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A FIVE-DECADE SYSTEMATIC REVIEW OF RESEARCH PROGRESS ON PRODUCTION AND MANAGEMENT OF SMALL RUMINANTS IN BANGLADESH

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Background: Small ruminant animals (SRA) have been associated with humans since their domestication are of world significance as socioeconomic animals providing products (meat, milk, wool, hair) that are in growing demand and sustainability of rural economics and many ecosystems with poverty elevation and food security in rural people in developing world including Bangladesh. People clearly want the benefit of SRA with the application of knowledge of science and technological research. Some research progress on production and management of SRA has been made during the past five decades in Bangladesh. However, such research information is often fragmented and not easily accessible, although these research findings are essential for further research and effective SRA development planning.
Objective: This review aimed to improve the information based on various aspects of production and management of SRA by compiling and reviewing published research findings to identify constraints of their production for practical and sustainable solutions.
Materials and Methods: A systematic literature of review of research articles on production and management of SRA published mainly in journals from 1968 to early 2021 of Bangladesh has been reviewed. A total of 332 inland research articles on these aspects supported with 19 foreign related articles have been reviewed and analyzed.
Results: Bangladesh has approximately 26.435 million goats and 3.607 million sheep. Among goat population, 90% Black Bengal goat (BBG), 8.0% Jamunapari (JP) and 2.0% crossbred goats. Ten phenotypic coat color characteristics of BBG with high performance with solid black color goats documented. Sheep and goats are considered polyestrous species, and the average gestation length lasts for 150 days and give birth twice a year under good management and nutrition. Most of the smallholder farmers (80.5-95%) are raised their goats in semi-intensive system and 47% rural women are involved in goat rearing. Approximately 96% goat farmers and 60% sheep farmers used roadside grass and tree leaves and only 4.0% goat farmers used cultivated fodder whereas 40% sheep farmers used cultivated and road side grass to feed their sheep. Daily supplement of 100-300g concentrate to grazing SRA improved the growth and carcass gain, productive and reproductive performances. Castrated goats at eight weeks of age showed a much higher growth rate (76.33g/day) than un-castrated (62.72g/day) goats. The productive and reproductive performances of SRA have been reviewed and discussed. The BBG has excellent reproductive efficiency but its lower live weight and milk yield encouraged for crossbreeding with exotic bucks. The meat and milk yield traits of crossbred improved but reproductive efficiency decreased in comparison to BBG. Selection breeding of BBG not only increased live weight but also improved carcass value and preserves the indigenous genetic resources from extinction of unplanned breeding. Similarly, the crossbreds between native ewes × exotic rams resulted positive effect on wool quality and live weight but a negative effect on prolificacy and lambing interval. Almost all SRA farmers depended on natural breeding system with some research data on the uses of AI and more than 70% farmers are being faced breeding service shortages. Major advances in methods of semen collection and evaluation, evaluation of male fertility, cryopreservation of sperm and estrous cycle control have been reported in both the goat and sheep in Bangladesh. In addition, knowledge of ovulation control, timing of insemination, gamete biology has also been reported in inland literature. The average slaughtering age of BBG reported to be approximately 12 months whereas in native Bengal sheep has been suggested to be 6 to 9 with an average of 8 months to get maximum return. The major challenges for SRA production are breeds, poor management, inadequate feeds, breeding bucks and rams and high neonatal mortality (kids 25.2%) and lambs (12.4%) in Bangladesh.
Conclusions: The SRA rearing as smallholder farmers managed mostly semi-intensive system and requires improved feeding, provision of veterinary medical services, financial assistance, improve natural breeding and/or AI services and extension services to encourage and enhance production of sheep and goat at rural levels in Bangladesh. An improvement in the performance of SRA would directly improve the diet and standard of living of rural smallholder farmers in Bangladesh.

Keywords: Systematic review, Five decades, Small ruminants, Production, Management, Bangladesh

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CONTENTS ON GOAT

CONTENTS ON SHEEP

CONTENTS (OTHERS)

INDRODUCTION

Small ruminant animals (SRA), predominantly sheep (*Ovis aries*) and goats (*Capra hircus*), were among the first livestock to be domesticated for food and fiber with historical evidence linking them to Western Asia approximately 9000-12,000 years ago.[1] These animals have been associated with human since their domestication, making them socioeconomically very important and providing meat, milk and milk products, hides and skins, wool, hair, mohair, cashmere and service to man throughout the world.[2,3] These farm animals play important roles especially employment, meat, weed control, dung and waste material as fertilizers. In addition, these animals have higher digestibility, social animals, easily raised by children and women, initial low investment, no religion taboo, very cheap to maintain and high demand of meat. 'Goats-pathway out of poverty,' argued that goats are worthy of serious investment with the potential for transforming the lives of some of the world's poorest people.[4] Even under extreme climate conditions, goats have several characteristics that enable their capacity to convert feed into meat and milk.[5] The total goat population has increased by approximately 240% in the last 50 years in the world, while large ruminant species maintained or decreased their population. Currently, there are approximately one billion goats in the world, of which more than 90% are reared in Asia and Africa and only 1.8% in Europe.[6] Most of the SRA raised in Bangladesh are of indigenous type with small body size and are primarily raised for meat production. They are reared on naturally grown grasses with usually no concentrate supplied and their levels of productivity are low and for meat the gap between output and demand is widening. The SRA make important contributions in the national economy of Bangladesh particularly to the stability of smallholder farming system by providing: (a) Financial resources for purchase of farm inputs and household needs, (b) Meat and milk, (c) Nutritional security, (d) Hides, skins and fibers, (e) Employment and organic manure, (f) People with cow's milk allergy could tolerate goat's milk, (g) They can easily be tended by the weak, women and children, (h) They are the most prolific domestic animals, (i) Goats can withstand heat stress and can endure prolonged water deprivation, (j) Increase of income and poverty reduction for smallholder farmers and (k) Cash income for empowerment of women. Therefore, SRA rearing and farming plays an important and potential role for poverty reduction, income generation, contribution to feed and nutrition security and employment generation. There are 26.435 million goats and 3.607 million sheep[7] whereas it has also estimated to be 14.8 million goats and 1.9 million sheep in Bangladesh.[8] However, some authors erroneously reported 35.37 million sheep population in Bangladesh.[9,10] Black Bengal goat comprises more than 90% of the total goat population[11] and the rest 10% comprises of Jamunapari and different crossbred goats.[12] More specifically reported 90% Black Bengal goats, 8.0% Jamunapari and 2.0% crossbred goats.[13] Recently, Boer goat breed has been introduced from Malaysia to BLRI, Savar, Dhaka and more recently in the American Dairy Farm Ltd., Gazipur from Australia.[14,15] Black Bengal goats are known to be famous for its high adaptability to stressful adverse environmental conditions, early maturity, fertility, prolificacy, resistance to common diseases, seasonality, delicious meat and superior quality skin.[16] There are five government goat development farms in different parts of Bangladesh including Dhaka, Sylhet, Rajshahi, Chuadanga and Jhenaidah. These goat farms are involved in conservation and extension of Black Bengal breed, buck production and

its distribution to poor and distressed women at low price @ BDT 1200/- buck of one year old. Some NGOs are actively involved in the production and development of goats at farmers' levels throughout the country. Different agricultural, Veterinary and Animal Science, Science and Technology Universities, Bangladesh Livestock Research Institute and concerned institutions and organizations are involved with livestock research including SRA production and health. Inland research reports on SRA production and management are voluminous but there seems to be no published comprehensive review report on this aspect. As a result concerned scientists are working without knowing all related published works and publishing similar research data in the journal. In continuation of the review of all the available research findings on SRA in Bangladesh, the first report has been published on the pre-clinical and clinical research on small ruminants,[17] more recently a review article on the 'Performance of Black Bengal goat: a 50-year review' has been published with an abstract without any data except medium body size goat with grown-up weight 25-30 kg with limited and erroneously presented references.[18] This paper reviews and analyze all the available inland research reports on the production and management of SRA particularly goats and sheep published mainly in the journals.

MATERIALS AND METHODS

This research reports on goat production and management published mainly in journals over the last five decades from 1968 to early 2021 from Bangladesh have been reviewed and analyzed during the two years period from 2019 and 2020 as described earlier.[17,19,20]

Status of small ruminant animals in Bangladesh

Originally, the sheep and goats were domesticated in the Western Asia for meat purpose and then disseminated globally because their great adaptability to varying environmental conditions and the different nutritional regimes under which they were evolved and subsequently maintained.[21] Later on they were bred for quality meat, milk and fiber production. In 2008, FAO reported 861.9 million goats and 1078.2 million sheep with a 1 : 1.25 ratio in the world[22] and in 2019, the world goat population is estimated at approximately one billion (1,003 million) and 1,173 million sheep population and most of them (94%) are reared in developing world particularly Asia and Africa.[23] It appears that the goat population has more than doubled during the last four decades in the world. Currently, there are different dairy and fiber breeds of SRA have been developed in the world and most popular goat breeds are Nubian, Alpine, La Mancha, Saanen, Toggenburg, Boer, Kiko, Angora, Cashmere goats, and Dorset, Merino, East Friesian, Awassi, Assaf sheep and Dropper sheep. Sheep and goats are both small ruminants but goats have 60 and sheep have 54 chromosomes. Goats prefer to eat with their heads up that is browsing while the sheep eat with their heads down that is grazing system.[24] Rearing and farming of SRA proved useful to man throughout the ages due to their productivity, small size, and non-competiveness to human for food and make a very valuable contribution, especially to the rural poor farmers in developing countries including Bangladesh. Bangladesh has a subtropical monsoon climate characterized by wide seasonal variations in rainfall, temperature and humidity which is suitable for goat rearing. Bangladesh has a native goat breed commonly

known as Black Bengal goat and some common exotic breeds like Jamunapari, Sirohi and Beetal and their crossbreds with BBG are available.

Black Bengal goats

Bangladesh has only one breed of goat that is known as Black Bengal goat (BBG) which comprises approximately 90% of the goat population. Most important phenotypic characteristics of the BBG are: (a) It has a broad chest, ears are always on top and horn may smaller medium, (b) They have usually colored black but brown, white or gray colored are also found, (c) Their body is tight and relatively shorter than other goat breed, (d) The hair of the skin is smooth, and (e) An adult male goat weights about 25 to 30 kg and female 20 to 25 kg.[16,25-27] Several reports on the phenotypic coat color characteristics of the BBG have been published from Bangladesh (Table 1).

Table 1. Phenotypic coat color characteristics of the Black Bengal goats

SN	Coat color	Gene	Mymen-Singh[!28] No. (%)	Mymen-singh[!29] No. (%)	Mymen-singh[!27] No. (%)	BLRI, Savar[16] %
01.	Solid black (SB)	A^a	461 (52.9)	105 (52.5)	45 (42.0)	57.46-73.29
02.	Black with Dutch belt (DB)	S^d	050 (05.7)	09 (04.5)	01 (01.0)	-
03.	Black with toggenburg (BT)	A^{sm}	080 (09.2)	18 (09.0)	106 (36.0)	-
04.	Black & white	-	-	-	-	26.35-46.89
05.	Solid brown (SBR)	B^d, B^l	004 (00.5)	05 (02.5)	-	-
06.	Black & brown	-	-	-	-	03.85-11.21
07.	Silver bezoar (SB)	A^+	267 (30.7)	29 (14.5)	-	-
08.	Brown bezoar (BB)	-	-	32 (16.0)	14 (13.0)	-
09.	White	-	-	-	-	07.69
10.	Non-distinguished (ND)	-	009 (01.0)	01 (00.5)	08 (08.0)	-
11.	Study villages	-	Same[!]	Same[!]	Same[!]	10 districts
12.	Photos included	-	Same [4][∂]	Same [7][∂]	Same [7][∂]	0
13.	Period of study	-	2009-2013	Not mentioned	Not mentioned	2006-2013
	Total		871	200	106	299

[!]**Plagiarism** [[!]Same study villages- Gangatia, Borachala and Pachpai) of Bhaluka upazila, Mymensingh district, [∂]Same photographs used in three articles, [ ] = No. of photographs, 10 districts = Bogra, Faridpur, Kishorgonj, Noakhali, Mymensingh, Jamalpur, Tangail, Manikgonj, Dhaka and Gazipur

According to coat color variation, BBGs have been categorized into: (a) Solid Black (Deshi chaaagol), (b) Toggenburg pattern (Boiragi chaagol), (c) Brown bezoar (Shiyailla chaagol), (d) Dutch belt, (e) Silver bezoar and (f) Others.[27] Black Bengal goats bear variety of coat color, black, black and white, brown, brown and white and white coat color.[29] There are four major different coat color of BBGs have been reported from BLRI goats including black 57.46-73.29%, black and white 26.35-46.89%, black and brown 3.85-11.21% and completely white 7.69% (Table 1).[16,30] The hilly Brown Bengal goat, a variety of BBG, is available at the hilly districts, which are dwarf type goats are reputed to be very hardy and capable of thriving in any adverse environmental condition.[30]

Definition of coat color pattern of BBG

Some coat color variants have been identified with specific characteristics of coat color.[27-29]

① **Solid black**- when entire body is black in color without any pattern (Photo 1& 2) and A^a gene has suggested being responsible for black coat.

② **Black with toggenburg pattern**- when BBGs have dark body and dark belly with pale legs, ears and facial stripes (Photo 3 & 4) are characterized as Toggenburg pattern (A^{sm}) that contains brown eumelanin.

③ **Solid brown**- when brown eumelanin skin coat of goat varies from very dark (B^d) to very light brown (B^1) are characterized as solid brown (Photo 7).

④ **Bezoar** - consists of two types e.g. (i) Silver bezoar (Photo 8) and brown bezoar (Photo 6). Color is darker in male than female goats. The color is characterized by wild color (A^+), tan body and dark head with stripe.

⑤ **Dutch belt pattern**- this coat color variety is characterized by a nice ring around the barrel to a nearly white with colored tail and head with some single side spots (Photo 5)

⑥ **Others**- white (Photo 10), light brown bezoar (deer color) with brown face and black tail tip (Photo 11) and black face and tail (Photo 13). When the goats can't be classified in any group based on coat color because some goats may have combination of different coat colors or mixed color with no distinct pattern are grouped as non-distinct pattern (**Photo 9,12**). The whole genome analysis of Black Bengal goat have identified 49,965 exotic variant sites that are distributed in 11,568 genes which might help to identify genomic variants underlying major phenotypic traits and genetic basis for improvement of meat quality of BBGs.[31]

The live weight and growth rates of three coat color variants (solid white, Dutch belt and Toggenburg) of BBG performed similar results, however, reproductive performance varied among color types.[32] Phenotypic association among live weight,[33] body measurement and behavior,[34] qualitative and quantitative traits,[35] morphometric characterization and relationship of body weight,[36] body weight and measurement[37] of BBG have been reported. Coat color is an identity of a specific breed's character but varied color in a breed like BBG may be ignored in evaluation of under same management system.[38]

Jamunapari goat

The Jamunapari is an Indian tallest dairy breed of goat and commonly known as the Pari (Angel) in its area of origin- Uttar Pradesh because of its majestic appearance. Jamunapari breed of goats are distributed throughout Bangladesh with high population in Chuadanga, Meherpur, Kushtia, Jhenidah, Pabna and Jessore district.[14] Its total population is not known but it has been estimated that about 8% goats are Jamunapari in Bangladesh. Name of the breed derived from the rivers the Yamuna, Jamuna (West Bengal and Bangladesh). Most common physical characteristics of the Jamunapari goat are as follows:[39]

- It has comparatively bigger body size, tall, long leg (leggy), centrally ridged (prominent Roman) nose (parrot like nose), large folded pendulous (hanging long) ears, short and flat horns are major physical features.
- There is a great variation in coat color but the typical color is white or whitish brown with small tan patches on head and neck (Photo 14).

Photo 1. Solid black (BBG) doe [27,28,29]

Photo 2. Solid black castrated BBG

Photo 3. Black with toggenburg [27,28,29]

Photo 4. Black with toggen burg BBG

Photo 5. Dutch belt[27,28,29]

Photo 6. Brown bezoar [27,28,29]

Photo 7. Solid brown / bezoar[27,29]

Photo 8. Silver bezoar with dorsal stripe[29]

Photo 9. Other color BBG[27,29]

Photo 10. White BBG

Photo 11. Light brown bezoar

Photo 12. Black and white spotted

Photo 13. Light brown bezoar

Photo 14. Jamunapari goat

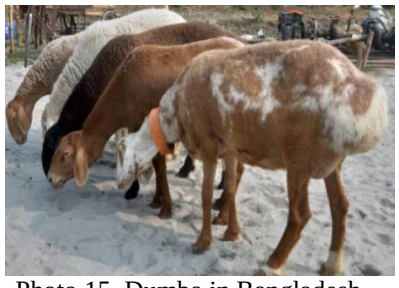

Photo 15. Dumba in Bangladesh

- They carry long and thick hair on their hind quarters and have a glossy coat.
- A thick growth of hair on the buttocks, known as feathers, obscures the udder when observed from behind.
- The udder is well developed, round with large conical teats.
- The body weight of an adult buck and doe varies from 65 to 85 kg and 45-60 kg, respectively.
- The age at sexual maturity in male varies from 9 to 12 months and age at first conception is 18 months in female goats. The female goats come in estrus throughout the estrus with no seasonality in breeding.

Crossbred goats

Approximately 2.0% crossbred goats mostly BBG × Jamunapari crosses are available in Bangladesh.[13] Bucks of some other exotic breeds especially Sirohi, Beetal, Kalahari are being imported from India and are used for crossbreeding of indigenous goats at personal levels. According to the Livestock Development Policy 2007, crossbreeding with BBG is not allowed in Bangladesh. However, the reproductive performances particularly early maturity, larger litter size, shorter post-partum period and minimum kidding interval are better in indigenous BBG, whereas the productive performances especially higher birth weight, higher body weight gain, high milk yield and longer lactation length have been reported with crossbred goats.[40]

Boer goat

The Boer goat is also known as Afrikaner, South African common goat and Boerbok goat. Boer goats evolved in South Africa from the indigenous African and the introduced European stock like Bantu and Nubian, Saanen, Toggenburg and probably Angora.[41] The Boer goats are also found in Botswana, Lesotho, Swaziland, Zimbabwe, Namibia, Kenya, Burundi, Mozambique, Australia, USA, New Zealand, Germany, Israel, France and China.[42] Currently the Boer goats (*Capra hircus*) have gained worldwide recognition for excellent body conformation, fast growing rate and good carcass quality. Among all superior traits for goat meat production, heavier body weight and faster growing rate are the major characteristics of Boer goats. Boer goats have desirable genetic traits for meat production and accordingly this breed of goat have successfully improved productive performance of indigenous breeds through cross-breeding program. The improvement of birth weight, daily body weight gain, weaning weight, breeding weight, mature weight, kidding rate and carcass quality have reported in the crossbred goat produced with indigenous and Boer goats.

The different organizations especially Bangladesh Livestock Research Institute, Savar and Bangladesh American Dairy Limited, Gazipur and others have introduced Boer breed of goat in Bangladesh. The adaptation, morphometric characterization and performances of this breed of goat under local agro-ecological climatic condition has been reported.[14,15] The findings of the productive and reproductive performances of Boer goats showed an average of 2.59 kg birth weight, 80.18g / day growth rate, 383.33 ml /day milk yield, sexual maturity at 208 days of age, 1.13 number of kids / doe and 95.2% survival rate of kids.[14,15] Boer goats are adaptable in the farming condition of Bangladesh as well as higher birth weight and subsequently higher adult body weight has suggested for rearing this breed to solve the high demand of goat meat and ensure nutritional security in people of Bangladesh.[15]

Sirohi goat

The Sirohi goat is mainly an Indian meat producing breed, which is native to the Sirohi district of Rajasthan. The breed is also known as Ajmeri, Devgarhi and Parbatsa. It is a medium sized goat, predominantly brown colored coat with dark or light brown patches and covered with fairly dense soft and coarse hair. Both buck and doe have small horns which are curved upward and backward, tail curved upward and medium in length, long and very strong legs, buck weight up to 50 kg and doe up to 30kg. They are easily adaptable to different climatic condition and have weight gain capability even in poor quality rearing conditions like Bangladesh. Accordingly, this breed of goat has been imported from India at personal level and missionary institution and rearing in different parts in Bangladesh.

Beetal goat

Beetal goats are likely named for the area 'Batala' of Gurdaspur district of the Punjab, India and distributed throughout the Punjab in both the countries India and Pakistan. This is a multi-purpose breed for milk, meat and skin. It is a large sized goat breed having long hanging ears 10-18 inches (25-45 cm) and prominent nasal bridge gives a distinct Roman nose which is more pronounced in males that ending abruptly. Both sexes have small and thick horns, lying horizontally backwards, close to the body. Teats are mainly funnel, tube or bottle-shaped. Males have a dewlap (loose skin under neck) but neither sex has a beard. It has different coat color including black, brown, red or white, sometimes pied, spotted or mottled. Does are prolific breeders, average 1.66 kids / litter, kidding yearly from about 17 months of age, produce 1-3 liter with an average of 1.8 liter milk daily for 150-170 days with an average of 161 days lactation period. The live weight of male (buck) varies from 60-70kg and in does 40-45kg. They are heat tolerant and cope well with the dry conditions and climate of Indo-Bangladesh sub-continent.

Kalahari red goat

The Kalahari red goat is a meat type goat that originated in South Africa. The name Kalahari red comes from the color of the sand in the Kalahari Desert which spans the borders of Botswana, South Africa and Namibia. Their framework is similar to that of the most popular South African Boer goat. The dominant red / brown color of the Kalahari reds creates the goat very suitable for crossbreeding programs to improve the color of the indigenous goats. The advantages of rearing Kalahari red breed of goats are adaptability, low mortality and resistance to disease, good mothering traits, meat and pelt of high quality, fertility and kid percentage, an abundance of milk and longevity.[43] The ideal is a brown goat with color shadings that range from light brown to dark brown, well-pigmented, smooth and short hair coat. The puberty age is about six months, 100-day weaning weight of male 25 kg and female 21 kg and mature weight 75kg. This breed of goat may be reared in different urban areas in Bangladesh but it has only been reported from Rajshahi metropolitan areas.[44]

Goat husbandry practices in Bangladesh

More than 98% goats are reared by the smallholder farmers at rural level with different housing and feeding system throughout the Bangladesh.[45,46] Most of the rural goat farmers used

indigenous BBG for goat farming. A study showed an average number of goats reared by the farmers approximately 8.85 in Jhenaidah, 3.7 in Mymensingh and 2.88 in Rangpur districts.[47] An investigation of 250 goat-raising households recorded number of goat per household varied from 2.39 to 13.75 with an average of 5.06.[48] A report shows that 55% smallholder goat farmers used average management practices compared to 45% poor management in respect of housing, feeding and drinking water to their goats.[49] Approximately 47.0% rural women have been reported to be involved in goat rearing in Bangladesh.[50,51]

Most of the farmers (80.5%) reared goats in semi-intensive system[52,53] but limited farmers (7.3%) used confinement (intensive) system and 12.2% farmers used free range (extensive) system of goat rearing in Bangladesh (Table 2).[13] Overall analysis of the data shows that 95%

Table 2. Goat production and management system at smallholder farmers level in Bangladesh[13,54]

SN	Region & districts	No. of farmers	No. and types of goats (Mean)				Mean kidding rate	Rearing system	Kid mortality %
			Doe	Buck	Kids	Total			
1.	Mymensingh	40	55	30	95	180	-	-	-
2.	Gazipur	25	24	19	60	103	-	-	-
A.	North-western	65	79 (1.22)	49 (0.75)	155 (2.38)	283 (4.35)	2.46	SI (95%) + E (5%)	08.0
3.	Bogra	25	21	15	42	78			
4.	Sirajganj	25	18	16	44	78			
B.	North-Bengal	50	39 (0.78)	31 (0.62)	86 (1.72)	156 (3.12)	2.48	SI (90%) + E (10%)	11.0
5.	Barishal	25	19	13	33	65			
C.	Southern	25	19 (0.76)	13 (0.52)	33 (1.32)	65 (2.6)	2.30	SI (100%)	21.0
6.	Jhenaidah	40	44	28	84	156			
7.	Bagherhat	30	26	20	49	95			
D.	South-western	70	70 (1.00)	48 (0.69)	133 (1.90)	251 (3.59)	2.51	SI (95%) + E (5%)	10.0
Overall (Mean)		210	207 (27.42)	141 (18.68)	407 (53.91)	755	2.44	-	50 (12.5)

SI = Semi-intensive E = Extensive

farmers reared their goats in semi-intensive management system and only 5.0% in extensive system (Table 2). Approximately 73.2% goat is reared under low input production system (only natural grasses and tree leaves) and the rest 26.20% are supported by the medium inputs (natural grasses + some concentrate). About 6.20%, 8.10% and 12.5% of goats supported by medium inputs are reared in the subsistence, smallholder and small-scale commercial operations, respectively.[13] Recently, the medium scale- semi-intensive farms (20-25 does) and large intensive / semi-intensive farms (≥ 100 does) also gaining popularity due to demand and profit from goat farming in Bangladesh.[13]

Housing system of goats in Bangladesh

Well design houses with adequate facilities are required for profitable goat rearing considering the importance of: (a) protection of goats from rain, cold, hot weather and predators, (b) prevention of diseases, parasites, morbidity and mortality and (c) Proper and easy management of goat flocks. The main criteria or principles of building a goat houses include: (a) Selecting the housing site at high and dry place, (b) Goat house floor should keep always dry and clean, (c) Ensure for adequate light and air inside the house, (d) Easy to control temperature, moisture and dump free conditions, (e) Rain and flood water should not be able to enter the house, (f) Houses should be strong and comfortable for taking rest of the animals, (g) Houses with all necessary facilities so that it can be easily clean regularly and adequate space based on age and nature are required as, 0.3 meter for kid, 1.5 meter for adult goat, 1.9 meters for pregnant goats and 2.8 meters for buck.

In Bangladesh, most of the goats are reared by landless farmers, especially women and they don't provide separate housing for their goats. Goats are housed in a part of their living house or kitchen or houses used for other large ruminants or storing of goods (Table 3). A report showed that 77.15% goat farmers in Jhenaidah, 20% in Mymensingh and 48.58% in Rangpur districts has provided houses to their goats.[47] Goat farmers are usually used medium scale semi-intensive system where animals are facilitated to shelter and supply feeds including grasses and concentrate. These types of house are usually prepared with bamboo and galvanized tin. Goat farmers are usually cultivate some grasses in their own land or rented land.

Large intensive and semi-intensive farm houses are also made with concrete structure where different types of facilities are made available for rearing goats. These farm owners are usually have own lands for grazing and cultivation of grasses. This type of goat farms are used in different government goat farms, research institute goat farms, universities goat farms and also in some commercial goat farms.[13] Table 4 shows that most of the traditional goat farmers used earthen wall (76.25%) and non-paved floor (71.25%) whereas commercial goat farmers used brick wall (50.0%) and slatted floor (66.67%). In addition, all of the commercial goat farms (100%) constructed away from their residence, whereas most of the traditional goat farms (77.25%) constructed attached to their own houses without any proper direction (75.0%) and ventilation (85.0%) comparison to 100% East-West direction and 100% ventilation in commercial housing (Table 4). The commercial farm management system provides cultivated fodder (100%), concentrate mixture (100%) and tube-well water (100%) to their goats whereas traditional management system provides natural roadside grasses (85.0%) and fallow land grasses, no concentrate mixture (85.0%) and tube well (48.0%) as well as pond (49.25%) water for drinking (Table 4). There are some hindrances concerning housing and feeding management practices of goat in both the traditional and commercial farming practices and concerned authorities should take necessary steps to minimize these problems of goat production in Bangladesh.

The north-western region (4.35/farm) has been reported more favorable for goat rearing, followed by south-western region (3.59/farm) and north-bengal (3.12/farm) and lowest in southern region (2.60/farm) of Bangladesh. Southern region has tropical climate with grazing land throughout summer and rainy seasons with high salinity that is why low kidding rate and

high kid mortality.

Table 3. Comparison of housing, feeds and feeding of rural goats between districts [55,56]

SN	Variants	Category	Mymen-Singh[!55,56] (n=50) No. (%)	Barguna & Patuakhali [56] (n= 41) No. (%)
A. Housing				
1.	Rearing system	Confinement	0	03 (07.3)
		Semi-intensive	50 (100)	33 (80.5)
		Free range	0	05 (12.2)
2.	Night shelter	Goat's house	34 (68)	31 (75.6)
		Cattle's house	04 (08)	02 (04.9)
		Veranda	08 (16)	08 (19.5)
		Living room	04 (08)	0
3.	Provide bedding during winter	Yes	49 (98)	32 (78)
		No	01 (02)	09 (22)
4.	Bath during summer	Yes	42 (84)	41 (100)
		No	08 (16)	0
5.	Bath during winter	Yes	09 (18)	18 (43.90)
		No	41 (82)	23 (56.1)
B. Feeds and feeding				
1.	Types of feeds	Green grass (GG)	09 (18)	25 (61)
		Concentrate + GG	41 (82)	08 (19.5)
		GG + Straw	0	08 (19.5)
2.	Stall feeding with GG	Yes	40 (80)	27 (65.9)
		No	10 (20)	14 (34.1)
3.	Concentrate supply	Yes	41 (82)	16 (39)
		No	09 (18)	25 (61)
4.	Particular feeder for concentrate	Yes	41 (82)	13 (31.17)
		No	09 (18)	28 (67.7)
5.	Watering daily	Yes	44 (88)	37 (90.2)
		No	06 (12)	04 (09.8)
6.	Watering frequency/day	Once	43 (86)	23 (56.1)
		Not counted	07 (14)	18 (43.9)
7.	Drinking water sources	Tube well	42 (84)	19 (46.3)
		Pond	01 (02)	21 (51.2)
		Pond & lake	02 (04)	0
		Tube well & Pond	05 (10)	0
		Supply water	0	01 (02.4)
8.	Feeding during rainy day	Green tree leaves	38 (78)	19 (46.3)
		Green grass	0	08 (19.5)
		GG + tree leaves	12 (24)	14 (34.10
9.	Graze in the rain time	Yes	50 (100)	0
		No	0	41 (100)

n = No. of goat farmers [!]Plagiarism- Same data used in both the articles[55,56]

Table 4. Comparison of housing and feeding management between traditional and commercial goat rearing system in the four northern districts*[46]

SN	Variable	Category	Traditional (%) (n = ?)	Commercial (%) (n = ?)
A. Housing profile				
1.	House wall:	Brick	23.75	50.0
		Earthen	76.25	0
		Wooden	0	33.33
		Iron fence	0	16.67
2.	Floor	Paved	28.75	33.33
		Slatted	0	66.67
		Non-paved	71.25	0
3.	Location	Attached to residence	77.25	0
		Separate	22.75	100
4.	Direction	East-West	25.00	100
		Others	75.00	0
5.	Ventilation	Well	15.00	100
		No	85.00	0
6.	Source of light	Natural	15.00	95.00
		Artificial	85.00	05.00
B. Feeding profile				
1. Type of grasses				
a. Natural			85.0	0
b. Cultivated			15	100
2. Feeding system				
a. Grazing			15	0
b. Tethering			70	0
c. Cut & carry			15	100
3. Grass processing				
a. Processed			15	100
b. Not processed			85	0
4. Concentrated mixture				
a. Supplied			15	100
b. Not supplied			85	0
5. Drinking water				
a. Tube-well water			48	100
b. Pond's water			49.25	0
c. Others			02.75	0

*Bogra, Sirajgonj, Gaibandha and Rangpur
(n = ?) = Only % data available in the report

Feed and feeding system of goats in Bangladesh

Goats generally produce more milk than a cow from the same quantity of nutrients and the nutrient conversion efficiency for the production of milk in goats is 45.71%, whereas a dairy cow averages 38%. It has been reported that goats are 4.04% superior to sheep, 7.90% superior to buffaloes and 8.60% superior to cows in crude fiber utilization.[57] Traditionally, goats are feeding mainly on the agricultural crop residues and by-products, low quality roughage, tree leaves and natural grasses in Bangladesh. Goats are grazed on harvested or fallow lands, roads, rivers and canal sides. Different tree leaves are also used to feed the goats during adverse weather condition and even in normal feeding practices. A questionnaire survey to the rural goat farmers revealed that 96% farmers used roadside grass and tree leaves whereas, only 4.0% farmers used cultivated fodder to feed their goats, 85% farmers used their prepared mixed feed and only 11% farmers used vitamin-mineral supplementation to their goats.[54] An investigation showed that the total CP intakes of all the categories of BBGs reported higher than the requirements. Intake lower amount of DM through roughage and concentrate feed mixture than their requirement but they intake surplus amount ME, TDN and CP rather than their body weight requirement.[58]

Fodder tree in Bangladesh

Fodder tree leaves are mostly used to feed ruminant animals particularly small ruminants especially during the rainy season. Most of the tree leaves are found very nutritious because deep root system of trees allow them to draw nutrients from deeper parts of the soil nutrients which are not available to grasses. The important fodder trees leaves commonly used to feed small ruminants in Bangladesh.[59,60]

- Jackfruit (*Artocarpus heterophyllus*)
- Mango (*Mangifera indica*)
- Tetul (*Tamarindus indica*)
- Kapila (*Garuga pinnata*)
- Menda (*Litsea polyantha*)
- Krishnachura (*Dolonix regia*)
- Boroi (*Zizphus manuritiana*)
- Ipil-ipil (*Leucaena leucocephala*)
- Indian jujube (*Zizyphus mauritiana*)
- Mehgoni (*Trichilia emetic*)
- Banana (*Musa* spp.)
- Koroi (*Albizi alebbek*)
- Mandar (*Erythrina indica*)
- Sal (*Shorea robusta*)
- Guava (*Psidium guajava*)
- Dumur (*Ficus racemosa*)
- Silk plant (*Albizia* spp.)
- Egyptian riverhemp (*Sesbani sesban*)
- Bamboo (*Bambusa* spp.)
- Babla (*Acacia nilotica*)
- Aswatha (*Fiscus religiosa*)
- Mander (*Erythrina variegata*)
- Sheora (*Streblus asper*)
- White fig (*Fiscus infectoria*)
- Mulberry (*Morus alba*)
- Jackfruit (*Atrocarpus integrifolia*)

Tethering with grazing up to five goats at a time are usually led by ropes held by women and children. In smallholder farms, goats depend on only natural grass and tree leaves where the medium input farms also provide some concentrate. Goats are usually fed on 19 varieties of forages and crop by-products in Bangladesh (Table 5).

The average number of goat population per farm has been estimated to be 10.53 in the study area of Chowgacha, Jessore and Jhinaidah districts. Dog grass, shayama, ulugrass, mango leaves, chickpea grain at chowgacha, and dog grass, shayama, vadla grass, ulugrass, mayna grass, mango leaf and jackfruit leaves are used as the major feeds of goat at kaligonj.

An experiment has been conducted to find out the effect of four feeding systems on growth,

Table 5. Forages and crop by-products commonly used for feeding goats.[61]

SN Name	Botanical names	% use	SN Name	Botanical names	% use
1. **Native grass**	*Digifuria sangninalis*	100	09. Banana	*Musa sapientum*	12
	Panicum repens		10. Coral tree	*Erythrina indica*	08
	Cynodon dactylon		11. Indian Blackberry	*Eugenia jembolana*	08
Tree leaves			12. Morunga	*Moringa oleifera*	07
2. Jackfruit	*Artocarpus heterophyllus*	98	13. Guava	*Psidium guyava*	04
3. Mango	*Mangifera indica*	87	14. Bamboo	*Bambusda tulda*	03
4. Shewra	*Streblus asper*	50	**Brans**		
5. Banyan	*Ficus bengalensis*	21	15. Wheat	*Tritium aestivum*	60
6. Jujube	*Zizyphus jujube*	20	16. Khesari kalai	*Lathyrus sativus*	48
7. Korai	*Albjzzia procera*	16	17. Mash kalai	*Phaseolus mungo*	53
8. Country almond	*Terminalia catappa*	12	18. Rice	*Oryza sativa*	18

feed intake, eating behavior, productive and reproductive performance of BBG. Approximately one year aged 24 does have been randomly selected for the four different treatment (feeding system) groups having six replications in each and the effect of different systems of feeding in BBGs recorded during the period of 219 days (Table 6). Overall performance of stall fed goats has been reported to be more satisfactory and that the tethering group showed better performance than the others (Table 6).

Evaluation of feeding native grasses in goats

Common grasses are the major source of livestock feed grown in roadside, river embankment, fellow land, crop land and high way tract. Both qualitative and quantitative growth *Phaseolus mungo*, *Imperata cyclindrica* and *Cynodon dactylon* are better than other grasses, whereas *Phaseolus mungo* is the best for yield, nutritive value as well as adaptability.[62]

Different species of native grasses are produced naturally in Bangladesh and ruminant livestock are mainly consumed these grasses but the knowledge of the nutrient contents and nutritive values of these common grasses are not well known. An attempt was made to evaluate nutritive values by feeding freshly-cut common grasses on the growth performance of BBGs during the pre-monsoon and pre-dry season with the available species of grasses (Table 7). Common grasses are mainly available on the harvested of fallow lands, roadsides, crop field ridges and canal sites.

Approximately 48 different native green grass fodders are grown in different agro-ecological zones, among which most available native green fodder are identified as dubra, badla, kawn, shama, khesari, gamma, ura, gobra, shama and maskalai. Most of these native grasses are grown more in summer and some others like kawn, khesari and maskalai are grown in winter.[63] Common grasses harvested during the pre-monsoon season contained higher nitrogen (15.6g / kg) and less dry matter (196.8g / kg) than the grass harvested in pre-dry season where nitrogen recorded as 12.8g /kg and DM as 454.9g/kg. The grasses which are grown during the pre-monsoon reported higher nitrogen value and appeared to be more palatable.[64]

A comparative trial among feeding road-side grass, *Sesbania aculeate* and *S. rostrata* in 5-months old castrated goats for 56 days trials reported *S. rostrata* is a superior than *S. aculeate* and road-side grasses, and suggested to be used as a good source on nutrients, particularly of protein for growing goats.[65]

Table 6. Comparative evaluation of four feeding system in BBG[66]

SN Parameters	Stall feeding	Tether-ing	Restricted grazing	Grazing
A. Effect on feed intake				
1. Av green grass intake (kg/d)	0.74^{a}	0.83^{ab}	0.68^{b}	0.77^{b}
2. Av concentrate intake (g/d)	172.5	172.5	172.5	172.5
B. Effect on LW gain				
1. Average initial LW (kg)	7.950	7.867	7.30	7.65
2. Average final LW (kg)	11.45^{a}	10.18^{ab}	9.62^{b}	9.37^{b}
3. Average LW gain (kg)	3.50^{a}	2.32^{b}	2.00^{b}	1.75^{b}
C. Effect on reproductive performance				
1. Av birth weight of kid (kg)	1.44^{a}	1.10^{b}	0.91^{c}	0.90^{c}
2. Av gestation period (days)	145	145	144	143
3. Milk yield / lactation (ml)	460^{a}	255^{b}	212^{b}	225^{b}
4. Litter size	1.0^{b}	1.5^{a}	1.0^{b}	1.0^{b}
5. Conception rate	1	1	1	1
6. Lactation period (days)	56^{a}	37^{a}	33.8	32.5^{b}
7. PP anestrus period (days)	68^{c}	73^{b}	81.5	85.25
D. Effect on parasitic infection				
1. *Fasciola* sp.	3.33^{b}	4.17^{b}	7.50^{b}	23.33^{a}
2. *Paramphistomum* sp.	7.5^{ab}	0^{b}	0^{b}	13.33^{a}
3. *Trichuris* sp.	1.0^{b}	13.33^{ab}	11.67^{ab}	22.50^{ab}
4. *Eimeria* sp.	11.00	0	0.83	0.33
5. *Strongylus* sp.	1.67^{b}	6.67^{ab}	23.33^{a}	23.33^{a}

Data of 6 animals in each group PP = Post-partum Av = Average
Means having different superscripts differed significantly

Table 7. Common grasses species identified in two different seasons at BAU campus[64]

SN	Local name	Scientific name
	A. Pre-monsoon	
01.	Alighasa	*Cyperus pygmaeus*
02.	Angta / Gaicha	*Paspalum scorbiculatum*
03.	Bara nirbishi	*Fimbristylis diphylla*
04.	Chagaldari1	*Cyperus iria*
05.	Chisra	*Scirpus juncoides*
06.	Chotochaise[2]	*Cyperus defformis*
07.	Dal ghas/Gobra	*Echinochloa crusgalli*
08.	Deobhadail[3]	*Cyperus nemorallis*
09.	Ghechu khui	*Aponogeton natans*
10.	Heicha	*Alternanthera philoxeroides*
11.	Joina[4]	*Fimbristylis miliacea*
12.	Joina chaise	*Fimbristylis dichotoma*
13.	Kanailala	*Commelina deffusa*
14.	Kheta ghas[5]	*Altera*n*anthera paronichioides*
15.	Khude patai	*Cyperus tenuiculmis*
16.	Mona ghash	*Leptochloa panicea*
17.	Panichaise	*Eleocharis artopurpurea*
18.	Satidhara	*Cyperus sanguinolentus*
	B. Pre-dry season	
1.	Bara dhudia	*Euphorbia hirta*
2.	Bhadail /Mutha	*Cyperus rotundus*
3.	Borati ghas	*Hemigraphis hirta*
4.	Chapli grass	*Chenopodium ambrosiodes*
5.	Chapra	*Eleusine indica*
6.	Choto dhudia	*Euphorbia perviflora*
7.	Durba	*Cynodon ductylon*
8.	Ghora ghas	*Cryptocoryne retonspirales*
9.	Nakful	*Wahlenbergia marginata*

[1]/Matichaise [2]/Moishroom [3]/Sagalbati
[4]/Chakti ghash [5]/Kheta buri

The effects of feeding Sesbania leaves as a sole feed on growth performance and nutrient utilization was conducted for 56 days using 9 five months old castrated male BBGs with initial live weight 9.0 kg. The animals fed *ad libitum* on either on road-side grass, *Sesbania aculeate* leaves or *Sesbania rostrata* leaves. Average DM intake recorded as 179, 229 and 259 g/day for goats fed road-side grass, *Sesbania aculeata* and *Sesbania rostrata*, respectively. Corresponding mean values for average daily live weight change was -6.6, 9.5 and 38.1g, respectively. *Sesbania rostrata* found superior to *Sesbania aculeata* for live weight gain as well as nutrient digestibility. The production of *Sesbania rostrata*, a legume fodder should be encouraged for feeding goats.

Among the goat farmers in the district of Mymensingh, 96% farmers used roadside grass and tree leaves to feed their goats whereas, only 4.0% farmers used cultivated fodder which cultivated in their own land.[54]

Evaluation of feeding tree leaves in goats

Tree leaves may become a rich source of supplementary protein, vitamins and minerals and their use in ruminant to enhance microbial growth and digestion. The effect of supplementation of Jackfruit (*Artocarpus heterophyllus*) tree leaves and mashkalai (*Vigna mungo*) barn on the intake and digestibility of freshly cut common grass by the castrated BBGs of 5 to 6 months old have been evaluated as: (a) Freshly cut common grass *ad libitum*, (b) Common grass + 100g Jackfruit tree leaves and (c) Common grass + 100g mashkalai bran. Supplementation of mashkalai bran promoted higher digestible nutrients intake with the consequent higher daily live weight gain (75g) than those fed grass alone (31g) or supplemented with Jackfruit tree leaves (30g). The mashkalai bran has been suggested to be a suitable supplement for goats consuming common grass in the tropics and subtropics.[67] The effect of replacement of green grass by jackfruit leaf on the performance of BBG,[68] tree forage on growth performances[69] and pakari leaf plus concentrate[70] have been evaluated.

Ipil-ipil (*Leucaena leucocephala*) leaves *ad lib* along with 10g concentrate mixture fed to adult castrated goats for 14 weeks without any signs of disturbances particularly alopecia.[71,72] The mango or shaora leaves have been used *ad lib* as the sole roughage source for goats in place of green grass with some wheat bran and molasses.[73]

Feeding of certain tree leaves in goats showed that the Ipil-ipil leaves found better than any other leaves; mander leaves considered as second better variety of leaves among them and Sal leaves may be considered as alternative feed resource for goats around forest zone in terms of TDN value. The digestibility of CP reported significantly higher in mander and Ipil-ipil leaves as compared to those in jackfruit, krisnachura, sal, guava and mango leaves. The CP digestibility of mander and ipil-ipil leaves in goats recorded as 51.22 and 70.7% respectively.[74] Seven types of tree leaves, e.g. mander, sal, krishnachura, jack fruit, ipil-ipil, mango and guava fed to the adult BBGs for 140 days. Animals fed guava leaves lost weight @ 3.9g/day, whereas ipil-ipil, jack fruit, mander, sal, krishnachura and mango leaves fed goats gained live weight 52.8, 43.9, 33.3, 26.9, 12.1 and 6.4 g/day respectively. Tree leaves such as ipil-ipil, jack fruit, mander and sal have been suggested to use as fodder for BBG when 100g concentrate mixtures are allowed for them.[59]

The chemical composition, fractions, mineral concentration, amino acid contents, *in vitro* organic matter digestibility and energy values showed a wide variation among the investigated tree leaves in Bangladesh. The crude protein (CP) ranged from 8.5 to 23.9% and *M. alba* showed the highest and *M. indica* the lowest. Mineral concentration varies among species but all leaves are rich in Ca and P, and moderate in K, Fe and Co. Organic matter digestibility ranged 41.2 to 76.9% with a mean of 53.4% and all leaves are quite rich in gross and metabolizable energby (ME) but poor in net energy for lactation. However, the tree leaves, especially *M. alba*, *S. sesban*, *L. leucocephala* and *S. asper* have the great potential to be used as feed for livestock considering nutritive points of view.[60]

Animals fed tree forage based diets significantly increased weight gain at 60.03, 59.10, 57.75 and 55.57 g/day for *Sesbania grandiflora*, *Leucaena leucocephala*, *Erythrina orientalis* and *Morus alba*, respectively compared to that of control group at 39.25g/day. The supplementation

of diets with tree forages resulted in better weight gain, digestibility and nitrogen balance compared to the control green grass. It has suggested that the diets of goats may be supplemented with tree forages for the improved growth performance.[69,75]

Evaluation of feeding water hyacinth leaves in goats

The voluntary intake of water hyacinth leaves has been estimated to be 232 g/day and the intake of DCP reported to be sufficient to meet the maintenance needs of goats.[76] The effect of 100% replacement of green grass (dhal grass) by 100% water-hyacinth leaves on the performance of goat supplied with common concentrate mixture (Wheat bran 108g, Til oil cake 60g, Fish meal 20g, Bone meal 8g and common salt 4g) showed that goat can efficiently utilize water-hyacinth leaves along with green grass.[77]

Water-hyacinth leaves (WHL) have been evaluated in adult BBG in four groups (I: 100% dal grass (DG), II. 75% DG + 25% WHL, III: 50% DG + 50% WHL and IV: 100% WHL) up to 60 days. All the goats provided 200g concentrate mixture every day. It has been suggested that the WHL may be used as green fodder in goat feeding. However, the nutritive value of WHL can be improved by adding other green grass and little amount of concentrate in the diet of goat.[78]

Evaluation of feeding fodder crops in goats

Based on daily newspaper reports that there is a requirement of 70 million metric tons of green grasses for animal feeding but produced only 24 million metric tons with approximately 60% deficit annually in Bangladesh. The benefit: cost ratio (BCR) for Napier fodder cultivation has been estimated to be 1.98 : 1 and the fodder production and marketing system reported as profitable enterprises in Bangladesh. Fodder crops are mainly used to feed large dairy ruminant animals and small ruminant animals hardly supply cultivated fodder crops for feeding in Bangladesh. Accordingly, the research reports on feeding fodder crops to small ruminants are very limited. Cowpea fodder has been evaluated in goats and considering the productivity and nutritive value of cowpea, it has been suggested to feed as a potential feed for goat.[79]

Evaluation of feeding straw in goats

Goats are primarily browser animals and they used to spend 61% of their active feeding time browsing and 39% grazing grass. Goats are very fond of leguminous fodders but usually not prefer cereal straw in presence of green grass and tree fodder leaves. However, exotic goat breeds may prefer silage, hay or straw which is limited in local goats. Barley straw fed to 18 Saanen female goats @ 50 g DM / kg weight daily in a 28 days trial. Increased in quantity of concentrate feed at 30 to 49% has depressed straw intake of 18.6 to 22.7%. Goats can select more leaf and sheath part of straw from the feeder than on the floor of the pen.[80,81]

Effect of concentrate (protein) supplement to grazing small ruminants

Small ruminants are efficient users of grasses, shrubs and tree leaves and by-products of human foods but this cannot satisfy their nutritional requirements. The productivity of small ruminants may be increased by concentrate feeding or supplying good quality forage. The importance of concentrate supplementation on growth and productivity of goats is well

recognized.[82-84] Feeding of concentrate (mashkalai 50g + wheat bran 50g)) supplementation daily to grazing does before the pre-partum increases nutrients intake as well as live weight gain and body tissue reserves in does which may help for exploitation of potential productivity of does in subsequent reproductive performance.[85] Daily supplementation of 250g concentrate (100kg of concentrate mixture contained 30kg crushed maize, 50kg wheat bran, 19kg mustard oil cake, 0.1 kg vitamin mineral premix and 1 kg salt) to suckling goats in addition to *ad libitum* roughage feeding could be recommended for productive and reproductive performances.[84] The concentrate supplementation increased feed intake of does and live weight gain of kids in the first month. An investigation showed that most of the goat farmers (82%) of central region supplied concentrate feed but 61% farmers of southern region did not supply concentrate to their goats in Bangladesh.[56]

The effect of concentrate protein supplementation has been studied on growth and reproductive performance in female goats and sheep under grazing condition. Ten does and six ewes 15 months aged and 13.9 and 14.4 kg live weight, respectively have been used to study for 112 days. Animals allocated to two feeding regimes (low protein 168g and high protein 208g per kg DM according to body weight). Supplemented concentrate feed contained wheat bran, rice polish and soybean meal. Average birth weight of kids (0.85 vs. 0.75kg) and lambs (1.10 vs 0.83kg) reported higher in both species that received high protein (HP) diet than those given the low protein (LP) diet. The effect of supplementing high protein to grazing improved the growth and reproductive performance of goats and sheep.[62]

Castrated male BBGs with an average live weight of 10.3 kg (8 months old) have been used to study the effects of dietary CP concentration of 20.3% high protein (HP) and 16.9% low protein (LP) and feeding level *ad libitum* and 85% *of ad libitum* (restricted) on growth and carcass characteristics. The HP (CP 20.3%) and LP (CP 16.9%) diet composed of wheat bran 62 &134, sesame oil cake 31 & 08, soybean meal 31 & 17, green grass 627 & 740 and sesbania leaves 249 & 101 g/kg respectively. The results indicate that growth rate and carcass gain highest in goats fed the HP diet *ad libitum* and therefore, diet containing 20.3% CP has been suggested for feeding growing goats.[86]

Effect of levels and sources of protein supplementation on growth performance and nutrient digestibility in BBG aged 8-10 months and average body weight 9.16 kg have been investigated for 56 days. The protein supplement composed of wheat bran 16-35g, rice polish 8-18g, maize 10-46g, mustard oil cake 22-45g, soybean meal 18-40g, premix 1g and common salt /100g mixture. The results showed no significant variation between protein sources and their levels on growth performance. Digestibility of DM, CP and OM reported significantly higher for soybean meal (SBM) than mustard oil cake (MOC) but their levels varied insignificantly. Therefore low protein supplementation (16%) in a concentrate mixture containing MOC and/or SBM could be suggested for optimizing growth performance of BBG under intensive management system.[87]

Concentrate mixture consisted of wheat bran, rice polish and soybean meal with estimated ME 10.8 MJ and 17% CP and this concentrate mixture supplementation has improved the growth rate and therefore, feeding of grazing goats and sheep with concentrate supplement has been suggested to optimize growth performance. Different concentrate mixtures have been used in small ruminant nutrition of which one is consisted of (a) Khesari bran - 35%, (b) Crushed gram - 08%, (c) Maize crushed - 20%, (d) Wheat bran -18%, (e) Soybean meal - 16%,

(f) Mineral mixture - 02% and (g) Common salt - 01%.[88] Another is consisted of (a) Corn- 25.0%, (b) Wheat bran- 20.0%, (c) Rice polish- 15.0%, (d) Khesari dal- 20.0%, (e) Soybean meal-17.0%, (f) DCP- 02.0% and (g) Common salt- 01.0.[89]

Jamunapari does allowed to graze for 6-7 hours and concentrate mixture offered each morning and evening at 400g / goat / day (100 kg concentrate mixture contained 30 kg crushed maize, 50 kg wheat bran, 19 kg mustard oil cake, 0.1kg vitamin mineral premix, 1 kg salt).[90] Feeding of green grass alone do not fulfill the appetite and nutrient requirements as a sole feed in crossbred goats. Concentrate supplement is essential to fulfill the nutrient requirements and concentrate can be supplemented up to 30% of required DM to obtain the best result.[91] Improved feeding and better management practices may help in higher reproductive and productive performances of goats that would be profitable for goat rearing at rural areas in Bangladesh.[92]

Evaluation of feeding vegetable oils in goats

Each of four groups of adult goats supplied with each of 20 ml of soybean oil, groundnut oil, til (sesame) oil and mustard oil respectively with the basal ration. The soybean oil and groundnut oil supplied goats consumed more feed and higher body weight gain than the rest groups of goats.[93] The role of dietary fatty acids e.g. palm oil @ 25g and soybean oil @ 25g mixed feed supplied to two separate groups of BBG twice a week for 2 months has been evaluated. The serum cholesterol of palm oil and soybean oil treated groups decreased significantly with the advancement of experimental period but growth performance not affected.[94]

Dhaincha feeding trial in goats

The nutritive value of Dhaincha fodder in terms of rumen degradable nitrogen (RDN) has been reported to be 64.8 lb/100 lb of the green fodder having 18.85% DM.[95] Each of three groups of goat fed Dhaincha *ad libitum*, ½ Dhaincha + ½ Roadside grasses and only Roadside grasses but 100g common concentrate in all the three groups. Concentrate consisted of gram 20%, groundnut cake 29%, wheat bran 50%, bone meal 0.5% and common salt 0.5%. The Dhaincha group showed highest live weight (43.2lb), carcass weight (21.3lbs) and dressing percentage (61.9%) in comparison to other two groups of goats up to 106 days of trial period.[96]

Feeding of hay prepared from native grasses in goats

Native monsoon grown grasses (*Cyanotis* spp., *Penicum* spp. and *Fimbrystylis* spp.) of approximately 20 cm height harvested, sundried and chopped into 4-5 cm long pieces. Each of the selected goats consumed this hay *ad libitum* approximately 3% of their live weight showed positive nitrogen and sulfur balance and retained nutrients between 16 and 22 hours.[97]

Urea feeding trial in goats

Crop residues are the fibrous parts of plant that remain after the harvest of crop for human consumption which are usually used for animal feeding but these crop residues are low nitrogen content, high proportion of cell wall constituents, poor digestibility and low intake. The physical (soaking, chopping, irradiation, grinding, boiling), chemical (urea, NaOH, CaOH,

KOH), physio-chemical (urea/pelleting, lime/pelleting, steaming) and biological (enzymes, pre/probiotics, organic acids) methods of pre-treatments have been used to improve the quality of these crop residues. In addition concentrate supplementation of limiting nutrients and urea-molasses multi-nutrient blocks (UMMBs) typically consists of 4-10% urea, 30-45% molasses and 6-15% binder are used to feed the animals. Out of the four groups of BB male goats, of which group A fed with vegetable protein only, while 25, 35 and 45% of the total CP of the ration B, C and D respectively replaced by equivalent nitrogen from urea by adding 5.2g, 7.2g and 9.2g of urea respectively. The 25% replacement of the total CP of the ration by urea nitrogen reported optimum level for goats to obtain higher digestibility of CP. However, 45% can be replaced without any detrimental effects.[98]

The effects of replacement of vegetable protein by urea nitrogen on the feed intake and live weight gain have been investigated in BB castrated goat with 6.5 to 9.0kg live weight. Goats consumed road side grass, concentrate mixture (composed of wheat bran 26-90%, til oil cake 7-50%, molasses 75% and vitamin-mineral premix 10%) and urea (0-7.5%). The highest feed efficiency and live weight gain have been reported when 30% of the ration replaced by urea but addition of increasing doses of urea feed efficiency and live weight gain decreased.[99,100]

The effects of replacement of vegetable protein by urea nitrogen on the nitrogen retention and CP digestibility have been investigated in one year old BB castrated goat with 11.4 to 12.3 kg live weight. Goats supplied with road side grass (175-280g), concentrate mixture (composed of wheat bran 31-100g, til oil cake 10-70g, molasses 100g and pectrin 10g) and urea 0-93 (50%). Results showed that the 30% replacement of vegetable proteins by urea nitrogen reported the best in respect to nitrogen retention and CP digestibility among the four rations.[99,100]

Castrated male BB goats aged between 9 to 10 months with 10 to 11 kg live weight divided equally into six groups fed on road side grass based diet at varied levels of fish meal (0-120g) with or without *ad libitum* access to urea molasses block (UMB). With increasing level of fish meal the live weight gain (g/day) reported as 17, 23, 46, 48, 48 and 52 with urea molasses block whereas 12, 21, 31, 49 and 47g without urea molasses block. The UMB contained 56% molasses, 27% wheat bran, 8% urea, 8% CaO and 1% mineral mixture. The size and weight of the block licks were 22 × 10 × 7 cm and 2.0 kg respectively. The beneficial effects of urea molasses feeding to goats caused to accelerate the DM intake, TDN intake and nutrient digestibility.[101] Overall performances of 100g UMB/day fed goats have been reported to be more satisfactory in relation to live weight gain (LWG), milk production of does and LWG of kids than respective control goats.[102]

Castrated four groups of Jamunapari male goats of 11 months old with 17.7 kg live weight fed four different diets with the different ratio of roughage and concentrate resulted highest daily live weight gain (110.5g) in goat fed roughage and concentrate ratio 1.8 : 1. The roughage comprised of para-grass 450g/kg and UMTS 200g/kg DM whereas concentrate included wheat bran 140g, Gram husk 80g, Mustard oil cake 120g, Bone meal 7g and common salt 3 g.[103]

Genetic studies in goats

Estimation of variance components and prediction of breeding values of some economically important traits,[104] performance and genetic parameters of economically important traits,[105]

PCR and molecular sequencing for characterization of goat genome[106] have been reported.

Breeding systems of goats in Bangladesh

The traditional breeding method of goats is used to provide impoverished farmers and herdsmen with limited income sources. Dairy goats can provide high-quality animal products like milk, meat, leather and manure and create a large avenue for farmers and industries.[107] Approximately 83% goat farmers are usually used village buck for natural service to their goats and approximately 89% farmers paid service charge to the buck keepers, while only 17% farmers uses artificial insemination system which is very limited in some research station for breeding goats in Bangladesh.[108] In another study, approximately 92% does are serviced by village buck with 100% service fee in the district of Mymensingh, whereas it is 70.7% in the districts of Barguna and Patuakhali with unpaid service fee system (Table 8). Genetic correlations between body weight traits ranged from 0.34 to 0.83, whereas phenotypic correlations ranged from 0.34 to 0.90 with high heritability estimates for body weight have been reported in BBG.[109] The BB bucks could be selected based on progeny performance.[110]

Table 9 shows the status on the availability, relationship between distance of does and Black Bengal breeding bucks and type of scarcity in five districts (Lalmonirhat, Rangpur, Tangail, Khulna and Mymensingh) in Bangladesh.

Table 8. Breeding management of rural goats

SN	Parameters	Category	Mymen-singh[!55,56] (n = 50)	Barguna, Patuakhali[56] (n = 41)
1.	Buck keeping	Yes	0	08 (19.5)
		No	50 (100)	33 (80.5)
2.	Service done by	Village buck	46 (92)	29 (70.7)
		Farmers buck	0	08 (19.5)
		BAU buck	04 (08)	0
		Own buck	0	03 (7.3)
		AI	0	01 (2.4)
3.	Service fee of village buck	Service charge	50 (100)	0
		No service charge	0	11(26.8)
4.	Close breeding practice	Yes	50 (100)	0
		No	0	41 (100)

n = No. of goat farmers [!]Plagiarism – same data used in two different articles[55,56]

Table 9. Distribution of BBG in Bangladesh[111]

SN	Categories	Five districts*
1.	Buck	0011 - 0029 (0020)
2.	Doe	1400 - 3300 (2434)
3.	Castrated	1100 - 1900 (1546)
Total		2511 - 5229 (4,000)
Buck : Doe		1:96 - 1: 164 (1 : 128)

*Lalmonirhat, Rangpur, Tangail, Khulna and Mymensingh

A survey report showed that the smallholder goat farmers had an average of 3.56 goats per family with 90.61% does and 9.39% bucks and almost all farmers used natural mating to serve their does in the district of Mymensingh.[55] However, more than 70% farmers are being faced severe shortage of breeding bucks for serving their doses in these districts which ultimately represent the overall situation of the country. Almost all farmers (100%) depended on natural mating to serve their doses except the farmers of Mymensingh where 12% farmers used AI in their goats. This also indicates that type of scarcity gradually may be reached to severe level which may create the inbreeding depression in goat breeding.

Goat crossbreeding in Bangladesh

Goat plays an important role in generating employment, income, capital storage and improving household nutrition. The BBG is the only recognized breed in Bangladesh but its lower live weight and milk yield encouraged for crossbreeding with exotic bucks (Table 10). Genetic improvement particularly in growth and lactation traits in BB goats may achieved through phenotypic selection for heavier live weight.[112]

Table 10. Evaluation of selection and crossbreeding status of Black Bengal goats (BBG) in Bangladesh

Year	Objectives	Results	Ref.No.
2000	Evaluation of carcass quality of crossbred	The BBG has an excellent reproductive efficiency but its meat and milk production capability is low in comparison to crossbred (BB does × Jamunapari buck) goats. Selection within BBG (SBBG) not only increased live weight but also improved carcass value.	113
2000	Evaluation of growth competence of three genetic Grs of goats	Significantly higher birth weight reported in JBB (1.46kg), followed by SBB (0.88kg) and RBB (0.80kg) goats. Overall growth potential of SBB reported to be very consistent and steady from birth to 6-month. Thus selective breeding within BBG may be more desirable than cross-breeding with Jamunapari for efficient growth.	114
2002	Assess cross-bred goats	The crossbred (Jamunapuri × BBG) goats has reported to be suitable for meat production, though higher mortality associated with crossbred.	115
2006	Selection of BB goats	Selection of BB goats for 3 generations for growth at 6 months subsequently improved growth efficiency and production performance without affecting fertility and fitness. Selection efforts could preserve the indigenous genetic resources from extinction or unplanned crossbreeding.	116
2013	Live weight for selection of goats	Six month's body weight considered as an indicator of growth and sire selection and suggested effective for enhancing growth of exotic kids. Improvement for the selected traits could be achieved by individual selection or performance.	117
2014	Selection of BB bucks	Selection of BB bucks based on their fertility and the performance of their progeny. Fertility, semen quality and non-return rate (NRR) are the important criteria for buck selection. Heritability estimates obtained from birth weight and LWG in progeny, and semen evaluation of bucks. Of the 10 bucks, 3 bucks selected based on highest selection index.	118
2014	Comparison of productive traits of JP, BBG and their crosses (CB)	Productive performance of JP and CB goats reported satisfactory, whereas an excellent reproductive efficiency of BBG but its meat and milk production capability reported comparatively low. Introduction of JP genes have positive effects in improving the meat and milk yield traits of BBGs. Improved feeding and better management practices may help in higher productive and reproductive performances of all types of goats	12

Productive and reproductive performances of goats

Reproductive activity of the goat begins when the female goats reach puberty, which is generally defined as the point of sexual development at which the animal becomes capable of

reproduction (first ovulation in the female and first spermatozoa in the ejaculate of the male), but often animals are not fully sexually mature at this stage. The ovarian or estrous cycle is the period between two consecutives estrus. It is also the time that lasts the development of the follicle in the ovary, until rupture occurs and ovulation takes place which coincides with the appearance of estrus. The goat has been characterized by being seasonal polyestrous that is during certain time of the year, it reproduces naturally.[119,120]

The assessment of reproductive performance of BBG in different genetic groups under village condition,[121,122] correlation among certain growth and production traits in different breeds of goats,[123] genetic status and reproductive performance,[124] effect of non-genetic factors on productive traits[125] have been reported. The fertile life of a doe has been reported to be 7 to 8 years.[126]

Length and duration of estrus cycle of goats

The estrus of BBG has been quantified and classified as short < 17 days, normal 17-25 days and long > 25 days with higher length of estrus cycle has been reported during summer (March to June) season (23.50 ± 1.57 days), followed by winter (November to February) season (21.33 ± 1.01 days) and rainy (July to October) season (20.79 ± 0.62 days). Significantly ($p< 0.05$) longer duration of estrus cycle recorded during winter (44.00 ± 1.95 hours) in comparison to summer (36.00 ± 0.70 hours) and rainy (35.44 ± 0.80 hours) seasons (Table 11). In addition, the higher rate of normal estrus of BBG has been reported during rainy (79.31%) compared to winter (72.73%) and summer (53.33%) seasons.[127] However, comparatively lower length of

Table 11. Seasonal influences on the estrus cycle in BBG[127]

SN Season	No. of does	Length of estrus cycle (days)	Duration of estrus cycle (hours)	SN Season	No. of does	Length of estrus cycle (days)	Duration of estrus cycle (hours)
1. Summer	20	23.50 ± 1.57	36.00 ± 0.70^{b}	2. Rainy	22	20.79 ± 0.61	35.54 ± 0.80^{b}
3. Winter	15	21.33 ± 1.01	44.00 ± 1.95^{a}	Pooled	57	21.62 ± 0.58	37.35 ± 0.78

Mean values having different superscripts differed significantly

estrus cycle in BBGs have been reported in inland literature including 20 days (n=100),[128] 16-19 days[129] and 15.76 days (n=153).[130] The highest length of estrus cycle has been reported during August to October and lowest during July to August.[129] However, the 21 days as an average goat's estrus cycle with duration of standing estrus cycle from 24 to 48 hours with an average of 36 hours have been reported depending on nutrition, age, breed, season of birth, body weight, growth rate and presence of a male elsewhere.[119]

External symptoms of the estrus in goats

Factors that affect the reproductive response in goats include genetics, health, nutrition, weather and male effect.[120] Relationship between growth and puberty traits in pure and crossbred BBG have been decribed.[131] Estrus does showed different signs of estrus in BBG of

which most important are mounting flock mates or willing to be mounted, mucus discharge from the vulva, tail flagging, increased vocal activity, interest in male or male pen, restlessness and nervousness, mock fighting, licking and rubbing each other and sniffing the vulva.[127] Estrus goats move their tail, increase vocalizations, decrease appetite, mount between them, increase urine excretion, red and swollen vulva and discharge of vaginal mucus have also been reported elsewhere.[119]

Influence of coat color on production and reproduction in goats

The productive and reproductive performances of goats with solid black color have been reported better than other coat colors in terms of adult weight of does, daily milk yield, lactation period, age at puberty, service per conception and litter size.[132] The BBG is not always solid black in coat color rather it has polymorphism in coat color. These variations of coat color include: ① White or tan, ② Bezoar, ③ Silver bezoar, ④ Solid black, ⑤ Black with Toggenburgh pattern of spotting, ⑥ Black with Dutch belt spotting.[27-29] Table 12 shows that the productive and reproductive performances of solid black color BB goats better than other coat colors in terms of adult weight of does, daily milk yield, lactation period, age at puberty, service per conception and litter size.

Table 12. Comparison the productive and reproductive performances among different coat color of Black Bengal goats[132]

SN Parameters	Coat color of goats ; Mean values (No. of goats)				Overall (Mean)	Level of sig.
	White	Solid black	BDBS	Bezoar*		
01. Age at puberty (days)	180.00 (11)	163.59 (32)	165.00 (09)	185.88 (17)	173.62 (69)	0.001
02. Age at 1st conception (days)	224.62 (08)	219.00 (25)	225.45 (11)	222.14 (14)	222.80 (58)	0.155
03. Age at 1st kidding (days)	378.40 (05)	371.25 (16)	380.62 (08)	272.22 (09)	350.62 (38)	0.156
04. Kidding interval (days)	196.00 (05)	183.16 (19)	190.71 (07)	183.89 (09)	188.44 (40)	0.179
05. Gestation period (days)	153.12 (09)	151.36 (21)	155.50 (11)	150.62 (15)	152.65 (56)	0.570
06. PP anestrus period (days)	36.88 (08)	31.88 (24)	35.77 (13)	34.50 (22)	034.76 (67)	0.230
07. No. of service/conception	02.18 (11)	01.17 (29)	01.46 (13)	1.50 (10)	001.58 (63)	0.001
08. Birth weight (gram)	682.86 (07)	790.87 (23)	891.67 (12)	862.50 (08)	806.98 (50)	0.001
09. Adult doe live weight (kg)	10.62 (12)	13.31 (16)	12.79 (07)	11.79 (07)	012.13 (42)	0.002
10. Milk yield (ml / day)	298.42 (37)	297.49 (46)	288.89 (09)	*298.80 (07)	296.62 (38)	0.005
11. Lactation period (day)	75.71 (07)	93.89 (18)	87.50 (06)	110.83 (12)	091.98 (43)	0.001

BDBS = Black with Dutch belt spotting PP = Post-partum *Including both brown & Silver bezoar
sig. = Significance () = No. of observation

The average gestation period in 1st parity, age at first conception and post-partum anestrus period of Black Bengal goats are not affected by the coat colors (Table 12). However, the performances of solid black color goats have reported better than other coat colors in terms of adult weight of does, daily milk yield, lactation period, age at puberty, service per conception and litter size (Table 12).

Pregnancy diagnosis in small ruminants

The pregnancy diagnosis in small ruminants is required for the better management of production and reproduction especially for the detection of conception rates, gestation period, drying-off and accurate parturition date which allows the timely repeated insemination and breeding or culling of non-pregnant animals. Non-return to estrus is a cheap, practical and widely used method for detection of pregnancy between post service days 17 and 21 and does without signs of estrus are assumed to be pregnant. Abdominal inspection, trans-abdominal palpation, recto-abdominal palpation (from 70 days), abdominal palpation (from 100 days) and increased live weight could be indicative for pregnancy in small ruminants but they are reliable only after the second half of gestation. A-mode, B-mode and Doppler ultrasonography are the alternative methods for pregnancy diagnosis. Real-time ultrasonography is a rapid, highly sensitive and very specific test for early (20-40 days) pregnancy diagnosis in small ruminants.[133]

Measurement of plasma and milk progesterone concentration after the 18-21 days of breeding until the end of gestation (detectable progesterone levels indicate an active corpus luteum). Blood plasma concentration >1ng/ml between days 18 and 22 in parous goats indicate pregnancy, and the accuracy of the assay is 75-86% in pregnant and 90-100% in non-pregnant goats.[133] The progesterone level in different stages of pregnancy of BBG has been reported in Bangladesh (Table 13).

Table 13. Progesterone level of BBG[134]

SN	Types of goats	No. of goats	Progesterone level (ng/ml)	SN	Types of goats	No. of goats	Progesterone level (ng/ml
1.	Mature buck	4	< 0.1	4.	Pregnant does with stages		
2.	Kids	4	01.54 ± 1.42	a.	25-30 days	3	01.5 ± 0.0
3.	Non-pregnant does	4	03.96 ± 1.88	b.	60-70 days	6	08.5 ± 0.80
				c.	90-92 days	3	14.5 ± 0.44

Progesterone level measured at 3 stages of pregnancy using the test kit (EIA Test Kit Progesterone Biocheck, Inc, USA). It is clear that the progesterone level simultaneously increased as the stages of pregnancy advanced in the blood of pregnant BB does.[134]

Comparative productive and reproductive performances of goats

Productive and reproductive performances of small ruminants may be varied due to several factors of which most important are breeds, region, season, parity, nutrition, health care and management.[135,136] Table 14 shows the comparative productive and reproductive performances different available breeds of goats in Bangladesh. Comparative performances of indigenous, exotic and crossbred goats reared under farming conditions are presented in Table 15.

Anglo-Nubian breed of goats is ranked highest in respect of LW at birth (3.16 kg) and at each stage of growth especially 31.94kg at 12 months of age among genetic groups compared from each other (Table 15). The productive and reproductive performances of BBG are ranked higher than JP goat in semi-intensive management. It has been suggested that considering the

Table 14. Comparative productive and reproductive performances different available breeds of goats in Bangladesh

SN	Traits/Parameters	Black Bengal goats (BBG)	Jamunapari goat (JP)	Cross-bred (BBG × JP)	Boer goat (ADL)
01.	Age at puberty (days)	216.13 (13)	341.15 (5)	273.5 (3)	284 (2)
02.	Body weight at puberty (kg)	9.26 (5)	14.1 (1)	9.50 (1)	-
03.	Length of estrus cycle (days)	17.88 (2)	-	-	-
04.	Age at 1st service (days)	279.03 (5)	388.27 (3)	321.25 (1)	-
05.	Age at 1st kidding (days)	406.33 (12)	502.05 (4)	441.38 (2)	420 (1)
06.	Gestation period (days)	146.36 (14)	149.50 (6)	147.45 (1)	147 (1)
07.	Post-partum weight of does (kg)	15.83 (10)	25.05 (4)	33.19 (3)	-
08.	Post-partum anestrus period (days)	51.82 (11)	57.71 (4)	121.25 (1)	-
09.	Kidding interval (days)	196.15 (17)	214.68 (4)	234.59 (2)	273 (1)
10.	Service per conception	1.38 (10)	1.36 (4)	-	1.80 (1)
11.	Lactation length (days)	69.54 (6)	144.44(6)	106.84 (2)	-
12.	Lactation milk yield (liter)	23.96 (3)	70.65 (2)	-	-
13.	Average milk yield (ml/day)	312.23 (11)	703.28 (4)	990.00 (2)	383.33(1)

() = No. of reports analyzed ADL = American Dairy Ltd. Goat Farm, Gazipur JP[12,14,90,123,141-143]

BBG [12,14,40,61,66,83,84,92,104,116,123,125,128,130,131,135,136-149] BBG × JP[12,40,123,131] Boer goat[14,15]

Table 15. Comparative performances of indigenous, exotic and crossbred goats reared under farming conditions[150-153]

SN	Parameters	Black Bengal goat	Anglo-Nubian (n=12)	Barbari (n=9)	½ Barbari× ½ BBG	¾ Barbari× ¼ BBG
A. Live weight (LW, kg)						
1.	Birth weight	1.35 (46)	3.16 (89)	2.22 (43)	1.64 (96)	1.95 (107)
2.	LW at 12 months age (kg)	11.28 (20)	31.94 (14)	21.92 (13)	16.54 (13)	-
B. Milk production (liter)						
1.	Lactation yield	23.96 (3)	171.26 (12)	88.22 (9)	52.31 (96)	-
2.	Average annual milk yield	-	208.41(12)	117.13 (9)	84.19 (96)	-
3.	Per day milk yield	312.23 (11)	000.82 (12)	000.61 (9)	000.43 (96)	-
4.	Lactation length (days)	69.54 (6)	207.67 (12)	143.89 (9)	116.75 (96)	-

- = Data mot available

socio-economic and climatic condition of Bangladesh, rearing of BBG under semi-intensive system would be more suitable than JP goats.[141]

Most of the exotic breeds of goats and their crosses are reared in the urban areas particularly different metropolitan areas under intensive management system in Bangladesh. In these

metropolitan areas higher population of exotic goat breeds and their crosses (93%) are reared in comparison to indigenous BB (7.0%) goats. Beetal and beetal crossbred goats comprised half of the total exotic genotypes of goat in Rajshahi metropolitan areas (Table 16).

Table 16. Genotypic population and productive and reproductive performances of exotic and their crosses reared under smallholder farming system in Rajshahi metropolitan area[44]

SN	Parameters	Category	Genotypes of exotic goats including their respective crosses				
			Beetal	Sirohi	Jamunapari	Kalahari	Anglo-Nubian
1.	Population (gender)	Male	12	05	01	06	02
		Female	25	05	05	05	04
		Does	18	05	05	05	04
		Bucks	07	02	01	04	02
2.	Types of goats	Castrated	04	03	-	02	-
		Nanny	03	-	01	-	-
		Kids	05	-	01	-	-
3.	Genotypes	Frequency %	50.68	13.70	08.22	15.07	08.22
4.	Live weight (kg)	Male	42.00-84.84	39.31-83.14	24.58-40.77	49.50-82.96	59.39-68.73
			46.88 (12)	56.07 (05)	32.67 (2)	59.54 (5)	64.06 (2)
		Female	20.00-39.55	10.91-30.58	08.75-26.51	20.94-29.69	10.91-43.44
			21.7 (25)	22.41 (5)	17.37 (4)	24.50 (6)	27.47 (4)
5.	Productive and reproductive performances	AP (days)	170.56 (18)	163.00 (5)	162.50 (2)	160.0 (4)	167.50 (4)
		LL (days)	80.32 (15)	74.00 (5)	62.50 (2)	82.50 (4)	65.00 (3)
		KI (days)	225.00 (9)	155.67 (3)	-	225.00 (4)	-
		DO (days)	47.87 (15)	56.25 (4)	59.00 (2)	-	44.76 (4)

() = No. of animals AP = Age at puberty LL = Lactation length KI = Kidding interval DO = Days open

Age at puberty in goats

The overall average age at puberty in BBG recorded as 173.62 days (Table 12) and 216.13 days (Table 14) which appears to be lower than the exotic breeds, Jumunapari (341.15 days, Boer goat (284 days) and their crosses (273.5 days) goats (Table 14). The age of first estrus in BBG has been reported in wide range in literature that has been discussed in our earlier report.[140] However, the onset of puberty in goats typically occurs between 5 and 12 months of age at a minimum of 15 kg live weight or an average of 28kg in Boer goats.[154] However, the age at puberty in goats dependent upon breed, weight, the season of birth, level of nutrition and presence of a male effect. However, breeding should be delayed until the she goat has reached at least 60% of its mature live weight to allow for higher conception rates and safer parturition.[154]

Number of services per conception

An average of 1.58 (Table 11) and 1.38 (Table 14) number of services per conception in BBG, 1.36 in Jamunapari and 1.80 in Boer goat (Table 14) have been reported in Bangladesh.

Gestation length of goats

Analysis of reports show that the gestation length in BBG of different coat color varied from 150.62 to 155.50 days with an overall average of 152.65 days (Table 12). Breed-wise analysis of gestation length reveals highest gestation length reported in Jamunapari goat (149.50 days), followed by similar in crossbred and Boer goats (147 days) and lowest in BB (146.36 days) goats (Table 14). Gestation period in goats is very consistent in different genetic groups but is slightly varied by the effects of parity of dam, season of mating and location.[155] A positive correlation has been reported between gestation length and the weight of kid at birth and weight of doe at service. In addition, older animals have extended gestation length and more dependent on season, year and also birth weight of kids and weight of dam at mating.

Litter size of kids

Comparatively higher litter size has been reported in BBG reared in scavenging (2.33) than intensive (1.5), semi-intensive (1.37) and extensive (1.01) systems (Table 17). The higher overall average litter size has also been reported in BBG (1.86) in comparison to 1.53 in JP and 1.33 in Boer goats (Table 18). The usual number of kids at per parturition in BBG varies from single to quadruplet of which twin reported most frequent (56.32%) and quadruplet least frequent (2.11%) whereas litter size in crossbred goats reported either single (75%) or twin (25%).[40] Litter size and weight reported to be significantly highest in selected BBG (does of 35-40 months of age at kidding) or does with 19-20kg live weight at service, or at 4th parity.[155]

Post-partum anestrus period in does

The post-partum anestrus period (PPAP) is the interval between parturition and first post-partum estrus that is an important trait, which contribute greatly to productive efficiency in goats. The earlier a doe returns to estrus after parturition, the earlier it can be bred resulting in a shorter kidding interval with more efficient production. The interval varies among breeds, location, nutrition, season and parities. The overall average 34.76 day PPAP reported in BBG based on coat color with lowest in solid black (31.88 days) and highest in white coat color (36.88 days) goats (Table 12). Based on breeds of goats, the lowest PPAP reported in BBG (51.82 days) in comparison of 57.71 days in Jamunapari and 121.25 days in their crosses (Table 14). Multifactorial causes have been reported to be associated with PPAP in small ruminant of which nutritional condition of the handling, the photoperiod and suckling of kids that can delay post-partum ovulatory cycles, since it inhibits the secretion of gonadotropin releasing hormone (GnRH).

Kidding interval in goats

Kidding interval is calculated as the difference (usually in days) between two sequential kidding. In other words, kidding interval is the period between two consecutive kidding times. Based on coat color of BBG, the overall average 188.44 days kidding interval recorded of which highest period recorded in white coat color (196.0 days) and lowest in solid black (183.16 days) goats (Table 12). Breed-wise kidding interval shows that the shortest kidding interval period recorded in BBG (196.15 days) in comparison to Jamunapari (214.68 days)

followed by crossbred (234.59 days) and highest in Boer (273 days) goats (Table 14). It appears that the coat color of BBG and breed have effect on the kidding interval in goats. However, the kidding interval is generally influenced by service per conception, gestation period, weaning age and first mating after giving birth or post-partum mating. Length of post-partum anestrus period is only the determinant factor for the variation of kidding interval.

Lactation length of does

Analysis of data on lactation length of BB does based on different coat color reveal an average of 91.98 days lactation period with highest lactation period in brown bezoar (110.83 days) in comparison to white coat (75.71 days (Table 12). Breed-wise analysis on lactation period shows highest in Jamunapari (144.44 days) in comparison BBG (69.54 days) and their crosses (106.84 days). Lactation length provides major contribution to the variation in lactation yield which seems to be primarily depends on environmental conditions especially feeding and breeds of goats. Genetic and non-genetic factors are mainly associated with the milk production and lactation length in SRA.

Daily milk yield of does

Table 12 shows insignificant differences on dairy milk yield in BB does based coat color. The genetic and phenotypic parameters of milk yield of BBG have been estimated.[149] Analysis of average daily milk yield of four breeds of goats show highest milk production by Jamunapari (703.28 ml/d) and crossbred (990 ml/ day) in comparison to BBG (281.71 ml/day) and Boer (383.33 ml/day) goats (Table 14). A kid may require approximately 200 ml milk daily. Therefore, BBG and Boer goat mostly used as meat breed. Feeds and feeding of lactating does may influence the milk production with inadequate feeding produced 334ml/day and adequate feeding produced 556 ml/day in BBGs.[156] Milk production of BBG may be varied due to feeding, age of dam, health condition and overall management system.[157] Milk producing ability is mainly controlled by genetic properties within and between the breeds but environmental factors also affects the total milk yield.

Total lactation milk yield

The overall average lactation milk yield is shown in Table 14 which shows an average of 23.96 liter in BBG and 70.65 liter in Jamunapari goats. Jamunapari goat produces more milk than BBG which might be due to breed characteristics. In addition to genetic factors, non-genetic factors also influence milk production in lactating goats. Lower level of feeding has produced decreased milk production (26.22kg) in comparison to 46.13 kg/ lactation with high level of feeding in BB does.[157] The difference of lactation milk yield among the different reports and goat flocks might be due to differences of feeding, nutrition and management. BBG as a unique small ruminant in Bangladesh, supplementation with 300 g concentrate mixture with *ad libitum* green forage per day per doe may be recommended for optimum performance.[158]

Effects of nutrition and management system on the productive and reproductive performances of goats

Nutrition is an important factor affecting productive and reproductive performances and the onset of post-partum ovarian cyclicity in farm animals. Prolonged and intense negative energy status delays resumption of estrus cycle. Supplementing of heat-stressed animals with protein, fat and/or mineral resources is required to correct their negative balances. Reproductive characteristics[146] and effect of feed supplement on the reproductive efficiency of BBG[158] under rural condition have been reported. Only grazing might not be sufficient for weight gain of goats and thus productivity of goat can be increased through nutritional manipulation by concentrate feeding.[91]

Supplemental diets (350g) containing either soybean meal or til oil cake increased the growth rate of female goats and sheep under grazing condition. The supplemental diet consisted of rice polish- 20.0%, wheat bran- 60.0% and soybean meal- 20.0%, which increased the productivity of female goats and sheep and accordingly, supplemental diet has been suggested in the goat's rear under rural areas in Bangladesh.[159]

Each of the grazing female goats has been supplied dietary energy supplementation @ 250 g (consisted of maize, wheat bran, rice polish and soybean meal) daily to detect its effects on feed intake, growth and reproductive performances. Supplementation of higher level of dietary energy (11.98 MJ ME /kg DM) has been suggested for optimizing growth and reproductive performance of female goats under grazing condition.[160]

Nutrition has an important impact on the productive and reproductive performance of goat. Under feeding of energy will delay puberty, reduce ovulations per estrus, cause weak or silent estrus and extended periods of anestrus. Low level of protein intake also leads to an increased post-partum anestrus period. More than 70% of the rural people are directly or indirectly engaged in agriculture and goats are generally reared by them as scavengers in Bangladesh. The poor farmers mainly keep goats in semi-intensive system without any supplementation. This system of production gives poor growth rate and poor reproductive performances of goats depend on both genetic and environmental factors like climate, housing, feeding etc. No single feed in itself is complete in all respect of nutrients when fed alone, leads to imbalance of nutrients in animals. Moreover, availability of forages is not constant throughout the year and varies with season particularly during the cropping seasons when more land is brought under cultivation.

Urea molasses block (UMB) is a solidified mixture of agro-industrial by-products (wheat bran 2.2%, rice police 2.1% and molasses 3.9%), urea 0.7% (non-protein nitrogen source), binder (e.g. lime 0.6% -source of minerals) and salt 0.5% (preserver and source of minerals). Overall productive and reproductive performances of BBG have improved with @ 100g UMB / day / doe for feeding 12 months periods.[102]

Management systems for goat farming

Goat farming has been practiced for thousands of years and several management systems have been developed for rearing goats based on available facilities, requirement and conditions. Management systems have a direct impact on productive and reproductive performances and

health and diseases of animals. The different types of goat farming or management systems practiced in Bangladesh have been comparatively evaluated (Table 17).

Extensive system (ES) of goat farming is one that is carried out on non-cultivated land or mountains of natural pasture where animals can graze freely and take advantage of the natural resources. It uses small amounts of inputs, capital and labor compared to other systems. Intensive system (IS) of goat farming is one in which the animals are housed all the time in houses with adequate necessary facilities required for animal health and production in mostly heavy populated areas. This system requires higher number of labor and physical capital cost for construction of goat houses and maintenance of production than extensive system. The feeding of BBG under intensive management with milk feeding in pre-weaned kids reported.[156] Semi-intensive system (SIS) goat farming is one in which the animals are housed and fed at night but are allowed to graze to a pasture area or move around the farm to scavenge within in an enclosed area of the farm in day time.

Feeding habit of goats in the scavenging system (SS),[161] physiological and reproductive performances of BBG rearing under SIS of management,[83] economic study on SIS goat rearing[162] have been reported from Bangladesh. Comparative evaluation between SIS and SS of rearing of BBG reported from Bangladesh (Table 17).[163] Goats maintained under SIS supplied required amount of chopped sorghum and natural grasses twice a day. Concentrate feeds (wheat bran, soybean meal), calcium oxide and common salt also given twice daily. In addition, does allowed for grazing and exercise for a specific period of 6 hours daily. Does reared under SS maintained by the rural landless farmers traditionally as scavenging system in which does allowed to graze naturally and residual rice and tree leaves supplied occasionally. The gross return of BDT 1094/- showed comparatively higher in goat reared with SIS than SS and suggested for better feeding including concentrate supplement with improved management for beneficial and profitable goat rearing.[163] Goats maintained under SIS supplied required amount of chopped sorghum and natural grasses twice a day. Concentrate feeds (wheat bran, soybean meal), calcium oxide and common salt also given twice daily. In addition, does allowed for grazing and exercise for a specific period of 6 hours daily. Does reared under SS maintained by the rural landless farmers traditionally as scavenging system in which does allowed to graze naturally and residual rice and tree leaves supplied occasionally. The gross return of BDT 1094/- showed comparatively higher in goat reared with SIS than SS and suggested for better feeding including concentrate supplement with improved management for beneficial and profitable goat rearing.[163] An investigation on the reproductive performance of BBG under SIS and extensive system of management suggested that rearing extensively with improved feeding and better management practices may help in higher reproductive performances of BBG that would be profitable for goat rearing at rural level in Bangladesh.[139] These results support the findings of Indian report in which BBG reared under extensive management system showed a better performance in terms of body weight gain, body measurements and biochemical profiles as compared to the goats reared under semi-intensive and intensive management system.[164] However, many of the productive and reproductive performances of BBG reported to be better in semi-intensive compared to intensive system.[165] The SIS of management of Jamunapari goat has also been suggested for rearing for future solution of poverty in Bangladesh.[142] In Brazil

Table 17. Comparative performance of BBG reared in different management systems[!]

SNParameters	Categories	Intensive	Semi-intensive	Extensive	Scavenging
A. Kid performances					
a. No. of kids	Male	68	23	-	-
	Female	60	16	-	-
	Overall	126	39	-	-
b. Sex ration (kids)	M : F	1 : 0.9	1 : 0.7	-	-
c. Litter size (No.)	M+F	1.5	1.37 (3)	1.01 (2)	2.33
1. Birth weight (kg)	Male	-	1.38	-	1.03
a. Gender-wise	Female	-	1.23	-	0.90
	Overall	1.49	1.31	1.06	0.96
b. Litter size:	1	1.06	1.02	-	-
(Type-wise)	2	0.78	0.76	-	-
	3	0.68	0.76	-	-
	Mean	0.81	0.80	-	-
2.Weaning weight	Male	-	5.55	-	4.27
(kg)	Female	-	5.31	-	4.06
	Overall	4.0	5.43	-	4.17
3.Weaning age (day)	M + F	-	92.00	-	81.00
4.Kid mortality (%)	M + F	27.3	12.64 (4)	10.07 (2)	14.28
B. Doe performances					
1. Weight at 1st estrus (kg)		9.62	9.34	-	-
2. Initial LW of doe (kg)		-	22.10	-	21.90
3. LW at 1st kidding (kg)		18.91	16.07	-	-
4. LW at kidding (kg)		-	22.61	-	22.35
5. LW just after kidding (kg)		-	18.73 (3)	16.2 (2)	19.63
6. Loss of LW just after kidding (kg)		-	3.01	-	2.71
7. Av final LW at PPHP (kg)		-	21.03	-	19.73
C. Milk production					
1.Daily milk yield (ml)		236.74	220.62 (2)	-	162
2.Lactation period (days)		48.83	78.60 (2)	-	84.66
3.Total lactation yield (L)		-	20.47	-	13.75
D. Reproductive performance					
1. Age at puberty (days)		170.67 (2)	211.05 (3)	208.82 (2)	-
2. Age at 1st conception (days)		-	292.96 (2)	287.65 (2)	-
3. Service per conception		1.0	1.2	-	
4. Gestation period (days)		145.35 (2)	144.08 (2)	-	-
5. Age at 1st kidding (days)		283.83	428.26 (3)	450.07 (2)	-
6. Post-prtum anestrus period (day)		53.15 (2)	54.07 (3)	-	95.33
7. Kidding interval (days)		216.3	192.8 (3)	178.23 (2)	-

() = No. of reports analyzed Intensive [105,165] Semi-intensive[105,139,163,166] Extensive [139,166] Scavenging[163]

[!]Plagiarism-same article published in two different journals[139 &166]

report showed that the SIS and ES management kids grew faster than IS animals (127,113 and 96 g /day, respectively) and this difference has been explained as differences of energy intake. The long leg and carcass reported larger in ES management kids than in kids from other management systems, presumably due to high physical activity on the free-range pastures.[167]

Effects of heat stress in goats

The effects of heat stress on behavior, physiological and blood parameters,[168] blood parameters, carcass and meat quality[169] have been described.

Rearing of goat kids

A proper program for raising goat kids begins prior to birth because producing a healthy newborn kids means meeting the nutritional needs of the doe while she is gestating.[170] The female kids of dairy and meat breeds which are later used for the production of dairy and meat doe's replacement, respectively. The male kids of all types of breeds of goat which are later used mostly for meat production and some are selected for breeding buck production. Goat kid rearing is the foundation of the goat herd productivity.

Birth weight of goat kids

The economic value of goat depends upon its growth, production and reproduction efficiency. Birth weight is an important criterion affecting productivity at adult age because it is strongly correlated with growth rate and also with kid viability. Growth and reproductive performance,[128] relationship between BB kid mortality and birth weight, age and seasons,[171] correlation coefficient between birth weight and weight at weaning,[172] heritability estimate of birth weight and multiple birth,[173] selection index of economic traits,[174] relationship between weight of does and birth weight[175] and effect of feeding system, sex and season on the birth weight[176] have been reported. Table 18 shows the average kid birth weight of BBG (1.18 kg), Jamunapari goat (1.60 kg), crossbred (1.59 kg) and Boer breed (3.0 kg) of goats. The overall higher birth weight reported in male kids than female kids of both the BBG (male kid 1.30 kg & female kid 1.18kg) and Jamunapari (male kid 1.61 kg & female kid 1.46 kg) goats (Table 18). The effect of birth type and sex reported significant with higher weights for single (1.03kg) and male kid (1.03kg),[177] however, no sex effect on birth weight of BBGs recorded in an earlier report.[178]

The year of birth, season, type of birth, parity, age and weight of dam at kidding significantly affect birth weight. Within breed, variation in birth weights is partly genetic but largely due to variation within the environment especially nutrition, management and health status of the does. The better environment especially nutrition and health which would have positive effect on total weaned kid production by reducing the kid morbidity and mortality and increasing the kid growth rate.[130] Coat color of dam especially white, brown and black has also influenced the birth of the kids.[132,179] Male sex, single type birth, third parity of dam and summer season reported better to the growth performance of BBG that showed profitable for goat rearing in village condition.[180] The reproductive peculiarities and litter weight in different genetic groups of BBG have been reported.[181]

Table 18. Factors associated with the production of different breeds of kids in Bangladesh[!]

SN	Variable	Categories	BBG	JP*	Cross*	Boer**	Barbari	Anglo-Nubian	½ Barbari × ½ BBG	¾ Barbari ×¼ BBG
1.	Birth weight, (kg)	Male	1.30 (12)	1.61 (2)	-	-	-	-	-	-
		Female	1.18 (12)	1.46 (2)	-	-	-	-	-	-
		Mean	1.18 (31)	1.60 (5)	1.59 (3)	3.00 (2)	2.22(2)	3.16 (2)	1.64 (2)	1.9 (1)
2.	Litter size	Overall	1.86 (8)	1.53 (3)	-	1.33 (2)	-	-	-	-
3.	Gender of kids, No (%)	Male	54.65 (4)	53.2 (1)	-	-	-	-	-	-
		Female	45.35 (4)	46.7 (1)	-	-	-	-	-	-
4.	Kid types, %	Single	28.17 (10)	39.85 (2)	75.00 (1)	-	-	-	-	-
		Twin	57.41 (10)	52.50 (2)	25.00 (1)	-	-	-	-	-
		Triple	13.61 (10)	07.53 (2)	-	-	-	-	-	-
		Quadruplet	00.81 (06)	-	-	-	-	-	-	-
4.	Growth rate (g/day)	0-3 M	57.95 (4)	44.22 (1)	-	80.18 (1)	-	-	-	-
		>3-6 M	27.2 (3)	-	-	-	-	-	-	-
		0-12 M	53.0 (3)	-	-	-	21.92 (1)	31.94 (1)	16.54 (1)	-
		Male	34.68 (1)	42.97 (1)	-	-	-	-	-	-
		Female	35.92 (1)	43.97 (1)	-	-	-	-	-	-
5.	Mortality, %	M+F	25.21(6)	6-30 (1)	-	4.8 (1)	-	-	-	-
5.	Adult live weight (kg)	Buck	24.27(1)	50.70(1)	40.38 (1)	32.56 [15]	-	-	-	-
		Female	16.36 (11)	25.05(4)	33.19 (3)	45.56 [16]	21.92 (1)	31.94 (1)	16.54 (1)	-

- = Data not available () = No. of reports analyzed M = Month/Male F= Female [ ] = No. of goats

BBG[12,14,38,40,61,66,83,84,92,105,116,123,125,128,130,136-141,143,146,148,149,151,153,172,175,177,180,182-187]

JP (Jamunapari) [12,14,90,123,141,142,143] Cross[12,40,117,123] Boer[14,15] Barbari[151,153]

Anglo-Nubian[151,153] ½ Barbari × ½ BBG[151,153] ¾ Barbari×¼ BBG[153]

[!]Plagiarism – same data published in two different articles116 & 130, 150 & 153, 177 & 183

Live weight gain (LWG) of kids

The growth rate (g/day) of kids up to 3 months of age in different available breeds have been reported from Bangladesh and it appears highest in Boer kids (80.18 g/d) in comparison to BBG kids (57.95 g/d) and Jamunapari kids (44.22g/d) whereas 0-12 months aged BBG shows 53.0g/ day (Table 18). The growth of kids from birth to adult stage depends on some environmental condition like climate, housing, feeding and diet, level of feed intake and interval factors such as genetic factors on which the growth potential, health, sex and litter size depended.[130] The variation of growth performance in goat kids in different reports might be caused by inappropriate management and inadequate feed availability around the year.[177,183] The influence of breed on the birth weight of kids are primarily correlated with genetic factors but also influenced by the environment specially nutrition, health and adult weight of dam but not age of the dam. The adult weight of dam and the mean weight of kids born are positively irrespective of the litter size which partly reflects the nutritional status of the dam.

Multiple births of kids

Types of kids like single (28.17%), twin (57.41%), triple (13.61%) and quadruplet (0.81%) have been recorded in BBG, whereas single (39.85%), twin (52.50%) and triple (7.53%) reported in Jamunapari goats, and only single (75.0%) and twin (25.0%) in crossbred goats (Table 18). Recently, Boer goat has been introduced in Bangladesh which has similar characteristics to produce relatively high levels of multiple births reported elsewhere as 7.6% single, 56.5% twins, 33.2% triplets, 2.4% quadruplets and 0.4% as quintuplets in South Africa.[188] Effects of birth type and gender traits are found significantly higher weights for single in comparison to twin, triplets and quadruplet kids (Table 18) and male kids in comparison to female kids (Table 18).

Feeds and feeding of kids

Goat kids are raised either as replacement stock or for slaughter for meat production. Feeding of kids can be divided into three periods which includes milk-feeding period, weaning and post-weaning period.

Milk-feeding period

Milk-feeding period may be lasts from birth to minimum three weeks or up to 6 months depending on the production system. The first milk for kids is the colostrum which is very important for newborn kids (require to feed @ 10% of live weight of kids) due to (a) its laxative action helps for excretion of meconium of the intestine, (b) provides nutrition particularly energy for the newborn, and (c) protective- contains antibodies (Igs) which protect the newborns approximately up to three weeks of age. Inland research reports on colostrum feeding in goat kids are very limited. There is little difference in growth of kids that are nursed by dam or fed milk replacer. The good quality milk replacer as on goat milk is required for better growth of the kids. However, feed efficiency appeared to be higher with goat milk than milk replacer especially during the first 30 days.

Suckling and/or bottle feeding of milk or milk replacer (Table 19 & 20) are used to feed the pre-weaned kids. Pre-weaned BB kids of about 4.5 kg live weight, growing @ 60g daily require at least 750g milk daily and accordingly teat-bottle feeding should be adjusted. In addition, kids should have free access to a kid starter (Table 21,22).

Three groups of BB kids of both sexes fed two different milk replacer using ingredient shotti (FM-1), Skim milk (FM-2) and no milk replacer-kids (suckling) with mother as control group (Table 19 & 20).

Average daily LWG reported significantly higher in Formula-1 and Formula-2 compared to FM-3 and FM-4 (Table 19). Feed intake, growth, FCR and nutrient utilization in kids fed three milk replacers reported similar to those in the control suckled group. Due to high price and unavailability of skim milk in the local market, the use of shotti or egg and wheat flour to produce a milk replacer may help profitable kid rearing in Bangladesh. Therefore, shoti and egg plus wheat flour can be used to feed the goat kids as an alternative to goat milk.

Based on feed intake, LW gain, FCE and nutrient utilization in kids fed two milk replacers (FM-1 and FM-2) showed similar to those in the control suckled group (Table 20). However, it is sometime necessary to bottle feed kids due to death of the dam or the dam's refusing to take them. Milk feeding to

kids of meat goats are usually not economical and it may be avoided by cross-fostering kids onto another lactating doe or supply of milk replacer.

Table 19. Composition of milk replacer (g/100g)[189]

SN Ingredient (%)	FM-1	FM-2	FM-3	Starter
01. Shoti	19	-	-	-
02. Skim milk	-	-	-	-
03. Fresh egg	-	30	-	-
04. Wheat flour	-	18	-	-
05. Soybean meal	64	27	-	57.0
06. Maize ground	-	-	20	35.0
07. Soybean oil	15	23	07	05.0
08. Molasses	-	-	-	05.0
09. Common salt	1	1	1	01.0
10. DCP	0.5	0.5	1.5	01.0
11. Vit-Min premix	0.5	0.5	0.5	01.0
Total	100	100	100	100
Effect on Average LWG				
1. Initial LW (kg)	1.87	1.89	1.93	1.92
2. Final LW (kg)	6.00	6.10	5.70	5.90
3. Feed cost/ kg (Tk)	42.76	89.54	360.64	42.76

FM = Formula

Table 20. Composition of milk replacers (g/100g)[190]

SN Ingredient	FM-1	FM-2	Suckling
1. Shotti	19.0	-	-
2. Skim milk	-	70.0	-
3. Soybean meal	64.0	-	-
4. Maize ground	-	20.0	-
5. Soybean oil	15.0	07.0	-
6. Common salt	01.0	01.0	-
7. DCP	00.5	01.5	-
8. Vit-Min premix	00.5	00.5	-
TOTAL	100	100	-
1. Initial LW (kg)	1.72	1.69	1.94
2. Final LW (kg)	5.94	6.00	5.96
3. Av daily gain (g/d)	60.29	61.20	57.42
4. FCE (kg feed/kg gain)	0.95	0.99	1.09

FM = Formula

Kid starter feed

The kid starter feed can be prepared (Table 21) or purchased commercial pellet packed from the market (e.g. Masterfeeds; Table 22). The formula for kid starter is usually designed to be

Table 21. Composition of kid starter used for feeding pre-weaned and weaned kids[156]

SN Ingredients	For kids	Growing & adult
01. Maize crush	30.0	35.0
02. Lathyrus sativa crush	16.0	16.0
03. Wheat bran	25.0	25.0
04. Soybean meal	20.0	20.0
05. Fish meal	0	01.5
06. Soybean oil	01.0	0
07. Molasses	05.0	0
08. Dicalcium phosphate	01.0	01.4
09. Common salt	01.5	01.0
10. Vit-Min premix	00.5	00.1
Total CP%	20.25	18.81
ME (MJ/kg DM)	10.87	10.31

Table 22. Chemical composition of kid starter (Masterfeeds)[191]

SN Ingredients	%
1. Crude protein	22.00
2. Crude fat	02.00
3. Crude fiber	10.50
4. Calcium	01.10
5. Phosphorus	00.60
6. Sodium	00.25
7. Vitamin A	18,500 iu/kg
8. Vitamin D3	3,000 iu/kg
9. Vitamin E	75 iu / kg

fed free-choice starting on day 2 to 4 until weaning, in conjunction with whole milk or milk replacer. The high CP in kid starter helps to promote early frame development, multiple sources of vegetable protein which provide a good balance of amino acids, optimum vitamin and mineral levels improve mineral absorption and enhances immunity, live yeast cells (Yra-Sacc® 1016) that stimulate the growth of ruminal bacteria, improves rumen fermentation, fiber digestion and feed efficiency, flavor and molasses enhances palatability and reduces dust and sorting (Table 22).

It appears that Boer goat can be easily adapted in local climate and farming condition with less disease occurrence and mortality. In addition, this breed of goat produces kids with birth weight and higher live weight at maturity. The birth weight of kids and milk yield of dam had a pronounced positive effect on kid survivability or mortality.[192]

Kid survivability and mortality

The survivability of BBG kids on some selected area and under rural conditions have been compared.[193] The mortality rates of kids of different breeds of goats are presented in Table 17.

Evaluation of semen and Artificial insemination in goats

Artificial insemination (AI) is the manual placement of semen in the female reproductive tract by a method other than natural mating. It is probably the most important biotechnology for significant genetic improvement used in the dairy goats. It entails semen collection, processing, and evaluation with an emphasis on bucks.[107] However, the techniques of AI in goats have been limited worldwide due to the lack of resources of producers and trained technicians.[119]

Breeding bucks are scarce in Bangladesh because male kids are usually castrated at 5 to 11 weeks for better quality of meat and skin. Selective breeding to improve the species requires an AI program using semen from males with high genetic merits. Buck ejaculates are small in volume with high concentrations of spermatozoa (Table 23). The phenotypic variations in size of spermatozoa in different breeds of sheep and goats have been described.[194] An extender increases the volume of semen and should prolong the life of spermatozoa with fertilizing capacity. At chilling temperature, the fertilizing ability of spermatozoa reduces with time and the motility and morphology of spermatozoa deteriorate after two days. During storage of mammalian spermatozoa phospholipids undergo peroxidation, the formation of toxic fatty acid peroxides causing structural damage to the sperm cell accompanied by decreased motility. Longer preservation at 5 ^{0}C may be achieved with the addition of antioxidant to semen diluents.

Repeatability estimates of semen characteristics of BBG have been determined for sperm concentration, volume per ejaculation, live-dead (%), abnormality (%) and pH showed very low estimates and these indicate less or no reliability on single record and suggested that the semen quality needs to be improved by incorporation of superior genes in the native goats.[195] Bucks' age, body weight and body condition along with testes volume have been suggested as selection criteria for improving semen quality and semen production of breeding bucks.[118,196]

Research findings on semen diluents and preservation

- Buck semen has been preserved better in egg yolk citrate (EYC) diluter than goat milk (GM) and powder milk (PM) and GM ranked second among the three diluents.[197,198]

- The glycerol (7.0%) containing media has reported to be suitable for preserving the BBG's semen at -196 ^{0}C temperatures with accepted post-thaw motility.[199]
- The buck semen preserved in liquid nitrogen with different percentages of glycerol with tris-glucose-citric acid-egg yolk media by one-step dilution method showed significantly higher sperm motility after two hours of chilling in 7% glycerol added diluents than that of 5 and 10% glycerol.[200]
- Two diluents, namely Tris-glucose-citric acid-egg yolk diluents and Triladyl-egg yolk diluents have been evaluated to compare the sperm motility reported that the Triladyl based diluents achieved higher sperm motility (73.33%) than Tris based diluents (70.00%) just after dilution (1:5) of the semen before cooling in refrigerator at 5 ^{0}C. Semen motility of BBG remains in an useable level when fresh semen can be stored for a period of less than 24 hours and diluted semen for a period of less than 96 hours (4 days) at 0 ^{0}C.[201]
- Cryopreservation of native rams semen using different diluents and manual freezing techniques have been described.[202]
- Glutathione (GSH) 0 (control), 2, 4 and 8 mM has been used in the preservation of chilled goat semen at 4-5 ^{0}C up to 7 days. The sperm motility reported significantly higher in the semen treated with 8 mM GSH (Table 24). Optimum sperm motility (≥ 50%) for AI retained for 3 days with 2 and 4 mM GSH and up to four days with 8 mM GSH and it has suggested that GSH may be used as an antioxidant for better preservation of goat semen for AI.[203]

Semen characteristics

Table 23 shows the characteristics of raw semen of selected and randomly selected bucks

Table 23. Characteristics of fresh buck's semen[203-207]

SN	Types of bucks	No. of bucks	Volume (ml) /ejaculate	Sperm conc. ($\times 10^6$/ml)	Sperm motility %	Live sperm %	Normal sperm %	pH	HA %	MPA %	TA %	Ref. No.
1.	Selected	02	0.44	2320	81.65	87.31	86.65	6.6	-	-	-	1
2.	RS	02	0.25	2072	72.9	82.86	86.1	6.6	-	-	-	1
2	RS	04	0.63	288	83.1	95.0*	99.0**	-	-	-	-	2
3.	RS	10	0.5	-	80.83	89.64	90.84	-	2.5	6.9	7.1	3

RS = Randomly selected *Normal acrosome, mid-piece and tail **Normal head of the sperm
HA = Head abnormalities MPA = Mid piece abnormalities TA= Tail abnormalities

- The recent advances in cryoprotectants for improving post-thaw recovery of buck semen have been reported elsewhere.[208]

Semen preservation and artificial insemination in goats

The effects of egg yolk concentrations in freezing buck semen and conception rate (CR) following AI with frozen-thawed semen have been evaluated.[209,210] A significantly lower sperm motility has been reported in semen preserved with 2.5% (50.3%) or 5% (51.5%) of egg yolk than that in 10 (55.0%) and 15% (56.8%) of egg yolk. Semen frozen with 2.5% and 10% of egg yolk produced CR of 39.1% and 48.4%, respectively. It appears that the increased concentration of egg yolk in the diluents provided better semen quality.[198] Table 24 shows the characteristics of fresh and diluted buck semen of their fertility with conception rate.

Table 24. Mean characteristics of fresh and diluted buck semen with their fertility and conception rate [204,211-216 !]

SN	Semrn diluted	No. of bucks	Semen volume (ml)	Sperm con. ($\times 10^6$ /ml)	Sperm motility %			Live sperm motility (%)	Normal sperm motility (%)	AI results	
					Initial	On dilution	Post-thawing			No. of does	CR
01.	Fresh	6	0.58	2797.22	77.82	-	-	86.72	91.39	-	-
02.	EYC	6	-	-	-	71.82	-	86.17	90.53	129	76 (58.9)
03.	GSH	4	0.63	287.7	-	-	50.4*	-	-	-	-
04.	EYC	5	0.75	2980	78.91	65.92	51.86	90.22	87.48	-	-
05.	LNT	4	-	-	-	-	-	-	-	70	28 (40.00)
06.	EYC	6	-	-	-	64.78	44.58	35.57	78.44	96	42 (43.75)
07.	Tris	6	-	-	-	68.96	55.63	42.73	78.56	111	62 (55.90)
08.	EYC	6	-	-	-	64.78	44.58	35.57	78.44	-	-
09.	Tris	6	-	-	-	68.96	55.63	42.73	78.56	-	-
10.	Triladyl	-	-	-	-	75.00-76.67	38.33-43.33	-	-	-	-
11.	Tris	-	-	-	-	73.33-80.00	06.00-06.67	-	-	-	-

EYC = Egg yolk citrate n = No. of goats inseminated *GSH = Glutathione @ 2,4 and 8 mM resulted 44.3, 47.8 and 50.4% sperm motility at 2nd, 3rd and 4th day of preservation, respectively LNT = Liquid nitrogen tank
[!]Plagiarism- articles No. 214 and 215 used same table Nos. 1 to 4 in both the articles

The efficacy of Tris extender has been reported better than that of EYC extender in buck semen and suggested for further studies and uses.[215] The AI program with frozen semen of BB buck would be beneficial to the farmers due to inadequate number of available bucks.

Embryo production and transfer in goats

Assisted reproductive technologies (ART) such as artificial insemination (AI) and multiple ovulation and embryo transfer (MOET) have been used to increase reproductive efficiency and accelerate genetic gain. The major limitations of MOET are due to variable female response to hormonal treatment, fertilization failures and pre-mature regression of corpus luteum.[217] Comparative follicular development of BBG under intensive and extensive production system has been decribed.[218] Early embryos of superior genotypes are collected prior to their implantation in uterus and they are implanted in the uterus of other females of inferior genotype where they complete its actual development which is referred to as embryo transfer. The main objective of embryo transfer is to achieve greater rate of conception, increase in number of progeny per year from single female animal of superior genotype.[219] The embryo transfer technology help to: (a) increase the number of offspring from best females, (b) ensure the imports are at no risk of introducing disease, (c) establish purebred lines for breeding programs and (d) save the valuable genetics of top females. The steps in embryo transfer technology includes (a) selection of donor, (b) induction of superovulation, (c) recovery of embryos, (d) transfer of embryos, (e) selection of recipients and (f) evaluation of embryos. However, the amount of embryo transfers done in small ruminants are a fraction of those recorded for cattle. The commercial and market factors are limiting the production of embryos in small ruminants.

Moreover, current embryo transfer techniques in small ruminant almost exclusively consist of surgical and/or laparoscopic methods for embryo collection and transfer.[220]

The morphometric analysis of ovarian follicules of BBG during winter and summer seasons,[221] qualitative and quantitative analysis of goat ovaries, follicules and oocytes in view of *in vitro* production of embryos reported.[222] The *in vitro* fertilization (IVF) is a procedure where the oocytes are removed laparoscopically (aspirated) directly from the ovary of a stimulated donor female. The oocytes are then shipped to an IVF lab overnight where they are fertilized in a petri dish with frozen / thawed semen.

The embryo transfer is rarely applied in animals in Bangladesh but some research efforts on this aspect have recently been made. The development and survivability of ovarian follicles of goat in different feeding system,[223] effects of alfaprostol and luprostiol on the embryo production within MOET technique,[224] *in vitro* production of goat embryos,[225] effects of PMSG doses and repeated surgical collection procedures on super-ovulatory response and embryo yield,[226] collection techniques and corpus luteum effects on quality and quantity of goat follicular oocytes for *in vitro* studies[227] have been made in goats in Bangladesh.

Carcass characteristics of slaughtered goats

The genetic variation and correlation of some carcass traits,[228] association between body measurement and carcass characteristics of goats,[229] live weight and dressed carcass weight from different body measurement,[230] and gross morphometrical analysis of muscles of different body region of castrated BBG and its carcass characterisics[231] have been reported. Age, live weight, several body measurements and slaughter yield parameters have been recorded on 300 (122 males + 178 females) free range reared BBG at Mymensingh slaughterhouse. Both males and females age not recorded as a good predictor of blood, head and skin weight and dressing percentage.[232]

Carcass quality of Jamunapari × Black Bengal (JBB), Selected Black Bengal (SBB) and Random Black Bengal (RBB) wethers of one year of age has been studied. Significantly higher dressing percentage and significantly smaller muscle fiber diameter recorded in JBB than in SBB, and performance of RBB reported significantly lower than JBB and SBB. The JBB has reported as ranked first in respect of meat quality.[113]

Four groups of BBG based on different feeding management like stall feeding, tethering, restricted grazing and grazing and supplied with concentrate mixture (consisting of wheat bran, matikalai bran) all groups of goats @ 150g/day per goat. In addition, Calfostonic @ 5g /animal/day as a vitamin-mineral premix and 1% common salt added to the ration and all the goats have been slaughtered after the experiment of 219 days. Among 4-treatment groups, performance of stall fed goat (carcass weight 5.17kg & dressing percentage 42.18kg) reported most satisfactory and then tethering (carcass weight 4.27kg & dressing percentage 39.0kg) showed better performance than any other groups.[233]

A study suggested that the goat meat production could be increased by reducing 305 recorded mortality rates in kids and enhancing reproductive rate of does.[162]

Different age and both sex groups of BBG slaughtered to determine the effect of age and gender on different carcass characteristics mainly suggested two observations, (a) Both carcass

yield and carcass composition changes with age and (b) Sex have little or no effect on carcass yield and carcass composition. Optimum slaughter age of BBG reared semi-intensive management with adequate feeding and management would be about 9 months when their live weight, warm carcass weight, edible and saleable weight of carcass can be about 16.74, 7.28, 12.05 and 13.18, respectively.[234] A significant correlation has been reported between hot carcass weight and eye muscle area in slaughtered castrated BBGs.[235]

Slaughter of goats has been estimated to be 7.14, 5.44 and 4.28 million at the age of 6, 10.5 and 15.5 months, respectively, and yield of meat and skin reported as 23.28, 31.99 and 31.67 million kg and 10.71, 15.46 and 14.98 million square feet, respectively. If goats are raised up to 15.5 months of age at higher weight of 17.10 kg may provide additional 41.08 million kg meat and 19.4 million square feet skins and their present market values would be Taka 14377 and 873 million respectively.[236]

Three different levels of energy have been fed to BBG to evaluate the growth and carcass characteristics on stall feeding for 150 days. Results showed that low weight gain with higher (28.3 g/day) in high energy fed goat than others. It appears that the high energy diet enhanced the growth, dressing percentage and carcass gain.

The effect of sex and age of goats on live weight, hot carcass weight, dressing percentage, chemical composition and pH of meat have been investigated in BBGs. Fifty goats of different age (between 3 months to 3 years) and sex groups (buck, castrated male, doe and kids) have been slaughtered. The meat quality in terms of hot carcass weight and dressing percentage reported higher when castrated male slaughter within one year of age whereas maximum high carcass weight (HCW) obtained when buck slaughter at the age 2 to 3 years.[237]

Crossbred (Jamunapari × Black Bengal= JBB), Selected BB and Random BB wethers of one year old have been evaluated for pre-slaughter traits and carcass characteristics. The pre-slaughter weight of JBB and SBB showed similar in yielding hot and chilled carcass as well as dressing percentage (JBB 41.54% & SBB 40.48%), whereas RBB reported as lighter than JBB and SBB in pre-and post-slaughter weights and inferior dressing (37.93%) percentage. The production and marketing of goat and goat meat in peri-urban areas in Bangladesh has been reported.[238]

Castration of kids

Surgically castrated goats at 8 weeks of age showed a much higher growth rate (76.33 g/day) than un-castrated (62.72g/day) goats. Significant difference has recorded at 11 weeks of age and remains significant up to 32 weeks (18.430 kg/ 15.301kg) of age.[239]

Blood serum testosterone concentration has been estimated to detect the efficacy after orchiectomy (castration) in Black Bengal goats showed significantly decreased of testosterone from day 0 (6.1 ± 2ng/ml) to 30 (0.6± 0 ng/ml) days, which has confirmed the efficacy of castration in goats.[240]

Economics and constraint of goat rearing

The potential market weight of goats has been reported to be found 17.10 kg at the age of 15.5 months. About 84% of farmers are sold their goats for cash income, of which 15% for rearing

problems and 1% for disease prevalence.[241]

A goat raising household has earned a profit of Tk. 2201.79 per annum from goat rearing which was about 5% of household income.[242] However, the main constraints to rearing goats reported as ① Prevalence of diseases - 77.20%, ② Lack of Veterinary services-72.80, ③ Social problems - 74.80, ④ Lack of grazing land - 57.60 %, ⑤ Destroy plant/crops - 64.00% and ⑥ Inadequate supply of buck - 61.20%.[48] The performance of BBG and increased income leading to better livelihood through goat rearing has been reported.[184,243]

Problem confrontations in managing goats by smallholder farmers

① Lack of knowledge related to goat management, ② Inadequate veterinary services, ③ Lack of knowledge of goat diseases, ④ Scarcity of feeds and fodder, ⑤ Natural catastrophe, ⑥ Lack of capital, ⑦ Lack of grazing land, ⑧ Kid mortality, ⑨ Inadequate extension service and ⑩ Lack of facilities of goat marketing.[244]

Constraints and challenges of goat production in Bangladesh

Socio-economic status of people in developing countries particularly Bangladesh encouraging in animal science industry especially sheep and goat industry among the new generation but some constraints have encounter in this system:

- Education and training on small ruminants- lacking of separate course on sheep and goats in the veterinary undergraduate curricula, inadequate training and extension services to the small ruminants farmers.
- Research on small ruminants- Review all the available published research findings reveal that some scattered and repetition of research works on small ruminant production and management have been carried out without considering the fundamental knowledge and future impact on small ruminants especially genetics, breeding, nutrition, growth, development, carcass and meat quality and nutritional benefits. Bangladesh have only one Black Bengal goat breed and it existence is in danger like indigenous cattle due to unplanned crossbreeding program throughout the country. It has more pronounced on visiting the Edul-Azha qurbani goat sale markets where a lot of cross-bred goats is usually made available to buy. Moreover, no record keeping system on small ruminants breeding which are made more difficult to distinguish origins of the animals and their breeds. Therefore, there is a need to find out the solutions through well-designed researchers and such findings will result in efficient, sustainable and profitable small ruminant production in Bangladesh.

Research findings on sheep production and management

There are approximately one billion sheep and one billion goat in the world but more than 50% sheep are distributed in China, Australia and New Zealand, whereas goat population are mainly distributed in Asia, Africa and South America.[119,120] There are approximately 3.607 million sheep populations in Bangladesh and its population has increased 20.12% during the last decade from 2010-2011 (3.002 million) to 2019-2020 (3.606 million).[7] Sheep make a very valuable contribution, especially to the poor in rural areas in developing countries including Bangladesh. These contribution ranges from precious animal proteins (meat and milk) to fiber and skins, food security and stable households. Special advantages of sheep rearing include higher production efficiency, easier marketability and lower risks, broader adaptability to different environments and smaller absolute feed requirements per animals. The creation of self-employment, good loan realization and woman livelihood reported to be improved positively through sheep rearing in Bangladesh.[245,246]

Most of the sheep population is indigenous type in Bangladesh, thinly distributed throughout the country except for a relatively higher concentration in several agro-ecological zones such as coastal regions (Noakhali), barind tracts (Naogaon, Rajshahi, Chapai Nawabganj), North-Eastern wetlands, Sundarbans-delta regions and Jamuna river basin (mostly in Tangail) areas. Most of the sheep farmers used to keep Bangladeshi coastal sheep as their family tradition and sheep meat tastier than goat meat in the district of Noakhali with sheep population varies from 19 to 277 sheep per farmer.[247] A survey report showed that all categories of farmers had higher number of sheep compared to goat and cattle in the coastal Noakhali district. The prospects and problems of indigenous sheep production in South-Western coastal regions of Bangladesh have been reported.[248] Livestock farming contributed about 17.2% of annual family income in which the contribution of sheep of the total household income reported as about 11.0% followed by goat (3.58%) and cattle (2.62%)[249]

Indigenous sheep

Native sheep (*Ovis aries*) might have originated from the wild Urial (*Ovis orientalis vignei*) of Asia. Native sheep are small (18-25kg), highly prolific (2-3 lambs per lambing and two lambing per year) and meat producing (7-10 kg) animals.[249] The most important characteristic of indigenous sheep is the prolificacy with twinning lambing twice a year and the main constraints for sheep production in Bangladesh are lack of good quality rams and feed supply.[250]

Physio-morphological characteristics of indigenous sheep

Phenotypic characteristics particularly the coat color reported 45% white, 26% brown, 24% white-brown and 3% black-brown. The differences of coat color between areas did not vary significantly except ears that reported significantly shorter in Barind than Jamuna and Coastal areas.[250] The morphometric characteristics of native sheep of Naogaon, Noakhali and Tangail districts with BLRI nucleus flock have also been investigated.[251] They are 19.4 ± 2.7 to 24.9 ± 7.3 with an average of 22.6 ± 6.2 kg live weight and are adapted to hot humid climate.[252]

Exotic and crossbred sheep in Bangladesh

Most of the sheep are indigenous with few crossbreds and are capable of bi-annual lambing and multiple births. It has observed that the crossbreeding of indigenous ewes with Pakistani rams showed a positive effect on wool quality but a negative effect on prolificacy and lambing interval. The fecundity gene (Booroola) in Australian Merino may be derived from this Bengal line.[253] The Indian Muzaffarnagar cross sheep are reared by the sheep farmers of some western districts particularly Meherpur, Chuadanga, Chapai Nawbabgonj and Tangail in Jamuna basin with a ratio 40 : 15 farms.[10] The exotic pure breed of 14 Parendale sheep, 13 Suffolk and 15 Dorper breeds of sheep have been imported from Australia on March 2016 by the BLRI, Savar, Dhaka and their quarantine method have been described.[254]

Phenotypically sheep can be classified by their tail type as fat-tailed and thin-tailed sheep, of which fat-tailed sheep are well adapted to harsh environments of the tropics and also contribute more meat than thin-tailed sheep. Fat-tailed sheep reserve fat in their tails to be used during times when natural food resources are scarce.[255] The rearing of fat-tailed sheep can increase meat production and provide more income and livelihood to the smallholder sheep farmers in Bangladesh. Recently, Fat-tailed sheep has been imported in Bangladesh at personal levels and rearing in different parts in the country and its existence has mainly noticed at the Eid-ul-Adha animal market. Currently, population of Fat-tailed sheep could not be traced in inland literature of Bangladesh but research report[256] and face-book status indicates that the rearing of the Fat-tailed sheep has already been started in Bangladesh (Photo 15).[257]

Management system of sheep

Sheep rearing are practicing throughout Bangladesh but higher population is found in the coastal region of Noakhali and some char lands of Cox's Bazar. Under traditional feeding systems, the sheep are raised on harvested or fallow lands, roads and canal sides[258] and also graze on aquatic weeds and grass in knee-deep water. No other domestic animals are capable of existing on such feed. With their small muzzles and split upper lips they can nibble tiny blades of vegetation, which cannot be eaten by bigger animals.

Inadequate feed supply with nutritional deficiency is the major constraints for livestock rearing. The average deficiency of DM (g/h/d), ME (MJ/h/d) and CP (g/h/d) of lamb reported as 70.24, 0.97 and 13.35; growing sheep as 257.31, 2.62 and 34.75 and in adult ewes as 441.87, 2.81 and 35.45, respectively.[249]

Genetic and breeding research of sheep

The sequence alignment of BMP15 and GDF9 in indigenous sheep has not shown mutation and it does not affect the ewe fertility. The phylogenetic tree of BMP15 and GDP9 genes of indigenous sheep of Bangladesh showed that these sheep has a genetic relationship with other indigenous breeds of sheep elsewhere[259]

The genetic variation and differentiation among different populations of sheep in Bangladesh have been studied by using 18 microsatellite markers. All sheep population in Bangladesh are divided into four groups based on geographical distribution and history of breeding and management systems, which include ① **BD East** (BGE) representing the sheep of eastern part

(Bandarban, Sylhet, Moulovibazar and Noakhali districts), ② **BD Central** (BGC) representing the sheep of central (Mymensingh and Tangail district) and ③ BD N**orthern** (BDN) part (Pabna, Chapia Nawbagonj, Gibandha and Chuadanga districts) where introgression of some exotic genes have occurred, and ④ Garole (GAR) representing Garole sheep found in the area adjacent to Sundarban forest (Satkhira district). Representative samples of all these four sources have been genotyped. The allele number per locus ranged from 2 to10. The genetic distance between BGN and GAR reported highest and between BGC and BGN the lowest. In the phylogenetic dendrogram, BGC and BGN grouped in the same cluster, while BGE and GAR formed another two separate clusters. The results indicate that all four sheep populations had rich genetic diversity and the Garole sheep (GAR) is considered as an independent variety in Bangladesh.[260]

Feeds and feeding in sheep

Effect on the supplementation of vitamin A, D, E and bone meal on live weight gain (LWG) and carcass weight in sheep for 62 days period feeding have been evaluated. Results showed no significant differences on LWG and carcass weight among the supplemented groups but better flavor, tenderness, texture and color recorded in bone meal and vitamin D supplement groups.[261] Supplementation of vitamin and minerals to a ration of deficient sheep showed to favor more digestibility of CP and DM.[262]

The effect of dietary energy supplementation to six grazing female sheep and each sheep received 250 grams of supplemental diet in addition to grazing for 90 days. Increasing level of supplemental energy improve growth and reproductive performance of female sheep. Supplementation of higher level of dietary energy (11.98 MJ ME/kg DM) has been suggested for optimizing growth and reproductive performance of female sheep under grazing condition.[160]

The protein-rich feed supplementation has been reported to have a positive impact on reproductive performance of ewes.[263] Accordingly, 13.96% CP supplement feed has been suggested for the grazing sheep for high fertility.[259] Gestation period and lambing interval have been reported significantly higher in non-supplement (154 & 186 days respectively) than protein supplement (151 & 174 days, respectively) groups of ewes. Higher birth weight in protein supplement groups (1.24 & 1.48kg) than non-supplemented control (1.17kg) groups.[259]

Best ration combination for sheep of one year of age reported to be included para-grass hay (227g), wheat bran (227g), molasses (75g) and urea (10g) daily.[264]

The nitrogen balance in male crossbred sheep has been reported to be positive in the treatments with 5% urea treated rice straw and suggested that the treatment of rice straw with ammonia through urea is possible under simple storage conditions e.g. earthen pit, bamboo basket etc.[265] The digestibility and voluntary intake of rice straw treated with slaked lime have been determined in sheep. The straw soaked in water (1kg straw in 10 liter water) containing 40g lime/kg straw for 48 hours in a concrete pit and then washed with water (5 liter of water / kg of straw and then sun dried and fed *ad libitum* to the sheep. The lime used contained 60% CaO and 1.3% MgO. No change in the N-content of the straw due to the lime treatment recorded. Digestibility of straw increased significantly with lime treatment from 38 to 49% and

then further increased to 54% when supplemented with 10% molasses and urea to give 2% N in the ration. The digestibility of rice straw showed to be increased with lime treated straw and urea-molasses supplement maximize intake and digestibility with nitrogen.[265]

The effect of supplementary urea molasses block (UMB) lick with rice straw based diet has been evaluated on the performance of six indigenous sheep of two years of age with 12.88 kg live weight, grouped into two for the study of 90 days (Table 25). The UMB lick consisted of ① Molasses- 55.0%, ② Wheat bran- 27.0%, ③ Urea - 09.0%, ④ CaO (Lime powder)- 08.0%, ⑤ Common salt- 00.3% and ⑥ Mineral mixture - 00.7%. The UMB is prepared by heating (boiling) of molasses at first to reduce moisture content and other ingredients like wheat bran, salt and mineral mixture are mixed with time. Then urea and mixed ingredients are placed in the molasses and it is well mixed by agitating with a stirrer. Then the mixture is placed in the dice to make a block. The size of block licks is 22 × 11 × 10 cm and weighing approximately 2 kg. Later it is covered with polythelene to prevent from dirts.[266]

Table 25. Effect of urea molasses block lick on live weight gain (LWG) in indigenous sheep[266]

SN Parameters	Group A	Group B
1. Initial LW (kg)	12.66	13.00
2. Straw	ad libitum	*ad libitum*
3. Ipil-Ipil leaves (g/d/sheep)	167	167
4. Wheat bran (g/d/sheep)	66	66
5. Urea molasses block lick (g/d/sheep)	-	*ad libitum*
Performance		
1. Initial LW (kg)	12.66	13.00
2. Final LW (kg)	14.33	16.05
3. Daily LWG (g)	41	70

Table 26. Performance of ewe lambs with supplement feeding.[267]

SN Feed ingredient	Gr- A	Gr- B	Gr- C	Gr- D
1. Grazing at day time	+	+	+	+
2. Panacur @ 10mg/kg	-	+	-	+
3. UMB licks	-	-	+	+
Performance				
1. Initial BW, kg	8.4	8.8	9.2	8.7
2. Final BW, kg	12.6	16.4	17.3	20.7
3. Age at puberty (d)	428.8	412.8	325.4	318.6

The feeding rice straw with urea molasses block lick able to utilize more crop-residues efficiently. The effects of UMB licks supplemented with Panacur anthelmintic have been studied on indigenous ewe lambs aged 5 months with an initial live weight of 8 to 11 (8.8) kg divided into four treatment groups (Table 26). It appears that the supplementation of Panacur with UMB licks resulted improve growth rate, certain hematological status and puberty age of ewe lamb (Table 26).

The castrated native sheep offered *ad libitum* urea (3%), molasses (15%) and straw (82%) as a basal diet with concentrate mixture @ 1% of live weight for 63 days to detect the slaughter age (Table 27). The concentrate mixture consisted of: ① Maize crush- 30.0%, ② Wheat bran- 25.0%, ③ Kheshery bran 26.0%, ④ Til oil cake- 15.0%, ⑤ Fish meal - 02.0%, ⑥ Common salt- 01.0%, ⑦ Di-calcium phosphate (DCP)- 00.5% and ⑧ Vitamin-mineral premix- 00.5% and results.[258]

The LWG at early stage (6-8 months of age) of life reported more economical than at the later stage of life and suggested that the optimum market/slaughter age for native sheep maintained under these feeding and management would be at around eight months of age (Table 27).

Table 27. Mean values on the performance of sheep.[258]

SNParameters	(>3 to ≤ 6 M)	(>6 to ≤ 9 M	(> 9 to ≤ 12 M)	(>12 to ≤ 15 M)	
1. Basal diet	+	+	+	+	+ = See text for composition
2. Concentrate	+	+	+	+	
3. Initial LW (kg)	12.9[a]	18.7[b]	21.0[c]	24.3[d]	
4. Final LW (kg)	17.7[a]	22.6[b]	24.3[c]	24.9[d]	
5. LW at slaughter (kg)	18.6a	22.6b	24.2b	25.7[b]	
6. Dressing (%)	48.5[a]	49.0[a]	51.4[a]	55.5[b]	

Means having different superscripts differed significantly

The effects of oral administration of 7.0 ml soybean oil / kg live weight monthly and fortnightly infusion on the performance and carcass characteristics of native ram have been studied for 162 days feeding trial. Experimental animals fed roughage (*ad libitum* urea molasses straw, UMS) and concentrate (1.5% of body weight). The protozoan population reduced by 74% and 84% in animals of monthly and fortnightly fed group, respectively than the control animals. Fortnightly treatment increased fat deposition in animals' body, which is unacceptable to the customers.[268]

Adult sheep offered 3% calcium salt of fatty acid an additional or as replacement of NaCl on the basis of total concentrate mixture during the last 5 days of experiment. Calcium salt of fatty acid is prepared by adding three different levels of saturated solution of calcium chloride to soybean oil. Calcium salt of fatty acid showed reduced protozoa number without affecting the rumen pH and rumen ammonia nitrogen.[269] A study has been conducted to evaluate the feeding effect of three different tree forages on the performance of growing sheep (Table 28).

Table 28. Feed intake and live weight gain of growing sheep fed different diets.[69]

SNParameters	Group A	Group B	Group C	Group D
1. Tree forages DM intake (g/day)	-	64.27[c]	136.90[b]	147.34[a]
2. Silage DMI (g/day)	356.12[a]	232.18[c]	273.16[b]	286.64[b]
3. Concentrate DM intake (g/day)	252.62[a]	214.97[b]	277.81[a]	264.58[a]
4. Total DM intake (g/day)	608.75[b]	511.43[c]	687.88[a]	698.58[a]
5. Initial LW (kg)	11.75	11.75	11.74	11.71
6. Final LW (kg)	15.86[ab]	15.76[bd]	17.21[ab]	16.28[b]
7. LW gain (g/day)	45.66[c]	44.58[c]	60.70[a]	50.7[b]

A= No tree forages (control group) B = Melia azadirach (Chinaberry) C = *Leucaena leucocephala* (Ipil-ipil) D = *Artocarpus heterophyllus* (Jackfruit) Means having different superscripts differed significantly

Diets with tree forages of *L. leucocephala* resulted better in terms of weight gain, digestibility and nitrogen balance compared to *A. heterophyllu, M. azardirachta* and control (Table 28).

An investigation on the lamb production potentiality in terms of nutrient intake and utilization, growth performances, carcass characteristics and meat quality of three regional native sheep of 4 to 6 months

under intensive management has been conducted. Approximately 40% urea molasses straw (UMS) and 60% concentrate mixture of the total diet supplied according to lamb live weight. All the regional sheep have the potentiality but coastal region sheep are more potential than other region sheep for commercial lamb production in Bangladesh.[270]

Feeding of water hyacinth

Feeding of whole water hyacinth (*Echhornia crassipes*) or its different parts to sheep has been evaluated its consumption pattern, chemical composition and nutritive value. Average daily intake of the group supplied with fresh leaf reported highest, followed by whole part (dry), whole part (fresh) and of stem consecutively. Nutritive value of whole plant and (fresh) supplemented with oil cake and that of fresh leaf reported higher than those of whole plant (dry) and of fresh stem + oil cake.[271]

Feeding trials of fodder and grasses

Most of the small ruminants are raised by smallholder farmers especially with the major participation of women and children who own little or no land which is considered as a major constraint for fodder cultivation for feeding of their animals. Comparative utilization between German grass (*Echinocloa crusgalli*) and native grasses (Barmuda grass, Love grass, Arail and common sedge) have been evaluated in sheep of 2.5 years aged and 16.6 live weight. Both grasses dried in the sun and chopped into 5 cm in length for feeding trail. The intake and digestibility of both forages by sheep are reported almost similar.[272] Sunnhemp forage has also been evaluated in sheep.[273]

Approximately 60% sheep farmers are used roadside grass and 40% cultivated and roadside grass in the district of Mymensingh.[246, 274]

Natural pasture land grasses, fellow land grasses, tree leaves / forages, road / river side grasses and crop residue have been supplied in 100% both the Jamuna basin indigenous (JBI) sheep and Muzzaffarnageri cross (MZN) breed sheep in experimental areas in Bangladesh.[9] Concentrate mixture (rice/wheat bran) is supplied both in JBI (52.5%) and MC (53.3%) sheep but rice straw supplied only in MC sheep (46.7%).[9]

Effect of feeding concentrate on live weight of sheep

Evaluation of concentrate supplements @ 100g, 200g and 300g per local sheep per day of about 6 months old with average live weight 10.78 kg to detect the live weight gain and dressing percentage (Table 29).

Concentrate supplement increased the live weight gain (LWG) in sheep on grazing. Live weight increases with increasing level concentrate supplement in grazing sheep from 15.7g to 40.5 g (Table 29).

Feeding of chopped grass as basal forages and a creap mixture (20g / lamb/day) for two weeks of age with a weekly increase of 10g/lamb improved with high plane of nutrition and positive effects on all weight traits of lambs and ewes milk yield.[275]

The concentrate supplementation with free grazing has improved live weight and scrotal circumference gain and semen production with increased quality in indigenous ram. The

Table 29. Effect of concentrate supplement on live weight and carcass dressing percentage[276]

SN Parameters	Grazing + Conc. (g/sheep/day)			
	0	100	200	300
1. Initial LW (kg)	10.03	10.35	10.30	10.78
2. Final LW (kg)	11.68	12.73	13.73	15.03
3. Trial duration (days)	105	105	105	105
4. Av LW gain (g/day)	15.7^{c}	22.7^{bc}	32.7^{ab}	40.5^{a}
5. Grazing sheep (hrs/day)	7.30	7.30	7.30	7.30
6. ERMAC (Taka / day)	0	0.24	0.84	1.18
7. Concentrate mixture				
a. Wheat bran (g/day)	0	50	100	150
b. Sesame oil cake (g/day)	0	50	100	150
c. Common salt (g/day)	0	05	005	005
Effects				
1. No. of carcass	2	2	2	2
2. Pre-slaughter LW (kg)	12.10	15.05	13.75	15.30
3. Warm carcass wt (kg)	4.05	5.90	5.20	5.90
4. Dressing percentage	32.75	38.50	36.90	37.75

Means having different superscripts different significantly
ERMAC = Extra return from meat for added concentrate

Table 30. Effect of concentrate feeding on growth performance of lambs[277]

SN Parameter	Gender	Grazing + Conc. (g/sheep/day)		
		0	100	200
1. Initial LW (kg)	Male	10.25	9.88	9.38
	Female	8.08	9.13	8.81
2. Final LW (kg)	Male	14.50^{b}	15.25^{ab}	16.38^{a}
	Female	10.31^{b}	12.31^{ab}	12.63^{a}
3. Total LWG (kg)	Male	4.25^{b}	5.38^{ab}	7.00^{a}
	Female	2.25^{b}	3.18a^{b}	3.81^{a}
4. Av LWG (g/day)	Male	47.20^{b}	59.73^{ab}	77.78^{a}
	Female	25.00^{b}	35.39^{ab}	42.33^{a}

Means having different superscripts different significantly

concentrate consisted of wheat bran (50%), crushed maize (25%), soybean meal (20%), fish meal (1%), DCP (2%), vitamin-mineral premix (0.5%) and salt (1.5%) @ 300g/head / day.[278]

Two levels of concentrate mixture @ 100g and 200g per head per day supplemented to the two separate groups of lambs aged between 5-6 months for 90 days feeding to evaluate the growth performance. The concentrate mixture prepared by mixing wheat bran, rice polish, soybean meal, mineral supplement and common salt @ 50 : 30 : 18 : 1 : 1 respectively. In addition, mineral-vitamin premix mixed with concentrate mixture @1g/kg mixed feed. The green roughage composed of road-side grass, jackfruit tree leaves and neem leaves. The results showed that 100g concentrate supplement with green roughages improved growth rate in lambs (male & female) under stall feeding condition (Table 30).[277]

Physiological parameters

Sheep and goats have some similar anatomical (a pair of teats) and physiological characteristics (gestation period approximately 150 days and presence of seasonal anestrus). However, they are completely different in feeding habits, nutrient needs and grazing systems. Sheep has been used to study the seasonal and diurnal variation of blood values. Significant difference in the RBC count and PCV has been reported in different seasons but not between morning and evening values.[279] The cross-bred sheep (Local × Australian Ramney) of F1 generation have been used for haemtological studies.[280] Blood values reported as RBC 10.0 million / cumm, Hb 11.7 g/100 ml, PCV 34.0%, ESR 1.03 / hour, WBC 12.61 thousand / cumm, Neutrophil 29%, Eosinophil 15.37%, Basophil 0.34%, Lymphocyte 52.68% and Monocyte 1.93%[281] Hematological and biochemical reference values[282] and serum transferrin polymorphismin the native sheep[283] have been reported.

Sheep of different age and sex have been used to detect the serum calcium and phosphorus levels. The serum calcium level varied from 6.96 to 8.91 mg/dl and phosphorus level varied from 3.72 to 4.85 mg/dl. Lactating ewes had the lowest serum calcium (6.96-7.17) but castrated animals had higher calcium and phosphorus values than un-castrated animals. Calcium value reported higher in summer (7.37 mg/dl) than winter (7.15mg/dl) whereas the phosphorus value higher in winter (4.19mg/dl) than summer (3.98 mg/dl).[284]

Research report on hematological reference values of healthy Fat-tailed sheep (also known as Dumba) under Bangladesh rearing condition has only been reported.[256] However, it has been claimed, 'Like other countries, many farmers of Bangladesh are rearing this sheep for meat, fat and wool' supported with foreign research reports.[285,286]

Wool production

The fleece yield, staple length, wool fibers and finess of wool between cross and native sheep have been compared (Table 31).[287-289] The wool quality between Romney and Parendale sheep have been described.[290] Sheep population in Bangladesh is about 3.607 million which are mostly indigenous type reared throughout the country.[7] Approximately 2.5 thousand metric tons of raw wool can be collected from sheep population of Bangladesh. Most of the wool of these sheep is going to waste due to lack of processing and proper applications. An attempt has been made for development of jute, cotton and sheep blended yarn using cotton spinning system and results showed that 30% wool, 30% jute and 40% cotton fiber 12s blended yarn used for blended yarn production.[291] Wool production has been reported to be associated with nutritional status of sheep.[292]

Table 31. Wool production and quality of native sheep in different region in Bangladesh[250]

SN Season	Wool production (g)			SNParameters		Wool quality		
	Jamuna	Barind	Coastal			Jamuna	Barind	Coastal
1. Summer	415.4	440.0	463.6	1. Staple length (cm)		7.21	7.26	7.95
2. Autumn	318.3	410.7	388.5	2. Crimp (bend/inch)		2.34	2.35	2.75
				3. Wool (%):	Fine	15.31	16.32	19.60
Yearly total	733.6	810.7	852.9		Hetero	8.17	7.35	10.27
					Hairy	76.52	76.33	70.13

Effect of heat stress

The effects of different heat exposure magnitude on some physiological and behavioral response of indigenous sheep have been investigated. The results showed that short term heat stress is tolerable but long term is physiologically detrimental to the health of indigenous sheep. Sheep exposed to cyclic heat treatments exhibited higher rectal temperature and respiratory rate whereas decreased heart rate and rumination. Long term heat treatment significantly increased RBC, WBC, PCV and Hb values and biochemical values including plasma glucose, uric acid, aspartate aminotransferase and blood urea nitrogen.[293]

The effect of heat stress on carcass characteristics and meat quality in three groups (control, four hours and eight hours heat exposure to direct sunlight) of indigenous sheep have been investigated. Heat stress had significant changes on carcass characteristics and meat quality of indigenous sheep.[294]

Estrus, natural services and AI in ewes

The average length (15.8 days) and duration (31.1 hours) of estrus cycle reported in native ewes and suggested that the pattern of exfoliation of vaginal cells along with progesterone concentration could be used to detect the reproductive stage of native ewes.[295] Most of the breeding sheep farmers (100%) are used natural breeding in Bangladesh.[245,246] Estrus synchronization with Ovuprost® and Prostenol® in indigenous ewes have also been reported.[296]

Characteristics of semen and sperm of ram

The seasonal variation in the semen characteristics of Lohi rams has been studied by using artificial vagina. High temperature and high relative humidity have apparently affected both spermatogenesis and mortality of spermatozoa. Poor semen quality during summer and rainy seasons has possibly been due to the high environmental temperature and RH which prevailed during those seasons.[297] The whole milk and egg yolk citrate glycine maintained ram sperm motility better than that of other extenders.[298] It has suggested that egg yolk citrate extender can be replaced by whole milk extender for the preservation of ram semen.[299]

Cross-bred rams divided into two maintenance groups, on closed chamber and open on atmosphere. Semen of good quality obtained from maintained at a comfortable temperature.[300] The daily output of spermatozoa has been measured in the urine of two rams for 12 consecutive days. It has realized that spermatozoa comes out through spontaneous emissions of semen in the normal urine of ram, however masturbation and ejaculation of semen by the ram during collection of urine may not contribute a major output of spermatozoa in the urine. An investigation showed that 2 to 3 times semen collection in a week can be followed in the schedule semen collection from native ram without any deteriorating the quality of semen.[301]

Mammalian spermatozoa exhibit more or less similar basic morphological feature and consist of head, mid-piece and tail. The measurements of its dimensional characteristics vary from species to species and determine the shape and size of spermatozoa in each species. The normal size of spermatozoa differs from breed to breed within species and also between individuals within each breed. Measurements on size may vary due to several factors such as genetic, nutrition, season, disease, interval between collections and others.[302] No significant differences reported in any of the measurements of spermatozoa between Parendale and Romney breeds of rams (Table 32).

Comparison of the efficacy of the soybean milk, egg yolk citrate and powder skim milk have been evaluated with ram semen preserved at 5 ^{0}C and tested for pH, motility, normal and live spermatozoa (Table 33). The Soybean milk (SM) prepared with ① Paste soybean - 25g, ② Distilled water- 75 ml, ③ Sodium citrate crystal- 1.5 g / 100 ml, ④ Penicillin - 1000 µg / ml, ⑤ Dihydro-streptomycin - 1000 g/ml and ⑥ Sulphanilamide - 0.6 g/ 100 ml. The Egg-yolk

Table 32. Measurements of spermatozoa (μ)[302]

SN Spermatozoa	Parendale	Romney
1. Head length	8.54	8.59
2. Head breadth	4.68	4.64
3. Head shape	1.85	1.83
4. Tail length	54.84	54.61
5. Total length	63.93	63.21

Table 33. Comparison of ram semen quality evaluation by using different diluents at 5 ^{0}C for 7days[303]

SN Diluters	pH	Motility	Sperm quality (%)	
			Normal	Live
1. Soybean milk	6.63^a	46.96^a	79.23^a	58.61^a
2. Egg-yolk citrate	6.50^b	42.90^b	75.79^b	54.33^b
3. Powdered skimmilk	6.42^c	37.38^c	54.33^b	48.26^c

Means having different superscripts different significantly

citrate (EYC) prepared with ① Egg yolk - 25 ml, ② Sodium citrate buffer (2.94%)- 50 ml, ③ Penicillin - 1000 iu / ml, ④ Dihydro-streptomycin - 1000 g/ml and ⑤ Sulphanilamide-0.6 g/ 100 ml. The powdered skim milk (PSK) prepared with ① Skim milk powder- 10 g, ② Distilled water -100 ml, ③ Dihydro-streptomycin - 1000 g/ml, ④ Penicillin - 1000 iu / ml, ⑤ Sulphanilamide - 0.6 g/ 100 ml. Soybean milk as a semen dilutor may be considered as a good alternative for preserving semen for AI.[303]

The qualities of ram semen in different age groups (1 to 3 years) have been evaluated. The scrotal diameter, serving capacity, normal and live spermatozoa reported comparatively better during the 3rd year than 1st and 2nd year of age while the values found almost similar at 3rd and 4th year of age. With the increasing age, the semen quality improved and stabilized up to the age of 3 years.[304]

The CR of native sheep by using AI with liquid ram semen has been determined in 63 ewes which are inseminated with stored liquid semen collected from 15 rams by artificial vagina method. The average semen volume per ejaculate recorded as 0.76 to 1.0 ml and the sperm concentration was 2.37×10^9 to 4.30×10^9 per ejaculate. The number of live spermatozoa and the sperm motility reduced with the increasing age of semen. The average CR (%) obtained as 63.61, 61.90, 52.38 and 47.61 with sperm in zero, 1st, 2nd and 3rd day storage respectively. The acceptable CR may be obtained with AI using liquid ram semen stored at 4 ^{0}C for 72 hours.[305]

The commercial extender (Triladyl®, Minitube, Germany) reported to be useful (pregnancy rate 27.3%) as an alternative to the conventional extender (Tris TFE= tris, fructose, egg-yolk, pregnancy rate 26.8%) for the longer time chilling and application of transcervical artificial insemination (TCAI) in Bangladesh. However, Triladyl has detrimental effect on sperm acrosome and TFE on sperm tail.[306,307]

The effects of preservation time on the quality of frozen semen collected using artificial vagina once a week of indigenous rams have been evaluated (Table 34).

Out of 16 selected local Wera variety of rams, two (12.5%) failed to show better performance and 14 (87.5%) rams trained for semen collection. The selected 10 (62.5%) best rams reported the semen parameters as volume ≥ 0.5 ml, color ≥ 3 (milky white), mass activity ≥ 4, sperm motility ≥ 80.0%, sperm viability 90%, sperm concentration ≥ 2500×10^6 / ml, sperm plasma membrane integrity ≥ 85.0%, sperm acrosome integrity ≥ 90.0% and normal sperm morphology ≥ 80.0%.[308]

The quality of fresh semen of native rams particularly volume, density and mass motility, concentration, motility, viability, functional integrity and normal morphology of semen have been

reported within the normal range and also reported satisfactory after chilling at 48 hours and freezing.[309] Accordingly, it has been suggested to introduce AI in ewes using semen from indigenous rams to observe the success of fresh as well as preserved semen and increase sheep population with high genetic merit.[309] Non significantly decreased of the semen quality with advance of preservation time indicates the suitability of the protocol used for freezing of indigenous ram semen in Bangladesh. Effects of

Table 34. Characteristics and evaluation of quality of semen of native rams

SN Parameters	Fresh (n = 9)[310]	Fresh (n = 32)[311]	Fresh (n=4)[312]	Fresh (n = 14)[313]	Fresh (n = 4)[314]	Fresh (n = 4)[315]	Overall (n = 67)
01. Volume (ml)	1.62 ± 0.16 (1.3-2.0)	0.8 ± 0.3	0.8	1.2 ± 0.0 (0.2-1.8)	1.0 ± 0.1 (0.9-1.2)	0.8 ± 0.3 0.7-1.0	1.04 (0.2-2.0)
02. Color, 1-4	-	3.9 ± 0.3	-	CW	CW/MW	3.9 ± 0.3 3.5-4.0	3.9 (3.5-4.0)
03. Density (1-4)	2.79 ± 0.28 (2.0-3.0)	-	3.0	2.9 ± 0.0 (2.0-4.0)	-	-	2.90 (2.0-4.0)
04. Mass activity (1-5)	3.88 ± 0.91 (2.5-5.0)	4.4 ± 0.6	3.2	4.1 ± 0.0 (2.5-5.0)	4.0 ± 0.1 3.8-4.1)	4.5 ± 0.5 (3.9-5.0)	4.01 (2.5-5.0)
05. Conc. ($\times 10^9$/ml)	-	3.52 ± 0.5	3.9	4.5 ± 0.1 (2.0-8.9)	4.1 ± 0.2	3.52 ± 0.5 (2.80-4.12)	3.91 (2.0-8.9)
06. Motility % (0 h)	85.37 ± 4.19 (80-92)	81.3 ± 5.0	83.3	89.0 ± 0.2 (80-95)	85.0 ± 1.3	81.7 ± 4.0 (77.5-85.1)	84.28 (77.5-95)
07. Viability (%)	-	90.0 ± 4.0	88.2 (70-93)	87.3 ± 0.2 (87.9-90.1)	89.4 ± 1.0 (85.0-93.3)	90.0 ± 4.0	88.98 (70-93.3)
08. Morphology (%)	-	-	84.2	-	85.5 ± 0.7 (84.9-86.4)	-	84.85 (84.9-86.4)
09. HOST +ve, %	-	87.4 ± 3.3	-	-	84.7 ± 0.5 (84.1-85.1)	-	86.05 (84.1-85.1)
10. Normal sperms, %	-	85.6 ± 1.8	-	94.0 ± 0.1 (86-98)	-	-	89.8 (86-98)

n = No. of rams - = Data not available CW = Creamy white MW = Milky white

duration of preservation and glycerol percentages of quality of frozen ram semen[316] and six ejaculates collected from nine native rams at seven days intervals[310] have been evaluated for quality of semen. The volume of native semen varies from 1.3 to 2.0 ml, color is creamy white, density is 2 to 3 score, mass activity ranged from 2.5 to 5.[310]

The pregnancy rates reported higher with fresh semen (71.0%) in comparison to that of separated sample (57.0%).[314] The frozen ram semen have been evaluated and used to detect the conception rate (CR) followed by intra-cervical AI in both natural and synchronized ewes, resulted 26.7% CR in natural and 25.0% CR in synchronized estrus (Table 34).[311]

Bacteriological test showed that *Escherichia coli* and *Staphylococcus* spp. have been contaminated with all the four ram fresh semen and only one semen with Bacillus organism but antibiotic treated semen samples showed no growth of any bacteria after three days of incubation.[315]

Physical examination, inspection of reproductive organs, semen collection and evaluation has been used to detect the potentiality and efficiency in breeding rams or semen production for AI.

Examination of different semen characteristics allows detection and elimination of clear-cut cases of male infertility or sub-fertility, whereas changes of semen color indicate damage or infection in male genital tract. The lost acrosome, membrane damaged and decapacitated sperm cells cannot fertilize oocytes because the intact acrosome is crucially important for transit, penetration, acrosome reaction and fertilization.[317]

Sperm concentration reported significantly ($p < 0.05$) higher in Muzzaffarnagari cross (MNC) rams than native rams (Table 35), whereas the seminal attributes of fresh semen did not differ significantly ($p > 0.05$) between Native and MNC rams but varied significantly ($p<0.05$) at pre-freeze stages between Native and MNC rams (Table 36). Both the Native and MNC rams reported that could be selected good quality rams for efficient frozen semen production

Table 35. Comparison of fresh semen characteristics between indigenous and Muzaffarnagari crossbred (MNC) rams[10]

SN	Parameters	Native rams	MNC rams	F values
1.	Volume, ml	0.77 ± 0.04	0.70 ± 0.04	0.217^{NS}
2.	Color (1-4)	3.73 ± 0.12	3.87 ± 0.09	0.800^{NS}
3.	Mass activity (1-5 grades)	3.6 ± 0.11	3.73 ± 0.12	0.571^{NS}
4.	Semen conc. ($\times 10^6$/ml)	364.47 ± 7.36	392.60 ± 5.71	9.121*

Table 36. Comparison of seminal attributes between Native and Muzaffarnagari cross-bred (MNC) rams at fresh and pre-freeze stages[10]

SN	Seminal attributes	Ram variety	Fresh semen	Pre-freeze	F values
1.	Sperm motility (%)	Native	80.00 ± 1.09	74.67 ± 1.33	9.582*
		MNC	81.67 ± 0.93	77.33 ± 0.83	12.071*
		F values	1.246	2.890	NS
2.	Live sperm (%)	Native	90.93 ± 0.74	80.73 ± 1.22	50.826**
		MNC	91.27 ± 0.57	73.67 ± 0.86	290.054
		F values	0.126	22.299	NS
3.	Normal sperm (%)	Native	85.33 ± 0.60	82.66 ± 0.52	11.256*
		MNC	85.27 ± 0.64	83.13 ± 0.74	4.763*
		F value	0.005	0.267	NS
4.	Membrane intact (%)	Native	81.93 ± 0.77	75.07 ± 0.87	35.129**
		MNC	82.40 ± 0.77	69.73 ± 0.92	111.370**
		F value	0.184	17.785	NS
5.	Acrosome, (%)	Native	94.73 ± 0.75	92.6 ± 0.53	5.413*
		MNC	95.80 ± 0.39	91.27 ± 0.37	70.365**
		F value	0.216	4.217	NS

^{NS}Non-significant *Significant at ($p < 0.05$) **Significant at ($p < 0.01$)

The non-return rate and conception rate in ewes by using AI with frozen semen indicate the suitability of produced frozen semen application in the field level (Table 37).[317] However, the low CR of used frozen semen has suggested for modification and refinement of the used frozen semen and AI techniques to produce higher post thaw sperm motility and conception rate.[311]

Effects of cloprostenil and flurogestone acetate sponge on embryo yield and quality in ewes.[318] The cervical ripening with estradiol and oxytocin treatment has been made and the AI gun able to penetrate through the cervical canal in comparison to control. This study identified an effective cervical ripening treatment protocol for increasing pregnancy rates following transcervical artificial insemination (TC-AI) in indigenous ewes of Bangladesh.[108,319,320] The diluent home-made tris based and sperm dose 100×10^6 reported to be most practical method for achieving high pregnancy and lambing rate following laparoscopic artificial insemination (LAP-AI) in Bangladeshi ewes.[320]

Table 37. Evaluation of frozen ram semen used for AI and CR in ewes

SN	Types[311]	No. of samples	Sperm motility % (%)	Sperm viability % (%)	SN	Comparison between fresh and frozen ram semen Types[312]	Motility (%)	Viability (%)	Morphology (%)
1.	Pre-diluted	4	83.8 ± 4.8	93.3 ± 1.0					
2.	Post-diluted: 120M	4	81.3 ± 2.5	90.0 ± 1.4	1	Fresh semen	83.3	88.2	84.2
	240 M	4	80.0 ± 4.1	88.8 ± 1.0	2	Chill semen	74.7	78.8	79.2
3.	Post-thawed	4	41.3 ± 9.5	58.3 ± 8.7	3	Frozen semen	40.1	44.6	70.0
4.	Conception rate, %	23	NRR: 30.4%	CR: 26.1	4	Preserved (30 d)	39.4	43.9	70.3

Embryo transfer in ewes

Production of embryos can be based on three steps: *in vitro* maturation (IVM) of oocytes, then *in vitro* fertilization (IVF) and then *in vitro* culture (IVC) for cleavage up to blastocyst stage. Ovaries from an abattoir have been collected and categorized as type I with no corpus luteum (CL) and type II with CL. It has suggested that type I (without CL) ovaries and follicles of 2-6 mm diameter reported suitable to collect good quality COCs (cumulus-oocyte-complex) for *in-vitro* maturation (IVM) of oocytes and the culture condition for IVM of sheep COCs are reported.[321]

Reproductive performance of sheep in Bangladesh

Puberty is when a female sheep reaches sexual maturity and exhibits estrus (heat) for the first time. The age of puberty is influenced by breed, genetics, weight, nutrition and season of birth. Most of the female sheep reach puberty between 5 and 12 month age. The age at puberty of sheep is determined as the age of first estrus and it is usually characterized by sign of wagging tail, swelling and mucus discharge of vulva, jumping tendency to other sheep, rubbing their body with the rams and remain closer to the rams.[311,322] The productive and reproductive performances of native and some crossbred (Native × Lohi) sheep have been compared (Table 38).[323,324]

Table 38. Productive and reproductive performance of sheep[323,324]

SN	Breed of sheep	Gestation period (d) No. of ewes	Range (Mean)	Litter size No. of delivery	Single No. (%)	Multiple No. (%)	Lambing interval (d) No. of ewes	Range (Mean
1.	Native	113	143-160 (149.60)	289	139 (48.0)	150 (52.0)	144	172-516 (253.93)
2.	Native x Lohi grade I	119	134-160 (149.18)	163	116 (71.0)	047 (29.0)	109	181-597 (294.13)
3.	Native x Lohi grade II	0 54	134-157 (150.74)	091	060 (65.5)	031 (34.5)	056	177-790 (484.55)
4.	Native x Lohi grade III	-	-	014	009 (64.3)	005 (35.7)	-	
	TOTAL:			557	324(58.1)	233 (41.9)		

One year old 24 anestrous ewes, divided into three groups (A, B, C), each ewe of Gr A supplied 4 oz concentrate (wheat bran + Oil cake @ 3:1) and group B 2 oz but not ewes in group C (Control). Results showed that the concentrate feeding have a marked effect on reproductive performance of ewes.

Reproductive traits of ewes reared in different regions

The overall performance of the sheep of BLRI nucleus flock reported comparatively better than the others which may be due to the result of selective breeding, improve feeding, housing, and health management (Table 39).

Table 39. Reproductive performances of indigenous sheep maintained in different areas, district and farms in Bangladesh.[250,251,325]

SN Parameters (day)	Jamuna+	Barind+	Coastal+	BLRI	Tangail	Naogaon	Noakhali
2. Age at 1st heat	239.9	224.4	279.0	266.50	333.17	329.00	341.23
3. No. of service/conception	1.3	1.3	1.4	1.30	1.47	1.52	1.44
4. Age at 1st pregnancy	277.0	264.7	292.3	-	-	-	-
5. Gestation length	152.8	145.0	146.6	147.83	151.46	150.33	149.57
3. Age at 1st lambing	409.8	389.9	439.5	432.72	491.92	488.09	499.92
4. Lambing interval	188.6	189.5	204.3	192.17	221.13	228.57	214.32

NSC = No. of services /conception + = Population not mentioned

The reproductive performances between semi-intensive and intensive management, Jamuna basin indigenous (JBI) and Muzzaffarnagari cross (MC) sheep, different districts have been compared (Table 40)

Table 40. Reproductive and productive performance of native sheep

SN Parameters	Management[326]		Breed types[9,10]		Six districts* Native [322]	Raj+Mym Native[252]
	Semi-I (n=22)	Intensive (n=22)	JBI sheep (n=277)	MC sheep (n=705)	(n=1768)	(n=52)
01. Age at 1st heat (days)	-	-	-	-	213	193.4
02. Duration of estrus (hrs)	-	-	-	-	-	36.00
03. Age at 1st service (M)	-	-	8.08	10.35	-	-
04. Service per conception	1.4	1.6	-	-	1.10	-
05. Age at first pregnancy (days)	-	-	-	-	-	201.4
06. Conception rate (%)	98	83	-	-	-	
07. Age at 1st lambing (day)	-	-	422.00	508.05	379.5	364.3
08. Litter size (No.)	1.45	1.65	-	-	1.93	1.6
09. Lambing interval (days)	263	258	178.50	188.25	-	193.3
10. Gestation length (days)	146.0	147.6	146.77	148.95	-	147.9
11. PP anestrus period (days)	-	-	26.36	48.35	-	25.2
12. Birth weight (kg)	1.56	1.60	-	-	0.94	-
13. Pre-weaning growth rate (g/d)	65.0	71.4	-	-	-	-
14. Lamb birth weight (kg)	-	-	-	-	-	1.5
15. Weaning weight (kg)	7.3	7.7	-	-	-	7.9
16. Mature weight (kg)	-	-	-	-	-	22.2
17. Milk yield (ml/d)	264.5	281.0	-	-	-	-
18. Lamb Mortality, %	8.0	0	-	-	-	-

SI = Semi-intensive JBI = Jamuna basin indigenous MC = Muzzaffornagari cross Raj= Rajshahi
*Six districts = Naogaon, Gaibandha, Tangail, Sylhet, Noakhali and Bandarban Mym = Mymensingh

The semi-intensive feeding system is found to be better to rear sheep for commercial purpose compared to intensive feeding system. Shorter reproductive traits with increased percentage of multiple births and expected theriogenological sex ratio of 50 : 50 for male and female lambs are indicative of prolific nature of Jamuna basin indigenous sheep (Table 40). Muzzaffarnagari cross sheep might be farmers' choice importantly based on morphometric and productive performances that directly involved with sale value and income sources.[9]

Influence of nutrition on reproductive performances of sheep

The relationship between nutrition and reproduction is a topic of increasing importance and concern among livestock farmers, veterinarians, feed dealers and extension workers. The interaction between nutrition and reproduction has long been known to have important implications for the reproductive performance. Under nutrition results in the loss of body weight and body condition, delays the onset of puberty, increases the post-partum interval to conception, interferes with normal ovarian cyclicity by decreasing gonadotropin secretion and increases infertility in ewes.[327,328]

Multiple nutrient are associated with health and production, however energy balance is probably the single most important nutritional factors related to poor reproductive function in animals and metabolic use of available energy in ruminants includes (a) basal metabolism, (b) activity, (c) growth, (d) energy reserves, (e) pregnancy, (f) lactation, (g) additional energy reserves, (h) estrus cycles and initiation of pregnancy and (i) excess energy reserves. Restricted energy intake during late gestation increases the length of post-partum anestrus and reduces subsequent pregnancy rate. Excessive energy intake during late lactation and the dry period can cause metabolic disorders like 'fat cow' syndrome which lower reproductive efficiency in the next lactation. Nutrient either in deficient amount or in higher amount has been shown to be capable of altering reproduction. The basic problem is that the degree of the excess, deficiency or imbalance which is required to alter reproduction is still unclear.[327]

Mostly 90% small ruminants are reared by rural household globally. The major issues of which are poverty, lack of new techniques and proper management skills. Both the small ruminant particularly sheep and goats are mainly reared by the poor farmers and distressed women in extensive system under ranged condition without any concentrate supplementation. Inadequate and imbalance nutrition results in the loss of body weight and body condition, delays the onset of puberty, increases the post-partum onset of estrus, interferes with normal ovarian cyclicity by decreasing gonadotropin secretion and increases infertility. Nutrition during gestation not only affects maternal body weight gain, body condition and reproductive performance but also affects prenatal and post-natal offspring growth and development.

The non-supplemented control group of ewes maintained on natural grazing with traditional feeding practice used by the farmers, whereas supplemented group maintained with supplement concentrate (composed of crushed maize 25%, wheat bran 50%, soybean meal 20%, fish meal 1.0%, DCP powder 2.0%, salt 1.5% and vitamin-mineral premix 0.5%) feeding (@ 300g/ewe/day) along with natural grazing.

The pregnancy rate, post-partum anestrus period, lambing rates, litter size, lamb survival rate, birth weight and pre-weaning average daily gain of lambs reported significantly different

between supplemented and non-supplemented groups of sheep (Table 41,42). These influences of nutrition on reproductive performances of ewes reported that may increase and improve the sheep production.[328] The concentrate supplementation with free grazing improved weight and scrotal circumference gain and semen production with increased quality in indigenous ram.[278]

Table 41. Comparison of reproductive performances between concentrates supplemented and non-supplemented indigenous ewes[328]

SN	Parameters	Non-supplemented	Concentrate supplemented
01.	No. of ewes	12	12
02.	Age at puberty (M)	8.43± 1.15a	6.22 ± 1.31b
03.	Av DWG (g/d/ewe)	21.19 ± 4.71^{b}	40.95 ± 12.07^{a}
04.	Estrus cycle length (days)	16.06 ± 0.35	15.81 ± 0.38
05.	Duration of estrus (hrs)	32.75 ± 3.19	33.17 ± 3.01
06.	Gestation length (days)	141.80 ± 1.23^{b}	144.50 ± 1.17^{a}
07.	PP anestrus period (days)	42.5 ± 5.57^{a}	28.67 ± 7.24^{b}
08.	Pregnancy rate, %	83.33	100
09.	Lambing rate %	75.00	100
10.	Litter size	1.22 ± 0.44	1.58 ± 0.67
11.	Lamb survival rate, %	91.67	100
12.	Lamb birth weight (kg)	1.00 ± 0.30^{b}	1.33 ± 0.25^{a}
13.	Weaning weight (kg)	3.58 ± 0.93^{b}	5.71 ± 1.03^{a}
14.	PADWG (g/d/lamb)	42.59 ± 14.44^{b}	72.96 ± 13.35^{a}

Table 42. Reproductive performance of ewes with concentrate feed supply [329]

SN	Parameters	Gr-A	Gr-B	Gr- C
1.	No. of ewes	8	8	8
2.	Conc. oz/day/ewe	4	2	0
3.	Grazing period, hr/d	4	4	4
4.	Ewes shown estrus	7	7	2
5.	Ewes gave birth	6	5	1
6.	Lambing pattern			
a.	Single lamb	3	4	1
b.	Twin lambs	3	1	0
7.	Gender			
a.	Male lamb	7	5	0
b.	Female lamb	2	1	1
8.	Lambing, %	75.0	62.5	12.5
9.	Twining, %	50.0	20.0	0

PP = Post-partum PADWG = Pre-weaning average daily weight gain
Means having different superscripts differed significantly

Effects of protein supplements on semen profile in native sheep

The seminal traits of native rams reported to be better in group of rams fed with 13.96% crude protein than the other groups of rams that the improved dietary intake above maintenance requirements showed positive effects on rams and reproductive performances.[330] A concentrate diet containing 20% CP during late pregnancy to lactation suggested to be supplied to obtain maximum performances of ewes and their lambs.[331] Effect of wheat bran substitution for corn and dehydrated alfalfa on finishing lamb has been reported.[332]

The influence of different factors on pregnancy rate in indigenous ewes following AI with frozen semen has been evaluated (Table 43). The ewes are synchronized by IM injection

Table 43. Effects of methods of AI and estrus intensity on pregnancy rate in ewes[333]

A. Effect of methods of AI

SN	Methods of AI	No. of ewes AI	Pregnant No. (%)
1.	TCAI	7	2 (28.6)b
2.	TCAI	5	3 (60.0)a
3.	LAPAI	12	9 (75.0)a

B. Effects of estrus intensity

SN	Estrus intensity	No. of ewes AI	Pregnant No. (%)
1.	High	12	9 (75.0)
2.	Medium	09	5 (55.6)

1. TCAI = Trans-cervically AI (WCRT= Without cervical relaxation treatment)
2. TCAI = Trans-cervically AI (WCRT= With cervical relaxation treatment)
3. LAAI = Laparoscopically AI

of PGF2α (Ovuprost® Bayer, New Zealand) and the onset and intensity of estrus determined by estrus behavior of ewes with vasectomized ram. Twelve ewes inseminated with AI trans-cervically and 12 laparoscopically, whereas five ewes with Misoprostol (Cytomis® 200 µg tablet; Incepta Ltd) to relax the cervix 12 hours before trans-cervically AI (Table 43).

Lamb production

Table 44 shows the factors associated with the lamb production in different breeds.

Table 44. Factors associated with the lamb production in different breeds in Bangladesh[9,10,250,251,275,334]

SN	Variable	Categories	Native	BLRI	Tangail	Naogaon	Noakhali	JBI (%)	MC (%)	Jamuna	Barind	Coastal
1.	Birth weight, (kg)	Male	-	1.36	1.34	1.33	1.50	-	-	-	-	-
		Female	-	1.19	1.09	1.28	1.07	-	-	-	-	-
		Mean	-	1.28	1.22	1.31	1.29	-	-	-	-	-
2.	Litter size	Overall	-	1.80	1.70	1.58	1.56	-	-	-	-	-
3.	Lamb types (Birth weight) (kg)	Single (Male)	1.68	-	-	-	-	-	-	1.5	1.4	1.9
		(Female)	1.45	-	-	-	-	-	-	1.1	1.0	1.4
		Total	1.57	-	-	-	-	44.33	89.3	1.3	1.2	1.65
		Twin (Male)	1.28	-	-	-	-	-	-	1.2	1.5	1.6
		(Female)	1.23	-	-	-	-	-	-	1.2	1.4	1.5
		Total	1.26	-	-	-	-	48.1	08.3	1.2	1.45	1.55
		Triplet (Male)	1.41	-	-	-	-	-	-	1.3	1.4	1.3
		(Female)	1.34	-	-	-	-	-	-	1.3	1.2	1.5
		Total	1.38	-	-	-	-	07.6	02.4	1.3	1.3	1.4
		Overall (Male)	1.46	-	-	-	-	41.9	58.9	-	-	-
		(Female)	1.34	-	-	-	-	58.1	41.0	-	-	-
		Total	1.40	-	-	-	-	50.0	49.95	-	-	-
4.	Mortality, %	M+F	-	-	-	-	-	-	-	12.4	-	-
5.	Adult live weight (kg)	Ram	-	25.83	18.04	19.10	23.64	14.92	50.48	-	-	-
		Ewe	-	19.20	16.52	15.25	17.93	14.23	35.35	-	-	-

JBI = Jamuna basin indigenous MC = Muzzaffornagari cross

Birth weight of lambs

Table 45 shows the birth weight and sexual maturity of native and different graded sheep.[250,334] The birth weight of lambs during summer varied from 2.0 to 4.5 lbs with an average of 3.0 lb and during winter varied from 2.35 to 4.0 lbs with a mean of 3.08 lb.[335]

Table 45. Birth weight and sexual maturity of different grades of sheep[250,334,335]

SN	Parameters	Grade I (n=34)	Grade II (n= 88)	Grade III (n=110)	Grade IV (n=16)	Total (n=248)
1.	Range birth wt (lb)	2.50-6.50	2.50-8.00	2.00-9.00	2.00-6.00	2.00-9.00
2.	Av. birth weight (lb)	4.03 ± 0.34	4.02 ± 0.38	4.00 ± 0.52	3.90 ± 0.37	3.99
	Sexual maturity (SM)	Native (n=27)	Grade I (n=43)	Grade II (n= 26)	Grade III (n= 5)	Total (n= 101)
1.	Range (SM= days)	195-717	189-941	200-942	292-606	189-942
2.	Average (SM= days)	430.15 ± 55.65	388.55 ± 50.86	438.34 ± 55.32	452.60 ± 37.40	427.41

Slaughter age and carcass characteristics of sheep

The native sheep is reared primarily for meat production in Bangladesh. Slaughtered weight, warmed carcass weight and dressing yield (%) of native sheep increased with advancement of age. Body weight gain at early stage (6-8 months of age) of life reported economical than at the later stage of life and around 8 months of age reported as the optimum market / slaughter age for native sheep.[268] Male lambs would be more economic for mutton production due to their higher rate of weight gain.

The lion of the experimental lambs consisted of 12-13% of total carcass which resulted highest weight at 7 to 9 months of age and this age group has suggested for slaughter for meat production in semi-intensive management system.[336]

The results of feed intake, digestibility and FCR indicate that both Jamuna river basin and Coastal lambs reported better for meat production in Bangladesh. The daily gain and total live weight gain reported significantly higher in Coastal sheep. However, cost per kg gain, dressing percent, carcass characteristics and nutritive value of meat did not differ among the groups.[270]

The effect of age and whole sale cut on the quality of indigenous sheep carcass [337] and relationship between carcass and non-carcass parameters with live weight of sheep have been reported.[338] The slaughtering age of the native Bengal lamb has been suggested to be 6 to 9 months to get maximum return.[331]

Sheep and goat meat reported to be nearly similar in meat characteristics and quality but the value of sheep meat reported lower than goat meat and also less popular. Sheep (39.85%) yielded more meat as dressing percentage than goat (37.22%). Sheep meat reported tenderer, juicy but goat meat reported to have more acceptable due its characteristic flavor.[339]

Lamb mortality

High pre-weaning mortality limits sheep production globally and despite significant advances in genetics, nutrition and management, the proportion of lamb mortality has remained stable at 15 to 20% over the past four decades.[340] The average lamb mortality of native sheep has been reported to be 12.4%.[250] Supplementing pregnant ewes with melatonin enhanced uterine blood flow and fetal oxygenation and potentially birth weight and neonatal thermogenic capacity. Melatonin freely crosses the ovine placenta and blood-brain barrier and provides neuroprotection to the fetal lamb during periods of chronic and acute hypoxia throughout gestation with improved behavioral outcomes in hypoxic neonates.[340]

Problems associated with sheep production in Bangladesh

Review of available literature reveals that feed shortages, low genetic potential of indigenous sheep, lack of good quality breeding rams and diseases especially parasites considered to be major constraints to sheep production in Bangladesh. The major problems in safety sheep production of high cost of vitamin-mineral supplement, unavailable organic fertilizer, lack of technical knowledge and lack of pasture land reported as 10, 27, 83 and 43% respectively.[245,246]

Miscellaneous research findings

The hematological values of native sheep of Bangladesh have been reported.[341] The native goat population in the tested regions reported to have high genetic diversity with medium

heterozygosity in Bangladesh. Significant introgression of genes from exotic breeds in the population of BBG of Western region, BBG of Central region and BBG of Hilly region have been reported.[342] The supplementary high protein to grazing management system improved the growth and reproductive performance of goat and sheep.[343] Significantly differences between two feeding regime of weaning weight in the semi-scavenging system have been reported in BBG[344]

Lower birth weight, dams with insufficient milk and lack of husbandry knowledge reported the main factors responsible for higher kid mortality and overall survival rates up to 3 months of age reported to be 71.7 to 91.3%.[345] The average birth weight and daily weight gain in phenotypic selected group (1.13 kg & 42.7g/day) reported significantly higher than the randomly selected (0.93kg & 33.3g/day) group respectively.[346]

The comparative carcass characteristics of ruminant species[347] and relationship of body measurements with meat and skin yield characteristics have been reported.[348] Transportation grazing on the physiological condition and meat quality traits have been reported.[349] The future mutton production in Bangladesh has been estimated.[350] The output o spermatozoa in urine of ram has been reported.[351]

Plagiarism status of the published reports

Comparatively higher plagiarism status has been observed on the production and management of small ruminant research reports than the earlier reported pre-clinical and clinical research on small ruminants,[17] buffalo health and production[19] and cattle production, management and dairy products[20] reviews. Most of the plagiarism status has been mentioned in different tables (1, 3, 8, 17, 18, 24) of this review article.

CONCLUSIONS

The SRA rearing has a great promise as source of income and employment and livelihood security of resource poor rural people in developing countries including Bangladesh. Most of the reproductive traits like age at first estrus, age at first kidding, kidding interval and litter size appear better in BBG compared to Jamunapari, their crosses and even Boer breeds of goats. Many people and infants have allergic reactions to cow's milk but not to goat's and sheep's milk and their dairy products, so there are medical benefits for caprine and ovine milk. The importance of valuable genetic resource of SRA is underestimated and the extent of contribution of these animals to the livelihood of the rural poor people is inadequately understood. The major challenges for SRA productions are breeds, poor management and feeds and nutrition and high mortality specially kids and lambs. However, the attractive prices, quality products and consumers' health consciousness provides an opportunity to increase SRA production through increased demand for meat and goat milk. Global demand for small ruminant products is increasing and achieving this demand requires scientific, educational and political infrastructures. Due to scarcity of quality bucks and rams under field conditions, AI techniques would be the alternative to develop and provide the services throughout the country. AI is perhaps the most powerful technique that reproductive physiologists and geneticists to contribute in SRA like large ruminants for their genetic improvement. Major advances in

methods of semen collection and evaluation, evaluation of male fertility, cryopreservation of sperm and estrous cycle control have been evaluated in both the goat and sheep in Bangladesh. The composition of semen diluent and freezing protocol has been standardized over the years and the research reports reveal wide variation in post-thaw seminal traits of buck semen. The recent advances in cryoprotectants for improving post-thaw recovery of buck semen have been reported. In addition, knowledge of ovulation control, timing of insemination, gamete biology has been reported in inland literature. Main target of recent research to establish the AI and embryo transfer technique and reduce the negative impact of anestrus and embryonic mortality in small ruminants. Crossing breeding of indigenous goat and sheep can be considered both a threat and an opportunities but recent unplanned crossbreeding result reveals that crossbreeding between BBG with Jamunapari breed not highly appreciated on research findings. However, if exotic genes are introduced into native breeds, crossbred with exotic genes might become better adapted to current conditions but it could lose native identity in the process. If sustainable crossbreeding plan and program are set up at national level and correctly managed, breed conservation can be assured and production will be able to exploit heterosis. Therefore, there is a need for appropriate national plan program and institutions for transfer of need based technologies to smallholder SRA farmers throughout Bangladesh. Government can set supportive mechanisms for producers and also make rules and policies to enhance standard level of raising these animals. It is the high time to consider and pay attention to the value and capacity of goats and sheep producing food security and elevation of poverty of rural poor people in Bangladesh. The review therefore recommends that government and non-governmental organizations should implement multi-sectorial interventions to provide the pre-requisite assistant to the smallholder farmers which could help to combat the multiple challenges affecting SRA production in Bangladesh.

ETHICAL APPROVAL

This review article does not contain any research studies with animals or humans participants performed by the author. Therefore, ethical approval is not required for this review article.

CONFLICT OF INTEREST

The author declares that this review work was completed without any commercial or financial relationships that could be constructed as a potential conflict of interest.

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