Tropical Animal Health and Production

Participatory identification of breeding objective traits and selection criteria for indigenous goat of the pastoral communities in Ethiopia

--Manuscript Draft--

Manuscript Number:	
Full Title:	Participatory identification of breeding objective traits and selection criteria for indigenous goat of the pastoral communities in Ethiopia
Article Type:	Regular Articles
Keywords:	Borena; breeding program; Konso; flock ranking; traits of interest
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Funding Information:	CGIAR Research Program (CRP) on Livestock and M-BoSs — Not applicable
Suggested Reviewers:	Solomon Abegaz Guangul, PhD Researcher, Amhara Regional Agricultural Research Institute soabgu96@yahoo.com Good technical capability and experience to work with goat community based breeding program in developing countries situation.
Opposed Reviewers:	

Participatory identification of breeding objective traits and selection criteria for indigenous goat of the pastoral communities in Ethiopia

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Abstract

Structured questionnaire, own-flock rankings and group discussions were undertaken to assess goat breeding practices and to identify traits of interest for genetic improvement of pastoral goats. Four pastoral villages in Ethiopia namely Jarso, Mesoya, Eleweya and Dharito were selected purposely based on their goat production potential and accessibility. A survey involving 70 households, and measurement of 199 goats in 4 villages was used. Data obtained from questionnaire, flock ranking and measurements were subjected to both qualitative and quantitative data analysis. In flock ranking experiment, goat owners were asked to choose the first three superior and a worst doe within their own flock. They were also asked to provide reason for ranking the animals. In addition, data on size traits, kid growth, kid survival, reproduction traits, and milk yield were recorded for each doe. Large variation was observed between top and last ranked does in most of the traits and price: for example, in body weight (33.6±0.88 vs 25.2±0.93 kg), doe's kid survival (92.1±4.01 vs 59.6±4.48%) and doe's price (1367±46.5 vs 833± 46.9 [1]Ethiopian Birr). Mobility is practiced with defined and known pattern, therefore recruitment of a mobile enumerators for data recording would assist in implementation of breeding programs. Breeding objective should emphasize mothering ability (kid growth

[1] 1 USD = 28.4 Ethiopian Birr

and survival), milk yield of does and coat colour in all areas. Due to its good correlation with other traits like kid growth and pre-weaning kid survival, considering milk yield alone as selection criteria or giving more weight for milk yield in the breeding program could generate better genetic benefit. Setting-up breeding program should be based on full participation and context of pastoralists.

Key words: Borena, breeding program, Konso, flock ranking, traits of interest

Introduction

Small ruminants in developing countries contribute to food security, income generation and socio-cultural benefits. Ethiopia has huge small ruminant population estimated at 60.9 million heads (CSA, 2017). Goat production is an integral component in pastoral systems of Ethiopia and plays a vital role for the livelihood of the community. Under a challenging pastoral environment, goat has multiple roles in providing food (milk and meat) for the household (Bett et al., 2009; Gebreyesus et al., 2013). In addition, they serve as source of income, socio-cultural benefits and as means of expressing social prestige (Gebreyesus et al., 2013). Goats are especially important to women, children and the aged, who are often the most vulnerable members of the society in terms of under-nutrition and poverty (Kosgey, 2004).

Breed improvement programs in developed countries are successful due to strong national breeding programs coupled with high level of input, good technical capacity and infrastructure and good enabling situations. However, many difficulties have been faced with the implementation of small ruminant breeding programs in developing countries (Ayalew et al., 2003). Community-based breeding programs (CBBP) have been suggested as attractive options and are being implemented in the highlands of Ethiopia (Haile et al., 2011) and other developing countries (Mueller et al., 2015). These CBBPs have shown remarkable genetic progress in targeted production traits (Haile et al., 2018). However, setting up and implementation of any breeding program in pastoral areas remain challenging. An earlier attempt to implement CBBP in the pastoral system in the Afar region of Ethiopia was discontinued due to lack of progress and a failure of adapting the approach to the challenging circumstances (Getachew et al., 2018). Irrespective of the challenges; huge variation, adaptive genetic resource and high dependency of community on small ruminants still justifies the importance of designing breeding programs fitting the system. Participatory way of breeding objective identification and understanding the context of local breeding practices is crucial for the success of such schemes. Therefore, with the overall objective of designing and implementing CBBPs in pastoral areas we investigated the breeding practices, breeding objectives and selection criteria adopted by pastoralists of different goat breeds.

Materials and methods

Study sites and their description

The study was carried out in Konso and Borena pastoral areas of southern Ethiopia. Two villages in each; Mesoya and Jarso in Konso and Eleweya and Dharito in Borena district were selected purposely based on their goat potential, representativeness of the pastoral system and their accessibility. The areas are characterized by low moisture, recurrent drought and seasonal mobility of animals in search of feed and water. Goat production is considered as major farming activity in both districts.

Data collection

Interview and group discussion

In each village, randomly selected goat owners were approached and interviewed using structured questionnaire. A total of 70 owners of goat (19 in Jarso, 20 in Mesoya, 11 in Eleweya and 20 in Dharito) were interviewed in October 2017 (Table 1). Questionnaire were focused on obtaining information on understanding source of currently available breeding animals, breeding practices, rank of important traits, mobility pattern and kid survival rate. Comprehensive list of traits was provided to each owner and each of them was asked to confirm the importance of the trait and direction of improvement they want. They were also asked if traits of importance were missed from the list. Then respondents were asked to rank them.

Table 1.

In addition, a focus group discussion was conducted in each village with 6-8 people (2-3 women). The discussions were focused on identifying breed uniqueness, breeding knowledge, socio-cultural role of goat breeding, sire sharing, mobility pattern, selection, culling and castration practices, fattening practices and goat production challenges.

Own animal scoring/ranking for does

Goat owners were asked to choose the first three superior and a worst doe within their own flock. They were also asked to provide reason for ranking the animals. In addition, data on coat colour type, size and growth traits like, body weight (BW), body length (BL), chest girth (CG), height at wither (HW), ear length (EL) and horn length (HL), reproductive performances and mothering ability (doe parity, number of kids born so far, number of kids survived to weaning age, kidding interval (KI) and kid growth (KG) score, milk yield (MY) score, body condition (BC) score were recorded for each does. BC score assessed subjectively and recorded 1 to 5 as 1 very thin and 5 very fat. Pre-weaning kid survival (PWKS) was calculated for each doe as proportion of kids survived to weaning age to total number of kids born in her life time. Twining rate (TR) was also calculated for each doe as a proportion of number of kids born to doe parity. Owners provided information on MY performance for each doe as low, medium and high; kidding interval as short, medium and long and doe's KG scored as slow, medium and fast for each animal based on their memory. Economic value in terms of amount of money the owner is willing to pay (WTP) if he were to buy the doe for breeding purpose were recorded for each doe.

Data analysis

All data were analyzed using R software. Cross table (crosstable) function in R using "gmodels" package was used to produce cross tabulations for qualitative data. Chi-square test was employed to assess independence between village and different variables like trait preferences, breeding buck availability and flock migration. Index based ranking was used to determine the relative importance of ranked traits. Index was calculated within district using the formula given by Zonabend König et al. (2016).

$$I_j = \sum_{i=1}^{3} r_i\ x_{ij}\ / \left(\sum_{j=1}^{7}\ \sum_{i=1}^{3} r_i\ x_{ij} \right)$$

Where, x_{ij} = is the number of respondents giving rank *i* (*i*= 1, 2 and 3) to trait *j* (*j*= seven trait categories include growth, survival, reproduction, morphological manly coat colour, milk yield, behavioral traits). r_i is the weight corresponding to the rank in which weight of 3, 2, and 1 assigned for the rank 1, 2 and 3, respectively; aiming to give the highest number for the most important trait.

Linear model (lm) function in R software was used to analyze quantitative data collected through questionnaire and own flock ranking experiment fitting village (Jarso, Mesoya, Eleweya and Dharito) and doe rank (first, second, third and last) as independent fixed factor and body condition score, litter size, kid survival proportion, willingness to pay, body weight and body measurements) as dependent variables. Interaction between village and doe rank was removed from the model as it was not significant (P>0.05) in preliminary analysis. When the model was significant a post-hoc test was employed using Tukey's honestly significant difference (HSD) tests, α = 5% to compare least squares means in a main effect.

Partial independence test using log linear model (loglm) in R was used to test if village was independence of the composite variables rank with kid growth score, rank with milk yield score and rank with kidding interval score. In all cases, this model was not significant (results not shown here) so that analysis was done ignoring village. Then a non-parametric, Kruskal-Wallis test was carried out to compare score of does for their performances (in their kid growth, milk yield and kidding frequency) and rank of does. There was a very strong evidence of difference in the mean score of kid growth, milk yield and kidding frequency of at least in one pair of ranking groups. Then pairwise post-hoc analysis using Tukey distribution approximation were employed to compare mean values of different rank levels.

Spearman's rank correlation of doe rank with thirteen different doe characteristics, doe BW, BC score, KI score, TR, PWKS, KG score, MY score, doe monetary value in terms WTP, BL, CG, HW, EL and HL was employed using R. Seven doe characteristics (KI score, KG score, MY score, PWKS, TR, CG and BW) were selected among the 13 based on their association level with doe rank and aiming to represent different traits. These traits were subjected to pair wise correlation analysis.

Results and discussion

Breeding and production practices

Source of breeding goats

Generally, available goat flocks are results of long-term natural selection for adaptation to specific environment as well as selection by human being based on indigenous selection criteria. Birth, purchase and gift were found to be important sources of building goat flock. There was no association (P>0.05) between location and the reasons for animal source. In this study, for majority (80.6 %) of the household's birth is the main way of acquisition of breeding does; among them, selection within the flock based on performance was the major source of currently available does for 54.8% of the respondent's while natural selection was the main source for 25.8 % of the respondents (Table 2). Acquisition from market and gift from parents were the major source of current does for the 11.3 and 8.1 % of the respondents, respectively. In Konso, source of buck is home grown, there is no purchase from outside. However, Borena community use bucks from other sources including those purchased from markets. This agrees with other study in southern Ethiopia by Tsedeke, (2007) who reported that birth has been the main way of flock building in sheep and goat and of bucks born in the flock has also been common in other pastoral areas of Borena and Shinele (Gatew et al., 2017).

Table 2.

Selection criteria and breeding knowledge

Size of the animal, milk yield, frequent lambing and prolificacy and morphological traits, mainly coat colour of the animal, were the frequently mentioned reasons to retain breeding does in the flock. Traits like big size, tall body frame, long leg; and white and brown colours were considered when buying animals. Black is unwanted colour in all villages and the price margin with black color (not preferred) for example in Konso area is 200-300 birr. Tera et al. (2013)

also reported that black colored Horro sheep received a price discount of about 15% as compared to red coat colored sheep. Flock size per household in Konso is between 15-200. Male to female ratio on average is 1:10 however, in some cases having larger number of breeding buck is common in Konso district. Breeding bucks are used for 2-3 years. There is no knowledge of inbreeding, they even encourage mating between relatives. pastoralists also reported that small size, lambs growing horn immediately after birth, curled tail shape and diseases, particularly coenuruses, could also be among the reasons for immediate culling of animals. Infertile does and short eared goats are also subjected to culling in Borena area. Selection and culling criteria mentioned by pastoralists in this study are in general agreement with other studies in smallholders and east Africa pastoralists (Gebreyesus et al., 2013; Marshall et al., 2016; Gatew et al., 2017) and we are not aware of any other study reporting culling of lambs growing horn immediately after birth. Pastoralists in the study areas believe that such incidence is considered as a curse and will bring bad luck to the family unless culled immediately.

Socio-cultural role of goats

Goat have multiple socio-cultural roles in all areas including source of income, milk, and are slaughtered for home consumption, for guests and relatives, wife delivery, cultural and religious festivals. Goat are also slaughtered as compensation when elders after conflict recommend that somebody is hurt; given as gift to help the poor and relatives; and they are bought for small money but can easily multiply and are sold to buy cattle. The same role of goats is also reported for Issa community in eastern Ethiopia (Gebreyesus et al., 2013).

Castration/ fattening

Fattening is a common practice in Konso while not in Borena. Fattening was done after breeding service (usually after 2-3 years) and is done for a period of 6 months to 3 years. However, fattening was proceeded by castration. They do castration after 2 years old. To start fattening they make sure that the animal has stopped growth, detected by the smell the buck produces. Fattening is based mainly on grass but are sometimes given local brewery by-products.

Goat production challenges

The major goat production challenges in both areas include disease (coughing, lung problem, liver fluke, coenurosis, Contagious Caprine Pleuropneumonia and skin disease), feed shortage, both in quantity and quality. This agrees with other studies in pastoral areas of Ethiopia (Loretto et al., 2015; Gatew et al., 2017). lack of appropriate markets has also been identified as one of the challenges. The communities reported that they have local markets and buyers come from different places but they believe the price they get for their animals is not attractive. Community animal health workers could be trained to reduce some of the challenges associated with disease.

Table 3.

Breeding buck availability in the flock

There was no association (P>0.05) between study sites and breeding buck possession (Table 4). Majority of the goat owner respondents (73.4%) reported that they had at least one breeding buck while the remaining 26.6% of goat owners reported that they had no breeding buck in their flock. Average number of breeding buck per household was 3.09 with range of 1 to 15 (Figure 1). In all sites, all the currently available breeding bucks were born in the flock and appeared as the result of selection by the owner for preferred traits.

Table 4.

Frequency distribution of number of buck available per household varied by location. It showed a wider range in konso district; Jarso (0 to 15 bucks) and Mesoya (0 to 10 bucks) compared to Borena district which was found in the range of 0 to 4 bucks per household (Figure 1). Irrespective of location, those without breeding buck reported that they used neighbors and relative buck in communal grazing land and watering points to mate their breeding does.

Average doe flock size per household in the study area is in the range of 9.3 to 15.1 (Netsanet, 2014; Gatew et al., 2017) and the majority (more than 90 %) had less than 25 does (Gebreyesus et al., 2012). This clearly indicated that goat owners in Jarso and Mesoya keep surplus breeding bucks in their flock. Surplus breeding bucks (~1:3 buck to doe ratio) was also reported in east Ethiopian pastoralists flocks (Gatew et al., 2017). Surplus bucks in the flock suggests that sufficient number of males are kept in the flock for mating purpose, however it affects the genetic progress due to less selection intensity. Wilson and Durkin (1988) recommended a male to female ratio of 1:25 for goats under traditional extensive systems. Thus, retaining best ones and culling surplus bucks in Jarso and Mesoya will be one the major intervention areas in implementing breeding program. Promoting profitable fattening technology and market linkage would be crucial to encourage pastoralists to sell unselected males. Unlike Jarso and Mesoya, availability of fewer bucks is an indication of over culling practice, which might be challenging in implementing community-based breeding program. Getting breeding buck from somewhere else at the beginning of the breeding programs; and devising mechanisms to retain best buck kids in the flock need to be considered in Eleweya and Dharito.

Figure 1.

Mobility, flock mixing and buck sharing

Majority (91%) of goat owners reported that they move their goat temporarily to other places in search of feed and water mainly during the dry season. When drought hits (water shortage) they evaluate the situation about possible migration place and move. They have clear mobility pattern where they go and establish their own sites. Usually they migrate to river side. By the way, the communities have permanent settlement area (house) and part of the family takes the goats, spend part of the year and return with their animals when situations improve. Usually mobility is practiced once in a year; usually they migrate in January and come back home in April. Goat owners reported that all goat classes migrate except with very few goat owners who reported that kids and goat for fattening are maintained and managed in permanent places. Mating and kid rearing were continued in new places as it were practiced in permanent place. Indeed, carrying new born animals during migration and preparing new house for the new born kids were a common practice by many goat keepers.

There was significant association between location and flock mixing (*P*=0.05) both in permanent and new settlement places (Table 5). Larger proportion (63 to 65%) of the respondents in Jarso and Mesoya mentioned that they herded their flock separately, where as in other locations, Eleweya and Dharito most of them (66 to 74%) reported that they mix their flocks. It has also been reported in other pastoral areas that majority of the communities herded their flock separately (Gebreyesus et al., 2013). Practices of sire exchange which is more common in sheep community-based breeding programs reported by Haile et al. (2011) should be promoted and reorganized with the keepers to reduce the negative effect of inbreeding. Proportion of goat owners mixing their flock increased during migration in all locations (Table 5).

Number of goat flocks mixed together were 8, 4.5, 3.5 and 2.8 in permanent place and 8, 5.7, 3.6 and 7.3 in new place for Jarso, Mesoya, Eleweya and Dharito, respectively. Mixing flock has usually been practiced among flocks of neighbors and relatives. Same bucks used in permanent place also used for about 41 % of the flocks during migration time. However, the remining 59% reported that a possibility of using new sires either from the same or different community.

Table 5.

Test of association between interest in buck sharing and location was in the margin (*P*=0.058). Among the respondents; 52.6, 50, 100 and 52.6% in Jarso, Mesoya, Elewya and Dharito, respectively were interested to share their breeding buck to others. Willingness of sharing a buck is a very important element in designing breeding program as it helps to increase buck accessibility, ease the transfer of genetic merit of best bucks to wider flocks as well as to reduce inbreeding level (Haile et al., 2011). On the other hand, almost half of goat owners in Jarso, Mesoya and Dharito are not willing to share bucks (Table 6). It is important to understanding their reasons, thorough discussion and bringing them on board is crucial for setting up community-based breeding programs.

Table 6.

Pre-weaning kid survival as perceived by pastoralists in different seasons

As expected survival proportion in good season were higher (78.4 to 96.1%) compared to survival values for kids born during the dry season (42.4 to 62.2 %). Better survival was observed in Mesoya and Jarso in both seasons and management type (Table 3). Kid survival was very low (42.4%) in Dharito during the dry season when managed in permanent places. Animal movement during the dry season tended to improve kid survival in all villages (e.g. in Jarso increased from 42.4 to 56.1%). Very low kid survival during the dry season observed in this study would have negative effect on breeding program as it limits the number of candidate buck kids available for selection. Feed and water shortage has mostly been reported as the major constraints limiting animal productivity in the pastoral areas (Gebreyesus et al., 2012). Thus, urgent interventions are needed to minimize the harsh effect of dry season and thereby reduce kid mortality and contribute to safe guarding the livelihood of pastoral communities. Successful pilot development interventions like water development and range land management in Borena pastoral areas which resulted in a year-round grazing (Homann et al., 2008) need to be implemented in a large scale. Additionally, traits having positive association with kid survival like good milk yield and optimum birth weight (Oseni and Bebe, 2010) need to be considered in the selection index.

Traits for genetic improvement

Trait ranking

Multiple traits with varied interest levels were identified as attributes of the goat owners would like to improve in the future (Table 7). Four trait categories; traits related to size and growth, reproduction traits like (frequent kidding, early age kidding and litter size), milk yield, and morphological traits mainly coat colour were highly ranked with very close index values. Survival of kids ranked next to those traits. It is obvious that survival traits are masked by other traits like fast growth and good milk yield of dam which has association with survival (Oseni and Bebe, 2010; Dossa et al., 20017). Some farmers, as observed during own flock ranking, preferred single kidding to have extra milk for the family (e.g. in Jarso).

Association between ranking for trait and village was significant ($P<0.05$) for survival, morphological and behavioral traits (Table 7). Relatively lower index value was observed in Jarso for survival trait compared to other locations. Coat colour of the animal ranked high (second) in Eleweya and Dharito site indicating the importance of this trait in these villages. Relatively larger index was observed in Mesoya for behavioral traits. Multiple breeding objectives of are reflection of multiple roles goats play in the livelihood of pastoral communities. Similar traits of interest and multiple breeding objectives have been documented in similar low input production systems (Bett et al., 2009; Ilatsia et al., 2012; Gebreyesus et al., 2013; Woldu et al., 2016).

Table 7.

Own flock ranking

Body condition score, TR and PWKS influenced decision of owners in ranking their own does (*P*<0.05) (Table 8). Does with significantly lowest mean BC score (2.7) and having history of lowest PWKS in her life time (59.6 %) were ranked as last by the owners. In contrary, does ranked first had the highest BC score. Does which ranked 1 to 3 had higher kid survival performance (83.9 to 92.1 %) compared to does ranked last but there was no difference among the top 3 does in kid survival. Similarly, does with higher LS were ranked as top. Does in Jarso and Mesoya had better *P*<0.05) body condition score compared to does in Eleweya and Dharito. However, pre-weaning kid survival was not influenced by location (*P*>0.05).

Table 8.

Ranking decision by owners for does was highly influenced by doe MY and her kid growth (*P*<0.05). According to the goat owner's perception those does which rank first produce more milk and their kids grow fast compared to third and last ranked does (Table 9). However, there was no association between kidding interval score and doe ranking (*P*>0.05).

Table 9.

Size, morphological traits like BW and linear body measurements and price of does were also influenced (*P*<0.05) by doe rank and village except for horn length which has not affected ranking decision. Does ranked as last had lowest value compared to the first, second and third ranked animals. Observed variation between top and last ranked does in size (Table10) indicated the existence of huge within flock variation which would be exploited through structured breeding program. For example, does chosen as first rank were on average 8.4 kg heavier than last ranked does. Goats in Jarso was lighter in body weight and smaller in size (*P*<0.05) compared to goats in other locations. Pastoralist were willing to pay higher (*P*<0.05) price for the first ranked does compared to others, and there was no difference in WTP between rank 2 and 3. Pastoralists expressed their WTP 64.1% more for first ranked, 37.4% for third ranked does than for the last ranked does (Table 10). Such significant difference between best and worst ranked does in size, BW and WTP was also reported in Red Massai and Dorper sheep in Kenya (Zonabend König et al., 2016).

Table 10.

Correlation of doe rank with other traits

Most of the doe size, production, reproduction and morphological traits considered in this study had positive association but with varied level with the rank of does given by the owner (Table 11). Maternal traits like MY of does and growth of kids had consistently high correlation with doe rank in all locations. Twining rate had positive association with rank of does in Jarso and Eleweya (P<0.001) whereas no association (P>0.05) in Mesoya implies twinning is not a preferred trait in Mesoya. Association of BW and linear body measurements with doe rank is not consistent across locations. All measurements had significant association with doe rank particularly in Jarso and Eleweya village. Ear and horn length had positive (P<0.05) association with doe rank in Jarso only. Large ear and horn is preferred by the community in Jarso.

Table 11.

Correlation among selected traits

Does with good twining rate had positive association with larger size and better milk yield (P<0.05). Pre-weaning kid survival was positively associated with KG, size measurements and MY of its dam. Positive association between lamb growth and survival were also reported in Menz sheep (Getachew et al., 2015). To ensure success of breeding program in small holder low input system, traits to be considered in selection program should be few and easy to measure (Sölkner et al., 1998). Positive relationship among TR, size traits like KG, doe size and doe body measurements and doe milk yield observed in this study suggested that selection index considering few among the list would suffice. Highest correlation coefficient between doe milk yield and rank (0.69) and doe's fast kid growth and doe rank (0.72) was found in this study (Table 12). Milk yield had also good (r=0.19 to 0.78) and significant (P<0.05) correlation with KI, TR, KPWS, CG and BW. The highest correlation found between MY and KG score and many other traits suggests that using MY as selection criterion is the most promising option to ensure reasonable kid growth and better kid survival. In agreement to this, significant and positive genetic progress has been achieved for number of kids survived to weaning age and weaning weight in the Egyptian Nubian sub-tropical goat breed when selection was made based on total milk yield (Afoul-Naga et al., 2012). Castañeda-Bustos et al., (2014) also found milk yield as one of the most important indirect prediction of real production life of goats in the US. Thus, due to its higher association with top ranked does and good correlation with other traits found in this study, and moderate to high heritability (Aboul-Naga et al., 2012; Castañeda-Bustos et al., 2014) and significant contribution of milk as staple food (Gebreyesus et al., 2013) inclusion of milk yield alone or giving more weight for milk yield in the breeding program could generate better genetic benefit. Recurrent drought in pastoral areas and low survivability of kids during the dry season justifies the importance of considering adaptation trait in the breeding program. However, measuring adaptation traits remain challenging and selection for indirect associated traits like milk yield and higher birth weight in the given environment will be more feasible and practical way. Two stages selection; selection based on records and participation of the community to approve selected animals based on their preference (Haile et al., 2011) is important to accommodate pastoralists preference of morphological characters.

Table 12. Pairwise Spearman's rank correlation among selected variables (upper diagonal) and associated P values (below diagonal)

Results confirmed that participatory approaches including questionnaire, group discussion and flock ranking seem useful tool in understanding the production situation and identifying key traits of interest for genetic improvement. Flock mobility is practiced in well-defined pattern and therefore, recruiting enumerator/s willing to move with flocks would likely address problem of data collection during mobility time. Thus, strategy to identify kids with top estimated breeding values at early age and sustain them (e.g. through better management) is crucial to minimize loss of best genotypes through kid mortality. Size traits, mothering ability (kid growth and survival), milk yield and coat colour in varied level were identified as major traits to be improved in all sites. Considering milk yield alone as selection criteria or giving more weight for milk yield in the breeding program could generate better genetic benefit. Organizing different mating groups and arrange buck sharing system would help to increase buck accessibility as well as speed up genetic progress by allowing use of few top ranked bucks. Training of the community about mating system, buck sharing and effect of inbreeding is recommended.

Acknowledgments

The authors are grateful to CGIAR Research Program (CRP) on Livestock and M-BoSs project for funding this research. We are grateful for pastoralists and staff of research and development agents who participated in data collection.

Conflict of interest

The authors declare that they have no conflicting interests.

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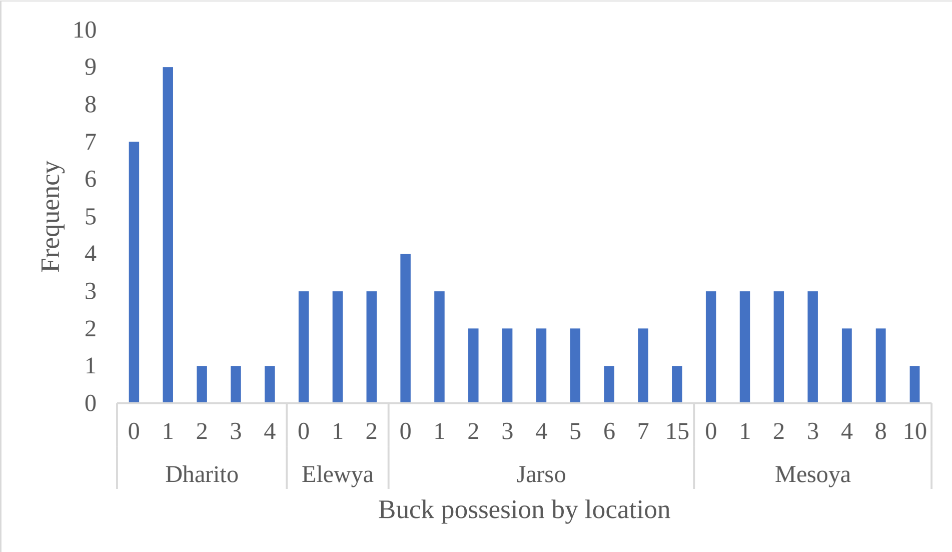

Figure 1. Frequency distribution of breeding buck possession in different locations.

Table 1. Sampling details by village

District	Village	Respondent households	Animals sampled
Konso	Jarso	19	72
	Mesoya	20	32
Borena	Eleweya	11	47
	Dharito	20	48

Table 2. Frequency of major reason for the source of breeding does in different locations

Reasons	Village				Overall	Chi square P value
	Jarso	Mesoya	Elewya	Dharito		
Selected based on performance	8 (44.6)	10 (66.7)	5 (55.6)	11 (61.1)	34 (54.8)	0.096
Appeared as result of natural selection	3 (16.7)	2 (13.3)	4 (54.5)	7 (38.9)	16 (25.8)	
Purchased	5 (27.7)	2 (13.3)	0 (0)	0 (0)	7 (11.3)	
Obtained as gift from parents	2 (11.0)	1 (6.7)	0 (0)	0 (0)	5 (8.1)	

Number in parenthesis are percentage for reasons within location

Table 3. Pre-weaning kid survival as perceived by owners in different locations and seasons of the year

Location	During good season	During dry season	During movement time
Jarso	96.1 (4.64)^{a}	59.4 (5.37)^{ab}	64.8 (8.70)
Mesoya	92.2 (4.64)^{ab}	62.2 (5.06)^{b}	73.9 (8.70)
Elweya	88.3 (4.92)^{ab}	54.4 (5.06)^{ab}	61.3 (9.23)
Dharito	78.4 (3.19)^{b}	42.4 (3.49)^{a}	56.1 (6.15)
P-value	0.0122	0.00723	0.421

Values with different superscript letters within column are significantly different at $P = 0.05$.

Table 4. Frequency of breeding buck availability in different location

Location	Yes	No	Chi square	P
Overall	47 (73.4)	17 (26.6)	2.229	0.5262
Eleweya	6 (66.7)	3 (33.3)		
Jarso	15 (78.9)	4 (21.1)		
Mesoya	14 (82.4)	3 (17.6)		
Dharito	12 (63.2)	7 (36.8)		

Number in parenthesis are percentage values

Table 5. Frequency of flocks herded separately versus mixed and average number of flocks mixed together in permanent place and new place

Location	Herded separately	Mixed with other flock	Chi square	P	Number of flocks mixed
In permanent place			12.54	0.05	
Jarso	12 (63.1)	7 (36.8)			8.0
Mesoya	11 (64.7)	6 (35.3)			4.5
Elewya	3 (33.3)	6 (66.7)			3.5
Dharito	5 (26.3)	14 (73.7)			2.8
In new place			15.726	0.0153	
Jarso	10 (58.8)	7 (41.2)			8.0
Mesoya	2 (15.4)	11 (85.6)			5.7
Elewya	1 (12.5)	7 (87.5)			3.6
Dharito	9 (47.4)	10 (52.6)			7.3

Number in bracket are percentage values

Table 6. Interest to share bucks in different villages

Village	No	Yes	Chi square	P-value
Jarso	9 (47.3)	10 (52.6)	12.14	0.058
Mesoya	8 (50)	8 (50)		
Elewya	0 (0)	9 (100)		
Dharito	5 (27.8)	13 (72.2)		

Table 7. Ranking of breeding objective traits for goat in different locations

Trait of interest	Ranking index (rank)				Chi-square	P value
	Jarso	Mesoya	Elewya	Dharito		
Growth	0.26 (1)	0.21 (2)	0.25 (1)	0.24 (1)	20.08	0.1689
Survival	0.07 (5)	0.16 (4)	0.14 (5)	0.13 (5)	29.41	0.01425
Reproduction (frequent lambing and litter size)	0.24 (2)	0.20 (3)	0.19 (3)	0.22 (3)	20.56	0.1514
Coat colour	0.17 (4)	0.10 (6)	0.23 (2)	0.23 (2)	35.66	0.00198
Milk yield	0.24 (2)	0.23 (1)	0.17 (4)	0.18 (4)	21.61	0.1185
Behavioral	0.004 (6)	0.11 (5)	0.02 (6)	0.01 (6)	20.01	0.006694

Table 8. Influence of body condition score, fertility and survival on ranking decision

Rank	Body condition score	Twining rate	Pre-weaning kid survival
Overall	3.2±0.04	1.22±0.03	80.6±2.22
CV (%)	15.92	26.12	37.14
Doe rank	<0.0001	0.006	<0.0001
First	3.5 ± 0.07^{a}	1.24 ± 0.04^{a}	92.1 ± 4.01^{a}
Second	3.3 ± 0.07^{ab}	1.14 ± 0.04^{ab}	87.0 ± 4.02^{a}
Third	3.2 ± 0.08^{b}	1.10 ± 0.04^{ab}	83.9 ± 4.37^{a}
Last	2.7 ± 0.08^{c}	1.08 ± 0.04^{b}	59.6 ± 4.48^{b}
Village	<0.0001	0.045	NS
Jarso	3.3 ± 0.49^{a}	1.20 ± 0.035^{a}	74.8±0.04
Mesoya	3.6 ± 0.71^{a}	1.08 ± 0.053^{ab}	86.8±0.56
Eleweya	3.1 ± 0.49^{b}	1.07 ± 0.044^{b}	76.4±0.05
Dharito	3.0 ± 0.58^{b}	1.14 ± 0.038^{ab}	84.6±0.39

^{a,b,c}Means within column with different superscripts are significantly different at $p<0.05$

Table 9. Least squares means ± standard error for kid growth, milk yield and kidding interval score on by doe ranking

Rank	N	Kid growth score	Milk yield score	Kidding interval score
First	53	2.96^{a}	2.94^{a}	2.64
Second	53	2.84^{a}	2.88^{a}	2.62
Third	46	2.35^{b}	2.47^{b}	2.57
Last	46	1.46^{c}	1.33^{c}	2.00
Kruskal-Wallis chi-squared		106.61	109.37	6.96
P value		<0.0001	<0.0001	0.07311

^{a,b,c}Means within column with different superscripts are significantly different at $p<0.05$

Table 10. Least squares means ± standard error for body weight, linear body measurements and price of does in Ethiopian Birr by doe rank and village

Rank/Village	Body weight	Body length	Chest girth	Height at wither	Ear length	Horn length	Willingness to pay (ETB)
Overall	31.2±0.35	62.0±0.33	74.4±0.30	63.7±0.27	13.3±0.09	8.1±0.29	1555±22.6
CV (%)	15.2	7.27	5.52	5.79	9.25	48.87	18.08
Doe rank	<0.0001	<0.0001	<0.0001	<0.0001	<0.0254	NS	<0.0001
First	33.6±0.88^{a}	65.2±0.78^{a}	76.6±0.74^{a}	63.8±0.72^{a}	13.7±0.25^{a}	8.8±0.55	1367±46.5^{a}
Second	31.3±0.89^{a}	64.0±0.78^{a}	74.3±0.74^{ab}	63.3±0.72^{a}	13.3±0.25^{ab}	8.5±0.53	1272± 1.4^{ab}
Third	30.9±0.96^{a}	63.1±0.86^{a}	73.6±0.81^{b}	63.0±0.79^{a}	13.3±0.23^{ab}	8.0±0.60	1145± 44.0^{b}
Last	25.2±0.93^{b}	58.4±0.85^{b}	68.0±0.80^{c}	59.0±0.79^{b}	12.7±0.25^{b}	7.5±0.63	833± 46.9^{c}
Village	<0.0001	0.00024	0.00072	0.00057	0.0056	<0.0001	<0.0001
Jarso	27.3±0.59^{a}	60.4±0.51^{a}	71.3±0.49^{a}	60.6±0.48^{a}	12.8±0.15^{a}	8.3±0.36^{a}	971±30.1^{a}
Mesoya	31.0±0.85^{bc}	62.8±0.78^{b}	74.6±0.74^{b}	61.8±0.73^{a}	13.1±0.23^{ab}	11.5±0.57^{b}	1363±37.6^{b}
Eleweya	32.5±1.09^{cd}	64.7±0.97^{b}	75.1±0.57^{b}	64.6±0.90^{b}	13.8±0.28b^{c}	4.8±0.66^{c}	1129±47.8^{c}
Dharito	33.6±0.60^{d}	62.0±0.58^{b}	76.3±0.53^{b}	66.9±0.48^{b}	13.9±0.16^{c}	6.5±0.48^{c}	NA

^{a,b,c}Means within column with different superscripts are significantly different at $p<0.05$; ETB = Ethiopian Birr; 1 USD = 28.40 ETB.

Table 11. Spearman’s correlation coefficient of doe rank with doe size, production, reproduction and morphological traits in different locations

Traits	Spearman’s correlation with doe rank in different locations			
	Jarso	Mesoya	Eleweya	Overall
Doe body condition score	0.43***	0.41*	0.34*	0.46***
Kidding interval score	0.24ns	0.15ns		0.2*
Twining rate	0.45***	0.21ns	0.38**	0.4***
Kid pre-weaning survival	0.18ns	0.06ns	0.33*	0.21**
Kid growth	0.67***	0.58***	0.74***	0.72***
Milk yield score	0.62***	0.61***	0.72***	0.69***
Doe price	0.66***	0.65***	0.73***	0.56***
Body length	0.45***	0.34ns	0.53*	0.41***
Chest girth	0.56***	0.38*	0.77***	0.52***
Height at wither	0.27*	0.08ns	0.81***	0.29**
Ear size	0.31**	0.09ns	0.28ns	0.22*
Horn size	0.37**	0.23ns	-0.28ns	0.24*
Body weight	0.49***	0.35ns	0.85***	0.48***

*** = <0.001, ** = <0.01, *** = <0.05, ns=non-significant

Table 12. Pairwise Spearman's rank correlation among selected variables (upper diagonal) and associated P values (below diagonal)

	KI	TR	SP	KGS	MY	CG	BWT
Kidding interval (KI)		0.01	0.07	0.31	0.29	0.18	0.27
Twining rate (TR)	0.8754		-0.05	0.26	0.27	0.36	0.45
Survival proportion (SP)	0.4940	0.4913		0.14	0.19	0.21	0.17
Kid growth score (KGS)	0.0019	0.0004	0.0596		0.78	0.39	0.39
Milk yield (MY)	0.0046	0.0002	0.0088	0.0000		0.47	0.51
Chest girth (CG)	0.0771	0.0000	0.0214	0.0000	0.0000		0.79
Body weight (BWT)	0.01003	0.0000	0.0723	0.0001	0.0000	0.0000	