Reproductive Performance and Farmer’s Traits of Interest and Selection Criterion Studies of Wollo Highland Sheep and Their F₁ Crossbreed Progenies

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Abstract: The study was conducted on-farm conditions reproductive performance assessment and breeding ewes and rams selection criterions. The feat of the research was conducted with questionnaire survey, on spot observation of flock monitoring and participatory-based focus group discussions. The three strata formed by available ram breed type for crossbreeding at smallholder farming situation. The first strat represented by Awassi F₁ crossbred progenies, second strata represented by Washera F₁ crossbred progenies and third strata is local Wollo highland breed lambs. The maximum number of flock size for third strata 289.0 which greater than first and second strata. The overall mean number of lambs, ewes, mated and pregnant ewes per flock comprised significant variation between the three strata (p<0.05) and higher with third stratum. The overall mean number of service per conception also showed significant variation between strata (p<0.05) and was higher in the third stratum 1.4 (0.2). Age at first mating, age at first lambing, single birth, twine birth, weaning rate and lambing interval varied significantly (p < 0.001) between each stratum. First stratum had comparatively higher fertility rate 89.8% and lower mortality rate than the third stratum. Lamb mortality due to disease and drought were higher in the second strata 32.2% and lower in the third strata 26.0%. Genetic improvement practices at smallholder farming condition showed promising result of using Washera ram crossed with Wollo highland ewes. Therefore, which designated for weaning rate, body size, marketing age, at first lambing, good temperament and large litter size traits? The contemporary breeding practice tended to reduce flock size to improve flock productivity via crossbreeding practices. The genetic improvement practice should have to embrace through controlled trait heritability test is a crucial research question.

Key words: Wollo Highland Breed - Reproductive Performance - Traits of Interest and Crossbreed Progenies

INTRODUCTION

Sheep production is a major component of the livestock sector in Ethiopia owing to the large population of 25.4 million head [1] and the diverse genetic resources [2]. In the highlands of the country, about 75% of the sheep population are found, while the remaining 25% are distributed in the lowlands [3]. Smallholder sheep productions are the major source of food security serving a diverse function including cash income, savings, fertilizer, socio-cultural functions and fibre production. Sheep are particularly important for farmers in the subalpine highlands and pastoralist/agropastoralist where crop production is unreliable. Moreover, the socio-cultural importance of sheep resources significantly contributed for foreign currency earning accounting for 34% of the live animal exports [2] in Ethiopia. Small ruminants account for 40% of cash income earned by farm households, 19% of the total value of subsistence food derived from all livestock production and 25% of total domestic meat consumption [4].

The objectives of improving indigenous sheep productivity in Ethiopia has been undertaken utilizing several exotic breed such as Merino breed from Italy, Bleu du Maine from France, Rambouillet from Spain, Romney and Corriedale from Kenya and Hampshire from UK [5] were mainly crossbred with the indigenous Menz and Wollo highland breed. Consequently, due to assumed
phenotypic similarity with the local sheep; Awassi breed was imported from Israel and was crossed with the indigenous Menz [5]. Conversely, efforts made so far did not bring significant change in the area; mainly because of sustainability problems and/or poor performance of imported breeds has created a negative impact for genetic improvement practices [6] and Workneh [7]. In addition, the less involvement of sheep producers in the genetic improvement programmes have mostly been implemented without taking into consideration the needs of the farmer [5]. Now adays smallholder sheep producers have being recogised their interested traits from available breed through subjective evaluation criterions of phenotype traits. Hence, pararal with the utilization of exotic breed, farmers also intersted to genetically superior indigenous breed for genetics improvement practices (crossbreeding).

However, the major problems of sheep crossbreeding which indicated by Workneh [7] and Tibo [5] were the lack of clear vision where to bring impact, lack of reproductive performance recording at smallholder level, exclusive nature of sheep producer’s traits of interest and incompatibility of the genotype with the existing environment. Subsistence farmers unlike commercial ones tend to keep animals for family need rather than purely as economic enterprise. They are keeping multi-purpose animals which produce meat, milk, wool, skin beside their transport and draught service. For that reason, it is important to consider all tangible and intangible roles of the breed, when defining breeding objectives at smallholder farmers level [8]. Hence, farmer’s selection criterions of their breeding ewes and rams need to be recognized with their production objectives. To bring impact on the genetic potential of the local breed the reproductive performance valuation of existed breed in the smallholder sheep producer’s farming situation also the call for task.

Consequently, lots has been done in on-station genetic improvement program assessment in nucleus and sub-nucleus farm level breeding practices. However, limited research effort has been done at smallholder farm circumstances assessment of flock reproductive performance, breeding ewes and rams selection criterions.

There for the objectives of this study were to evaluate existing breed reproductive performance, farmer’s traits of interest and trait selection criterion at smallholder farmers breed improvement practices.

**MATERIAL AND METHODS**

**Livestock Population of the Study Area:** Dessie Zuria and Kutaber districts had populous sheep production area from other Distriicts of the administrative Zone. Even though, the livelihood economy depend on crop production, its strongly supported by livestock production and mainly with sheep, cattle, goat and chicken production. The districts were historically chronic food insecure area for several decades because of shortage of rain fail and drought infected area. Sheep were sold to get immediate cash income through petty trading including buying, fattening and selling practice.

**On-Farm Flock Management Practice:** Smallholder farmer’s allowed their sheep flocks together (in groups) in a communal grazing land during daytime and depart during night time for enclosure in which they are housed together with other livestock separated by woodlot. Some farmers who own only small flock do tie their sheep to a peg. The main feed sources for sheep were grazing on private and communal natural pasture, improved forage (snare grass, vetch). During crop harvesting times, however, sheep have access to feed crop aftermath. Some farmers give supplemental feeds (wheat bran, milling and local brewery by-product, straw, salt and roasted bean) for the pregnant and nursing ewes, suckling lambs and castrated rams. Breeding practice is year-round for flocks under smallholder management systems. Rams are selected for mating based on smallholder farmer’s traits of interest. The phenotype attributes of rams and ewes were used as the major selection criterions.

**Description of the Study Breeds**

**Local Wollo Highland Sheep Breed:** Wollo highland sheep breed is one of the indigenous sheep breed found in the highland part of South Wollo administrative Zone at North East part of Ethiopia. The production system is mixed crop–livestock farming systems of smallholder farmers. They are characterized by; short fat tail with short twisted/coiled end, occasionally turned up at end; small size; well-developed wooly undercoat; predominantly black, white or brown, either plain or with patches of white, black or brown; long hair with wooly undercoat and horned males [2]. It is most commonly recognized by adaptation for feed shortage, high, lamb survival percentage and wool production [2].

**Washera Ram Crossed with Wollo Highland Ewes F₁ Crossbred Progenies:** Washera sheep breed is one of the indigenous sheep breeds reared by the rural farmers in the mixed crop–livestock farming systems of northwestern highlands of Ethiopia [9]. Lemma [9] reported that the Washera breed has an important genetic potential for growth and adaptation to a wide range of agro-climatic...
conditions. Chipman [11] has also reported their relatively fast growth rate under harsh circumstances with potentials to support farmers and national economy.

**Awassi Ram Crossed with Local Wollo Highland Ewes F₁ Crossbred Progenies** The Awassi crossbreeding projects were operates by the Debre Birhan and Amed Guya Sheep Multiplication center in Ethiopia. The multiplication center has been closed from 2004 to 2007 due to an outbreak of a respiratory disease (Maedi-visna) [10]. The Awassi × Wollo highland sheep breed crossbreeding scheme involves importation of pure Awassi rams, production of 3/4 Awassi × Wollo highland sheep crossbred progenies in guguftu private breed multiplication center, distribution of 6-month-old 3/4 Awassi crossbred ram lambs to villagers and upgrading of the village flocks to 75% Awassi [10] with back crossing.

**Research Design:** The study areas were stratified in to three strata. The first, second and third strata comprised Awassi rams F₁ crossbred progenies, Washera rams F₁ crossbred progenies and local Wollo highland progenies, respectively. The stratified areas were done by the assumption of available ram breed type, sheep population, agro-ecology similarity, flock management system, breeding strategies and producers breeding objectives. The main feats of data collection were conducted by questionnaire survey, flock monitoring, participatory based focus group discussion. Thus, producer’s breeding objectives, breeding strategies and flock structure information were gathered via questionnaire survey and group discussion.

**Sampling Methods**

**Purposive Sampling:** Dessie-zuria and Kutaber Districts and six peasant association areas (four from Dessie-Zuria and two from Kutaber) were selected by purposive sampling method. It was based on infrastructure accessibility, sheep population, availability of Awassi and Washera rams and crossbreeding practices and uniformity of existing breeding strategies. After the decision of household sample size by the stratified sampling method each individual sampling unites was selected by purposive sampling techniques.

**Stratified Probability Proportional to Size (PPS) Sampling:** Stratified probability proportional to size (PPS) sampling has the draw back of variable sample size and different portions of the population may still be over- or under-represented due to chance variation in selections. To address this problem, PPS combined with stratified approach was used.

Hence, six peasant association areas were stratified in to three strata. Thus, the sampling frame was selected from each stratum. Hence, the first, second and third strata consisted of 230, 370 and 675 household flocks as sampling frames, respectively. Awassi rams F₁ crossbred progenies, Washera rams F₁ crossbred progenies and local Wollo highland sheep were clustered in the first, second and third stratum, respectively. Then the sampling fractions from each stratum were synthesized and sampled elements were drawn. First decided the stratum which has the smallest size then divided the size of each stratum by the smallest stratum [12, 13] using the equation.

Proportional size of the three strata were: \[ \frac{675}{230} : \frac{370}{230} : \frac{230}{230} \approx 2 : 2 : 1 \]

Thus, these proportions mean that; when 3 households drawn from local Wollo highland sheep breed owners, at the same time there should be 2 and 1 households draw from Washera rams F₁ crossbred progenies and Awassi rams F₁ crossbred progenies owners, respectively. In this way the sample drawn as proportional to size stratified method from each stratum. Accordingly, this proportionality the sampling ratio was calculated using addition of proportions (3+2+1), which gave the product (6), as value of total proportion. Finally, it was divided the smallest proportion which equals to 1 by the total proportion of 6 and the sampling ratio were, 0.17 = 0.2(≈ \( \frac{1}{6} \)) for all strata. Then the elements of the sample drawn from each stratum were = 0.2*675=135 household flocks were selected from local Wollo highland sheep breed flocks. Whereas, 0.2*370 = 74 household flocks selected from Washera rams F₁ crossbred progenies. Similarly 0.2*230 = 46 household flocks were selected from Awassi rams F₁ crossbred progenies [12,13]. Therefore, 255 sampled household flocks (135 from local Wollo highland breed, 74 from Washera rams F₁ crossbred progenies and 46 from Awassi rams F₁ crossbred progenies) were randomly selected from the three strata.

**Data Collection Methods:** Multistage questionnaire survey used via semi-structured questionnaire and focus group discussion were held at each three strata household flock owners, development agents, experts and animal health technician. The questionnaire were initially
pre-tested on key informants and adjusted before administrated for actual respondents. Through questionnaire survey and group discussion farmer’s traits of interest, breeding ewes selection criterions of lamb survival rate / flock, twins rate, temperament, lamb growth rate, lambing interval, parental history, tail type and body conformation data were collected. Likewise, breeding rams selection criterions of body size, growth rate, coat color, body conformation, hair type, meat characteristics, marketing value, horn orientation and tail typedata were collected.

On spot observation of flock monitoring data collection method, reproductive performance information on number of breeding ewes/flock, number of breeding rams/flock, number of lamb/flock, number of lambs /ewes, number of pregnancies /flock, number of parturation/flock, embryonic mortality, number of service/conception, age at first mating and lambing, number of single and twin birth/ flock, lambing rate, lambing interval and weaning rate were gathered from Wollo highland sheep and their F1 crossbred progenies to be compared and contrasted each other.

Data Analysis

Ranking Analysis: Smallholder sheep producers’ breeding rams and ewes selection criterions of lamb survival rate / flock, twins rate, temperament, lamb growth rate, lambing interval, parental history, tail type and body conformation were analyzed via index method of ranking. Likewise, breeding rams selection criterions of body size, growth rate, coat color, body conformation, hair type, meat characteristics, marketing value, horn orientation and tail type information were also analyzed using index method of ranking analyses.

$$\text{Ranking Index} = \frac{R_n * C_1 + R_n - 1 * C_2 ... + R_1 * C_n}{\sum R_n * C_1 + R_n - 1 * C_2 ... + R_1 * C_n}$$

where, \(R_n\)=value given for the least ranked level (example if the least rank is 9th, then \(R_n = 9, R_{n-1} = 8, R_1 = 1\)). \(C_n\) = Counts of the least ranked level (in the above example, the count of the 9th rank = \(C_n\) and the count of the 1st rank = \(C_1\) Musa et al. [14].

Least Square Mean Analysis Variance: The fixed effect model of ANOVA of reproductive performance traits in each breed type (Awassi F1 crossbred progenies, Washera crossbred progenies and local Wollo highland) were analyzed using the GLM procedure of SAS [15] to separate and compared the different groups of mean. Tukey’s studentized range significance test used to separate different group means.

Model 1: Reproductive performance

$$Y_i j = \mu + b_i + e_{ij}$$

where: \(Y_{ij}\) = Reproductive performance traits (breeding ewes /flock, breeding rams /flock, lambs /flock, lambs/ewes, pregnancies /flock, parturition /flock, embryonic mortality /flock, service /conception, age at first mating, age at first lambing, lambing rate (birth/year/ewes), lambing interval and age at weaning).

\(\mu\) = Mean

\(b_i\) = Fixed effect of the \(i\)th breed type or strata (Awassi and Washera rams F1, crossbred progenies and local Wollo highland breed)

\(e_{ij}\) = Effect of the \(i\)th random error of measurements

Explanatory Statistics Analysis of Reproductive Performance Traits: Ewe’s reproductive performance parameters of fertility rate, prolificacy rate, lamb survival rate and weaning rate, for a given candidate flock were analysed by explanatory methods:
RESULT AND DISCUSSION

Breeding Ewe’s Selection Criterion and Farmers Traits of Interest: In present study, the recognized selection criterions of breeding ewe’s were lamb survival rate, twin rate, parental history, lambing interval, temperament, lamb growth rate, tail type and body conformation were in the order of their importance’s (Table 1). Getachew [19] revealed that, Menz sheep breeders considered lambing interval, mothering ability, ability to give multiple birth (twining) and coat color type as the first four reasons for ewe selection criterions and in agreement with present study. He also stated that, Afar sheep breeders were considered milk yield, mothering ability, appearance and/or size of ewe and lambing interval as the four more important traits and which is different from the present study. Which stipulated that, ewe’s selection criterion in the crop-livestock mixed farming and pastoral production system had different. Asresu et al. [16] reported that, body conformation trait was first ranked for both breeding rams and ewes at smallholder sheep producers selection purpose. Eventhough, body conformation was last ranked in the present study, its prefered one of breeding ewes selection criterion. Kosgey et al. [18], Kahsa [17] also revealed that, litter size was one of the most economically important attributes for breeding ewes. Kahsa [17] also reported that, functional traits have the highest absolute and relative economic values in Menz and Horro breeds.

In the current finding producers were prefered economic traits of ewe’s attribute and inagreement with Kosgey et al. [18]and Kahsa [17]. Thus, this study revealed that, breeding ewes were selected by producer’s trait of interest of lamb survival rate, mothering ability and twinning rate were the three most important traits (Table 1). Smallholder sheep producer’s interest had multiple of attributes to be improved their breeding objectives. However, most researchers often distinguished only the first three top traits of interes. Therefore, multiple trait selection need to be considered for the wide-ranging turnover of the flock productivity.

Further more culling practices at smallholder level need to avoid keeping unproductive ewes for longer time in flock. Breeding ewes selection criterion is one of the factor that determine the productivity and reproductive performance. Thus, sheep producers, researchers and development agents have to focus on producer’s interested traits during breeding ewes selection before commencing crossbreeding activities.

Breeding Rams Selection Criterions and Farmers Traits of Interest: Currently smallholder on-farm sheep producers were being enhanced understanding to select their interested attributes of breeding rams selection from existing breeds and their crossbred progenies. When producers select breeding ram for breeding purpose, the major considerable attributes were presented in table 2 in the order of their importance. Hence, body size, growth rate and Marketing value were the first, second and third rank of ram selection criterions, respectively. Kahsa [17] reported that, economic values of functional traits were improved when increasing the price of breeding rams. Therefore, this indicated that, a higher value to breeding rams rather than fattened purpose; since breeding ram is considered genetically valuable as parent for the next generation. According to Getachew [19], body conformation of breeding ram ranked first for both Menz and Afar sheep owners and which is mostly in agreement with the present study of breeding ram selection criterion.

| Table 1: Index analysis of smallholder farmers traits of interest and ewe's attributes |
|----------------------------------|-----------------|--------|---|
| Ewe’s selection criterion | Weighted Average (*W) | Index | Rank |
| Lamb survival rate per ewes | 656 | 0.190 | 1 |
| Twin rate | 649 | 0.154 | 2 |
| Temperament | 545 | 0.125 | 5 |
| Lamb growth rate | 528 | 0.124 | 6 |
| Lambing interval | 606 | 0.126 | 4 |
| Parental history | 630 | 0.127 | 3 |
| Tail type | 505 | 0.082 | 7 |
| Body conformation | 488 | 0.081 | 8 |

| Table 2: Index ranking analysis of ram's attribute for producers breeding objective |
|----------------------------------|-----------------|--------|---|
| Study parameters | Weighted Average (*W) | Index | Rank |
| Body size | 1497 | 0.175 | 1 |
| Growth rate | 1354 | 0.159 | 2 |
| Coat color | 1045 | 0.102 | 5 |
| Body conformation | 1058 | 0.103 | 4 |
| Hair type | 1011 | 0.083 | 8 |
| Marketing value | 1094 | 0.135 | 3 |
| Horn orientation | 1018 | 0.085 | 7 |
| Tail type | 1044 | 0.089 | 6 |
| Meat characteristics | 942 | 0.071 | 9 |
Yadeta and Manzur [20] reported that, body conformation (size) selected as first preferences trait for breeding ram in all the three agro-ecological zones and which inagreement with current finding. Getachew [19] also revealed that, body size was a primary ram selection attribute both in mixed crop-livestock and pastoral production systems in Menz and Afar areas, respectively. Zewudu et al. [12] in Adiyi Kaka district of Kaffa zone was presented body size as first preference attribute and colour was second and tail formation was third ram selection criterion. Fasahatsion [22] in Gamo Gofa zone reported that, body size was as primary criteria in mid-altitude. Getachew [19] also revealed that, body conformation ranked first for both Menz and Afar sheep owners and whereas, growth rate, coat colour, tail size and shape and mating ability were ranked second, third, fourth and fifth in Menz area. This indicated that, body size was the commone and first trait of interest to select breeding ram in all agro-ecological zone of the country. The above authors revealed that, large body size, fast growth rate, marketing value, body conformation, drought tolerance, coat colour, tail formation, horn orientation, libido and hair type phenotype attributes were preferable for future genetic improvement practices by smallholder producers.

Generally with the above mentioned preferable breeding ram traits village community had ram exchange experience during breeding practices for a long period of time. This experience enabled them to have common interest of breeding goal and mutually genetic improvement efforts. Eventhough, the past breed improvement efforts didn’t realized on genetic improvement target, producers had obtained lessons from past efforts. Therefore, nowadays village community had their own breeding strategies with introduction of new ram breed type from available area according to their smaller propertion of male to female ration might have an advantage to reduce inbreeding cofficient and since common traits of interest.

Reproductive Performance

Breeding Ewes and Rams Proportion in the Flock: The number of breeding rams between the three stratum were didn’t have significantly variation. The current finding revealed that, 39% lambs, 29.2% breeding ewes, 13.3% breeding rams (approximatly equals to 1:2.2 breeding rams to ewes ratio) and the remaining were fatten and unfertile sheep (Table 3) and in agreement with Getachew et al. [31, 32]. However, the number of ewes between stratum had significant variation (p=0.05) and higher number of ewes in second stratum (Table 3). The overall mean number of ewes per/flock/year was presented in Table 3 and much lower than Fasahatsion [22] finding of 15.9 (0.62) and 8.45 (0.22) in highland and mid-highland of Tigray region in Ethiopia, respectively. Gizaw et al. (30) reported in sub-alpine sheep barely and pastoral system number of ewes/flock were 14.7 ± 8.6 and 11.3 ± 7.8, respectively and much higher than the present finding. The same author also reported that, in perennial crop-livestock and cereal livestock system the mean number of ewes per flock were 3.7 ± 2.7 and 3.9 ± 2.8, respectively and to some extent it’s greater than current finding (Table 3). Agyemang et al. [24] reported 74.8% male, 22.4% entire males and 2.8 % castrated for Menz sheep in the traditional sheep production systems of Ethiopian highlands. Mengiste [23] also revealed that, Washara sheep flock constituted 81% females, 17.3% intact males and 1.7% castrated in traditional way of proroduction system. In Southern part of Ethiopia Endashew [25] reported that, 53.5% breeding females, 10.6% and 8.8% suckling female and male, respectively, 13.8% intact males and 13.4% castrated and fattening males. Similarly Tsedeke, [54] revealed that, 39.3% breeding ewes and 27.6% lambs and 3.6% castrated and fattening males in Alaba special district of southern region of Ethiopia. Getachew [19] once again reported that, the ratio of breeding rams to ewes were 1:8.3 and 1:17.4 in Menz and Afar sheep flocks, respectively. Further more, Abebe [26] and Solomon [27] reported that, 1:7.5 for Menz sheep and 1:6.7 for Gumuz sheep, respectively. In other area of the country Solomon, et al. [28] in East Wollega and West Shewa reported that, male to female ratio of 1:12 obtained for Horro sheep. Generally in present study of Wollo highland sheep production area the number of male to female ratio were much more lower than Getachew [19], Abebe [26] and Solomon [27] and Solomon et al. [28]. Therefore, this finding indicated that, smaller proportion of male to female ration might have an advantage to reduce inbreeding coefficient and since single ram might have achance of mated with small number of breeding ewes. Hence, the prolificancy and annual lambing rate of ewes per flock were higher. In general the present study revealed that, the ration of rams to ewes were below the recommended level and extra number of rams might be increased feed cost and other managemental input.

Number of Lambs Born per Year per Flocks: The overall mean number of lambs born per year per flock had significantly difference (p=0.05) between the three strata (Table 3). Thus, second stratum had significantly higher (p=0.05) number of lambs per flock and lambs per ewes than first and third strata (Table 3). The reason behind
Table 3: Least square means of on-farm annual flock reproductive performance valuation.

<table>
<thead>
<tr>
<th>Number of strata/ Breed type</th>
<th>First strata (n=46)</th>
<th>Second strata (n=74)</th>
<th>Third strata (n=34)</th>
<th>Overall (n=53)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td>Mean ±SE</td>
<td></td>
</tr>
<tr>
<td>Breeding ewes /flock</td>
<td>3.2 (1.6)a</td>
<td>3.5 (1.0)b</td>
<td>3.3 (4.2)c</td>
<td>3.3 (2.3)c</td>
<td>**</td>
</tr>
<tr>
<td>Breeding rams /flock</td>
<td>0.4 (0.0)</td>
<td>1.1 (0.0)</td>
<td>1.4 (0.2)</td>
<td>0.9 (0.0)</td>
<td>ns</td>
</tr>
<tr>
<td>Lambs /flock</td>
<td>6.2 (2.0)a</td>
<td>8.3 (2.7)b</td>
<td>7.7 (2.8)f</td>
<td>7.4 (2.3)f</td>
<td>**</td>
</tr>
<tr>
<td>Lambs/ewes</td>
<td>1.9 (0.6)a</td>
<td>2.4 (0.0)</td>
<td>2.3 (1.0)</td>
<td>2.2 (0.8)</td>
<td>**</td>
</tr>
<tr>
<td>Pregnancies /flock</td>
<td>5.6 (2.9)a</td>
<td>7.3 (1.0)b</td>
<td>7.1 (2.1)f</td>
<td>6.3 (2.7)f</td>
<td>**</td>
</tr>
<tr>
<td>Parturition /Flock</td>
<td>4.4 (2.0)a</td>
<td>5.7 (1.0)b</td>
<td>5.4 (1.6)a</td>
<td>5.2 (1.5)f</td>
<td>**</td>
</tr>
<tr>
<td>Embryonic mortalit /Flock</td>
<td>1.2 (0.7)a</td>
<td>1.6 (0.0)b</td>
<td>1.7 (0.7)f</td>
<td>1.4 (0.5)b</td>
<td>**</td>
</tr>
<tr>
<td>Service /conception</td>
<td>1.3 (0.1)</td>
<td>1.1 (0.0)</td>
<td>1.4 (0.2)</td>
<td>1.3 (0.1)</td>
<td>**</td>
</tr>
<tr>
<td>Age at first mating</td>
<td>6.3 (0.7)a</td>
<td>5.0 (0.6)d</td>
<td>7.0 (0.8)f</td>
<td>6.1 (2.5)d</td>
<td>***</td>
</tr>
<tr>
<td>Age at first lambing</td>
<td>11.9 (0.7)a*</td>
<td>10.1 (3.0)a</td>
<td>12.3 (0.1)a</td>
<td>11.4 (3.6)a</td>
<td>***</td>
</tr>
<tr>
<td>Single birth /flock</td>
<td>2.6 (1.3)a</td>
<td>3.1 (1.0)</td>
<td>3.1 (4.0)</td>
<td>2.9 (1.1)</td>
<td>***</td>
</tr>
<tr>
<td>Twin birth /flock</td>
<td>1.8 (0.8)a</td>
<td>2.6 (0.0)a</td>
<td>2.3 (2.8)a</td>
<td>2.2 (0.9)a</td>
<td>***</td>
</tr>
<tr>
<td>Lambing rate (birth/year/ewes)</td>
<td>1.4 (0.2)</td>
<td>1.6 (0.2)</td>
<td>1.6 (0.2)</td>
<td>1.5 (0.6)</td>
<td>ns</td>
</tr>
<tr>
<td>Lambing interval</td>
<td>6.3 (2.7)a</td>
<td>5.8 (1.6)b</td>
<td>6.1 (3.0)a</td>
<td>6.1 (2.1)a</td>
<td>**</td>
</tr>
<tr>
<td>Age at weaning</td>
<td>5.8 (0.6)a</td>
<td>4.6 (1.0)b</td>
<td>6.3 (1.0)a</td>
<td>5.6 (1.9)a</td>
<td>ns</td>
</tr>
</tbody>
</table>

First stratum = Awassi rams crossed with local Wollo highland ewes F1 crossbreed progenies, second stratum = Washera rams crossed with local Wollo highland ewes F1 crossbreed progenies, third stratum = local Wollo highland sheep breed progenies.

might be prolific nature of ram breed effect in second stratum (Washeram) than Awassi ram in first stratum and local Wollo highland rams in third stratum. The same breed type of dam was used in all strata, however, different ram breed type and number of ewes per flock might have an effect on number of lambs born per year per flock. Markos et al. [5] reported that, 0.92 lambs per ewes per year were recorded for Menz indigenous breed type and which less than the present study. While, Kosgey [8] reported that average number of lambs per ewes per year were 1.5 in the smallholder farmers and in pastoral area were similar with tropical region. While, the current finding revealed that, overall mean number of lambs per ewes per year was greater than Kosgey [8] and Markos [5] report. Whereas, Deribe [29] also reported that, annual lambing rate of Alaba ewes in Southern Region of Ethiopia was 1.2 lambs per ewes per year and which much lower than current finding.

Gizaw et al. [30] also reported that, the mean number of lambs per flock per year in sub-alpine sheep barely, perennial crop-livestock, cereal livestock and pastoral system of sheep production area were 6.3 ± 4.2, 4.0 ± 1.6, 1.9 ± 1.3 and 5.4 ± 4.7, respectively. However, the current study had grater number of lambing rate than Gizaw et al. [30] and that might be the effect of greater prolificacy rate and short lambing interval performance of the ewes. Getachewet al. [33] had also reported that, 1.86 lambs born per ewes per flock in Wollo highland area and it was illustrated higher number of lambs born per ewe which coincide with present study (Table 3). The same author [19] also reported that; 6.3 ± 4.2 lambs (both male and female of less than 6 months) per flock crop-livestock production system area and which was less than the current finding lambing rate (Table 3). Large number of lambs per flock implies that higher lambing rate of ewes in turn might increase the intensity of within breed selection. In smallholder sheep production context high lambing rate of ewes were more important to increase flock size and number of saleable lambs to be exposed to local market. Hence, smallholder sheep producers had the long year experience of exploitation of lambs as cash crop for their immediate household needs. For this reason, fast growing once were sold at early aged and kept for short duration of time in the flock, but slow growing lambs (stagnated growth) kept for long period of time within flock that mostly used for breeding purpose and consequence of negative selection.

Average Age at First Mating and Lambing: In the current study the overall average age at first mating of ewe lambs were attained at 6.1±2.5 months with significant (p= 0.0001) variation between strata (ram breeds). The second stratum (Washera ram F1, crossbred progenies) had significantly (p= 0.0001) lower age at first mating than first stratum with (Awassie ram F1, crossbred progenies) and third stratum with (Wollo highland breed progenies).

Mukasa-Mugerwa et al.[34] revealed that, in most situations estrus was observed in ewe lambs at the age of 5 to 6 months and which indicated that, puberty might be attained at earlier age, but fertility will only improve with age and weight. Begum et al. [38] reported that, the age at puberty varied from 5-11 months and ewe lambs on
supplemented group reached puberty at significantly (p<0.05) younger age (6.22±1.31 months) than controlled group (8.43±1.15 months). As the level of supplement feed increased from low to medium and high energy level, the age at first mating decreased by 71, 153 and 155 days, respectively [55]. However, the current finding was revealed that, age at first mating (puberty) within smallholder management condition of ewe lambs were mated at earlier age than most other finding. Its might be earlier maturing behavior of the breed or the effect of hybrid-vigor of the dam and sire.

Berhanu and Aynalem [35] was presented 404 days under village management conditions in southwestern Ethiopia. Gizaw et al. [30] furthermore recently reported that, the same pattern was found for Afar sheep breed under pastoral management condition. Mukasa-Mugurwa and Lahlou-Kassi [3] were presented age at first lambing frequency at 450 days for Menz ewes. Other studies reported that, age at first lambing for Menz breed were 495 days [36], 511.8 days [37] and 450-660 days [26]. Moreover, Zewdu and Tesfaye [45&19] reported 400 and 470 days of age at first lambing, for Horro and Menz sheep breed, respectively. In general the current study revealed that, short and faster age at first lambing and which was bellow the national average of 342 ± 108 days at smallholders sheep producer’s production circumstances (Table 3) were observed. The reason behind might be the potential effect on service per conception and embryonic mortality of the breed endowed with early maturing behaviors. However, the effect of suplimentary diet on the age at first mating and lambing are need to be investigated with in controlled situation.

**Service per Conception and Abortion Rate per Flock:**

Reproductive performances of ewes/ flock were also determined by the average value of service per conception, parturition/flock, fetal losses in the flocks. Hundie [41] recently reported that, mean number of services per conception were 1.3±0.56 for Horro ewes under traditional management situation in Western Ethiopia Horro Guduru area and which inagreement with current study with 1.3±0.1 number of service per conception. Accordingly Mukasa-Mugurwa et al. [42] conception rate were 88.2% and 79.1% for Menz sheep breed at dry and wet season, respectively. The author also revealed that, 77.6% and 71.7% for Horro sheep breed at dry and wet season, respectively through hormonal treatment of synchronisation.Whereas, Mukasa-Mugurwa and Lahlou-Kassi [3] reported that, conception rate with first mating of 69% and 78% of for pubertal and mature ewes, respectively.

Previous research showed that conception and lambing rates (lamb born/ewes mated) were affected by breed type [3]. Menz ewes had 81% lambing rate compared to 76% of Horro ewes [43] in comparable management condition and which indicated that, 19% and 24% of embryonic mortality were recorded. However, in the current study was 86% of lambing rate at on farmers situation which much more greater than Menz and Horro ewes. Mukasa-Mugerwa and Lahlou-Kassi [3] reported = 90% conception rates, 72% lambing rate for Menz ewes. This suggested that, moderate embryonic mortality was observed. Abassa [44] also reported that, abortion rate was high and variable within 3.7 to 40% among breeding females. In the current finding overall mean number of embryonic mortality was reported as 0.7 to 9.3% per flock and which slightly resembling with Mukasa-Mugerwa and Lahlou-Kassi [3]. In the present study embryonic mortality had significantly higher (p=0.05) in second and third strata than the first strata at field management condition. Service per conception also had significant difference (p=0.05) between strata and higher in the third stratum followeded by first stratum. However, the second stratum had significantly (p=0.05) lower service per conception than first and third strata. The reason behind this might be the effect of fertility difference of ram breed type. Therefore, further investigation on fertility of ram effect on service per conception and embryonic mortality might be important. The number of service per conception might be affected by management practices and fertility of rams. Hence, fertile ram selection with management improvement practice need to understand for service per conception rate and embryonic mortality improvement actions.

**Number of Twin and Single Birth/flock and Flock Prolificacy Rate:**
The number of twince and single birth per flock per year had significant difference (p = 0.0001) between first stratum and second stratum. The higher twin birth was recorded in second stratum followeded by third stratum (Table 3) and the reason behind this fact might be the ram breed effect on flock prolificacy rate in second stratum. The number of twin birth per flock between second and third stratum had no significance differences. Whereas, the number of single birth per flock were significantly (p = 0.0001) higher in the first stratum than second and third strata. This indicated that, the Awassi ram breed has lower possibility of prolificacy rate potential than local Wollo highland breed and Washera F1 crossbred. However, Overall mean number of twin and single birth per flock were 2.2±0.9 and 2.9±1.1,
respectively at smallholder farming condition. This twin birth per flock was comprised the annual prolificacy rate of ewes per year were 134.4, 150.0 and 143.8%, respectively for first, second and third strata (number of offspring produced per year/ number of birth per ewes/year *100). Hence, both annual twin birth and prolificacy rate indicated that, the second stratum higher than first and third strata. The overall, prolificacy rate was 142.7% in the present study. Ermias et al. [46] reported that, litter size mainly influenced by breed, level of nutrition, season and age extensively. The average litter size or prolificacy rate was obtained by Fsahtsion et al. [22] in the traditional sheep production and breeding practice in Gamogofa Zone, Southern Ethiopia was 1.3 lambs per head, however, less than the present study. Whereas, Mukasa-Mugerwa et al. [42] reported 1.13 for Menz and 1.14 for Horro Ethiopian highlands sheep and much lower than the current finding. In other part of the country Hundie [41] moreover reported that, Western Ethiopia Horro Guduru area was 1.57 ±0.52 liter size per ewes and which was inagreement with second stratum of current finding. Inaddition according to Zewdu [47] twining rate of 39.9 % or litter size of 1.40 and 36 % or litter size of 1.36 were obtained for Horro and Bonga sheep breeds, respectively and wch was mostly inagreement with the current finding of third and first strata, respectively. Ingeneral, the current study annual prolificacy rate was greater (Table 3) than Menz and Horro sheep breed when compaired with Mukasa-Mugerwa et al. [42] report, however, inagreement with Hundie [41] and Zewdu [47] for Horro sheep breed litter size. Baker et al. [48] also stated that, until the age of ewes were attained five years or fourth parity, liter size can be increased then it likley to decreased slightly above this age. Abegaz et al. [50] and Berhan and van Arendonk [43] reported that there were no significant differences in litter size between Horro and Menz ewes, which may equate to no differences in ovulation rate. However, the annual program report of ILCA [51] reported that litter size was slightly higher in Menz (1.16) than in Horro ewes (1.13). The management system is also a major source of variation in litter size as reported by Mekuriaw et al. [49]; this is indeed the case of Washera sheep for which performances were significantly higher under farm management in comparison to on-station. The overall prolificacy rate in the current study revealed that, comparable value with most other local sheep breed with had higher prolificacy rate in the country. Consequently, together with other reproductive performance traits overall prolificacy rate of local Wollo highland sheep breed had considerable value for breed improvement activities.

**Lambing Interval:** In the current study lambing interval was significantly shorter in the second stratum than first and third strata. Thus, the second stratum generated more number of lambs per ewes per year it might be short lambing interval. However, lambing interval had no significant difference between first and third stratum. Lambing interval was the interval between two successive parturitions and it can be affected by season of lambing or nutritional accessibility, breed types, number of parities of ewes and management practice [52]. Reproductive efficiency also affected by the length of parturition interval i.e. ewes with long lambing interval had lower lambing rate efficiency [29]. Girma [53] reported that, at least three times lambing is expected per two years under normal circumstances. Lambing interval were recorded in Menz sheep with 8 and half months and Afar sheep with 9 months [19], however, inthis study the shortest lambing interval recorded in the second stratum. Previously Solomon [27] reported short lambing interval in the country for Gumuz sheep breed (6.64 months), however the present finding overall lambing interval was the shortest one and can produce three lambing in two years even under the traditional management system. According to Zewdu [47] finding lambing interval was around 8.9 months for Bonga ewes and 7.8 month for Horro ewes and it also geater than the current report of overall lambing interval. While, the current study indicated that, overall mean lambing interval of 6.1 (2.1) months and which was the shortest lambing interval contrast with Solomon [27], Getachew [19], Zewdu [47] and Mekuriaw [63] for Gumuz, Menz, Afar, Bonga, Arsi-bale and Washera sheep local breeds. Mekuriaw [63] also reported that, 7.8, 8, 7-10 and 9 months of lambing interval, for Arsi-bale, Bonga, Menz and Washera sheep breed, respectively. Getahun [54] and Dibissa [40] also reported that, possibility of attaining three parturitions from indigenous small ruminants in two years with traditionally managed sheep was influenced by various factors including previous litter type, parity and lambing season. Generally, Wollo highland sheep had shortest lambing interval most other Ethiopian sheep breeds and greater possibility to collect more number of offspring per year per ewes and resulted large flock size at smallholder sheep producers condition.

**Ewe’s Reproductive Performance Attributes**

**Fertility Rate:** Fertility rate defined as the number of females that given birth per the total number of females exposed to mating in the given flocks. The current study revealed that, annual overall fertility rate of ewes per flock was 86% and it had variation between the three strata and
Table 4: Descriptive analysis of ewe’s reproductive performance attributes

<table>
<thead>
<tr>
<th>Annual ewe’s reproductive traits</th>
<th>First strata</th>
<th>Second strata</th>
<th>Third strata</th>
<th>Overall Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertility rate (%)</td>
<td>89.8</td>
<td>84.3</td>
<td>86.3</td>
<td>86.8</td>
</tr>
<tr>
<td>Prolificacy rate (%)</td>
<td>134.4</td>
<td>150.0</td>
<td>143.8</td>
<td>142.7</td>
</tr>
<tr>
<td>Weaning rate (%)</td>
<td>132.7</td>
<td>128.1</td>
<td>155.4</td>
<td>138.7</td>
</tr>
</tbody>
</table>

Lamb survival rate (%)

<table>
<thead>
<tr>
<th>Birth-90 days</th>
<th>86.8</th>
<th>88.1</th>
<th>88.0</th>
<th>87.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>91-180 days</td>
<td>98.3</td>
<td>88.5</td>
<td>93.2</td>
<td>93.3</td>
</tr>
<tr>
<td>181-270 days</td>
<td>91.4</td>
<td>93.3</td>
<td>95.1</td>
<td>93.2</td>
</tr>
<tr>
<td>271-365 days</td>
<td>92.4</td>
<td>95.6</td>
<td>94.9</td>
<td>94.3</td>
</tr>
<tr>
<td>Overall annual survival rate (%)</td>
<td>68.5</td>
<td>65.5</td>
<td>71.2</td>
<td>68.4</td>
</tr>
<tr>
<td>Mortality because of disease and drought (%)</td>
<td>27.9</td>
<td>32.2</td>
<td>26.0</td>
<td>28.7</td>
</tr>
<tr>
<td>Mortality because of predator (%)</td>
<td>3.6</td>
<td>2.8</td>
<td>2.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Overall annual mortality rate (%)</td>
<td>31.5</td>
<td>34.5</td>
<td>28.3</td>
<td>31.6</td>
</tr>
</tbody>
</table>

First stratum = Awassi ram crossed with local Wollo highland ewes clustered area, Second stratum = Washera ram crossed with local Wollo highland ewes clustered area and Third stratum = local Wollo highland sheep clustered area.

which might be ram breed effect. Therefore, first stratum had higher annual fertility rate than second and third stratum. Higher fertility rate indicated that, higher conception rate of the given breed type. The present study overall fertility rate was higher than the report presented by Berhan and Arendonk [55] for Menz and Horro breed of 70.2 and 79.5%, respectively. Derbie [29] also reported that, fertility rate is 54.04% for south western part of Ethiopian sheep breed and much lower than current study. The present finding of fertility rate was slightly comparable with Tsedeke, Rosa et al. [56] 83.6%. However, Mukasa-Mugerwa and Lahlou-Kassi [3] were reported higher fertility rates of 90% for Menz ewes which greater than the current finding. On the other study Mukasa-Mugerwa et al. [42] was reported fertility rate for Menz and Horro ewes were 73 and 65%, respectively. Various literatures indicated that, difference fertility rate within the breed were observed and might be difference in producer’s management practices. Rosa et al. [57] also reported for Romney Marsh and Merino Branco ewes had 96 and 93% of fertility rate, respectively at intensive management condition. While, Moural et al. [58] had also presented 86.8% and 98.3% of fertility rate in the duration of dry and rainy season for Santa Inês ewes in eastern Amazon at intensive management situation. Mukasa-Mugerwa et al. [42] reported that, the effect of breed, season and year had significant variation on fertility rate. Although, fertility rate was high in the present study of on-farm management practice, controlled or intensive management system of fertility rate evaluation might be important for the confirmation of potential effect of breed on reproductive performance. If the management system improved the fertility of the breed might be improved because of ovulation rate and oestrous cycle influenced by nutrition. Generally, Wollo highland sheep breed has imperative reproductive performance behavior at existing smallholder production condition. Hence, if this breed commerically used for reproductive purpose high offtake rate might be observed due to fast lambing rate. Its important for improvement in flock size and annual cash income. In the present study smallholder sheep producers were extremely dependent on cash cropping from sheep sale.

Lamb Survival and Weaning rate: Survival rate is the total number of offspring weaned per total number of offspring produced. Awgichew [59] reported that, survival rate between birth and weaning (90 days) age was 89% and 76% for Menz and Horro breed, respectively. In the present study the overall survival rate at the age between birth to weaning (90 days) was 87.6% which is slightly lower than Menz and appreciably higher than that of Horro lambs survival rate. Kahsa [17] also reported that, Menz lambs shown higher survival rate from birth to 180, 270 and 365 days of age (81, 71 and 62%) compared to Horro (51%, 39% and 37%), respectively. However, its lower than the present study lambs survival rate at birth to 90, 91 to 180, 181 to 270 and 271 to 365 days of age (87.6, 93.3, 93.2 and 94.3%), respectively. Survival rate were observed increasing rate in all strata at the age of birth to 365 days. On the other hand, its slightly greater in second (Washera ram F1 crossbred) and third strata (Wollo highland breed) than the first stratum (Awassie ram F1 crossbred progenies) from the age of 180 to 365 days. It might be the adaptability differences of the breed effect. Mengistie et al. [60] reported that, 98.4± 0.6, 93.6 ± 0.9, 91.2± 1.1, 90.0± 1.2 and 89.9± 1.2% of survival at the age of 30, 90, 180, 270 and 365 days, respectively and which is slightly comparable with the current finding (Table 4).
Conversely Tibbo [5] reported that, a pre-weaning mortality of 33.1% for Horro and 19.2% for Menz sheep were recorded and which is in agreement with first strata (Table 4) in the current study. However, Berhan and Van-Arendonk [43] found an overall mortality rate for Menz and Horro breeds of 13.5% and 27%, respectively at on-station management circumstance. While, the current study revealed that much higher overall mortality rate (31.6%) at village management situation compared with Berhan and Van Arendonk [43] finding and the reason behind this might be management differences. Gizaw and Getachew [10] also revealed that, annual lamb mortality rate was 11.4%, 10.1% and 9.4% for local, Awassi and Coriedial ram F1 crossbred lambs, respectively under village management condition and which is lower than the current mortality rate for Awassi, Washera ram crossbreed progenies and local Wollo highland lambs. The reason might be the effect of season of birth, birth weight, birth type, age of ewes and production year difference. A trend of mortality from birth to 1 year of age was 12.6% at station controlled condition. However, in the current study the overall annual mortality rate per flock was presented in Table 4 and hence, the trend of lamb mortality was decreasing order from birth to yearling age and agreed with Mandal et al. [63], but higher mortality was observed. Therefore, it’s the major challenges for smallholder sheep producers and reduced their number of lambs that might be present marketing age.

Sulieman et al. [62] elucidated that, the survival rate of lambs birth to weaning was affected by the age of the ewes, type of birth (single, twin or triple born), season of birth (wet or dry season) and birth weight of the lambs. This could be mainly due to the fact that twins, have lower body weight compared to single lambs and seasonal feed availability. Gemeda et al. [64] once again presented that, survival rate for Horro breed was significantly affected by birth weight of lambs. The lightest lambs generally had the highest mortality rate. Moreover, Niftalem [37] revealed that, lambs born from heavier dams had a significantly higher survival rate at all level of the specified age, than those from lighter ewes. However, Tibbo [5] also presented that, there is an adequate within and between breed genetic variation for survival rate, which can be exploited through selective breeding for permanent improvement of the breeds.

In the current study there were slight survival rate difference between local and their crossbreed progenies or between strata (Table 4) were identified. Hence, the first stratum (Awassi ram F1 crossbreed progenies) had to some extent lower survival rate than second and third strata; however, its being presentation of acceptable adoptive feature at smallholder farming condition. Washera F1 crossbreed progenies had comparable survival rate with local Wollo highland breed progenies and the reason behind this might be the indigenous character of the breed make better adoption with local environment. Hence, crossbreeding practices of local Wollo highland sheep breed with indigenous Washera sheep breed being adopted by smallholder sheep producers genetic potential improvement practices. Suprior indigenous sheep breed for crossbeding purpos was selected by the smallholder sheep producers them selves from the nearest loca regions based on their trait of interest. Sheep research and development have been practiced for decades in Ethiopia to improve the productivity of the local flocks, increase off take rates and increase their contribution to the livelihoods of farmers and pastoralists and to the national economy. However, the main challenging factors were adaptability of the local environment. The current research out put indicated that, the genetic improvement program need to revised according to the interest of smallholder sheep producers interest. Hence, Awassi crossbread sheep shown adoptive features and ascertain extent achieving its objective at cool highland smallholder farming condition. Therefore, local breed improvement practices through crossbreeding with selected exotic breed (Awassi breed) is crucial to continued for coming genetic improvement practices. Within intensive management conditions survival and mortality rate evaluation of local Wollo highland and their crossbred progenies are crucial to confirm the potential effect of the breed for future genetic improvement practices.

**CONCLUSION**

All interested trait have to prioritized and considered through breeding practices and productivity improvement program for designing long term research and development plan. Eventhough, farmers can select their interested breed type lack of planed breeding, record keeping and negative selection practice were also current principal limitations in the area. Smallholder farmers sometimes pointed out their interested traits from their long term previous experiences to achive their breeding objectives and that might be disagreement with scientific point of view. However, researchers and development workers should have to understand and attempt to
incorporate farmer’s interest through genetic improvement activities inorder to create ownership perception and sustainable development. Fast growing once were sold at early aged and kept for short duration of time in the flock. However, slow growing lambs (stagnated growth) kept for long period of time within flock that mostly used for breeding purpose and consequence of negative selection. Age at first lambing, lambing and prolificacy rate and lambing interval were most promising reproductive attributes of Wollo highland sheep breed and their crossbreed progenies.

Abbreviations:
CSA …..Central Statistics Authority
EPA……Extension Planning Area
PPS……..Stratified probability proportional to size
SPS ……Sanitary and phytosanitary standards
UNCTD..United Nations Conference on Trade and Development

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