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Performance Evaluation of Khari and Boer Crossbred Goats in Mid Hills Under Optimum Management Regime.

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ABSTRACT

Goats are recognized as a vital and versatile livestock commodity with significant importance in rural farmers' communities of developing countries, including Nepal. Growth, reproductive and litter performances are considered as the major economic traits of goats. This study was designed to compare the growth, reproduction and litter traits of goat kids and does at mid hill region for different non-genetic factors such as genetic groups (Khari, Boer 75% and 50%), parity (early, mid and late), season of conception and kidding (summer, autumn, winter, spring), sex (male and female) and type of birth (single, twins and triplet) under optimum management regime. Data for the four-year study period (2017 to 2021) on production performance were entered into MS-Excel sheet from the data record book of the National Goat Research Program, Bandipur and analyzed by using Mixed Model Least-square and Maximum Likelihood Computer Program PC-2 statistical package. The means were compared using Duncans' Multiple Range Test (DMRT). Results revealed that the effect of genetic group, parity, type of birth and sex were significant ($p<0.05$) with respect to growth at different stages along with genetic group and parity that were significant with major non-genetic factors affecting reproduction and litter traits. Better reproduction parameters were recorded for the Khari goat breed than Boer crossbred. Similarly, litter traits at both birth and weaning were found better in later parities with better performance in Khari. Males were born heavier and consistent throughout the study period up to eighteen months. Hence, based on the findings of this study, it can be concluded that Khari goat breed has high potential for its reproduction and litter traits with a massive scope of improvement through selection within the population. Likewise, it is also important to consider the growth of inferior Khari goats can also be genetically improved through upgrading up to 75% blood level using an appropriate breed, such as Boer.

Keywords: Genetic group, breed, parity, season, weight

सारांश

नेपाल लगायत विकासोन्मुख देशका ग्रामीण किसान समुदायमा बाखालाई महत्त्वपूर्ण र बहुउपयोगी पशुधनको रूपमा लिइन्छ । शारिरीक वृद्धि, प्रजनन र पाठापाठी पाउने क्षमता बाखाको मुख्य आर्थिक विशेषताहरु मानिन्छन् । यो अध्ययन बाखाका पाठापाठीहरूको वृद्धि, प्रजनन र पाठापाठी जन्माउने विशेषताहरू तुलना गर्न गरिएको थियो र मध्य पहाडी क्षेत्रमा हुने विभिन्न गैर-आनुवांशिक कारकहरू जस्तै, आनुवांशिक समूहहरू (खरी, बोर ७५% र ५०%), बेत (प्रारम्भिक, मध्य र ढिलो), गर्भाधान र पाठापाठी जन्मेको मौसम (गर्मी, शरद, जाडो, वसन्त), लिङ्ग (पाठा र पाठी) र जन्मको प्रकार (एकल, जुम्ल्याहा र तिम्लिया) जस्लाई एकै व्यवस्थापन प्रणाली अन्तर्गत पालन गरिएको थियो । उत्पादन कार्यसम्पादनमा चार वर्षको अध्ययन अवधि (२०१७ देखि २०२१) को लागि तथ्याङ्क राष्ट्रिय बाखा अनुसन्धान कार्यक्रम, बन्दीपुरको तथ्याङ्क अभिलेख बुकबाट Ms–Excel पानामा प्रविष्ट गरिएको थियो र मिश्रित मोडेल Least–square and Maximum Likelihood कम्प्युटर प्रोग्रामको प्रयोग गरेर विश्लेषण र मध्यक विभाजन Duncans Multiple Range Test (DMRT) प्रयोग गरेर तुलना गरिएको थियो ।

नतिजाहरूले आनुवांशिक समूह, बेत, जन्म प्रकार र लिङ्गको महत्वपूर्ण (p <०.०५) प्रभाव शारिरीक वृद्धिको विभिन्न चरणहरूमा साथै आनुवांशिक समूह र बेतका साथमा देखायो जुन प्रजनन् र पाठापाठीको गुणहरूलाई असर गर्ने महत्त्वपूर्ण गैर-आनुवंशिक कारकहरू थिए। खरी जातका बाखा बोर क्रस भन्दा राम्रो प्रजनन मापदण्डहरू अभिलेख गरिएको थियो। त्यसैगरी, खरी जातका बाखाको जन्म र दूध छुटाउने समय, पाठापाठीका विशेषताहरू पछिल्लो बेतहरूमा राम्रो प्रदर्शन भएको पाइयो। पाठाहरू पाठीको तुलनामा बढि तौल भएका जन्मिएका थिए र अठार महिनासम्मको अध्ययन अवधिभर यो नतिजा कायम रहयो। तसर्थ, यस अध्ययनको निष्कर्षको आधारमा, प्रजनन् र पाठापाठीको विशेषताहरूको सन्दर्भमा खरी बाखामा उच्च क्षमता तथा जनसंख्या भित्र छनौट मार्फत यसको नश्ल सुधार गर्न सकिने प्रशस्त सम्भाव्यताहरु छ। त्यसैगरी, उपयुक्त नस्ल जस्तै बोरको प्रयोग गरी कम उत्पादन क्षमताका खरी बाखाको ७५ प्रतिशतसम्म रगतको स्तरवृद्धि गरी आनुवंशिक रूपमा पनि सुधार गर्न सकिने यस अध्ययनको निष्कर्ष छ।

INTRODUCTION

Goats are renowned for their adaptability and resilience, as well as contribute immensely to livelihoods, nutrition, and rural economy. As a source of meat, milk, and fiber, goats play a crucial role in addressing food security, especially in regions where access to diverse protein sources is limited (Kolachhapati 2006; Sapkota et al 2008, Bhattarai et al 2019). Their ability to thrive in diverse agroecological zones, often in areas unsuitable for other livestock, underscores their unique value in sustainable agriculture. Moreover, goats often require minimal investment and space, making them accessible to smallholder farmers and marginalized communities. As a cornerstone of agricultural systems, goats contribute to soil fertility through browsing, help manage vegetation, and generating income through various product sales. Their importance extends beyond economic benefits, as they hold cultural significance and contribute to social resilience in many societies. Thus, goats stand as a resilient and adaptable livestock commodity that embodies the intersection of livelihoods, agriculture, and sustainable development.

Goat farming is a key enterprise being adopted by the farmers irrespective to caste, ethnicity, religion and economy (rich and poor) for family food and nutrition security (AFSP 2016, Neupane et al 2018). These days an increasing trend of commercial goat farming in Nepal has been seen since last decade with an increased number of goat population from 9.5 million in 2011/12 producing 53, 956 metric ton to 13.99 million in 2021/22 producing 7,424 metric ton with an increment of 27.3% in a decade (MoALD 2023). However, the total goat meat contribution decreased from 18.7% to 14.8% in the same period. Goat meat ranks in third position after chicken and buffalo meat production in Nepal and contributes around 4% in agriculture GDP (DLS 2022). Due to the culture and religion adopted in the country, the demand for goat meat is ever increasing and need to address the knowledge and gap for genetic improvement of low-producing indigenous breeds through selective breeding within the population as well as crossing them with breeds having higher growth rate.

Khari is a popular and dominant indigenous breed existing across mid hill of Nepal sharing 56% of the total goat population (Parajuli 2012, Bhattarai et al 2019). This breed is one of the well-adopted breeds of Nepal with higher prolificacy, multiple kidding abilities and carcass quality (Bhattarai et al 2017). Despite some better characteristics of the indigenous Khari breed, such valuable genetic resource has been given low priority by the farmers due to the large and attractive body size of exotic pure breeds and their crossbred kids (Kolachhapati 2006) of goats such as Jamunapari and Boer. Boer goats and their frozen semen were introduced in Nepal in 2006 (GRS 2010). Boer goat, which is popular for its fast growth rate as well as meat quality, has been strategically introduced to cross with the non-descript goat population of the country protecting the pure indigenous goat breed populations in 2012 by projects like Agriculture Food Security Project (World bank funded) (AFSP 2016), and later in 2015 by Improved Seeds for Farmers Programme which is funded by International Fund for Agriculture Development (IFAD). The importation has helped to improve the goat productivity to address the demand in projects implemented and nearby districts to some extent.

Per capita consumption of meat is 15 kg and meets recommendations set by FAO for the developing countries (DLS 2021). To fulfill the domestic requirements of meat and to check the import of exotic goat breeds, these poor productive goats should be upgraded through selection or cross-breeding (Bhattarai et al 2017, NGRP 2021). Boer is the choice of breed to improve the growth performance of non-descript goats through crossing and upgrading. Boer goats have been recognized worldwide as goats having excellent body conformation fast growing and good carcass quality. Boer goat has heavier body weight and faster growth rate, have higher prolificacy with not less than 2 litters in size and are able to improve the productive performance of indigenous breeds through cross-breeding (Lu 2001, NGRP 2022). A few researches have been conducted in the performance evaluation of different filial generations of Boer crossbred at National Goat Research Program (NGRP), Bandipur, Tanhun, Directorate of Agricultural Research, Khajura, Nepalgunj and some at commercial goat farms across the country (NGRP Annual Report, 2022 DoAR Lumbini Province Annual Report, 2022) . This study was conducted to evaluate the effect of different non-genetic factors on performance evaluation (production, reproduction and litter traits) of Khari and Boer crossbred goats at mid-hills regions of Nepal so that optimum breeding strategy could be formulated in line with improving overall crossbreeding approach of Khari with heavy bred such as Boer.

MATERIALS AND METHOD

The research was done by using secondary and primary data generated at the National Goat Research Program (NGRP), Bandipur, Tahanun district of Nepal. NGRP is one of the goat commodities programs of Nepal Agricultural Research Council (NARC) located at an altitude of 850 masl, which receives an average annual rainfall of 2000 mm with 85% relative humidity and maximum and minimum temperatures of 32^{oc} and 8^{oc}, respectively (NGRP 2022). The goats used in this study were indigenous Khari breeds, Boer bucks crossed with Khari does to produce 50% Boer blood crossbred, and Boer bucks crossed with 50% Boer blood crosses (50% Khari) to produce 75% Boer blood crossbred. Boer crossbreds (both 50% and 75%) were kept under complete stall feeding whereas indigenous Khari goats were reared under semi-intensive (both stalls feeding as well as grazing for 6 hours each day). A commercial feed with 18% CP and seasonal fodders were provided according to feeding thumb rule. Additional balanced feed were given during special stages.

Data recorded for four years from 2018 to 2021 were aimed to study on production performances and litter traits. Thus, weight at different stages of growth was recorded and incorporated in the analysis. A total of 567 kids were recorded for birth weight, 534 kids for weaning weight (3 months); 510 kids for post-weaning (6, 9 and 12 months); and 232, and 172 adults for fifteen and eighteen months of age respectively. Similarly, 160 does were taken into recording for reproductive traits namely age at first conception (AFC), and age at first kidding (AFK) 258 and 426 does were recorded for Post-Partum Estrus (PPE), and gestation length (GL), respectively. In addition to this, 426 and 395 goats were considered for litter size/weight at birth (LSB/LWB), and litter size/weight at weaning (LSW/LWW). These all variations are entirely based on the available population and sample size to meet the objective of this research.

All the relevant and collected data of different genetic groups of goats and their kids were entered into the computer in Microsoft Excel package programs. The data were analyzed by using a Mixed Model Least-square and Maximum Likelihood Computer Program PC-2statistical package (Harvey 1990) developed by Walter R. Harvey based on the C.R. Henderson model (Henderson 1953), and the means were compared by Duncans' Multiple Range Test (DMRT) (Duncan 1955).

Body weight and mean daily weight gain (MDWG) at different stages of growth (at birth, 3, 6, 9, 12, 15 and 18 months) were analyzed by using the following fixed effect model:

$$Y_{ijklmn} = \mu + a_i + b_j + c_k + d_l + f_m + e_{ijklmn}$$

Where,
μ is the overall mean
a_i is the effect of ith genetic group (i=1, 2 and 3)
b_j is the effect of jth number of parities of does (j = 1, 2 and 3)
c_k is the effect of kth season of kidding (k= 1,2,3 and 4)
d_l is the effect of lth type of birth (l=1,2 and 3)
f_m is the effect of mth sex (m=1 and 2)
e_{ijklmn} is the random element (error mean) assumed to be normally and independently distributed among the sampled population.

Age at first conception (AFC) and Age at first Kidding (AFK) were analyzed using following fixed effect model i.e.

$$Y_{ijkl} = \mu + a_i + b_j + c_k + e_{ijkl}$$

Where,
$Y_{ijk}l$ is the adjusted mean for AFC and AFK in days
μ is overall mean
a_i is the effect of ith genetic group (i=1,2 and 3)
b_j is the effect of jth season of conception (j=1,2,3 and 4)
c_k is the effect of kth season of kidding (k=1,2,3 and 4)
e_{ijkl} is the random element (error mean) assumed to be normally and independently distributed among the sampled population.

Similarly, Postpartum estrus (PPE), Kidding interval (KI), Gestation length (GL), LSB/LWB and LSW/LWW were analyzed using following fixed effect model i.e.

$$Y_{ijklm} = \mu + a_i + b_j + c_k + d_l + e_{ijklm}$$

Where,
Yijklm is the adjusted mean for AFC and AFK in days
μ is the overall mean
a_i is the effect of ith genetic group (i=1,2 and 3)
b_j is the effect of jth parity (j=1 and 2)
c_k is the effect of kth season of conception (k=1,2,3 and 4)
d_l is the effect of lth season of kidding (l=1,2,3 and 4)
$e_{ijklklmno}$ is the random element (error mean) assumed to be normally and independently distributed among the sampled population.

RESULTS

Effect on non-genetic factors on growth performance of goat

The effect of non-genetic factors such as genetic group, parity of dam, season of kidding, type of birth and sex on early growth stages (birth to six-month age) of goats at NGRP is presented in **Table** 1. Results thus revealed that the overall mean for birth, weaning (three- months) and post weaning (six- months) body weight were 2.21±0.038, 12.83±0.18 and 18.80±0.22 kg, respectively. Indeed Boer 75% and Boer 50% blood level were significantly heavier ($p<0.001$) than Khari at birth three month and six months of age. 75 % and 50 % blood level of Boer were 33% and 36% heavier than Khari during birth. During weaning (three months) and post-weaning (six months) both crossbreds were only 18 to 28% heavier than Khari of the respective age group.

There was no any significant effect of parity during birth and six months of age ($p>0.05$) but it differs significantly ($p<0.05$) for weaning age (**Table** 1). Higher weights were observed for early and mid-parities as compared to late parities.

Similarly, the effect of kidding season and type of birth were observed significant ($p<0.05$) at birth weight but were statistically similar ($p>0.05$) at weaning (three months) and post-weaning (six months) weight. Likewise, it was also revealed that single and twin-born kids were 27 and 16% heavier than the triplets respectively. On the other hand, the effect of sex was non-significant ($p>0.05$) at birth and weaning, however male was heavier than female at all stages of growth and was significantly ($p<0.01$) affected at six months weight (**Table** 1)

Table 1. Effect of non-genetic factors on birth weight, weaning weight, and post weaning weight of Khari and Boer crossbred goats at NGRP, Bandipur, Tanahun

Factors		LS Mean ±SEM	
	Birth	3 months	6 months
Overall Mean	2.21±0.038 (567)	12.83±0.18 (534)	18.80±0.22 (510)
Genetic Group	***	***	***
Boer 75%	2.39±0.051a (185)	13.15±0.24a (179)	20.07a±0.30 (171)
Boer 50%	2.42±0.053a (209)	14.23±0.25a (195)	19.79a±0.32 (180)
Khari	1.80±0.054b (173)	11.10±0.26b (160)	16.55b±0.31 (159)
Parity	NS	*	NS
Early	2.18±0.046 (215)	13.30a±0.22 (205)	19.15±0.27 (201)
Mid	2.27±0.044 (296)	13.07a±0.21 (274)	19.14±0.27 (255)
Late	2.16±0.083 (56)	12.11b±0.39 (55)	18.12±0.48 (54)
Season of Kidding	**	NS	NS
Spring	2.17ab±0.064 (101)	12.39±0.29 (99)	18.43±0.37 (96)
Summer	2.09b±0.078 (72)	12.82±0.37 (68)	18.75±0.45 (68)
Autumn	2.22ab±0.048 (212)	12.97±0.24 (192)	19.33±0.29 (191)
Winter	2.34a±0.052 (182)	13.13±0.25 (175)	18.70±0.31 (155)
Type of Birth	***	NS	NS
Single	2.45a±0.066 (93)	13.38±0.32 (90)	19.43±0.39 (88)
Twins	2.24ab±0.038 (386)	12.77±0.18 (363)	18.69±0.23 (349)
Triplet	1.93b±0.067 (88)	12.34±0.32 (81)	18.28±0.41 (73)
Sex	NS	NS	**
Male	2.19±0.046(286)	13.03±0.22 (267)	19.25±0.27 (249)
Female	2.21±0.0044(281)	12.67±0.21 (267)	18.36±0.26 (261)
CV	25.84	20.94	17.5
R^2	0.37	0.35	0.31

Note: LSM: Least Square Mean, SEM: Standard Error of Mean, ***: Significant at 0.1% level ($P<0.001$), **: Significant at 1% level ($P<0.01$); *: Significant at 5% level ($P<0.05$), NS: Non-significant, values within the braces indicates the number of observations, CV: Coefficient of Variation, R^2: Coefficient of Determination.

Similarly, the least square means for post-weaning and adult (nine to eighteen months) weight as affected by non-genetic factors such as genetic group, parity of dam, the season of kidding, type of birth and sex is presented in **Table** 2. The overall mean for nine, twelve, fifteen and eighteen months a body weight were 25.33±0.24, 31.35±0.28, 34.83±1.21, and 43.08±0.53 kg, respectively. The results showed significant differences ($p<0.001$) in different genetic groups for all post weaning and adult weights (**Table** 2). 75% blood level Boer was found 30 to 41 percent heavier and 50% blood level Boer was found 23 to 32 percent heavier than Khari during nine to eighteen months age. Parity had no significant (p>0.05) effect at nine, fifteen and eighteen months, but was significant (p<0.01) at twelve months. However, kids born from mid parity dams were heavier than early and late parity dams during all stages of growth.

Kidding season also had a significant effect (p<0.001) at twelve- and fifteen-months weight and kids born during the autumn season were heavier. In addition, males were heavier than females (p<0.001) during all stages of growth. (**Table** 2)

Table 2. Effect of non-genetic factors on nine, twelve, fifteen and eighteen months weight of Khari and Boer crossbred goats at NGRP, Bandipur, Tanahun

Factors		LS Mean ±SEM			
		Nine months	Twelve months	Fifteen months	Eighteen months
Overall		25.33±0.24 (510)	31.35±0.28 (509)	34.83±1.21 (232)	43.08±0.53 (172)
Genetic group		***	***	***	***
	Boer 75%	27.90a±0.33 (171)	35.17a±0.38 (170)	39.57a±1.32 (65)	48.61a±0.78 (52)
	Boer 50%	26.61a±0.35 (180)	33.16a±0.40 (180)	36.86b±1.27 (68)	45.79b±0.86 (45)
	Khari Pure	21.47b±0.35 (159)	25.72b±0.39 (159)	28.05c±1.29 (99)	34.82c±0.67 (75)
Parity		NS	**	NS	NS
	Early	25.52±0.30 (201)	31.82a±0.34 (201)	35.01±1.30 (79)	43.17±0.72 (58)
	Mid	25.73±0.29 (255)	32.14a±0.34 (254)	35.39±1.22 (123)	44.16±0.68 (87)
	Late	24.73±0.53 (54)	30.09b±0.60 (54)	34.08±1.44 (30)	41.91±0.98 (27)
Season of Kidding		NS	***	***	NS
	Spring	24.99±0.41 (96)	31.31ab±0.46 (96)	34.96a±1.28 (71)	43.36±0.74 (52)
	Summer	25.31±0.50 (68)	31.39ab±0.57 (68)	35.56a±1.34 (35)	42.84±0.94 (35)
	Autumn	25.97±0.32 (191)	32.25a±0.36 (191)	36.81a±1.33 (57)	44.44±0.71 (58)
	Winter	25.04±0.35 (155)	30.44b±0.39 (154)	32.71b±1.24 (69)	41.67±0.94 (27)
Type of Birth		*	**	**	NS
	Single	26.14±0.43a (88)	32.51±0.49a (88)	39.33±0.86a (35)	44.30±0.98 (26)
	Twins	25.06±0.25b (349)	31.01±0.28b (348)	36.76±0.45b (168)	42.76±0.50 (125)
	Triplet	24.77±0.45b (73)	30.53±0.52b (73)	35.98±0.89b (28)	42.18±1.04 (21)
Sex		***	***	***	***
	Male	26.15±0.30 (249)	32.56±0.35 (248)	36.12±1.26 (76)	44.37±0.74 (60)
	Female	24.50±0.29 (261)	30.14±0.33 (261)	33.54±1.25 (156)	41.79±0.56 (112)
CV		14.5	13.29	12.81	10.83
R^2		0.38	0.5	0.57	0.66

Note: LSM: Least Square Mean, SEM: Standard Error of Mean, ***: Significant at 0.1% level (P<0.001), **: significant at 1% level (P<0.01); *: significant at 5% level (P<0.05), NS: Non-significant, values within the braces indicates the number of observations, CV: Coefficient of Variation, R^2: Coefficient of Determination.

Effect of non-genetic factors on reproductive traits of does

The overall mean age at first conception (AFC) and age at first kidding (AFK) were 399.52±79.29 and 539.83± 78.72 days, respectively (**Table** 3). Findings revealed that indigenous Khari breed conceives 38 and 85 days earlier for the first time as compared 50% and 75% Boer, respectively. Likewise, season of conception and season of kidding had no significant effect on AFC. However, season of conception had significant effect (p<0.05) on AFK with lower days for the dams that conceived during the autumn and summer seasons.

Table 3. Effect of non-genetic factors (Least square mean and Standard error of mean) on age of first conception (AFC) and age at first kidding (AFK) of does of Khari and Boer crossbred at NGRP, Bandipur, Tanahun

Factors	LS Mean ±SEM (days)		Number
	Age of first conception (AFC)	Age at first kidding (AFK)	
Overall Mean	399.52±79.29	539.83±78.72	160
Genetic Group	***	***	
Boer 75%	463.75±79.02a	605.96±78.45a	47
Boer 50%	386.46±81.69ab	525.60±81.10ab	69
Khari	348.34±82.73b	487.93±82.14b	44
Season of Conception	NS	*	
Spring	462.45±83.79	607.22±83.19a	41
Summer	394.48±92.19	531.33±91.53b	30
Autumn	324.82±92.77	465.49±92.1c	66
Winter	416.33±77.01	564.29±76.45a	23
Season of Kidding	NS	NS	
Spring	401.89±77.43	550.79±76.87	40
Summer	368.10±97.19	498.37±96.49	27
Autumn	383.56±90.26	516.65±89.61	37
Winter	444.53±79.04	593.52±78.47	56
CV	34.49	25.4	
R^2	0.168	0.175	

Note: *: Significant at 5% level (P<0.05); ***: Significant at 0.1% level (P<0.001); Means, within an effect, with the different superscript are significantly different; LS mean: Least square means; SEM: Standard error of Means; No: Number of observations; CV: Coefficient of variation; R^2: Coefficient of Determination

The effect of non-genetic factors such as genetic group, parity, season of conception on reproductive parameters (PPE, KI and GL) has been presented in Table 4. The results of this research revealed that the overall mean of PPE, KI and GL were 227.29±18.39, 376.07±18.50, and 149.86±0.29 days (Table 4). Findings thus, revealed that the genetic group has a significant effect (p<0.01) on these reproductive traits. Khari goat has earlier PPE days of 187 as compared to 218 and 277 days for 50% and 75% Boer crosses. In this study, the Khari goat has 28 and 85 days shorter KI than 50% and 75% Boer crosses respectively. (Table 4). GL was shorter for Khari and 75% Boer crossbred. Parity had no significant effect (p>0.05) on PPE, KI and GL. However, season of conception had a highly significant effect (p<0.001) on the PPE whereas season of conception and season of kidding had no significant effect on PPE but vary significantly different (p<0.05) for KI in this study.

Table 4. Effect of non-genetic factor on Post-partum Estrus (PPE), Kidding Interval (KI), and Gestation Length (GL) of Khari and Boer crossbred does in days at NGRP, Bandipur, Tanahun

Factors	LS Mean±SEM (days)		
	PPE	KI	GL
Overall	227.29±18.39 (258)	376.07±18.50 (258)	149.86±0.29 (426)
Genetic Group	***	***	**
Boer 75%	277.35±24.18a (96)	423.76±24.33a (96)	149.69±0.36b (144)
Boer 50%	217.91±20.82ab (107)	366.04±20.95ab (107)	150.56±0.39a (98)
Khari	186.62±27.96b (55)	338.42±27.96b (55)	149.32±0.31b (184)
Parity	NS	NS	NS
Early	223.81±17.56 (111)	373.63±17.66 (111)	150.25±0.19 (279)
Mid	231.30±16.51 (133)	379.94±16.60 (133)	150.02±0.26 (133)
Late	226.76±47.67 (14)	374.66±47.95 (14)	149.31±0.79 (14)
Season of Conception	NS	*	NS
Spring	257.94±27.83 (122)	411.65±27.99a (122)	150.28±0.41 (166)
Summer	213.16±35.16 (45)	358.78±35.37ab (45)	149.65±0.49 (78)
Autumn	261.26±33.35 (57)	407.41±33.55a (57)	149.67±0.45 (124)
Winter	176.80±34.49 (34)	326.45±34.69b (34)	149.84±0.49 (58)
Season of Kidding	NS	*	*

Factors	LS Mean±SEM (days)		
	PPE	KI	GL
Spring	271.52±33.50 (47)	422.11±33.70a (47)	150.31±0.45a (87)
Summer	203.54±32.53 (62)	346.96±32.72ab (62)	149.19±0.46b (91)
Autumn	166.92±32.34 (92)	310.64±32.73b (92)	149.15±0.47b (133)
Winter	267.18±31.06 (57)	424.58±31.25a (57)	150.78±0.42a(115)
CV	42.55	24.76	1.91
R^2	0.32	0.27	0.27

Note: *: Significant at 5% level (P<0.05); **: Significant at 1% level (P<0.01); ***: Significant at 0.1% level (P<0.001); NS: Non-significant at 5% level (P≥0.05); Means, within an effect, with the different superscript are significantly different; LS mean: Least square means; SEM: Standard error of Means; No: Number of observations, CV: Coefficient of variation

Effect of non-genetic factors on litter traits

In this study, the overall mean for liter size at birth and at weaning were 1.87±0.05 and 1.73±0.05 kids (**Table** 5). The effect of genetic group was found significant on LSB (p<0.01) and LSW (p<0.05) with higher litter size obtained for both birth (1.96) and weaning (1.84) for Khari goat breed as compared to 75% and 50% Boer crosses. Likewise, highly significant effect (p<0.001) of parity on LSB and LSW were observed in this study. However, there was no significant effect (p>0.05) of season of conception and season of kidding on LSB and LSW. Results of this research also revealed that the overall least square mean of litter weight at birth and litter weight at weaning were 4.20±0.15 and 23.69±0.87 kg, respectively. LWB and LWW differ significantly (p<0.001) for parity and higher at middle and later parities (**Table** 5).

Table 5. Effect of non-genetic factors on litter size and weight (kg) at birth and weaning (LS Mean±SEM) in number of Khari and Boer crossbred goat of NGRP, Bandipur, Tanahun

Factors	LSB	LSW	LWB	LWW
Overall	1.87±0.05 (426)	1.73±0.05 (394)	4.20±0.15 (426)	23.69±0.87 (394)
Genetic Group	**	*	**	NS
Boer 75%	1.86±0.06ab (144)	1.71±0.07ab (133)	4.36a±0.19 (144)	24.46±1.09 (133)
Boer 50%	1.79±0.07b (98)	1.64±0.07b (91)	4.47a±0.19 (98)	23.97±1.17 (91)
Khari	1.96±0.06a (184)	1.84±0.06a (170)	3.77b±0.16 (184)	22.66±0.93 (170)
Parity	***	**	***	***
Early	1.56±0.03b (279)	1.51±0.03b (258)	3.52±0.10a (279)	20.99±0.56c (258)
Mid	1.86±0.05ab (133)	1.77±0.05ab (123)	4.55±0.14a (133)	23.92±0.79b (123)
Late	2.19±0.14a (14)	2.91±0.15a (13)	4.55±0.40a (14)	26.18±2.35a (13)
Season of Conception	NS	NS	*	NS
Spring	2.00±0.07 (166)	1.82±0.08 (154)	4.67±0.21 (166)	25.08±1.23 (154)
Summer	1.89±0.08 (78)	1.80±0.09 (72)	4.25±0.25 (78)	24.87±1.46 (72)
Autumn	1.80±0.08 (124)	1.67±0.08 (115)	3.81±0.23 (124)	22.48±1.35 (124)
Winter	1.79±0.08 (58)	1.64±0.09 (53)	4.08±0.25 (58)	22.35±1.46 (58)
Season of Kidding	NS	NS	NS	NS
Spring	1.99±0.08 (87)	1.85±0.08 (81)	4.36±0.23 (87)	24.83±1.36 (81)
Summer	1.89±0.08 (91)	1.77±0.08 (84)	4.50±0.24 (91)	24.29±1.38 (84)
Autumn	1.76±0.08 (133)	1.63±0.09 (123)	3.82±0.24 (133)	22.41±1.41 (133)
Winter	1.84±0.07 (115)	1.66±0.08 (106)	4.59±0.22 (115)	23.25±1.27 (115)
CV	29.83	22.4	28.06	28.98
R^2	0.25	0.31	0.28	0.56

Note: *: Significant at 5% level (P<0.05); **: Significant at 1% level (P<0.01); ***: Significant at 0.1% level (P<0.001); NS: Non-significant at 5% level (P≥0.05); Means, within an effect, with the different superscript are significantly different; LS mean: Least square means; SEM: Standard error of Means; No: Number of observations, CV: Coefficient of variation

DISCUSSION

Poudel (2019) also reported higher weight of 3.30±0.06, 12.45±0.26, and 19.23±0.36 kg at birth, 2 months and 4 months, respectively for overall weight of Khari and Boer crosses. Bhattarai et al (2019) and Gautam (2017) had reported lower weights of kids as similar ages compared to the results of our study. The higher weight of the crossbred kids at birth, three and six months might be due to better adaptation of local genes to the environment affecting the growth performance as also reported by Teklebrhan (2018) and Ghimire et al (2020) in their earlier studies. Heavier weight in mid parities might be due to a well-established reproductive tract, good maternal ability, adequate milk production and uterine environment as dams mature which could well contribute to better growth and development of the kids (Gautum 2017, Bhattarai 2017, Deribe and Taye 2013, Pandey et al 2009 and Sodiq et al 2009) which degenerates as the dams get older (Simoes and Stilwell 2021).

Kids born during the autumn and winter months were heavier as dams might have access to sufficient nourishment through grazing throughout the spring season before they advance to the summer (Poudel 2019 and Gautam 2017). Higher weight of male kids compared to females might be due to dominating/aggressive behavior of males during feeding and suckling mother along with anabolic effect of male sex hormone as reported by various researchers (Ghimire et al 2020, Poudel 2019, Bhattarai 2017, Gautam 2017, Parajuli et al 2015 and Tudu et al 2015).

The kids during autumn season have access to sufficient green flush and nutritious feed and forages (NGRP 2021 and Poudel) which improved their daily weight gain and overall body weight at different stages of growth. Likewise, type of birth had significant effect at nine ($p<0.05$), twelve and fifteen ($p<0.01$) months of age and kids born single were heavier than those born twin and triplets. Males were heavier than females ($p<0.001$) during all stages of growth which is due to aggressive feeding behavior of males as they reach puberty (Poudel 2019 and Ghimire et al 2020).

The result observed in this study for AFC and AFK was almost similar to the findings reported by Pokharel and Khanal (2006), as 342.44±94.21 days in hill goats but Khari of Kaski and Syanjga district have different situation (234.10 days for age at first conception; Gautam 2017) and that of Lamjung was observed as 252 days (Rana et al 2022). Kolachhapati (2006), in his study reported that goats in Surkhet, Kavre and Udayapur, had earlier AFK i.e. 442.13, 320.41 and 405.00 days, respectively. Similarly, Rana et al (2022) recorded 403.9 days of KI in Khari goat of Lamjung. However, Pandey (2007) in the study on goat breeds found longer AFK for Khari breeds, 549.50±18.69; Khari-Jamunapari cross- 696.36±18.69, and Khari-Barbari cross- 588.05±18.69 days that slightly differed to the findings of our study. The lower days for AFK might be due to improvement in management practices (including feeding, vaccination, deworming etc) as reported in NGRP (2022).

Earlier PPE was reported also by Bhattarai et al (2022), Gautam (2017), and Bhattarai (2017). However, Gautam (2017) and Pandey (2007) in a study on Khari, Jamunapari crossbred, Barbari crossbred and Boer crossbred reported non-significant effect of breeds with PPE, KI and GL of this study is in line with research report of earlier researchers (Sapkota et al 2017 and Sapkota 2007). However, in a similar study, Gautam (2017), Bhattarai (2017), and Parajuli (2012) reported different level of significance ($p<0.05$, $p<0.01$ and $p<0.001$) of dam's parity on PPE. In addition, Sharma et al (2022), Bhattarai (2017) and Sapkota et al (2017) also obtained significant ($p<0.05$) effect of season of conception on PPE, KI, and GL.

The results of this study were obtained by Gautam (2017), Menezes et al (2016), and Rhone (2014) during their studies on Boer and Jamunapari crosses (1.76±0.08), Boer (1.7±0.66), and Boer-Spanish (1.70±0.05) respectively. Lower values of 1.43±0.04, 1.45±0.02, 1.51±0.05, and 1.63±0.06 for litter size at birth were obtained by Bhattarai et al (2022), Bhattarai et al (2017), Sharma et al (2017), and Sapkota (2007) on Khari × Boer goats, Khari, Khari goats, and Chitwan local goats, respectively contrasting results. Bhattarai et al (2022) while studying Khari and Boer crossbred; Gautam (2017) in a study on Khari and Khari-Jamunapari cross, Pandey (2007) in a study on Khari goat, Khari-Jamunapari cross and Khari-Barbari cross does, and Sapkota (2007) in research with does from multi-locations (Chitwan, Udayapur, Siraha and Tanhun districts) had reported significant effect ($p<0.05$) of season on LSB and LSW.

Bhattarai et al (2022) reported slightly higher litter weight at birth (5.16±0.11kg) and litter weight at weaning (28.00±0.68kg) than what we had found in this study. In contrast, several authors found lower LWB (3.97±0.06, 3.41±0.09, 3.03±0.07, and 3.14±0.12 kg by Bhattarai et al (2015) in hill goats. Bhattarai (2007) in terai goats, Pandey (2007) in hill goats and Sapkota (2007) in Chitwan local goats respectively) and LWW (18.21±0.34, 11.94±0.64 and 13.83±0.55 kg by Bhattarai et al (2015) in hill goats, Pandey (2007) in hill goats and Bhattarai (2007) in terai goats respectively)

The genetic group has significant effect ($p<0.01$) on LWB as observed by Bhattarai et al (2022), but not significant ($p>0.05$) on LWW as observed by Pandey (2007) while studying on Khari and crosses with Jamunapari and Barbari; and Shrestha (2002) while studying Terai and Barbari goats. Higher parities at later parities might be because of better reproductive efficiencies and well-developed reproductive system in later parities. But the effect of season of conception and season of kidding was reported non-significant with respect to LWB and LWW which is in line with findings of Bhattarai (2007), Pandey et al (2009), Sapkota et al (2008), Gautam (2017) and Bhattarai et al (2022).

CONCLUSION

Genetic group, parity, type of birth and sex are important non-genetic factor affecting growth performance of goats whereas genetic group and parity are the most important non genetic factors affecting reproduction and litter traits. Results of this research revealed that almost all of the phases of growth performances were observed better for 75% Boer crosses than 50% Boer cross and Khari. However, better reproduction parameters were recorded for Khari goat breed than 75% Boer and 50% Boer cross. Similarly, litter traits at both birth and weaning were observed better in later parities with better performance results in the Khari goat breed. Hence, based on the findings of this study, it can be concluded that the Khari goat breed has high potential for its growth, reproduction traits, and litter traits with a massive scope of improvement by following an appropriate selection procedure within the population and thus growth traits of inferior Khari goats can also be genetically improved through appropriate crossbreeding with for example, heavy breed, Boer by upgrading up to 75% blood level.

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