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NON-GENETIC FACTORS INFLUENCING REPRODUCTIVE TRAITS AND PRE-WEANING MORTALITY OF LAMBS AND KIDS UNDER SMALLHOLDER MANAGEMENT, SOUTHERN ETHIOPIA

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ABSTRACT

This study was conducted to evaluate effects of non-genetic factors on litter size, age at first parturition (AFP), parturition interval (PI), seasonality of parturition, and pre-weaning mortality rate of sheep and goats flock with 587 kids and 467 lambs owned by 60 households. The litter size, AFP and PI (months) of lambs were 1.52±0.04, 12.43±0.1, 9.19±0.08, respectively, while the corresponding values were 1.47±0.04, 11.95±0.13 and 9.05±0.08 for kids. The average pre-weaning mortality rate was 14.84 and 12.59% for lambs and kids, respectively. Ewes of parity three had ($p < 0.05$) higher litter size than parity one. Does having parity four and five had ($p < 0.05$) higher litter size than parity three while does and ewes having parity three had ($p < 0.05$) higher litter size than parity one. Site and season influenced litter size ($p < 0.5$) and pre-weaning mortality of ($p < 0.01$) lambs and kids. Birth weight ($p < 0.05$) and parity influenced ($p < 0.01$) pre-weaning kid mortality. To exploit reproductive potential of dams and enhance rural income from small ruminants, improved management measures have to be warranted.

Key words: Litter size, Kids, Lambs, Non-genetic factors, Parturition, Southern Ethiopia

INTRODUCTION

Ethiopia is endowed with huge sheep and goats resources, with more than 40 million heads, of which 99% is indigenous breeds or populations (Tibbo, 2006). Generally, indigenous sheep and goats are resistant to diseases and parasites, survive to droughts and low and fluctuating feed availability. However, mortality due to extreme drought, poor nutrition, and healthcare, is a major constraint for low productivity of sheep and goats (Tibbo, 2006).

Studies indicated that non-genetic factors are largely expected to contribute to kid and/ or lamb mortality (Vostry and Milerski, 2013) and affect production potential (Gbangboche *et al*., 2006). Knowledge of the non-genetic factors on production traits allows a more accurate assessment of breeding values (Momoh *et al*., 2013). To this end, identifying and targeting the specific causes and the underlying factors of mortality at on-farm is essential (Tibbo, 2006). However, information is lacking in this regard, particularly in the southern part of the country (Tsedeke *et al*., 2011). Hence, this study was conducted to determine influences of non-genetic factors on reproductive traits and pre-weaning mortality rate of sheep and goats of Halaba district under farmer's management conditions.

MATERIALS AND METHODS

Descriptions of the study area: Halaba district is situated in South Nation, Nationalities and Peoples Region (SNNPR), 310 kilo meters south of Addis Ababa. The district is located in 7^{o} 17' N latitude and 38^{o} 06' E longitude. Altitude of the district ranges from 1554 to 2149 meters above sea level (m a.s.l), classified as arid to semi-arid zones. The annual rainfall varies between 857 to 1085mm and in a bimodal pattern with light rains between March and June and main rains from July to October. There are three distinct seasons: dry (November, December, January and February), light (March, April, May and June) and heavy rain seasons (July, August, September, and October). The annual mean temperature varies from 17^{o} C to 20^{o} C with a mean of 18^{o} C. Halaba is the district with mixed farming practices and the major crops grown include maize, sorghum, teff (*teff eragrostis*), finger millet (*Eleusine coracana*), wheat, hot pepper, chata (*chat edulis*) and haricot bean.

Breed descriptions and flock management: Halaba goat is categorized under the Arsi-Bale breed (Tesfaye, 2004). The Arsi-Bale goat is a relatively tall goat with a predominantly straight facial profile (98%). Males have curved (47%) and straight (41%) horns mainly pointing backwards (58%) with some pointed straight upward (28%). The dominant coat colors are white, black and brown. Sheep of Halaba categorized under the Adilo types (Gizaw *et al.*, 2011). It is characterized by long fat tail reaching the hocks, broad at the base and upper third with long tapering end; predominantly brown (43%), brown with white patches (32%), black (16%), and black with brown patch (9%).

Farmers manage their flocks in communal lands when the flock size is large. In small flock size, tethered feeding is a common management practice during cropping season, with uncontrolled year-round breeding system. Rams/bucks run with flock to mate with any ewe/doe in heat during the day. Young kids/lambs and does/ewes at late pregnancy are kept around home while the owner treks over other flock to long distances as water points are located far apart, particularly during dry season.

Source and management of data: A multistage stratified sampling technique was employed to select sheep and goat holders, based on the size of land holding and sheep density and distribution. In addition having at least three female sheep or goat per household was the criteria for household selection. A total of 60 households were selected; from which 30, 15, and 15 households were selected from sheep dominant site (SDS), mixed flock site (MFS) and goat dominant site (GDS), respectively. Site grouping criteria have been described by Tsedeke *et al.* (2011). In addition, the SDS is teff-haricot bean-based system, with a very small land size, and tethered grazing; GDS is wheat-based farming system, big land and flock size, group herding, better feed availability, and higher proportion of goat in the flocks while MFS is a hotpepper-maize based farming system, medium land size, tethered and free roaming, were the major grouping criteria. Parameters (traits) were recorded in framed data sheets. Within 24 hours of parturition; date of birth, birth weight, type of birth, sex of lamb and dam parity were recorded. Lambs/**kids** remained with their dams until weaning which occurred at about 90 days. All lambs were weighed at birth then fifteen day intervals up to 3 months and monthly interval up to 12 months of age. We monitored a total of 467 lambs and 587 kids. All the weight measurements were recorded to the nearest 0.1 kg. Pre-weaning mortality rate (%) was calculated from number of deaths to total births until 90 days.

Data were analyzed using the Statistical Analysis System (SAS, 2009) and the differences in means by Tukey's test. Sub-class proportions were calculated and their standard errors were estimated. Mortality rate was defined as 0 if the animals were dead and as 1 otherwise, by fitting fixed effects of flock density, season of birth, sex, litter size and parity. The associations between effects of non-genetic factors on mortality rate were analyzed using cross tabulation of SPSS (2006) version 17.

The model was $Yijklmno = \mu + FDi + Sj + Lk + Pl + BWm + Tn + eijklmn$

$Yijklmn$= is the observation on litter size (excludes birth weight category), AFP and PI (flock density and season effect only), the individual mortality rate:

μ =overall mean

FDi= the effect of i^{th} flock density sites (i = SDS, GDS, MFS)

Sj= the effect of j^{th} sex of kid/lamb (j = male, female)

L_k= the effect of k^{th} litter size (k=, 1=single, >=2=multiple)

Pl= the effect of l^{th} season of birth (l=Dry, light rain, heavy rain)

BW_m =the effect of m^{th} birth weight of kid/lamb {m=1 ($\leq$2 kg), 2(2-2.5kg) and 3 ($\geq$2.6kg)}

T_n the effect of n^{th} parity (n=1, 2, 3, 4, $\geq$5) and $eijklmn$= is the residual error.

RESULTS AND DISCUSSION

Effects of litter size /prolificacy/: The mean litter sizes for lambs and kids were 1.51$\pm$0.04 and 1.47$\pm$0.04, respectively (Table 1). The percentage of single and twin born were 53.3% and 46.7% in sheep flocks while in goat flock the values for single, twins and triplets were 48.4% singles, 49.7 % twin and 1.9%, respectively.

Table 1 LSM ($\pm$SEM) total litter size as affected by site, parity and season (N=60 households) of sheep and goats in Halaba district

Fixed effects	Total litter size at birth					
	Sheep			Goats		
	n	LSM	SEM	n	LSM	SEM
Overall	155	1.52	0.04	135	1.47	0.04
Site		*			NS	
SDS	114	1.47^b	0.05	31	1.48	0.09
GDS	20	1.70^a	0.11	64	1.48	0.06
MFS	21	1.57^b	0.11	40	1.40	0.08
Parity		*			***	
1	29	1.31^b	0.09	26	1.15^c	0.07
2	33	1.55^{ab}	0.09	27	1.26^{bc}	0.09
3	45	1.62^a	0.07	26	1.42^b	0.10
4	30	1.50^{ab}	0.09	39	1.69^a	0.07
$\geq$5	18	1.56^{ab}	0.12	17	1.82^a	0.10
Season		NS			*	
Dry season	45	1.42	0.07	18	1.39^b	0.12
Light rain season	49	1.51	0.07	49	1.57^a	0.07
Heavy rain season	61	1.59	0.06	68	1.41^b	0.06

Means with different letters (a-c) within a trait in a column are different, NS- non-significant, * P <0.05), *** (P <0.0001), N=number of household heads, n= number of observations, LSM=least squares mean, SEM=standard error for mean

There were variations in resource endowment among the flock density groups in the study locations. The GDS had higher (p <0.05) litter size compared with SDS and MFS. Feed availability due to larger landholding and feed flushing before mating might have contributed for the higher litter size at the GDS. The results concur with other reports in Ethiopia (Mukasa *et al*., 2002; Taye *et al*., 2011) and elsewhere in Africa (Mukasa *et al*., 2002) that nutrition governs the shed of either single or multiple ova and the probability of being single or multiple.

Parity (age of dam) is one of the sources of variation for litter size (Table 1). Ewes of parity one had lower (p <0.5) litter size than parity three while does at parity four and five and above had (p <0.05) higher litter size than parity three and the lower parties. Does having parity three had (p <0.05) higher litter size than parity one. These results are consistent with those of Hailu *et al.* (2006) and Vostrey and Milerski (2013), who reported higher litter sizes from the higher parities. However, after fifth parity, litter size tended to decline. Our study also confirms results of Mukasa *et al.* (2002) who has shown maximum productivity of ewes in the third parity. Litter size increases as parity advances, as a matter of fact that ewes and does physiologically mature with age (Taye *et al*. 2011). According to Vostrey and Milerski (2013), with an increasing number of lambs per litter, the probability of survival decreases. Higher (p <0.05) litter size was obtained in goat flocks during light rain season. Under Halaba arid and semi-arid condition, ewes giving birth during light rain season are not advantageous, as all lands put under cultivation and feed shortage is a serious problem.

Flock density and season on age at first parturition (AFP) and parturition interval (PI): The AFP on both species and the PI in goat flock were affected by the density group (Table 2). The SDS had earlier AFP (p <0.05). The GDS possessed earlier AFP (p <0.01) and shorter PI (p <0.001) compared to SDS and MFS. Similarly, ewe lambs growing during dry season reaches AFP faster (p <0.05) than those growing during light and heavy rain seasons while doe kids growing at heavy rain season had shorter PI (p <0.01) compared to dry and light rain seasons. The results concur with studies on Menz, Washara, and Djallonke sheep (Mukasa *et al*., 2002; Gbangboche *et al*., 2006; Taye *et al*., 2011) and for Adilo and Kaffa goats (Gizew *et al*., 2011). Gbangboche *et al.* (2006) has shown lambing interval of 242.62 days for Djallonke sheep, which is shorter than the current results.

Table 2 LSM (±SEM) of AFP and PI as affected by flock density group and season of birth of lambs and kids (NHHs =60 households) in Halaba district.

Fixed effects	Age at 1st parturition (AFP)		Parturition interval (PI)	
	Sheep	Goats	Sheep	Goats
	LSM (±SEM)	LSM (±SEM)	LSM (±SEM)	LSM (±SEM)
Overall	12.43(±0.10)	11.95(±0.13)	9.19(±0.08)	9.05(±0.08)
Flock density	*	**	Ns	***
SDS	11.66(±0.10) [b]	12.01(±0.06)[a]	9.10±0.1	12.01(±0.12)[a]
GDS	13.22(± 0.20) [a]	11.13(±0.12)[b]	9.86±0.12	8.88(±0.04)[c]
MFS	12.41(±0.10)[b]	12.74(±0.06)[a]	8.58±0.20	10.45(±0.07)[b]
Season	**	Ns	**	**
Dry	10.29(± 0.20)[b]	11.24(±0.08)	9.4 1(±0.10)[a]	9.60(±0.08)[a]
Light	13.86(±0.15) [a]	12.36(±0.01)	9.67(±0.10)[a]	9.22(±0.07)[a]
Heavy	13.10(±0.15) [a]	12.42(±0.03)	8.47(±0.20)[b]	8.32(±0.12)[b]

Means with different letters (a-c) within a trait in a column are different, ns, non-significant, * P < 0.05, ** P < 0.01, LSM=least squares mean, SEM=standard error for mean, NHHs=number of household heads.

However, the PI of the current study is in the lower range (7.67-14.57) of reports for African sheep and goats (Tibbo, 2006). The faster AFP in dry season and shorter PI during heavy rain season are partly due to the availability of crop residues, feed aftermaths and free wondering for feed selection and mating.

Seasonality of parturition /lambing and kidding/: Lambing and kidding events occurred throughout the year. Higher parturitions, 56.7% for kid and 37.9% for lamb crops, were obtained within four months period (March to June). The apparent peaks were observed during the light rain season, May being the highest. Chi-square analysis showed that there was non-significant difference (p >0.01) in the proportion of lambing whereas significant differences (p <0.01) on proportion of kidding, revealing less general seasonal effect on lambing than kidding. Significantly higher (p <0.01) kidding occurred (40%) during the light rain season (March to June), compared to the dry season. Ewes and does that gave birth in April to June must have conceived during the months of November to January, after crop harvest. During this period, they probably had enough feeds from grain leftovers in the field, grasses and weeds at farm boundary and tree and shrub browse leaves.

This is in agreement with reports of Mukasa *et al.* (2002) who have shown higher mating and conceptions during crop harvesting and flock free roaming period (November to February) in traditional farming system of Ethiopia. For the lambing and kidding to occur between May and June, most conceptions had to occur during the immediate post-rains and early dry periods, when feed is abundantly available. This is in agreement with Hailu *et al.* (2006) and Vostrey and Milerski (2013) who have shown the role of feed flushing on breeding activity in the tropics and subtropics.

Fixed factors and birth weight on pre-weaning mortality: Maximum-likelihood analysis of variance of pre-weaning mortality rate for Halaba sheep and goats is summarized in Table 3 and pre-weaning mortality rate by fixed factors and birth weight category is presented in Table 4. Pre-weaning mortality rate averaged 14.84% and 12.59% for sheep and goats, respectively, excluding stillbirths and abortions. The findings of this study concurs with Birhanu *et al*. (2006), who reported the mortality rate of 15% under uncontrolled breeding conditions, for Menz sheep in Ethiopian highlands. However, the value obtained in our study was smaller than other reports (Hailu *et al*., 2006), revealing that sheep and goats of Halaba are resistant to water stressed environments compared to other breeds and/ or types.

Table 3 Maximum-likelihood analysis of variance of pre-weaning mortality rate of lambs and kids in Halaba district

Fixed effects	Sheep			Goats		
	df	Chi-square	P-value	df	Chi-square	P-value
Flock density	2	9.420**	0.009	2	13.398**	0.001
Season	2	7.402*	0.025	2	8.984*	0.011
Sex	1	0.918ns	0.338	1	2.669ns	0.102
Litter size	1	0.738ns	0.457	1	1.112ns	0.892
BWT	2	1.674ns	0.390	2	3.833ns	0.05
Parity	4	2.282ns	0.578	4	11.653**	0.003

* $P < 0.05$, ns, non-significant
** $P < 0.01$

Flock density influenced the pre-mortality rate of lambs and kids. Season had effect ($p < 0.01$) on pre-weaning mortality rate in both species (Table 3) due to the fact that feed availability fluctuates within and across the seasons, diseases and parasites and extreme droughts. Of the total mortality, the majority (44%) were occurred during the early dry season (October to January), confirms the reports of high mortality rate (42%) for Arsi-Bale goats in the early dry season (Hailu *et al*., 2006). In contrast, Safari *et al*. (2012) reported faster growth and lower pre-weaning mortality of kids during the early dry season.

Our results showed that there was no effect of sex on pre-weaning mortality rate. Vostrey and Milerski (2013) and Hailu *et al*. (2006) have found high death incidences among male kids than females.

Birth weight affected ($p < 0.01$) mortality rate of the kids while had no effect on the lambs (Table 3). Lower birth weight contributed for pre-weaning kid mortality (Table 4). The results obtained in this study are in agreement with the findings of Hailu *et al*. (2006). Safari *et al*. (2012) has shown less effect of parity on pre-weaning mortality of kids. The non-significant effect of parity on pre-weaning mortality rate of the lambs is in agreement with results of Boujenane *et al.* (2013) who has shown the non-similar effect of parity on pre-weaning mortality of lambs. Vostry and Milerski (2013) have stated higher mortality of lambs born from higher parities due to teat deformations and losses of the dams. According to Hailu *et al.* (2006), there is a gradual decrement in kid mortality up to the fourth parity, and thereafter it increased. Vostrey and Milerski (2013) have also reported the highest survival of weaned lambs born from three to four year of ewe's age. The lower mortality rate observed for sheep and goats of the study area under minimal feed supplement, poor health extension and moisture stressed environmental condition is an opportunity for further improvements.

Table 4 Pre-weaning mortality rate of lambs and kids as influenced by flock density, season of birth, sex, parity, litter size, and birth weight category in Halaba district

Fixed effects	Total births		Pre-weaning mortality (%)			
	Lambs	kids	Lambs		Kids	
	n	n	n	%	n	%
Overall births	155	135	23	14.84	17	12.59
Flock density						
SDS	114	32	13	8.39	5	3.70
GDS	20	64	2	1.29	3	2.22
MFS	21	40	8	5.16	9	6.67
Season						
Dry	45	18	13	8.39	2	1.48
Light rain	49	49	6	3.87	12	8.89
Heavy rain	61	68	4	2.58	3	2.22
Sex						
Male	74	76	9	5.81	6	4.44
Female	81	59	14	9.03	11	8.15
Parity						
1	29	26	6	3.87	4	2.96
2	33	27	5	3.23	3	2.22
3	45	26	7	4.52	4	2.96
4	30	39	3	1.94	2	1.48
>5	18	17	2	1.29	4	2.96
Litter size						
Single	75	72	13	8.39	6	4.44
Multiple	80	63	10	6.45	11	8.15
Birth weight category						
1 (≤2 kg)	25	25	3	1.94	4	2.96
2(2-2.5 Kg)	80	70	10	6.45	11	8.15
3 (>2.6 kg)	50	40	10	6.45	3	2.22

n=number of observations

Conclusion: The results indicated that the non-genetic factors in this study were shown to influence reproductive traits and pre-weaning mortality of kids and lambs. Flock management group due to resource endowment, parity, litter size, and season due to feed fluctuations in quality and quantity are important factors need to be considered in the improvement plan of sheep and goats. Improving management, particularly dams carrying twins and triplets, is crucial to improve reproduction and reduce mortality rate of lambs and kids. Balance of replacement rates between young ewes and old ones may contribute to exploit the prolificacy. To improve ewe/doe productivity and enhance household income from small ruminants, adequate management improvement measures have to be warranted.

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