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Review article

Morphometric traits with reproduction and production performances of indigenous and exotic sheep breeds of Bangladesh

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Abstract

The purpose of this study was to review the existing literature on some important morphological traits associated with reproductive and productive performance in Bangladeshi indigenous and exotic cross sheep. Sheep as small ruminants are essential parts of the crop-livestock of the mixed agricultural farming system playing a crucial role in the livelihood of smallholders in Bangladesh. They are considered risk averters for farmers in a family crisis and seasonal needs through quick sale by direct cash income. Furthermore, their physical products have socio-economic, cultural, and nutritional values: meat, milk, skin, manure, etc. In the past, a number of researchers investigated the relationship between morphometric features and reproductive and productive performance of the referred sheep. Any compilation report is yet not available. Therefore, an update database on Bangladeshi indigenous and exotic cross-breed sheep is required to identify for management and production strategy program. This paper reviewed, discussed, summarized, and compared all articles on morphometric traits and the reproductive and productive performances of sheep in Bangladesh.

Keywords: Morphometric traits, Production, Reproduction, Sheep

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INTRODUCTION

In Bangladesh, livestock is densely populated, and mainly the smallholders rear them. Over 70% of rural households produce animals, which contribute significantly to the livelihood of small-scale farmers and landless people. Primarily, poor village households raise livestock for fertilizers and fuel, ready income sources, and protein (meat and milk). As a result, livestock is essential to the poor rural section and the country's economic development. About 88% of the female population in this sub-sector works for livestock rearing, and 70% of them work as unpaid family workers. In the backyard, they feed and milk animals, including small ruminants and poultry (World Bank, 2018). Farmers keep significant numbers of cattle, buffaloes, and small ruminants like sheep and goats in a mixed livestock production system. The cattle densities in Bangladesh are the greatest (145 ruminants/km2) compared to 90, 30, and 20 in India, Ethiopia, and Brazil, respectively, but most have a poor genetic base. Compared with other animals such as cows or buffaloes, small ruminants need little investment to supply more meat per unit weight per year (FAO, 2003). The majority (64.43%) of the world's total sheep population is found in Asia and Africa, while 25.32% of the total number (920) is located in Asia (FAO, 2003). According to the current report, Bangladesh has 35.37 million sheep (DLS, 2019), ranking third after cattle and goats. They are sparse across the country and reared about 37.5%, 40.0%, and 22.3% of the total sheep of Bangladesh by small and landless, medium and large farmers (Faylon, 1988), respectively. Farmers in 3 ecological zones, such as Barind, Jamuna Basin, and the Coastal, keep large commercial meat-producing native sheep relatively in higher concentrations. They are popularly named Vera-Veri or Mera-Meri, with little difference in phenotypic, reproductive, and productive characters (Pervage et al., 2009). Pervage et al. (2009) differentiated the Bangladeshi native sheep of Naogaon, Noakhali, and Tangail areas with few reproductive traits from the Bangladesh Livestock Research Institute (BLRI) nucleus flock where better results were obtained in BLRI nucleus flock. Hassan and Talukder (2011) observed that the breeding performance was comparatively better for Jamuna basin sheep than for Costal and Barind sheep in terms of liter size. The phénotypes and reproductive properties were not significantly differentiated, except for the days open and post-partum weight of Barind, Jamuna, and Coastal Sheep. Diarrhea, pneumonia, and skin diseases were most common in all sheep. Islam et al. (2016) studied sheep feeding, feeding hours, health care -vaccinated, and anthelmintic in coastal region sheep. Ahmed et al. (2018) studied lamb production potentiality and growth performance daily gain in three regional native sheep and found coastal sheep more potential. Islam et al. (2018) learned indigenous sheep from twelve Upazilas phenotypic, productive and reproductive potential and identified significant variations in production and reproduction characteristics excepting their scrotal circumference.

As per Sahana et al. (2001) study, farmers are found to rear another exotic prolific 'Garoles' in some Sunderban Delta areas carrying from Western Bengal, India. Ghalsasi and Nimbkar (1993) described the prolific nature of this Garole sheep was due to the presence of the Booroola (FecB) gene. Afterward, Piper and Bindon (1996) first introduced the FecB gene into Australian Merino in the early 20th century to improve births and developed CSIRO Booroola Merino. This sheep, due to its smaller body size, might not become popular to smallholders of Bangladesh. By commercialization of agriculture farming system pointed in 7th FYP, a new Indian exotic long-tailed meat-type cross breed Muzaffarnagari sheep is popularly and extensively reared by the Western part of Bangladesh viz. Meherpur, Choadanga, Rajshahi, and Chapainawabgonj districts. These Muzaffarnagari sheep originate in the western Uttar Pradesh districts of Muzaffarnagar, Bulandshahar, Meerut, and Bijnor, India. The Bangladeshi subtropical climate is favorable for sheep breeding and production. Since sheep are resistant to parasitic and infectious diseases compared with goats and cost-effective rearing on natural grass with less care (Ahmed et al., 2018), sheep can influence livestock production and income generation. However, a farmer who keeps many sheep is not productive because of poor genetic values.

TYPES OF BANGLADESHI SHEEP

Indigenous sheep

Most sheep are indigenous non-descript native sheep (Ovis aries) and do not belong to any specific breed, might have orig¬inated from wild Australian Urial sheep (O. Orientalis vignei). They are efficient users of low-quality roughages and can efficiently utilize stubbles of harvested crops, tree toppings, farm waste, small vegetation in harvested fields or fallow lands, roads, and canal-side grasses. They even graze on aquatic weeds and grass in knee-deep water, making them suitable for swampy habitats and coastal regions (Ramanuj et al., 2010). They can also be reared on the open non-agricultural field with low or mini¬mum care and management (Sultana et al., 2010). They can adjust quickly to hot wet conditions and disease-tolerant (Hassan and Talukder, 2011). These native sheep are highly resistant to infectious diseases, including PPR, and have relatively better resistance to parasitic diseases (Bhuiyan, 2006). The farmers rear sheep in traditional and semi-intensive production system, but they are raised in an intensive production system. They have a reputation for early maturity and prolific characters (Sultana et al., 2011) and can lamb with multiple births twice a year (Hassan and Talukder, 2011). They are sparsely distributed throughout the country but mostly concentrated into three ecological zones (Figure 1) jamuna basin, barind and coastal tract and accordingly called Jamuna basin, barind and coastal sheep.

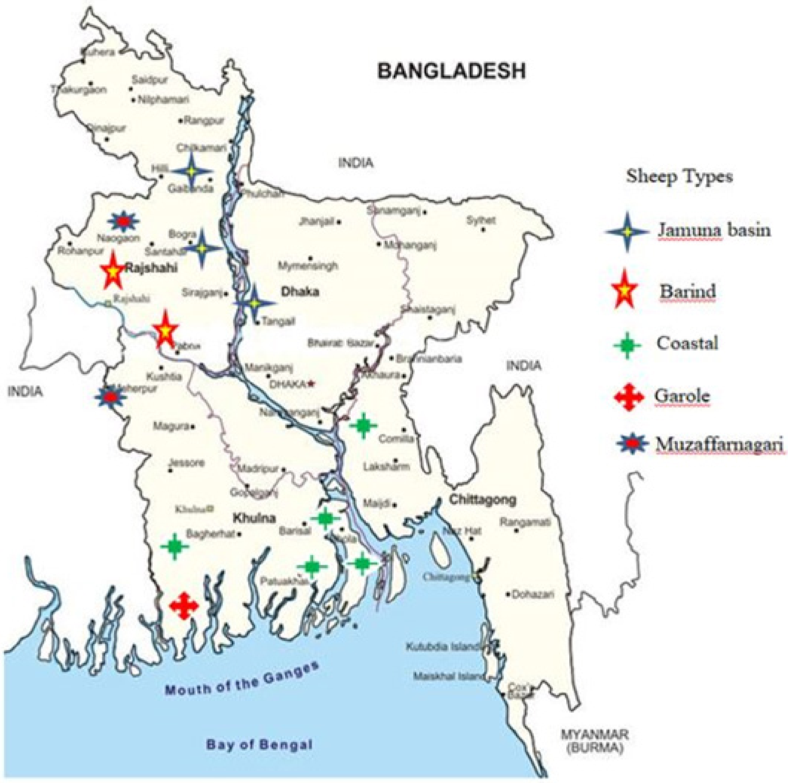

Figure 1 Different type of sheep with their ecological distributions

Coastal sheep

The coastal indigenous sheep (Figure 2.1) are mainly concentrated in the Patuakhali, Vola, Noakhali, Chittagong, and Lakhimpur districts of Bangladesh. They are primarily reared at wet and salted grazing field areas (Islam et al., 2018). Their coat color is 70% white and 30% white-brown (Hassan and Talukder, 2011). They have a straight nose of about 18-19 cm in length. The face, leg, and abdominal region are covered with more minor and short fur, comparatively finer than the Jamuna basin and Barind sheep. The ram has just a superficial backward-curved horn (Islam et al., 2018).

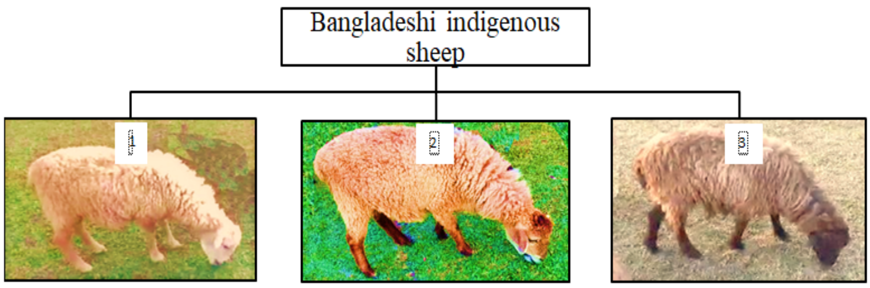

Figure 2 Bangladeshi indigenous sheep; Costal (1), Jamuna basin (2), Barind (3).

Jamuna basin sheep

The Jamuna basin indigenous sheep (Figure 2.2) are reared in Jamuna basin areas under Tangail, Jamalpur, Sirajgonj, Bogura, and Gibantha districts. Their coat color is while, white and black mixed, light to dark brown. The face, leg, and belly also have less and short fur. The oral and nasal areas are blackish brown, whitish brown strip aside the muzzle and mandible. The nose is also straight of about 18cm in length and the ear is comparatively shorter about 10.5 cm (on an average). The horn is comparatively larger, curved, and coiled than the coastal ram (Sardar, 2016). The ear is comparatively more extended than the Barind area's sheep and similar to the coastal area's sheep. They adapted to hot-humid climates. The wool is coarse with high medullation.

Barind sheep

Barind types of indigenous sheep (Figure 2.3) are reared in Rajshahi, Chapai Nawabganj, Naogaon, and Natore districts. The face and leg are blackish browns; the ear is comparatively short (7-11cm), coarse hair, white coat, or brown mixed. The tail is narrow and short. Ram has a blackish curved horn (Sardar, 2016).

Exotic sheep

Apart from non-descriptive indigenous, two Indian exotic sheep: Garole (Figure 3.1) and Muzaffarnagari cross (Figure 3.2) are also available to be reared in the filed farmer's flocks.

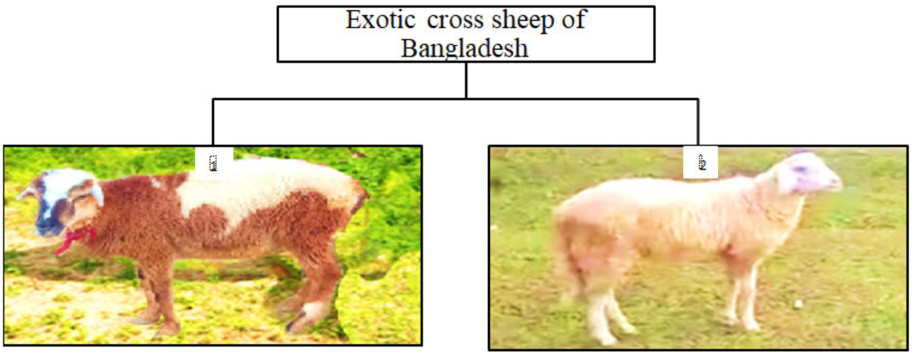

Figure 3 Exotic cross breed sheep; Garole (1), Muzaffarnagari cross (2).

Garole sheep

The "Garole" is a well-known Indian exotic small size sheep, found to be thriving in Bangladesh's Sundarban (Sharma et al., 1999; Khan et al., 2009). This Garole sheep (Figure is more popular and commonly rear by the farmers in West Bengal (Singh and Bohra 1996; Sharma et al., 1999; Sahana et al., 2001), especially in Jalpaiguri and Kochbihar (Singh and Bohra 1996; Sharma et al., 1999; Sahana et al., 2001; Sardar, 2016). The Booroola FecB gene for high prolificacy is an essential characteristic of Garole sheep (Ghalsasi and Nimbkar, 1993). The Australian Merino introduced the prolific properties to increase the birth and develop CSIRO Booroola Merino in the early 20th century (Piper and Bindon, 1996). The coat color of this small compact meat type animal is mostly black, with a fawn or brown back patch at the lower portion of the body (Ghalsasi et al., 1994; Nimbkar et al., 1998; Bose et al. 1999; Bose and Maitra, 1999; Sharma et al., 1999). The ear is long, pendulum, medium, erect, rudimentary in length illustrated by Bose et al. (1999), Sharma et al. (1999), Das (2000) and Banerjee and Banerjee (2000) along with different length in tail also. The male is usually horned and females are pooled. Garole sheep can graze in knee-deep conditions in marshy land.

Muzaffarnagari cross-sheep

The Muzaffarnagari cross-sheep is an exotic Indian breed that is now popular among farmers of the Western part of Bangladesh like Meherpur, Choadanga, Rajshahi, Chapainawabgonj districts. Muzaffarnagari sheep is known as Bulandshahri sheep, native to Western Uttar Pradesh districts viz. Muzaffarnagar, Bulandshahar, Meerut, and Bijnor. Muzaffarnagari was the name given to the location of origin (Sardar, 2016). They have a slightly convex face line and are medium to large animals. The face and body are white, with brown or black spots here and there. Occasionally, the ears and face are black. Both sexes take polls. Sometimes, males have rudimentary horns on occasion with drooping and long ears. The trail crosses the fetlock and is exceptionally long. It has a white, coarse, and open fleece. Wool is missing from the belly and thighs (Sheepfarm, 2019).

MORPHOMETRIC TRAITS

Body weight and morphometric traits

Sheep production is the widespread form with an extensive animal husbandry system in Bangladesh. Rural people sell animals to stabilize their household income and livelihood (Koutinhouin et al. 2017). The professional production corresponds with the carcasses of animals delivered by the farmers and producers (Kirton et al., 1995). Also, biological functionality and production determine the state of the animal body (Bravo and Sepulveda, 2010; Toro et al., 2010). Bodyweight, body, and testicular measurements are essential characteristics for selecting better animals regarding better genetics and reproductive yield (Tariq et al., 2012; Mwacharo et al., 2006). Morphometric measurement reflects the body shape and breed standards of animals (Riva et al., 2004). Knowing the body mass of a small ruminant is essential for good animal management, medication dosage, adjustment of feed supply, growth monitoring, and male and female replacement (Shirzeyli et al., 2013). Biometric assessment and live weight have a broader application of laboratory work and animal selection techniques (Lawrence and Fowler, 2002; Cam et al., 2010). They provide comprehensive information to investigate sheep performance (Yakubu, 2010; Cardoso et al., 2013; Parés-Casanova, 2013). Bodyweight is correlated with positive genotype and phenotype and vice versa (Abbasi and Ghafouri-Kesbi, 2011; Thiagarajan and Jayashankar, 2012). The breeders use these relationships for desirable lamb production through crossbreeding programs (Bianchi et al., 2006). Many researchers use body weight; wither height, and chest girths to measure live animals in addition to the live weight in meat animals (Attah et al., 2004). Animal breeds differ in terms of body weight and other physical measurements. According to traits, some important reports found on body weight and biometric measurements of Bangladeshi indigenous and exotic sheep breeds are presented in Tables 1.

Testicular traits

A male counts for half of the flock. As a result, it's important to choose males with superior genetic material. There are no specific means of selecting males with superior quality due to a lack of basic information on fertility-related traits and cost value. Obtaining such data from an individual male is difficult (Lunstra and Coutler, 1993). The size and length of the scrotum were used as an indirect screening criterion for genetically enhanced fertility (Koyuncu et al., 2005). Larger testes are linked to more sperm development (Coutler and Foote, 1977; Blockey, 1980). Testicular features are related to body measurements and weight. Males with higher testicular values have more weight on their bodies (Raji et al., 2008). Males' body size and testicular traits within a given age range are used to choose superior genetics for production and reproduction (Tariq et al., 2012). Male with massive testes shares more paternities and more sperm insemination in breeding females on available (Preston et al., 2011). Scrotal circumference (SC) is also used to determine ram fertility and breeding health and to correlate with the animal's age (Brito et al., 2002). The scrotal circumference is also related positively to the overall reproductive efficiency of sperm percentage, the number of sperms, motility, and the concentration of sperm (Hoogenboezem and Swanepoel, 1994). Coe (1999) reported that scrotal circumference and age were associated with approximately 11% variation in semen quality. The testicular characteristics of Bangladeshi indigenous and exotic sheep breeds observed by different researchers are presented in Table 2.

Table 1 Morphometric measurements of Bangladeshi indigenous and exotic sheep

Sheep types	Sex	Morphometric traits				References
		Weight (kg)	Length (cm)	Height (cm)	Chest girth (cm)	
Muzaffarnagari	M/F	50.20 / 39.60	--	--	--	Kumar et al., 2006
Muzaffarnagari	M/F	--	82.90	83.90	85.10	Dass and Prasad, 2007
Muzaffarnagari	M/F	--	--	75.97 ± 0.86	79.67 ± 0.02	Dass and Prasad, 2007
Jamuna basin	M	18.04 ±0.44	64.42 ±1.32	47.71 ±0.80	58.57 ±1.37	Pervage et al., 2009
	F	16.52 ± 0.30	62.67 ± 0.87	49.03 ± 0.49	57.10 ± 0.93	Pervage et al., 2009
Barind	M	19.10 ±0.80	65.70 ±1.13	48.50 ±1.06	60.20 ±1.48	Pervage et al., 2009
	F	15.25 ± 0.49	62.20 ± 1.09	46.03 ± 0.89	57.31 ± 1.15	Pervage et al., 2009
Coastal	M	23.64 ±0.75	67.60 ±2.62	56.30 ±1.63	67.50 ±2.28	Pervage et al., 2009
	F	17.93 ± 0.24	63.48 ± 0.56	51.11 ± 0.67	60.05 ± 0.62	Pervage et al., 2009
Garole	M/F	8.00-10.00/10.00-14.00	42.00-53.00	42.00-49.00	58.00-65.00	Ramanuj et al., 2010
Garole	M/F	12.00-15.00	--	--	--	Sardar, 2016
Jamuna basin	M/F	41.20	41.50	51.70	62.70	Hassan and Talukder, 2011
Barind	M/F	40.60	43.40	52.90	61.50	Hassan and Talukder, 2011
Coastal	M/F	41.60	45.90	53.50	64.90	Hassan and Talukder, 2011
Muzaffarnagari	M/F	--	83.07 ± 1.35	--	--	Yadav et al. 2013
Jamuna basin	M	17.84±0.29	53.66±0.88	54.83±0.66	62.78±1.35	Islam et al., 2018
	F	14.62±0.11	48.45±0.62	50.83±0.38	58.46±0.61	Islam et al., 2018
Coastal	M	19.19±042	65.78±0.59	66.12±0.98	76.68±0.87	Islam et al., 2018
	F	16.16±0.51	53.57±0.90	51.45±0.81	62.6±1.01	Islam et al., 2018
Barind	M	16.85±0.83	48.70±1.37	54.37±1.41	59.58±0.92	Islam et al., 2018
	F	15.95±0.27	46.38±0.42	47.52±0.49	57.72±0.32	Islam et al., 2018
Indigenous	M	10.42 ± 0.16	72.54 ± 0.43	--	--	Hussain et al. 2019
	F	17.01 ± 0.08	81.93 ± 0.10	--	--	Hussain et al. 2019
Jamuna basin	M	14.92 ± 0.92	43.33 ± 1.15	46.80 ± 1.30	61.53 ± 1.23	Asaduzzaman et al. 2020
	F	14.23 ± .0.29	51.65 ± 0.46	49.15 ± 0.31	57.88 ± 0.44	Asaduzzaman et al. 2020
Muzaffarnagari	M	50.48 ± 1.75	70.60 ± 0.74	70.07 ± 0.67	90.33 ± 1.35	Asaduzzaman et al. 2020
	F	35.35 ± 1.08	69.47 ± 0.94	65.65 ± 0.70	78.68 ± 0.95	Asaduzzaman et al. 2020
Barind	M	18.84±.41	54.90±3.13	54.78±1.88	63.09±2.21	Haque et al., 2020
	F	17.94±1.94	55.69±3.06	52.53±2.52	61.47±3.45	Haque et al., 2020

Table 2 Testicular traits of Bangladeshi indigenous and exotic sheep

Ram breeds	Testicular traits		References
	Scrotal length (cm)	Scrotal circumference (cm)	
Jamuna basin	10.70	--	Hassan and Talukder, 2011
Barind	11.00	--	Hassan and Talukder, 2011
Coastal	10.70	--	Hassan and Talukder, 2011
Jamuna basin	08.75 ± 0.19	16.72 ± 0.42	Islam et al., 2016
Jamuna basin	08.75±0.19	16.72±0.42	Islam et al., 2018
Coastal	11.35±0.20	16.77±0.36	Islam et al., 2018
Barind	11.03±0.71	14.78±0.55	Islam et al., 2018
Garole	10.50±0.27	15.43±0.28	Islam et al., 2018
Indigenous	--	13.10	Hossain et al. 2019
Jamuna basin	10.67 ± 0.45	18.20 ± 0.51	Asaduzzaman et al. 2020
Muzaffarnagari	15.53 ± 0.51	28.07 ± 0.61	Asaduzzaman et al. 2020

cm- centimeter

Reproductive performances

Reproduction is essential in the profitability of a farm household or company. If an animal does not reproduce, its current slaughter value is worth nothing more than its (Larbi et al., 2014). Good breeding performance is a condition of sustainable production of livestock. It is important for effective overall production in small ruminants (Owen, 1977). Poor young breeding performance is a significant loss for the sheep sector (Muñoz et al., 2009). The more intensive the meat production system, the more desirable the production of large numbers of young per breeding female (Fall et al., 1982). Sheep breeds usually have different reproductive performances. These differences require investigation to increase sheep production profitability (Unal et al., 2006). Reproductive performance can be measured by various factors such as puberty age, first lambing age, lambing interval, litter size of the breed. Genetic potential, dietary, management, and natural variables are also included in the reproduction performance measurement.

Age at first service

When the reproductive organs first become functional or show first functional estrus is the age of puberty or age at first service (AFS) (Ibrahim, 1998). At the advent of puberty, sexual maturity does not become fully explicit, or reproductive organs are not fully matured to carry a fetus (Lawrence and Fowler, 1997; Dyrmundsson, 1981; Senger, 2003). The heifer and ewe lambs undergo one or more ―quiet oestruses and ovulations before displaying whole oestrus behavior; it is just to establish the characteristic pattern of cyclic activity (Pineda, 2003; Senger, 2003). The age of first service or puberty, however, is an essential reproductive feature of productivity. Many factors such as species, breed, body weight, heterosis, the proximity of male animals, season, and other environmental factors such as temperature affect it (Noakes et al., 2001). For attaining puberty, species differences are considered. Puberty is earlier for smaller animals than for more giant animals. The puberty of mouse, egg, feeding stuff, stubble, or elephant cow, for example, takes place 35 to 45 days, 6 to 15 months, 7 to 18 months, 12 to 24 months, and 12 to 23 years, respectively.

Nutrition levels at puberty modulate age due to their impact on body weight (Hafez et al., 2000). Fed on a higher level of nutrition, animals grow more quickly than under food animals and reach puberty earlier. The underfed animal even attains puberty at an older age (Noakes et al., 2001). Well-fed lambs come to puberty at nine months, but with inadequate nutrition, puberty may not be onset until twenty months (Gatenby et al., 1997). Awassi lambs on a good diet show the first oestrus at an average age of 274 days (Younis et al., 1978), while Rambouillet crossbred lambs puberty in Rajasthan at about 615 days (Kishore et al., 1982). Unlike temperate regions, the season has an insignificant influence on the age at puberty in the tropics (Ibrahim, 1998). The female body weight is more critical than its chronologic age to attain puberty (Jainudeen et al., 2000; Noakes et al., 2001; Pineda, 2003). Lambs have higher body weight generally reach puberty earlier with more estrous cycles, fewer with subsequent silent ovulations than lighter animals (Dyrmundsson, 1973). Ibrahlim (1998) report puberty to females at 45% to 60%. These results may be affected by breed variations such as 30, 40, and 63 percent in Romany, Suffolk, and Scottish Blackface ewes and may reach puberty in mature body weight (Hafez et al., 2000). Table 3 shows the variations of age at first service of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Gestation length

Gestation length (GL) is the physiological stage of dam fetal development (Bellows and Ansotegui, 2005). According to Ibrahim (1998), gestation is the period from fertilization to delivery of the fetus. It varies at a rate of 5 to 10 % for different breeds (Stewart, 1991). Sire breed, dam-age, litter size, and birth weight of lamb affect gestation duration (Fogarty et al., 2005). The genetic, fetal, environmental, and maternal environmental factors were described by Jainudeen and Hafez (2000). The most important factor among these is lamb genotype (Dwyer et al., 1996). Age and parity exert some influence on the gestation length (Jainudeen and Hafez, 2000) as eight or older sheep have their gestation length, which is 148 days on average, extended by two days. The older dams have longer gestation than the young dams (Koyuncu et al., 2001). The gestation length decreases from the third parity to the fifth parity (146.80 - 145.90 days) and then increases from the fifth parity to the eighth parity (145.90 - 149.70 days) (Forbes, 1967). As fetal factors, the sex of the fetus and the number of fetuses being carried simultaneously by the dam influence the gestation length. Male lamb carrier dam may have a longer gestation length than female lamb carrier dam (Koyuncu et al., 2001; Fogarty et al., 2005). The gestation length is longer in single lamb carriers than multiple Jcarriers (Koyuncu et al., 2001; Dwyer, 2003; Fogarty et al., 2005). Likewise, lamb weight also affects gestation length (Fogarty et al., 2005). Table 3 shows the variations of Gestation length of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Age at first lambing

The age at the first lambing (AFL) is the number of years from the birth of a female animal at which it gives her first offspring. AFL has economic importance in the lifetime productivity of small ruminants like sheep and goats as it expresses the faster population turnover and genetic progress within the flock (Abassa, 1995). Early lamb production can increase lifetime Lamb production (Amelmal, 2011), and environmental factors like year and season impact it (Wilson, 1989). The season influences the food supply and the age at first lamb (Donney et al., 1982). Many studies showed that only seasons (dry-wet) of the year affected age at first lambing; other factors viz. year, litter size, birth weight, weaning age, and weaning weight on age had no effects (Majid and Singh, 2011). The availability of fodder and a lower parasitic infestation promote these effects, whereas the opposite results in the wet area. Controlled breeding system delays first lambing compared to uncontrolled breeding systems where rams were mated freely with females and serve them at the earliest possible display of oestrus (Wilson, 1989). The lambs born for twins had longer age at first lambing than their counterpart singles-born lambs. Maternal parity also significantly affects the age at first lambing. The offspring of young and old ewes are matured later age than those of mid-aged dams (Wilson and Murayi, 1988). Table 3 shows the variations of age at first lambing of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Lambing interval

The time for two consecutive lambing is the lambing interval (LI). The LI defines the efficiency in the production process of small ruminants and is influenced by their breed (Wilson and Murayi 1988), season (Mengiste, 2008), and lambing year (Dibessa 1990). The parity, body weight, management, and matting types also impact LI, reported by Gbangboche et al. (2006). Furthermore, the sex of the offspring affects the lambing interval. Wilson and Durkin (1983) said that male lamb crop shows longer lambing interval than female lamb in Sahel type sheep. The levels of genetic make-up and breeding system affect the lambing interval. Wilson (1989) has reported long lambing intervals among African small ruminants under station management in delayed mating or controlled mating for desired conditions to achieve. Table 3 shows the variations of LI of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Post-partum interval

Puerperium or Post-partum interval (PPI) is the period that ranges from parturition to normal ovarian and uterine cycling. During this repair stage, the uterus reverts to its normal condition of being pregnant (uterine involution). When lochia expels by myometrial contractions, bacteria gained entry into the reproductive tract and produce uterine infections. Uterine involution is, therefore, essential for normal reproductive activities. Generally, the expected uterine involution is between 20 to 30 days in sheep (Senger, 2003). After the parturition, the ewe undergoes an acyclic period, and this stage varies with uterine involution time, suckling intensity, body condition, animal health, season, and breeding (Fray et al., 1996; Senger, 2003).

The acyclicity results in a low release of GnRH and LH with a refractory anterior pituitary (Noakes et al., 2001). The length of time to resume ovarian cyclicity has significant economic implications for sheep production.

The ewes have to be conceived for an ideal 6-month lambing interval within 35 days of parturition. The length of acyclicity after parturition compromises reproductive efficiency. Prolonged postpartum returns reduce reproductive efficiency and economic losses (Fray et al., 1996; Yavas and Walton 2000; Obese et al., 2009). Inadequate LH production and release from insufficient GnRH synthesis affect follicular development and ovulation (Wright et al., 1981). Malnutrition and suckling intensity can also lead to anovulatory conditions (Wiltbank et al., 2002; Obese et al., 2009).

The breeding season also influences shorter postpartum intervals. Ewes lambed in November had shorter postpartum intervals than ewes lambed in May, according to Dufour (1975) (18.0 and 87.1 days, respectively). Ewes were lambed during breeding had first ovulation by 25±1.8 days with short post-partum, and the late lambed ewe had delayed post-partum until the following breeding season (Santiago-Moreno et al., 2001). According to Arsoy and Sağmanlıgil (2018), the postpartum anestrous durations were 18.5 and 120.78 days in October and June-July, respectively. Table 3 shows the variations of the post-partum intervals of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Table 3 Reproductive performances of Bangladeshi indigenous and exotic sheep

Sheep types	Reproductive performances (day)					References
	AFS	GL	AFL	LI	PPI	
Muzaffarnagri	--	--	--	--	212	Sinha et al. (1979)
Indigenous	--	149	--	--	--	Husain and Amin (2003)
Jamuna basin	333 ± 4	151 ± 1	491 ± 6	221 ± 4	39	Pervage et al., 2009
Barind	329 ± 4	150 ±1	488 ± 5	228 ± 5	41	Pervage et al., 2009
Coastal	341 ± 5	149 ±1	499 ± 5	214 ± 4	43	Pervage et al., 2009
Coastal	279	146 ± 5	440	204 ± 7	37 ± 4	Hasan and Talukder (2011)
Jamuna basin	239	152 ± 3	410	188.6 ± 6	30 ± 3	Hasan and Talukder (2011)
Barind	224	145 ± 4	390	189 ± 5	32 ± 4	Hasan and Talukder (2011)
Native sheep	--	146	--	263	102	Sultana et al. (2011)
Indigenous	253 ± 34	141 ± 1	--	--	42 ± 5	Zohara et al., 2014
Native sheep	330	146	450	226	64	Salma et al. 2015
Indigenous	252 ± 7	147	398 ± 7	162 ± 2	16 ±1	Sardar et al., 2015
Jamuna basin	--	--	406 ± 4	177 ± 1	37 ±1	Islam et al., 2018
Barind	--	--	361±2	162 ±1	49 ±1	Islam et al., 2018
Coastal	--	--	400 ±3	159 ±1	41 ± 1	Islam et al., 2018
Barind	199 ± 24	148 ± 3	372 ± 27	197 ± 24	26 ±11	Al-Mansur et al., 2018
Jamuna basin	241 ± 4	146	422 ± 5	178 ± 1	26 ± 1	Asaduzzaman et al., 2020
Muzaffarnagari	310 ± 7	148 ± 0.7	508 ± 5	188 ± 2	48 ± 1	Asaduzzaman et al., 2020
Coastal	--	148 ± 3	383 ±11	212±7	--	Islam et al., (2021)
Indigenous	--	153 ± 1	--	183 ± 1	--	Hossain et al., (2020)

AFS-Age at first service, GL- Gestation length, AFL- Age at first lambing, LI- Lambing interval, PPI- Post-partum interval,

PRODUCTION PERFOEMANCES

Growth is an important character that affects flocks' overall productivity and economic return. While heredity dictates maximal growth and development, nutrition and other environmental factors are responsible for the actual growth rate (Oddy and Sainz, 2002). Faster lamb growth is desirable due to the improved efficiency of sheep production (Unal et al., 2006). For many years, growth has therefore been studied. Growth characteristics like body weight and daily average gains in weight are key measurement indicators (Ganesan et al., 2013).

Birth weight

The birth weight (BWT) of the lamb is taken immediately after lambing. Lamb birth weight is an early measurable trait that has a favorable genetic link to increased live weight (Budai, 2013). This trait is important to achieve better sheep production (Petrovic et al., 2011) and is considered a primary factor in natural growth and development (Petrovic, 2007). Higher birth weights are associated with vigor and vitality in the lamb (Abassa, 1995). Low birth weight increases the slow rate of growth, accretion of fat, and reduction in lamb bone growth in subsequent stages; (Greenwood et al., 2000). Low birth weights also have later repercussions for animal health and reproduction (Steinheim et al., 2002; Gardner et al., 2007).

Breed value influencing the birth weight of all domestic animals for optimum meat production. Several studies have been shown that sheep breed and sex significantly affect birth weight (Thirunavukkarasu, 2009; Oyebade et al., 2012) . AHDB (2019) reported on 16 different breed effects on birth weight. At birth, ram lambs were significantly larger than ewe lambs across all breeds, although the difference was less pronounced in the Romney Marsh breed. Meatlinc, Suffolk, Charollais, and Shropshire sheep had the highest average lamb birth weights, with Welsh Mountain, Scotch Blackface, and Romney Marsh sheep having the lowest. Terminal type' sheep of Southdowns had the lowest average birth weights Ram lambs of different sheep breeds had higher body weight reported by many researchers (Iyeghe et al., 1996; Sivakumar et al., 2006; Gardner et al., 2007). Management factors such as ewes feeding and lambing times are not taken into account but will affect birth weight. Table 4 shows the variations of birth weight of lambs of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Table 4 Productive performances of Bangladeshi indigenous and exotic sheep

Sheep types	Productive performances					References
	BWT (0 day) (kg)	Pre-WWT (30 days) (kg)	WBT (60 days) (kg)	AGD (0-30days) (gm/day)	AGD (30-60 days) (gm/day)	
Jamuna	1.34	--	5.74	--	50.19	Pervage et al., 2009
Barind	1.33	--	5.70	--	49.18	Pervage et al., 2009
Coastal	1.50	--	5.89	--	51.21	Pervage et al., 2009
Native sheep	1.56	--	7.3	65.0	--	Sultana et al., 2011
Indigenous	1.00 ± 0.30	--	3.58 ± 0.93	42.59 ± 14.44	21.19 ± 4.71	Zohara et al., 2014
Jamuna basin	1.03 ± 0.01	--	5.61b ± 0.06	--	--	Islam et al., 2018
Barind	0.92 ± 0.01	--	4.13d ± 0.07	--	--	Islam et al., 2018
Coastal	1.16 ± 0.01	--	6.63 ± 0.22	--	--	Islam et al., 2018
Barind	1.7 ± 0.6	--	8.9±2.7	--	--	Mansur et al., 2018
Indigenous	1.07 ± 0.03	--	--	--	--	Hossain et al., 2020
Jamuna basin (M/F)	1.34 ± 0.06/ 1.08± 0.06	2.43 ± 0.14/ 2.29 ± 0.14	4.72 ± 0.18/ 4.29 ± 0.24	44.80 ± 1.89/ 43.47 ± 1.89	66.93 ± 3.96 / 59.13 ± 3.96	Asaduzzaman et al., 2020
Muzaffarnagari (M/F)	2.82 ± 0.06/ 2.61 ± 0.06	7.24 ± 0.16/ 6.62 ± 0.16	10.41 ± 0.21/ 9.35 ± 0.28	146.00 ± 6.57/ 130.00 ± 6.57	110.73 ± 12.20/ 103.07 ± 12.20	Asaduzzaman et al., 2020

BWT-birth weight, Pre-WWT- pre-weaning weight, WBT- weaning weight, AGD- average daily gain, M-male, F-Female

Pre weaning weight

The growth before weaning hinges on birth weight and subsequent development of developing lamb (Awgichew, 2000). The weaning rate of change of lamb is affected by the liter and sex (Taye et al., 2010). Singleton's birth generally has higher body weight, good feeding condition, and larger body size. It indicates those heavier lambs at birth produce larger adult weight with a high growth rate (Awgichew, 2000; Taye et al., 2010). Mothering ability of ewe, availability of milk in the udder, external environment, parasites, and lamb management also affect the pre-weaning lamb growth (Kumaravelu and Pandian, 2012).

Dam parity also influences the pre-weaning weight (Pre-WWT) from birth to 30 days of age. Lambs of two to third-party dams grow better than first and fifth-parity lambs (Awgichew, 2000, Tibbo, 2006). Moreover, the genotype of lambs shows a significant difference in growth. Table 4 shows the variations of pre-weaning weight of lambs of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Weaning weight

In meat sheep production, the weight of weaning is of great economic importance due to its influence on growth and survival rates (Taye et al., 2010). This characteristic is as important as pre-weaning growth rates, especially if the purpose is to produce the meat by producing lamb. Different values of weaning weight (WWT) by various authors were reported in other breeds (Awgichew, 2000; Tibbo, 2006). Breed potentiality, external environment, and lamb management factors influence the variation in weaning weight. Table 4 shows the variations of weaning weight of lambs of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

Pre-weaning average daily gain

The growth rate of lamb before weaning is called pre-weaning average daily gain (ADG) and it is important for sheep care, management, improvement, and production. As per Hassen et al. (2004), various factors viz. season, availability of feeds, diseases, and management affect the pre-weaning daily gain. Among all other elements, birth type is the important barrier for competitive birth suckling to weaning periods. According to breeds and management systems, the growth rate varies significantly on single and multiple births (Rios-Utrera et al., 2014, Teklebrhan et al., 2014). The sex of birth favours the weight gain at the pre-weaning stage. Many reports describe faster growth of male lambs than female lambs before weaning (Mohammadi et al., 2010; Ramanuj et al. 2010). Ewes breed also affects the lamb's growth at the pre-weaning stage, and many workers in different breeds in different environments have reported (Momany-Shaker et al., 2002; Rashidi et al., 2008; Mohammadi et al., 2010). Table 4 shows the variations of average daily weight gain of lambs of Bangladeshi indigenous and exotic cross breeds sheep under reviewed works.

CONCLUSIONS

The smaller flock's size of Jamuna basin sheep farm might be due to less growth performance which does not fulfill the farmer's demand. Body size, growth rate, and breed type are the main interest of smallholder sheep producers. Although sheep producers in both study areas practice a free mating breeding system, the farmers of Jamuna basin areas do not go for ram selection. They bred their ewes with flock-born or neighborhood non-selective small size ram. Moreover, every farmer does not adopt a breeding ram. Therefore, inbreeding might be another reason for this poor growth performance in this area. Whereas, Muzaffarnagari cross-breed sheep producers are aware of the selective breeding system. Diseases and parasite infestations are the crucial constraints of sheep production in studied regions associated with revenue loss to the farmers and stockholders. Due to good body weight and body size, as per studied reports, farmers at Meherpur and surrounded districts are adopting Muzaffarnagari cross-breed sheep to meet their socio-economic demand. In contrast, lower values of the reproductive traits of Jamuna basin sheep showed a more productive sheep breed than the Muzaffarnagari cross-breed sheep. Moreover, the higher number of lamb production and female lambs also esteemed Jamuna basin sheep as genetically productive sheep. These improved reproductive performances are factors for farmers' and breeders' choices in sheep production. On the contrary, lower growth performance and average daily gain of the lambs of Jamuna basin sheep are not fulfilling their demand.

RECOMMENDATIONS

• Traits of Sheep producer's interests should be organized, and flock productivity improvement programs should be designed to bring together their production objectives.

• Jamuna basin indigenous sheep is a slighter/smaller breed in body weight and body size with more prolific whiles the Muzaffarnagari cross sheep is medium sized non-prolific breed. Breed-wise, appropriate and strategic breeding programs should be planned and applied for increasing farmers' and country sheep production.

• Awareness creation on selective breeding and capacity building on improved animal husbandry practices through training is required to improve sheep production in their agro-pastoral management system.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

M Asaduzzaman conceived the topic, while FY Bari supervised, reviewed, and edited the final paper, A Saha and PK Datta tabulated all data, A Jemy collected and provided photographs of sheep, and MGS Alam edited the final paper. All authors read the manuscript.

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