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Characterization of the Production System and Breeding Practices of Sheep Producers in Tahtay Maychew District, Northern Ethiopia

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Abstract
The study was conducted in Tahtay Maychew district of the central zone of Tigray, Northern Ethiopia. The objective of the study was to understand the sheep production system, the breeding practices, selection criteria, and sheep production constraints to identify sheep farming practices about future production strategies in the study area. A total of 70 households from 2 kebeles (lower administrative structure) were selected purposively based on sheep population and production potential and accessibility. Data was collected through semi-structured questionnaires, focus group discussions, and key informants. An index was calculated to provide an overall ranking of the purpose of keeping sheep, culling rams and ewe, according to the formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3]. It is concluded that both female and male sheep are maintained mainly for income generation followed by breeding. A variable that was given a higher priority in selecting breeding males and females was body size. Disease, feed shortage, lack of grazing, and predator are the major constraints of sheep production mentioned in the study area. Therefore, addressing these constraints is important to design a successful genetic improvement scheme in the area for sheep.
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1. INTRODUCTION

1.1. Background and Justification

It is believed that the livestock population in Ethiopia is the largest in Africa (Tsegay Lijalem and Gebreegziabher Zeru, 2016). Livestock is an important source of income for the agricultural community and is also one of Ethiopia's major sources of foreign currency through the exportation of live animals, meat, and skin (Habtamu Lema, 2015). Climate change and livestock issues have been only modestly considered even though livestock production is the most important sector and influenced by climate change (Niemi and Ahlstedt, 2014). Livestock production and productivity negatively affected climate change and it needs justification on the need to conserve and sustainably use available local animal genetic resources. Conservation and sustainable utilization of local AnGR however requires information on their morphology and production system (Osei-Amponsah *et al*., 2017).

The huge livestock resources and diversified genetic pools in Ethiopia are adaptive to different agro-ecologies. Farm animals are raised both in the highland, midland, and lowland areas of the country and they are the integral parts of Ethiopia's agricultural system. Livestock production in most developing countries is mostly subsistence-oriented and fulfills multiple functions that contribute more to food security (Duguma G et al., 2010). Despite the large livestock resources with high potential for meat and milk production, several factors influenced the development of the livestock sector in Ethiopia includes the poor genetic performance of the indigenous animals, inadequate veterinary services, shortage of animal feeds as well as the absence of good management systems (Kebebe Ergano, 2015).

Sheep production is among the most crucial agricultural activities in the highlands of Ethiopia where crop production is unreliable. Sheep provide farm households with cash income, meat, fiber, and manure. As compared to large ruminants Small ruminants have shorter production cycles, faster growth rate, ease of management, and, low capital investment (Tadesse E et al., 2015). In the absence of enough grazing land, small ruminants are efficient meat and milk producers for the smallholder farmers. They require small space and feed. These days, as a result of crop encroachment and degradation of communal grazing lands there is a general shift in livestock holding from cattle to small ruminants because of the consistently dwindling grazing land (Mengstie Taye et al., 2010). Feed scarcity, water shortage, disease/ parasite, and shortage, market problem, inbreeding, Capital problem, poor management, awareness problem and, untimely credit access are among the constraints for the sheep production system in Ethiopia (Assefa Feleke et al., 2015).

The main objective of this study is to characterize the production system, describe the production objectives and breeding practices of the sheep producers, generate information on the sheep breeds and breeding systems, and provide baseline information for designing breeding programs for Tigray sheep in the Tahtay Maychew district.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The study was conducted in Tahtay Maychew district of the central zone of Tigray in northern Ethiopia. The study district was selected for the reason that it is known as the center of distribution for Tigray sheep breeds. The study district covers a total area of 18,618 km^2 and with an altitudinal range of 1992-2333 m.a.s.l. and lies approximately between 130 52' and140 19' North and 38 0 29' and 380 42' East. The mean annual temperature is about 19.90ºC and the minimum and maximum temperatures were 9.9ºC and 30.3ºC recorded in December and June respectively. The estimated livestock population in the study district is about 247,907 consisting of 75,707 cattle; 55,517 goats; 110 mules; 6,716 donkeys; 25,195 sheep and 84,102 poultry (Atsbeha Genet et al., 2015). The prominent farming system of the study area is mixed crop-livestock production.

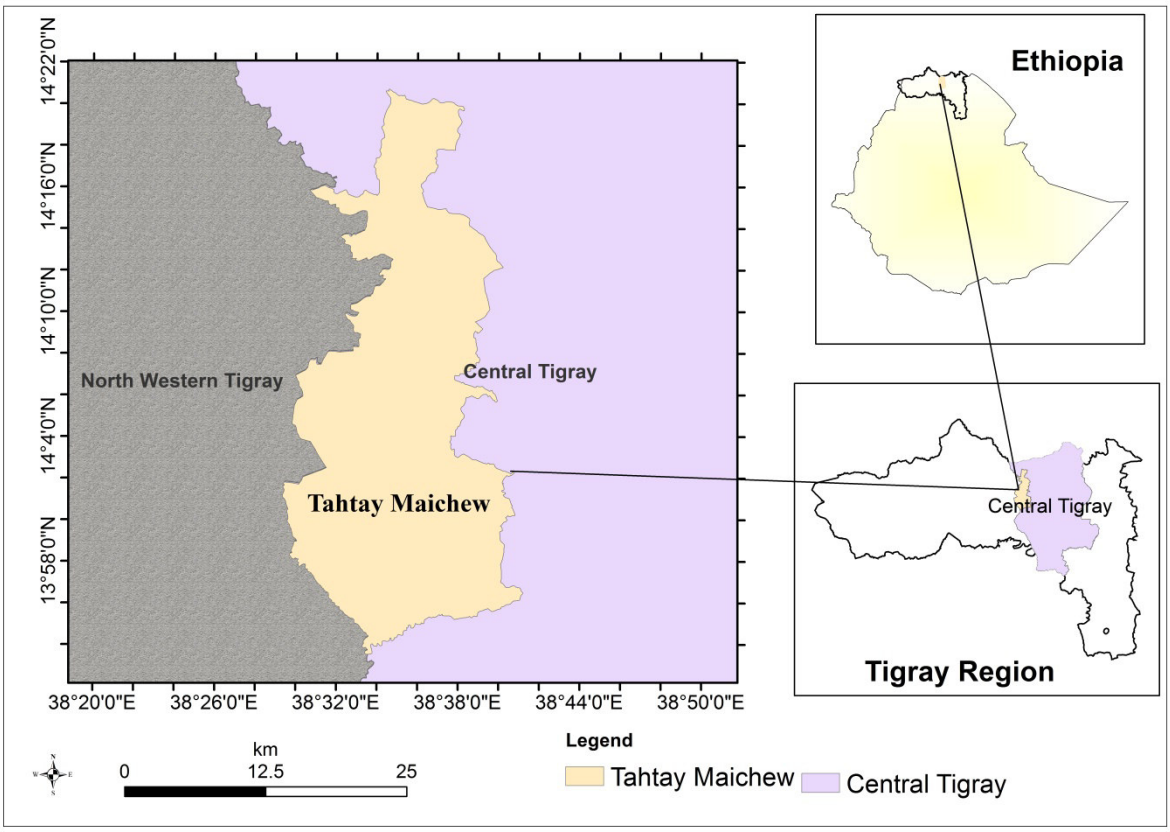

Figure 1. Map of the study area

2.2. Sampling procedure and Data Collection

Data was collected through interviews with randomly selected 70 sheep owners from Tahtay Maychew district. To check the clarity of the questionnaire to respondents and appropriateness of the questions the questionnaire was designed, pre-tested, and modified before the commencement of the actual administration. Staff from the Ethiopian biodiversity institute administered the modified and finalized questionnaire. The questionnaire gathered information on socio-demographic characteristics of the households (age, gender, educational background, family size), livestock holding, flock characteristics (number and composition), source of income of the respondents, livestock and their importance, farming system characteristics, the purpose of keeping sheep, selection criteria of sheep, culling criteria of sheep, sheep diseases in the study area, and reproductive characteristics and constraints of sheep production in the study area.

2.3. Data Analysis

The data was entered and analyzed by SPSS 23.0 software. Descriptive statistics of SPSS 23.0 software was used to describe the survey. An index was calculated to provide an overall ranking of the source of income of the

respondents, importance of livestock, major crops cultivated, the purpose of keeping sheep, culling criteria of sheep, selection criteria of sheep, a major disease in the study area, and constraints of sheep production, according to the formula: Index = Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] given for particular qualitative variables divided by Σ of [3 for rank 1 + 2 for rank 2 + 1 for rank 3] for all-qualitative variables. The rank was calculated by Microsoft excel 2010. The map of the study area was mapped with quantum GIS (QGIS 3.10.0).

3. RESULT AND DISCUSSION

3.1. Results

3.1.1. Individual and Household Characteristics of the Respondents

Household characteristics: In the study area, the majority of the small ruminants owning households were male-headed (93.2%) while the remaining were (6.8%) were headed by females. The average family size of the households was 6.32 ± 0.23 (ranging from 2-11) and this result is lower than the report of Shimels Mengistu (2020) which is 7.66 persons. This may be due to low awareness of family planning. Many members within the family seem to be considered as an asset and security in times of retirements.

The educational status of the respondents was illiterate, elementary, secondary, and informal education 37.0%, 52.1%, 6.8%, and 4.1%, respectively.

3.1.2. Livestock holding and composition, sheep ownership

The average reported livestock holding in the household is presented in Table 1. In Tahtay Maychew, the mean (±SEM) number of cattle, sheep, goat, chicken, donkey, horse, mule, camel, and bee hives per household were 3.5068±0.33, 8.16±0.59, 1.55±0.33, 4.19±0.41, 0.74±0.11, 0.03±0.03, 0.03±0.03, 0.07±0.04, and 0.4±0.15, respectively. Mostly the household head (husband) and spouse jointly, are flock owners.

Table 1: Mean (±SEM) livestock holdings in the study district

Livestock	Mean ± SEM (N=70)
Cattle	3.5068±0.33
Sheep	8.16±0.59
Goat	1.55±0.33
Chicken	4.19±0.41
Donkey	0.74±0.11
Horse	0.03±0.03
Mule	0.03±0.03
Camel	0.07±0.04
Beehive	0.4±0.15

N= number of respondents; SEM = standard error of the mean

3.1.3. Income Sources of the respondents

The source of income of the respondents is presented in Table 2. The existence of the respondents is mostly depending on crop cultivation followed by the rearing of livestock species. As the result showed trade is not as such an important income source for the existence of the respondents.

Table 2. Source of income of the respondents

Item	Rank1	Rank2	Rank3	Index
Crop	68	2	0	0.36
Livestock	2	67	0	0.24
Salary	0	0	3	0.01
Trade	0	0	0	0
Other	72	1	12	0.4
Total	142	70	15	1

3.1.4. Livestock and their importance in the study area

The uses of livestock in the study area are presented in Table 3. As the result showed cattle are the leading livestock species used for the lives of the respondents. Sheep and chicken are the second and third important livestock species, respectively.

Table 3. Importance of livestock in the study area

Livestock Breeds	Rank1	Rank2	Rank3	Index
Cattle	47	11	3	0.43
Sheep	14	42	6	0.34
Goat	0	3	6	0.03
Chicken	1	6	19	0.09
Donkey	0	3	9	0.04
Horses	0	0	0	0
Mule	0	0	0	0
Camel	1	0	0	0.01
Beehives	3	0	5	0.04
Others	0	0	7	0.02
Total	66	65	55	1

3.1.5. Farming system characteristics

Most of the respondents in the study area practiced mixed farming system, both crop-livestock productions are practiced integrated. According to the respondents, the major crops grown in the study area were Teff (index=0.38) Maize (index=0.24) Sorghum, Milt, Wheat, Barley, and Bean with an index value of 0.14, 0.14, 0.05, 0.03, and 0.03, respectively (Table 4). Crop cultivation was the most important sector in the crop-livestock production system and crop residues were the main source of feed for livestock. Livestock were invaluable components of the farming system in the study area and contribute enormously towards ensuring food security.

Table 4. Major crops and their importance

Item	Rank1	Rank2	Rank3	Index
Bean	0	3	7	0.03
Barley	1	2	4	0.03
Sorghum	12	5	12	0.14
Milt	13	9	2	0.14
Teff	37	18	16	0.38
Maize	16	19	17	0.24
Wheat	0	9	2	0.05
Total	79	65	60	1

3.1.6. Purpose of keeping sheep

The reasons for keeping sheep depend on the long or short term needs of the producers. The results of this survey revealed that sheep play multi-functional roles in the study district. Small ruminants are kept to meet both tangible and non-tangible benefits. The purpose of keeping sheep **is** presented in **Tables 5**. Sheep are highly valued livestock species by the Tahtay Maychew people next to cattle and reared to fulfill diverse socio-cultural needs (Table 3). Sheep are slaughtered at wedding ceremonies, Cultural festivals, and in honors of special guests and given as dowry.

Table 5. Purposes of keeping sheep

Item	Rank1	Rank2	Rank3	Index
Meat	7	10	21	0.1
Milk	0	0	0	0
Breeding	27	23	8	0.21
Manure	36	15	5	0.23
Blood	3	0	0	0
Hide	0	0	0	0.01
Hair	0	0	0	0
Income generation	72	12	18	0.41
Ceremonies	1	5	9	0.03
Others	0	1	0	0
Total	146	66	61	1

3.1.7. Culling reasons for sheep

Livestock keepers need to evaluate each animal and decide whether that animal is productive or not, with increasing production costs. Nonproductive ewes and rams should not be maintained in the flock.

The best way to increase the efficiency of the sheep breeds is culling. Culling criteria for ewe and ram in Tahtay Maychew district with corresponding index values are presented in Table 6. Most of the respondents cull their breeding rams in which body conformation (index = 0.17) and body condition (index=0.17) were the most important ram culling criteria followed by color (index = 0.16) and the next culling criteria were temperament and poor fertility with an index value of 0.14 and 0.13, respectively. And again most of the respondents cull their breeding ewes in which poor fertility (index = 0.25) and body size (index=0.18) were the most important ewe

culling criteria followed by body conformation (index = 0.16) and the next culling criteria were body condition and color with an index value of 0.13 and 0.10, respectively.

As the study showed the respondents cull their sheep mostly through sale and slaughter. As reported by Mengstie Taye et al. (2010) sale of sheep at an early age is common in other areas too. This, the sale of young animals negatively influenced flock productivity that fast-growing and good looking lambs could be removed out from the flock before reaching breeding age and replacing themselves (Mengstie Taye et al., 2010), and therefore drains the genetic pool of the flock. However, the practice can be taken as an efficient method of culling less productive and unselected animals out of the system, if properly managed. Therefore, care should be taken to maintain the productivity of animals while removing those with unwanted traits.

Table 6. The culling reason for male and female sheep in Tahtay Maychew district

	Male				Female			
Item	**Rank1**	**Rank2**	**Rank3**	**Index**	**Rank1**	**Rank2**	**Rank3**	**Index**
Size	2	4	4	0.05	14	7	6	0.18
Conformation	9	16	4	0.17	9	13	4	0.16
Colour	6	14	12	0.16	2	8	14	0.10
Temperament	11	6	5	0.14	3	1	3	0.04
Health problem	3	4	7	0.07	3	10	3	0.09
Body condition	15	6	5	0.17	3	13	10	0.13
Old age	1	5	7	0.05	1	4	6	0.05
Poor fertility	9	6	7	0.13	21	8	7	0.25
Others	0	0	26	0.07	0	0	0	0
Total	56	61	77	1	56	64	53	1

3.1.8. Selection of breeding animals and trait preferences

The most common way of selecting sheep as parents for the coming generations is to use the offspring of a chosen parent (ewe/ram). A linear index is the best strategy for selecting replacements in the livestock industries (Chawala AR et al., 2019). The selection criteria for ewe and ram in Tahtay Maychew district with corresponding index values are presented in Table 7. Most of the respondents select their breeding ewes and rams in which body size (index = 0.27) was the most important ewe and ram selection trait followed by body conformation (index = 0.26) and the next selection criteria that the respondents prefer were growth performance and color with an index value of 0.24 and 0.18, respectively. Therefore; This study is not in line with Demeke Haile et al. (2015) who reported that Basonawerena farmers do not include an appearance as a primary criterion for selecting breeding ewes. Instead, they ranked twining ability (index=0.26) as first, followed by age at first sexual maturity (index=0.19) and appearance (index=0.14).

Table 7. Ranked selection criteria for breeding males and females

Item	**Rank1**	**Rank2**	**Rank3**	**Index**
Size	26	9	16	0.27
Conformation	12	31	10	0.26
Color	4	17	29	0.18
Temperament	3	4	1	0.04
Growth performance	25	8	9	0.24
Others	1	0	0	0.01
Total	71	69	65	1.00

3.1.9. Disease of sheep in the study area

The major sheep health problems mentioned by the respondents are presented in Table 8.

The major sheep health problems mentioned by the respondents were diarrhea, loss of appetite, dermal disease, mucus discharge, stomach ache, and weight loss. In the study area, the most important sheep health problems mentioned by the respondents were diarrhea (0.29), loss of appetite (0.26), dermal disease (0.17), mucus discharge (0.16), stomach ache (0.07), and weight loss (0.04) was mentioned as important health problems (Table 8). As reported by **Zewdu Edea** (2012) in Adillo Kaka, the most important sheep health problems mentioned by the households in Adiyo Kaka, farmers indicated pasteurellosis, coenurosis, diarrhea, and lungworm in that order, as the most important diseases of sheep at different seasons of the year. Zewdu Edea (2012) also reported lungworm, liver fluke (fasciolosis), and coenurosis were mentioned as important health problems of Horro sheep producers, which is not in agreement with reports of this finding.

Table 8. Major disease in the study area

Type of disease	Rank1	Rank2	Rank3	Index
Stomach ache	5	0	0	0.07
Diarrhea	19	1	1	0.29
Mucus discharge	9	3	0	0.16
Dermal disease	2	11	7	0.17
Loss of appetite	11	6	8	0.26
Weight loss	1	0	6	0.04
Total	47	21	22	1

3.1.10. Sheep breeding and reproduction performance

3.1.10.1. Average sexual maturity of male and female sheep

The average age at sexual maturity for male and female sheep varies from breed to breed. Reproductive performances of Tigray sheep are summarized in Table 9. The average reported age at sexual maturity for Tigray sheep breeds were 6.76±0.20 and 7.86±0.32 months for male and females, respectively. The age at sexual maturity in this study is shorter than the finding of Zewdu Edea et al. (2012) who reported that the average sexual maturity of Horro and Bonga sheep was 7.5 ± 2.1 and 9.3 ± 2.2 months for male and female sheep, respectively. Therefore; the age at sexual maturity in this study is not in agreement with Zewdu Edea et al., 2012 who reported that average sexual maturity was 7.5 ± 2.1 and 9.3 ± 2.2 months for males and females, respectively.

3.10.2. Age at first lambing (AFL)

The average AFL of the study area was 12.09±0.35 months. The average age at first lambing for Tigray sheep breeds was shorter than 13.3 and 14.9 months reported by Zewdu Edea et al. (2012) for Horro and Bonga sheep, respectively. Feed shortage and disease can also lead to delayed age at first lambing through limiting early animal growth. Year of lambing and season of birth, influence age at first lambing through their effect on feed supply and quality. The type of birth of the ewe/lamb significantly affects the age at which the ewe/lamb first lambed. The good performance of Tigray sheep breeds has an opportunity for genetic improvement as a greater population turnover and more rapid genetic progress.

3.1.10.3. Lambing interval (LI)

The average lambing interval of Tigray sheep was 7.26±0.31 months (Table 9). It appears that this value is shorter than 8.9 and 7.8 months reported by Zewdu Edea et al. (2102) for Bonga and Horro sheep, respectively. Tigray sheep breeds, under traditional management production systems, lamb three times in two years. This is in agreement with the literature (Shimels Mengistu, 2020) who indicated that through the provision of better nutrition and management in organized farms of tropics it is practically possible to attain three lambings in two years. This kind of breeding schedule would permit the exploitation of the full reproductive potential, while at the same manner avoiding overly stressing females. To achieve such optimum reproductive performances from the Tigray sheep breeds, the prevailing feeding system needs to be adequate throughout the year.

3.1.10.4. Market age

The average market age of Tigray sheep in both sexes is not fixed. The market age of Tigray sheep is summarized in Table 9. The average reported market age for Tigray sheep breeds were 6.76±0.20 and 7.86±0.32 months for males and females, respectively.

Table 9. Reproductive performances of Tigray sheep in Tahtay Maychew district

Reproduction parameters	N=70 (Mean ± SEM)
Average sexual maturity of male (month)	6.76±0.20
Average sexual maturity of female (month)	7.86±0.32
Age at first lambing (month)	12.09±0.35
Lambing interval (month)	7.26±0.31
Average market age of male (month)	6.86±0.29
Average market age of female (month)	7.66±0.30

3.1.11. Major constraints of sheep production

The major constraints of sheep production in the study area as mentioned by the households were a disease, feed shortage and lack of grazing land, predator, and lack of housing (decreased in both size and productivity (Table 10).

Table 10. Major Sheep production constraint in Tahtay Maychew district

Constraints	Rank1	Rank2	Rank3	Index
Lack of water	1	0	0	0.01
Disease	30	9	0	0.34
Lack of drug	1	0	0	0.01
Lack of improved breed	0	0	4	0.01
Lack of grazing	11	13	2	0.19
Feed	17	7	0	0.21
Animal stole	0	0	1	0
Lack of vet	0	6	0	0.04
Lack of housing	7	3	0	0.09
Predator	2	11	4	0.1
Lack of proper management	0	0	0	0
Total	69	40	11	1

3.2. Discussion

The result showed that the majority of the small ruminants owning households were male-headed (93.2%) while only small proportions (6.8%) were headed by females. This finding is in line with Abegaze Beyene (2018), households were predominantly headed by males and that most livestock farmers are old aged are common phenomena in most developing countries. The current study described and documented Tigray sheep production systems in the traditional sector of Tahtay Maychew as an essential step towards the development of a sustainable breed improvement program.

Livestock farming was identified as the second activity in the study area; farmers had alternative means to source income. Similarly, farm produce alone could not sustain the household upkeep. Mohamed Adem et al. (2018) attributed this to unreliable food crop yield in the province. 'Even in good years', the result showed that, 'crop cultivation is not enough to guarantee the respondents sufficient food and income for one year'. Hence, other sources of income (salary and others like labor work, selling wood and manure) reported in the current study, seemed to serve as supplements to farming income. This phenomenon presents an opportunity for sustainable utilization of indigenous livestock; which can withstand drought and can produce under conditions of low input and low-level management, thus requiring less input and availing farmers time to conduct other activities.

As the result showed both female and male sheep are maintained mainly for income generation followed by manure and breeding. This builds financial capital and allows the sale of animals for cash that can be used for other agricultural enterprises, school fees, and medical bills, etc. Functions like hiding and hair received a lower ranking among sheep breeders. The purpose of keeping sheep for milk is zero, due to the culture of the society restricts not to drink sheep milk. As Shimels Mengistu (2020) reports, sheep milk is not used for drink and it is not also supplied to the market due to culture in acceptance of the society. Diverse functions are particularly important under the subsistence production system. The importance of diverse values of indigenous livestock breeds under low input system were well documented (Maria Wurzinger et al., 2011)

The culling of rams for sale or family consumption is another possible factor contributing to the high proportion of ewes per flock in this study. One aim of this study was to document information that would be useful in the future when formulating a breeding program for Tigray sheep. As the result showed sheep were commonly used as a family income, manure, breeding, and source of meat. The other use mentioned by respondents was hiding. Only 15 farmers, in the Tahtay Maychew district, used sheep for ceremonies (Table 5). Tsegay Teklebrhan, (2012) mentioned that fibers, hides, skins, and pelts of indigenous sheep breeds are better than the crossbreeds. These could be possible opportunities that farmers can exploit to better utilize their indigenous sheep.

As the result showed most of the respondents' major cause of loss of sheep identified in this study was a disease with an index value of 0.34. This concurred with findings by Solomon Weldemariam et al. (2014) Diarrhea and pneumonia are most commonly associated with an endemic condition in Ebinat and he ensured that poor health is the key limiting factor to productivity of sheep raised by most rural farmers in the study area. As reported by Solomon Weldemariam et al. (2014) most farmers interviewed depended on drug suppliers for veterinary help; this raises some doubts on the accuracy of the diagnosis of diseases. Maximum productivity in a given system of production emerges when disease control is optimal (Zewdu Edea, 2012). Thus, healthcare is an important problem to consider before the genetic program can be seriously contemplated. Community-based animal health programs may be one way forward and wider utilization of indigenous breeds tolerant to disease another (Tadele Mirkena et al., 2012). Feed shortage was identified as the second constraint for the sheep producers in the study area. Causes of feed shortage were due to human population growth, and frequent occurrence of drought, the low genetic potential of the breed, and lack of drug were ranked lowly in the study

area. This might be due to a lack of awareness of sheep owners about genotype. Solomon Woldemariam et al. (2014) reported that pneumonia and diarrhea are the major cause of sheep mortality in the Ebinat district. Wendimu B et al. (2016) also reported that the lack of strong animal health services and recurrent drought was mentioned as the main cause of sheep mortality. Another constraint for the sheep producers was the lack of grazing land. Other constraints such as lack of improved breed, lack of veterinary service, and drug identified in the present study were less significant (Table 10).

Conclusion

This study provides insight into agricultural production systems, breeding practices, and major production constraints encountered in sheep farming in the study area, which are preconditions in developing breeding programs. Livestock production is the main means of livelihood of the Tahtay Maychew community in the study area. Cattle and sheep have a great role in the livelihoods of the community. Tigray sheep breeds are the most promising for their better adaptability under low input extensive production environments where scarcity of feed and grazing land are the two major constraints. Sheep are highly valued animals by the Tigrian people next to cattle and reared to fulfill diverse socio-cultural needs. Body size and growth performance are given high priority in selecting breeding males among his mates. Similarly for breeding female body size, body conformation and growth performance are among the most considered criteria for selection. Disease, feed shortage, and predator are the major constraints of sheep production in the study area.

To avoid early disposal of breeding males, strong extension service is required to convince farmers and to develop an interest in the benefits of better genotypes or incentives that might be provided for those keeping their best males for breeding purposes. Owing to the small flock size in the study area, reasonable genetic gain demands the formation of breeders' group or co-operatives, which in turn require full participation and long-term commitment of sheep keepers and other livestock development actors. To realize the full benefits of breeding programs, approaches should be holistic, and a concurrent improvement in the non-genetic factors (disease and feed) is central.

Conflict of interests

The authors have not declared any conflict of interest.

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