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Performance evaluation of Indigenous and Garole crossbred sheep (F_1) under semi-intensive management system

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ABSTRACT

A crossbreeding program was sought to enhance the genetic attributes of coastal sheep by mating them with Garole rams. The breeding program involved a combination of two male Garole with a group of twenty indigenous ewes. These sheep were permitted to mate naturally, without external intervention. Data collection focused on key metrics like birth weight (kg lamb^{-1}), litter size, sex of lambs, instances of dystocia, weaning weight (kg lamb^{-1}), weaning age (days), body weight (kg), age at puberty (days), and mortality rates (%). Crossbred male lambs had an average birth weight of 1.48±0.12 kg, while female lambs averaged 1.57±0.10 kg. Male to female ratio among crossbred lambs was 54.1% to 45.9%. As for weaning, males and females averaged 151.92±2.24 days and 144.00±4.20 days, respectively, with respective weaning weights of 7.98±0.85 kg for males and 8.31±0.90 kg for females. Between 30 and 60 days, male and female lambs gained at 50.16±5.94 g day^{-1} and 51.44±7.82 g day^{-1}, respectively. Between 331 and 360 days, growth rates were 15.33±3.84 g day^{-1} and 22.33±6.00 g day^{-1} for males and females respectively. Dystocia, or difficult births, occurred in 75% of cases. There was no mortality for male lambs, but female lambs experienced a 20% mortality rate. Crossbreeding has emerged as a viable strategy for increasing meat production due to enhanced growth rates and their adaptability to certain environments. It can be concluded that crossbreeding of indigenous coastal sheep with Garole ram can be carried out to increase body weight and ADG.

Introduction

The sheep holds significant value as a farm animal in Bangladesh and it serves as a crucial source of revenue and food, while also impacting the socio-economic status of poor farmers (Hossain et al., 2023; Sarker et al., 2017). Currently, sheep population in Bangladesh has reached approximately 3.827 million, and this population has increased by 16.23% over the past nine years (DLS, 2023). Sheep husbandry makes a substantial economic contribution to Bangladesh by not only helping to provide animal protein but also by empowering women and reducing poverty (Islam et al., 2021). The majority of sheep in Bangladesh belong to the non-descript indigenous population, with a few crossbred individuals (Asaduzzaman et al., 2020). Three distinct varieties of indigenous sheep can be identified based on factors such as concentration, morphology, production, and reproduction performance: Coastal, Barind, and Jamuna River Basin (Hassan and Talukder, 2011; Pervage et al., 2009). Apart from native sheep, the Garole breed is also widely distributed in the nearby regions of Bangladesh's Sundarban delta area and the Indian

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state of West Bengal (Khan et al., 2009; Mukesh et al., 2006). According to Islam et al. (2018), the primary grazing sites for the indigenous sheep of the coastal regions are damp and salted. Thirty percent of their coat color is white-brown and seventy percent are white (Hassan and Talukder, 2011). The wool of indigenous coastal sheep on the forehead, legs, and abdomen is shorter and sparser than that of the Barind sheep and the Jamuna basin. The ram's horn of indigenous coastal sheep is only slightly bent backward (Islam et al., 2018). On the other hand, the popular Indian exotic sheep known as "Garole" is currently flourishing in Bangladesh. In marshy areas, Garole sheep may graze in water up to their knees (Khan et al., 2009). The Garole sheep is a small-sized breed that have a compact, square body and a short stature. Its head is small and straight. Head is positioned slightly higher than the body which results in a triangular appearance when viewed from the front. While males of the Garole sheep breed usually have horns, females are typically polled (Sahana et al., 2001). Garole has been suggested to be a source of the Booroola gene (FecB gene), which gives sheep their high rate of prolificacy (Ghalsasi and Nimbkar, 1993). On an average, male lambs attain puberty at the age of 8-9 months (Roy et al., 2023). Crossbreeding in animals can provide advantages such as increased feed efficiency and better performance. Microsatellite markers were used in a study to investigate the genetic links between the indigenous sheep populations of Bangladesh, which include the Barind, Jamuna river basin, coastal, and Garole sheep. According to Deb et al. (2019), it was discovered that the genetic distance between Barind and the Jamuna river basin sheep was the greatest, while that between Garole and Coastal sheep was the lowest. Small ruminant production has the potential to address the worldwide challenge of significantly boosting food production in rural disadvantaged areas in a way that is carbon-efficient and socioeconomically sustainable (Lalljee et al., 2019). Therefore, this study aims to investigate the performance of F_1 generation of indigenous crossbred sheep which will help to understand its full utility.

Materials and Methods

Site of the experiment

The study was carried out at Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, Khulna University, Bangladesh. The experimental site is located in the Agro-Ecological Zone (AEZ) of the Ganges Tidal Flood Plain. The research unit's latitude and longitude are 22º80' N and 89º53' E.

Indigenous female sheep (ewe)

Twenty indigenous female sheep were procured from southwestern coastal regions before its first lambing. The ages of female sheep were between 4 to 6 months.

Garole male sheep (ram)

Two Garole male sheep was procured from Chuadunga district to carry out the crossbreeding program. Chuadanga was selected to procure the Garole sheep as Chuadunga and Meherpur regions are considered native territory to Garole sheep. The area was selected to procure the Garole sheep to ensure high genetic purity as most famers often lack proper pedigree records. Also, it was bought from a reliable source. The age of the male sheep was between 8 to 10 months.

Housing and management of sheep

The experimental sheep were housed in wooden slatted flooring system where gaps between the wooden pieces to allowed sheep manure to fall onto the floor. There were adequate ventilation systems in the sheep shed. Regular cleanings were done for the waterer, feeder, and shed. All sheep were provided similar environment and facilities. It also minimizes variations which can affect research results. Sheep house was located near the pastures. Washing was done at a regular interval for the removal of any waste materials and dung, to eradicate ectoparasites such as lice and ticks. The shed, feeder and waterer were cleaned regularly.

Feeding and Nutrition

Sheep were permitted to graze on the Khulna University campus's playground, roadsides, and field laboratory of the Agrotechnology Discipline. Sheep were let out at eight in the morning and taken in at six in the evening. Every sheep had *ad libitum* access to clean drinking water.

Vaccination and healthcare

Following collection, experimental sheep underwent deworming, which was repeated every three months using an anthelminthic injection (A-mectin plus). Every sheep received vaccinations against the infectious diseases listed in Table 1.

Table 1. Vaccination/medication schedule

Name of vaccine/medicine	Dose	Route	First Dose	Interval
A-mectin plus (Deworming)	1.0 ml/50kg body weight	Sub-cutaneous	8 weeks of age follow up booster dose at 3 months	3 months
Peste des petits ruminants (PPR)	1.0 ml/sheep	Sub-cutaneous	4 months of age	6 months

Crossbreeding

To improve the genetic potentials of coastal sheep, intensive cross-breeding programs continued throughout the year. Natural breeding program has been practiced randomly among the males and females. The dates of insemination and estrus have been noted in a registrar.

Data collection and analysis

Data for different production and reproductive traits were kept regularly. Collected data included birth weight (kg $lamb^{-1}$), litter size, sex of lambs, weaning weight (kg/lamb), weaning age (days), body weight (kg), age at puberty (days), gestation period (days), age at first lambing (days), post-partum weight of ewes (kg), post-partum heat period (days), lambing interval (days), dystocia problem (difficult birth) and mortality (%). Every two weeks, in the morning, body weight measurements were taken before letting the animals to graze. Growth rates were computed as g day^{-1}, subtracting previous weight from current weight and divided by the number of days in the period. The data were recorded in a register. Data were analyzed using SPSS computer program.

Results

Sex ratio of crossbred lambs (F_1)

The male and female ratio for crossbred lambs were 54.1 and 45.9 per cent, respectively (Table 2). The results revealed that the occurrence of male lambs was little higher than female.

Table 2. Male female ratio of lambs in first generation (F_1)

Sex of crossbred lambs	Frequency	Percent
Male	20	54.1
Female	17	45.9
Total	37	100.0

Performance of crossbred lambs (F_1) from birth to weaning

The study measured various parameters of crossbred lambs (F_1), including birth weight, weaning age, weaning weight, age at puberty, and weight at puberty which are shown in Table 3. Birth weights were observed to be 1.48kg ± 0.24 for males (n=20), 1.57kg ± 0.10 for females (n=17) with an overall mean of 1.52kg ± 0.08 (n=37). The weaning age was recorded 151.92 days ± 2.24 for males (n=12), 144 days ± 4.20 for females (n=8), with an overall mean of 148.75 days ± 2.27 (n=20). Average weaning weight was 7.98kg ± 0.85 per male lamb (n=12), 8.31kg ± 0.90 per female lamb (n=8), and an overall mean of 8.12kg ± 0.61 (n=20). Age at puberty was found to be 271.11 days ± 7.43 for males (n=9) and 279.80 days ± 3.97 for females (n=5) with an overall mean age of 274.21 days ± 4.99 (n=14). The weight at puberty was 12.13kg ± 0.84 for males (n=9), 11.71kg ± 1.18 for females (n=5) with an overall mean of 11.98kg ± 0.66 (n=14).

Table 3. Birth weight, age and weight at weaning and puberty of crossbred lambs (F_1)

Parameters	Mean±SEM		
	Male	Female	Overall
Birth weight (kg)	1.48±0.24 (20)	1.57±0.10 (17)	1.52±0.08 (37)
Weaning age (day)	151.92±2.24 (12)	144.00±4.20 (8)	148.75±2.27 (20)
Weaning weight (kg $lamb^{-1}$)	7.98±0.85 (12)	8.31±0.90 (8)	8.12±0.61 (20)
Age at puberty (days)	271.11±7.43 (9)	279.80±3.97 (5)	274.21±4.99 (14)
Weight at puberty (kg $lamb^{-1}$)	12.13±0.84 (9)	11.71±1.18 (5)	11.98±0.66 (14)

The figures within the parenthesis indicate the number of observations.

Reproductive performance of crossbred sheep (F_1)

Table 4 provides reproductive parameters of crossbred sheep. Average litter size was 1.40 ± 0.11. The number of services per conception was 1.30 ± 0.15. Gestation length was 147.70 days ± 0.63. The age at first lambing was 361.40 days ± 18.91. The observed post-partum lambing weight of ewes 11.71kg ± 0.26. The post-partum heat period was 77.60 days ± 6.67, and the lambing interval was 229.90 days ± 10.30.

Table 4. Reproductive performance of crossbred sheep

Parameters for sheep	**Mean ± SE**
Litter size	1.40±0.11
No. of services per conception	1.30±0.15
Gestation period (d)	147.70±0.63
Age at first lambing (d)	361.40±18.91
Post-partum weight of ewes (kg)	11.71±0.26
Post-partum heat period (d)	77.60±6.67
Lambing interval (d)	229.90±10.30

Body weight of crossbred lambs (F_1)

Body weight of crossbred sheep at different ages are showed in Table 5. At 30 days of age, males weighed to be 3.30kg ± 0.37 (n=19) and females 3.28kg ± 0.25 (n=17), with an overall mean of 3.29kg ± 0.17 (n=36). At 60 days, the weights were 4.78kg ± 0.59 (n=14) for males and 4.88kg ± 0.45 (n=16) for females, with an overall average of 4.83kg ± 0.28 (n=35). By 90 days, males weighed 6.07kg ± 0.76 (n=13) and females 6.36kg ± 0.65 (n=12), with a combined mean of 6.20kg ± 0.43 (n=26). At 120 days, the weights were 7.30kg ± 0.77 (n=13) for males and 7.93kg ± 0.79 (n=9) for females, overall weight was 7.55kg ± 0.55 (n=22). At 150 days, males had a weight of 7.90kg ± 0.90 (n=12) and females 8.48kg ± 0.77 (n=9), with an overall mean of 8.13kg ± 0.55 (n=22). By 180 days, males weighed 8.96kg ± 0.82 (n=12) and females 9.45kg ± 0.78 (n=8), resulting in an overall mean of 9.15kg ± 0.61 (n=20). At 210 days, males weighted 10.20kg ± 0.75 (n=12) and females 10.01kg ±0.95 (n=6), with an overall mean of 10.13kg ± 0.61 (n=18). At 240 days, the weights were 11.27kg ± 0.75 (n=12) for males and 10.50kg ± 0.99 (n=6) for females, overall weight was 11.01kg ± 0.59 (n=18). At 270 days, males weighed 12.18kg ± 0.70 (n=11) and females 10.96kg ± 1.38 (n=5), with an overall mean of 11.79kg ± 0.64 (n=16). At 300 days, the weights were 12.80kg ± 0.82 kg (n=10) for males and 12.15kg ±1.48 (n=4) for females, leading to an overall of 12.61kg ± 0.70 weight (n=14). At 330 days, males averaged 13.31kg ± 0.94 (n=9) and females 14.11kg ± 2.44 (n=2), with an overall mean of 13.46kg ± 0.83 (n=11). At 360 days, males weighed 13.60kg ± 1.13 (n=8) and females 14.98kg ± 2.68 (n=2), resulting in an overall weight of 13.88kg ± 0.99 (n=10).

Table 5. Body weight (kg) of crossbred sheep (F_1) at different ages

Age (d)	Mean±SEM		
	Male	Female	Overall
30	3.30±0.37 (19)	3.28±0.25 (17)	3.29±0.17 (36)
60	4.78± 0.59 (14)	4.88±0.45 (16)	4.83±0.28 (35)
90	6.07±0.76 (13)	6.36±0.65 (12)	6.20±0.43 (26)
120	7.30±0.77 (13)	7.93±0.79 (9)	7.55±0.55 (22)
150	7.90±0.90 (12)	8.48±0.77 (9)	8.13±0.55 (22)
180	8.96±0.82 (12)	9.45±0.78 (8)	9.15±0.61 (20)
210	10.20± 0.75 (12)	10.01±0.95 (6)	10.13±0.61 (18)
240	11.27±0.75 (12)	10.50±0.99 (6)	11.01±0.59 (18)
270	12.18±0.70 (11)	10.96±1.38 (5)	11.79±0.64 (16)
300	12.80±0.82 (10)	12.15±1.48 (4)	12.61±0.70 (14)
330	13.31±0.94 (9)	14.11±2.44 (2)	13.46±0.83 (11)
360	13.60±1.13 (8)	14.98±2.68 (2)	13.88±0.99 (10)

The figures within the parenthesis indicate the number of observations.

Average daily gain of crossbred lambs (F_1)

Table 6 shows average daily gain (ADG) of crossbred sheep (F_1) across various age categories. From 30 to 60 days of age, male lambs had an ADG of 50.16 ± 5.94 g day^{-1} (n=18), while females had 51.44 ± 7.82 g day^{-1} (n=16), resulting in an overall mean of 50.76 ± 4.77 g day^{-1} (n=34). Between 61 and 90 days, males gained 37.78 ± 6.47 g day^{-1} (n=14), females 34.80 ± 6.87 g day^{-1} (n=12), with an overall mean of 36.41 ± 4.63 g day^{-1} (n=26). From 91 to 120 days, males showed an ADG of 14.04 ± 2.22 g day^{-1} (n=13) and females 10.81 ± 2.32 g day^{-1} (n=10), averaging 12.64 ± 1.61 g day^{-1} (n=23) overall. In the 121 to 150 days age range, males gained 37.23 ± 5.14 g day^{-1} (n=12) and females 27.96 ±5 .45 g day^{-1} (n=10), with an overall mean of 33.01 ± 3.79 g day^{-1} (n=22). From 151 to 180 days, male lambs had an ADG of 39.23 ± 3.10 g day^{-1} (n=12) and females 28.19 ± 6.43 g day^{-1} (n=6), averaging 35.55 ± 3.13 g day^{-1} (n=18) overall. Between 181 and 210 days, males gained 38.79 ± 5.40 g day^{-1} (n=12) and females 27.67 ±1 0.26 g day^{-1} (n=4), with an overall mean of 36.01 ± 4.78 g day^{-1} (n=16). In the 211 to 240 days, males had an ADG of 41.91 ± 7.57 g day^{-1} (n=11), females 23.14 ± 8.86 g day^{-1} (n=5), gaining 36.04 ± 6.15 g day^{-1} (n=16) overall. From 241 to 270 days, male lambs showed an ADG of 30.73 ± 9.11 g day^{-1} (n=11) and females 26.20 ± 11.36 g day^{-1} (n=5), with an overall mean of 29.32 ± 7.01 g day^{-1} (n=16). In the 271 to 300 days age range, males gained 18.37 ± 3.13 g day^{-1} (n=9) and females 16.17 ± 1.50 g day^{-1} (n=2), resulting in an overall average of 17.97 ± 2.55 g day^{-1} (n=11). From 301 to 330 days, male lambs had an ADG of 17.33 ± 3.67 g day^{-1} (n=8) and females 30.17 ± 3.50 g day^{-1} (n=2), with an overall mean of 19.90 ± 3.40 g day^{-1} (n=10). Between 331 and 360 days, males showed an ADG of 15.33 ± 3.84 g day^{-1} (n=4) and females 22.33±6.00 g day^{-1} (n=2), resulting in an overall mean of 17.67±3.24 g day^{-1} (n=6). Across all age categories, the total average daily gain was 30.99±5.05 g day^{-1} for males, 27.17±6.40 g day^{-1} for females, and an overall mean of 29.57±4.10 g day^{-1}.

Table 6. Average daily gain (g day^{-1}) of crossbred sheep (F_1) at different age categories

Age categories	Mean±SEM		
	Male	Female	Overall
30 to 60 days of age	50.16±5.94 (18)	51.44±7.82 (16)	50.76±4.77 (34)
61 to 90 days of age	37.78±6.47 (14)	34.80±6.87 (12)	36.41±4.63 (26)
91 to 120 days of age	14.04±2.22 (13)	10.81±2.32 (10)	12.64±1.61 (23)
121 to 150 days of age	37.23±5.14 (12)	27.96±5.45 (10)	33.01±3.79 (22)
151 to 180 days of age	39.23±3.10 (12)	28.19±6.43 (6)	35.55±3.13 (18)
181 to 210 days of age	38.79±5.40 (12)	27.67±10.26 (4)	36.01±4.78 (16)
211 to 240 days of age	41.91±7.57 (11)	23.14±8.86 (5)	36.04±6.15 (16)
241 to 270 days of age	30.73±9.11 (11)	26.20±11.36 (5)	29.32±7.01 (16)
271 to 300 days of age	18.37±3.13 (9)	16.17±1.50 (2)	17.97±2.55 (11)
301 to 330 days of age	17.33±3.67 (8)	30.17±3.50 (2)	19.90±3.40 (10)
331 to 360 days of age	15.33±3.84 (4)	22.33±6.00 (2)	17.67±3.24 (6)

The figures within the parenthesis indicate the number of observations.

Incidence of dystocia

Incidence of dystocia is shown is Table 7. Among the experimented sheep, it was observed that dystocia occurred in 75.0% of the cases (n=15). In contrast, 25.0% of the cases (n=5) did not experience dystocia.

Table 7. Incidence of dystocia

Incidence of dystocia	Frequency	Percent
Occurring of dystocia	15	75.0
No occurring of dystocia	5	25.0
Total	20	100.0

Lambs' mortality

Mortality of the crossbred lambs are shown in Table 8. For male lambs, there were no recorded cases of mortality, resulting in a 0% mortality rate, while the survivability rate was 100% with all 12 male lambs surviving. In contrast, female lambs showed a mortality rate of 20%, with 2 out of 10 lambs not surviving, and a survivability rate of 80%.

Table 8. Mortality of crossbred lambs

Sex of the lambs		Frequency	Percent
Male	Mortality	0	0
	Survivability	12	100.0
Female	Mortality	2	20.0
	Survivability	8	80.0

Discussion

Sex ratio

An investigation revealed that the sex ratio among Jamuna Basin Indigenous sheep was 41.9% male and 58.1% female, whereas the Muzaffarnagari cross sheep had a sex ratio of 58.9% male to 41% female and in the present findings it was observed that there were some similarities with the Muzaffarnagari cross sheep as it also showed to have higher percentage of male (Asaduzzaman et al., 2020). However, the 41.9% male lambs in the Jamuna Basin Indigenous sheep which was inconsistent with the results of our study. This difference can be attributed to litter size as a study which was done over six consecutive lambing seasons of a commercial flock of Suffolk crossbred sheep analyzed the birth sex ratio among 1,820 lambs. Proportion of male lambs was 49.56%, indicating a nearly even split between males and females. However, while examining ewes with single lambs it was also found that the proportion of male offspring was significantly higher (56.23%). This trend shifted with same-sex twins and triplets. The percentage of male lambs dropped to 47.73% and 41.79%, respectively. These findings suggest that the number of lambs per birth influences the sex ratio. Larger litters tending to have fewer males (Kent, 1992).

Performance of crossbred lambs (F_1) from birth to weaning

According to Asaduzzaman et al. (2020) birth weights of Jamuna Basin Indigenous sheep were 1.34kg ± 0.06 and 1.08kg ± 0.06 for of male and female respectively and in Muzaffarnagari crossbred sheep it was 2.82kg ± 0.06 and 2.61kg ± 0.06 for male and female respectively. Present study found higher birth weight of crossbred sheep than Jamuna Basin Indigenous sheep and lower than Muzaffarnagari cross sheep. Another investigation (Sultana et al., 2011) found birth weight for Bengal sheep in semi-intensive and intensive condition was 1.56kg and 1.60kg, respectively, which is similar to our results. According to Hossain et al. (2020) birth weight of indigenous sheep was ranged from 1.07 to 1.65 kg and the present findings showed results within this range. In a different investigation by Islam et al. (2018), mean birth weight of indigenous sheep was 1.04kg ± 0.01 which is lower than current findings. Pervage et al. (2009) demonstrated that the birth weights of male sheep from BLRI, Jamuna, Barind and Costal region were 1.36kg ± 0.07, 1.34kg ± 0.07, 1.33kg ± 0.05 and 1.50kg ± 0.05, respectively, and for female sheep birth weights were 1.19kg ± 0.04, 1.09 ± 0.04, 1.28kg ± 0.06, 1.07kg ± 0.03, respectively. Present findings showed higher birth weight than indigenous sheep of different regions of Bangladesh. According to Zohara et al. (2014), birth weight of the indigenous ewes was 1.00kg ± 0.30 when solely relied on natural grazing and 1.33kg ± 0.25 when supplemented ration was provided with natural grazing while present study found higher birth weight than indigenous sheep even when supplemented ration was provided. According to Al Mansur et al. (2018), average lambs' birth weight of indigenous sheep was found to be 1.5kg ± 0.5 and in this case, it was similar to the current findings in the crossbred lamb. Environmental factors, ewe weight at parturition, litter size, genetics, physiology, and sex all influence birth weight and weaning period; notable variations have been noted (Valencia et al., 1975).

According to Forster and Falder (2024), weaning usually occurs when the lambs are between 12 and 14 weeks old; however, this should not be a set date; instead, it should depend on the amount of grazing that is available, the ewe's body condition score, and the lambs' fastest rates of growth. The impact of weaning weight on growth and survival rates makes it a crucial economic factor in the production of meat sheep (Taye et al., 2010).

An experiment found that BLRI sheep had the highest average weaning weight of 6.74 kg. Coastal sheep follows with an average weaning weight of 5.89 kg, while Jamuna and Barind had slightly lower, with averages of 5.74 kg and 5.70 kg, respectively (Pervage et al., 2009). Weaning ages of crossbred lambs in the present study were 151.92 days ± 2.24 and 144 days ± 4.20 for male and female, respectively. Average weaning weight of indigenous sheep breed was recorded at 3.58±0.93 kg. However, when the sheep were given a supplemented diet, the average weaning weight increased to 5.71±1.03 kg, both are lower than the current investigation (Zohara et al., 2014). A study by Asaduzzaman et al. (2020) showed that both for Jamuna Basin Indigenous sheep and Muzaffarnagari crossbred sheep were weaned at the age of 60 days. They also noticed that the weaning weights were 4.72kg ± 0.18 and 4.29kg ± 0.24 for male and female Jamuna Basin Indigenous sheep, respectively, while, 10.41kg ± 0.21 and 9.35kg ± 0.28 were seen for male and female of Muzaffarnagari crossbred sheep. Previous study (Asaduzzaman et al., 2020) also indicated that Jamuna Basin Indigenous sheep showed lower weaning weight and Muzaffarnagari crossbred sheep showed higher weaning weight. According to Sultana et al. (2011), Bengal sheep raised in semi-intensive and intensive conditions had mean weaning weights of 7.3kg and 7.7 kg, respectively, while the present study found similar weaning weight to that of the Bengal sheep. Another study also found that indigenous sheep weaning weight was 5.40kg ±0.08, which is lower than current study (Islam et al., 2018). According to Al Mansur et al. (2018), weaning weight of Barind sheep was 8.9kg±2.7 which was higher than current studies. The inconsistency with our results can be due to the breed of the ram, plane of nutrition, amount of supplemented feed etc. can influence the weaning weights of lambs, making it an important consideration in effective lamb husbandry practices (Yaqoob et al., 2005). A study revealed that in Tazegzawt ram lambs reach puberty between 29 and 45 weeks, typically when their body weight was around 43.2±4.6 kg where puberty age which was in alignment with our findings for crossbred sheep but weight at puberty was much higher compared to our study (Moulla et al., 2018).

According to Asaduzzaman et al. (2020), Jamuna Basin Indigenous sheep and Muzaffarnagari cross sheep showed age at first service at 8.04 months ± 0.13 and 10.35 months ± 0.24, respectively. Another investigation by Hassan and Talukder (2011) showed that, age at first heat of Jamuna, Barind and Coastal region sheep were 239.9 days ± 35.5, 224.4 days ± 24.3, 279.0 days ± 50.3, respectively. Coastal region sheep showed similar results to the current study but rest of it was inconsistent. Zohara et al. (2014) observed that, age at puberty was 8.43 months ± 1.15 when sheep were allowed to naturally grazed only and 6.22 months ± 1.31 when supplementary feed was supplied. Similarity was observed with the current investigation with naturally grazed indigenous sheep. This inconsistency can be due to the significant variation which was seen in sheep regarding the age and body weight at puberty. This variation occurred both among different breeds and within the same breed. It could be linked to genetic influences and environmental elements like the nutrition played a crucial role for both male and female sheep, while photoperiod was found to be a particularly important factor for females (Dýrmundsson, 1987). Another study found that selecting Merino ewe lambs for their genetic potential for growth could hasten the onset of puberty which enhanced both fertility and reproductive rates (Nieto, 2013).

Reproductive performance of crossbred sheep (F_1)

According to the observations of Pervage et al. (2009), average litter size across four indigenous sheep breeds namely BLRI, Jamuna river basin, Barind, and Coastal sheep typically ranged from 1.56 to 1.80 but current study found lower litter size. In a different study, the average litter size was found to be 1.22±0.44 that was lower than that of the current result. When feed supplementation was introduced, the average litter size rose to 1.58±0.67 which was higher than our findings indicating nutrition might play role in litter size other than genetics (Zohara et al., 2014). In another experiment, Assan (2020) noticed that in goats and sheep, parity order, dam age, and seasonal fluctuation were considered to be the most important non-genetic factors influencing litter size. Age and parity order seemed to improve litter size, therefore it's very possible that dams with large prior litter sizes may had a higher likelihood of having numerous births in a row while kidding or learning to lamb. There was a risk of increased litter sizes during the reproductive seasons, which was another significant cause of diversity in litter size. The maximum litter size at 3.5 years of age with three parities was found to vary depending on the breed by a number of researchers working with hair sheep breeds (Macías-Cruz et al., 2012; Koycegiz et al., 2009; Gootwine, 2005; Godfrey, 2005). The difference in the results can be attributed to various factors as according to a study age of the dam, parity order, and seasonal variation are highly regarded non-genetic factors that affect the size of litters in sheep and goats. It is quite possible that dams with large earlier litter sizes may have a high possibility of generating multiple births in successive kidding/lambing because litter size tends to improve with age and parity order (Assan, 2020).

According to Hassan and Talukder (2011), gestation periods of indigenous ewes of Jumuna, Barind and Coastal regions were 152.8 days ± 3.8, 145.0 days ± 4.1 and 146.6 days ± 5.4, respectively, where Barind and Coastal region's sheep showed similarity with the present study. Number of services per conception were 1.3 ± 0.1, 1.3 ± 0.1 and 1.4 ± 0.1 for the sheep of Jumuna, Barind and Coastal regions, respectively and those findings in case of number of services per conception were in accordance with the current study. Post-partum ewe weight was 17.8kg ± 0.4, 19.2kg ± 0.4 and 19.6kg ± 0.6 respectively, which was lower in our findings. In the same study by Hassan and Talukder (2011), age at first lambing was 409.8 days ± 75, 389.9 days ± 43 and 439.5 days ± 58.3 for Jumuna, Barind and coastal region indigenous sheep, respectively. But age at first lambing in the current study was earlier. According to Islam et al. (2018), age at first lambing, lambing interval, postpartum heat period and number of services per conception were 12.81 months ± 0.06, 179.68 days ± 1.06, 41.37 days ± 0.58 and 1.18 ± 0.01, respectively. Current study showed similarities in age at first lambing and number of services per conception but inconsistent with lambing interval and postpartum heat period. Pervage et al. (2009) observed productive and reproductive performance of native sheep from BLRI, Jamuna, Barind and Coastal regions and found that gestation period from the four-region sheep were 147.83 days ± 0.89, 151.46 days ± 1.29, 150.33 days ± 1.28, 149.57 days ± 1.12, respectively, where current research found similar results. Post lambing ewe weight for sheep from above mentioned four regions were 17.19kg ± 0.31, 14.0kg ± 0.49, 15.45kg ± 0.50, 18.77kg ± 0.41, respectively, where in all cases it was found higher than the present study. Post-partum heat period for the sheep from four regions were 34.13 days ± 0.67, 39.14 days ± 1.26, 41.30 days ± 0.96, 43.12 days ± 1.13, respectively, while the post-partum heat period was significantly longer in the current findings. Age at first lambing for those native sheep from four regions of BLRI, Jamuna, Barind and Coastal were 432.72 days ± 5.54, 491.92 days ± 6.26, 488.09 days ± 5.59, 499.92 days ± 5.78, respectively, while it was found shorter in the crossbred sheep of the present study. Lambing interval was found from the study of Pervage et al. (2009) with native sheep for those four regions were 192.17 days ± 4.36, 221.13 days ± 4.97, 228.57 days ± 5.34, 214.32 days ± 4.63, respectively, where the present study showed similar findings of Jamuna and Coastal region sheep. According to Al Mansur et al. (2018), gestation length, lambing interval and post-partum heat of indigenous sheep was 147.9 days ± 3.4, 193.9 days ± 21.7 and 25.2 days ± 10.4, respectively. Where gestation length and lambing interval is in accordance with the present study but post-partum heat period for the crossbred sheep of the current findings was longer.

Body weight of crossbred sheep (F_1)

The body weight of sheep is vital because it affects their overall health, productivity, and economic worth, influencing wool quality, meat production, and reproductive success. A study conducted by Sun et al. (2020) noticed that, body weight of Jamuna basin sheep changes with age and at 1 to 9 months, the average weight was 11.49±2.44 kg. They also observed that sheep aged between 1.3 years and 1.6 years had a higher mean weight of 13.3±2.5 kg and finally, by 1.9 years to 2 years, the average weight to 14.55±3.43 kg which was partially similar to our findings. A study by Mobin et al. (2022) stated that Coastal sheep had highest average weight of 12.81±0.169 kg at 180 days of age. In contrast, Jamuna Basin sheep at this age (180 days) weighed 9.48±0.110 kg, and Barind sheep weighed of 8.88±0.176 kg. The weight disparity continues into their first year, with Coastal sheep showing a combined average weight of 19.97±0.221 kg at 360 days. This was higher compared to Jamuna Basin sheep, which weigh 17.21±0.312 kg, and Barind sheep, which had an average weight of 13.24±0.204 kg. They also reported that after 90 days, Coastal sheep (6.55±0.092 kg) continued to hold a marginally higher weight than crossbred sheep (6.20±0.43 kg). At this stage, Jamuna Basin sheep's weight was similar to that of the crossbred variety. The difference became more visible by the 180-day mark, where Coastal sheep (12.81±0.169 kg) showed higher body weight over crossbred sheep (9.15±0.61 kg). When the sheep reached a year, Coastal sheep maintained their higher average weight of 19.97±0.221 kg. In the present findings performance of the crossbred sheep was lower than Jamuna Basin sheep and Coastal sheep observed by Mobin et al. (2022). Asaduzzaman et al. (2020) demonstrated that the body weights of Jamuna Basin Indigenous at 30 days of age were 2.43kg ± 0.14 and 2.26kg ± 0.04, respectively for male and female and at 60 days it was 4.72kg ± 0.18 and 4.29kg ± 0.24, respectively. Body weights for male and female Muzaffarnagari cross sheep at 30 days were 7.24kg ± 0.16 and 6.56kg ± 0.24, respectively, and at 60 days it was 10.41kg ± 0.21 and 9.35kg ± 0.28. At 30 days of age, body of Jamuna Basin Indigenous sheep was lower than the current findings but at 60 days it was found to be similar. This difference in the body weight can be explained by an investigation by Allden (1970) where researcher recorded over 112 days post-weaning at about 7 weeks, the energy intake of Merino crossbred sheep and pure Merinos and analyzed. The crossbreds were heavier which averaged 20-23% more in weight. Supplementation of nutrition can play crucial role in body weight gain.

Average daily gain of crossbred sheep (F_1)

Pervage et al. (2009) reported that native sheep from BLRI, Jamuna, Barind and Coastal regions had body weight gain of 60.70g day^{-1} ± 3.08, 50.19g day^{-1} ± 3.33, 49.18g day^{-1} ± 2.70 and 51.21g day^{-1} ± 2.21, respectively. Current study found lower average daily gain. According to Zohara et al. (2014), average daily gain per day per ewe when only fed on grazing was 21.19g day^{-1} ± 4.714 and when supplemented feed was given it was 40.95g day^{-1} ± 12.07, in the current study higher average daily gain was observed than ewes fed on grazing but average daily gain found lower than those ewes that were given supplementary feed indicating nutrition playing a direct role in average weight gain and causing the difference. Asaduzzaman et al. (2020) noticed that, average weight gain in Jamuna Basin Indigenous sheep at 30-60 days for male and female was 66.93g day^{-1} ± 3.39 and 59.13g day^{-1} ± 4.46, respectively. Asaduzzaman et al. (2020) also noticed that in case of Muzaffarnagari cross sheep average daily gain for male and female at 30-60 days was 110.73g day^{-1} ± 13.05 and 103.07g day^{-1} ± 11.29 and both breeds showed higher average daily gain than the current study. The reasons for differences from others might be due to better nutrition, more effective health care, and a strict adherence to proven scientific methods, all essential for greater average daily gains in field environments (Selvakkumar et al., 2016).

Incidence of dystocia

Dystocia in sheep refers to difficult or abnormal labor, often requiring intervention to ensure the health and survival of both the ewe and the lambs. It was seen in our findings mainly due to the fact that, the experimented mother sheep (Indigenous sheep) were smaller and rams were larger in size (Garole breed) and lambs' size was bigger at birth as compared to indigenous lambs. On the other hand, the female indigenous sheep gave lambs for the first time (primiparous). Therefore, the incidence of dystocia was observed in most of the cases. An investigation by Purohit (2006) noticed that, rate of dystocia in sheep and goats ranged from 8% to 50% which was consistent to the current findings. Cervical dilation failure emerged as the primary maternal cause of dystocia, with uterine inertia as the one of the most frequent reason, according to same study.

Mortality of crossbred lambs

A study showed that male lambs face greater mortality risks compared to female lambs which was inconsistent to the findings of current study, it may be due to lambs with lighter birth weights were more likely to die than those with heavier weights at birth (Bangar et al., 2016). Another study by Zohara et al. (2014) found 91.67% survivability rate in sheep which was partially similar to our findings.

Conclusion

It was observed that the body weight and average daily gain (ADG) of crossbred sheep in the present study were higher than Indigenous sheep as reported by other researchers. However, in some reproductive traits as stated by other researchers, the litter size of crossbred ewes was comparatively lower than that of Indigenous ewes. As the indigenous ewes were collected before giving birth, the litter size was small because it was the first time, they gave birth and birth problems (dystocia) were observed for the same reason. However, the higher overall growth rate and higher adult weight of crossbred sheep will open new possibilities for increasing meat production. Based on the results of the study, it can be concluded that crossbreeding of indigenous coastal sheep with Garole ram can be implemented to increase body weight and ADG, keeping in mind the conservation of indigenous sheep breeds by carrying out selective breeding program among them.

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Conflict of interest

Regarding the publishing of this work, the authors state that they have no conflicts of interest.

Data availability

The authors have granted permission for all the data used in this study to be made publicly available.

Consent to Participate

The authors have granted their full permission to participate as needed.

Consent for publication

The publication of this article in the Bangladesh Journal of Animal Science has the complete consent of the authors.

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