Dorper sheep cross breeding with Indigenous sheep breed in Ethiopia

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Abstract

The objective of this review paper was to review dorper sheep cross breeding with indigenous sheep breed in Ethiopia. The paper reviewed and discussed the history of dorper breed introduction, research and development efforts in crossbreeding and their performance under on-station and on-farm management. Formal survey on farmers’ perception on Dorper cross sheep indicated that the crossbred dorper sheep have non selective feed behavior and excellent in meat production under farmer’s management. On other study showed that dorper sheep was not meet farmer interest in breeding sheep aspect because of black coat color. The performance of indigenous sheep and their crosses with Dorper varied as per the location, management, farming conditions and percentage of exotic blood level inheritance. Different research output by team of researchers on farm and on-station performance evaluation of dorper indicated that crossbreds often outperformed their local contemporaries. Under on farm condition, body weight at different ages was significantly higher in 50% Dorper crosses as compared to their 25% and 75% counter parts. On-station birth weight of Dorper (3.39 3.8 kg) better than crossbreed (3.0 3.24 ± 0.04 kg) and local sheep (2.36 2.77 kg), respectively. While the mean weaning weight (14 16 kg) and yearling weight (26.95 32.43 ± 0.46 kg) of 50% Dorper crossbreed was better than indigenous sheep breeds. However, crossbred ewes and local sheep breeds did not differ in litter size. Dorper crosses as Afar under on station is not economically important due to lower weight in all aspects. Crossbreeding programs of dorper with indigenous sheep require strong research and development support from public service and non-governmental institutions for sustainable design, optimization, and implementation in clearly defined production environments.

Keywords: Dorper cross, Reproductive performance, Cross breeding

Introduction

The importance of sheep production as a source of meat in Ethiopia has been increasing from time to time. This sheep production has experienced changes regarding the use of introduced exotic breeds, in order to increase the growth rate of lambs. Thus, there is a great demand for improved sheep breed such as Dorper sheep to improve the growth performance of lambs, which is an important trait that determines the overall productivity of the flock. Farmers rear sheep mainly for sale and consumption. Sheep owners gain a vast range of products and services such as meat, milk, skin, wool, manure, gifts, religious rituals, etc. (Hirpa, 2008). Sheep are also a means of risk mitigation during crop failures, property security and monetary saving in addition to many other socio-economic and cultural functions (Gatenby, 2002). Sheep contributes 21% of the total ruminant livestock meat output of the country, with the annual national mutton production estimated to be at 77 thousand metric tons (Sebsibe, 2008). While contributing significantly to meat production of the country, productivity or output of per sheep is low (Tibbo, 2006). Thus, the productivity of indigenous sheep has to be improved and efficient sheep genetic improvement programs must be initiated to boost output and profitability of the producers (Kosgey, 2007). To improve sheep productivity, therefore, crossbreeding with exotic breeds is considered as the most rapid way of improving productivity of indigenous sheep breeds (Hassen, 2004). To accomplish the crossbreeding program, the Ethiopian Sheep and Goat Productivity Improvement Program (ESGPIP) took the responsibility for importation of improved genotypes, multiplication of purebreds, crossing with indigenous sheep and distribution of both crossbreed and pure exotic animals to sheep producers. To carry out the activities, four nucleus and ten Breeding, Evaluation and Distribution (BED) sites were established in different regions of the country.

History of Dorper Sheep Introduction to Ethiopia

Dorper is a superior meat type sheep breed in South Africa developed through the long time effort of crossbreeding of Black headed Persian and the Dorset Horn in 1930 (Gavojidian et al., 2013). To improve the productivity of indigenous sheep, crossbreeding with high yielding exotic Dorper sheep breed is valuable for market oriented meat production and for enhancing the benefits obtained from the local sheep (Helen et al., 2015). The Ethiopian Sheep and goat productivity Improvement Program (ESGPIP) brings this sheep breed and began a crossbreeding Program at different breeding, evaluation and distribution sites of the country. Overview of Crossbreeding Effort with Dorper Sheep in Ethiopia.

Currently, to improve the genetic potential of local sheep in Ethiopia, Dorper sheep were imported into Ethiopia, mainly for crossbreeding purposes. The most obvious and quickest means of greatly elevating meat sheep productivity in Ethiopia is to take advantage of the heterotic effects of crossbreeding. The South African Dorper sheep was chosen as a primary candidate for crossing with Ethiopian sheep breeds. Attributes of the Dorper sheep are well known and they include large size, considerable
muscling, high dressing percentage, and fast growth. Dorper sheep were placed at Fafen (Somali) and Werer (Afar) Research Centers. At the above (Nucleus) sites, purebred animals are being bred to produce pure offspring for multiplication and for the crossbreeding programs at the respective Breeding, Evaluation and Distribution (BED) sites (Tilahun, 2012).

**Growth Performance of Dorper Cross Sheep**

**On station Performance**

According to Tilahun (2012) who works at Sirinka breeding, evaluation and distribution experimental site, body weight, average daily gain, total dry matter intake, gain efficiency and feed conversion efficiency of the three sheep breeds are presented in Table 1. Initial BW was greater (P<0.001) for 25% Dorper x 75% CH (central highland) sheep (20.25 kg) compared to 50% Dorper x 50% CH sheep (17.9 kg); both were greater than CHS (14.41 kg). At the beginning of the experiment, the Dorper crossbreds had greater initial body weight (P<0.001) compared to the CHS indicating that around similar age the crossbreds appears to have greater live weight. Meanwhile, 25% Dorper x 75% CH sheep had greater initial body weight than 50% Dorper x 50% CH sheep at around similar age which was not expected, the reason behind this is that the 25% Dorper x 75% CH sheep were well managed at farmers field before the start of the experiment while 50% Dorper x 50% CH sheep suffer drought problem at the main station SARC (Sirinka agricultural research center) farm before the start of experiment and 50% Dorper x 50% CH sheep did not get sufficient amount of feed during pre-weaning stage from mother’s milk or additional supplemental feed. Widdowson (1980) reported that growth rate can be influenced by factors such as plane of nutrition, hormonal status, and environment resulting in a mature body size that is below the genetically determined maximum.

Both Dorper crossbred sheep genotypes were significantly (P<0.01) higher in final body weight, average daily gain and gain efficiency than CHS. Average daily gain for 25% Dorper x 75% CH sheep and 50% Dorper x 50% CH sheep was 130.79 and 125.84 g day⁻¹, respectively and both crossbreds gained more rapidly (P<0.01) than CHS (91.39 g day⁻¹). After 90 days of experimental trial sheep genotypes had gain a total of 8.19, 11.80 and 11.23 kg for CHS, 25% Dorper x 75% CH sheep and 50% Dorper x 50% CH sheep genotypes, respectively. Incomparable to this result, Genet (2012) reported that crossbreds of Black Head Ogaden × Dorper and Hararghe Highland × Dorper sheep supplemented with concentrate at either 0.9% or 1.5% of body weight and noted that high level of nutrition (1.5% body weight) resulted significantly higher value of average daily body weight gain for intact males 110±4.66; than animals maintained on low level of nutrition (0.9% body weight) 94±2.18 g day.

**Table 1.** Effects of genotype on growth performance characters of CHS and their crosses with Dorper Sheep

| Item                        | Sheep genotypes          | CHS           | 25% Dorper Crossbred | 50% Dorper crossbred | SEM | SLI |
|-----------------------------|--------------------------|---------------|----------------------|----------------------|-----|-----|
| Initial BW (kg)             |                          | 14.41         | 20.25                | 17.9                 | 0.42| ***|
| Final BW.(kg)               |                          | 25.85         | 29.37                | 29.19                | 0.27| **  |
| ADG (g/d/head)              |                          | 91.39         | 130.79               | 125.84               | 2.94| **  |
| Total DMI (kg)              |                          | 83.02         | 91.72                | 87.66                | 0.71| *   |
| FE (g DMI/g gain)           |                          | 9.17          | 7.35                 | 7.23                 | 0.18| **  |
| GE (g gain/kg DMI)          |                          | 107.71        | 138.72               | 139.50               | 2.58| **  |

Source (differ; **= (P<0.01); ***=(P<0.001); ns= non-significant; SEM= standard error of means; SL= significant level; FE = feed efficiency and GE= gain efficiency and 1the covariate was initial body weight for all variables

**Table 2.** Live body weight and daily body weight gain of the local and crossbred sheep.

| Breed (months)                  | Sex | Number of observation | Live body weight (kg) | Average daily weight gain (g/day) |
|---------------------------------|-----|-----------------------|-----------------------|----------------------------------|
| Cross breed                     |     |                       |                       |                                  |
| Male                            |     | 2                     | 10 ± 1                | 162.5 ± 12.5                    |
| 0-4                             |     | 2                     | 27 ± 2                | 137.0 ± 24.1                    |
| 5-9                             |     | 3                     | 32 ± 0.0              | 88.9 ± 0.0                      |
| 10-12                           |     | 1                     | 45 ± 0.0              | 83.3 ± 0.0                      |
| > 12                            |     | 5                     | 13 ± 0.1              | 158.2 ± 9.7                     |
| Female                          |     | 7                     | 38 ± 0.0              | 111.1 ± 5.6                    |
| Local sheep (highland)          |     |                       |                       |                                  |
| Male                            |     | 2                     | 15 ± 0.2              | 63.5 ± 9.4                     |
| 5-9                             |     | 2                     | 17 ± 0.0              | 47.2 ± 0.0                     |
| 10-12                           |     | 1                     | 16 ± 6               | 33.6 ± 19.7                    |
| Female                          |     | 1                     | 3 ± 0.0               | 66.7± 0.0                      |
| > 12                            |     | 1                     | 22±0.0               | 30.6± 0.0                      |

| Total                           | 27  | 1                      |                                 |                                  |

In agreement with this also Wildeus et al.,(2004) noted that, when forage-based diets were supplemented with concentrate feeds, growth rates increased to 67–165 g day⁻¹, dependent on forage quality and level of concentrate supplementation. In contrast to this, the average daily gain obtained by Teklebrhan (2011) for Dorper x Hararghe Highland breed fed different diet levels of grass hay ad libitum and concentrate mixture of wheat bran and noug cake during the growth periods reported average daily gain values (g day⁻¹) which were lower than Tilahun’s study. These differences may be due to the effect of type of crossing between different sire and dam, which may show the effect of the hybrid vigor and may come from the effect of the plane of nutrition. But this result shows the potential of Dorper crosses to finish at early age with good quality feed supply. In addition, the 50% Awassi × Charollais and Awassi × Romanov F1 crossbred cross bred sheep showed better growth performance than purebred Awass which may presumably indicate the effect of hybrid vigour in first generation crosses on half Charollais and Romanov blood.
compared with pure Awassi (Shaker et al., 2002; Shaker et al., 2010). The Central Highland sheep had scored higher average daily gain when compared to other works and comparable results of weight were reported for growing Ethiopian highland sheep (96 g day\(^{-1}\)) and Horro rams (90 g day\(^{-1}\)) when 35% and 50% of their ration were hay, respectively (Galal, 1979).

Another research result by Gebreyowhens et al. (2017) at mekele agricultural Research station shows comparison of local sheep and dorper crosses, as a result, the comparison of local and crossbred based on the live body weight is presented in Table 2. The average daily body weight gain for male crossbred at the age group of 0-4, 5-9, 10-12 and >12 months was 162.5 ± 12.5, 137.0 ± 24.1, 88.9 ± 0.0 and 83.3 ± 0.0 g, respectively. Whereas for the female crossbred, the average daily body weight gain at the age group of 0-4 months and >12 months was 158.2 ± 9.7 and 111.1 ± 5.6 gm. The average daily body weight gain for male local sheep at the age group of 5-9, 10-12 and >12 months was 63.5 ± 9.4, 47.2 ± 0.0 and 33.6 ±19.7, respectively. Whereas for the female local sheep, the average daily body weight gain at the age group of 0-4 and >12 months was 66.7± 0.0 and 30.6 ± 0.0 g, respectively.

The current study observed that the average body weight gain was higher for Dorper crossbred sheep under traditional management system. The male crossbred sheep reached marketable weight (27 kg at 5-9 months) as compared to the male local sheep (15 kg at 5-9 months). Dorper lambs can grow daily by 206 g/day post weaning supplemented with concentrated feeds (Cloetea et al., 2000). According to Byrne et al., (2009) Doper lambs have live body weight gain of 240 to 280 g/day tested at varied environmental conditions. The early weaning age (2 to 3 months) of the Doper lambs have a potential of enhancing post-weaning gains 180 to 200 g/day (Byrne et al., 2009).

Attempts have been made (Ayele et al., 2015) in order to evaluate the growth performance of Dorper and its F1 crossbreds at DebreBirhan Agricultural Research Center (DBARC). In his study the overall birth weight, weaning weight and yearling weight of pure Dorper and Dorper x Menz sheep (31.33 kg) was superior to the 50 (26.95 kg) and 75% Dorper x Local sheep (29.13 kg) (Mekonnen et al., 2012). However, the estimated birth weight of Dorper lambs under extensive condition was 3.8±0.8 kg (Mellado et al., 2016) and yearling weight reached an average weight of 55.0 kg at 18 months of age (Gavojdian et al., 2013). In other cases Lakew et al., (2014) at Sirinka Agricultural Research Center found that the local sheep and their Dorper crosses mean birth weight and weight at weaning was 2.36±0.05 kg, 3.24±0.04 kg; 8.53±0.14 and 14.95±0.21kg, respectively. On station representative's of productive performance of indigenous and their cross with Dorper sheep are summarized in Table 3. The body weight performances of the Dorper crossbred have got premium result in improving the local sheep worldwide (Lakew et al., 2014). The current suggested that Dorper sheep is an appropriate technology for producing crossbred lambs with better growth rates under Smallholder farmers.

Table 3. On station growth performance of dorper sheep and their crosses in Ethiopia

| Genotype             | BWT(kg)     | WWT(kg) | YWT(kg) | References     |
|----------------------|-------------|---------|---------|----------------|
| Local                | 2.36±0.05   | 8.57    | 22.38   | Lakew et al., 2014 |
| Dorper x local       | 3.24±0.04   | 14.95   | 31.37   | Lakew et al., 2014 |
| Pure dorper          | 3.39±0.08   | 16.18±0.35 | 34.43±0.79 | Ayele et al., 2015 |
| Dorper x Afar(50%)   | 2.57±0.06   | 9.45±0.87 | 24.96±3.77 | Ayele et al., 2015 |
| Dorper x Menz        | 2.77±0.04   | 12.34±0.25 | 31.33±0.56 | Ayele et al., 2015 |

Table 4. On station reproductive performance of dorper sheep and their crosses in Ethiopia

| Genotype             | Reproductive performance traits |
|----------------------|--------------------------------|
| AFL                  | WFL | LI | references |
| local                |               | 22.8±0.43 | 287±2.38 | Lakew et al., 2014 |
| local X dorper       | 55±6:25 days | 32.7±0.63 | 306±4.62 | Lakew et al., 2014 |
| Pure dorper          | 12 month    | NA      | NA      | Flourie et al., 2009 |

On-farm Performance

On-farm performance assessment concerned with the whole farm environment provides information in location specific production conditions that could lead to breed improvement options that are appropriate to the system (Getahun, 2008). However, unlike on station experiments, on-farm study is influenced by many factors which could not be controlled. Sisay (2002) identified that under on farm condition variation exists between indigenous and exotic sheep breeds for body weight traits. The trend of varied productivity performances of Crossbred sheep across

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locations implies the importance of G x E interaction due to differences in feed supply and farmers' management capability (Getachew et al., 2016). The mean birth weight of 3 and 3.5 kg for crossed and pure Dorper sheep (Gavojdaian et al., 2013) concurs well with the birth weight of 3.3-3.9 kg of Dorper lambs that found by Neser et al. (2001) and Hinojosa-Cuellar et al. (2013) under pasture conditions. Besides, Snyman and Olivier (2002) reported 4.06, 30.0 and 64.4 kg for birth weight, weaning weight and yearling weight of Dorper sheep breed under extensive management condition.

Although Cloete et al., (2000) estimated mean weaning weight of 18.2 kg for Dorper sheep breed. However, Belete et al., (2015) reported that the means of birth weight (kg), weaning weight (kg), weaning age (month), market age (month) and market weight (kg) of Dorper sheep crosses in Wolita and Silte Zone was 2.25, 17.30, 3.16, 12.66 and 30.66 kg, respectively. The mean market weight (30.68 kg) and market age (12.66 months) of Dorper sheep breed (Ermias, 2014) was significantly lower than the report of 36 for female crossed and 70 for male pure Dorper sheep (Agricultural Research Center, Ethiopia. He confirmed that the local ewes weighed more than the local sheep ewes at the age of 469±8.45 vs 555±6.25 days), while the crossbred sheep attained faster age at first lambing than the crossbred ewes, whereas the crossbreds were heavier at first lambing than the local sheep. Moreover, the local sheep had higher reproductive rate, while litter size and mortality rate were comparable for both breeds. In contrast to (Budai et al., 2013) there was no significant difference between lambing interval of pure Dorper (8 months) and Dorper crosses (8months), respectively.

On farm Performance

A study which was conducted by Belete et al., (2015) shows that Dorper cross with Adilo indigenous sheep show a Mean birth weight, weaning weight, weaning age, market age, market weight, litter size, age at first lambing and sexual maturity for Dorper sheep were 2.25±1.72 kg, 17.30±0.98 kg, 3.16±0.55 months, 12.66±1.39 months, 30.66±3.26 kg, 1.48±0.71, 11.81±1.37 months and 5±0.74 months, respectively. Location, season, birth type, parity, sex and blood group had significantly (P<0.05) affected weaning weight. Season had influence on weaning age. Pre-weaning mortality rate of Dorper sheep was 2.93% and lower in Wolaita than Siltie zone.

Reproductive Performance and Lamb Mortality

Onstation Performance

According to Fourie et al., (2009), Dorper ewes in South Africa had age at first lambing of 346 days (11.5months), in contrast to, a well-managed ewes can lamb at the age of 13-15 months (Gavojdian et al., 2013). Age at first lambing and lambing interval of 12 and 8 months was reported for pure Dorper sheep breed (Budai et al., 2013), while age at first lambing of 12 and 13 months for pure Dorper and Dorper crossbred in South Africa (Fourie et al., 2009).

Table 5. Reproductive performance of Dorper crosses

| Blood level | AFL(months) | LI (months) | Litter size | References |
|-------------|-------------|-------------|-------------|------------|
| 50% Dorper  | 11.07±0.53  | N/A         | 1.88±0.27   | Belete et al., 2015 |
| 25% Dorper  | 12.50±0.65  | N/A         | 1.96±0.26   | Belete et al., 2015 |

WT = birth weight, WWT = weaning weight, YWT = yearling weight, AFL = age at first lambing, LI = lambing interval, N/A = not attend

Adopted from Destaw et al. (2017)

According to Helen et al., (2015) the age at first lambing and lambing interval of indigenous sheep in eastern Ethiopia were 13.8±0.14 and 8.58±0.14 months, respectively. In contrast, age at first lambing of local sheep breed of 17.01 months (Samuel, 2005), 20.7 in pastoral and agro--pastoral system of Southern Ethiopia (Adugna and Aster, 2007), 14.6 for Adilo sheep (Getahun, 2008), 470.10 days for Menz sheep (Tesfaye, 2008), 12.43 months (Solomon, 2007; Zewdu, 2008; Deribe, 2009) and 12.88 months of Dawuro sheep (Amelmal, 2011). However, the least square means of age at first lambing of Dorper sheep of 11.81 (Belete et al., 2015) and 11.5 months (Fourie et al., 2009) was comparable with the report of 12 months (Teklebrhan, 2011) in Ethiopia. Dorper sheep crosses had better reproductive performance than indigenous sheep breed of Adilo especially in weaning weight and market weight even though it has similar sexual maturity and litter size (Belete et al., 2015).

Farmer’s Perception to Dorper Cross Sheep

Informal interview of the smallholder farmer indicated that the crossbreds have non-selective feed behavior and excellent in meat production under farmer’s management. Farmers are highly interested and demanding introduction of additional rams. Some of the beneficiaries have earned up to 2200 Birr form the sale of adult crossbreds (Gebreyohens et al., 2017). On the contrary a study by Kebede H/giorgis and Zekarias Bassa (2017) showed that Dorper sheep was not meet farmer interest in breeding sheep aspect because of black coat color. It is suggested that to achieve upsetting farmer breeding ram interest which is increasing time to time further increasing of breeding ram producer cooperative workshould be considered.

Conclusion and Recommendation

Ethiopia has a diverse indigenous sheep population, estimated about 28.89 million, out of which about 72.84
percent are females, and about 27.16 percent are males. Sheep production in Ethiopia is based on indigenous breeds except for less than 1% exotic sheep group of mainly Dorper crossbred. However, comparing the presence of large sheep population similar to other tropical countries, present production levels are far below their potential and productivity per sheep is very low mainly due to low genetic potential as compared to improved tropical breeds. The productive and reproductive performance of sheep in Ethiopia showed variation among breeds/types, locations and differences. Besides, under farm and station condition variation exists between indigenous and exotic sheep breeds for productive and reproductive traits. The evidence from this paper points towards the idea that productive and reproductive performance of indigenous and its crossbred with Dorper found to vary under on farm and on station conditions. It was revealed that on station performance of Horro out performed well in birth, weaning and yearling weight than other local breeds of Ethiopia, with minimum birth weight of 2.3 and maximum of 2.6 kg, respectively. With consideration of crossbreed, under on farm conditions body weight at different ages was significantly higher in 50% Dorper crosses as compared to their 25% and 75% counter parts. On station birth weight of pure Dorper out performed well than that of cross and local contemporaries, while Dorper Crossbred (50%) is better than local breeds in terms of mean birth weight; ranges from 2.6 3.8 kg, weaning weight; ranges from 13 16 kg and yearling weight; ranges from 24 35 kg. Dorper crosses with Afar under station condition is not economically important due to lower body weights in all aspects. However, researches regarding on farm performance of indigenous and their crosses with Dorper and Awassi sheep breeds are not well grounded due to the reason that many researcher has tended to focus onstation performance evaluation rather than on farm condition. Indeed future research on On-farm performance evaluation of indigenous and their crosses with Dorper sheep breeds with different blood level inheritance should be encouraged.

References
Adugna, T., and Aster A. (2007). Livestock production in pastoral and agro-pastoral production systems of southern Ethiopia. *Livestock Research for Rural Development*, (19), 4, 177

Amelmal, A. (2011). Phenotypic characterization of indigenous sheep types of Dawuro zone and Konta special districts of SNNPR, Ethiopia. MSc thesis. Haramaya University, Ethiopia

Ayele, A., Solomon, G., Asfaw, B., Shenkte, G., Shambel, B., Tefera, M., Tesfaye, Z., and Yeshimebet, C. (2015). Growth performance of dorper and its F1 crossbreds at Debre Birhan Agricultural Research Cente.

Byrne, T.J., Amer, P.R., Fennessy, P.F., Rohloff, R.M., Cromie, A., Donnellan, P., Potterto, G., Hanrahan, J.P., and Wickham, B. (2009). Progress in the development of breeding schemes for the irish sheep industry: The maternal lamb producer groups bacusbio limited, Irish cattle breeding federation society limited, high field house shinagh, Galway, Ireland. Proceedings of the Association for the Advancement of Animal Breeding and Genetics, Barossa, South Australia. pp 434-437

Cloete, S.W.P., Snyman, M.A., and Herselman, M.J. (2000). Productive performance of Dorper sheep. *Small Ruminant Research*, 36, 119–136.

Deribe, G. (2009). On-farm performance evaluation of indigenous sheep and goats in Alaba, Southern Ethiopia. Msc. Thesis. Hawassa University, Awassa, Ethiopia.

Belete, E., Goshu, G., and Tamir, B. (2015). Productive performance evaluation of Dorper sheep crosses (50% Dorper × pure Adilo indigenous sheep breed) under farmer conditions in different agro ecological zones. *International Journal of Livestock Production*, 6(5), 61-68.

Budai, C., Gavojdian, D., Kovacs, A., Negrut, F., Olah, J., Czisztter, L.T., Kusza S, Javor A. (2013). Performance and adaptability of the Dorper sheep breed under Hungarian and Romanian rearing conditions. *Animal Science and Biotechnologies*, 46(1), 344-350.

Cloete, S.W.P., Snyman, M.A., and Herselman, M.J., (2000). Productive performance of Dorper sheep. *Small Ruminant Research*, 36, 119-135.

Ermias, B.(2014). On- farm performance evaluation of Dorper sheep breed crosses in Siltie and Wolaita Zones, Southern Ethiopia. MSc thesis. Harmaya University, Ethiopia.

Fourie, P.J., Vos, P.J.A., and Abiola, S.S. (2009). The influence of supplementary light on Dorper lambs fed intensively. *South African Journal of Animal Science*, 39(S1), 211-214.

Galal, E.S.E., Kassahun A., Beyene, K. Yohannes, G., and B. O’ Donovan. (1979). A study on fattening Ethiopian sheep: 1. Performance of high land lambs under feedlot conditions. *Ethiopian Journal of Agricultural Science*, 1(2), 93 - 98.

Gatenby, R.M. (2002). Sheep. Macmillan Education, London.

Gavojdian D, Sauer M, Pacala N, Czisztter LT. (2013). Productive and reproductive performance of Dorper sheep and its crosses under a Romanian semi intensive management. *South African Journal of Animal Science*, 42(2), 219-228.

Gavojdian, D., Sauer, M., Pacala, N., and Czisztzer, L.T.(2013). Productive and reproductive performance of Dorper and its crossbreds under a Romanian semi intensive management system. Banat's University, Romania. *South African Journal of Animal Science*, 2013, 43, 219-228.

Gebreyowhens,W., Mengistu R., and Awet E.,(2017). Improving live body weight gain of local sheep through crossbreeding with high yielding exotic Dorper sheep under smallholder farmers. *International Journal of Livestock Production*, 8(5), 67-71.

Getachew, T., Haile, A., Wurzinger, M., Rischkowsky, B., Giaz, S., Abebe, A., Solkner, J. (2016). Review of sheep crossbreeding based on exotic sires and among indigenous breeds in the tropics: An Ethiopian perspective. *African Journal of Agricultural Research*, 11(11), 901-911.

Getahun, L. (2008). Productive and economic performance of small ruminant production in production system of the
highlands of Ethiopia. PhD thesis. Hohenheim, Germany University of Hohenheim.

Hassen, Y., Sölkner, J., and Fuerst-Waltl, B. (2004). Body Weight of Awassi and indigenous Ethiopian sheep and their crosses. Small Ruminant Research, 55, 51-56.

Helen, N. (2015). Phenotypic and genetic characterization of indigenous sheep breeds of eastern ethiopia. PhD Thesis. Harmaya University.

Hinojosa-Cuíllar, J.A., Oliva-Hernandez, J., Torres H.G., and Segura-Correa, J.C. (2013). Productive performance of F1 Pelibuey x Blackbelly lambs and crosses with Dorper and Katahdin in a production system in the humid tropic of Tabasco, México. Archivos de medicina veterinaria, 47(2), 167-174.

Hirpa, A., and Abebe, G. (2008). Economic Significance of Sheep and Goats. In: Yami, A. and Merkel, R.C., Eds., Sheep and Goat Production Handbook for Ethiopia, Branna Printing Enterprise, Addis Ababa, 2-24.

Kosgey, I.S., and Okeyo, A.M. (2007). Genetic improvement of small ruminants in low-input, smallholder production systems: Technical and infrastructural issues. Small Ruminant Research, 70, 76-88.

Lakew, M., Haile-Melekot, M., Mekuriaw, G., Abreha, S., and Setotaw, H. (2014). Reproductive performance and mortality rate in local and dorper × local crossbred sheep following controlled breeding in Ethiopia. Open Journal of Animal Sciences, 4, 278-284.

Mekonen,T., Girma, A., and Kefelegn, K. (2012). Growth performance and carcass characteristics of Dorper sheep and Boer goat crosses compared with local sheep and goat breeds. MSc thesis. Haramaya, Ethiopia: Haramaya University.

Mellado, M., Macias, U., Avendaño, L., Mellado, J., and Garcia, J.E. (2016). Growth and pre-weaning mortality of Katahdin lamb crosses. Revista Colombiana de Ciencias Pecuarias, 29, 288-295.

Neser, F.W.C., Erasmus, G.J., and Van Wyk, J.B. (2001) Genetic parameter estimates for pre-weaning weight traits in Dorper sheep. Small Ruminant Research, 40(3), 197-202.

Tilahun, M. (2012). Growth performance and carcass characteristics of Dorper sheepand Boer goat crosses compared with local sheep and goat breeds. Msc Thesis. Harmaya University.

Sebsibe, A. (2008). Sheep and goat meat characteristics and quality. In: Yami, A. and Merkel, R.C., Eds., Sheep and goat production handbook for Ethiopia, Branna Printing Enterprise, Addis Ababa, 325-340.

Shaker, M.M., Kridli, R.T., Abdullah, A.Y., Malinov, Á.M., Sanogo, S., Sáda, I., and Lukešová, D. (2010). Effect of crossbreeding European sheep breeds with Awassi sheep on growth efficiency of lambs in Jordan. Agricultura Tropicaet Subtropica, 43(2), 127-133.

Shaker, M.M., Abdullah, A.Y., Kridli, R.T., Sada, I., Sovjak, R., and. Muwalla, M.M. (2002). Effect of crossing indigenous Awassi sheep breed with mutton and prolific sire breeds on the growth performance of lambs in a subtropical region. Czech Journal of Animal Science, 47, 239–246.

Sissay, L., (2002). Phenotypic classification and description of indigenous sheep types in the Amhara national regional state of Ethiopia. M.Sc. Thesis Submitted to the Department of Genetics, University of Natal, Pietermaritzburg, South Africa, 104

Solomon, A. (2007). In situ characterization of Gumuz sheep under farmers management in north western lowland of Amhara region. M. Sc thesis. Haromaya University, Dire Dawa, Ethiopia.

Snyman, M.A., and Olivier, W.J. (2002). Productive performance of hair and wool type Dorper sheep under extensive conditions. Small Ruminant Research, 45, 17-23.

Tesfaye, G. (2008). Characterization of menze and afar indigenous sheep breeds of smallholders and pastoralist for designing community based breeding strategies in Ethiopia. M. Sc thesis. Harmaya University, Dire Dawa, Ethiopia.

Tibbo, M. (2006). Productivity and health of indigenous sheep breeds and crossbreds in the central Ethiopian highlands. Ph.D. Thesis, Swedish University of Agricultural Sciences, Uppsala.

Tilahun, M., Kefelegn, K., Abebe, G., Goetsch, A.L. (2014). Feed intake, digestibility, weight gain, and slaughter characteristics influenced by genetic percentage of Boer in goats and Dorper in sheep in the central highlands of Ethiopia. Tropical Animal Health and Production, 46(4), 593-602.

Teklebrhan, T. (2011). Growth Performance, Carcass Trait and Skin/Leather Quality of Indigenous and Cross Bred (Dorper X Indigenous) F1 Sheep. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University, p 99.

Widdowson, E.M. (1980). Definitions of growth. In: T.L.J. Lawrence (Ed.) Growth in Animals. pp 1-9. Butterworth, London.

Wildes, S., (1997). Hair sheep genetic resources and their contribution to diversified small ruminant production in the United States. Journal of Animal Science, 75, 630–640.

Zewdu, E. (2008). Characterization of Horro and Bonga indigenous sheep breeds of smallholders for designing community-based breeding strategies in Ethiopia. M. Sc thesis. Haramaya University, Ethiopia.