Research Journal of Veterinary Sciences

ISSN 1819-1908

Academic Journals Inc.

www.academicjournals.com

OPEN ACCESS Research Journal of Veterinary Sciences

ISSN 1819-1908
DOI: 10.3923/rjvs.2017.1.13

Review Article
Buffalo Genetic Resources and their Conservation in Bangladesh

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Abstract

The present study attempts to examine the existing buffalo genetic resources and their conservation in Bangladesh. The buffalo plays a very important role in the South Asia which constitutes 73.77% of world buffalo population. This region has a great biodiversity of buffalo germplasm, including the world famous buffaloes Murrah and Nili-Ravi. The South Asian countries share 93.19% of world buffalo milk production where India and Pakistan contributes 67.99 and 23.96%, respectively. About 71.4% of world buffalo meat is produced in South Asian countries. Although buffalo is an essential part of livestock in South Asian countries, it has never been addressed in Bangladesh and always neglected despite their important role in the national economy. In Bangladesh, the total buffalo population are 1.457 million heads that are managed in household subsistance farming and extensive Bathan farming in saline coastal region that are used as a draught animal and partially for milk and meat production. The buffaloes of Bangladesh are mainly indigenous in origin and their productivity is low. So, far their genotypes need to be improved through appropriate breeding program to meet the future demand of the country and the germplasm of such native breeds constitute a valuable genetic resource which needs to be conserved on priority basis. This review has tried to unreath the present scenario of buffalo genetic resources, their production and reproduction performances and their conservation in Bangladesh. This study has also explored the further development of buffalo in Bangladesh.

Key words: Buffalo, conservation, genetic resources, SAARC, production performances, reproduction performances

Received: October 15, 2016 **Accepted:** November 30, 2016 **Published:** December 15, 2016

Citation: M.A. Hamid, M.A. Zaman, A. Rahman and K.M. Hossain, 2017. Buffalo genetic resources and their conservation in Bangladesh. Res. J. Vet. Sci., 10: 1-13.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Buffaloes are economically and culturally important livestock species especially in developing countries[1]. It plays a significant role through contributions in social and cultural aspects[2]. They possess the highest potential for production with a promising gene pool, which is still not fully used. It is also source of meat and milk. Buffalo milk can be converted into many kinds of cheese, primarily mozzarella[3]. Furthermore, buffaloes are valuable work animals[4], commonly used as draught animals in crop fields. Due to these reasons, water buffalo is often called the living tractor of the East since it is relied upon for draught and transportation in many parts of Asia[5]. Leather is another major contribution of buffalo in the world market[6]. Dung is used as organic fertilizer. Buffalo racing and plowing contests and fighting are among traditional festivities after rice harvest in Thailand[5]. The water buffalo is the second most important species in the world in terms of milk production, after dairy cows[7] and good source of milk and meat in South Asia. Comparing to cow, buffalo milk is higher in protein, fat, lactose and energy. The population of global buffalo is 194.29 million, Asian buffalo dominate the world population, representing 92.52% (179.75 million) of the total buffalo population[8,9]. Within the Asian region, about 74.80% of buffaloes in the South Asia, 12.80% in East Asia and only 8.40% found in South-East Asia.

Buffaloes are members of bovine animals classified into two main species[5]. These are African wild buffaloes (*Syncerus*) and Asian buffaloes (*Bubalus bubalis*), which is the most domesticated[10]. Asian buffaloes are further classified in to river and Swamp buffalo sub species[4]. River buffaloes are often called water buffaloes and have high lactation yields than swamp buffaloes. Presently, there are 72 buffalo breeds in the world, where as 57 are in Asia. In India, there are 20 buffalo breeds, most popular of which are the Murrah and Nili-Ravi, noted for their high milk yield performance[11]. India is the highest buffalo populated country in the world comprising 112.91 million buffalo (58.11% of the world). India is the world's topmost milk producing country in the world where buffalo forms the backbone of India's dairy industry which share 67.99% of world's buffalo milk production[9]. It is the largest exporter of dairy and dairy products globally. Pakistan is the 2nd most buffalo populated country in the world, contributes 16.83% of world buffalo population[8]. The famous Pakistani breeds are Nili, Ravi, Nili-Ravi, Kundi etc.[12]. Pakistan is the 2nd largest buffalo milk producing country in the world, contributes 23.96% of total buffalo milk production. The Asian countries represent 91.89% of world's buffalo meat and with volume[13] of 3.08 Mt in 2008. About 78.5% of Asian buffalo meat was produced in South and South West Asia with the greater bulk contributed by India and followed by Pakistan[14]. India is the world's 4th meat producing country and largest buffalo meat exporting country globally.

The economy of Bangladesh is based primarily on agriculture and livestock is an essential component of the rural economy. The buffalo is an important part of livestock in Bangladesh. The total buffalo population of the country is 1.457 million[15] of which coastal regions posses about 40%[16]. Most of the populations are riverine type with the exception of some swamp type found in Bangladesh. In Bangladesh, buffalo used primarily for draught purpose or dairy and meat production is a secondary option. There is no recognized breed of water buffaloes in Bangladesh and are mainly indigenous non-descriptive types. Though total milk production of Bangladesh is about 6.09 Mt in 2014 out of which about 3-4% is produced by the buffalo in spite of the number buffalo growth rate are increasing during last 10 years[15]. The consumption of milk and meat was increased by at 4.0 and 12.7% during 2005-2010. At the same time, rice consumption was decreased by 5.0%. Presently, it is increasing the number of consumer of buffalo milk because of its white color, high fat content and flavor. As a result there is a high demand for buffalo milk in the country, but milk yield per dairy buffalo is very low. This indicates that Bangladesh have great opportunity to produce buffalo milk because of its high consumer preference and demand. However, the sector is not poetically utilized yet due to many constraints. In Bangladesh, buffalo has never been addressed and always neglected species despite their important role in the national economy[17].

According to the national health strategy, an adult people need 250 mL milk and 120 g of meat every day. However, presently the availability is only 43.44 and 67.17%, respectively[15]. Under these circumstances to meet up the deficiency of milk and meat, the government and private organizations should put efforts together to enhance the present milk and meat production status. Recently, the demand for animal derived products such as milk, meat, butter, cheese, ice-cream, baby foods and locally made sweets are increasing which are heavily dependent on milk plus sugar.

Though the buffalo is an important part of livestock in Bangladesh, there is no documented research studies so far that investigated the buffalo genetic resources and their conservation in Bangladesh. It is emerging for Bangladesh to develop buffalo breeds, their production and reproduction performances through various scientific programs with quality breeds, improved management system, providing training, credit and finance, consultancy services, adequate veterinary services, feed conservation etc. In order to develop buffalo

Table 1: Types and distribution pattern of buffalo in Bangladesh

Types	Region	District
Native buffaloes in the Western part (Indigenous Murrah type)	Western region	Rajshahi, Natore, Naogan, Bogra etc.
Native buffaloes in the central part (Indigenous Riverine type)	Plain land (Brahmaputra-Jamuna belt)	Rajshahi, Jessore, Rangpur, Bogra, Pabna, Jamalpur, Mymensingh etc.
Native buffaloes in the Southern part (Wild type Arni/crossbreed type)	Coastal belt (Southern region)	Noakhali, Feni, Laxmipur, Bhola, Patuakhali, Khulna, Barguna, Pirojpur, Chittagong etc.
Native buffaloes in the Eastern part (Swamp type)	Marshy land (Eastern region)	Sylhet, Sunamgonj etc.
Exotic breed and their crosses with indigenous (Murrah, Nili-Ravi, Surti, Jaffrabadi etc.)	Surrounding Indian border, Southern region etc.	Bagherhat, Bhola, Noakhali, Feni, Khulna etc.

Faruque[19], Lal Teer Livestock Farm report

production in Bangladesh, it would be worthy to know details about buffalo genetic resources, their distributions, their physical and inheritance characteristics, their production and reproduction performances, strategies for buffalo development etc. Therefore, we did this review study to solve the problems related to buffalo development in Bangladesh.

The purpose of the present studies was to examine the existing buffalo genetic resources, their distribution pattern, their productive and reproductive performances, conservation of buffalo genetic resources, strategies for buffalo development in Bangladesh.

BREED TYPES, ORIGIN AND DISTRIBUTION

Domestic buffaloes of Bangladesh belong to the *Bubalus bubalis*[18] with most of the population are reverine type with exception of some Swamp type found in Eastern part of Bangladesh. The undefined crosses population[16] with Murrah, Nili-Ravi, Surti and Jaffrabadi blood lebel are scantly available surrounding Indian border of Bangladesh due to border migration from India[17]. Bangladesh imported a small number of Nili-Ravi from Pakistan during 1960 without any scientific improvement program. Department of Livestock Service (DLS) again imported 100 live Nili-Ravi pregnant heifer and 1st lactating cows from Pakistan during 1990 that were reared in newly established buffalo farm at Bagherhat district, in South-West part of Bangladesh. Most of the buffaloes are non-descriptive in type and variable composition being either non-descriptive or crosses among various breeds and cannot be catagorized in any well-established breed. They are concentrated particularly in agro-ecological zones viz., sugarcane belt, hilly region, coastal area and marshy land. In Brahmaputra-Jamuna flood plain area, dairy buffaloes are observed along the riverside village of Rangpur, Bogra, Jamalpur and Mymensingh district. They are also distributed along the coastal areas of Noakhali, Feni, Laxmipur, Bhola, Patuakhali and Borguna district. Draught buffaloes are found in sugarcane belt and forest areas like Jamalpur and Modhupur. No clear information is yet available about the origin of the water buffalo available in the country.

The water buffaloes of Bangladesh are mostly indigenous type and grouped into five types on the basis of their history of domestication, distribution and morphology. These are (1) Native buffaloes in the Eastern part, (2) Native buffaloes in the Western part, (3) Native buffaloes in the central part, (4) Native buffaloes in the Southern part and (5) Exotic (Nili-Ravi) and their crosses with indigenous[19].

Blood protein polymorphism studies[20] show the existence of 7 polymorphic loci (Alb, Tf, Hb-, CAS, Alp and peptidase-B) of buffalo population of Bangladesh. They reported 50 chromosomes for the water buffaloes of the central part and 48 chromosomes for those of the Eastern part. All the buffaloes are raised in the rural areas throughout the country. The distribution of buffaloes has been presented in Table 1.

BUFFALO GENETIC RESOURCES IN BANGLADESH

In Bangladesh, buffalo did not get any attention from the policy makers and professionals in the past time. In Bangladesh, all buffalos are local varieties and there is no systematic mating plan or breeding policy. The available buffalo genetic resources of Bangladesh are native buffaloes in the Western part (Indigenous Murrah type), native buffaloes in the central part (Indigenous Riverine type), native buffaloes in the Southern part (Wild type Arni/crossbreed type), native buffaloes in the Eastern part (Swamp type) and exotic breed and their crosses with indigenous.

Native buffaloes in the Western part (Indigenous Murrah type): The native buffaloes in the Western part (Indigenous Murrah type) are presented in Fig. 1. The buffaloes of this group is different from other breeds. Their coat color is usually black and some animals have brown coat color with sport in the tail switch. White stockings are also observed in some animals that have brown coat color. The horns are short, tight,

Fig. 1(a-b): Indigenous Murrah type buffalo in Bangladesh

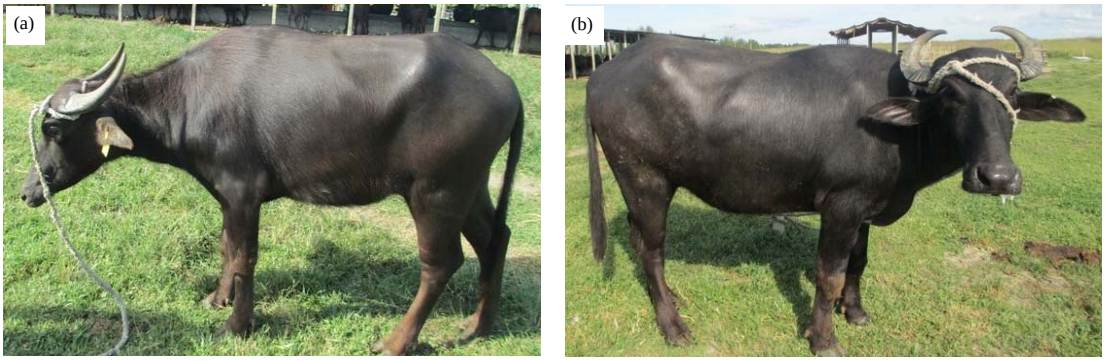

Fig. 2(a-b): Indigenous Riverine type buffalo in Bangladesh

turning backward and upward and finally spirally curving inward. The horns should be somewhat flattened. As the age advances the horns get loosened slightly but spiral curves increases. Body sound built, heavy and wedge shaped. Head comparatively small, face and neck comparatively long. Skin soft, smooth with scanty hairs as compared to other buffaloes. Udder fully developed and drooping. Teats equally distributed over the udder but hind teats are longer than fore teats. This type of buffalo used for dual purpose, males are used for meat purpose and that of females for dairy.

Native buffaloes in the central part (Indigenous Riverine type): The native buffaloes in the central part (Indigenous Riverine type) are presented in Fig. 2. These types of buffaloes are found in the sandy islands of the river Brahmaputra and the Jamuna of the central part of the country. Their morphological characteristics are almost similar to those of the Western part. Their coat color is usually black. The utility and management practices are the main differences between these buffaloes with those of the Western part of the country. They are kept absolutely for dairy purposes. The horns are medium in size and curving inward. Body sound built, medium and wedge shaped. Head medium in size, face and neck comparatively long. Skin slight course with long hairs as compared to other buffaloes. Udder fully developed and drooping. Teats equally distributed over the udder but hind teats are longer than fore teats. This type of buffalo used for dual purpose, males are used for meat purpose and that of females for dairy.

Native buffaloes in the Southern part (Wild type Arni/crossbreed type): The native buffaloes in the Southern part (Wild type Arni/crossbred type) are presented in Fig. 3. These type buffalo is referred to a different species (*Bubalus arnee*) which is not characterized at all. They are grey to black in color with off-white "Socks" and one or two white chevrons on the neck. Horns in both sexes curve backward in a crescent. The record horn length is just under 2 m (6.6 ft) the longest among cattle or any other bovid. The hooves are large and splayed and two flexible joints (fetlock and pastern) near the hooves allow for easier walking through deep mud. Longevity of the domesticated water buffalo can be 40 years,

Fig. 3(a-b): Wild type Arni/crossbreed buffalo in Bangladesh

Fig. 4(a-b): Swamp type buffalo in Bangladesh

but the wild form is not as long-lived, even in captivity. This wild form is a huge animal, nearly 3 m (10 ft) long and 2 m tall and weighing up to 1200 kg (2600 lb), females are about two-thirds this size. It can interbreed with domestic water buffalo. Wild water buffalo live in Southeast Asian swamps and forests, where they feed on grass and sedges, mostly at night. By day they rest in water up to their nostrils or they wallow and "Shovel" mud onto themselves with their horns to keep cool and escape biting insects. In Bangladesh, this types of buffalo found in the coastal area of the Southern part. They are larger in size than the indigenous buffaloes of that area. This type of buffalo mostly used for meat purpose and partially for milk purpose.

Native buffaloes in the Eastern part (Swamp type): In Bangladesh, swamp buffaloes are available in the Eastern part. They consists 48 chromosomes[20]. Beside Bangladesh, Swamp buffaloes are found in China, Thailand, Philippines, Indonesia, Vietnam, Burma (Myanmar), Laos, Sri Lanka, Kampuchea and Malaysia etc. They are mainly used as draught animals, particularly in rice cultivation. Swamp buffalo produce relatively small quantities of milk 1.0-1.5 L day^{-1}, so they are not heavily used in milk production[21]. The swamp buffalo might however be used in meat production[22]. The name 'Swamp' has probably arisen from their preference for wallowing in stagnant water pools and mud holes[23]. The native buffaloes in the Eastern part (Swamp type) are presented in Fig. 4.

Exotic breed and their crosses with indigenous: The government has imported Nili-Ravi buffalo from Pakistan in the year of 1960 to supply breeding bulls to the farmers in the coastal area of Southern part for crossbreeding purpose. In the year of 1985 Buffalo Breeding Farm was established in Bagherhat where production and distribution of Nili-Ravi bull among farmers. Sometimes Murrah was used for upgradation of native stock. Presently, buffalo development project is running since 2010 where crossbreeding of indigenous

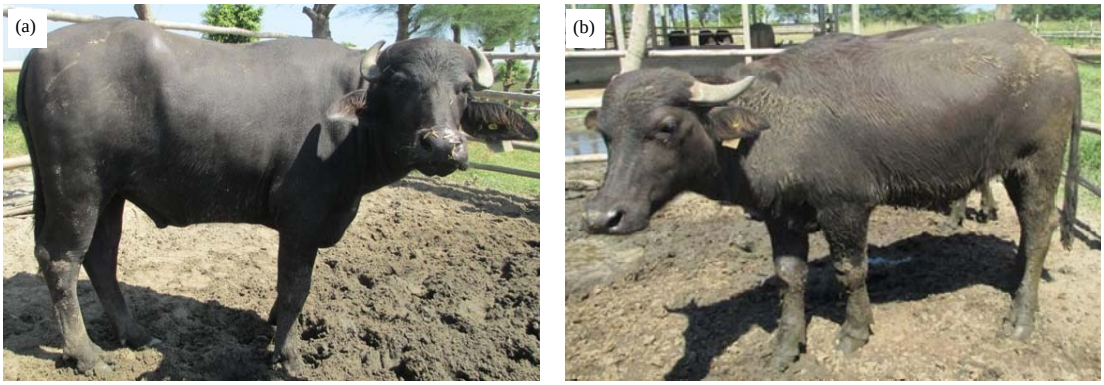

Fig. 5(a-b): F_1 male and female crossbreed buffalo calves in Lal Teer R and D center

Table 2: Production performance of native and crossbreed buffalo in Bangladesh

Parameters	Production status	References
Birth weight (kg)	27.5	Amin *et al.*[24]
	28	Siddiki *et al.*[25]
	30.5	Siddiki *et al.*[25]
	24.28±4.00	Karim *et al.*[26]
	24.12±3.60	Karim *et al.*[26]
	22.00±3.50	Faruque and Amin[27]
	28.66±7.5	Faruque[28]
	40.5 (n = 29)	Data based on Lal Teer R and D center (F_1 cross buffalo)
	28.41 (n = 23)	Data based on Lal Teer R and D center (Native buffalo)
Growth rate (g day^{-1})	340±56	Faruque[28]
	360	Hasnath[29]
	645.20 (n = 29)	Data based on Lal Teer R and D center (F_1 cross buffalo)
	442.76 (n = 23)	Data based on Lal Teer R and D center (Native buffalo)
Milk yield (L day^{-1})	2.7	Amin *et al.*[24]
	3.32	Siddiki *et al.*[25]
	3.43±0.744	Karim *et al.*[26]
	3.33±0.68	Karim *et al.*[26]
	2.32±0.63	Faruque[28]
Lactation yield (L)	730±9	Faruque[28]
	598.06 (n = 55)	Data based on Lal Teer R and D center (Native buffalo)
Lactation period (days)	286.12±11.27	Karim *et al.*[26]
	290.44±10.92	Karim *et al.*[26]
	328±28.76	Faruque[28]
	311.2 (n = 55)	Data based on Lal Teer R and D center (Native buffalo)

buffalo with Italian Mediterranean semen in limited area using Artificial Insemination (AI) (39 Upazilas of 13 districts). This project also including genetic characterization of buffaloes, formation of least cost ration based on regionally available feed resources, packages for control of major buffalo diseases etc. Similar to cattle breeding programme no monitoring or recording system is followed at field levels. At farmer's level, they select bulls/cows depending on their availability in the locality and/or on the basis of mass selection. Sometimes, the bulls of their own herds are used without understanding inbreeding effects. The productivity of water buffaloes has been decreasing in the country in the absence of any approved breeding, record keeping or artificial insemination system either of the public sector or of breed association/non-government organizations, especially for water buffaloes. The crossbreed buffaloes are presented in Fig. 5.

There is a private organization in the country, named Lal Teer (LTL) Livestock started artificial insemination program of local buffalo with Italian Mediterranean semen in its Research and Development (R and D) farm. They started AI program from 2011 and also synchronization program in their R and D center. At present they have 56 F_1 buffalo with 27 males and 29 females with maximum age of 35 months.

Buffalo genome decoded by Lal Teer Livestock (LTL): Lal Teer Livestock (LTL) Limited and Beijing Genomics Institute (BGI) jointly sequenced buffalo genome under a 3 years project based on Bangladeshi local buffalo stock. It was announced at a press briefing on 24 January, 2014 by authorities of Beijing Genomics Institute and Lal Teer Livestock Limited. Hopefully it will increase the country's milk and meat production using the genetic information of local buffalo.

Productive and reproductive performances of buffalo in Bangladesh: The productive and reproductive performances of buffalo are summarized in Table 2 and 3, respectively. The birth weight of different buffalo ranged from 22.00±3.50 to 40.50 kg according to breed (native or crossed). The highest birth weight was found in F_1 cross buffalo of Lal Teer R and D center (40.5 kg) and lowest was found in indigenous buffalo of coastal area of the country (22.00±3.50 days). The growth rate is also varied according to native and crossed buffalo.

Table 3: Reproduction performance of native and crossbreed buffalo in Bangladesh

Parameters	Reproduction status	References
Age at 1st heat	3.4 (years)	Amin *et al.*[24]
	3.46±0.20 (years)	Siddiki *et al.*[25]
	1411.58±43.01 (days)	Faruque *et al.*[16]
Age of 1st calving	4.51 (years)	Amin *et al.*[24]
	4.55±0.22 (years)	Siddiki *et al.*[25]
	50.88±1.71 (m)	Karim *et al.*[26]
	51±1.8 (m)	Karim *et al.*[26]
	1735.47±42.33 (days)	Faruque *et al.*[16]
	41.3 (m)	Data based on Lal Teer R and D center (F_1 cross buffalo)
	42.23 (m)	Data based on Lal Teer R and D center (Native buffalo)
Age at 1st pregnancy	3.8 (years)	Amin *et al.*[24]
	3.82±0.19 (years)	Siddiki *et al.*[25]
Gestation length	10.0 (m)	Amin *et al.*[24]
	10.0±0.00 (m)	Siddiki *et al.*[25]
	319.56±5.93 (days)	Karim *et al.*[26]
	319.12±4.69 (days)	Karim *et al.*[26]
	308.9 (days)	Data based on Lal Teer R and D center (F_1 cross buffalo)
	309.63 (days)	Data based on Lal Teer R and D center (Native buffalo)
Post-partum heat	4.9 (m)	Amin *et al.*[24]
	5.30±0.38 (m)	Siddiki *et al.*[25]
	153.6±6.13 (days)	Karim *et al.*[26]
	153.44±6.78 (days)	Karim *et al.*[26]
	179.32±10.31 (days)	Faruque *et al.*[16]
Calving interval	15.8 (m)	Amin *et al.*[24]
	13.5±1.35 (m)	Siddiki *et al.*[25]
	547.92±10.88 (days)	Karim *et al.*[26]
	547.24±14.32 (days)	Karim *et al.*[26]
	544.04±17.57 (days)	Faruque *et al.*[16]
	482.66 (days)	Data based on Lal Teer R and D center (Native buffalo)
Service per conception	3.1	Amin *et al.*[24]
	3.42±0.24	Siddiki *et al.*[25]
	1.86	Faruque *et al.*[16]
	1.6	Data based on Lal Teer R and D center (F_1 cross buffalo)
	2.0	Data based on Lal Teer R and D center (Native buffalo)

The highest growth rate was found in F_1 cross buffalo of Lal Teer R and D center (645.20 g day^{-1}) and lowest was found in indigenous buffalo of Mymensingh district (340±56 g day^{-1}). The daily milk yield was varied from 2.32±0.63 to 3.33±0.68 L day^{-1}. Lactation length varied from 286.12±11.27 to 328±28.76 days in different buffaloes.

Table 3 shows the reproduction performance of buffalo in Bangladesh. The average age at first heat was varied according to native and crossed buffalo. The lowest age of first calving was found in F_1 cross buffalo of Lal Teer R and D center (41.3 months) and highest was found in indigenous buffalo of Mymensingh district (179.32±10.31 days). The highest gestation length was found in indigenous buffalo of Mathbaria Upazila under Pirojpur district (319.56±5.93 days) and lowest in indigenous buffalo of Subornochar Upazila under Noakhali district (10 months). The lowest post-partum heat period was found in indigenous buffalo of Subornochar Upazila under Noakhali district (4.9 months) and highest was found in indigenous buffalo of Mymensingh district (179.32±10.31 days). The lowest calving interval was found in native buffalo of Lalpur Upazila of Natore district of 13.5±1.35 months and highest was in indigenous buffalo of Mathbaria Upazila under Pirojpur district (547.92±10.88 days). The lowest service per conception is required in F_1 cross buffalo of Lal Teer R and D center (1.6) and highest in native buffalo of Lalpur Upazila of Natore district (3.42±0.24).

CONSERVATION OF BUFFALO GENETIC RESOURCES

The country's buffalo genetic resources need to be developed and used judiciously. The rich biological diversity of this species is progressively being eroded due to unplanned breeding. There is no organized buffalo breeding farms which maintain restricted breeding among different breeds/types. Buffalo breeding in Bangladesh is almost unrestricted interbreeding among different breeds/types and there is a marked decline in the availability of unique animals conforming to the attributes of defined breeds, particularly in their native breeding tracts. There has been a non-judicious utilization of buffalo genetic resources in the country. The males are only partially utilized in the form of bulls and bullocks. There is always a scarcity of breeding bulls of superior genetic merit.

A program for buffalo development and conservation involving identification, characterization, improvement and utilization of native buffalo following the scientific concept of Open Nucleus Breeding System (ONBS) was initiated in 2009 through Buffalo Development Project (Component-A) by Department of Livestock Services (DLS) with an initial tenure of 5 years through funding by Government of Bangladesh (GoB)[30]. The project is being carried out in collaboration with scientists of Department of Livestock Services and Bangladesh Livestock Research Institute (BLRI) having household native buffaloes in farmer's house of selected 39 Upazilas of 13 districts under 7 divisions of the country and in Bagerhat buffalo breeding and development farm. This project is being undertaken incorporating multidisciplinary approaches of buffalo production and development such as breeding, nutrition, management and preventive animal health care. The main goal of the project is improvement of productivity of native buffalo through artificial insemination, development of technology related buffalo rearing and improvement of skill of scientists, selection of breeding bull, collection, processing

and preservation of semen, technology transfer to farmers and proper utilization of resources of poor farmers through keeping high yielding buffalo. The expected outputs of the project are to develop need based technology to conserve with a concomitant improvement of the native buffalo both at farm (*ex situ*) and village conditions (*in situ*), provide a chain to distribute the development achieved on-station to the wider buffalo population in the country and produce a group of trained manpower in the field of buffalo breeding, nutrition, dairy production and preventive health care along with buffalo raisers at the villages having knowledge on scientific and profitable methods of dairy buffalo production.

Justification for conservation: Different reasons for conservation of animal genetic resources include[31]:

Economic and biological reasons:

- Genetic variation both within and between breeds is the raw material with which the animal breeder works. Therefore, any loss of genetic variation will limit our capacity to respond to changes in economic forces for the exploitation of animal production in future
- Breeds with specific qualities like disease resistance, heat tolerance, ability to survive and produce under stress and low input conditions need to be preserved for future use
- Future requirements of type and quality of animal produce (milk, draught power) may change and this requires conservation of animals with better performance in specific production traits
- Magnitude of heterosis depends upon the breeds crossed. For exploiting the heterosis in animal production, it is necessary to maintain breeds which are complementary to each other and on crossing result in maximum heterosis

Scientific reasons:

- Breeds with unique physiological or other traits are of great value as they provide missing links in the genetic history of a livestock species by the study of blood groups or polymorphic traits. To identify the DNA sequences causing the distinctive traits, preservation of breeds with unique traits will be essential for long term research in molecular engineering
- To evaluate the magnitude of genetic change due to selection, maintenance of a sample as control population is very much essential
- Investigations in different areas like physiology, biochemistry, genetics immunology, etc., require maintenance of diverse populations
- Variety of populations are an asset for research study in biological evolution, behavioural studies, etc.
- Diverse populations form an excellent teaching material for students of animal science, ecology, ethology etc.

Historical and cultural reasons: Conservation of historically important, culturally interesting and visually unusual and attractive population is very important for education, tourism etc. Further, conservation of breeds:

- Can be a valuable material of nature and culture
- Serve as research and teaching material in history and ethnography
- Will be preservation of populations with diverse sizes, colours and other morphological features, foraesthetic reasons
- Need be done to take care of existence of different creations of the nature for posterity. A range of motives are often put forward for conservation of genetic resources. These can be grouped into matters of principle and pragmatic considerations. A summary of these motives for conservation of animal genetic resources, with conservation being treated both in the narrow and broader sense is presented here under[32]

Approach for conservation: Broadly, there are two means of conservation i.e., *in situ* and *ex situ*. Conserving the live animals that exist in nature is *in situ* conservation. The animals are maintained in their original habitats under native conditions with no interference in their mode of management, feeding and other conditions. The main problem of *in situ* conservation is inbreeding and genetic drift typical of small populations. The *ex situ* conservation is to be used when the endangered population is dismally low in numbers, as this process has its own innate problems. It may suffer from spread of disease or neglect during periods of institutional weakness, besides being costly in long term preservations and losing the relatedness of current genotype with environment when one of these is preserved for long time[33].

CONSERVATION STRATEGIES

***Ex situ* conservation:** Generally sperm, oocytes, embryos, DNA and embryonic stem cell are conserved. It is possible now to store a wide variety of living cells for long periods of time. The techniques can be used for the conservation of endangered breeds as follows:

- **Sperms and oocytes:** Deep freezing of semen is suitable for most of the species of domestic animals
- **Embryos:** Cryopreservation of embryos of cows, buffaloes, sheep, goats and horse has successfully been done to produce offspring. This is a better tool for conservation as all the genetic information is stored in one diploid zygote
- **Storage of DNA:** Cryogenic storage of DNA is another method of preservation of genetic material
- **Cloning of somatic cells:** Cloning offers the advantage of producing series of exact replica/copy of the concerned animals
- **Embryonic stem cells:** Embryonic stem cells are derived from culture of inner cell mass of a young blastocyst. These embryonic cells are totipotent and have potential to develop into viable embryos

***In situ* conservation:** Explicit efforts to select males from superior dams under farm conditions and making wider use of the selected best bulls and also preserving their semen are necessary. The process has been initiated for some of the breeds by NBAGR. These strategies are:

- **Data bank strategy:** Maintenance of a database containing all relevant breeds, population census and ecological data is essential for designing and implementing conservation strategies. Several agencies are engaged in generation and dissemination of data/information on animal genetic resources. A useful body of knowledge has already been generated/gathered at NBAGR and at other locations
- **GenBank strategy:** Semen from indigenous breeds has been cryopreserved for use in the future. Ideally sufficient doses should be storedat at least at two locations remote from each other. The preserved material should be periodically evaluated and put into use
- **DNA bank strategy:** Genetic material can be preserved in the form of DNA fragments under cryogenic conditions. This has the advantage over storage of live cells as it is economical, occupies less space and there is no spread of diseases. Within and across different countries the storage of DNA has been made feasible
- **Somatic cell strategy:** With the advent of Dolly sheep, somatic cell technology has received a great fillip. In future it may be possible to produce a live animal from stored somatic cells. This possibility is very important since the protocols for collecting somatic cell samples are less demanding and inexpensive than for collection of spermatozoa and embryos

Strategies for buffalo development in Bangladesh:

- Buffalo farming as a secure and sustainable sector in the Southern belts
- Encourage buffalo breeding and production through supply of free semen/breeding bull, fodder seeds and support purchase of milch buffalo and construction of improved shed on cost sharing basis
- Create incentives for the conservation and development of buffalo
- Increase buffalo production capacity of farmers, institute community bull management scheme and form breeders groups and association
- **Improve feeding:** Encourage to utilize good quality forage and agricultural by-products, crop conservation and enrichment technologies to increase efficiency and reduce production cost
- **Improving health measures:** Designate proactive animal health action plans to prevent infection and parasitic diseases as well as zoonoosis and enhance monitoring and laboratory diagnostic services
- **Post harvest facilities:** support product processing, diversification and marketing of buffalo milk and milk products (collection centers, processing units, processing plants and sales counters)
- **Institute NBIS:** National buffalo information and recording system (NBIS) to be instituted to ensure traceability for performance recording, disease out-breaks and progeny testing program
- **HRD and capacity building:** Invite expertise to provide training to extension staff and farmers on breeding and improved buffalo husbandry practices including buffalo nutrition and health aspects
- **Research and development:** Enhance knowledge and skill of national professional to take up research and development works on:
  - Buffalo breed characterization and advanced breeding techniques
  - Buffalo nutrition and diseases
  - Reproductive bio-technologies in buffalo (e.g., MOET, Ovum pick-up etc.)
  - Buffalo production management practices to increase productivity and communicate research findings to farmers
- Expand regional collaborations and strengthen institutional linkages with all SAARC countries for exchange of:

- **Germplasm:** Import of breeding materials such as semen and quality breeding bulls (e.g., Murrah, Nili-Ravi and other productive breeds)
- Information sharing on advanced reproductive bio-technologies, nutrition and health aspects
- Hold expert consultative meetings to enhance technical capacity and knowledge of national counterparts on buffalo breeding and production
- Conduct research on genetic characterization of buffalo breed types of Bangladesh with buffalo research and development institutes and centers within SAARC countries

- **Long term strategic plans and areas of collaboration:**
  - Build capacity of national professionals and laboratory facilities to conduct research on *in vitro* Maturation, *in vitro* fertilization and *in vitro* culture, embryo splitting, sexing, grading and cloning etc.
  - Molecular genetic studies for identification of genes of interest (milk quality and quantity traits) and marker assisted selection
- **International networking:** Building linkages and collaboration with Asian and world buffalo federations for exchange of germplasm, knowledge through participation and presentation of papers during; international conferences/congress, symposiums, expert consultative meetings etc.

DISCUSSION

Buffalo production has been a tradition in South Asia, especially in India, Pakistan and Bangladesh. Majority of the buffalo milk in South Asia is produced by smallholder producers[34]. The world's best milch breeds Murrah, Nili, Ravi and Nili-Ravi are originated in India and Pakistan. They have high potential for milk and fat production besides being used for work and surplus stock used for meat production. Moreover, the society prefers buffalo milk than milk from other livestock species. The production performance of Murrah buffalo above[11] 18 L day^{-1} milk. In India, buffalo contributes 48% of total milk production whereas, cow and goat contributes 48.7 and 3.3%, respectively[35]. India is the world's 4th meat producing country and largest buffalo meat exporting country globally. Growth rate of buffalo meat production is 4%, where cattle meat is 3.5%. In Pakistan, buffalo contributes around 67% of annual milk production and share 29.78% in world's buffalo milk production and it is called the Black Gold of Pakistan.

The total buffalo population of Bangladesh is 1.457 million[15] of which coastal regions posses about 40%[16]. They are managed in household subsistance farming in the villages. In Bangladesh, buffalo used primarily for draught purpose or dairy and meat production is a secondary option. There is no recognized breed of water buffaloes in Bangladesh and are mainly indigenous non descriptive types. The production performances of buffaloes are summarized in Table 2. Amin *et al.*[24] found that the birth weight, weaning weight, weaning and slaughter age of indigenous buffalo were 27.5 and 56.5 kg and 14, 55 months, respectively. They stated that the weaning and slaughter age of buffaloes was almost close in indigenous and crossbreed buffaloes but higher than cattle. They also found that the average milk productions of indigenous buffaloes were 2.7 L day^{-1}. Siddiki *et al.*[25] stated that birth weights of indigenous and crossbreed buffalo calves were 28 and 30.5 kg, respectively, weaning and slaughter age of indigenous buffalo were 16 and 57 months, respectively. They found that weaning and slaughter age of buffaloes were almost close in indigenous and crossbreed buffaloes but higher than in cattle. They also stated that average milk productions of buffaloes are 3.32 L day^{-1}. Karim *et al.*[26] stated that the average birth weight of indigenous buffalo calves were 24.28±4.00 and 24.12±3.60 kg in Mothbaria Upazila of Pirojpur and Pathorghata Upazila of Borguna district, respectively (Table 2). The birth weight of indigenous buffalo calves were similar to the findings of Chantalakhana *et al.*[36] who reported that the average birth weight of Swamp male and female calves as 28.60 and 26.97 kg, respectively in Thailand. Karim *et al.*[26] also found that average milk yield of indigenous buffalo were 3.43±0.744 and 3.33±0.68 L day^{-1} under Barguna district and Pirojpur district, respectively (Table 2). Similar findings were also reported by Faruque *et al.*[16] and Shabade *et al.*[37]. They also observed that average lactation length of indigenous buffalo cows were 286.12±11.27 and 290.44±10.92 days, respectively, in Mathbaria and Pathorghata Upazila under Barguna district of Bangladesh (Table 2). Faruque and Amin[27] reported the average birth weight of indigenous buffaloes of the coastal areas of Bangladesh as 22.00±3.50 kg. Faruque[28] stated that birth weight of river buffalo were 28.66±7.5 kg and the result was more or less similar to the findings of Bangso[38]. The average daily gain of buffalo calves below 1 year was reported 340±56 and 360 g, respectively by Faruque[28] and Hasnath[29]. He also found that average daily milk yield per buffalo cow in the central region were 2.32±0.63 L with average lactation yield

of 730±90 L for 328±28.76 days lactation period. Hasnath[29] observed that average live weight at slaughter was 320 kg with 44% dressing percentage. Gupta *et al.*[39] reported that daily milk production of non-descript buffalo cows in the Eastern region of India varied from 1.56-4.12 L day^{-1}. The milk production of indigenous Bangladeshi buffaloes varies[26,24] from 2.1-2.7 L day^{-1}. Khan *et al.*[40] reported that Azikheli buffalo in Pakistan produce daily 7.19±0.18 L day^{-1} of milk. In this study, the buffaloes were crossbreed type and milk production was better than in cattle.

The reproductive parameters that are age at first heat, age at first pregnancy, age at first calving, gestation period, number of service per conception and inter calving period of buffaloes are shown in Table 3. Amin *et al.*[24] found that the average age at first heat and first pregnancy that was puberty of buffaloes was almost similar (3.4 years). The gestation period of buffaloes in selected area was 10 months. The average number of service per conception was 3.1 times. The average post-partum heat period was 4.9 months and inter calving period was 15.8 months found in this investigation. Siddiki *el al.*[25] stated that the average age at first heat that was puberty of buffaloes was 3.46 years. The average gestation period, number of service per conception, post-partum heat period and inter calving period of buffaloes in selected area were 10 months, 3.42 times, 5.31 and 13.5 months, respectively. Karim *et al.*[26] stated that the age at first calving of indigenous buffaloes of Mothbaria Upazila of Pirojpur and Pathorghata Upazila of Borguna district of Bangladesh is 50.88±1.71 and 51.00±1.80 months, respectively (Table 3). The reported age at first calving in buffalo varied from 36-48 months[41-43]. So, it could be stated that age of first calving in indigenous buffalo calves of Bangladesh is almost 12 months later than the buffaloes of other countries. They also stated that the average gestation period of indigenous buffalo cows of Mathbaria Upazila under Pirojpur district of Bangladesh is 319.56±5.93 days, while the average gestation period of Patharghata Upazila under Barguna district of Bangladesh is 319.12±4.69 days (Table 3). Hadi[44] reported an average gestation period of Marathwada buffalo as 309.60±2.11 days. The average gestation period of Egyptian buffalo as 316.70±0.19 days[45]. The average gestation length in Indian buffalo cows as 308±9.6 days[46]. So, the findings of the present study were similar to the findings of various previous researchers. They found that the average post partum heat interval of indigenous buffalo cows in Mothbaria Upazila of Pirojpur and Pathorghata Upazila of Borguna district of Bangladesh are 156.30±6.13 and 156.44±6.78 days, respectively (Table 3). The range of reported post-partum heat interval varied from 30-171 days[41,47-51]. They said that the average calving interval of indigenous buffalo of that studied areas are 547.92±10.88 and 547.24±14.32 days of Mothbaria Upazila of Pirojpur and Pathorghata Upazila of Borguna district, respectively (Table 3). The findings of the present study were similar to the findings of El-Sheikh and Mohammed[45] who found that first calving interval of Egyptian buffalo was 484.74±2.86 days. Fadzil[41] carried out an experiment on swamp buffalo in Malaysia under village condition and found that calving interval was 639 days. Parera *et al.*[52] found that average calving interval of indigenous buffaloes in Srilanka was 384.9±62.9 days. The calving interval ranged from 329-816 days. Faruque *et al.*[16] reported that the average age at first heat of indigenous buffaloes were 1411.58±43.01 days. The average age at first calving, number of service per conception, post-partum heat period and calving interval were 1735.47±42.33, 1.86, 179.32±10.31 and 544.04±17.57 days, respectively.

The productivity and performances of buffalo in India and Pakistan is much more than Bangladesh. The productivity of Bangladeshi buffaloes is much lower with less milk yield due to the fact that India and Pakistan has established a great deal of effort in recording, selection, breeding and improving feeding strategies. This indicates that Bangladesh did not apply appropriate production strategies to fully utilized and benefited from the available buffalo resources. Huque and Borghese[17] emphasis that lack of effective sustainable breeding programs for local buffalo breeds is the major reason that such breeds are not efficiently utilized. Moreover, nutritional deficiency, infrastructure, diseases and lack of skilled manpower cause inefficient utilization of buffaloes in Bangladesh.

CONCLUSION

Buffaloes are economically and culturally important livestock species especially in developing countries. They possess the highest potential for production with a promising gene pool, which is still not fully used. In Bangladesh, water buffaloes would be the important and popular livestock for milk production. The study shows that there is a great opportunity for development of buffalo in Bangladesh for milk and meat production and create employment opportunity. Buffalo could be a major source of milk and meat to reduce the milk and meat demand gap in the country. Although, the productivity of buffaloes in India and Pakistan is higher than Bangladesh, the country is not obtaining maximum benefit from the sector. Therefore, there is a need to improve the current buffalo production potential through scientific crossbreeding with quality breed, improved management

system, providing training, credit and finance, consultancy service, adequate veterinary service, feed conservation, adoption of improved forage and use of agro-industrial by products such as oilseed cakes and infrastructure to increase the production of buffalo in Bangladesh.

ACKNOWLEDGMENTS

The corresponding author is very grateful to all employees of the School of Agriculture and Rural Development, Bangladesh Open University, Gazipur-1705, Bangladesh for their help and co-operation in completing this review study.

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