difference in kids'

Table 8. Least Squares means (±SE) of kids' birth weight in the study areas

	Factors		90 DW (kg)			180 DW (kg)	
	Overall	N	LSM±SE		N	LSM±SE	
	Pastoral	146	10.52±0.13		146	13.75±0.21	NS
	Agropastoral	48	10.58±0.14		48	14.01±0.42	
Pastoral	Sex			NS			NS
	Male	68	11.12±0.26		68	14.10±0.27	
	Female	78	10.16±0.38		78	14.24±0.33	
	Parity			NS			NS
	1	18	10.79±0.31		18	14.14±0.32	
	2	36	10.92±0.33		36	14.34±0.28	
	3	42	9.80±0.27		42	13.60±0.25	
	4	29	11.35±0.8		29	14.62±0.46	
	5	21	10.60±0.24		21	13.87±0.37	
	Birth Type			*			NS
	Single	87	10.50±0.78		87	13.95±0.78	
	Twin	59	9.78±0.89		59	13.72±0.37	
Agropastoral	Sex			NS		NS	
	Male	20	11.41±0.29[a]		20	14.23±0.54	
	Female	28	10.28±0.34[b]		28	14.36±0.36	
	Parity			NS			NS
	1	8	10.85±0.23		8	14.23±0.21	
	2	10	10.97±0.26		10	14.27±0.17	
	3	18	9.87±0.15		18	13.68±0.24	
	4	7	11.43±0.11		7	14.68±0.32	
	5	5	10.67±0.12		5	13.80±0.20	
	Birth Type			*		NS	
	Single	35	10.65±0.25		35	14.40±0.18	
	Twin	13	9.82±0.14		13	14.27±0.23	

Means in the same column with different superscripts are significantly different at * p <0.05; DW=day weight; LSM=Least Square Mean; SE=standard error; N= number observation, NS= non-significant.

birth weight in both pastoral and agropastoral study areas. The difference in birth weight in livestock may be attributed to the effect of non-genetic parameters like parity. The birth weight of the kids is also influenced by the nutrition the dam receives during the pregnancy (Otuma and Osakwe 2008; Singh and Ramachandran 2007).

The current study revealed that parity significantly affects (P<0.05) birth weight in both study areas. Third and fourth parity birth weights and growth rates are relatively better than other parities. The decline in birth weight after the fifth parity might be due to tooth wear and the subsequent loss of maternal body condition and hence the delay in the rate of the foetus growth. Deribe (2009) reported that does in parity one, two, and five had significantly (P<0.05) lower birth weight than those in parity three and four.

In both pastoral and agropastoral study areas, sex had a significant effect on birth weight where males were heavier than females at birth (Table 8). According to Nkungu *et al*., (1995), the heavier body weight obtained by males may be attributed to the effect of the male sex hormone (androgen) which is responsible for the development of male characteristics.

In the current study, a kid's birth weight was influenced by the number of kidding. Single-born kids were heavier than their multiple contemporaries in both study areas. The heavier body weight of single-born kids is attributed to the weight advantage of having

Table 9. Least square means of daily weight gain of raised goats in the study areas

		Pastoral			Agropastoral	
Factor	N	ADWG/g/day (0 – 90)	ADWG/g/day (91-180)	N	ADWG/g/day (0– 90)	ADWG/g/day (91 – 180)
		NS	NS		NS	NS
Overall Mean	146	91.67±1.53	36..56±4.63	48	90.78±2.24	38.34±2.19
Sex		NS	NS		NS	NS
Male	78	89.78±3.61	38.45±2.23	20	89.56±3.21	38.55±3.21
Female	68	83.34±3.52	46.19±3.21	28	86.67±2.62	40.45±5.33
Parity		NS	*		NS	*
1	18	92.56±3.52	35.145±2.23^{ab}	8	94.43±1.14	20.54 ±5.47^{ab}
2	36	86.62±2.42	38.235±5.18^{a}	10	86.36±3.26	34.16±8.14^{a}
3	42	78.70±4.12	40.14±4.32^{a}	18	84.14±2.32	42.29±7.19^{a}
4	29	96.83±2.46	26.84±1.21^{b}	7	98.65±1.86	56.24 ±6.58^{b}
>5	21	88.65±3.11	34.45±3.25^{b}	5	90.29±2.26	32.52 ±7.42^{b}
Type of birth		NS	NS		NS	NS
Single	87	98.45±3.41	39.78±2.32	35	90.0±4.34	38.33±1.32
Twin	59	83.45±2.24	44.24±3.25	13	82.67±2.24	43.77±3.21

$^{a\ b\ c}$ Means in the same column with different superscripts are significantly different LSM= least-square means, SE standard errors, ADWG= average daily weight gain, N= number of observations, * P<0.5 NS = non-significant.

no competition for nutrients (milk) and having more inter-uterine space in cases where does carry one foetus compared to two or more Zahraddeen *et al*., 2008). Most of the literature supported that single-born kids are heavier than twins and that twins are heavier than triplets (Belay and Mengistie, 2013; Bushara *et al*., 2013; Shumuye *et al*., 2014).

Average body weight at 90 and 180 days of age

The average body weight (kg) of goats from 90 to 180 days of age for the studied goats is listed in Table 8. The overall least square means of body weight at 90 and 180 days were 10.52±0.13 kg and 13.75±0.21 kg, respectively in the pastoral study areas; and 10.58±0.14 kg and 14.01±0.42 kg in the agropastoral ones. The overall least square means, in both study areas, were not significantly different. The overall weaning weight of kids in the current study was lower than the values reported by Zeleke (2007) on-station (11.67 kg). In the current study, the overall growth rate of goat kids showed retarding trend after 90 days of age. This might be due to the environmental stress (drought) and feed shortage during the dry season.

Furthermore, the current result revealed that the effect of parity was not significantly different (P>0.05) in both study areas. The non-significant effect of parity on weaning weight was reported by some studies (Getahun, 2008; Endeshaw, 2007). In the current study, single kids grew faster and reached the weaning age earlier than multiple born. The influence of birth type on the daily growth rate of kids was significantly different (P<0.05) before weaning. The effect of birth type affected the growth of goats with a similar trend and consistently up to weaning; and thereafter diminished. During the monitoring period, pastoralists and agropastoralists suggested that they wean single-birth kids earlier because they could reach weaning weight earlier than the multiple-born.

The results of the kidding numbers in both study areas demonstrated that single kids grew quicker and reached weaning age earlier than multiple-born kids. Hence, the influence of the kidding number on the growth rate of kids was significantly different (P<0.05) before weaning. Further, while monitoring the performance of selected goat kids', goat keepers reported that single-birth kids weaned faster than multiple-birth kids.

Average daily weight gain (0-90 days)

The average daily weight gain of goats from 0-90 days in the study areas was not significantly different (Table 9). The 0-90 days growth (average daily gain) recorded in the present study was 91.667±0.53 g day^{-1} in the pastoral study area and 90.778±0.24 g day^{-1} in the agropastoral ones. The current result was higher than the result reported by Gemiyu

(2009) of 82.34 g day^{-1} for indigenous goats in the Southern part of Ethiopia. This might be due to genetic differences and feed availability. Furthermore, the current research's result was also higher than the value indicated by Girma (2002) for Arsi-Bale goats under field conditions (56.2 g d^{-1}). Furthermore, the current research report is also higher than Arsi-Bale goats under field conditions 56.2 g d^{-1} (Girma, 2002).

In terms of daily body weight gain, there was no significant difference between male and female kids. Furthermore, the average daily weight gain at age 0-90 days of goats was not affected by sex or parity. However, Bazzi and Tahmoorespur (2013) reported heavier average pre-weaning daily gain of females than males. The influence of the type of birth on the daily weight gain of kids at ages (birth - 90 days) was not significantly different and only with numerical differences in favour of kids born as single.

Average daily weight gain (91-180 days)

The daily weight gain after 90 days of age was smaller as compared with before 90 days of age (Table 9). Post-weaning growth (average daily gain) obtained in the present study was 36.56±4.63 and 38.55±3.21 g day^{-1} in the pastoral and agropastoral study areas, respectively. The daily weight gain of male and female goats was not-significantly different for all age categories. However, the parity effect was significantly different ($P<0.05$) at 91-180 days of the age of kids on daily weight gain in the study areas. Even though, the increment of daily weight gain in the advancement of parity at different ages was inconsistent, in most cases kids at 2nd, 3^{rd,} and 4th parity had better daily weight gain. Belay and Mengistie (2013) reported that kids from the 3rd and 4th parity had relatively higher daily weight gain as compared with kids from 1st and ≥5th parity.

Conclusion

In Ethiopia, different breeds of goats are reared across diverse agroecological zones and under an extensive production system. Goats were the predominant livestock species in the study areas mainly reared for income generation. The goat keepers select the best goat for production using traits like body size, growth rate, milk yield, kid survival rate, reproduction rate, and coat colour. Body size/ conformation was ranked 1st for males' and females' goat selection in both study areas. Survival, morphological characteristics, and behavioural traits were among the preferred traits for female goat selection. The growth rate and body conformation/body size of the goats in the study areas were reasonably the best. The indigenous goat keepers reported that goat productivity was being challenged by a lack of feed and recurrent drought, which impacted their income. As a result, it is important to continue genetically improving the performance of the goat population in the study areas through selection and the development of goat improvement strategies that largely focus on livelihood improvements of goat keepers. Indigenous goat keepers also reported that the government and non-government organizations' intervention will be highly necessary.

Authors Contribution

Dr. Hussein Mohammed: Data collection, data analysis, and manuscript writing. Dr. Birhanu Tesema: study design, planning, data analysis, manuscript writing, and editing.

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