Livestock Research for Rural Development 32 (9) 2020 | LRRD Search | LRRD Misssion | Guide for preparation of papers | LRRD Newsletter | Citation of this paper

Growth, reproductive performance and survival rate of Bonga sheep and their crossbreds in Southern Ethiopia

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Abstract

The dissemination of improved Bonga sires from Bonga sheep community-based breeding for the purpose of genetic improvement have been start in different parts of Ethiopia since 2012. Four districts from southern Ethiopia were selected for this study purposively. Monitoring and survey tools were used to evaluate the growth and reproductive performance and survival rate of Bonga crosses in the areas. Lambs obtained from Bonga sire show better and fast growth rate than lambs obtained from local sire. The obtained body weights for Bonga cross lambs at their birth, three and six-month heavier by 0.56, 1.92 and 4.4kg than local lambs under the same management practices of farmers. Based on survey result, 0.29 more lambs were obtained from ewes mated by Bonga ram than ewes mated by local ram. The findings indicated that, lambing interval were minimized by one month and age at first lambing of Bonga cross ewe earlier by 2.4 months than local ewe lambs. We observed that, the pre and post weaning mortality rate for Bonga cross lambs was significantly lower than local sheep in the present study areas. The fast growth rate of Bonga crosses over local sheep attracts farmers in the study areas to use Bonga rams as a breeding sire.

Key words: *bonga cross, bonga ram, local ewe, local lamb, pre-weaning, post-weaning*

Introduction

Sheep production is a major component of the livestock sector in Ethiopia owing to the large population of 30.7 (CSA 2017) and the diverse genetic resources (Gizaw et al 2008). They support regular income in both tangible and/or intangible manners to a large human population through the sale of live animals and skins (Abebe et al 2010) and provide their owners with a vast range of products and services such as immediate cash income, meat, milk, skin, manure (Adane and Girma 2008). They are also considered as living bank against the various environmental calamities (crop failure, drought and flooding) and have socio-cultural values for diverse traditional communities (Edea et al 2010; Melesse et al 2013).

In spite of the large population of sheep, genetic diversity and its role in the country, the productivity of sheep is constrained by several factors, including low genetic potential of the animals (Girma et al 2009), along with lack of planned breeding programs and breeding policies (Solomon et al 2013).

To overcome the low productivity of sheep, national level sheep crossbreeding program using high producing were started as far back as in 1944. The introduced exotic genotypes included, Merino, Hampshire, Romney, Corriedale, Awassi, and later Dorper which were imported from various countries. However, the program had no significant effects on sheep productivity or on farmers' and pastoralists' livelihoods and the national economy at large (Gizaw et al 2013). These breeding programs were also neglected by farmers as they did not meet the preference of the farmers and indigenous practices (Tibbo 2006; Gizaw and Getachew 2009).

In an attempt to support such endeavors the International Center for Agricultural Research in the Dry Areas (ICARDA), the International Livestock Research Institute (ILRI) and the Austrian University of Natural Resources and Applied Sciences (BOKU) in partnership with the National Agricultural Research System (NARS) in Ethiopia designed and implemented a new approach called community-based breeding programs (CBBP) for four selected sheep breeds (Menz, Bonga, Horro, and Afar) (Haile et al 2018).

Evaluation of these CBBPs indicated that promising results have been achieved (Gutu et al 2015; Haile et al 2018), Given the successes of these CBBPs, improved rams produced from the established breeding programs were disseminated to other communities including out of their breeding tracts. For example, in Bonga CBBP over the years many breeding rams with high EBV were selected and top 10% of them were maintained for further breeding in the communities and the rest were disseminated as a genetic material for genetic improvement of local sheep of different breeds in different areas in Ethiopia. Overall, a total of 5238 breeding rams were distributed through the country for crossbreeding with local ewes. Although dissemination of improved rams has been implemented, there is no information on performance and survival of the disseminated rams and those of the F1 crossbred lambs produced in the disseminated areas. Therefore, this paper reports growth, reproductive performance and survival rate of F1 Bonga crossbred lambs in southern Ethiopia.

Materials and methods

Description of the study site

The study was conducted in four selected zones of Southern Ethiopia, namely Silte, Wolayta, Gurage and Sidama, where improved Bonga rams, from Bonga CBBPs were disseminated. One district from each selected zone were purposely chosen based on a greater number of Bonga ram introduction in the areas and agroecology of the districts (Figure 1).

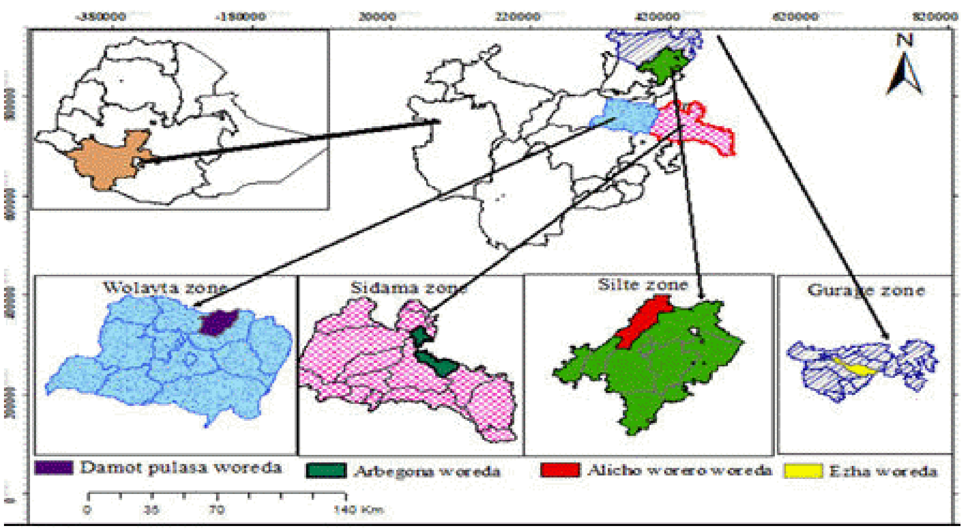

Figure 1. Map of the Study areas

The districts were Arbegona, Ezha, Damot Pulasa and Alicho Worero from Sidama, Gurage, Wolayta and Silte zone. Both Arbegona and Ezha districts were considered as highland and the habitats were wet humid (2785 m.a.s.l.) and cool highland (2930 m.a.s.l.) respectively (Table 1). The rest Damot Pulasa and Alicho Worero were considered as midland and the habitats were semi-humid. The production system of the districts was mixed crop livestock production.

Table 1. Agro-ecology and production system of study districts

Location	# sires isseminated	Agro-ecology	Altitude (m.a.s.l)	Longitude (North)	Latitude (East)
Arbegona	60	Highland	2985	$6^{0}39'60''$	$38^{0}44'60''$
Ezha	28	Midland	2930	$8^{0}55'02''$	$38^{0}\ 6'\ 22''$
Damot Pulasa	71	Midland	1919	$7^{0}00'08''$	$37^{0}47'34''$
Alicho Worero	105	Highland	2295	$7^{0}55'02''$	$38^{0}7'42''$

Source: GPS and Secondary sources

Breeding programs and animal management

The breeding program in Bonga ram home track was sated by collaboration of ICARDA-ILRI and SARI/Bonga ARC which is called Community based Bonga sheep improvement program (CBBP). Before set up of CBBP, farmers breeding objectives and interest of traits such as growth rate or Body size, mothering ability or lamb survival rate and twining rate (for details Mirkena et al 2011 and Haile et al 2018) was identified first. The breeding program is based on selection of best breeding rams from sheep flocks of all participating farmers. Farmers were organized as Bonga sheep improvement cooperatives and get technical support from research systems. The community decides how Top 10% rams are managed and how they are shared in the community (Haile et al 2014).

The Bonga rams were introduced in disseminated areas by either regional government or NGOs (Non-government Organization) for local sheep improvement purpose through crossbreeding. The breeding objective of farmers in all study districts aimed to improve growth rate and reproductive performance of local sheep through crossing local ewes with Bonga Ram and improving income gain through sale of fast grower Bonga cross lambs at early ages. The traits considered were growth rate, body size, coat color and litter size. The farmers were using Bonga rams as breeding sire for mating with selected either local or Bonga cross female sheep for production F1 progeny and F1 crossbred ram lambs were then sold in the market. This practice is repeated continuously and farmers were unconsciously practicing terminal crossbreeding. Bereket et al (2017) reported that terminal sheep crossbreeding with Bonga sires as Best fit practice in SNNPRS, Ethiopia.

The patterns of Bonga ram management and utilization were different in all districts. In Alicho Worero Bonga rams were managed and utilized from either FTC or "Limat Budin" (local sub-group). In Ezha District Bonga ram utilized by rotating from farmer to farmer and one farmer keep the ram for one month then shift to another farmer with the norm of good management and all farmers should use the ram freely. In Damot Pulasa, Bonga rams were maintained by model farmers and then other farmers (Not owning Bonga rams) use these rams for mating. The model farmer continues to maintain the Bonga ram and can dispose it off after prescribed age. in Arbegona area, the rams were maintained by model farmers. Farmers in the community who are constituted for Bonga ram maintenance use Bonga ram for mating free charge and non-participant farmers have to pay a nominal charge of 3 ET Birr / service.

Data type and collection methods

This study is based on secondary data archived from performance and health data recorded in the ongoing CBBPs in Bonga, data collected by bureau of agriculture in the four districts where Bonga rams have been disseminated and survey. For the survey part, a total of 320 farmers (80 in each site) were selected randomly. Half of the farmers were involved in Bonga crossbreeding program while the remaining half use local animals.

Monitoring of lamb growth performances and mortality were carried between October 2016 and June 2017. For this purpose, a total of 382 pregnant ewes (n=177 mated by local sires and n=205 sired by Bonga sires) from 301 farmers (n=142 managing local with local mating and n=159 engaged in Bonga with local mating) were randomly selected (Table 2). All lambs born were separated from their dam and sire at birth and lambing details were recorded immediately after birth.

Table 2. Details of sampling of ewes for monitoring studies

Location	Local ewe x Local ram		Local ewe x Bonga ram		Total	
	#Ewes	#HH	#Ewes	#HH	#Ewes	#HH
Alicho Worero	39	34	50	31	89	65
Ezha	53	37	56	44	109	81
Damot Pulasa	37	37	42	41	79	78
Arbegona	48	34	57	43	105	77
Pooled	177	142	205	159	382	301

Notes: #Ewes means Number of ewes and #HH means Number of Household

During the monitoring, dam parity, genetic group of rams, date of birth, type of birth, sex of lamb, lamb birth and growth weights up to six months by using weighing balance (50kg) were recorded. Lamb mortality was also recorded using developed format and calculated using the formula of number of died lambs before and after weaning/total number of lambs born. Routine animal identification, data collection and recording were handled by trained development agents with close supervision. Reproductive data including, age at first lambing, lambing interval and age at first service, were collected using structured questionnaires during the survey from a total of 320 farmers (80 from each district ;40 Bonga ram users and 40 local ram users from each district).

Data analysis

The recorded growth performance and collected reproductive performance data were subjected to General Linear Model (GLM) procedures of the Statistical Analysis System (SAS) software (SAS Institute 2012). A fixed effect model was fitted. The Tukey–Kramer test was used to separate least squares means with more than two levels. The collected survey data through questionnaire were subjected to crosstabs of descriptive statistics using Statistical Package for Social Sciences (SPSS 2011 ver. 20). Chi square (X^2) test was used to test the significance differences of the variables

The statistical model for growth performance traits:

$Y_{hijklmno}=\mu + B_h + L_i + X_j + P_k + T_l + S_m + Z_n + e_{hijklmo}$,

Where;

$Y_{hijklmo}$ = Observed in the level h of genetic group, level I of location, level j of lamb sex, level k of dam parity, level l of birth type and level m of birth season = the overall mean;

B_h= Fixed effect of h^{th} genetic group (h =Local, Bonga x local crossbred);

L_i= Fixed effect of the i^{th} location (i= Alicho Worero, Ezha, Damot Pulasa, Arbegona)

X_j = Fixed effect of j^{th} sex (j= male, Female)

P_k = Fixed effect of k^{th} parity (k= 1…,6)

T_l= Fixed effect of l^{th} type of birth (l=Single, twin, triplet and quadruplet)

S_m= Fixed effect of m^{th} season (wet (March-September and dry (October-February) season)

$e_{hijklmo}$= Random error

The statistical model for reproductive performance traits:

$Yijkl = \mu + B_i + L_j + I_k + e_{ijkl}$,

Where;

Y_{ijkl} = Observed values of the sheep reproductive performance

μ = Overall population mean

B_i = Fixed effect of i^{th} genetic group (i =Local; Bonga cross).

L_j = Fixed effect of the j^{th} location (j= 1, …,4-- Alicho Worero, Ezha, Damot Pulasa, Arbegona)

I_k= Fixed effect of k^{th} interaction between location and genetic group (k = B_i, L_j)

e_{ijk}= Random error

Results and discussion

Growth performance

Birth weight:

The overall least squares mean of birth weight was 2.58 kg and the coefficient of variation (CV) was 19.61% in the present study. The effects of location, parity, type of birth, sex and genetic group were significant (p <0.01) on birth weight but season of birth had no effect (Table 3). The least squares mean of birth weight for Bonga sired crossbreds and local lambs were 2.93±0.2 and 2.37±0.2 kg, respectively which were significantly different (P<0.001). The current birth weight for Bonga crossbreds, was higher than that reported by Ermias (2014) for Dorper cross lambs in Wolayta and Silte (2.25kg), and Mekuriaw et al (2013) for Washera and Farta crossbreed lambs under farmer's management system (2.59kg). However, the current birth weight was lower than pure Bonga sheep breed (3.42 kg) reported by Haile et al (2014) in its home tract. The birth weight of the local sheep was comparable with the report (2.5kg) of Mekuriaw et al (2013) for Farta sheep.

The least squares mean of birth weight for the six parities were presented in Table 3. The pair wise comparisons showed that least mean squares of 1-6, 3-6 and 4-6 parities were significant (P<0.05). The highest birth weight was observed in 6th parity. This difference could be correlated to maturity age of the ewes. The same effects for Dorper cross lambs was reported by Deribe et al (2017) but non-significant effect of parity was observed in Horro and Menz sheep (Haile et al 2014).

The least square means of birth weight for single, twin, and multiple lambs were 2.77±0.1, 2.62±0.1 and 2.56±0.2, respectively. The difference between single and other birth types was significant (P<0.05). Similar results have been reported by Deribe et al (2017), Lakew et al (2014) and Berhanu and Aynalem (2009); whereas non-significant effect of type of birth on birth weight was reported by Ermias, (2014) in Dorper x Local sheep crosses.

Males were heavier (p<0.05) than females (2.71±0.2 vs 2.59±0.2 kg) Similar findings have been reported by Deribe et al (2017) and Haile et al (2014) for Dorper X local cross and Bonga sheep respectively. Contrary to our findings non-significant effect of sex of lamb on birth weight were reported by Ermias (2014) and Getahun (2008) for Adilo indigenous sheep type.

Three-month body weight:

The effects of location, genetic group (breed), season of birth, parity, type of birth and sex had significant on three-month body weight (Table 3). The least squares mean (LSM ± SE) of three-month body weight for Bonga sired crossbreds and local lambs were 11.4±0.6 and 8.31±0.6 kg, respectively. Bonga cross lambs were 3.1kg heavier (P<0.001) than local sheep in the study areas. The result obtained in the current study for Bonga cross was comparable with report of Mekuriaw et al (2013) who reported 11.17kg for Washera and Farta crosses. The results were, however, higher than that of Gizaw et al (2013) for 50% Awassi and Menz crosses (10.03kg) but were lower than 14.8kg for Pure Bonga on its own home tract (Haile et al 2014) and 12.42 for On-farm Awassi X Menz sheep crosses (Hassen 2004).

The three-month weight of lambs born during wet season was higher than those born in dry seasons and the difference was highly significant (P<0.001). This difference could be attributed to feed availability.

The effect of parity had showed a significant effect on three – month weight of lambs (Table 3). The pair wise comparisons showed that LSM of 1-6, 3-6 and 4-6 parities were significant differences (P <0.001).

The least squares mean of three-month body weight for single, twin, and multiple lambs were 11.4±0.3, 10.8±0.3 and 9.81±0.5, respectively. Single born lambs were heavier (P<0.001) than all the other type of births (multiple). The difference is that single born lambs always suckle without competition and their weight at birth is higher than those of multiple birth. Tibbo (2006), also reported that the variation comes from solely use of milk from their dam.

The current study revealed that three months' weight of Bonga cross lamb excelled local sheep under the same management practices of farmers.

Six-month body weight:

The effects of genetic group, type of birth and sex was highly significant (P<0.001) on six-month body weight, whereas the effects of location, season of birth and parity were non-significant (Table 3). The least squares mean of six-month body weight for Bonga sired crossbreds and local lambs were 17.4 ± 0.8 and 13 ± 0.8 kg, respectively.

The difference in the two genetic groups was highly significant (P <0.001) in which Bonga cross weighted heavier than local. The present result of six-month body weight for Bonga cross were heavier than the reports of Mekuriaw et al (2013) and Gizaw et al (2013) for Farta X Washera, and Awassi X Menz crosses, respectively. However, present results were lower than the reports of Haile et al (2014) and Mekuriaw et al (2013), for pure Bonga sheep in its own home tract and Dorper cross, respectively. The high growth performance for Bonga cross observed in the current study were in close agreement with reports of Lakew et al (2014) for Bonga X Menz crosses. Thus, Lambs obtained from Bongapsire show better and fast growth rate than lambs obtained from local sire. This is the reason why the farmers prefer Bonga rams as a breeding sire in the study areas.

Table 3. Least Squares Means of pre-weaning body weights (kg) and weight gain (g)

Effects	**Birth weight**		**3 Month weight**		**6 Month Body Weight**		**Pre-DAG**	**Post-DAG**
	N	**LSM ± SE**	**N**	**LSM±SE**	**N**	**LSM±SE**	**LSM±SE**	**LSM±SE**
Overall	532	2.58±0.5	473	10.7±1.9	190	15.66±3	87.99±18	76.62±15
R2		27.6		45.3		48.14	42.30	50.19
CV (%)		19.6		17.4		19.29	20.74	20.24
Location		0.010		0.001		0.061	<.0001	0.0001
Alicho Worero	124	2.62±0.2^{ab}	115	9.74±0.6^{b}	48	15.1±0.9	77.7±5.4^{b}	74.2±4.3^{b}
Ezha	170	2.66±0.2^{ab}	158	9.40±0.6^{b}	42	13.9±1	70.9±5.6^{c}	63.7±5.2^{b}
Damot Pulasa	105	2.49±0.2^{b}	84	10.5±0.6^{a}	29	16.4±0.8	88.7±5.6^{a}	85.3±4.1^{a}
Arbegona	133	2.74±0.2^{a}	116	9.81±0.6^{b}	71	15.3±0.9	76.6±5.7^{bc}	75.6±4.7^{ab}
Genetic group		<.0001		<.0001		<.0001	<.0001	<.0001
Bonga cross	304	2.93±0.2	260	11.4±0.6	95	17.4±0.8	92.2±5.4	86±4
Local	228	2.37±0.2	213	8.31±0.6	95	13±0.8	64.8±5.5	63.4±4
Season		0.222		0.0002		0.174	<.0001	0.850
Wet Season	255	2.62±0.2	247	10.2±0.6	151	15.7±0.7	82.7±5.4	74.4±3.8
Dry season	277	2.68±0.2	226	9.48±0.6	39	14.7±0.9	74.3±5.5	75±4.7
Parity		0.013		0.001		0.127	0.154	0.336
1	59	2.36±0.2^{b}	49	8.80±0.6^{b}	19	13.5±0.9	71.9±7.7	67.2±4.5
2	109	2.53±0.1^{ab}	100	9.68±0.5^{ab}	52	14.8±0.6	78.5±5.3	72.3±3
3	189	2.51±0.1^{b}	175	9.31±0.5^{b}	68	14.5±0.6	76.1±5.2	72.6±2.9
4	117	2.45±0.1^{b}	99	9.20±0.5^{b}	33	14.6±0.7	75.2±5.3	74.8±3.3
5	36	2.61±0.2^{ab}	31	9.72±0.6^{ab}	10	16.6±1.1	79.9±5.9	80.9±5.7
6	23	2.81±0.2^{a}	19	10.6±0.7^{a}	8	17.4±1.9	82.3±6.5	88±9.7
Type of Birth		0.008		0.0004		0.0001	0.001	0.003
1	220	2.77±0.1^{a}	192	11.4±0.3^{a}	78	17.1±0.7^{a}	93±2.8^{a}	83.3±3.7^{a}
2	290	2.62±0.1^{b}	263	10.8±0.3^{b}	106	15.2±0.6^{b}	88.2±2.6^{b}	76.4±3.2^{b}
3	22	2.56±0.2^{ab}	18	9.81±0.5^{b}	6	13.2±1.5^{b}	76.9±5.1^{c}	64.3±7.5^{b}
Sex		0.012		0.0012		0.009	0.003	0.027
Male	267	2.71±0.2	239	10.1±0.5	101	15.8±0.8	81±5.3	77.3±4.2
Female	265	2.59±0.2	234	9.57±0.6	89	14.6±0.8	75.9±5.5	72.1±4.1

Means in columns by treatments without common superscript are different at p<005; N= Number of observations

The effect of location, genetic group, season of birth, type of birth and sex on Pre-DAG were significant, whereas the effect of parity was found to be non-significant (Table 3). The least squares mean (LSM ± SE) of Pre-DAG for Bonga sired crossbreds and local lambs were 92.2±5.4 and 64.8±5.5 g/day, respectively and the difference was significant. The current findings of Pre-DAG for Bonga cross lambs in the study areas were comparable with results of Deribe et al (2017) and Mekuriaw et al (2013). However, daily average body weight gain of Bonga crosses was heavier by 27.4

g/day than local sheep at the same management system. The possible reason for this may be the heterotic effect of crossbreds.

The Pre-DAG of lambs born in wet season was 8.4 g/day more than lambs born in dry season and the difference was significant (*P*<0.001). The possible reason may be that during dry season there is paucity of forage. Similarly, male lambs gained 5.1g/day more than female lambs in this study and the difference was significant (*P*<0.001). The pre-weaning daily average gain of multiple born lambs was lower than single and twin type of births.

Post-weaning daily average gain (Post-WDAG)

The effect of location, genetic group, type of birth and sex were highly significant on Post-WDAG, whereas season of birth and parity didn't have effect on Post-WDAG (Table 3).

The least squares mean (LSM ± SE) of Post-WDAG for Bonga sired crossbreds and local lambs were 86 ± 4 and 63.4± 4 g/day, respectively. The present results of Post-DAG for Bonga crosses was higher than findings of Lakew et al (2014) for Dorper X local crosses and Haile et al (2014) for Bonga but lower than Deribe et al (2017) for Dorper x Local sheep in Areka area. The superior post weaning daily average body weight gain of Bonga crosses over local sheep attracts farmers in the study area to use Bonga rams as a breeding sire.

Reproductive performance

Age at first service (AFS)

The AFS for both sexes varied among breed, location and breed by location interaction and the differences were significant (Table 4). Shorter AFS (5.9±0.8 and 6.3±0.8 months for male and female, respectively) was reported for Bonga crosses than the local sheep (8.6±1.6 and 8.6±1.5 months for male and female, respectively). The present results of AFS for Bonga crossbred in both sexes was shorter than the reports of Zewdu (2008) for Bonga breed (7.51 and 9.3 months for males and females, respectively). The shorter AFS observed in crossbred lambs may possibly be due to the higher body weight in crossbreds compared to local sheep and heterotic effect. Different scholars agree that, genetic as well as environmental factors, and the interaction between these clearly affect sexual development, i.e. earlier attainment of puberty. Besides, Younis, et al (1978) reported that body weight has more influence on puberty than the age.

The pair wise comparison of means (Table 4) of locations showed that difference in AFS of all pairs was significant except Ezha and Damot Pulasa pairwise. The lowest AFS was observed in Arbegona whereas highest AFS was observed in Alicho Worero districts. The results showed that shortest AFS in both local and crossbred male lambs was observed in Arbegona district (7.8±1.3 and 5.6±0.8 months in local and Bonga ram crossbreds, respectively) whereas the shortest AFS in local and crossbred females was found among lambs of Damot Pulasa (7.8±1.2 months) and Arbegona (6.1±0.6 months), respectively. The location difference may be attributed to management practice of farmers in the respective areas.

Age at first lambing (AFL)

The current result of AFL was significant different among locations and breed by location interaction (Table 4). The results showed that Bonga crossbred ewes lambed at an earlier age (11.5±0.9 months) compared to local (13.9±1.6 months) ewes. The effect of genetic group was in agreement with report of Ermias (2014) for Dorper cross breed. The shorter AFL in crossbreds could possibly be explained heterosis effect. The possible reason for late AFL among local females compared to crossbred females could as well be due to the fast growth among crossbreds. The overall results of AFL for Bonga crosses indicated that lifetime lamb crop could be increased in all the study areas.

The AFL obtained in the present study (Table 4) revealed that, Bonga crosses had AFL shorter by 2.5 months than Local sheep. The pair-wise comparisons of location by genetic group (Breed) interactions showed that AFL of Bonga crossbred and local lambs were significant different (*P*<0.001) in all locations. The late AFL of local females at Alicho Worero (14.8±1.9 months) indicated that these ewes lambed at very old age. This AFL at Alicho Worero location was significantly different from all other values of AFL for the other three locations (Both for crossbred and local females). The AFL of crossbred females didn't differ at the four locations.

Table 4. Reproductive performance of sheep

Effects		AFS Male (Months)	AFS Female (Months)	AFL (Months)	LI (Months)	ALS (LSM±SE)
Overall		7.82±1.8	7.9±1.7	13.17±1.8	8.3±1.1	1.62±0.5
Genetic Group (Breed)		<.0001	<.0001	<.0001	0.001	<.0001
	Local	8.6±1.6	8.6±1.5	13.9±1.6	8.5±1.1	1.46±0.5
	Bonga Cross	5.9±0.8	6.3±0.8	11.5±0.9	7.5±0.7	1.75±0.3
Location		<.0001	<.0001	0.002	0.019	<.0001
	Alicho Worero	9.12±2.3^{a}	8.9±2.03 ^{a}	13.9±2.2 ^{a}	8.6±1.0 ^{a}	1.7±0.05^{a}
	Ezha	7.7±1.5^{b}	7.9±1.4 ^{b}	13.09±1.5^{b}	8.3±1.2 ^{b}	1.7±0.04^{a}
	Damot Pulasa	7.4±1.4^{b}	7.4±1.3^{c}	12.9±1.4 ^{b}	8.3±1.1 ^{b}	1.5±0.05^{b}
	Arbegona	6.8±1.4^{c}	7.5±1.6 ^{bc}	12.6±1.6 ^{c}	8±1.08 ^{c}	1.4±0.05^{c}
Location X Breed		<.0001	0.007	0.04	0.729	0.047
Alicho Worero	Local	10.3±1.5^{a}	9.8±1.6 ^{a}	14.8±1.9^{a}	8.9±0.9	1.7±0.06^{b}
	Bonga Cross	6.2±0.6^{c}	6.6±0.7^{c}	11.6±0.8^{c}	7.7±0.5	1.9±0.07^{a}
Ezha	Local	8.2±1.1^{b}	8.4±1.2^{b}	13.7±1.1^{b}	8.2±1.2	1.6±0.06^{b}
	Bonga Cross	6.2±1.1^{c}	6.5±1.1^{c}	11.5±1.2^{c}	NA	1.8±0.06^{ac}
Damot Pulasa	Local	8.0±1.2^{b}	7.8±1.2^{b}	13.4±1.4^{b}	8.3±1.1	1.4±0.08^{b}
	Bonga Cross	5.8±0.3^{d}	6.2±0.6^{c}	11.7±0.7^{c}	NA	1.7±0.06^{ac}
Arbegona	Local	7.8±1.3^{b}	8.5±1.3^{b}	13.5±1.3^{b}	8.5±0.9	1.2±0.07^{d}
	Bonga Cross	5.6±0.8^{d}	6.1±0.6^{c}	11.4±0.7^{c}	7.3±0.8	1.6±0.06^{c}

Means in the columns without common superscript are different at p<005

Lambing interval (LI)

The effect of breed and location on LI was highly significant (*P* <0.001). The LI was 7.5±0.7 and 8.5±1.1 months in the crossbred and local ewes, respectively (Table 4). The overall LI observed in the present study was comparable with the earlier reports of Getachew (2008), Edea (2008) and Marufa et al (2017) for Menz, Bonga and Abera sheep, respectively. The LI was found to be short (7.5±0.7 months) in crossbreds compared to local (8.5±1.1 months) in the present study. The shorter LI provided an opportunity to increase lifetime productivity of ewes by increasing the number of lamb crop.

Average litter size (ALS)

The results of ALS varied among breed, location and breed by location and the differences were significant (Table 4). The observed ALS was within the ALS reported for tropical sheep (Girma 2008) and was also in agreement with the report of Gutu *et al* (2014) for Bonga community-based breeding site.

Higher litter size (1.75±0.3) was reported by Bonga ram users compared to local ram users (1.46±0.5). The reports of current ALS for Bonga crosses was higher than that reported by Marufa *et al* (2017) and Edea (2008) for Abera and Bonga sheep. However, the present report for local sheep were lower than those reported by Marufa *et al* (2017) and Deribe (2009); but comparable with Getahun (2008) and Edea (2008). The significant location effect may be attributed to differences in the ewe management practices across locations (Mekuriaw *et al* 2013). On the other hand, data generated from monitoring study revealed that, the overall twining rate of Bonga crossbreds (51.7%) was much higher than local sheep (30.5%). Twining rate of Bonga crosses was higher than the report of Edea (2008) and lower than the report of Gutu *et al* (2014) for Bonga and Horro CBBPs, respectively. The triple births were recorded in all districts except Arbegona district. However, higher twining rate was observed in Ezha and Arbegona districts. High litter size is economically important trait to improve sheep flock productivity.

Survival rates of lambs

The results on mortality (pre-weaning and post-weaning) of lambs is presented in figure 2. The pre and post weaning mortality rate for Bonga cross lambs were 4.8 and 2.5 % at Alicho Worero, 2.1 and 0 % for Ezha, 1.1 and 1.1 % for Arbegona and 1.6 and 0 % for Damot Pulasa, respectively. The pre and post weaning mortality rate for local lambs at Alicho Worero (7.1 and 3.8%), Ezha (5.3 and 0), Arbegona (1.8 and 0) and Damot Pulasa (2.3 and 0) were recorded during monitoring study (Figure 2).

The results showed that, more mortality rate was observed in pre-weaning than post-weaning age. However, the monitoring data showed that, the pre and post weaning mortality rate of local lambs were higher than Bonga cross lambs in all study areas. The possible reason was that pre weaning body weight of Bonga cross lambs were significantly higher than local lambs and this possibly contributed to less mortality in crossbreds compared to local lambs. Berhanu and Aynalem (2011) reported that survival rate of lamb was significantly affected by birth weight. The low mortality rate observed might also be attributed to tolerance of the crossbred to some commonly occurring lamb diseases. The current findings of mortality rate were lower than 13.9% reported by Deribe (2009) for Adilo sheep and 20.9% reported by Belete (2009) in South west Ethiopia.

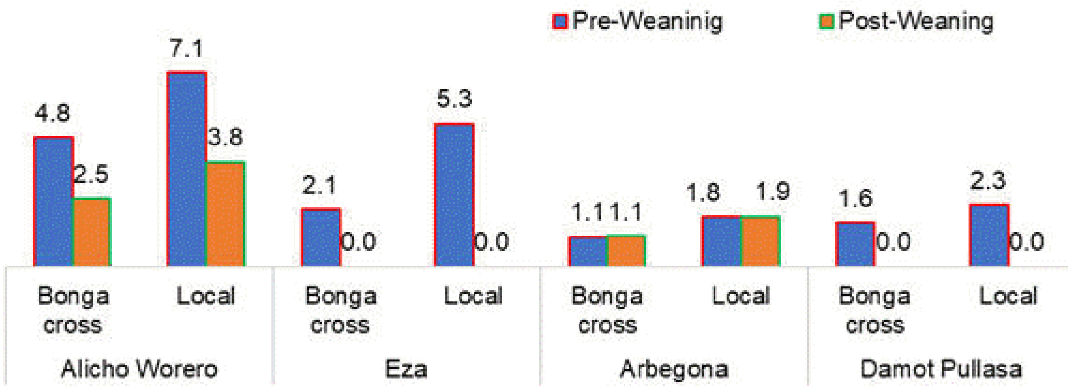

Figure 2. Pre and Post Weaning Mortality Rate

The weaning rate of Bonga crossbreed and local lambs is presented in Figure 3. The results showed that, the higher proportion of Bonga crossbreed lambs were weaned than local lambs. This indicated that post weaning rate of offspring obtained from crossing Bonga rams with local ewes is higher than locally weaned lambs. On other side, Bereket et al (2017) reported that Bonga rams and its crosses survive successfully in agro-ecology from 950 m.a.s.l. in Cheha district to 3000m.a.sl in Malga district of southern Ethiopia.

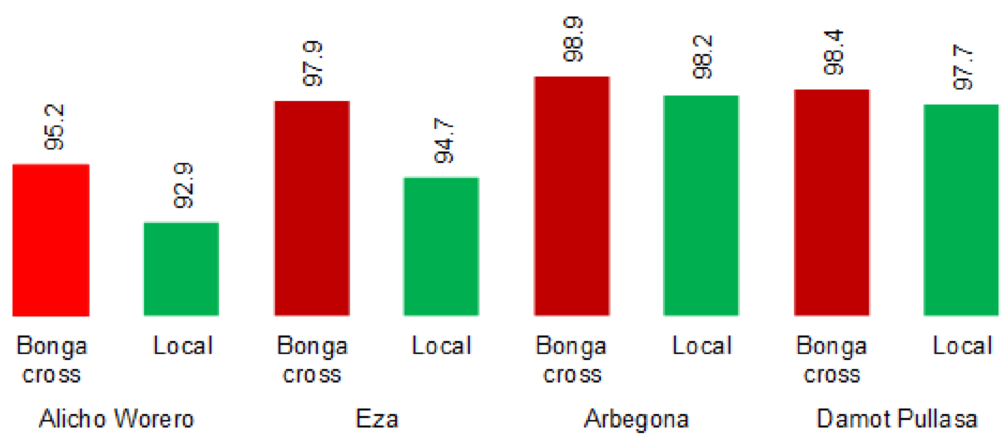

Figure 3. Weaning rates of lambs

Conclusions

- The results show that Bonga crossbred lambs were better for all growth and reproductive performance and survival than local lambs in all study areas under farmer's management condition.
- This shows that, crossbreeding local ewes with Bonga rams improved growth and reproductive performances as well as survival rates of lamb, hence increased flock productivity as compared to local lambs. In view of present results, it is suggested that use of improved Bonga sires, through CBBP, for crossing with local sheep in Southern Ethiopia could be an option.
- However, blanket recommendation should be avoided and suitability of Bonga breed in various parts of the country should be studied before any introduction is made. Additionally, given the relatively better performance

of Bonga as sire breed in crossbreeding, introduction of exotic breeds needs to be re-evaluated.

Competing interests

The authors declare that they have no competing interest.

Acknowledgments

The authors acknowledge the assistance received from the College of Agriculture and Veterinary Medicine in Jimma University, International Center for Agricultural Research in the Dry Areas (ICARDA), Southern Agricultural Research Institute (SARI) and district Livestock and Fishery Development Office. We are highly indebted to farmers whose animals were used for this study. The financial support of the ICARDA and SARI is also highly acknowledged.

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Received 16 June 2020; Accepted 26 July 2020; Published 1 September 2020