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Growth Performance in Boer × Black Bengal (BB) F_1 Goats and their Chevon Production Potential in Bangladesh

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ABSTRACT

The average least square means of birth weight, weight at 1-, 3-, 6- and 12-months were observed as 1.76 ± .06, 4.13 ± .15, 8.94 ±. 31, 13.81 ±. 53 and 23.23 ± 1.00 and 1.81 ±. 07, 4.02 ±. 15, 8.41 ± .35, 13.06 ± .51 and 26.51 ± .75 kg in male and female, respectively having insignificant sex difference (p<.05). ADG1 (birth-weaning) and ADG2 (weaning-six month) were found as 54.13 ± 2.65 and 54.30 ± 2.89 and 47.41±3.00 and 51.08±4.58 g/d in male and female, respectively. Both ADG did not differ (p>.05) between sexes. Sire, region, birth type, dam's parity and season of birth, birth type×kid sex and birth type×birth season impacted growth traits mostly in the earlier stages. Season of birth (p<.001) and its interaction with birth type (p<.05) affected 12-months body weight. Dam parity (p<.05) and birth type (p<.001) influenced ADG1 and sire (p<.05) and season of birth (p<.05) influenced ADG2. Only 5% of the F_1 does manifested behavioural oestrus within 1 year of age. Boer × BB F_1 crossbreds gained more than two times higher than BB goats under similar extensive management and environment. Since dams are BB, therefore, litter size remains unaffected. It suggests that goat farmers in Bangladesh can have more than two times higher benefit by producing this type of crossbreds. As sex of the kids does not affect body weight and body weight gain, animals of both sexes may be recommended for slaughter without further breeding.

HIGHLIGHTS

- Evaluation of growth performance of F_1 crossbreds.
- Determination of genetic and non-genetic factors affecting body weight and body weight gain at different ages.
- Exploration of more chevon production potential in Bangladseh.

Keywords: Boer, Black Bengal, crossbred, body weight, average daily gain

Goat is envisaged as the second important ruminant livestock species in Bangladesh. The country possesses 25.43 million goats (Chowdhury, 2018) of which around 90% belong to Black Bengal (BB) breed (Amin *et al.*, 2000; Amin, 2001; Amin, 2014; Akhtar, 2018; Chowdhury *et al*., 2015). Of them about 96% are being reared by medium, small and landless farmers (Faruque, 2006). Some 65% households are involved in goat keeping (Chowdhury *et al*., 2015). That's why goat is being aptly called "poor man's cow". There are currently 570 goat breeds in the world (Shrestha and Fahmy, 2005) and their distribution all over the globe was principally determined by zoo-ecological condition, farming system and market demand. Goat rearing is considered to be a dominant tool for poverty reduction and living insurance to the rural people in the country. Goat meat contributes 5% of total meat supply but it has got unique demand in religious festivals and socio-cultural occasions to prepare rich dishes (Amin, 2001; Chowdhury, 2015). Till now there is a wider gap between demand and supply of chevon in Bangladesh. BB is the only recognized goat breed in Bangladesh distributed all over the country (Amin, 2021;

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Amin, 2014). Despite having a number of desirable qualities in BB goat it suffers from lower birth weight, slower growth rate, higher pre-weaning kid mortality and inadequate milk production even not enough to nurse kids (Amin, 2001; Akhtar, 2018, Gond *et al.,* 2019). These lead to lower production efficiency that results in lower profit. In order to optimize profitability from goat farming BB goats need to breed differently to earn more profit in unit time. Enhancing growth rate particularly in the early life can largely contribute positively in the mature body weight of goat.

Boer is a very famous fast-growing meat type breed of goat originated in South Africa. The breed was developed with some infusion of blood of European, Angora and Indian goats synthesized in South Africa in 1900 (Bhattarai, 2019). In addition to higher growth rate (>300g/day) the breed has been noted for its high degree of fertility, conception rate (>90%), kidding rate (189%), fecundity rate (210%), weigh around 21 kg at weaning (at 120 day) and produces enough milk to nurse twins. In young stage it produces high quality lean meat and it has an average productive life span of 10 years (Malan, 2000). Because of its outstanding virtues, the breed quickly has been dispersed in many parts of the world such as Australia, New Zealand, USA, Malaysia, Indonesia, Sri Lanka, Nepal and many more. Since it's a fast-growing goat with superb feed efficiency, the animal of this breed necessitates intensive feeding and management which does not prevail in our farming system. We need something intermediate between Boer and BB. A crossbred evolved from Boer × BB might serve the purpose for semi-intensive goat farming in the country. Gond *et al.* (2019) demonstrated prospect of developing a crossbred derived from Boer and BB in Bihar, India. Indigenous goats graded by Boer were found to be a suitable alternative type for better production and reproduction in Nepal (Bhattarai, 2019; Parajuli, 2020). In Ethiopia Boer×Central Highland crossbreeding has been in practice to intensify goat production as an option to quickly increase goat productivity (Tesema *et al.,* 2021; Tesema *et al.,* 2022). This kind of crossing may be considered as crossbreeding for breed complementarity where a fast-growing efficiency, dressing % and mothering ability from Boer and prolificacy and carcass quality from BB will be complemented together (Simm, 2000). Since the growth is the principal trait for meat animal, therefore, the current investigation was designed to look into the effect of aforementioned crossbreeding across different fixed factors on the growth performance efficiency of F_1 progeny.

METHODOLOGY

For conducting the research three potential goat raising area at the vicinity of Mymensingh city in Bangladesh were chosen to replicate the trial. The areas were 1) Area-1 (Boyra, Brahmaputra riverside characterized by down town site, highly dense semi-pacca dwelling houses, house owners are lower class employees having mid-level education, often goats are kept in the same room where they live in), Area-2 (Digarkanda, Fakirakanda, Salakandi Characterized by rural area, farmers are mostly illiterate, having enough grazing facilities for the goats, no concentrate feed given to the goats), Area-3 (Mashkanda, Kewatkhali, Balashpur characterized by urban site, farmers have mid-level education, limited grazing land, provision of giving small quantity of concentrate to the goats). Goat farmers of these areas are small holders and keep few goats in their farms mostly in extensive or semi-extensive system. For each area more or less 50 healthy, well grown breedable BB does from farmers' flock were selected and ear tagged. Three mature 100% Boer bucks with sound breeding potential weighing 57-70 kg were procured from in-country reliable source and maintained at Bangladesh Agricultural University (BAU) to offer natural services. Each of the bucks was allowed to serve does from each of the three areas. Primiparous or multiparous does in estrus under this breeding program were bred. Does in field were maintained in such way so that health of the breeders can be kept optimum. A mating design was implemented to produce F_1 progeny from Boer♂ × BB♀ mating. All goats were vaccinated against *Paste des Petits Ruminants (PPR)* and dewormed using anthelmintic drug. Breeding records were kept in each of the does. Records on sex of the kids, litter size, season of birth, body weight in empty stomach (at birth, 1-month 3-month, 6-month, and 1 year), parity order of dam and mortality was recorded on progeny. Birth weight was recorded within 6 hours from birth. Live weight gains were calculated by subtracting initial live weight from final live weight divided by period in days and expressed in ADG. Male kids were castrated within one month of age to make them wether in order to have better carcass finishing. Live weight and live weight gain data were analyzed across area (3), sire (3), season of birth

(4) (winter: Dec-Feb, spring: Mar-May, summer: June-Aug, autumn: Sept-Nov), dam's parity (5) and sex of the kids (2) using R studio computer software to determine the significance of main fixed effects. Means, when effect was significant, were separated using Agricole in R package version 1.4.0 (Mendiburu and Yaseen, 2020). The linear statistical model used for analyzing body weight and live weigh gain data were

$$Y_{ijklmn} = \mu + SR_i + AR_j + SX_k + BT_l + SB_m + DP_n + (BT \times SX)_{lk} + (BT \times SB)_{lm} + e_{ijklmno}$$

Where

Y_{ijklmn} = Observation

μ = General mean

SR_i = Effect of sire

AR_j = Effect of area

SX_k = Effect of sex of the kids

BT_l = Effect of birth type

SB_m = Effect of season of birth

DP_n = Effect of dam parity

$(BT \times SX)_{kl}$ = Interaction effect between birth type and sex

$(BT \times SB)_{lm}$ = Interaction effect between birth type and season of birth

$e_{ijklmno}$ = Random error term

RESULTS AND DISCUSSION

Live weight

Birth weight (Bwt)

Bwt is an indicator of subsequent growth and is a determinant of survivability in kids in most of the cases. In the current investigation Bwt of F_1 kids was affected by area ($p<0.0001$), sire ($p<0.01$), season of birth ($p<0.05$), type of birth ($p<0.05$), dam parity ($p<0.0001$), birth type × sex ($p<0.05$) and birth type × season ($p<0.01$) but not sex of the kids ($p>0.05$) (Table 1). Mean Bwt of kids in area-3 was significantly ($p<0.05$) higher than in other two areas (Table 2). Area-3 is urban area where relatively feeding and management of the mother goats were better and that might be a cause of heavier Bwt in the progeny. Sire no 412 and 416 produced heavier ($p<0.05$) kids than sire no 413. This difference might be due to genetic variation in Transmitting ability of Boer bucks. Spring and summer born kids were heavier than those born in winter and autumn. Kids born from dams of parity 3 and 4 had highest Bwt than those of their counterpart seasons. Interaction effect between birth type × sex ($p<0.05$) and birth type×season of birth ($p<0.01$) were significant on Bwt (Table 1). Gond *et al.* (2019) in Bihar, India found mean Bwt of Boer×Black Bengal F_1 as 2.36 kg which is higher than that of the present findings. However, Paul *et al.* (2011) and Asad *et al.* (2020) recorded 1.08 and 1.10 kg Bwt respectively, in BB kids in Bangladesh which are much lower than present values.

Table 1: Main and interaction effect of different factors on live weight

Effect	Bwt	1 mwt	3 mwt	6 mwt	12 mwt
Area	***	**	NS	NS	NS
Sire	**	***	*	NS	NS
Season of birth	*	NS	*	*	**
Dam parity	***	***	***	**	NS
Sex of kid	NS	NS	NS	NS	NS
Birth type	*	*	**	***	NS
Birth type × Sex of kid	*	NS	NS	NS	NS
Birth type × Season of birth	**	NS	NS	*	*

*,p<0.05; **,p<0.01; ***,p<0.001; NS, Not significant (p>0.05).

1-month weight (1 mwt)

Live weight at 1 month significantly varied between area, dam parity ($p<0.0001$), sire ($p<0.01$) and birth type ($p<0.05$) but not between season of birth and kid sex ($p>0.05$). Interaction effects of birth type × sex and birth type×season of birth were insignificant ($p>0.05$) (Table 1). Table 2 exhibits body weight of kids attained at 1 month of age. Pattern of variation of 1 mwt due to area (3>2 = 1) and sire (465 > 412 = 413) were same as in Bwt. Unlike Bwt variation owing to birth season was insignificant ($p>0.05$). Of the 5 dam parities, maximum 1 mwt was found in kids of 3rd parity dam (4.54 ± .15 kg) and the kids

Table 2: Live weight of Boer ×Black Bengal F_1 crossbreds at different ages

	N	BWT	N	1 mwt	N	3 mwt	N	6 mwt	N	12 mwt
		Mean ± SE		**Mean ± SE**		**Mean ± SE**		**Mean ± SE**		**Mean± SE**
Area		***		**		NS		NS		NS
1	52	$1.641^{b}\pm.07$	37	$3.80^{b}\pm.150$	32	$8.57\pm.29$	20	$13.29\pm.52$	5	25.27 ± 1.51
2	64	$1.743^{b}\pm.06$	51	$3.96^{b}\pm.140$	42	$8.47\pm.35$	28	$13.82\pm.62$	18	25.93 ± 1.05
3	42	$2.023^{a}\pm.10$	30	$4.61^{a}\pm.270$	32	$9.18\pm.55$	24	$13.27\pm.76$	17	23.62 ± 1.00
Sire		**		***		*		NS		**NS**
412	36	$1.95^{a}\pm.08$	30	$4.23^{a}\pm.19$	30	$8.40^{b}\pm.29$	21	$13.64\pm.63$	12	24.51 ± 1.06
413	34	$1.74^{b}\pm.08$	30	$3.44^{b}\pm.14$	27	$7.99^{b}\pm.37$	17	$13.61\pm.76$	12	26.38 ± 1.36
416	88	$2.02^{a}\pm.07$	58	$4.32^{a}\pm.17$	49	$9.31^{a}\pm.41$	34	$13.33\pm.59$	16	23.74 ± 1.01
Season of birth		*		NS		*		*		**
Winter	70	$1.65^{b}\pm.07$	49	$4.05\pm.18$	37	$8.79^{a}\pm.53$	37	$14.28^{ab}\pm1.06$	20	—
Spring	45	$1.95^{a}\pm.09$	38	$4.09\pm.19$	36	$9.21^{a}\pm.26$	36	$12.84^{bc}\pm.35$	8	$23.34^{b}\pm.77$
Summer	17	$2.13^{a}\pm.10$	7	$4.75\pm.55$	11	$7.40^{b}\pm.70$	11	$11.95^{c}\pm1.01$	12	$23.67^{b}\pm1.52$
Autumn	26	$1.64^{b}\pm.09$	24	$3.92\pm.18$	22	$8.43^{ab}\pm.34$	22	$14.33^{a}\pm6.75$		$28.22^{a}\pm1.08$
Dam's parity		***		***		***		**		NS
1	22	$1.52^{c}\pm.15$	16	$3.58^{b}\pm.33$	15	$8.59^{b}\pm.65$	9	$12.44^{b}\pm.65$		—
2	49	$1.69^{bc}\pm.07$	36	$3.83^{b}\pm.19$	33	$8.00^{b}\pm.37$	27	$12.25^{b}\pm.49$	19	$24.49\pm.96$
3	54	$1.96^{a}\pm.11$	43	$4.54^{a}\pm.15$	38	$9.10^{a}\pm.33$	25	$15.33^{a}\pm.65$	14	24.48 ± 1.00
4	28	$1.88^{ab}\pm.09$	19	$3.10^{b}\pm28$	16	$7.79^{b}\pm.65$	9	$13.88^{ab}\pm1.25$	7	24.48 ± 1.00
5	5	$1.39^{c}\pm.23$	4	$3.66^{b}\pm.19$	4	$6.62^{b}\pm.38$	2	$13.88^{ab}\pm1.25$		
Birth type		*		*		**		***		NS
1	18	$2.23^{a}\pm.132$	13	$5.02^{a}\pm.342$	12	$10.77^{a}\pm.68$	9	$15.13^{a}\pm1.51$	4	25.58 ± 2.26
2	88	$1.81^{b}\pm.64$	71	$4.11^{b}\pm.122$	71	$8.55^{b}\pm.27$	45	$15.13^{a}\pm1.51$	22	24.29 ± 8.4
3	44	$1.65^{b}\pm.67$	29	$3.68^{c}\pm.232$	18	$8.81^{b}\pm.47$	16	$14.66^{a}\pm.77$	14	25.571 ± 1.29
4	4	$1.36^{bc}\pm.58$	2	$2.95^{c}\pm.405$	2	$4.61^{c}\pm.59$		—		—
5	4	$1.16^{c}\pm.30$	3	$3.85^{bc}\pm.617$	3	$6.45^{bc}\pm.48$	2	$10.10^{b}\pm0.00$		—
Sex		NS		NS		NS		NS		NS
Male	78	$1.81\pm.07$	53	$4.02\pm.15$	45	$8.41\pm.35$	31	$13.06\pm.51$	20	$26.51\pm.75$
Female	80	$1.76\pm.06$	65	$4.13\pm.15$	61	$8.94\pm.31$	41	$13.81\pm.53$	20	23.23 ± 1.00

*,p<0.05; **,p<0.01; ***,p<0.001; NS, Not significant (p>0.05).

of remaining parities did not differ significantly (p>0.05). Single born kids weighed heaviest of all like Bwt and triplets, tetralets and pentalets stood lowest in rank with insignificant difference (p>0.05) between them. The latter group, however, had very limited number of replicates. No interaction effect was significant (p>0.05). Literature available to compare the present results was very scanty.

3-month weight (3 mwt)

Three months is considered as weaning age of kids after which kids become independent. Effect of area, kid sex and birth type×sex and birth type×season of birth interaction effects were insignificant (p>0.05) on 3 mwt (Table 1). Similar to previous records, kids of sire no 416 weighed heavier (p<0.05) than those of its counterparts. Spring, winter and autumn born kids had higher (p<0.05) 3mwt than those born in summer. Mimic to previous live weights dams of 3rd parity produced significantly kids with higher (p<0.05) 3 mwt than kids born in other parities of dam. It demonstrates that does of mid age are the best in giving heaviest kids at weaning. This might be attributed by age-related better mothering ability including higher milk production of dams. Of birth type, like live weight of previous stages single born kids were heavier followed by those of multiple birth. Highest Bwt, 1 mwt and better gain in single born kids might resulted in heavier 3 mwt. Paul *et al.* (2011) and Asad *et al.* (2020) noted that at 3-month, BB kids weighed 5.22 and 5.02 kg respectively. It highlights that at the same age Boer × BB F_1 kids grow faster and gain body weight at weaning nearly two times than in BB kids (Table 2).

6-month weight (6 mwt)

6 mwt of crossbred kids differed between season of birth (p<0.05), parity of dam (p<0.001) and type of birth (p<0.001) only. Autumn (14.33 kg) and winter (14.28 kg) born kids weighed highest than their counterparts. Summer born kids weighed lowest at this stage. Commercial farmers can breed their does considering birth season to have heavier kids. Asad *et al.* (2020), however, observed that summer born BB kids weigh heavier than winter and rainy season born BB kids in Bangladesh which contradicts with present findings. This difference might be attributed to difference in management and feeding along with gene-environment interaction. Single, twins and triplets had similar (p>0.05) live weight but higher than pentalets although pentalets had only 2 observations in the same farm. Data on tetralets were missing. It suggests that effect of birth type diminishes at this age. Siddiqa and Amin (2009) found 6 mwt of BB goats to be varied between 5.97 and 6.73 kg in Bangladesh which are less than half of F_1 crossbred in question. Asad *et al.* (2020) mentioned body weight of BB kids at 6 month to be ranked as single > twin > triplet showing significant effect of birth type which contradicts with present findings. However, a mean value (13.8 kg) of 6 months body weight closer to the current mean was recorded by Tesema *et al.* (2021) in Boer×Central Highland F_1 crossbreds in Ethiopia.

12-month weight (12 mwt)

Age at 12 months of goat in most breeds is said to be mature or slaughter age. Area, sire, parity of dam, sex of the kids and birth type did not have any significant (p>0.05) effect on 12-month body weight. It signifies that most of the non-genetic effects minimized when the animal reaches maturity. However, autumn born kids acquired maximum (p<0.05) body weight (28.22±1.08 kg) relative to kids born in spring (23.34±.77 kg) and summer (23.67±1.52 kg). Asad *et al*. (2020), on the contrary, reported that summer born BB kids weighed heavier than kids born in winter and rainy season in Bangladesh. Difference in 12 mwt (also in previous stages) in male and female was insignificant (p>0.05) although males were numerically 3.28 kg heavier. Siddiqua and Amin (2009) working with live weight in BB goats of different regions of Bangladesh having different types of coat color reported that 12 mwt of BB goats ranged from 12.74 to 13.95 kg which are around half of that of crossbreds at the same age. A lower body size of Boer × Central Highland F_1 cross at 12 months of age was mentioned by Tesema *et al.* (2021) in Ethiopia and the weight averaged at 20.5 kg.

Pre- and post-weaning growth rate

Both ADG1 (pre-weaning) and ADG2 (post-weaning) varied in erratic fashion between different levels of each of the fixed effects. ADG2 of progeny of sire 416 was lowest (p>0.05) despite those born with heaviest body weight (Table 2, Table 3).

Table 3: Average daily gain (ADG) as affected by different genetic and non-genetic factors

Sources of variation	N	ADG1 (Mean ± SE)	N	ADG2 (Mean ± SE)
Region		NS		NS
1	32	51.56±2.41	21	47.91±4.65
2	41	52.57±3.46	29	54.40±5.34
3	34	55.01±4.23	23	44.86±4.73
Sire		NS		*
412	30	49.36±2.33	21	56.45^{a}±6.00
413	27	51.45±4.66	17	57.98^{a}±5.43
416	50	56.11±3.19	35	41.26^{b}±3.79
Birth season		NS		*
Winter	36	55.02±4.29	18	55.23^{b}±5.72
Spring	36	55.79±2.46	28	36.22^{c}±3.66
Summer	13	45.86±7.04	9	41.04^{bc}±6.88
Autumn	22	49.55± 3.58	18	68.75^{a}±5.24
Dam parity		*		NS
1	15	59.31^{a}±6.38	9	42.51±3.78
2	32	51.09^{ab}±2.99	28	47.87±5.04
3	38	58.77^{a}±2.93	25	51.56±4.78

4	18	43.69[b]±5.95	9	57.17±11.59
5	4	32.83[b]±5.10	2	45.69±2.08
Birth type		**		NS
1	12	64.38[a]±5.06	9	30.07±8.18
2	72	51.45[b]±3.48	45	49.60±3.36
3	18	59.73[bc]±3.73	17	60.08±6.82
4	2	18.39[c]±2.06	—	—
5	3	28.97[c]±4.69	2	45.69±2.08
Sex		NS		NS
Male	45	54.13±2.65	31	47.41±3.00
Female	62	54.30±2.89	42	51.08±4.58
BT*Sex		0.919699		0.05199
BS*BT		0.59247		0.63755

*,p<0.05; **,p<0.01; ***,p<0.001; NS, Not significant (p>0.05).
ADG1 = Pre-weaning daily gain (birth-3 month); ADG2 = Post-weaning daily gain (3-6 month).

Like body weight, sex of kids had no significant (p>0.05) effect on ADG. Highest and lowest (p<0.05) ADG2 were observed in kids born in autumn and spring season respectively. Of five parities, kids from first three dam parities grew with higher (p<0.05) ADG1 than those born in fourth and fifth parities. This effect did not sustain in ADG2. Interaction effect between birth type and sex and birth season and birth type were insignificant (p>0.05) (Table 3). Solaiman *et al.* (2020) noted ADG1 and ADG2 in BB goats and the figures averaged at 45.89 and 43.44 and 41.89 and 33.89 g/d for male and female respectively and they found that males grew significantly (p<0.05) at higher rate than females which contradicts with the result of current study. Although owing to great variation in sample size there was much variation in average ADG but most of the values were higher in the present crossbreds than those mentioned by Solaiman *et al.* (2020) for pure BB goats.

Attainment of puberty in crossbred does

Out of 20 only 5 (25%) does manifested behavioural oestrus (not shown in Table) within one year of age suggesting that they require much longer time in showing first oestrus than BB does which require an average age of 6 months only.

CONCLUSION

Results revealed that Boer × BB crossbreds acquire more than 2 times yearling live weight than BB at the same age under extensive management irrespective of sex. Sex differences in yearling weight as well as in average daily gain were insignificant (p<0.05). Crossbred does exhibited delayed sexual maturity compared to BB dictating that further breeding of F_1 cross may not be profitable. Considering the facts, 100% Boer × BB F_1 crossbreds of either sex can be utilized in commercial venture for sacrificial purpose. Higher probable dressing percentage in the crossbreds may be an added advantage although further researches are required to confirm the hypothesis. Breeding companies, meat marketing agencies or NGOs can produce large number crossbreds through contact farming system involving community growers to boost up goat meat production in Bangladesh.

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