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Early growth and survival rates of crossbred lambs (*Dorper x indigenous*) under semi-intensive management at Areka, Southern Ethiopia: Effects of non-genetic factors

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Stagnant early growth and poor lamb survival are the major constraints of sheep production in Ethiopia. The aim of this study was to evaluate early growth and survival rate of crossbred lambs (Dorper × indigenous, *Adilo*) under semi-intensive conditions. Body weight (BW, kilograms) at 0-180 days, average daily gain (ADG, g/day), pre- (0-90), post (90-180) and overall (0-180 days), and pre-weaning survival rate (PSR) of crossbred (50%) lambs (n=305) were evaluated. The non-genetic factors (season, parity, sex of lambs, litter size) were also determined. The least squares means (±SE) of BW at birth, 30, 60, 90, 120, 150 and 180 days of age were 2.6± 0.63, 5.6± 0.12, 8.7± 0.18, 11.6±0.23, 15.0±0.46, 17.2± 0.31, and 18.4±0.26 kg, respectively. The crosses were higher by 11.9% and 9.3% at 90 and 150 days, respectively, than indigenous Adilo lambs. There was clearly evident effect of season on body weights at various ages, pre- and post-weaning and overall ADG. Parity influenced weight at 30, 60, and 90 days, and ADG (pre, post and overall). The litter size (1.68 ± 0.6) consistently affected BW at all ages, pre-weaning and overall ADG. Weight at birth, 30 and 90 days, and ADG from 30-60, 60-90 and 120-150 days were affected by parity-by-litter size interaction. The PSR rate (90.2%) was influenced by all non-genetic factors except sex. The improvement in litter size, body weight, and survival represents potentially significant economic advantage of crossbred over local sheep. Managing dam age through replacement ewes, and improving nutrition and litter size would improve lamb survival and growth that enhances total lamb output per ewe per year.

Key words: Growth rate, market weight, crossbred lamb, fixed factors.

INTRODUCTION

Small ruminant production is an integral part of mixed farming system of smallholder farmers in Southern Ethiopia. It plays a significant role in creating employment opportunities, income generation, capital reserve, and improving household nutrition (Kocho et al., 2011; Teklebrhan et al., 2014). Ethiopia's sheep population is estimated at 24 million heads categorized into 18 to 19 sheep breeds or populations (Gizaw et al., 2011).

Adilo sheep, named after routes to terminal market, is widely distributed in semi-arid to sub-humid areas of Central Southern Ethiopia. Generally, Adilo sheep is relatively productive than many other sheep populations or breeds of the region due to their higher prolific capacity (Deribe et al., 2014). In most parts of the country, the major objective of sheep rearing is for lamb production and is the main source of income for smallholder farmers (Kocho et al., 2011). As lamb marketing price depends mainly on the animal's body weight, improvements in lamb birth weight, pre-weaning and post-weaning growth rates are of interest (Gootwine et al., 2008). This could be achieved through optimization of growth (Deribe et al., 2014) and reproduction and survival traits (Gavojdian et al., 2013). To improve productivity of the indigenous breeds, Ethiopian Sheep and Goats Productivity Improvement Program (ESGPIP) imported tropically adapted sire breed (Dorper sheep). Dorper sheep breed is generally documented as one of the most popular mutton breeds in South Africa (Fourie et al., 2009). The Dorper rams can be used as terminal sire to produce lambs with high growth rates, better post-weaning feed efficiency, and superior carcass traits (Gavojdian et al., 2013). The advantage in growth and body composition of crossbred lambs over pure bred dam line lambs results from the additive contribution of the sire line and from the heterosis effect (Gootiwne et al., 2008). Evaluation of growth and survival performance of Dorper sheep and their crosses, under various and prevailing environment is essential before their wider use under smallholder management conditions. This study, therefore, was aimed at evaluating early growth performance and survival rate of crossbred (50%) lambs (Dorper ram × local, Adilo-ewes). It was hypothesized that non-genetic factors would not suppress growth and survival rate of crossbred lambs under semi-intensive management conditions.

MATERIALS AND METHODS

The study site

This study was conducted at Areka research sub-site, Boloso district of Southern Ethiopia, 309 km South of Addis Ababa. The area is situated at 7° 06'N latitude, 37° 47'E longitude, and altitude of 1772 m above sea level. It was characterized by semi-arid to sub-humid agro-ecological zones. The sub-site is a micro-environment suitable for production of diverse grass and legume species. Major cultivated grasses adapted in the area include *Chlorias gayana, Panicum maximum, Brachiaria brizantha* ('desho' grass) and *Pennisetum purpureum* while major legumes are *Medicago sativa, Vigna unguliguleta, Lablab purpureous* and *Sasbania sasban.*

Data collection

Four Pure Dorper rams were introduced to Adilo ewes flock in 2012, end of rainy season. 64 local Adilo ewes were categorized into 4 mating groups. The rams were 18 months old with a mean weight of 46 ± 3 kg. The rams were crossed with Adilo ewes (indigenous sheep) selected based on their reproductive traits, with initial body weight of 19.9 ± 2.30, reared under similar management conditions. The ewes were housed indoors during last trimester, early lactation period, and part of winter periods. Animals had *ad-libitum* access to a medium-quality *Rhodes* and *Brachiaria* hay, water, mineral and shade. Ewes were kept on a natural pasture with the average stocking rate of 6 to 8 heads ha^{-1}. During indoor housing, ewes received medium-quality Napier and Rhodes grass hays *ad libitum*, as well as 200 to 300 g concentrate per head, based on physiological status of ewes. Lambs were allowed to suckle their dams from birth until weaning (90 days). Supplementary concentrate feeds containing 120 g CP kg^{-1} DM on average was provided to all lambs. Within 24 h of parturition; date of birth, birth weight, litter size, sex of lamb and dam parity were recorded. All lambs were weighed at birth and then at weekly interval up to 180 days of age. Mortality of lambs at pre-weaning (birth until 90 days of age) was also recorded.

Data analysis

Data were subjected to the general linear model (GLM) procedure of SAS (SAS, 2008). In the analysis, all non-genetic factors were considered as fixed effects except the error term considered as random effect. Where F test declared significant, Tukey's test was used to compare least squared means (LSMs). The following linear model was employed to analyze the traits:

$$Y_{invmjo} = \mu + x_n + p_j + b_m + y_b + (px)\ jn + (pb)\ jm + \varepsilon_{njmbo}$$

where Y_{injmo} is the observation on production traits: birth, weight at various ages and average daily gain (ADG) (excludes birth weight category); pre-weaning survival rate (includes birth weight category):

μ = is the overall mean; x_n = is the fixed effect of n^{th} lamb sex (n=male, female); p_j = is the fixed effect of j^{th} ewe parity (j = 1, 2, 3, 4); b_m = is the fixed effect of m^{th} type of birth of lamb (m=1=single, 1=twin, 3=triple); y_b = the effect of m^{th} birth weight of lamb {b=1 (≤ 2 kg), 2(2 to 2.5 kg) and 3 (≥ 2.6 kg)}; $(px)_{jn}$ = the interaction effect of parity and sex on body weights and ADGs; $(pb)_{jm}$ = is interaction effect of parity and litter size on body weights and ADGs; ε_{njmbo} = effect of random error

RESULTS

Body weights at various ages

The non-genetic factors considered in this study were shown to affect body weights of crossbred lambs at birth and various ages (Table 1) and trends of weight changes (Figure 1). The least squares means and ±standard error

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Table 1. Least squares means ±SE analysis of variance for body weights (kilograms) from birth to 180 days of age of crossbred lambs (Dorper × indigenous) as affected by sex, parity and litter size in Areka.

Fixed effects	Body weight (kilograms) at various ages (days)						
	Birth weight	30 days	60 days	90 days	120 days	150 days	180 days
Overall	2.55 ± 0.63	5.57 ± 0.12	8.72 ± 0.18	11.6 ± 0.23	15.3 ± 0.46	17.2 ± 0.31	18.4 ± 0.26
Sex	*	NS	NS	NS	*	*	*
Male	2.62 ± 0.05[a]	5.56 ± 0.17	8.74 ± 0.26	11.79 ± 0.34	16.02 ± 0.89[a]	17.68 ± 0.42[a]	19.55 ± 0.39[a]
Female	2.48 ± 0.05[b]	5.57 ± 0.16	8.70 ± 0.24	11.55 ± 0.32	14.59 ± 0.34[b]	16.70 ± 0.36[b]	18.51 ± 0.35[b]
Parity	NS	***	***	**	NS	NS	NS
1	2.63 ± 0.06	5.37 ± 0.20[b]	9.08 ± 0.29[a]	12.00 ± 0.41[a]	16.10 ± 0.48	17.64 ± 0.49	19.15 ± 0.43
2	2.49 ± 0.07	6.30 ± 0.19[a]	9.34 ± 0.28[a]	11.63 ± 0.36[a]	15.34 ± 1.38	16.73 ± 0.44	18.84 ± 0.47
3	2.47 ± 0.10	5.02 ± 0.19[b]	7.58 ± 0.32[b]	10.14 ± 0.46[b]	13.14 ± 0.46	16.14 ± 0.46	18.75 ± 0.40
4	2.55 ± 0.08	4.75 ± 0.29[b]	6.88 ± 0.41[b]	11.69 ± 0.37[a]	14.30 ± 0.47	17.44 ± 0.41	-
Litter size	***	***	***	***	***	***	***
Single	2.93 ± 0.07[a]	6.51 ± 0.21[a]	10.34 ± 0.32[a]	13.79 ± 0.40[a]	18.47 ± 1.04[a]	19.61 ± 0.47[a]	21.04 ± 0.47[a]
Twin	2.36 ± 0.03[b]	5.07 ± 0.12[b]	7.65 ± 0.16[b]	10.24 ± 0.23[b]	13.27 ± 0.27[b]	15.58 ± 0.28[b]	17.68 ± 0.27[b]
Triplet	1.95 ± 0.02[c]	4.42 ± 0.49[c]	8.48 ± 0.91[b]	10.39 ± 0.81[b]	13.03 ± 0.65[b]	14.82 ± 1.21[b]	17.25 ± 1.09[b]
Parity×Sex	*	NS	NS	NS	NS	NS	NS
Parity×Litter size	***	**	NS	*	NS	NS	NS

Means with different letters (a, b) within a trait in a column are different at indicated P value: NS non-significant (*P*>0.05):*$P<0.05$; ** $P< 0.01$; ***$P<0.001$.

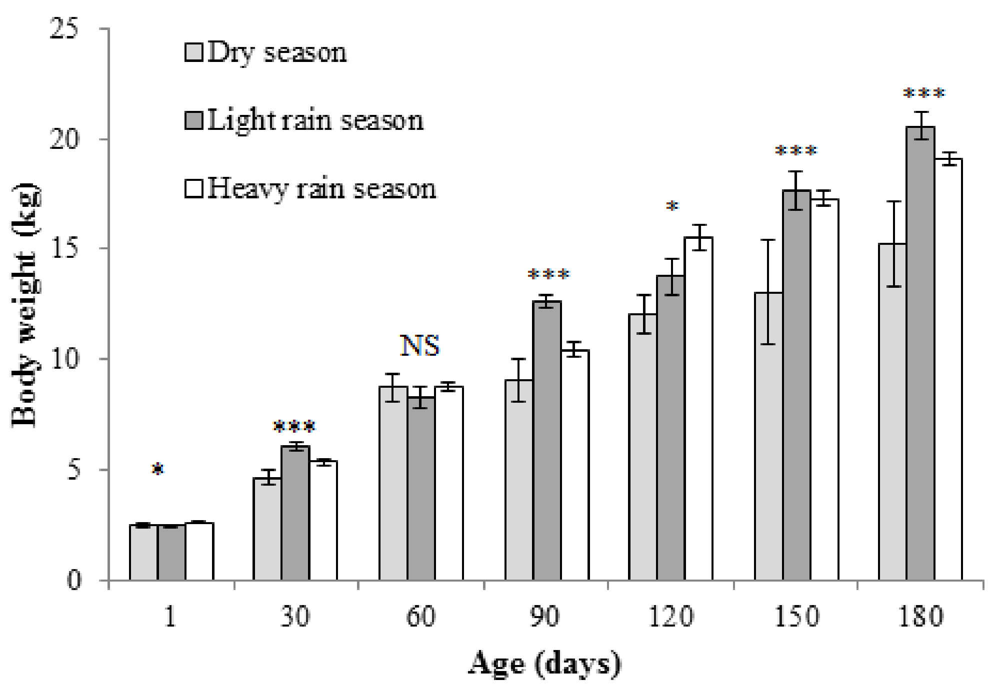

Figure 1. Body weight of crossbred lambs (Dorper x indigenous) from birth to 180 days of ages as affected by the season of birth in Areka. NS, non-significant (*P*>0.05); *$P<0.05$; **$P<0.01$; *** $P<0.001$.

(SE) for birth weight (kilograms) of lambs was 2.6±0.63 (ranges from 1.3 to 4.2), while for weights at 30, 60, 90, 120, 150 and 180 days of age were 5.6±0.12, 8.7±0.18, 11.6±0.23, 15.0±0.47, 17.2±0.31, and 18.4±0.26 kg, respectively (Table 1).

Season is one of the most important sources of

Table 2. Least squares means ± SE analysis of variance for average daily weight gain (grams) from birth to 30,30-60, 60-90, 90-120, 120-150, and 150-180 days of age of crossbred lambs (Dorper x indigenous Adilo) by season, sex, parity and litter size in Areka.

Fixed effects	**Average daily gain (g) at various ages (days)**					
	Birth to 30 days	**30-60 days**	**60-90 days**	**90-120 days**	**120-150 days**	**150-180 days**
Overall	101 ± 3.20	109 ± 3.45	98.6 ±3.08	122 ± 13.73	80.3 ± 4.53	76.4 ± 4.14
Season	NS	**	**	*	NS	*
Dry season	95.9 ±12.5	77.3 ± 11.35^{b}	119 ± 9.85^{a}	103 ± 9.82^{b}	85.1 ±18.7	117 ±17.2^{a}
Light rain season	95.6 ± 9.00	88.3 ± 6.74^{b}	98.5 ± 6.92^{b}	92.5 ± 7.71^{b}	89.1 ± 9.62	105 ± 29.4^{b}
Heavy rain season	102 ± 3.56	115 ± 3.93^{a}	96.7 ± 3.53^{b}	129 ± 17.0^{a}	78.5 ± 69.7	72.0 ± 3.79^{b}
Sex	NS	NS	**	*	NS	NS
Male	98.1 ± 4.52	109 ± 5.00	104 ± 4.45^{a}	142 ± 27.4^{a}	83.9 ± 6.33	82.9 ± 5.05
Female	104 ± 4.52	109 ± 4.81	92.9 ± 4.22^{b}	103 ± 4.11^{b}	76.6 ± 6.49	70.0 ± 6.53
Parity (age of dam)	***	***	***	NS	**	**
1	126 ± 5.39^{a}	139 ± 5.62^{a}	122 ± 4.41$_{a}$	135 ± 3.86	61.0 ± 6.14^{c}	65.8 ±4.26^{b}
2	94.5 ± 4.64^{b}	101 ± 4.76^{b}	69.7 ± 5.01^{c}	132 ± 47.8	90.5 ± 5.64^{b}	89.4 ± 8.80^{a}
3	85.2 ± 4.88^{c}	78.1 ± 4.05^{c}	82.4 ± 4.89^{b}	80.4 ± 5.35	94.4 ± 4.06^{b}	103 ± 14.19^{a}
4	70.2 ± 8.45^{c}	65.5 ± 7.52^{c}	107 ± 7.12^{a}	94.1 ± 6.53	123 ± 25.17^{a}	-
Litter size	***	***	***	*	NS	NS
Single	123 ± 6.00^{a}	142 ± 6.16^{a}	118 ± 5.13^{a}	162 ± 34.82^{a}	77.1 ± 5.59	64.5 ± 7.54
Twin	89.4 ± 3.46^{b}	87.1 ± 3.17^{b}	86.7 ± 3.59^{b}	97.5 ± 3.45^{b}	83.8 ± 6.79	84.6 ±4.77
Triplet	83.0 ± 14.1^{b}	127 ± 18.8^{a}	63.8 ± 10.40^{c}	89.2 ± 16.4^{b}	52.2 ± 18.51	81.1 ± 16.7
Parity×Sex	NS	NS	NS	NS	*	NS
Parity×Litter size	NS	**	*	NS	**	NS

Means with different letters (a, b) within a trait in a column are different at indicated P value: NS non-significant (*P*>0.05); **P*<0.05; ***P*<0.01; ****P*<0.001

variation on lamb birth weight and weight at various ages (Figure 1). Lambs born during the heavy rain season demonstrated higher birth weight (*P*<0.01) and 120 (*P*<0.001), and those born during the light and heavy rain seasons attained higher body weights at 30 (*P*<0.001), 90 (*P*< 0.001), 150 and 180 days (*P*<0.001) compared to the dry season.

Litter size (1.68 ± 0.6) influenced body weights of crossbred lambs at all ages consistently (Table 1). Single births showed consistently higher body weights over their twin and triplet counterparts. Likewise, twin births were higher compared to triplets at birth (*P*<0.001) and 30 days (*P*<0.001) while non-significant (*P*>0.05) in the remaining ages. There was significant effects of sex on body weights at birth (*P*<0.05), non-significant from 30 to 90 days (*P*>0.05) and the influence resumed after 90 days (weaning) (Table 1). Male lambs were superior over their female counterparts at birth, 120, 150 and 180 days.

Parity (dam age) due to differences in ewe weight influenced body weights of lambs at 30, 60 and 90 days (Table 1). Lambs born from the 2nd parity attained significantly higher (*P*<0.001) body weights at 30 days compared to those from the 1st, 3rd and 4th parities. Likewise, lambs from the 1st and 2nd parity demonstrated higher (*P*<0.001) 60 day weight compared to 3rd and 4th parities. Similarly, lambs from 3rd and 4th parities attained significantly lower body weights at 90 day (*P*<0.01) and 120 days (*P*<0.05), respectively. There was parity-by-litter size interactions on birth weight (*P*<0.001), 30 (*P*<0.01) and 90 days (*P*<0.05). Single births from 3rd and 4th parities exhibited higher weights over single births from the 1st and 2nd parities and multiple births from the 3rd and 4th parities.

Average daily gain

All fixed factors considered in this study were shown to influence average daily gain at some stages of lamb ages (Table 2). Pre-weaning, post weaning and overall ADG were affected all fixed factors except sex at pre-weaning and litter size at post weaning (Table 3). The least squares means and SE for ADG from birth to 30, 60, 90, 120, 150, and 180 days of age were 101±3.2, 109±3.5, 98.6±3.1, 122±13.7, 80.3±4.5, and 76.4±4.1 kg, respectively. The pre-weaning, post-weaning and overall ADG were 99.8±2.4, 85.9±2.0 and 96.1±1.5 g/day, respectively. Lambs born during the heavy rain season had higher ADG at 30-60 days (*P*<0.01) and 90-120 days (*P*<0.05) compared to the dry season (Table 2). Conversely, lambs born during the dry season had higher ADG at 60 to 90 (*P*<0.01) compared to the heavy rain season. Likewise, lambs born during the dry and light rain seasons grew faster (*P*<0.05) from 150 to 180 days than

Table 3. Lease squared means ± SE of pre-weaning, post-weaning and overall ADG of crossbred lambs (Dorper-Adilo) as affected by season, sex, parity and litter size in Areka.

Effects	Pre-weaning ADG	Post-weaning ADG	Overall ADG
Overall	99.8 ± 2.43	85.9 ± 1.98	96.1 ± 1.52
Season of birth	**	*	**
Dry season	87.3 ± 10.8[b]	110 ±20.1a	85.0 ± 5.17[b]
Light rain season	105 ± 5.43[a]	89.2 ± 5.18[a]	109 ± 3.65[a]
Heavy rain season	101 ± 2.67[a]	84.9 ± 2.10[b]	94.4 ± 1.69[a]
Sex	NS	**	**
Male	101 ± 3.44	95.0 ± 2.48[a]	98.2 ± 2.06[a]
Female	98.9 ± 3.43	76.8 ± 2.76[b]	94.1 ± 2.23[b]
Parity (age of dam)	***	*	**
1	105 ± 4.25[a]	82.1 ± 2.56[b]	91.9 ± 2.28[b]
2	101 ± 3.49[a]	88.9 ± 4.86[b]	91.5 ± 3.19[b]
3	78.8 ± 4.46[b]	96.9 ± 2.89[a]	109 ± 3.04[a]
4	97.4 ± 5.63[a]	-	98.8 ± 2.80[a]
Litter size	***	NS	**
Single	120 ± 4.29[a]	86.1 ± 3.87	104 ± 2.73[a]
Twin	86.7 ± 2.49[b]	86.1 ± 2.12	91.9 ± 1.75[ab]
Triplet	93.2 ± 8.59[b]	80.4 ± 7.80	84.4 ± 7.09[b]
Parity×Sex	NS	*	NS
Parity×Litter size	NS	NS	NS

Within main effect and trait, means followed by different letters are different at indicated P level; NS, non-significant (*P*>0.05); **P*<0.05;***P*<0.01.

those during the heavy rain season. The influence of season was also important on pre-weaning ADG (*P*<0.01), post-weaning ADG (*P*<0.05) and overall ADG (*P*<0.01). Litter size demonstrated variation on ADG at early ages of lambs: birth to 30, 30-60, 60-90 and 90-120 days (Table 2), pre-weaning, post weaning and overall ADG (Table 3). Single births were consistently heavier over their twin and triplet contemporaries from birth to 30 (*P*<0.001), 60-90 (*P*<0.001) and 90-120 days (*P*<0.05). Similarly, single and triple births grew faster (*P*<0.001) than twin from 30-60 days. Single births showed faster (*P*<0.001) pre-weaning ADG in comparison to twin and triplets, while single and twin births had heavier (*P*<0.01) overall ADG compared to triplets. Litter size by parity showed significances from 30-60 (*P*<0.01), 60-90 (*P*<0.05) and 120-150 days (*P*<0.01). Single births from 1st and 2nd parity were heavier over single birth of 3rd parity and twin and triplets of other combinations (data not presented). Single births showed faster pre-weaning growth (*P*<0.001) and overall ADG (*P*<0.01) over triplets. Triplet births from the 1st parity were found to be the least (1.91±0.11 kg) in birth weight compared with other combinations.

Except 30-60 (*P*<0.01), 60-90 (*P*<0.01) and 90-120 days (*P*<0.05), where male lambs were superior over their female contemporaries, sex effect was not significant (*P*>0.05) (Table 2). Sex effect was significant on post-weaning and overall ADG (Table 3). Highly significant, but variable, effect of parity was observed on ADG of lambs (Table 2). It was significant on ADG at all ages except from 90-120 days. Lambs born from the 1st parity demonstrated faster ADG compared to the higher parities at birth to 30 and 30-60 days (*P*<0.001). Similarly, lambs born from dams of 2nd parity grew faster (*P*<0.001) compared to the 4th parity from 0-30 and 30-60 days. The higher ADG of lambs from the 1st parity at early ages was reversed from 120-150 and 150-180 days. At 60-90 days, lambs from 1st and 4th parity were heavier (*P*<0.001) over 2nd and 3rd parities.

Lambs born from the 4th parity from 120-150 days and 2nd and 3rd parities from 150-180 days were heavier (*P*<0.01) over those born from the lower parities (Table 3). The pre and post weaning, and overall ADG were consistently and significantly affected by parity. Parity by sex interaction showed a marginal difference (*P*<0.05) at birth while non-significant (*P*>0.05) in the remaining ages while it was significant on ADG from 120-150 days (*P*<0.05) and post weaning ADG (*P*<0.05). Male lambs from 1st and 2nd parities where superior over males from 3rd and 4th parities and female lambs from other combinations (data not presented). Similarly parity by type of birth was significant on body weights at birth (*P*<0.001), 30 (*P*<0.01) and 90 days (*P*<0.05) while it was significant on ADG from 30-60 (*P*<0.01), 60-90 (*P*<0.05) and 120-150 days (*P*<0.01). Single births from 2nd parity were higher over single births of other parties and twin

Table 4. Maximum-likelihood analysis of variance of pre-weaning survival rate of crossbred lambs (Dorper x indigenous) in Areka.

Fixed effects	df	Chi-square	P-value
Season of birth	2	8.56*	0.036
Sex	1	1.44NS	0.223
Litter size	1	8.44**	0.012
Birth weight category	2	7.83*	0.020
Parity (age of dam)	4	10.45**	0.01

Table 5. Pre-weaning survival rate of crossbred lambs (Dorper x indigenous) as influenced by fixed factors and birth weight category in Areka.

Fixed effects	Total births	Pre-weaning survival		Died (%)
	Number	Number	Percent	Number
Overall births	305	275	90.2	30
Season of birth				
Dry	38	35	92.1	3
Light rain	31	25	80.6	6
Heavy rain	236	215	97.9	21
Sex				
Male	156	139	89.1	17
Female	149	136	91.3	13
Parity (age of dam)				
1	135	122	90.4	13
2	99	89	89.9	10
3	32	28	87.5	4
4	40	37	92.5	3
Litter size				
Single	112	108	96.4	4
Twin	181	165	91.2	16
Multiple	12	10	83.3	2
Birth weight category				
1 (<2 kg)	37	26	70.7	11
2 (2-2.5 kg)	137	125	91.2	12
3 (>2.5 kg)	131	128	97.7	3

Pre-weaning survival rate

Maximum likelihood analysis of variance of pre-weaning survival rate of crossbred lambs is indicated in Table 4. Effects of season, sex, litter size, parity and birth weight category on pre-weaning survival rate is shown in Table 5. The average pre-weaning survival rate of the crossbred lambs was 90.2%, excluding stillbirths and abortions. Sex ($P > 0.05$) did not affect pre-weaning survival rate while litter size ($P < 0.01$), influenced pre-survival rate of lambs (Table 4). The survival rate of lambs born during the dry and heavy rainy seasons is higher by 11.5 and 17.3%, respectively, compared with the light rain season. Lambs from 1st and 2nd parities had higher survival rate compared with 3rd and 4th parities. With average birth weight of 1.95 kg, the mortality rate of triplet births reached to16.7%, and was significantly ($P < 0.05$) higher at lower birth weight category. The maximum survival rate (98%) was found from lambs with >2.5 kg (2.6 to 4.2) of live weight at birth and triplets births of all other combinations.

DISCUSSION

Effect of season of birth

The influence of season of birth on birth weight, weight at various ages and ADG has been well documented at station (Gootwine et al., 2008; Teklebrhan et al., 2014) and under smallholder management systems (Hassen et al., 2002; Deribe et al., 2014). Generally, higher birth weight and subsequent weights found in our study, during the heavy rainy season, concurs with the previous reports (Taye et al., 2010; Teklebrhan et al., 2014). Except pre-weaning growth rate, there was a general faster post-weaning and overall ADG during the light and heavy rain season mainly due to feed availability both in quality and quantity. However, there were no clear cut trends of season on body weights and ADG's. This could be associated with seasonal nutrient fluctuations (Legesse, 2008) and feed selection behaviour of sheep (Deribe et al., 2014). The reported higher body weights and ADG of lambs during the heavy rain and part of light rain seasons is consistent with other reports (Teklebrhan et al., 2014). On the other hand, the higher body weight and faster pre-weaning gain during early dry season at some ages is partly due to better body reserves of dams at the end of heavy rain season, and the associated higher milk yield. It has been noted that during early dry season lambs born with higher weight and usually grew faster due to feed flushing of the dams during the heavy rain season (Deribe et al., 2014). The fluctuation of lamb weight (gain and loss) within and across seasons is a commonly reported event, and is attributed to heat stress during the dry season and disease and parasite infestation during the light and heavy rain seasons. Yilmaz et al. (2007) noted seasonal differences on weight of lambs due to differences in ambient temperature and maternal pre-natal effects during gestation. According to Hassen et al. (2002) and Gbangboche et al. (2006), effects of heat stress affects feed intake, and consequently body weights among indigenous lambs in sub-humid ecological zones. On the other hand, quality of feed and variations in feed composition as well as milk yield of dams are factors that have frequently been reported to influence lamb weight during early growth period (Legesse, 2008; Yilmaz et al., 2007; Deribe et al., 2014).

Effect of litter size

Litter size consistently affected lamb growth in our study due to the higher prolific capacity of the sire (Gavojdian et al., 2013) as well as dam breeds (Deribe et al., 2014). The higher litter size or percentage of multiple births, twins (59.3%) and triplets (3.9%) may have resulted in lower body weights of individual lambs at birth but have improved the overall lamb outputs. That could be a reason for decreased body weights and ADG as litter size increased. The overall ADG (0 to 180 days of age) and lamb output found in our study is comparable with previous reports of crossbred lambs under similar management condition (Teklebrhan et al., 2014). Generally, single births attained higher body weights (0 to 180 days) and ADG (pre, post and overall) than twin and triplets. At the same time, single births from 1st and 2nd parities were higher by 20.2 to 62.3% compared with single births of the 4th parity and twin and triplet births from other parity-by-birth combinations. The higher body weights and overall ADG of single births is due to the fact that they were the sole consumers of their dam's milk while twins and triplets compete for limited milk of their dams (Tibbo, 2006; Taye et al., 2010; Deribe et al., 2014).

Effect of parity (dam age)

Differences in parity due to ewe age affected body weights of lambs mainly at early ages, pre-weaning, post weaning and Overall ADG. Generally higher parities (3rd and 4th) attained higher body weights and faster overall ADG compared with lower (1st and 2nd) parities. This results are consistent with reports of Teklebrhan et al. (2013) who have shown profound effect of parity on body weights of crossbred lambs (Dorper × Somali) in Eastern Ethiopia. The higher body weights and ADG (0 to 90 days) obtained from the lower parities, however, is that most ewes at lower parities gave birth of single lambs. Single births had advantage over their twin or triplet counterparts because they are the sole users of milk of their dams (Tibbo, 2006). This suggests that the individual weight of multiple births was lower compared to single although the total lamb output is higher from the prolific dams at higher parties. Dams from 3rd and 4th parities gave birth of large number of multiple births, which compete for limited milk of their dams, and it could be a possible reason for the reported lower body weights of lambs at some ages from 3rd and 4th parities.

Sex effects

The effect of sex on body weights has been variable. Majority of the findings indicated that male lambs had usually higher weight at birth and grew faster than females (Gardner et al., 2007; Deribe et al., 2014), while few have shown that there is less general effect of sex on body weights (Legesse, 2008). The higher weight and faster growth of male over female might be explained by the favour of sexual precocity articulated on body growth. This sexual dimorphism favours body growth in males than females. Hormonal differences between sexes and their resultant effects on growth may also be implicated. The difference in sex hormones, sexual dimorphism, affects feed intake, growth rate and feed efficiency (Mabrouk et al., 2010). In our study the general trend of sex variation was evident at later ages of lambs, which agrees with the findings of Hassen et al. (2002) who reported the importance of sex as lambs get older in the cool highlands of Ethiopia.

Survival up to weaning

In a smallholder farming system, where lambs are produced and kept for income generation, lamb survival is an important economic trait, influences overall productivity of a farm (Tibbo, 2006; Deribe et al., 2014). Except sex, all the fixed factors contributed to the survival or death of lambs. The survival rate obtained in our study concurs with previous reports under similar management condition (Gavojdian et al., 2013). This is due to the adaptive capacity of Dorper sheep under multi-environments (Brien et al., 2014; Teklebrhan et al., 2014). The higher survival rate observed during the rainy compared to the dry season may be due to feed availability. The higher deaths recorded during the light rainy season could mainly be attributed to disease and parasite infestations (Teklebrhan et al., 2014) who noted higher disease and parasite infestation in small rainy season. With average birth weight of 1.95 kg, the mortality rate of triplet births reached to16.7%, and was higher at lower birth weight category. The maximum survival rate (98%) was found from lambs with >2.5 kg (2.6 to 4.2) of live weight at birth. This higher survival rate among higher birth weights categories (2.6 to 4.2 kg) obtained in our study is consistent with previous reports (Taye et al., 2010; Teklebrhan et al., 2014). The crossbred lambs were heavier by 1.24 (11.9%) and 1.46 kg (9.3%) at 90 and 150 days, respectively, compared with indigenous Adilo lambs, which could partly be a reason for the higher survival rate. This agrees with reports of Teklebrhan et al. (2014) who found heavier lamb weights at 90 and 150 days of age from crossbred lambs (Dorper × Somali) in eastern Ethiopia. With the higher number of multiple births (63.2%), the overall survival rate attained in our study, is reasonably higher than other crossbred programs in the country under similar management conditions.

The results of this study indicated that the crossbred lambs (Dorper rams × Adilo ewes) performed well at Areka semi-intensive management conditions, and proved to be adaptable under this semi-arid environment. The non-genetic factors, particularly season, parity and litter size, were shown to influence body weight and daily gain considerably and need to be considered in the improvement plan. Higher prolific potential of the sire and dam breeds contributed to larger number of lamb crops, warrants improved husbandry practices under farmer's management condition. This may help smallholder farmers exploit the prolificacy advantage of the crossbred lambs by improving growth rate and lamb survival, and thus enhance total lamb output per ewe per year.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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