Participatory Traits Preferences of Smallholder and Bio-economic Modeling to Design Alternative Breeding Schemes for Genetic Improvement of Arab Goats in Western Lowland of Ethiopia

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Abstract: This study aimed to identify the breeding objectives of smallholder goat keepers and to compare designs of alternative-based breeding schemes for genetic improvement of western lowland Arab goats in Assosa Zone, Western Ethiopia. In the present study methods of trait preference ranking, own-flock ranking and bio-economic modeling were used to identify goat breeding objectives. Based on the bio-economic evaluation results, the economic values of each trait were included as an input to design breeding schemes. Six alternative breeding schemes, four schemes for the village program and two for the central nucleus program were evaluated for optimal breeding programs in terms of their genetic and economic efficiencies considering the top three most important traits identified. The schemes varied from 1 to 5% in the nucleus breeding unit, and 200 to 500 in the nucleus flock size. The results showed that there were close covenant farmer's trait preferences through the two participatory ranking experiments and bio-economic model, and thus, body size (6-month weight (6-MW)), multiple births (litter size (LTS)), and pre-weaning survival rate (PWS) were the top three highest breeding objective traits identified for goat keepers. The highest genetic gain for 6 month's weight was predicted from scheme-5, and scheme-1 was the highest among the village schemes. However, this scheme was not appreciable under smallholder breeders' management practices due to the requirement of large central nucleus flocks and logistics. In view of these limitations, a cooperative village scheme linked with a central nucleus scheme is suggested as the best option to attain fast genetic gains and profits. However, to upgrade the entire Arab goat flocks which are kept under small-scale farmers' condition, scheme-1 could be used as an alternative option.

Keywords: *Bio-economic; Breeding objectives, Economic efficiencies, Genetic gain*

Introduction

Identification, characterization, and understanding of local breeds as well as associated contexts of their development and utilization is the first step in making well-informed decisions pertaining to breed improvement interventions. Previous studies in Ethiopia (Gemeda *et al.,* 2010; Tadelle, 2010) noted that breeding systems or genetic improvement efforts need to consider the trait preferences of producers in designing breeding programs. The breeding objective traits on which the livestock keepers wish to improve should be identified through the full participation of smallholder farmers (Wurzinger *et al.,* 2011). In Ethiopia, breeding objectives have been defined so far for Gumz and Abergelle, Abergelle and central highland goats and Begait goats (Solomon, 2014; Alemu, 2015; Abraham *et al*., 2018a). However, information about trait preference (selection criteria), breeding objectives traits and their relative economic importance through participatory community approaches in providing a comprehensive understanding of trait preferences from producers' perspectives using bio-economic model is scanty for Arab goat.

Identifying breeding objective traits and their relative economic importance through participatory community approaches is crucial for the success of any breed improvement programs (Kargar *et al.,* 2017). Therefore, identifying breeding objective traits could be done through participatory trait preference ranking (Solomon *et al.,* 2010), own flock ranking (Haile *et al.,* 2011) and bio-economic models (Gunia *et al.,* 2012; Lopes *et al.,* 2012). Thus, defining the breeding objectives of the breed in their habitat with the full participation of the community are prerequisite to setting up breeding strategy at the smallholder level (Kosgey *et al.,* 2006).

Designing a suitable breeding scheme for smallholder livestock production systems has remained a challenge in most developing countries. Until recently, livestock breeding in Ethiopia has adopted exclusively the conventional hierarchical breeding schemes (Gizaw *et al.,* 2013). Even if not well-established and progressive changes, a village-based breeding scheme was established in Ethiopia in 2009. Despite empirical data on the description of the economically important traits of the breeds, conventional approaches have so far felt short of capturing a holistic picture of breeding in the context of traditional systems since it requires high investments. In developing countries with low-input

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production systems, breeding schemes and structures are uncommon and livestock keepers have usually limited access to get improved breeding stock and rely mainly on their own traditional breeding practices. In addition, the lack of infrastructure for breed improvement and scarcity of logistics are other factors in establishing such breeding schemes (Mueller *et al.,* 2015). In view of these limitations, the recent approach of establishing community-based breeding programs (CBBP) is advocated for low-input traditional smallholder farming systems (Wurzinger *et al.,* 2011; Haile *et al.,* 2019). Some indigenous goat populations including Abergelle, Central Highland and Woyto-Guji goat in Ethiopia has been selected and selective breeding (Gizaw *et al*., 2013; Alemu, 2015; Netsanet *et al.,* 2016; Tatek, 2016; Temesgen *et al.,* 2019). In addition, CBBPs for sheep in Ethiopia have been established (Gemeda *et al.,* 2010; Haile *et al.,* 2011; Gizaw *et al.,* 2014b). Although the range of challenges is enormous and stands to be one of the reasons for slowing positive progress, the stepladder finding animals of superior performance has been demonstrated by some previous studies (Berhanu *et al.,* 2012; Batten, 2014).

The lack of effective, sustainable breeding programs for local breeds is one reason that such breeds lose their competitive advantage due to changing production systems and external conditions. The Arab goat, on which this study focused, is one of the goat breeds of Ethiopia that have been traditionally kept by local farmers in the arid environment of Assosa and Kurmuk districts under mixed crop-livestock farming systems of Western Ethiopia. Arab goat is important and mainly used for milk and meat production. It is mainly reared in arid and semi-arid agro-ecology and known for their adaptation to the warm environment and tsetse infested areas of the western lowlands of Ethiopia (Getinet *et al*., 2005). Due to multiple function of Arab goat in the area, it serves as a source of income generation for the community, saving money as live animals and a source of food in terms of milk and meat. Despite these special features of this local breed, comprehensive information on the design of breeding strategies to improve Arab goats still scant in the study area. This requires suitable breeding strategies and optimal breeding programs, which consider the prevailing farmer organizations, social networks and available support services. Therefore, the present study was envisaged with the objective to assess breeding objectives of smallholders and used as in put to design optimal breeding program for genetic improvement of indigenous Arab goat.

Materials and Methods

Study Area

The research was conducted in Assosa and Kumruk districts, Assosa zone, Benishangul-Gumuz region, Ethiopia. Assosa district is located between 10° 02.922' N latitude and 34° 33.868' E longitude. It is characterized by diverse topography with altitudinal range of 580-1544 m.a.s.l. Mono-modal rainfall pattern from April-September with an average annual rainfall of 1316 mm, temperature of 11 to 30°C and the hottest months of March and May (Assefa *et al.,* 2015). The other district is Kumruk and it is located between 10°32'N and 34°17'E. The altitudes range from 500 96 to 1200 m.a.s.l. The temperatures range from 25 to 33oC and the hottest months are March and 97 May (Befikadu *et al.,* 2020). The district is characterized by mono-modal rainfall with a mean annual rainfall range of 800-to1200 mm (Assosa Agriculture Research Center, 2011).

Data Collection Methods

Method of breeding objectives identification: The methods employed in the present study in defining the breeding objectives were trait preference ranking, own flock ranking and bio-economic models. A total of 180 goat keepers (70 from each kebeles) were selected from the two districts were participated on trait preference ranking experiment. Semi-structured questionnaires were used to cover traits that are of economic interest to the owner and selection criteria. Listings of preferred traits for selection of breeding does were independently ranked for each of trait categories.

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In own-flock ranking experiment, a total of hundred households were visited in the morning before animals were released for grazing. The own-flock ranking experiment was performed from June to September 2019. Family members of selected households were asked to identify, with reasons, their 1st best, 2nd best, 3rd best and the worst does within each monitored flock. The reasons of ranking and historical records of each individual ranked doe was evaluated for reproduction (number of kids born, litter size, number of kidding and number of kids weaned) and production (milk yield of doe/day number of cups) and economic values (economic weight given by the farmers). Besides, morphometric (length, heart girth and heights at withers and rump) measurements and live body weight of ranked animals was taken. Weighting of ranking for a given sets of trait preference of the farmers' were done according to previous work (Tadelle *et al*., 2012; König *et al*., 2016).

Using the bio-economic model, identification of breeding objectives includes: (i) specifying the environment (breeding, production and marketing systems); (ii) identifying sources of income and expenses in the system; (iii) determining the biological traits influencing income and expense; and (iv) deriving appropriate economic values for each trait in the breeding objective (Solomon, 2016). All parameters required for developing bio-economic models relating to different breeding objective traits with the components of the production and marketing system of Arab goats were constructed. The total annual profit of a flock was calculated as the difference between the costs and revenues of the system. The productive unit was the doe, and the time unit was one year. The source of revenue and cost information used is presented in Table 1. A total of 200 does were used based on reproduction parameters to calculate revenues and costs. The average prices in 2022 were used and all costs and prices were expressed in birr. Sources of costs included the feed, marketing veterinary and fixed costs. Sources of revenues (income) were derived from the sale of culled does, bucks, excess kids and milk. Therefore, profit was calculated as the difference between revenues and costs per doe joined per year.

Table 1. Sources of revenues and costs used for defining breeding objectives of Arab goat.

Sources of revenues and costs	Unit	Value
Source of revenue:		
Price of 6-month old male	ETB/kg	83.75
Price of 6-month old female	ETB/kg	66.35
Price of yearling male (unfinished)	ETB/kg	50.59
Price of Yearling female (unfinished)	ETB/kg	44.87
Price of Culled doe	ETB/kg	33.69
Price of Culled buck	ETB/kg	29.79
Price of Milk (Birr/kg or liter)	ETB/kg	15.50
Sources of costs:		
Total feed price	ETB/kg DM	7.20
Veterinary and management cost:		
De-worming	ETB/kg BW/year	0.20
Spray against external parasites	ETB/head/year	1.00
Vaccinations	ETB/head/year	1.50
Veterinary treatment and drugs	ETB/head/year	1.00
Management [a]	ETB/doe/year	0.88
Marketing [b]	ETB/doe/year	2.65
Total fixed cost	ETB/head/year	0.073

[a]Management (herding and feeding); [b]Marketing cost (personal expenses, marketing tax).

Biological traits (6-month weight (6-MW)), post-weaning average daily gain (PoADG), mature weight (MWT), litter size (LTS), pre-weaning kid survival rate (PWS), kidding interval (KI), and daily milk yield (DMY) that influence revenue and costs of the subsistence production system were included for developing deterministic bio-economic modeling to derive economic values of each trait. The performance parameters are presented in Table 2.

Methods for description of alternative breeding schemes: The schemes were designed based on the practical situation on the ground. These include the actual population of Arab goats in the two main districts, the feasible size (number of does) of the cooperative breeding groups that can be organized (which were varied from 500 to 200 does) depending on several factors including the proximity of villagers, sharing of common resources such as grazing land which are necessary for organizing a controlled breeding within the cooperative breeding group, and the central nucleus size which can be established by the Assosa research center or ranch (which varied in the model from 5% of the population which is 12224 to 1% which is 242 does).

In the study, two main schemes (a cooperative village breeding and central nucleus schemes) and four sub-schemes for the village program and two sub-schemes for the central nucleus program were designed and evaluated optimal breeding program. Each scheme varied in the nucleus breeding unite in percentage (1 and 5) of the population, number of nucleus, flock size and selection method. The two scenarios schemes identified were village-based schemes (schemes 1, 2, 3 and 4) and conventional central nucleus-based schemes (scheme-5 and 6) were used. The six alternative schemes are; Scheme-1: (dispersed village nuclei with 5% of the total doe population and a village nucleus size of 500). The scheme involves cooperation among farmers in a village. Scheme-1 was designed to scale up genetic improvement from single village-based activities to entire population of the district goats kept by small-scale farmers breeding programs. It involves establishing nuclei breeding villages where genetic improvement is generated, which then serve as sources of improved bucks to the whole population. The size of one breeding unit and village nuclei were designed to be 5% of the base population and 500 does (one village nucleus size), respectively. Selection of candidates based on mass selection (phenotype). Each year the inferior buck of the nucleus is replaced by a new best performing young buck whereas the base male progeny are castrated or else revolve fund, and nucleus male progeny are performance tested. It was planned to keep superior males during the mating season to allow community members to take their best females for mating. Genetic generation and dissemination occur within this single breeding unit. A total of three village nucleus, 500 does in each nucleus unit was modeled in this alternative scheme; Scheme-2: (dispersed village nuclei breeding scheme with 5% breeding unit and a village nucleus size of 200). Scheme-2 is similar with scheme-1 but scheme-2, the size of one village nuclei was modeled to be 200 flocks with seven number of village nucleus. It simulates a selection program addressing the entire population of Arab goat kept by small-scale farmers in the districts. Candidates are selected using mass selection and farmers' assessment. Genetic generation and dissemination occur within this single breeding unit; Scheme-3: (dispersed village nuclei breeding scheme with 1% breeding unit and a village nucleus size of 500). Same as scheme-1 and 2, but this scheme was designed with a breeding unit 1% of the total base population. In this scheme, the size of one village nuclei was modeled to be 500 breeding does. The cooperative village was required one nucleus that can be organized based on proximity and exclusion of other flocks outside the cooperative villages. Genetic generation and dissemination occur within this single breeding unit; Scheme-4: (dispersed village nuclei breeding scheme with 1% breeding unit and a village nucleus size of 200). This alternative breeding scheme was one-tier cooperative village breeding scheme. Similar to scheme-3 but in scheme-4, the size of one breeding unit was designed to be 1% of the base population with a total of two village nuclei. Genetic generation and dissemination occur within this single breeding unit; Scheme-5: (conventional central nucleus-based scheme with 5% nucleus size). Scheme-5 was modeled with a nucleus size of 5% of the total population of does. This scheme involves a single tier of multipliers for single community flocks. The does away with the intermediate sire multiplier flock stage and requires full cooperation between participating farmers and the elite nucleus breeders. Assosa Agriculture research institution can manage the central nucleus breeding flock. The number of does (480) comprises 5% of the total control base population and 19 breeding bucks. There would be 10 nucleus flocks and each does will be divided into ten flocks of 48 does/flocks. The top 5% of the bucks will be selected as the future sires for the nucleus flocks. In the central nucleus flock, the top performing females will then be bred to the top (5%) bucks for use within the nucleus flock. The second top sires will be distributed to flocks of smallholder farmers participating in the breeding program; Scheme-6: (central nucleus-based scheme with 1%of nucleus size): Same as scheme-5, but the scheme was modeled with 1% nucleus size. The central nucleus breeding program consists of 240 breeding does and 10 bucks. There will be 10 nuclei and each nucleus consists 24 does/flocks. The top 1% of the bucks will be selected as the future sires for the nucleus flocks. The second top sires will be distributed to flocks of smallholder farmers participating in the breeding program.

Table 2. Flock, production and reproduction parameters used for defining breeding objectives of Arab goat.

Flock and reproduction parameters	Value	**Production parameters**	Value
Doe number in the flock	544	Kid weight (3-month, male, twin-born)	11.97
Kidding interval (days)	238.30	Kid weight (3-month, female, single-born)	12.81
Kidding freq. per year	1.53	Kid weight (3-month, female, twin-born)	10.97
Conception rate	0.83	Kid ADG (3-6 month, male single-born)	0.05
Litter size	2.08	Kid ADG (3-6 month, male twin-born)	0.04
Replacement rate	30.0		
Buck culling rate	0.33	Kid ADG (3-6 month, female single-born, kg)	0.04
Barren doe culling rate (proportion of barren does)	0.30	Kid ADG (3-6 month, female twin-born)	0.04
Weaning age of kids (months)	4.5	Doe weight (kg)	31.0
Age of kids sold (months)	6.5	Buck weight	37.0
Age of selection replacement (months)	8	Kid weight (3-month, male, single-born)	11.94
Age at first mating (months)	13	Kid ADG, male (6-12 month on grazing)	0.03
Age at mature weight (months)	13	Kid ADG, female (6-12 month on grazing)	0.03
Does life time service (age of culling)	6	Milk yield (kg/doe/day, single kid)	0.34
Buck life time service (years) (age of culling)	4	Milk yield (kg/doe/day, twin kid)	0.42
Survival (0-3 month), singles	90	Proportion of milk harvested for sale/consumption	0.36
Survival (0-3 month), multiples	90	Milk price (Birr/kg or liter) (Birr/kg)	15.50
Survival (3-6 month) rate	90		
Survival (6-12 month) rate	95		
Mortality, breeding does/bucks	0.04		

In Table 3, all input parameters of Arab goat for modeling (running ZPLAN) are presented. The population parameters were number of breeding does, mating ratios, age at first kidding, number of kids per doe per kidding, productive lifetime and survival rates. The phenotypic standard deviations of trait parameters required for the designs were derived from the results of on-farm Arab goat performance monitoring study

(Befikadu *et al.,* 2022). However, estimated genetic as well as phenotypic parameters (heritabilities and correlations) were derived from published reports of indigenous and exotic small ruminants (Solomon *et al.,* 2010; Gizaw *et al.,* 2014a; Jembere, 2016). Breeding objective trait parameters were generated based on the results of trait preference ranking, own flock ranking and bio-economic model. In the current study, an attempt was made to establish relationships among the objective traits and only economically relevant traits that directly influence the profitability/income of Arab goat farmers were considered. Thus, the selected breeding objective traits for the simulation of alternative breeding plans were six month weight (SMW), litter size (LTS) and pre-weaning survival rate (PWS).

The fixed costs include salaries of animal breeding experts for genetic evaluation, technical field assistant, and village coordinators, as well as costs for maintaining nucleus flocks, data processing facilities and supplies and communications. Costs for animal identification (for initial does plus expected number of kids born per year) and recording traits (recording books) were included as variable costs. Costs for data analysis (animal breeding expert and electronic data encoders and processing) were calculated only for conventional breeding schemes. Then the total fixed and variable costs for each were divided by the total number of animals involved. Finally, a two-step selection procedure was envisaged for young bucks in village flocks. First selection procedure was based on the performance of the dam (dams' kid rearing record) and the second was based on own growth performance (6-MW) of the young bucks, unlike the selection of female breeding stock in the central nucleus. Costs were computed per doe per year using local currency (birr). The investment period considered was ten years, using three percent and five percent of interest rates for costs and returns, respectively.

Table 3. Proportion of input parameters for simulation of an alternative breeding plan for Arab goat.

Parameters	Village nucleus schemes				Central nucleus schemes	
	Scheme-1	Scheme-2	Scheme-3	Scheme-4	Scheme-5	Scheme-6
Population parameters						
The proportion of the population in the production unit	0.95	0.95	0.99	0.99	0.95	0.99
Population size	23264	23264	24244	24244		
The proportion of the village nucleus	0.05	0.05	0.01	0.01		
The proportion of the central nucleus					0.05	0.01
Flock size (number of does)	500	200	500	200	200	500
Number of village nuclei	3.0	7.0	1.0	2.0	-	-
Biological parameters:						
Lifetime use (years) of bucks in the nucleus	-	-			2.0	2.0
Breeding bucks use in villages	2.33	2.33	2.33	2.33	2.5	2.5
Does used in the central nucleus					6	6
Does used in villages	7.0	7.0	7.0	7.0	7	7
Mating ratio (F:M)-village	30	30	30	30	35	35
Mating ratio(F:M)-central nucleus					25	25
Conception rate-central nucleus					0.91	0.91
Conception rate-villages	0.90	0.90	0.90	0.90		
Kidding interval (years)	0.73	0.73	0.73	0.73	0.66	0.66
Age at first kidding (years)	1.50	1.50	1.50		0. 90	0. 90
Age of buck at first mating (years)	1.50	1.50	1.50		1.00	
The mean number of kids per litter (litter size)	1.44	1.44	1.44	144	1.44	1.44
Survival of bucks-villages	0.90	0.90	0.90	0.90		
Survival of bucks-central nucleus					0.95	0.95
Survival of does-villages	0.89	0.89	0.89	0.89	0.90	0.90
Survival of does-central					0.90	0.90
Kid weaning rate -village	0.90	0.90	0.90	0.90		
Kid weaning rate-central					0.93	0.93
Suitability for breeding [(a)]	0.90	0.90			0.90	
Cost parameters:						
Fixed costs/doe (Birr)	36.55	91.38	36.55	91.38	115.56	36.55
Variable costs/doe (Birr)	6.86	6.86	6.86	6.86	6.86	6.86

[(a)]*Proportion of proven selection candidates physically suitable for breeding.*

Data Analysis Methods

The ranking of trait preferences was summarized into index. Indices were calculated for ranked variables (selection criteria) and computed as: the sum of (3x for rank 1 + 2x for rank 2 + 1x for rank 3) given for a given reason divided by the sum of (3x for rank 1 + 2x for rank 2 + 1x for rank 3) for overall reasons (Kosgey *et al.,* 2004). Under bio-economic models, the economic values of breeding objective traits were calculated using Excel Tool (Solomon, 2016). Marginal economic value for a given trait was estimated as the change in profit resulting from an increase in one additive genetic standard deviation of the trait of interest while keeping all other traits constant. Economic values for 6-MW, PoADG, MWT, LTS, PWS, KI, and MY were estimated as: $EV = \frac{(\Delta R - \Delta C)}{\Delta T}$ (Abraham *et al.,* 2018a), Where: EV= the economic value of the trait per unit change; ΔR and ΔC = the marginal change in revenues and costs after 1% increase in the trait of interest and ΔT = the marginal change in a trait after 1% increase in the trait of interest.

Six alternative breeding scheme studies were designed and evaluated using the computer program ZPLAN (Willam *et al.,* 2008). Using the gene flow method and selection index procedures, the program enables to simulate different breeding plans by deterministic approach. Based on the population, biological and economic parameters the program calculates the annual genetic gain for the breeding objective, genetic gain for single traits and return of investment adjusted for costs (profit) using the gene flow method and selection index procedures and the annual response for each trait and discounted return and discounted profit for a given investment periods.

Results and Discussion

Trait Preference Ranking Experiment

The farmers' trait preferences (Table 4) indicate that the breeding objectives of the farmers were mainly breeding of animals to increase meat production and income through increasing the number of kid crops in goat flocks. Farmers have different criteria for selecting female breeding stocks (Table 2). Based on the index derived from farmers' ranking of goat traits, the most important selection criteria for breeding does were multiple births, kid growth, body conformation (size), and kidding interval in their order of importance. Farmers evaluated their live animals' productivity on the conceptual perceptive of doe with fast growth, large size and good reproduction performance are the once most likely selected.

The higher preferences of farmers for body size, growth and reproduction traits were also previously reported for western lowland and southwestern goats (Solomon, 2014; Tegegn *et al.,* 2016). Similarly, another study (König *et al.,* 2016) in Kenya reported the preferences of the communities for large and resilient small ruminant animals. Similarly, body size and growth rate were given higher ranking by the communities in goat populations of Gambella (Tsigabu, 2015) and Woyito goat of Southern (Netsanet *et al.,* 2016) regions of Ethiopia. Large animals were particularly desired by the market-oriented farmers, due to their higher demand and fetched better prices.

Table 4. Selection criteria for doe in the study area as ranked by owners.

Class and selection criteria	Rank			Index	Rank
	Rank 1	Rank 2	Rank 3		
Body conformation (Size)	72	16	12	0.119	3
Colour	-	-	12	0.014	10
Kid growth	24	84	40	0.176	2
Kid survival	40	12	24	0.090	6
kidding frequency	-	52	40	0.110	4
Twining	80	56	52	0.224	1
Mothering ability	20	4	20	0.052	8
Milk yield	8	24	36	0.081	7
Age of 1st kidding	0	8	24	0.038	9
Disease resistance	36	20	24	0.095	5
Heat tolerance	-	-	-	-	-
Drought tolerance	-	-	-	-	

Index= Sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) give for each selection criteria divided by sum of (3 X number of household ranked first + 2 X number of household ranked second + 1 X number of household ranked third) for all selection criteria (Kosgey et al., 2004).

Own Flock Ranking Experiment

Farmers ideal (theoretical trait preference): Weighted reasons for farmers classifying does as best quality and inferior quality does are presented in Table 5. The result of the study indicated that body size and growth, multiple birth and reproduction (mothering character, and kid survival) were first, second, and third important traits for selecting the best breeding does. The farmers interested animals that grow fast, with higher body weight, and preferably with high twinning rate that enable sell of more animals per year. Similarly, study by Tegegn *et al.* (2016) reported that multiple birth, growth rate, and body size were top selection criteria for breeding does. According to the result of the present study (Table 3) those traits considered for improvement were conformation traits (body size and growth), reproduction, twinning rate and disease resistance. Similar trait preferences were reported in Malawi (Nandolo *et al.,* 2016) and highlands goat breeds of Ethiopia (Yaekob *et al.,* 2017). Therefore, breeding objectives of the community are to improve growth of goat thereby improving meat production potential of goats and increased income.

Farmers' own goat flock traits: The respondents prefer does for the next generation with traits of higher body weight, milk yield, number of kidding, litter size, number of kid born and weaned. There were also a highly significant (P<0.01) effect of body weight and other body measurements for the selection of best breeding does (Table 5). There is important changes in body composition and conformation in indigenous goats with increasing age, resulting in increases in carcass mass, body dimensions, carcass lean and fat content and dressing out percentage. In accordance with the present findings, previous studies (König *et al.,* 2016; Abraham *et al.,* 2018a) reported similar preferences of farmers for sheep and goats in Ethiopia. The mean values milk yield and selling price of does was significantly (P<0.05) affected by rank. The average values milk yield and selling price of does ranked as 1st best was 0.99 cup/day and $10.51 (US Dollar) higher than inferior does. Similar magnitude differences were also reported for Abergelle and Gumuz goats (Solomon, 2014). Results of the present study reveal that farmer' decisions for ranking of breeding does were highly correlated with the performance of the given animals.

Table 5. Overall means (± SE) body weight and attributes from life history of the ranked does and weight reason of goat owner's trait preference for the best quality and inferior does.

Attributes	P	Overall mean	Ranks 1st best	2nd best	3rd best	Inferior
LBW, kg	***	27.33±4.46	31.03±0.45[a]	29.46±0.45[a]	25.99±0.45[b]	22.85±0.45[c]
NK, number	***	2.75±1.13	3.52±0.13[a]	3.16±0.13[a]	2.40±0.13[b]	1.92±0.13[c]
NKB, number	***	5.20±4.00	8.10±0.40[a]	5.41±0.40[b]	4.35±0.40[bc]	2.93±0.40[c]
NKW, number	***	2.58±2.59	4.80±0.26[a]	2.44±±0.26[b]	2.00±±0.26[bc]	1.08±0.26[c]
BL, cm	***	60.65±5.76	65.12±0.58[a]	62.36±0.58[b]	59.34±0.58[c]	55.78±0.58[d]
WH, cm	***	59.38±3.46	61.68±0.35[a]	60.72±0.35[a]	58.12±0.35[b]	57.00±0.35[b]
CG, cm	***	70.63±5.54	74.92±0.55[a]	72.04±0.55[b]	68.16±0.55[c]	63.40±0.55[c]
Milk yield, cups/d	**	1.45±0.06	1.95±0.06[a]	1.65±0.06[b]	1.24±0.06[c]	0.96±0.06[d]
Sold (USD ($))[a]	***	37.62±18.8	42.75±18.8[a]	40.23±18.8[a]	35.27±18.8[b]	32.24±18.8[c]

Does traits

Traits	Best doe Reason 1	2	3	Sum	Rel.wt	Rank	Inferior does Reason 1	2	3	Sum	Rel.wt	Rank
Body size and growth	27	41	20	88	0.29	1	20	40	33	93	0.28	1
Body condition	0	0	26	26	0.08	5	8	4	8	20	0.06	6
Twinning abilities	36	16	12	64	0.21	2	36	4	4	44	0.13	4
*Reproduction	8	32	20	60	0.20	3	20	12	20	52	0.15	2
Coat color	12	4	12	28	0.09	4	20	0	16	36	0.11	5
Milk yield	12	8	8	28	0.09	4	12	8	16	36	0.11	5
Disease resistances	0	0	7	7	0.02	6	12	3	32	47	0.14	3
Drought tolerance	0	0	3	3	0.01	7	0	0	8	8	0.02	7

[a, b, c, d]*Means on the same row with different superscripts are significantly different; LBW= Live body weight; NK=Number of kidding; NKB=Number of kids born; NKW = Number of kid weaned, BL = Body length; WH = Height at wither; CG = Chest girth;* [a]*USD= Unites State Dollar; *Reproduction includes kidding interval, mothering ability and kid survival; **P< 0.01; ***P< 0.001.*

Using bio-economic Models

Revenues and costs: In the current study feed cost per doe per year in birr was 893.66, whereas the total revenue per doe per year was 1681.60 Birr (Table 6). Among inputs (costs), feed cost constituted 94.00% of the total costs while marketing and veterinary constituted the second largest source of costs. The result indicated that the presence of large numbers of 6-month, yearling kids and unsold surplus does and bucks consume more feed to fulfill the demand of nutrients for high growth and maintenance and this tends to increase the feed cost. The current result coincided with the results of Kargar *et al.* (2017), who reported that feed cost constituted higher than the total cost of marketing and veterinary. Live weight income was the most important source of revenue followed by milk production with a proportion of 62.05 and 37.95% of total profit, respectively. Meat and milk consumption were also one of the primary purposes of farmers for keeping goat, hence this confirmed that sales of goats to generate cash constitute the main breeding goal of western lowland goat breeders (Befikadu *et al.,* 2020) but goat breeders wish also to increase milk production which concurs with the finding reported by earlier work (Vatankhah, 2010; Kargar *et al.,* 2017). Among all animal categories, the highest income is generated from 6-month kids since selling of excess 6-month kids fetch higher revenue with the value of 886.46 due to its high demand as compared to other animal categories and due to large number of surpluses 6-month kids available for selling. However, replacement buck and does had no revenue from the sale of meat. Total profit was 1277.10 birr per doe per year, which could be increased when producers mostly use pasture for feeding since the feed costs decrease.

Derivation of economic values of breeding objective traits: Estimation of economic values, economic weights and relative importance for all traits under fixed flock size was positive, except for the adult doe body weight (Table 7). Positive economic values indicated that genetic improvement in the traits would result in a positive effect on profitability. The negative value due to a unit increase in genetic merit of these traits has greater influence on revenues than costs. This suggested considering adult doe mature body weight in the selection criteria for long-term genetic improvement programmes and sale of does at late maturity age may be important. Similar negative economic values for adult doe body weight were also reported by different studies for dairy, native black Cashmire and Begit goat breeds (Vatankhah, 2010; Kargar *et al.,* 2017; Abraham *et al.,* 2018b) in Kenya, Iran and in Ethiopia, respectively.

The result of the present study indicated that economic values of 6-month weight, litter size and survival rates traits have relatively high economic value. Among the productive traits, average daily gains and milk yield have intermediate economic value. However, longevity trait (KI) has lower economic value which indicates that this trait has low heritability value and cannot be improved by selection. Similar to the present finding, Abraham *et al.* (2018b) reported that high economic values were obtained for litter size, six month weight and pre-weaning kid survival. Hence, these traits are the most important traits to increase the profitability of the flocks and should be considered as useful breeding objective traits to design improvement program for Arab goats.

Design of Alternative Breeding Schemes

Table 8 provides the expected annual genetic gains of the individual breeding objective traits from the different alternative breeding schemes. The results of this study indicated that annual genetic gains of the breeding objective traits were higher under central nucleus-based breeding schemes when compared to village-based breeding schemes. Among central nucleus-based schemes, scheme-5 gave higher genetic progress. From village-based schemes, Scheme-1 was the highest genetic gain followed by scheme-3. Hence, village-based scheme-1 which involves breeding unit at 5% selection proportion with flock size of 500 does using a total of three village nuclei was effectively performed in creating genetic gain. The highest prediction of genetic gain from central nucleus-based than village- schemes in the current study may be due to inaccurate genetic evaluation and inefficient utilization of selected animals due to uncontrolled village breeding practices. A study by Solomon *et al.* (2011) described that genetic progress could be slow under village programs because of inaccurate genetic evaluation due to difficulties in implementing advanced selection tools such as best linear unbiased prediction (BLUP) selection and inefficient utilization of selected animals due to uncontrolled village breeding practices.

In a previous study (Gizaw *et al.*, 2014a) in Ethiopia explained that the difference in genetic gain between central and village nucleus schemes is attributed to the availability of infrastructure, logistics and technical know-how and support. Faster genetic progress and profit from scheme-1 was also predicted through improved breeding practice with other complementary interventions (improved health care and feeding) and assimilating/extent-out a breeding program intervention (integrate/link a village-based nucleus scheme to central nucleus scheme). A study by Gizaw *et al.* (2014a) recommended that central nucleus scheme linked to dispersed village schemes would be a feasible option to overcome the operational difficulties of the conventional central nucleus scheme. In addition, earlier study by Peters (1989) also suggested that nucleus breeding units could be integrated with on-farm performance evaluation and as a result immediate, faster and more effective genetic progress can be achieved through selection of superior foundation animals. The integration increases births of more kids at a certain kidding period of the year, induces faster growth, and reduce mortality and acute shortage of breeding bucks, which enable the program to achieve faster genetic progress and higher selection intensity.

The highest annual genetic gain in six-month weight (SMT) was obtained from the conventional central breeding scheme whereas the village-based scheme was lower. The results of predicted annual genetic gains year^{-1} for six months weight and litter size (LTS) per doe were higher in central nucleus schemes than village based schemes (Table 8). The genetic gains for PWS were similar in schemes 1 and 3 and in schemes 2 and 4 whereas genetic gains for PWS of central nucleus-based schemes were different and high in scheme-5. The highest annual genetic gain in SMW was obtained from conventional central breeding scheme might be due to implementing advanced selection tools and efficient utilization of selected animals through controlled mating and higher selection intensity from large number of flock size. However, the lowest annual genetic gains in SMW traits were lower for village-based schemes, due to the fact that candidates' animals are selected based on phenotype through mass selection and farmers' trait preferences which may not include all traits. Previous studies (Solomon *et al*., 2011; Gizaw *et al*., 2014b; Abraham *et al*., 2018b) also noted-

Table 6. Costs and revenues per animal in each category to number of does present and profit Birr per doe per year.

	Born kid	Weaning kid	Surplus 6-month		Surplus yearly 12-month		Replacement		Unsold surplus		Culled		Total	Proportional to total
			Buck kid	Doe kid	Buck kid	Doe kid	Buck	Doe	Buck kid	Doe kid	Buck	Doe		
Proportion of goat/ doe	1078	922	248	285	83	71	7	67	83	71	7	50		
Cost (C)														
Feeding	0	0	214.99	117.54	231.43	198.00	5.80	24.86	71.66	29.38	0.00	0.00	893.66	0.94
Market and veterinary	0	0	8.29	8.44	7.71	7.61	4.42	4.71	7.45	7.38	2.65	2.65	61.31	0.06
Total			223.28	125.98	239.14	205.61	10.22	29.57	79.11	36.76	2.65	2.65	954.97	1.00
Revenue (R)														
Live weight	0	0	419.69	466.77	15.55	11.80	0	0	15.89	10.50	11.60	76.58	1029.51	0.62
Milk	0	0	0	0	0	0	0	625.53	0	0	0	0	652.09	0.38
Total	0	0	419.69	466.77	15.55	11.80	0	625.53	15.89	10.5	11.6	76.58	1681.60	1
Profit	0	0	196.41	340.79	15.55	11.80	0	577.64	15.89	10.50	8.96	73.93	1277.10	-

Table 7. Economic value (birr) per unit increase in genetic merit of Arab goat traits.

Trait	Economic value[a]	Economic Weight [b]	Relative important
6-month weight	40.41	43.00	0.868
3-6 month ADG	18.68	0.06	0.001
Mature weight	-5.30	-10.12	-0.204
Litter size per doe/kidding	35.56	2.74	0.055
Survival 0-3 month	26.79	0.94	0.019
Kidding interval	6.61	12.79	0.258
Daily Milk yield	15.83	0.18	0.003

[a]Economic value (EV)+ the proportional of the difference between the marginal change in revenues and costs after 1% increase in the trait of interest to the marginal change in a trait after 1% increase in the trait of interest.; [b]Economic weight (EW)+ the product of economic value (EV) and genetic standard deviation (GSD).

Table 8. Genetic gain year-1 for the breeding objective traits achieved from selection using three alternative Arab goat breeding schemes.

	Dispersed village-based scheme				Central nucleus scheme	
	Scheme-1	Scheme-2	Scheme-3	Scheme-4	Scheme-5	Scheme-6
Breeding objective[a]	8.587	8.470	8.530	8.384	31.271	30.948
SMW (kg)	0.1995	0.1968	0.1982	0.1948	0.7267	0.7192
LTS (%)	0.0022	0.0021	0.0021	0.0021	0.0068	0.0067
PWS (%)	0.0017	0.0016	0.0017	0.0016	0.0045	0.0044

[a]The genetic gains in the breeding objective (monetary genetic gain) were calculated as the sum of the products of the genetic gains in the component traits (SMW, six months weight; LTS, litter size; and PWS, pre-weaning survival rate) and their corresponding economic values.

that central nucleus-based scheme with selection of animals using breeding values of their traits had an advantage over a village-based scheme. The genetic gain of 6-month weight in village and nucleus schemes (0.1948 to 0.7267) in the current study were higher than the range for Abergelle (0.174 to 0.249 kg) and Woyto-Guji (0.188 to 0.270 kg) goats (Jembere, 2016), Gumz sheep (0.154 to 0.336 kg) (Yohannes, 2018). However, it is lower than the 0.7590 to 0.6747 kg for Begit goat (Abraham *et al.,* 2018b) and 0.871to 0.8724 kg for Abergelle goat (Solomon, 2014). Higher genetic improvements in all traits were found in village nucleus scheme-1 and central nucleus scheme-5, due to the fact that higher returns benefited from selection higher profits per doe per year (Birr).

The annual returns, costs and profit per doe of the population for different alternative schemes are presented in Table 9. The annual costs calculated per doe in the whole population were higher for central nucleus-based scheme compared to village-based scheme. Among village-based scheme the annual costs were higher for schemes 1 and 2 that were designed for 5% selection proportion than designed with 1% selection proportion in schemes 3 and 4.

The relative profitability of all schemes followed a similar pattern as their returns, except that scheme-3 and scheme-4, but sheme-4 was found to be less profitable than Scheme-3 despite its higher cost. This implies that as flock size increases high selection differentials could be achieved and profitability maximize through genetic gain of the flock. Hence, village-based scheme with breeding unit of 5% of the total doe population (scheme-1 and scheme-2) were a better alternative breeding scenario to schemes in the village farmer breeding programs. Increasing the breeding unit from 1 to 5% in the village nuclei (Scheme-1 and 2) increased the returns by 45.57% and 4.38% over scheme-3 and 45.80% and 5.06% greater than scheme-4. This is due to the higher total returns on investment in the breeding program in scheme-1 and scheme-2 than in scheme-3 and scheme-4. In central-based schemes, scheme-6 was more profitable than scheme-5, due to the high discounted costs for maintenance (107.965Birr//does/year) in scheme-5 than scheme-6 (34.148Birr//does/year). A study by Yohannes (2018) also noted that flock size increase high selection differentials could be maximized profitability through genetic gain of the Gumuz sheep flock.

Table 9. Returns, costs and profits per doe per year (Birr) obtained from selection in Arab goat using six alternative breeding schemes.

	Dispersed village-based scheme				Central nucleus scheme	
	Scheme-1	Scheme-2	Scheme-3	Scheme-4	Scheme-5	Scheme-6
Return/doe/year	43.17	42.65	30.74	30.17	177.18	135.25
Cost/doe/year	2.05	4.61	0.41	0.92	114.72	40.91
Fixed costs per doe	1.71	4.27	0.34	0.85	107.97	34.15
Variable costs	0.34	0.34	0.07	0.07	6.759	6.76
Profit/doe/year	41.13	38.05	30.33	29.25	62.46	94.35

Returns per trait per year (birr) were obtained from selection in Arab goat using six alternative breeding schemes (Table 10). The total returns with the breeding objective of genetic improvement in Six Month Weight (SMT), Litter Size (LTS) and Post-weaning Survival rate (PWS) traits were higher in central nucleus-based schemes than village breeding schemes. Among the component traits for the predefined breeding objective, genetic improvement in SMW was almost the sole contributor to higher returns on investment in all the six schemes. Higher genetic improvements in all traits were found in village nucleus scheme-1 and central nucleus scheme-5. Return per year for SMW, twining rate and PWS traits ranges from 30.45-29.89, 0.13–0.21 and 0.15-0.24, respectively in village-based schemes while in central nucleus schemes, it ranges from 133.96-175.37, 0.66-0.92 and 0.63-0.89, respectively.

Table 10. Returns per year (Birr) obtained from selection in Arab goat using six alternative breeding schemes.

Breeding objective	Dispersed village-based scheme				Central nucleus scheme	
	Scheme-1	Scheme-2	Scheme-3	Scheme-4	Scheme-5	Scheme-6
SMW (kg)	42.72	42.20	30.45	29.89	175.37	133.96
LTS	0.21	0.21	0.13	0.13	0.92	0.66
PWS	0.24	0.24	0.15	0.15	0.89	0.63

SMW= Six months weight; LTS= Litter size; PWS= Pre-weaning survival rate.

Very low progress in genetic gains obtained in LTS (litter size) and PWS (Pre-weaning survival rate) traits in the present study did not adversely affect the efficiency of genetic progress among all six alternatives. The low genetic gain in reproductive traits is attributed to their low heritability and genetic correlations with growth traits (Safari *et al.,* 2005). In addition, a study by Jembere (2016) noted that predicted annual genetic gain of selection criteria such as LTS and PWS were small implying adequate management actions should be part of the breeding activity. This study indicates that the central nucleus-based schemes were profitable and has high return as compared to village-based schemes. The result of the current study indicated that relatively little difference return per trait was observed among village-based nucleus schemes (scheme-1 to 4) and central nucleus schemes (scheme-5 and 6). However, the total returns for the component traits of breeding objective genetic improvement in SMW, LTS and PWS were higher in the central nucleus-based schemes. This is due to good environment and management in central nucleus- schemes than village schemes which could increase animal efficiency for low heritable traits. The result of the current study indicated that relatively little differences return per traits was observed among village-based nucleus schemes (scheme-1 to 4) and central nucleus schemes (scheme-5 and 6). However, the total returns for the component traits of breeding objective genetic improvement in SMW, LTS and PWS were higher in the central nucleus-based schemes. This is due to good environment and management in central nucleus- schemes than village schemes which could increase animal efficiency for low heritable traits. The developing genetic improvement program an integrated approach that is taking into account genetics, nutrition, health, input supply and services and markets are vital (Haile *et al.*, 2011). In addition, a study by Abraham *et al.* (2018a) reported that higher discounted return for all breeding objective traits in the government ranch breeding scheme and commercial breeding scheme than cooperative village.

Conclusion

The identification of breeding objective traits relevant to specific production environments with the involvement of target beneficiaries is an innermost plan and decisive to the success of any genetic improvement. The study shows that the traits preferences of the respondents are similar using ranking and bio-economic models. Accordingly, the top three breeding objectives traits identified for goat owners were body size, litter size and survival rate. Hence, the identified specific breeding objective traits and the calculated economic values can be used for designing and evaluating alternative breeding schemes for Arab goats. In this study, six alternative breeding schemes were proposed for evaluating optimal breeding programs. A comparison of the various breeding scenarios showed that from central scheme (scheme-5: 5% selection proportion) and village schemes (scheme-1: a breeding unit of 5% and a village nucleus size of 500) are the most efficient schemes that need to be optimized. Thus, to improve the entire Arab goat flocks under small-scale farmers' conditions, scheme-1 is suggested to start a feasible community-based breeding program. On the other hand, a cooperative village scheme linked with central nucleus scheme is suggested as the best option to attain fast genetic gains and profits.

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Conflict of Interests

The authors declare that they have no competing interests.

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