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Indigenous Sheep Production System in Eastern Ethiopia: Implications for Genetic Improvement and Sustainable Use

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Abstract

Most of the sheep exports (live animal and mutton) are from eastern lowlands of Ethiopia due to the fact that mutton from these lowland sheep has special merits in the Middle East countries. Both local and export market for mutton and live animals has been increased. However, productivity and the levels of foreign exchange earnings from sheep are much lower than would be expected. Hence there is a need to improve the productivity of sheep. Therefore, this survey was conducted to understand exisiting sheep production systems and identify major constraints as a prerequiste to develop sustainable genetic improvemnt strategies for indigenous sheep in eastern Ethiopia. The study areas were selected based on the potential for sheep production in three production systems namely, mixed crop-livestock, agro-pastoral and pastoral systems. Reconnaissance survey, group discussion and interview with structured questionnaire were used to collect data from 270 households (90 from each production system).

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The average number of sheep per household in the present study was 58.6±3.29 with significantly higher flock size in pastoral system. Natural pasture, fallow land and crop residues were the major feed resources available in the study area. Average age at sexual maturity, age at first lambing, lambing interval were 7.24±1.74, 13.8±0.14 and 8.58±0.14, respectively even though, there was a significant difference among production systems. Feed shortage (0.31), drought and water scarcity (0.19) and disease prevalence (0.13) were identified as major constraints. However, index intensity and ranking have varied across production systems. Drought (0.47), water scarcity (0.33) and feed shortage (0.38) were the most important constraints and ranked first in pastoral, agro-pastoral and mixed crop-livestock system, respectively. Significant difference among production systems in most parameters considered in the current study indicating the need for specific interventions with respect to the production systems. The relatively large sheep flock size and higher contribution of sheep to the livelihood suggests that introduction of carefully planned and pertinent genetic improvement strategy through the involvement of the community is likely to have good chances of success. However, major constraints limiting sheep production need to be addressed along with the genetic improvement.

Keywords: Agro-pastoral; constraints; mixed crop-livestock; pastoral; special attributes and sheep

1. Introduction

The combination of growing demand for animal products in the developing world and stagnant demand in industrialized countries represents a major opportunity for livestock production in developing countries, where most demand is met by local production, and this is likely to continue well into the foreseeable future [1]. In Ethiopia, similar to other developing countries, changes in the demand for livestock products have been largely driven by human population growth, income growth and urbanization. Along with this, large export and domestic market for mutton and live animal has created opportunity for sheep production in Ethiopia. Besides, strategic location of Ethiopia to Middle East is also an opportunity to export meat (largely from sheep and goats) and live animals to these countries.

In Ethiopia, sheep are the second numerous farm animals with nine diverse breeds and ecotypes distributed across the different agro-ecologies ranging from cool alpine climate of the mountains to the arid pastoral areas of the lowlands [2]. Estimates indicated that about 27.3 million sheep found in Ethiopia, out of which, 99.9% of the total sheep population is indigenous breeds [3] which are owned and managed by resource poor smallholder farmers and pastoralists under traditional systems. Sheep serve as a major means of livelihoods of poor livestock keepers, and thereby contribute to poverty reduction and means of attaining sustainable agriculture and food security [4].

According to [5] sheep production system in Ethiopia is classified into five sub systems, out of which highland cereal–livestock system, lowland crop–livestock system (agro-pastoral) and pastoral systems are predominant in eastern Ethiopia. Afar and Black Head Somali (BHS) sheep, which are the dominant sheep breed in eastern Ethiopia, has special merits in export market and fetches premium prices [6]. However, productivity and the levels of foreign exchange earnings from small ruminants are much lower than would be expected, given the size of the population [7]. In Ethiopia, sheep production is of subsistence nature with little or no market

orientation. Additionally, the production system is constrained by several factors such as feed unavailability, both in terms of quality and quantity, disease prevalence, poor productivity of the animal and socio-economic circumstances of farmers/ pastoralists. There is a need to improve sheep productivity through breeding to meet the protein demand by the ever increasing human population and to ensure conservation and sustainable utilization. Improving the productivity of sheep will improve the livelihoods of producers and alleviate poverty among the rural poor dwellers and improve the country's foreign currency earning [8]. As a prelude to initiate genetic improvement program, it is important to have a good understanding of the production system and the relative importance of the different constraints [9, 10]. A comprehensive description of the production environment is essential to make use of performance data and to understand the special adaptations of breeds/populations [10]. However, there is limited information on existing sheep production system and associated constraints in eastern Ethiopia. Different research works have been done to characterize indigenous sheep production systems in Ethiopia. These included characterization of Afar and Menz sheep [11] and Bonga and Horro sheep [12]. The findings revealed that the opportunities and constraints of sheep production varied according to the type of the production environment. Although characterization of indigenous sheep production system was undertaken for BHS sheep [13] and Hararghe highland (HHL) sheep [14], it was fragmented and not comprehensive to understand the production environment, productivity within the production environment and the relative importance of major constraints. Understanding the production environment of indigenous sheep would enable a better comparative understanding of the adaptive fitness and performance of the breed. The objective of this study was, therefore, to characterize the existing sheep production systems, and major constraints that limit productivity of sheep in eastern Ethiopia. The information generated from this study will have a paramount importance to set up sustainable genetic improvement strategy in the area.

2. Materials and methods

2.1. Descriptions of the study areas

The study was conducted in Eastern Ethiopia, Jijiga and Shinile (Somali National Regional State), and east Hararghe (Oromia National Regional State) zones.

Jijiga zone is located at about 620 km south-east of Addis Ababa at 4^{o}-11^{o} N Latitude and 40^{o}- 48^{o} E Longitude. Its altitude ranges from 500 to 1600 m.a.s.l. The average temperature ranges from 16 to 20ºC. It has a bimodal pattern of rainfall (March to May; July to mid-October); with annual rainfall ranging from 600 to 700 mm [15]. The total domestic livestock population in Jijiga zone is estimated to be about 2.45 million, of which 40.5% are sheep [3]. Agro-pastoralism is the dominant production system in this zone.

Shinile zone is located 460 km south-east of Addis Ababa and 179 km northwest of Jijiga (capital city of SNRS) at 9^{o}-10^{o} N Latitude and 41^{o}-42^{o} E Longitude. Its altitude ranges from 950 to 1350 m.a.s.l. The average temperature ranges from 28 to 38 ºC. The rainfall pattern of the area is bimodal similar to Jijiga zone, and the annual rainfall ranges from 300-600 mm [16]. The total livestock population in the zone is estimated to be about 0.22 million, of which 21.4% are sheep [3]. Pastoralism is the predominant production system in the zone.

East Hararghe zone is located 518 km south-east of Addis Ababa at 8^{o}-9^{o} N Latitude and 40^{o}-42^{o} E Longitude. Its altitude ranges from 500 to 3405 m.a.s.l. The mean annual temperature varies between 13ºC to 28ºC, while mean annual rainfall ranges from 400-1200 mm. The zone receives bimodal type of rainfall pattern which covers the period from June to September (main season), and from April to May (short season) [17]. The total livestock population in the zone is estimated to be 4.39 million of which 10.4% is sheep [3]. Mixed crop-livestock system is the predominant production system in this zone.

2.2. Sampling strategy and data collection procedures

Jijiga, Shinile and east Hararghe zones were selected purposively based on sheep distribution, production system and agro ecologies. Focus group discussions were held with experts working at Zonal and District levels and with elders before commencement of the actual survey. These discussions were used to obtain appropriate information about the history of sheep breeds, population trends (declining, stable or increasing), social laws such as herding, communal land use and mobility; and major sheep production constraints. Special attribute of the sheep, the reason why sheep owners keep available sheep breed was also included to get information on this aspect. The discussion with key informants were used to obtain information on origin of the breed, special distinguishing feature of the sheep population, and on introduction of other sheep breed(s) within the last five years in the area (if any). Group discussions were also made with elders, sheep owners and development agents across all the production systems during the actual survey. Such discussions were also used to validate information collected from the individual farmers.

Multi-stage stratified sampling was employed to select districts and rural localities (*Kebeles*) purposively based on sheep population, production system and accessibility. Following identification of 3 production systems in the study area (mixed crop-livestock, agro-pastoral and pastoral production systems) 3 districts were selected from each production system purposively based on accessibility. The number of *Kebeles* selected, based on the same criteria, from each district was 2. Simple random sampling was used to select target households. Thus, a total of nine districts (3 from each production system) and 18 rural *Kebeles* (2 from each district) were selected for the study. The total number of households considered for the study was 270 (90 from each production system).

Semi-structured questionnaires and formal interviews were used to gather information from the selected households. The questionnaire was tested before the actual survey to ensure that all questions were of sufficient clarity for the interviewees. Data on general household information, feeding, grazing, watering, housing, disease prevalence and animal health management; sheep owner's perception and special attribute of sheep; productive and reproductive performance and major constraints were collected by trained enumerators.

2.3. Data analysis

Statistical Package for Social Sciences [18] was used to describe the general household characteristics across all the production systems. A one-way analysis of variance was applied for quantitative dependent variables using production systems as independent variable. The responses of nominal and ordinal variables were tested using

chi-square ($\chi 2$) tests and whenever found important, the tests were followed by correspondence analysis to show the relationship among nominal variables.

In preference ranking method, index was computed with the principle of weighted average, and indexes were ranked among each other. The following formula was used to compute index as suggested by [19]. Index = Sum of [3 for rank 1, 2 for rank 2, and 1 for rank 3] as given for an individual reason divided by the sum of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] summed for all reasons.

3. Results

3.1. General household characteristics

The average family size of the households in the study area were 7.83±0.20, 6.32±0.21 and 6.83±0.28 for mixed crop-livestock, agro-pastoral and pastoral production system, respectively. Male headed households constituted 90%, 92.2% and 88.9 % of the households in pastoral, agro-pastoral and mixed crop-livestock system, respectively. The mean age of respondents was 42.9 years (ranged from 28 to 70) for pastoral, 42.6 years (25 to 68) for agro-pastoral, and 38.0 years (27 to 55) for mixed crop-livestock production system. Regarding education status of the repondents only 6.67% of the respondets could read and write in pastoral production system. Whereas, 21.1 and 65.6% of the respondents in agro-pastoral and mixed crop-livestock system, repectively, could read and write. The majority (100% in pastoral and 63.3% in agro-pastoral) of the respondents stated that livestock especially sheep are their main source of food and income. About 92.2% of respondents in mixed crop-livestock system indicated that crop production was their main source of food and livestock/sheep and cash crop such as chat (*chata edulis*) were the main source of income.

3.2. Livestock holding and species composition

The major livestock species in the study area were sheep, goat, cattle, camel and donkey (Figure 1). Due to the fact that this study considered only those households who had sheep all households own sheep. About 75.5% of the households kept goats, which were followed by cattle, camels, donkeys and others including horse and chicken (Figure 1). Sheep and goats were the dominant livestock species followed by cattle in the study area.

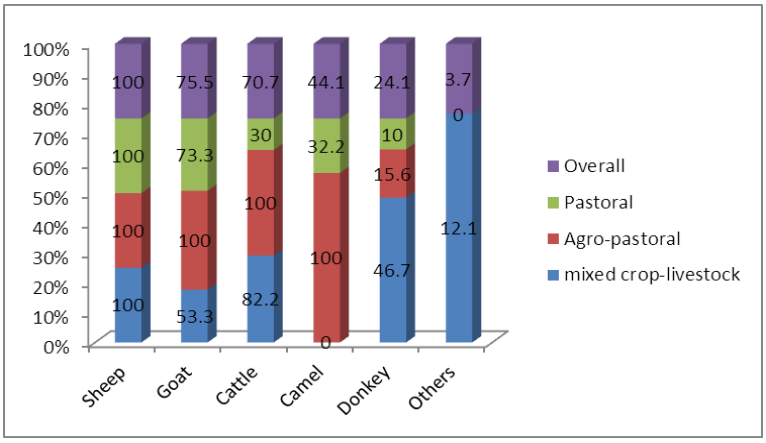

Figure 1: Livestock possession per household as reported by respondents

Mean number of various livestock species per household in all production systems are summarized in Table 1. The overall mean number of livestock in the study area was 58.6±3.29, 22.5±1.38, 6.00±0.29, 4.28±0.23 and 0.49±0.07 for sheep, goats, cattle, camel and donkey, respectively (Table 1). There was a significant difference ($P<0.05$) in average number of sheep and goat across production systems. Higher numbers of sheep were observed in pastoral system. Camel is predominated in only agro-pastoral and pastoral production systems.

Table 1: Average livestock size per household (Mean ± SE) in different livestock production systems

Livestock species	Overall (N=270)	Mixed crop-livestock	Agro-pastoral	Pastoral
Sheep	58.6±3.29	$6.42±0.39^{c}$	$72.3±4.37^{b}$	$97.1±5.24^{a}$
Goat	22.5±1.38	$4.48±0.51^{c}$	$22.5±1.81^{b}$	$32.0±2.25^{a}$
Cattle	6.00±0.29	$3.21±0.15^{b}$	$1.96±2.50^{b}$	$8.10±3.08^{a}$
Camel	4.28±0.23	NA	4.11±0.45	4.30±2.19
Donkey	0.49±0.07	0.54±0.07	0.41±0.65	0.53±0.14

N=number of respondents; SE= standard error; values connected by different letters are significantly different ($P<0.05$) within rows

3.3. Distribution and special attributes of indigenous sheep

The sheep owners in pastoral and agro-pastoral systems could not trace back the origin of the sheep breeds, rather they pointed out that the breeds were kept for long past by their ancestors. Based upon the results of group discussion in the study area, the major sheep breed was BHS which is distributed within the Somali national regional state and in some parts of Oromia national regional state. On the other hand, the sheep owners in mixed crop-livestock production agreed that they brought their sheep, HHL, from different areas such as Somali, Afar and west Hararghe. Sheep owners in this production system believe that their sheep do not have uniform coat color and tail type like that of the BHS sheep, rather are intermixed. This is because of the fact that purchasing sheep from pastoral and agro-pastoral system and fatten/mange them in mixed crop-livestock system is common practice in the study area. They might have come from adjoining areas where BHS, Afar or Arisi Bale sheep exist. Majority of the respondents (75.5 %) stated that the population of sheep is at a decreasing trend though there was a significant difference ($P<0.05$) in sheep population trend between production systems. The possible reasons reported for this trend were mainly due to drought (pastoral production system), feed shortage and disease. Almost all (96.3%) sheep owners in all production systems have good attitude about their breed and they preferred to maintain them because of their special attribute such as ability to thrive feed shortage, tolerance to drought, disease, heat and cold (HHL sheep). However, respondents in mixed crop-livestock system showed interest to get different sheep breed if it has superior productivity, even if they have positive attitude for the existing sheep breed/type.

3.4. Feed resources and grazing management

Available feed resources for sheep, seasonal fluctuations and coping mechanisms in study area are presented in Table.2. According to the respondents in the study area, natural pasture from the communal rangeland and grazing on fallow land (48.9% and 24.5%) were the main source of feed for sheep. There was a significant difference ($P<0.05$) in type of available feed resource among the production systems. Crop residues from cereals (maize and sorghum) were used as a main source of feed during dry season in mixed crop-livestock and agro-pastoral production systems. Agro-industrial by-products such as wheat bran were the only feed used as supplement for breeding animals during the dry season in mixed crop-livestock system. Most of the respondent (95.2%) in the study area reported that there was seasonal fluctuation in feed availability (Table 2). The sheep owners use different coping mechanism to overcome feed shortage, and this varies significantly ($P<0.05$) among production systems. In mixed crop-livestock system, 94.4% of the respondents stated that they purchase feed while the rest 5.6% are forced to destock their sheep in the form of sell during sever feed shortage. In agro-pastoral and pastoral systems, 75.6% and 81.1% of the sheep owners, respectively move their animals to the areas where feed and water is available. Majority of the respondents in pastoral system stated that the only supplement to sheep is natural mineral soil collected from different areas.

Table 2: Feed resources, availability and coping mechanisms during feed shortage in different livestock production systems as reported by respondents (%)

	Mixed crop-livestock	Agro-pastoral	Pastoral	Overall	X^2 P value
Feed resources					
Natural Pasture	27.8	45.6	73.2	48.9	
Fallow land	5.6	41.1	26.8	24.5	
Crop residue	37.8	13.3	0.0	17.0	0.000
Concentrate	28.9	0.0	0.0	9.6	
Seasonal fluctuation of feed availability					
Yes	92.2	93.3	100	95.2	0.031
No	7.8	6.7	0.0	4.8	
Coping mechanisms					
Purchasing feed	94.4	13.3	18.9	40.4	
Moving to search feed	0.0	75.6	81.1	52.2	0.000
Destocking	5.6	11.1	0.00	7.4	

Grazing mangement and way of herding sheep in the study area is presented in Table 3. Management with respect to grazing and herding was significanly different across production systems (Table 3). About half of the respondents (50.3%) practice free grazing followed by herding (41.4 %) and tethering (8.3%). However, tethering of sheep was practiced only in mixed crop-livestock system which was not common in both agro-pastoral and pastoral production system. Majority of the respondents (75.5%) in pastoral areas reported that

sheep flock of a household was herded alone without mixing with other flocks. Besides, breeding rams were separated from the flock during grazing to prevent mating especially during dry season. Mixing of sheep flocks of several households was practiced by most of the sheep owners in both mixed crop-livestock (70.0%) and agro-pastoral (55.6%) production system (Table 3).

Table 3: Percent of respondents who used different management type for grazing and herding of sheep in different livestock production systems

Management type	Mixed crop-livestock	Agro-pastoral	Pastoral	Overall	X^2 P value
Grazing management					0.000
Free grazing	58.9	62.3	30	50.3	
Herding	16.7	37.7	70	41.4	
Tethering	24.4	0.0	0	8.3	
Way of herding					0.000
Only one household	30.0	44.4	75.5	50.0	
More than one household	70.0	55.6	24.4	50.0	

3.5. Water resources and watering

According to the respondents, natural ponds and constructed dams, water wells and rivers were the main sources of water during the dry season in all production systems. Whereas, during the wet season pond and dams filled by the rainy water were the main sources of water. The distances to watering points and frequency of watering varied with seasons and production systems. The majority of the respondents in pastoral and agro-pastoral production systems take their animals up to 10 km in search of water during the dry season, but during the wet season distance is reduced to about 5km. There was seasonal variation in water availability and frequency of watering in all production systems. Pastoral production system had limited water access during both wet and dry seasons (Figure 2).

3.6. Housing of sheep

Type of sheep house and the place where it is constructed is presented in Table 4. According to the respondents, 61% of the households in the study area house their sheep in Kraal without roof, 35.6% in barn and only 3.3% within the family house (Table 4). There were significant differences ($P<0.05$) in housing system between production systems. In mixed crop-livestock system, majority of the respondents construct barn for sheep adjacent to family house (62.2%) which is made from wooden wall, earth mud floor and thatch or corrugated iron sheet roof. In agro-pastoral and pastoral production systems, mostly sheep were kept in open kraal (68.9% and 86.7%, respectively) and separated from family house which is constructed from wood and branches of acacia. The rest of the respondents in the respective production systems housed their sheep in barn (31.1 and 13.3%, respectively). The house is adjacent to the family house made from wooden, earth mud and thatch roof.

About 6.7 percent of the respondents in pastoral system use both type of housing system depending on the situation (Table 4). Most of the respondents house their sheep only during night time in all the production systems.

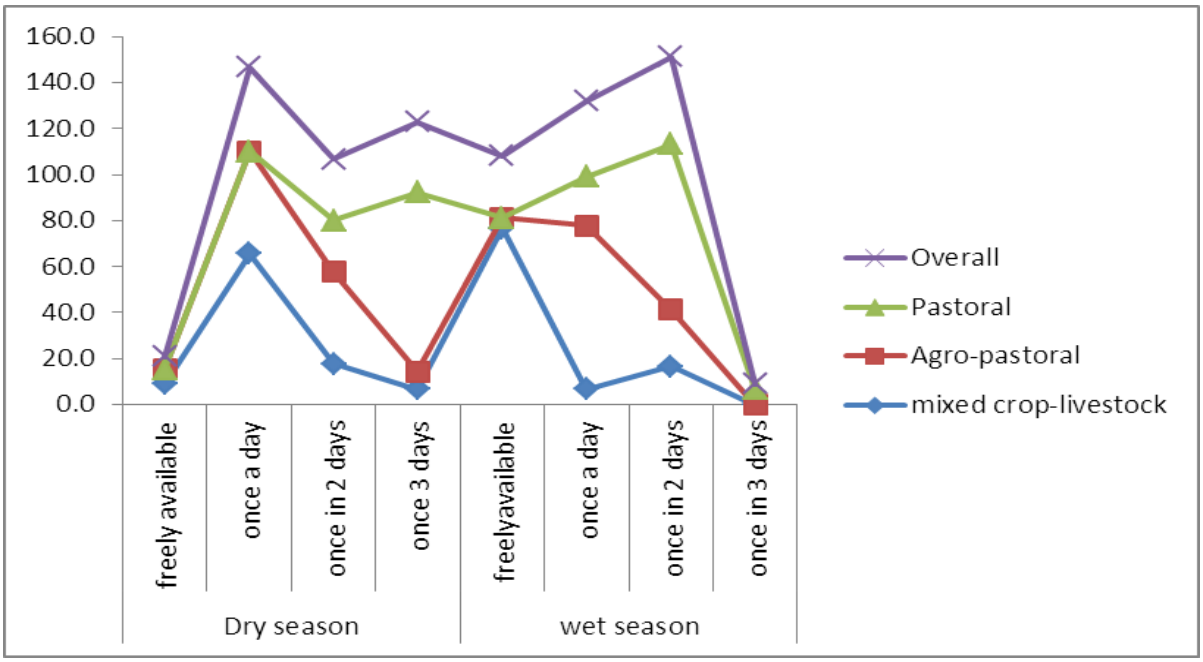

Figure 2: Frequency of watering sheep as reported by respondents in different livestock production systems

Table 4: Distribution of households according to their sheep housing systems and places of shade in different production systems (%)

Housing /places	Mixed crop-livestock	Agro- pastoral	Pastoral	Overall	X^2 P value
Types					
Kraal without roof	27.8	68.9	86.7	61.1	
House with roof (barn)	62.2	31.1	13.3	35.5	0.00
Within family house	10.0	0.00	0.00	3.3	
Places					
Adjacent to family house	81.1	27.8	18.9	42.9	
Separate from family house	18.9	72.2	74.4	55.9	0.00
Both places	0.0	0.00	6.7	2.2	

3.7. Disease prevalence and accesses to veterinary services

According to group discussion, pastoralist/agro-pastoralist stated that sheep pox, skin disease (dermatitis), Coenurosis, Pasteurellosis and abortion were the major diseases which affect sheep in the study area. Although vaccination was provided, it is limited to few common diseases and the service was provided by the government only during seasonal outbreak. In mixed crop-livestock system, Pasteurellosis, respiratory problem, Fasciolosis and Anthrax were reported as major diseases affecting sheep productivity and survival. Limited animal health service delivery has been reported by sheep owners in the same production system.

About 43.9% of the respondents use traditional practices and 38.2% rely on veterinary practice to treat their sick animals, while 21.1 % use both methods (Table 5). However, there was significant difference ($P<0.05$) between production systems in methods of treatment of sick animals' and access to veterinary services. Most of the pastoralist and agro-pastoralists use traditional practice to treat their sick animals while smallholder farmers in mixed crop-livestock system use veterinary treatment. Only 75 percent of the respondents had accesses to veterinary services and medicament supply from the government while, the rest 16.1 and 8.7% had access from private veterinarian and drug from shops/open markets, respectively. Distance to nearest veterinary services was significantly longer in pastoral system compared to the other two production systems (Table 5).

Table 5: Percent of the households who had access to veterinary services, distance to nearest veterinary services and method of treatments

	Production systems				
	Mixed crop-livestock	Agro- pastoral	Pastoral	Overall	X^2 P value
Methods of treatments					
Veterinary practices	72.2	29.3	30.4	43.9	
Traditional practices	17.6	39.6	57.3	38.2	0.00
Both	10.2	31.1	12.3	17.9	
Access to veterinary services/medicament					
Government veterinarian	96.7	61.2	67.8	75.2	
Private veterinarian	3.3	28.2	16.7	16.1	0.00
Shop or open market	0.0	10.6	15.6	8.7	
Distance to nearest veterinary services					
Less than1 km	7.8	6.7	5.6	6.7	0.00
1-5 km	64.4	82.2	14.4	53.7	
6-10 km	27.8	11.1	80.0	39.6	

3.8. Reproductive and productive performances

Reproductive and production performance of indigenous sheep in all production systems are summarized in Table 6. Reproductive performance, such as age at sexual maturity of sheep for both sexes and age at first lambing, lambing interval and average marketing age were significantly higher ($P<0.05$) in pastoral production

system whereas life time lamb crop was significantly higher (P<0.05) in mixed crop-livestock system as compared to the other two production systems. Average milk yield per ewe and lactation length were relatively higher in agro-pastoral production system compared to pastoral production system (Table 6).

Table 6: Average reproductive and productive performance (Mean±SE) of indigenous sheep in different livestock production systems

Parameters/traits	Mixed crop-livestock	Agro-pastoral	Pastoral	Overall (N=270)
Age at sexual maturity male (months)	6.38±0.13[b]	6.27±0.21[b]	10.22±0.17[a]	7.63±0.14
Age at sexual maturity female (months)	6.65±0.12[b]	7.07±0.19[b]	8.00±0.09 [a]	7.24±0.11
Age at first lambing (months)	12.7±0.14[c]	13.8±0.27[b]	14.7±0.28[a]	13.8±0.14
Lambing interval (months)	6.63±0.19[c]	8.81±0.24[b]	10.2±0.19[a]	8.58±0.14
Life time lamb crop (number)	13.9±0.34[a]	9.13±0.19[b]	8.60±0.24 [c]	10.5±0.17
Marketing age (months)	6.39±0.17[b]	6.40±0.09[b]	6.89±0.12[a]	6.56±0.08
Average milk yield per ewe (liter)	NA	0.91±0.02	0.86 ±0.03	0.88 ±0.22
Lactation length (month)	NA	3.13 ±0.07	2.87 ±0.12	3.00 ±0.06

N=number of respondents; NA= not available SE=Standard Error; values connected by different letters are significantly different (P<0.05) within rows

3.9. Major constraints of sheep production

Major constraint of sheep production as ranked by respondents in the study area is presented in Table 7. Feed shortage, water scarcity, drought and disease prevalence were considered as the most important constraints limiting sheep production in the study area. There was variation in index intensity in prioritizing constraints among the production systems. Feed shortage, disease prevalence and predators were the first three constraints in mixed crop-livestock system with index value of 0.46, 0.23 and 0.15, respectively (Table 7). Water scarcity, feed shortage and poor productivity of sheep were the major sheep production constraints in agro-pastoral system with index value of 0.33, 0.31 and 0.20, respectively. Drought, feed shortage and water scarcity were also the most important constraints ranked by pastoralists with index value of 0.47, 0.25 and 0.18, respectively (Table 7). Poor productivity and disease prevalence were also most important constraints in agro-pastoral and mixed crop-livestock systems, respectively.

Table 7: Sheep production constraints ranked by respondents and priority indices in different livestock production systems

	Mixed crop-livestock				Agro- pastoral				Pastoral				
	Rank				Rank				Rank				
Constraints	1	2	3	I	1	2	3	I	1	2	3	I	Overall I
Feed shortage	62	9	0	0.38	12	60	6	0.31	12	36	18	0.25	0.31
Water scarcity	7	3	1	0.05	42	18	12	0.33	0	22	48	0.18	0.19
Disease prevalence	5	38	30	0.23	0	0	30	0.06	0	20	12	0.10	0.13
Drought	1	15	10	0.08	0	6	6	0.03	78	4	0	0.47	0.19
Poor productivity	10	5	13	0.10	30	6	0	0.20	0	0	0	0	0.10
Predators	5	17	33	0.15	0	0	36	0.07	0	0	0	0	0.07
Total number	85	70	54	1	84	90	90	1	90	82	78	1	1

I=index; I=sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] given for an individual constraint divided by sum of [3 for rank 1+2 for rank 2 + 1 for rank 3] summed for all the constraints

4. Discussion

A good understanding of a production system is important for initiating any genetic improvement program [20]. The current study provides a better understanding of the indigenous sheep production system of eastern Ethiopia; evaluates its sustainability, and identifies some constraints limiting sheep productivity. This information could be useful for policy makers and extension services in devising strategies to improve the productivity and sustainability of different production systems, more importantly to set up sustainable genetic improvement strategy for sheep breeds.

Better educational background of respondents obtained in mixed crop-livestock and agro-pastoral system might be a good potential for adoption of improved technologies and facilitate performance and pedigree recording [21]. It is also important to consider upgrading of the education status of pastoralists for the success of development interventions in general and sheep breeding strategies in particular. All the pastoralists and more than two-third of the agro-pastoralists in the study area depend almost on livestock/sheep as means of income and food source for the family which needs more emphasis and the issue should take into account during designing of development strategy. Majority of the respondents in mixed crop-livestock system depend on sheep as a source of income. The contribution of sheep for the family income obtained in this study was in agreement with a previous report elsewhere in Afar [11, 22]. [8] Reported the same trend in western and south western Ethiopia for Horro and Bonga sheep.

The average number of sheep per household in the present study was higher than the average number reported at different districts of Shinile zone [13], east Hararghe zone [14] and Chifra district of Afar [22] which were 19.2, 5.7 and 28.1, respectively. A significant difference in sheep flock size found in the current study might be due to

the suitability of the environment for sheep production and the role of sheep for the livelihood of the owners. According to [23] flock sizes of sheep and goat vary with the production system and the production environment in Ethiopia. The same authors indicated that the specific factors determining flock size include role of livestock as major source of livelihood, availability of land and feed and reliability of crop production. The relatively larger sheep flock size and higher contribution of sheep for the family income in all production systems indicated that the area is in favor of sheep than larger animals. The same trend was observed in Afar area where sheep and goat flock size was relatively higher than other livestock species [22, 24].

The main feed resources in the study area are natural pasture, fallow land and crop residues. These feed resources are low in CP content and poor in digestibility. According to [25], the minimum protein level for maintenance is about 8% on dry matter basis. Strategic supplementing sheep with better quality feed resources is essential to improve sheep productivity. If increased productivity is needed, efforts should be made to increase the quantity as well as the quality of feed given [26]. Limited availability of water in the study area will have implication in availability of feed/ grazing pasture which is critical in pastoral production system. The same information has been reported previously [11, 22] for Afar area where low watering frequency due to scarcity of water was common in. Both feed and water resources are equally important and they are interrelated with each other. This might be due to the environment which is harsh and receive low amount of rain and sometimes absence of rain at all throughout the year. According to group discussion, the pastoralist claimed that they did not see enough rain during the rainy seasons for a long period of time which forced them to move to different areas in search of feed and water for their animals. Besides, they are forced to keep relatively higher number of small ruminant especially sheep than cattle. The pastoralists did believe that sheep have adaptation for feed and water scarcity.

A significant difference in reproductive performance among production systems observed in the current study might be due to difference in environment, feeding management and breeding practice among the production systems. The current finding in age at sexual maturity for male and female and age at first lambing were lower than reported for BHS sheep [13] which was 17.9±4.75, 13.7±3.97 and 23.5±3.63 months, respectively and for HHL sheep [14] which was 12.2±0.7, 10.2±0.9 and18.1±0.7 months, respectively. But it is comparable with reports of [22] for Afar sheep which was 6.5, 7.4 and 13.4 months, respectively. Lambing interval found in the current study were lower than the previous report of 10.5 months for Back head Somali [13] and 11.8 months for Afar sheep [22] and higher than reported for HHL sheep which was 6.5 months [14]. The amount of milk per ewe per day was higher than the previous report of 224±54 ml by [11] and 0.3±0.20 by [22] for the Afar sheep. However, the lactation length was comparable to values reported by the [11, 14, 22]. The amount of milk and lactation length were determined by season (dry and wet) and feed availability [11, 22]. Milk production form sheep for human consumption were common only in agro-pastoral and pastoral production systems [27]. Higher milk production and better lactation length in agro-pastoral system might be associated with less stress and better environment found the production system. The reproductive and productive performances of sheep in current study were better and within acceptable range for most tropical sheep. These would be an important input for sheep improvement actions in the future.

Feed shortage in terms of both quantity and quality was identified as a major constraint in all production systems which is in the agreement with different research report elsewhere in the country. [6, 22] Indicated that feed shortage were the major constraints affecting the sheep productivity in different parts of the country. Feed shortage especially in the long dry season is critical problem in all the production systems. This factor extremely affects the growth rate and body energy reserve of animals rendering them to have a low quality meat [28]. Proper feeding with high-energy diets increases the meat quality through increasing the muscle glycogen reserve, which helps to keep the pH low after rigor mortis, and improve intramuscular fat content [29]. Therefore, proper feeding of animals for growth and meat quality should be practiced carefully.

Water scarcity and drought were identified as the second major constraints for sheep production in all production systems. Though most pastoralists recognized the sheep breed for its tolerance to local prevalent harsh environmental conditions, the major cause for loss of sheep identified in pastoral production system was drought. This sounds equivocal, but drought intensity in some parts of the districts can be so high that its effects override the sheep's adaptive attributes [30]. Maximum effort should be exerted for water resource development and sustainable mitigation strategy should be in place to minimize loss of animals/gene pool due to drought.

Disease prevalence was identified as the third major cause of sheep mortality and affects the productivity in the present study. Types of disease and limited veterinary services reported in this study were in agreement with the report of [13, 11, 6, 14] in different parts of the country. [19] Stated that poor health is the key limiting factor to the productivity of sheep raised by most rural farmers in developing countries. Most interviewee sheep owners depended on drug suppliers for veterinary help; this raises some doubts on the accuracy of the diagnosis of diseases and the efficacy of the drugs. Maximum productivity in a given system of production emerges when disease control is optimal [25].Thus, healthcare is an important problem to consider before genetic programs can be seriously anticipated.

5. Conclusion and recommendations

This study revealed that average household sheep flock size was relatively larger and its contribution to the family income is significant in the eastern Ethiopia. The higher dependency of agro-pastoralists and pastoralists on sheep production than other species of livestock in the study area suggests that introduction of carefully planned and pertinent genetic improvement strategy could have good chances of success. Besides, relatively better reproductive and productive performance of sheep under harsh environment would create an opportunity to improve the productivity of sheep through addressing the major constraints. The study also showed that there was a difference in flock size, major farming activities, feed and water resources, productive and reproductive performances of sheep among the production systems indicating the need for specific interventions with respect to the production systems. Accordingly, suitable genetic improvement strategy for pastoral and agro-pastoral system should focus on existing sheep breeds and sheep owners' driven strategy. Similarly, suitable genetic improvement strategy for mixed crop-livestock system should focus on improving the existing sheep breed as well as introducing new ones. Across all the production systems, community should be involved in genetic improvement of sheep starting from the beginning.

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