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Research article

Reproductive performance and milk production of Central Highland and Boer x Central Highland goats

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ABSTRACT

This study was conducted to evaluate the reproductive performance and milk production potential of Central Highland and Boer x Central Highland goats under semi-intensive management. Data were collected from 2009 till 2018 in the Sirinka goat breeding station. A general linear model procedure of the Statistical Analysis System (SAS) was used to analyze the data. The overall least-squares mean litter size at birth (LSB), litter size at weaning (LSW), total litter weight at birth, total litter weight at weaning and gestation length (GL) were 1.6 ± 0.02 kids, 1.4 ± 0.02 kids, 3.9 ± 0.05 kg, 13.6 ± 0.35 kg and 148.0 ± 0.33 days, respectively. The LSB, LSW and GL did not differ between Central Highland and their F1 and F2 crossbred dams. However, F2 dams produce the lightest kid at birth and weaning. Besides, birth type, season, year and parity were important sources of variation for most of the reproductive traits. The least-squares mean for daily milk yield (DMY), lactation milk yield (LMY) and lactation length (LL) were 0.34 ± 0.02 kg, 39.16 ± 3.00 kg and 104.2 ± 4.45 days, respectively. The DMY and LMY of Boer x Central Highland goats were higher than pure Central Highland goats by 46.4% and 27.2%, respectively. However, the LL for both genotypes was found to be similar ($P > 0.05$). Dams kidding during the short rainy season produce more milk than kidding during dry and main rainy seasons. Boer x Central Highland goats produce more milk than pure Central Highland goats. However, using Boer crossbred dams did not reveal any advantage over the base Central Highland dams in terms of reproductive performance. Therefore, using Central Highland goat as a dam line, improving the management and integration of crossbreeding with selection could be an ideal option to improve the overall productivity of goats.

1. Introduction

Reproductive performance is an indicator of productivity, adaptability and economic viability of goat production. Doe productivity is measured as the total weights of kids weaned per doe exposed, the number of kids born, survival and growth of kids during pre-weaning age (Vanimisetti et al., 2007; Snowder, 2008; Menezes et al., 2016). The total weight of kids at weaning per doe kidding is the result of the prolificacy of does, growth efficiency and survival potential of kids during the pre-weaning period (Vanimisetti et al., 2007; Snowder, 2008). Besides, the number of kids born and weaned indicates the fitness and mothering ability of their dam. In general, these traits are the major components of profitability in goat and sheep production (Zhang et al., 2009; Rashidi et al., 2011; Yavarifard et al., 2015). Therefore, these traits are economically important traits of the doe that measures the mothering ability, adaptability to the production system and overall productivity.

Milk production potential of dams is highly associated with their kid growth and survival (Berhane and Eik, 2006a, b; Andualem et al., 2016; Tesema et al., 2019). Moreover, goat production accounts for 16.7% of milk consumed in Ethiopia (Tsedeke, 2007). Goat milk is well tolerated by individuals sensitive and allergic to cow milk, has beneficial effects on health, easily digested, high content of minerals and vitamins (Brito et al., 2011). Besides, goat milk contains protein, trace elements, electrolytes, enzymes and fatty acids that can be easily absorbed and digested by the body (Hayam et al., 2014). Hence, due to its nutritive and medicinal value, goat milk will be preferable for consumption than cow milk if awareness creation is made.

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However, the expressions of the genetic effects on reproduction and milk production traits are affected by numerous environmental factors such as climatic conditions, management, health, nutrition, breeding ratio, age of doe, the libido of buck and fertility (van der Waaji, 2004; Zhang et al., 2009; Bedhane et al., 2012; Kebede et al., 2012). Thus, identification of genetic and environmental factors that influence reproduction and milk production and thereby including them in breeding programs can enhance goat productivity. Although there are many reports for temperate goat breeds, there is a paucity of information for Boer crossbreds in Ethiopia. Except for Mustefa et al. (2019) who reported reproductive traits of crossbreds, no study has yet been conducted to identify factors affecting the milk production and reproductive performance of Boer crossbred goats in Ethiopia. On account of this, the study was conducted to determine the influences of the genetic and non-genetic factors on reproductive and milk production performance of Central Highland and Boer x Central Highland goats.

2. Material and methods

2.1. Study area

All the experimental animals were raised in Sirinka Agricultural Research Center goat breeding station which is located 508 km away from Addis Ababa at an altitude of 1850 m.a.s.l and at 11°45′ 00″ N and 39°36′ 36″ E. The rainfall pattern is bimodal, with the two-rainfall seasons, '*belg*' (February/March–April) and '*meher*' (July–September) and the mean annual rainfall amount is on average about 950 mm. The area is a moderately warm temperature zone with a mean daily temperature ranges from 13.7 - 26.4 °C.

2.2. Flock management

Animal care and all experimental procedures were complied with FASS (2010) and were approved by the Amhara Agricultural Research Institute animal nutrition, health and welfare researchers' team. Goats were raised under semi-intensive conditions and housed in semi-opened concrete barns based on their sex, age, physiological and health status. Goats were mated following controlled breeding, with kidding throughout the year. A single sire mating system was practiced with a ratio of 20–30 female breeding goats per buck and the mating season lasted for 45 days. The kids were kept together with their dams in their barn for the first three to five days. Then after kids were isolated from their dams and suckled three times per day until three months of age.

The male and female breeding goats were herded separately and were graze/browse on natural pasture for 6 h per day and had access to water three times a day. Besides grazing or browsing, goats were supplemented with a commercial feed based on their physiological status and age. Kids were supplemented with 0.10 kg/day starting from one month of age to weaning (90 days) and weaned kids were supplemented with 0.20 kg/day. Depending on their body condition, pregnant, lactating does and bucks were provided with 0.30–0.40 kg of commercial concentrate composed of *Noug* cake, wheat bran and salt. However, due to financial limitations, the supplementation of the flock was not consistent throughout the year. Vaccination, de-worming and spraying were conducted as per the schedule, physiology and age of goats.

2.3. Studied traits and data collection

The reproductive traits investigated in this study were litter size at birth (LSB), total litter weight at birth (LBW), litter size at weaning (LSW), total litter weight at weaning (LWW) and gestation length (GL). LSB and LSW were the number of kids born alive and the number of kids present at weaning (90 days of age) per doe kidding, respectively. LBW was the sum of birth weights of kids born for each doe kidding. LWW was calculated as the sum of weight of kids at weaning. Gestation length is the interval between the date of mating and the date of kidding.

Milk yield was determined once weekly during the rearing period by the milk difference technique according to Louca et al. (1974). Does were kept away from their kids for 12 h (overnight) starting from one month of age and then one teat was hand-milked in the next morning while the other teat was suckled by the kid. So, the daily milk yield was estimated as the amount of milking milk for one teat multiplied by four according to Alsheikh (2013).

2.4. Statistical analysis

Preliminary data analysis like checking for outliers and normality tests were employed before conducting the main data analysis. The general linear models (GLM procedures) of SAS (2002) were used to identify the important factors which have a significant effect on the reproductive and milk traits. Differences between the least-squares mean of a trait for different genetic and non-genetic factors were tested using the Tukey-Kramer test.

Model 1. The statistical model for reproductive traits:

$$Y_{ijklmn} = \mu + S_i + X_j + D_k + T_l + G_m + e_{ijklmn}$$

where; Y_{ijklmn} is dependent variables, μ is overall mean, S_i is the effect of i^{th} season of kidding (3 levels: main rain, short rain and dry), X_j is the effect of j^{th} sex of kid (2 levels: male and female), D_k is the effect of k^{th} parity of doe (5 levels: 1, 2, 3, 4 and ≥5), T_l is the effect of l^{th} year of kidding (9 levels: 2009–2018), G_n is the effect of m^{th} genotype (3 levels: Central Highland, Boer x Central Highland F1and Boer x Central Highland F2 goats) and e_{ijklmn} is random error term associated with each observation.

Model 2: The statistical models for milk traits:

$$Y_{ijkl} = \mu + G_i + S_j + P_k + e_{ijkl}$$

where; Y_{ijkl} is dependent variables, μ is the overall mean, G_i is the effect of i^{th} genotype (2 levels: Central Highland and Boer x Central Highland goat), S_j is the effect of j^{th} season of kidding (3 levels: main rain, short rain and dry), P_k is the effect of k^{th} parity of doe (4 levels: 1, 2, 3, and 4) and e_{ijkl} is random error term associated with each observation.

3. Results

3.1. Doe reproductive traits

The least-squares mean and standard error for reproductive traits are presented in Table 1. The overall least-squares mean LSB, LSW, LBW, LWW and GL were 1.55 ± 0.02 kids, 1.36 ± 0.02 kids, 3.91 ± 0.05 kg, 13.6 ± 0.35 kg and 148.0 ± 0.33 days, respectively. In this study, 47.1 % of does had singles, 51.0 % had twins and 1.90 % had triplets.

The influences of genetic and non-genetic factors on reproductive traits of goat are summarized in Table 1. Genotype was an important source of variation for LBW and LWW. The F2 crossbred goats had a lower ($P < 0.05$) LBW and LWW than pure Central Highland and F1 crossbred goats. But, the F1 crossbreds did not superior to pure Central Highland goats. However, Central Highland goat, F1 and F2 crossbred goats did not differ ($P > 0.05$) in LSB, LSW and GL.

The birth type had a pronounced ($P < 0.05$) influence on LBW, LWW and GL (Table 1). Multiple bearing dams had higher LBW and LWW than single bearing dams. The gestation length for dams of multiple kids was shorter by 2.6 days than the dams of the singleton. Litter birth weight (LBW) and litter weight at weaning (LWW) were lowest for 1^{st} parity and increases with the age of dams. However, the effect of dam age on LSB and LSW was found to be non-significant ($P > 0.05$).

The kidding year had a considerable influence ($P < 0.05$) on all investigated reproductive traits except for LSB. The lowest LWW was observed in 2011 and 2017 and the lowest LSW was observed in 2012 and 2017. Dams kidding during 2018 had a higher LBW compared with other periods. In this study, the season of kidding was found to be a

Table 1. On-station reproductive performance of goats (LSM±SE).

Source of variation	N	LSB (kid)	LBW (kg)	N	LSW (kid)	LWW (kg)	N	GL (days)
		LSM±SE	LSM±SE		LSM±SE	LSM±SE		LSM±SE
Overall	565	1.55 ± 0.02	3.91 ± 0.05	455	1.36 ± 0.02	13.6 ± 0.35	282	148.0 ± 0.33
CV		3.54	15.8		13.1	16.1		0.66
Genotype		ns	*		ns	***		ns
CH	271	1.58 ± 0.03	4.02 ± 0.08[a]	240	1.40 ± 0.03	14.3 ± 0.58[a]	74	149.1 ± 0.43
B xCH F1	212	1.48 ± 0.03	3.81 ± 0.07[ab]	170	1.34 ± 0.03	13.4 ± 0.39[a]	149	147.1 ± 0.45
B xCH F2	82	1.62 ± 0.06	3.78 ± 0.14[b]	45	1.17 ± 0.05	10.3 ± 0.77[b]	59	147.6 ± 0.77
Birth type		-	***		-	***		***
Single	266	-	2.85 ± 0.03	207	-	11.8 ± 0.26	138	149.3 ± 0.42
Multiple	299	-	4.85 ± 0.06	248	-	15.1 ± 0.60	144	146.7 ± 0.49
Parity		ns	***		ns	*		ns
1	194	1.43 ± 0.03	3.45 ± 0.08[d]	149	1.24 ± 0.03	11.6 ± 0.41[c]	102	148.6 ± 0.47
2	162	1.52 ± 0.04	4.01 ± 0.11[c]	130	1.37 ± 0.04	14.6 ± 0.47[ab]	72	147.5 ± 0.82
3	107	1.68 ± 0.05	4.29 ± 0.12[ab]	91	1.46 ± 0.05	13.8 ± 0.57[ab]	45	148.7 ± 0.88
4	59	1.63 ± 0.07	4.11 ± 0.17[bc]	50	1.40 ± 0.07	13.8 ± 0.90[ab]	32	147.6 ± 0.87
≥5	43	1.74 ± 0.07	4.35 ± 0.21[a]	35	1.48 ± 0.08	17.4 ± 3.27[a]	31	146.8 ± 0.85
Season		ns	*		ns	ns		***
Dry	279	1.58 ± 0.03	3.92 ± 0.07[a]	215	1.36 ± 0.03	13.3 ± 0.64	144	146.1 ± 0.45[b]
Main rain	68	1.41 ± 0.06	3.45 ± 0.13[b]	62	1.24 ± 0.05	13.2 ± 0.61	15	150.5 ± 2.26[a]
Short rain	218	1.54 ± 0.03	4.03 ± 0.09[a]	178	1.40 ± 0.03	14.0 ± 0.40	123	149.9 ± 0.40[a]
Sex		ns	*		ns	ns		ns
Female	273	1.49 ± 0.03	3.74 ± 0.07	217	1.33 ± 0.03	13.4 ± 0.62	130	147.7 ± 0.42
Male	292	1.60 ± 0.03	4.06 ± 0.07	238	1.38 ± 0.03	13.7 ± 0.38	152	148.3 ± 0.50
Year		ns	***		*	***		***
2009	67	1.52 ± 0.06	3.73 ± 0.15[de]	61	1.39 ± 0.06[ab]	12.4 ± 0.55[bcd]	28	147.9 ± 0.50[bcd]
2010	82	1.56 ± 0.06	4.37 ± 0.16[b]	74	1.42 ± 0.06[a]	15.0 ± 0.71[ab]		-
2011	64	1.47 ± 0.06	3.67 ± 0.14[de]	48	1.31 ± 0.06[abc]	10.6 ± 0.54[d]	5	149.6 ± 3.47[ab]
2012	60	1.40 ± 0.06	4.07 ± 0.16[bc]	51	1.23 ± 0.05[c]	14.1 ± 0.65[abc]	41	151.6 ± 0.80[a]
2013	76	1.54 ± 0.06	4.13 ± 0.13[bc]	62	1.40 ± 0.06[a]	14.6 ± 1.88[abc]	58	149.3 ± 0.72[abc]
2014	41	1.58 ± 0.08	3.43 ± 0.18[e]	31	1.35 ± 0.08[abc]	12.1 ± 0.68[bcd]	28	145.9 ± 0.66[cd]
2016	84	1.55 ± 0.06	3.51 ± 0.13[e]	75	1.44 ± 0.06[a]	15.7 ± 0.71[a]	67	147.1 ± 0.62[bcd]
2017	67	1.65 ± 0.08	3.83 ± 0.15[cd]	53	1.24 ± 0.06[bc]	11.6 ± 0.91[cd]	34	145.2 ± 1.01[d]
2018	24	1.83 ± 0.07	4.71 ± 0.26[a]	-	-	-	21	147.4 ± 1.79[bcd]

B, Boer goat; CH, Central Highland goat; LSB, litter size at birth; LSW, litter size at weaning; LBW; total litter weight at birth per dam; LWW, total litter weight at weaning.
N, number of observations; ns, $P > 0.05$; ***, $P < 0.001$; **, $P < 0.01$; *, $P < 0.05$.
Least squares mean with different superscripts within the same column and class are statistically different.

source of variation ($P < 0.05$) for LBW and GL. The LBW of dams kidding during the main rainy season was lower than dams kidding during the dry and short rainy season. Dams kidding during the dry season had shorter GL compared with doe kidding during the short and main rainy season.

3.2. Milk yield and lactation length

The least-squares mean (±SE) of daily milk yield (DMY), lactation milk yield (LMY) and lactation length (LL) are presented in Table 2. The differences between the genotypes in milk production traits were marked. The DMY and LMY of Boer x Central Highland goats were higher than pure Central Highland goats by 46.4% and 27.2%, respectively. However, the LL for both genotypes was found to be similar ($P > 0.05$).

Goats kidding during the short rainy season had higher DMY and LMY than those goats kidding during the main rainy and dry seasons. However, does kidding during the short rainy and dry season did not differ ($P > 0.05$) in DMY. Likewise, does kidding during the dry and main rainy seasons were statistically similar ($P > 0.05$) in LMY. Lactation length was not significantly affected by the season of kidding. The influence of parity on DMY, LMY and LL was found to be non-significant ($P > 0.05$).

4. Discussion

4.1. Reproductive performance

The twinning rate of goats in this study is higher than the report of Dereje et al. (2015) for the Ethiopian indigenous goats (5% twining rate for goats pastoral in arid areas and 36% for goats in the humid areas) and Rashidi et al. (2011) for Markhoz goats. The current finding is consistent with Tesema et al. (2017) who noted a moderate twining rate for Central Highland goats. But a relatively higher twinning rate than the current result was noted by Menezes et al. (2016) for Boer goats. Litter size at weaning was lower by 0.19 than litter size at birth. This reduction could be explained by the postnatal mortality of kids due to infectious and non-infectious diseases and also due to parasites.

Litter size at birth (LSB) and litter size at weaning (LSW) are the most important traits (Zhang et al., 2009) and could be considered as an indicator of fitness and mothering ability of does. The LSB and LSW in this study are comparable with the report of Kebede et al. (2012) for Arsi-Bale goat (1.60 ± 0.03 for LSB and 1.37 ± 0.03 for LSW) and higher than the

Table 2. Milk production potentials of Central Highland and Boer x Central Highland goats.

Source of variation	N	DMY(kg/day)	LMY(kg/lactation)	LL(days)
Overall mean	71	0.34 ± 0.02	39.16 ± 3.00	104.2 ± 4.45
Genotype		*	*	ns
Central Highland	36	0.28 ± 0.02	34.5 ± 3.22	103 ± 3.34
Boer x Central Highland	35	0.41 ± 0.03	43.9 ± 5.03	105 ± 8.43
Season		*	**	ns
Dry	22	0.36 ± 0.04^{ab}	33.3 ± 4.87^{b}	91.3 ± 10.2
Short rainy	27	0.41 ± 0.03^{a}	49.6 ± 5.54^{a}	114 ± 7.05
Main rainy	22	0.25 ± 0.02^{b}	32.3 ± 4.05^{b}	105 ± 4.34
Parity		ns	ns	ns
1	35	0.33 ± 0.03	38.0 ± 3.86	110 ± 5.76
2	13	0.32 ± 0.04	37.0 ± 7.02	98.1 ± 10.2
3	12	0.35 ± 0.05	39.3 ± 7.48	89.0 ± 9.79
4	11	0.40 ± 0.06	45.2 ± 10.2	109 ± 15.1

DMY, average daily milk yield; LMY, lactation milk yield; LL, lactation length.
N, number of observation; ns, $P > 0.05$; **, $P < 0.01$; *, $P < 0.05$. Least squares mean with different superscripts within the same column and class are statistically different.

result (1.50 ± 0.01 for LSB and 0.72 ± 0.13 for LSW) noted by Mustefa et al. (2019) for F1 Boer x Central Highland goat. Likewise, lower results than the current finding were also reported by Mia et al. (2013) for Black Bengal goat and Rashidi et al. (2011) for Markhoz goats. The variation of prolificacy among breeds probably related to the genetic potential of breeds (ability to ovulate more ova and survival rates of embryo or fetuses), the variation of climatic variables, feed availability and management conditions.

Litter weight at weaning (LWW) reflects the combined effect of reproduction such as litter size, pre-weaning survival and pre-weaning growth rates of kids (Vanimisetti et al., 2007; Snowder, 2008; Mohammadi et al., 2013; Yavarifard et al., 2015). LBW is also an important reproductive trait that measures the capacity of the dam to produce kid weight at birth (Rosati et al., 2002). The LBW and LWW in this study are higher than the reports of Kebede et al. (2012) for Arsi-Bale goat. The superior litter weight of crossbreds than this indigenous breed is probably related to the individual heterosis of kids and maternal heterosis of crossbred does. Likewise, a relatively lower LBW and LWW were reported by Nguluma et al. (2013) for Boer x Spanish goat and by Mustefa et al. (2019) for Boer x Central Highland goats, respectively. This variation among crossbreds can be explained by the genetic potential of local goat used as a dam line, pre-weaning survival of kids, and prolificacy of does.

Gestation length (GL) observed in this study is longer than 144.7 days reported by Mia et al. (2013) and shorter than 151.7 ± 4.43 days reported by Zhang et al. (2009) for Boer dam. The variation in gestation length might be explained by litter size (Peaker, 1978), litter weight, breed size (Mellado et al., 2000) and nutritional stress of dams. According to Mellado et al. (2000), gestation length is shorter in lighter breeds of goats and shorter gestation length result in lower survival of kids, whereas prolonged gestation (152–160 days) in goats increase the litter weight at birth and neonatal viability of kids.

4.2. The influence of genetic and environmental factors on reproductive traits

The lower LWW for F2 crossbreds may be due to litter size at weaning and lower weaning weight of individual kids. The absence of a significant difference among genotypes in investigated reproductive traits is agreed well with Nguluma et al. (2013) who reported that crossbreeding with Boer did not improve the productivity (LBW, LWW, LSB and LSW) of Kiko and Spanish does and also in line with Mustefa et al. (2019) who noted a non-significant difference among Central Highland and Boer x Central Highland F1 does for LSB, LSW, LBW and LWW. Likewise, Khanal (2016) noted that Boer F1 does exhibit similar reproductive and health merit with Kiko, Spanish and Myotonic does in low to medium input management conditions. The absence of a significant difference in LSW among dam genotypes could be an indicator of a lack of difference in the mothering ability of dams necessary to successfully raise kids to wean. These all, therefore, imply that using F1 and F2 crossbred dams did not reveal any advantage over the base Central Highland dams in terms of reproductive traits. Thus, crossbreeding with Boer goat did not improve doe productivity as F1 and F2 Boer x Central Highland does were similar or lower to Central Highland does.

The LBW increased with the increase of litter size and this result is consistent with Zhang et al. (2009), Kebede et al. (2012) and Yavarifard et al. (2015). It is quite clear that as the litter size increases, the total weight of litter also increases, but the weight of an individual kid may not be improved. The influence of birth type on GL is consistent with Peaker (1978). The shorter GL for multiple bearing dams than single bearing dams is associated with hormone secretion and concentration. According to Khan and Ludri (2002), the decline in progesterone concentration from day 20 to day one before kidding was 56% in twin and 42% in single bearing goats. When the progesterone level decreases the level of estrogen becomes increased thereby facilitate the delivery process. The plasma cortisol level was remained elevated from day five till the day of kidding in twin bearing goats, but it elevated during kidding day for single bearing does (Khan and Ludri, 2002). Besides, the higher serum estradiol concentration in dams of twins as compared to single-bearing does was noted by Malanu et al. (1997). This estrogen causes the uterus to contract, contraction continues and releases PGF2α which causes more contractions and facilitates the delivery.

There was a tendency for the productivity of does (LBW and LWW) to improve with age and this result is in agreement with Kebede et al. (2012) and partly agrees with Mia et al. (2013). This improvement can be explained by the conflict of fetal nutritional demand with the maternal nutritional requirements as primiparous goats did not reach their mature body weight (Luther et al., 2007). Besides, differences in maternal effects, nursing, and maternal behavior of doe at different ages are also the possible reasons for the effect of age of dams. Thus, the increment in LBW and LWW with parity point toward the improvement of reproductive traits as does reach maturity.

The sizable effect of year on reproductive traits was noted elsewhere (Zhang et al., 2009; Kebede et al., 2012; Nguluma et al., 2013; Menezes et al., 2016; Mustefa et al., 2019). A significant influence of season on reproductive traits has been noted in the literature (Yavarifard et al., 2015; Mustefa et al., 2019). The short GL during the dry season may be due to the nutritional stress of dams. The absence of a kidding season effect on LWW in the present study is consistent with the result of Ibnelbachyr et al. (2014) for Draa goat. The influence of kidding year and the season could be explained by the variation in the climate variables, breeding conditions of does, kids feeding in various years (Yavarifard et al., 2015; Tesema et al., 2020), diseases and parasite distribution and management variability as these all associated with ovulation rate, prenatal and early postnatal development of kids indirectly.

4.3. Effect of genetic and non-genetic factors on milk production

The DMY of Central Highland and Boer x Central Highland goats in this study is higher than the result reported for Arsi-Bale goat (Bedhane et al., 2012). However, a relatively higher DMY for different Ethiopian indigenous goats has been reported in the literature (Tesfaye et al., 2000; Berhane and Eik, 2006a; Mestawet et al., 2012; Mestawet et al., 2014; Abraham et al., 2017). The LL for both genotypes in the present study agrees with the findings of Dereje (2011) and Abraham et al. (2017). However, it appeared to be higher compared to the reports of Lemma et al. (2003) for Borena goat, Berhane and Eik (2006a, b) for Begait goat and Bedhane et al. (2012) for Arsi-Bale goat. The observed variation among different goat breeds/populations for milk traits could be attributed to the genetic potential of breeds, the variability of management or physical environment, weaning age of kids, starting date of milking, type of milking and milking frequency.

The influence of kidding season on milk production in this study is consistent with Bedhane et al. (2012). According to Bedhane et al. (2012), the short rainy season and early dry seasons are favorable for better milk production in goats. However, extremely cold weather (Mourad, 1992) and heat stress (Lu, 1989) can reduce the milk production potential of goats. The absence of a significant difference among parities in milk yield in this study is agreed with Bedhane et al. (2012). On the contrary, a tendency for milk yield to increase with dam age has been noted in several studies (Hansen et al., 2006; Carnicela et al., 2008; Abraham et al., 2017). According to these previous studies, the metabolic activity, secretory cells, hormonal status, and nutrient intake which are used in milk synthesis increases with the age of dams and thereby increases the milk yield of does.

5. Conclusions

This study revealed that season of kidding, year, genotype and birth type plays a major role in the expression of reproductive traits. The milk production potential of Boer x Central Highland goats was higher than pure Central Highland goats. However, using F1 and F2 Boer x Central Highland dams did not reveal any advantage over the base Central Highland dams in terms of reproductive performance. Thus, using Central Highland goat as a dam line, improving the management and integrating crossbreeding with selection could be an ideal option to improve the overall productivity of does.

Declarations

Author contribution statement

Zeleke Tesema: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Kefyalew Alemayehu, Damtie Kebede, Tesfaye Getachew, Alemu Kefale, Belay Deribe:Performed the experiments.

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Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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