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Original Research

Estimation of Genetic Parameters for Reproductive Traits in Horro Sheep Managed Under On-farm Conditions

Tamiru Kebebew[1], Tesfaye Getachew[2] & Gemeda Duguma[3 ¥]

[1]Buno Bedele Zone Agricultural and Natural Resource Office, Buno Bedele Zone, Oromia, Ethiopia
[2]The International Center for Agricultural Research in the Dry Areas (ICARDA), Addis Ababa, Ethiopia
[3]School of Veterinary Medicine, Wallaga University, Ethiopia

Abstract

The study was carried out on flocks of Horro sheep owned by participants in a community-based sheep genetic improvement programme in the Horro district, Horro Guduru Wallaga zone, Oromia Regional State, Ethiopia. The objective of the study was to estimate genetic parameters for reproductive traits (lambing interval and annual reproductive rate) and to evaluate the reproductive performances of the flock. A total of 307 records collected on 1398 breeding ewes sired by 101 breeding rams from 2010 to 2015 were used for both lambing interval and annual reproductive rate produced. The General Linear Model (GLM) Procedures of the Statistical Analysis System (SAS, 2016, version 9.4) were employed to determine the effects of fixed factors. (Co)Variance components and genetic parameters were estimated by restricted maximum likelihood procedures (REML) applying the VCE 4.2.5 package of Groeneveld (1998). The least-squares means obtained for lambing interval and annual reproductive rate were 8.13±0.06 months and 2.02±0.02, respectively. Estimates of direct heritability (h2a) obtained from the simple animal model were 0.01±0.01 and 0.01±0.02 for lambing interval and annual reproductive rate, respectively. The laming interval and the annual reproductive rate obtained in the current study enable producers to have about three lambings per two years, which requires improved feeding management. The direct heritability (h2a) estimates obtained in the current study were very low. The likely reason may be the size and quality of data used and the model used for the (Co) Variance estimation.

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*Corresponding Author:
Gemeda Duguma

E mail
gdjaallataa@yahoo.com

INTRODUCTION

Sheep production is one of the most important agricultural activities in Ethiopia. According to the Central Statistics Agency (CSA, 2017), sheep is the second most important species of livestock in the country, with an estimated population size of 30.7 million heads. Almost 99% of Ethiopia's sheep population is local breeds that are widely distributed in different parts of the country. Duguma (2010) reported that different indigenous sheep breeds are owned and managed by resource-poor smallholder farmers and pastoralists under traditional and extensive production systems. There are nine identified sheep breeds characterised through phenotypic and molecular methods in the country (Gizaw et al., 2008). Sheep have a significant contribution to the country's economy.

Even though sheep play important roles in the country's economic development and the livelihoods of farmers and pastoralists, their productivity remains low due to several reasons. Some of the major problems are weak genetic improvement efforts associated with the absence of planned breeding programmes and breeding policies, diseases and parasites, feed shortages, inadequate extension service delivery or lack of improved technologies, poor infrastructure, and a lack of market information (Duguma, 2010; Mirkena, 2010; Gizaw et al., 2013). The genetic improvement efforts that have been done for over four decades have not succeeded due to a lack of clear and documented breeding and distribution strategies, very little consideration of farmers' needs and indigenous practices, and the unsuitability of the environment (Tibbo, 2006; Duguma, 2010; Haile et al., 2011). The limited involvement of relevant stakeholders, particularly smallholder farmers and pastoralists, in the planning and implementation of sheep improvement endeavours contributed to such failures (Duguma et al., 2011).

Considering the above facts, the International Centre for Agricultural Research in Dry Areas (ICARDA), the International Livestock Research Institute (ILRI), and the Austrian University of Natural Resources and Life Sciences (BOKU), in collaboration with the Ethiopian National and Regional Agricultural Research Systems (NARS), have designed and implemented community-based sheep breeding programmes (CBBP) through an Austrian Development Agency-funded project from 2007 to 2011.

The Horro sheep breed is one of the four local breeds for which the community-based sheep breeding programme has been implemented since 2009. Evaluation of any designed genetic improvement programme is fundamental, either to optimise the programme if it is progressing towards the set goals or to redesign other improvement alternatives if it fails or deviates from the preset goals. Until now, only the institutional and organisational aspects of the community-based sheep genetic improvement programme and phenotypic evaluation were performed (Gutu et al., 2015; Kasahun, 2019). Therefore, the current study was proposed to estimate (Co) variance components and genetic parameter estimates for the reproductive performance of the Horro sheep breed managed under community-based breeding programmes in Horro district.

Objectives

1. To evaluate fixed effect factors that influence the reporoductive performances of Horro sheep flocks managed under a community-based breeding programme at Horro District
2. To estimate the genetic parameters of the reproductive performances of Horro sheep flocks managed under the community-based breeding programme in Horro district

MATERIALS AND METHODS

Description of the Study Area

The study was conducted on flocks of Horro sheep owned by members of the ongoing Horro sheep community-based breeding program. The programme was initiated at Gitilo and Lakku Igu villages in Horro district in 2009. Horro district is found in the Horro Guduru Wallaga zone of the Oromia Regional State. Horro district is located about 315 km from Addis Ababa, in the north-west direction. The geographical coordinates of the district are 9034 at $9^0$34´N latitude and $37^0$06´ E longitude. The map of the study area is indicated in Figure 1. The production system of the area is mixed-crop livestock. The area has one long rainy season that extends from March to mid-October, with a mean annual precipitation of about 1800 mm and maximum and minimum temperatures of about 22.67 and 11.750 °C, respectively. Horro district has eleven kebeles or villages, of which the CBBP was initiated in two kebeles or villages: Gitilo and Laku Igu. Gitilo and Laku Igu k*ebeles/villages* are found about 12km and 7km, respectively, from Shambu town, the capital town of Horro Guduru Wallaga zone. The topography of both villages ranges from 2170 to 2853 metres above sea level (Kasahun, 2019). In both villages, more than 130 households have more than 2500 sheep members in the breeding programme (Duguma et al., 2012).

Description of the Breed

The Horro sheep breed is one of nine sheep breeds identified so far in Ethiopia. The breed derives its name from the Horro region, the major natural home tract of the breed. Though Horro is known as a place name, it was the name of one of the renowned Oromo tribes in Horro Guduru Wallaga zone. The Horro sheep breed is widely distributed in most of the western part of the country, which lies between 35-38^0 E and 6-10^0N. The sheep breed is mostly uniform in colour, ranging from solid tan (very light brown) to dark brown. Exceptionally, some of them may be creamy white, black, or spotted (Galal, 1983). The body of the sheep breed is covered with short, smooth hair. The face has a straight profile but is somewhat convex in the rams. Both males and females are polled, but occasionally there are males with curved horns. The long, fat tail is triangular with a relatively narrow base, and the pointed end hangs downward or has a slight twist, reaching just below the hocks (Zewdu, 2008).

Data collection and management

Reproduction data collected between 2010 and 2015 from Horro sheep flocks maintained under on-farm management conditions by the Bakko Agricultural Research Centre (BARC) was used in the current study. A total of 307 records collected from 101 breeding sires and 1398 breeding ewes were used for both lambing interval (LI) and annual reproductive rate (ARR) estimation. Lambing year, season of lambing, and location were fixed factors. In the current study, seasons were categorised into four: early rainy season, rainy season, early-dry season, and dry season.

Statistical Analysis

The General Linear Model (GLM) Procedures of the Statistical Analysis System (SAS, 2016, version 9.4) were employed to determine the effects of fixed factors. (Co)Variance components and genetic parameters were estimated by restricted maximum likelihood procedures (REML) applying the VCE 4.2.5 package of Groeneveld (1998). The following statistical models were fitted to determine the fixed effects:

$$Y_{ijk} = \mu + S_i + Y_j + L_k + e_{ijk}$$

Where:

Y_{ijk}= the observation on Lambing interval (LI) and annual reproductive rate (ARR)

μ = Overall mean

S_i= Fixed effect of lambing season (i = 4, early-rain, wet, early-dry, dry)

Y_j = Fixed effect year of lambing (2010, 2011, … 2015)

L_k = Fixed effect of location (k = 2, Gitilo, Laku)

e_{ijk} = effect of random error

The animal model fitted to estimate the (Co)variance components was:

$\mathbf{Y} = \mathbf{X}b + \mathbf{Z}a + e$

Where **Y** is the vector of records,

b is a vector of an overall mean and fixed effects with incidence matrix **X**; a, is vectors of random additive direct genetic effects with incidence of fixed effect **Z** respectively, and e is a vector of random errors as it was necessary.

RESULTS AND DISCUSSION

Lambing interval

In the present study, season and year had significant effects (at $p<0.05$) on LI. Those ewes born in dry and eraly-rainy seasons (*Afraasaa* in Afaan Oromoo) have a shorter lambing interval than those born in wet and early dry seasons (Table 1). The reason for these effects might be related to the availability of feeds and ram distribution among community members (between the different ram use groups). In agreement with this, Duguma (2001) also reported that differences in performance between years might be a reflection of differences in feed availability caused by variations in total annual precipitation and the distribution of rainfall.

Table 1

Least squares means (LSM±SE) of the annual reproductive and lambing interval of Horro sheep

Effects	N	Annual Reporoductive Rate (ARR)	Lambing Interval (LI) (month)
		LSM (±SE)	
Overall	307	2.02±0.05	8.12±0.06
Location		NS	NS
Laku Igu	69	2.21±0.12	8.03±0.15
Gitilo	238	2.20±0.05	8.16±0.07
Lambing Season		NS	***
Early-rain	57	2.29±0.12	7.71±0.14[c]
Wet	52	2.18±0.10	8.23±0.11[ab]
Early-dry	103	2.11±0.10	8.42±0.11[a]
Dry	55	2.19±0.12	7.84±0.15[bc]
Lambing year		**	***
2010	11	2.65±0.25[a]	7.67±0.27[ab]
2011	67	2.13±0.11[ab]	7.94±0.13[b]
2012	20	2.30±0.19[ab]	7.54±0.19[b]
2013	NA	-	-
2014	90	1.97±0.08[ab]	8.15±0.13[ab]
2015	120	3.22±0.01[a]	7.55±0.01[b]

Different superscripts in the same column indicate significant different. NA = data not available, ARR= annual reproductive rate.

The overall mean lambing interval obtained in the current study was 244 days, or 8.13 months (Table 1). The mean value obtained for LI in the current study was slightly longer than the 7.9 months reported by Admasu *et al*. (2017) for indigenous sheep flocks raised in the Wolaita zone, Ethiopia. It was also slightly longer than the 242 days (8.07 months) reported by Gbangboche *et al*. (2006) for Djallonke sheep. The value of the current study was shorter than the 9.8-month mean LI interval reported by Eyob *et al*. (2017) for Abera sheep found in Sidama Regional State and the 8.8-month LI reported by Yadeta (2016) for local sheep populations found in Ada'a Baraga and Ejere districts of west Shewa Zone, Oromia Regional State. Longer lambing interval values ranging from 8.5 to 9.02 months were reported for different indigenous sheep breeds in the country (Tesfaye, 2008; Mengistie *et al*., 2011; Gebregiorgis *et al.*, 2016).

The current LI is also longer than the 7.8-month mean LI reported for the same Horro sheep breed (Zewdu, 2008). The likely reason for the difference may be due to the fact that the current study was based on performance data collected over six years from the flocks of CBBP members, while that of Zewdu (2008) was based on survey data collected from wider areas of the Horro district. Generally, the distribution of breeding rams (fairly to all breeding ram groups) as designed during the beginning of the project would improve LI and ARR in the flocks.

Annual reproductive rate (ARR)

The least squares means of annual reproductive rate obtained in the current study for Horro flocks maintained under on-farm management conditions is 2.02. This value is higher than the mean values of 1.46 and 1.40 reported by Zelalem *et al*. (2013) for the Washera sheep breed maintained at on-station and on-farm management conditions, respectively. The current ARR is also slightly higher than the 1.90 reported by Metsafe (2015) for the Bonga sheep breed managed under a similar community-based sheep breeding programme in the Kafa zone of the Southern Nations Nationalities and Peoples Regional State, Ethiopia. The Horro sheep breed is one of the most prolific and largest breeds in the country (Galal, 1983). The Bonga sheep breed used to be known as the Horro sheep breed until Gizaw (2008) characterised it as an independent breed using phenotypic and molecular classification.

Lambda year had significant effects ($p<0.05$) on ARR. ARR was highest in 2015, followed by 2010 and 2012, respectively (Table 1). However, the season of lambing did not impose a significant effect ($p> 0.05$) on ARR. The year of lambing might be attributed to the variation due to the amount and distribution of rainfall between years that influence the natural pasture and then the performance of the ewe. That means the variations might be attributed to fluctuations in feed availability between years. The effects of the year of lambing reported in the current study were in agreement with the effect of fluctuation in feed availability between years reported by Admasu *et al*. (2017) and Zelalem *et al.* (2013).

Genetic Parameter Estimates

The results of the (Co) variance components and genetic parameters for the reproductive traits considered in the current study are presented in Table 2.

Heritability (h^2_a)

The direct additive heritability (h^2_a) estimates for both ARR and LI in the present study are

0.01±0.01 and 0.01±0.02, respectively (Table 2). The current heritability estimate of LI for Horro ewes is in line with the 0.009 h^2 value reported for Bonga sheep flocks raised by members of the community-based sheep breeding programme at Kafa zone of the South Western Ethiopia Peoples Regional State, Ethiopia (Asrat *et al*. 2020). Estimates of the heritability of a trait can vary considerably from study to study depending on the breed, environmental condition, population sampled, management system, and statistical model used. Most reproduction traits, such as lambing interval, age at first lambing, and lamb survival, have low heritability estimates (Shigdaf & Aynalem 2014). In other words, additive genetic effects have little effect on reproduction traits, while environmental and non-additive genetic effects considerably affect these traits. In general, a low heritability value indicates a low possibility of achieving rapid genetic progress for reproductive traits through phenotypic selection. Heritability estimates for the reproductive traits, like in other reports, are generally low and indicate that their improvement through selective breeding would be difficult even though genetic gains have been achieved in the CBBP.

Table 2

Phenotypic (above diagonal) genetic (below diagonal) correlations and heritability (on diagonal) for Annual reporoductive Rate (ARR) and Lambing Interval (LI)

Traits	Annual Reproductive Rate (ARR)	Lambing Interval (LI) in month
ARR	0.01±0.01	-0.93
LI	0.41	0.01±0.02

Genetic and phenotypic correlations

In the present study, the genetic correlation between reproductive traits (annual reproductive rate and lambing interval) is 0.41. However, high negative phenotypic correlation estimates of 0.93 are obtained between the annual reproductive rate and lambing interval in the present study. Enetic correlation estimates are necessary for designing effective breeding plans and breeding strategies.

Genetic trends

The genetic trends for lambing interval and annual reproductive rate are indicated in Figures 1 and 2, respectively. In the present study, the genetic trends of the annual reproductive rate did not follow regular patterns. The genetic trend of lambing intervals across the years showed a negative slope, which indicates there was continuous genetic improvement across the selection years. The trend of the ARR obtained in the current study is in agreement with the report of Aynalem *et al.* (2020). The authors indicated that the genetic trend for prolificacy over the years in both Bonga and Horro flocks showed significant progress. The genetic trend for ARR and LI over the years is significant, implying that the genetic improvement intervention has resulted in measurable genetic gains.

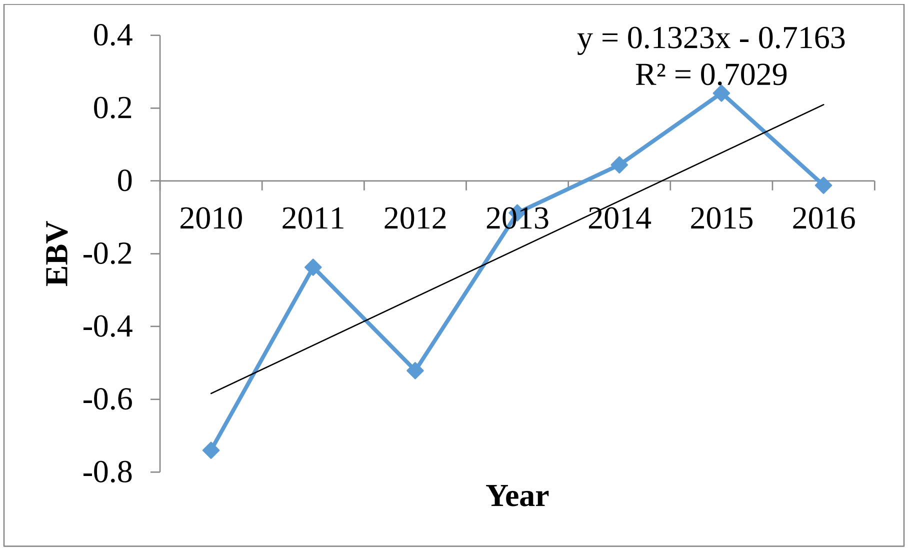

Figure 1 *Mean EBV of annual reproductive rate (ARR)*

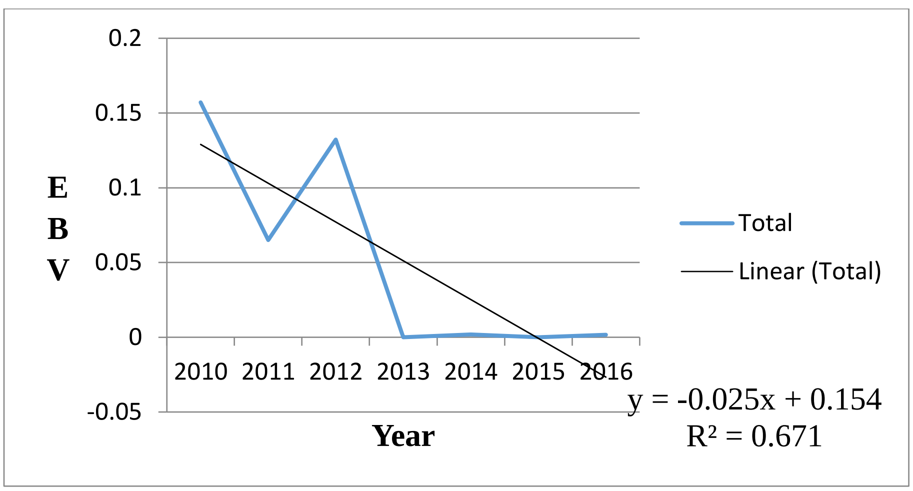

Figure 2 *Mean EBV of lambing interval (LI)*

CONCLUSIONS

The current study was carried out to estimate genetic parameters for reproductive traits in flocks of Horro sheep raised by members of the community-based sheep breeding programme (CBBP) in Horro district. In the present study, season and year had significant effects (at $p<0.05$) on LI. Those ewes born in dry and eraly-rainy seasons (*Afraasaa* in Afaan Oromoo) have a shorter lambing interval than those born in wet and early dry seasons. Ewes born in 2010 and 2012 had the highest ARR as compared to the other years considered in the present study.

The direct additive heritability (h^2_a) estimates for both ARR and LI in the present study are very low. A moderate positive genetic correlation was obtained between LI and ARR. The phenotypic correlation between the two traits is highly negative.

Recommendation

From the results of the present study, the following recommendations are drawn:

- Season of lambing has a significant (at least at $p < 0.05$) influence on LI, indicating that fixing breeding during those seasons is important. In addition, supplementary feeding during seasons of feed scarcity is necessary. Awareness-raising training for sheep producers and farmers is important.
- Year has significant influence both on ARR and LI. The difference in ARR and LI was likely due to differences in feed availability resulting from differences in rainfall and distribution. As Horro district is a surplus cereal production area, conservation and utilisation of crop residues would be important options.
- The distribution of breeding rams (fairly to all breeding ram groups) as designed during the beginning of the project should be implemented.
- The trend for both ARRs has been increasing. In addition, the genetic trend of lambing intervals across the years showed a negative slope, which indicates there was continuous genetic improvement across the selection years.

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