Constraints in Buffalo Rearing and Disease Investigation for Livelihood Improvement in Haor and Border Areas of Sylhet, Bangladesh

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ABSTRACT

Background and Objective: Haor and border areas are very suitable for buffalo rearing zoogeographically, therefore, this study was designed with the aims of knowing the status of buffalo rearing and production, identification of different constraints such as farmer's demography, zoogeography, investigation of buffalo diseases, motivational approach for farmers to increase buffalo rearing and production at haor and bordered hilly areas. **Materials and Methods:** Five haor and bordered Upazila of Sylhet District were selected as study areas. A survey was conducted using a pretested questionnaire to collect all sorts of data from the study areas. Retrospective hospital prevalence data (4 years) were collected from the registered book of Upazila Veterinary Hospital and livestock office and disease occurrence was investigated from 300 randomly selected study buffalo during the study period by clinical examination and close observation. The lab investigated blood protozoan diseases. Examination of blood and parasitic infestation was identified using different fecal laboratory tests. Marginal farmers were motivated by conducting group discussions and training. Descriptive statistics (percentage) were performed. **Results:** The study found that 47.5% of landless farmers were involved in buffalo rearing, with 87% of buffalos raised in free-range systems and primarily fed on green grass (87.3%). Commercial feed and artificial insemination were absent. Consumers (65-85%) held positive attitudes toward buffalo milk and meat. Parasitic diseases, particularly fascioliasis (20.5%), were more prevalent than infectious ones, with an overall parasitic prevalence of 84.5%. Trematode infections (45%) were more common than nematode infections (23%). **Conclusion:** It is concluded that buffalo rearing and production can be increased by ensuring veterinary services, farmers' motivation and controlled breeding programs of buffalo such as artificial insemination.

INTRODUCTION

Livestock constitutes a crucial sub-sector of agriculture in Bangladesh, significantly contributing to public health and the national economy. In Bangladesh's entire livestock sector, buffaloes play an important role in the agricultural framework[1]. Buffalo is a productive domestic animal that yields high-quality milk and meat for consumption, dung for fuel and organic fertilizer, draft power and hides and skins for industrious purposes[2]. Buffaloes are more adept at utilizing low-quality fibrous foods of inferior quality in milk and meat. Compared to high-yielding cows, they supposedly digest 5% more crude fiber and use 4-5% more metabolizable energy to produce milk[3]. As of 2020, About 1.493 million buffalo live in Bangladesh, with coastal areas housing roughly 40% of this population[4]. Developed nations have a far larger consumption of animal products based on per capita, whereas emerging Asian countries have also experienced significant development in this direction[5]. In Bangladesh, buffaloes are broadly categorized into two types; indigenous buffaloes found in coastal and marshy regions and buffaloes that migrated from India and Myanmar, primarily found in the sugarcane belt and Cox's Bazar, respectively[6].

The buffaloes that have migrated from India typically belong to river types, whereas those from Myanmar originating from coastal regions or marshy lands, are classified as swamp types. In addition, a variety of crossbreeds between swamp and river types can be observed in the coastal areas[7]. Distribution data indicate that 42.8% of buffaloes are located in sugarcane-growing areas, 39.9% in coastal regions and 11.8% in marshy land[8]. Buffaloes raised on communal grazing lands, locally called Bathan, serve as a communal space where the animals are maintained for a significant portion of the year. Buffaloes that are raised outside of the Bathan system are classified as belonging to a non-Bathan system. The haor regions of Sylhet are predominantly adjacent to the Meghalaya Hill tracts of India, representing one of the largest belts in Bangladesh, with a population of approximately 10,000-15,000 buffaloes. Local farmers widely embrace management practices concerning buffalo; however, there exists a notable absence of documented research studies that explore the potential avenues and opportunities for buffalo production in these haor areas, as well as the resulting profit gains for the farmers.

In general, buffalo is regarded as more productive, healthier and more useful than the cow, especially for the poorest "backyard" farmers in Asia, even though it is said that buffaloes are more resistant to many diseases than cattle. On the other hand, the people of haor areas are continuously suffering natural calamities (heavy rain, flash flood) losing their crops and having/facing stagnant water for almost half part of a year (the wet season is longer, ranging from April to September of a year) therefore buffalo production can be a co-income source as well as a food source if they got motivated as buffalo biology is zoogeography related to the wet season. Therefore, this study was designed with the aims of knowing the status of buffalo rearing and production in haor areas, investigation of diseases and motivational approach to increase buffalo rearing and production for improvement of livelihood.

MATERIALS AND METHODS

Conduction of a survey

Selection of study area: Based on zoogeography five haor and bordered Upazilas (Zakiganj, Kanaighat, Jaintapur, Gowainghat and Companiganj) of Sylhet District were selected as study areas.

Study design and target population: The cross-sectional survey spanned 12 months, running from 23 July to 24 June[9]. Respondents were chosen based on fulfilling a minimum of three inclusion criteria:

• Owning a minimum of five buffaloes irrespective of the purpose of rearing
• Residing and farming in areas adjacent to bordered haor (wetland) regions
• Residing in areas where Government Veterinary Services are unavailable

Surveyors: These surveyors were veterinarians with expertise relevant to the study's aims. A lead supervisor was responsible for overseeing the enumerators and managing the investigation.

Survey method: Initially, a pilot study was undertaken involving 200 buffalo farmers (40 buffalo farmers from each Upazila) to assess the questionnaire's clarity, reliability and validity. Following team discussions and analysis of pilot results, the questionnaire underwent revisions and was used for the survey pertaining, to knowledge, attitude and practices regarding buffalo production and rearing. The questions comprised both open and closed formats, including multiple-choice and Likert scale responses. For data collection, respondents were interviewed face-to-face by trained surveyors. Each surveyor had a specific role: One posed the questions, another recorded response using KOBO Toolbox (www.kobotoolbox.org) and a third observed the interview process. Interviews were conducted in the local language to ensure clear communication and understanding among respondents.

Interpretation and statistical consideration: All the data were primarily assessed, sorted and recorded in Excel 2013 and then descriptive analysis is used for statistical consideration. Differences in means were analyzed, with statistical significance determined at a level of $p < 0.05$.

Investigation of diseases: Investigations were accomplished with the help of DLS personnel of the related Upazila Livestock office in three stages. The first stage includes retrospective data collection on different diseases of buffalo from the registered book of related Upazila livestock office and Veterinary Hospital for 4 years from 2020-2024, second stage includes the study of the occurrence of diseases of 300 study buffalo (60 buffalo from each Upazila) by close observation and clinical examination and third stage includes collection of different samples (feces (200 feces samples) and blood) from diseased and healthy buffalo, shifted to the laboratory for investigation.

Retrospective data collection for investigation of different buffalo diseases: Retrospective data (for 4 years from 2020-2023) were collected from respective veterinary hospital registered books for all types and subtypes of diseases, analyzed and interpreted.

Study of the occurrence of diseases of selected buffaloes during the study period: A total of 300 buffaloes (60 buffaloes from each study Upazila) were closely inspected, observed and examined clinically by expert's veterinarian for the investigation of different disease occurrences over some time (12 months; starting from 01 July, 2023 to 30 June, 2024) and recorded and studied.

Collection of different samples (blood and feces) from diseased and healthy buffalo for laboratory investigation: About 200 fecal samples from buffaloes (40 samples from each Upazila) and 25 blood samples (5 from each Upazila) were collected and examined in the laboratory following different standard protocols. Parasitic examinations of feces were done to identify parasites and blood was tested for investigation of hemoprotozoa infection.

RESULTS

Demography or socioeconomic status of the buffalo farmer's: Study areas (five Upazila belonging to Sylhet District) were visited and a survey was conducted revealing that the highest percentage (47.5%) of landless farmers were found associated with buffalo farming (Table 1).

Rearing system and management of buffaloes at haor and bordered areas in Sylhet: In haor and hilly areas, 87% of buffalos were reared in a free-range system (Table 2).

Feeding system and management of buffaloes at haor and bordered areas in Sylhet: Haor areas are rich with plenty of green grasses and the study found the highest parcentage (87.3%) of buffalos were

Table 1: Socioeconomic status of buffalo farmers in haor and bordered areas of Sylhet District (n = 200)

Serial no.	Parameters/characteristics	Categories	Frequency	Percentage
01	Status of the farmers (based on cultivable land ownership; other than home yard)	Landless farmer (no cultivable land, only home yard/homestead)	95	47.5
		Marginal farmers (home yard+ less than 0.5 ha cultivable land)	68	34
		Medium farmer's (home yard+ 0.5 to 1.0 ha land)	10	5
		Large farmers (home yard+ above 1.0 ha cultivable land)	27	13.5
02	Age	<30 years	10	5
		30-40 years	23	11.5
		40-50 years	130	65
		>50 years	37	18.5
03	Gender	Male	200	100
		Female	0	0
04	Education	Illiterate	50	25
		Primary	90	45
		Secondary	40	20
		Graduated	20	10
05	Training on buffalo rearing and production from any organization (GO/NGO)	Have training on buffalo rearing, production and management	126	63
		No training	74	37
06	Co-occupation	Agriculture	140	70
		Service (GO/NGO)	10	5
		Business	43	21.5
		Other's	7	3.5

Table 2: Rearing system and management of buffalo at haor and bordered areas in Sylhet (n = 200)

Traits	Category	Frequency	Percentage
Rearing system	Extensive/free range	174	87
	Semi-intensive	26	13
	Intensive	0	0
	Separate buffalo house	20	10
	With cattle in the house	134	67
Night shelter	Householder house veranda	46	23
Winter care to manage cold stress	Yes	0	0
	No	200	100
In dry season (October-March)	Most time of the day in Bathan		
	Yes	100	0
	No	0	100
In wet season (April-September)	Most time of the day in the wetland		
	Yes	100	0
	No	0	100

Table 3: Feeding system and management of buffaloes at haor and bordered areas in Sylhet

Traits	Category	Dry season (%)	Wet season (%)
Feed supply	Only green grass	100	87.3
	Green grass+Roughage	0	9.4
	Green grass+Roughage+Concentrate	0	3.3
Commercial feed	Yes	0	0
	No	100	100
Feeding balanced ration	Yes	3	6
	No	97	94
Additional diet in pregnancy and lactation	Yes	19.6	42.8
	No	80.4	57.2
Water supply	Yes	80	0
	No	20	100
Feeding mineral supplements	Yes	11.6	20.3
	No	88.4	79.7

Table 4: Breeding and progeny health care of buffaloes at haor and bordered areas in Sylhet (n = 200)

Traits	Category	Frequency	Percentage
Artificial insemination practice	Yes	0	0
	No	200	100
Bull selection for natural mating	Yes	0	0
	No	200	100
Human-controlled natural mating	Yes	0	0
	No	200	100
Knowledge about buffalo calf health management	Slight	96	48
	Moderate	84	42
	Good	20	10
	Excellent	0	0
Experience with buffalo calf mortality	Slight	28	14
	Moderate	74	37
	Good	98	49
	Excellent	0	0
Knowledge about causes of calf mortality	Slight	64	32
	Moderate	106	53
	Good	30	15
	Excellent	0	0
Knowledge about common diseases of buffalo calf	Slight	42	21
	Moderate	60	30
	Good	98	49
	Excellent	0	0

Table 5: Knowledge, attitude and practices about the utilization of buffalo products (milk and meat) at haor and bordered areas in Sylhet (n = 200)

Traits	Category	Frequency	Percentage
Availability of buffalo milk in the local market	Yes/available	20	10
	No/not available	150	75
	Moderate	30	15
Availability of buffalo meat in the local market	Yes/available	30	15
	No/not available	120	60
	Moderate	50	25
Positive attitude of farmers about buffalo milk consumption	Slight	4	2
	Moderate	64	32
	Good	106	53
	Excellent	26	13
Attitude of farmers about buffalo meat consumption	Slight	2	1
	Moderate	14	7
	Good	138	69
	Excellent	46	23
Knowledge about buffalo milk nutritive value in comparison to cow milk	Slight	4	2
	Moderate	56	28
	Good	102	51
	Excellent	38	19
Knowledge about buffalo meat nutritive value in comparison to buffalo meat	Slight	4	2
	Moderate	130	65
	Good	46	23
	Excellent	20	10

found to live on green grass. No commercial feed was found familiar to the farmers. In the wet season, aquatic plants played an important role and in the dry season the buffalos were found roaming around Bathan (Table 3).

Breeding and progeny health care of buffaloes at haor and bordered areas in Sylhet: No provision of artificial insemination for breeding was found in the study areas (Table 4). The table summarizes various traits related to buffalo calf management among 200 respondents. It highlights that artificial insemination, bull selection and human-controlled natural mating were not practiced (0%). Knowledge and experience in buffalo calf health, mortality and diseases were predominantly rated as "Slight" to "Good," with no respondents achieving an "Excellent" level.

Knowledge, attitude and practices about the utilization of buffalo products (milk and meat) at haor and bordered areas in Sylhet: The majority percentage of farmers were found familiar with and bear positive attitudes towards using buffalo milk and meat (Table 5). The table summarizes traits related to the availability, farmer attitudes and knowledge about buffalo milk and meat in local markets. Key findings include the unavailability of buffalo milk (75%) and meat (60%) being most common, with moderate or higher knowledge and positive attitudes generally observed, especially toward buffalo milk's nutritive value (70% good/excellent).

Knowledge, attitude and practices of buffalo farmers about buffalo diseases, treatment, management and prevention at haor and bordered areas in Sylhet: The knowledge, attitudes and practices of buffalo farmers about buffalo diseases, treatment, management and prevention at haor and bordered areas in Sylhet were given in Table 6. The table presents the knowledge, attitudes and practices of buffalo farmers (n = 200) in Sylhet regarding buffalo diseases, treatment and management. Most farmers had limited knowledge about infectious and bacterial diseases, with "slight" knowledge predominating across categories. Vaccination and deworming practices were irregular and fecal examination for deworming was absent. A small proportion were aware of fungal and non-infectious diseases, while a significant majority knew about veterinary hospital services but only 29% utilized them.

Prevalence/occurrence of different diseases of buffaloes in the study area
Hospital prevalence of different diseases of buffaloes in the study area during the last four years: Data were analyzed using descriptive statistics and presented in Fig. 1- 4.

Figure 1 shows that non-infectious diseases were the most prevalent each year, consistently above 64%, peaking at 67.97% in 2021. Infectious diseases maintained a steady prevalence of 27.3% across all four years. Parasitic diseases showed the least prevalence, consistently at 6.8% throughout the period. The proportions of the disease categories remained constant over the years with minor variations, showing no significant annual changes.

Figure 2, the bar chart depicts the prevalence of various infectious diseases in buffaloes across five upazilas of Sylhet District from 2020 to 2023. Mainly foot and mouth disease (FMD) consistently had the highest prevalence yearly, peaking at 14.04% in 2022. Haemorrhagic septicaemia (HS) was the second most prevalent disease, ranging between 8.60% in 2023 and 9.84% in 2020. Pneumonia prevalence ranged from 2.21% (2021) to 4.31% (2022), showing moderate variation over the years. Ephemeral fever and dermatophilosis were the least prevalent diseases, both staying below 1% annually.

Figure 3(a-b) illustrates the prevalence of buffalo's gastro-intestinal parasitic infections and ectoparasitic infections in five upazilas of Sylhet District from 2020 to 2023. Mainly gastro-intestinal parasitic infections
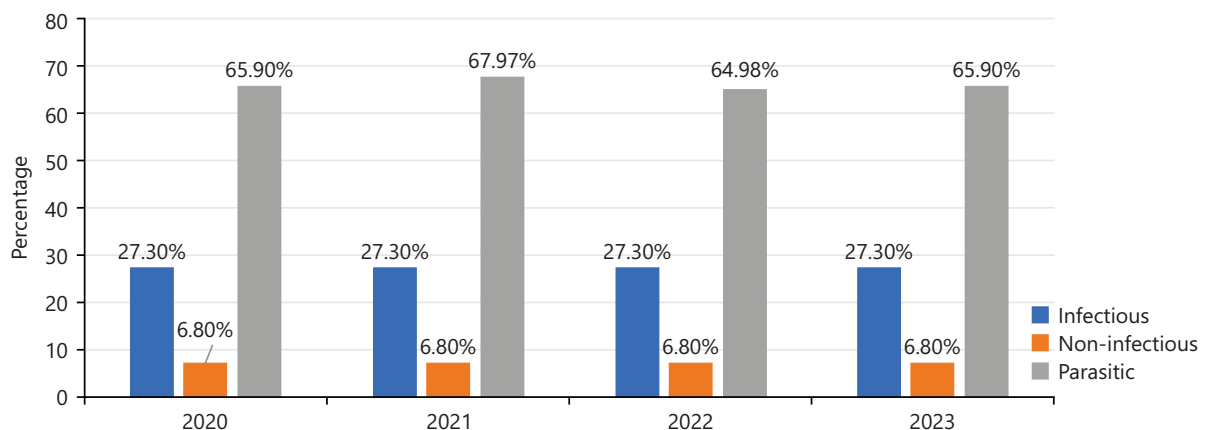

Fig. 1: Overall prevalence of buffalo diseases at five Upazila in Sylhet District from 2020 to 2023

Table 6: Knowledge, attitude and practices of buffalo farmers about buffalo diseases, treatment, management and prevention at haor and bordered areas in Sylhet (n = 200)

| Traits	Category	Frequency	Percentage
Knowledge about infectious disease	Slight	138	69
	Moderate	62	31
	Good	0	0
	Excellent	0	0
Knowledge about bacterial disease	Slight	158	79
	Moderate	42	21
	Good	0	0
	Excellent	0	0
Knowledge about anthrax	Slight	174	87
	Moderate	26	13
	Good	0	0
	Excellent	0	0
Knowledge about the black quarter	Slight	174	87
	Moderate	26	13
	Good	0	0
	Excellent	0	0
Knowledge about hemorrhagic septicemia	Slight	174	87
	Moderate	26	13
	Good	0	0
	Excellent	0	0
Knowledge about viral disease	Slight	174	87
	Moderate	26	13
	Good	0	0
	Excellent	0	0
Knowledge about FMD	Slight	78	39
	Moderate	86	43
	Good	34	17
	Excellent	2	1
Knowledge about vaccination	Slight	76	38
	Moderate	102	51
	Good	22	11
	Excellent	0	0
Vaccination practice	Regular	0	0
	Irregular	200	200
Knowledge about parasite	Slight	12	6
	Moderate	122	61
	Good	60	30
	Excellent	6	3
Knowledge about the harmful effect of parasitic infestation	Slight	88	44
	Moderate	82	41
	Good	24	12
	Excellent	6	3
Knowledge about anthelmintic/deworming	Yes	112	56
	No	88	44
Deworming practices	Yes	42	21
	No	158	79
Deworming frequency per year	1 time/year	194	97
	2 times/year	6	3
	3 times/year	0	0
Fecal examination for deworming	Yes	0	0
	No	200	100
Knowledge about liver fluke	Yes	118	59
	No	82	41
Knowledge about fungal disease (hump sore)	Yes	26	13
	No	174	87
Knowledge about non-infectious (deficiency and metabolic) diseases/disorders	Yes	4	2
	No	196	98
Knowledge about Veterinary Hospital and services	Yes	186	93
	No	14	7
Take service from Veterinary Hospital	Yes	58	29
	No	142	71
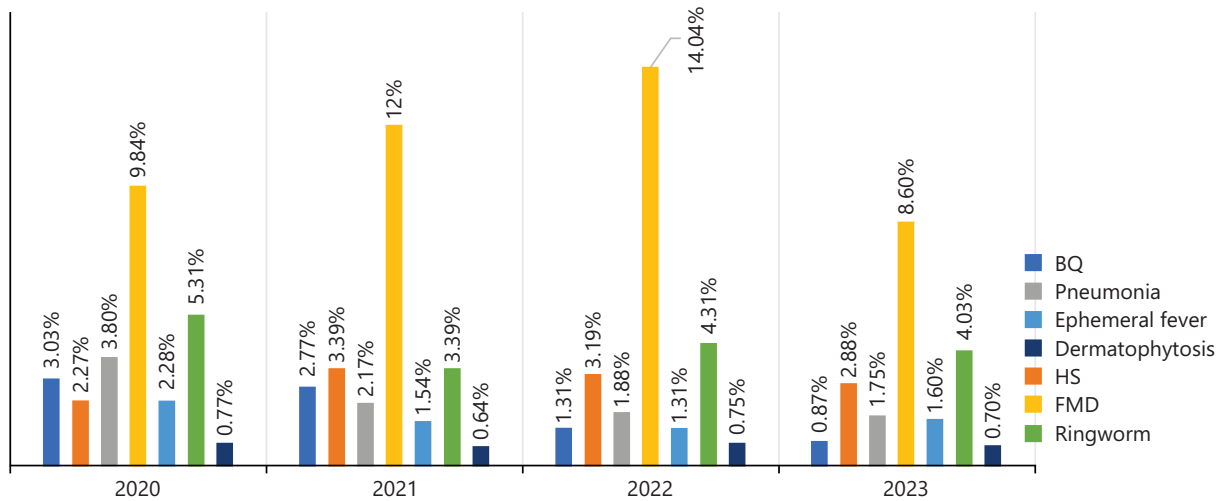
Fig. 2: Prevalence of buffalo's infectious diseases at five Upazila in Sylhet District from 2020 to 2023
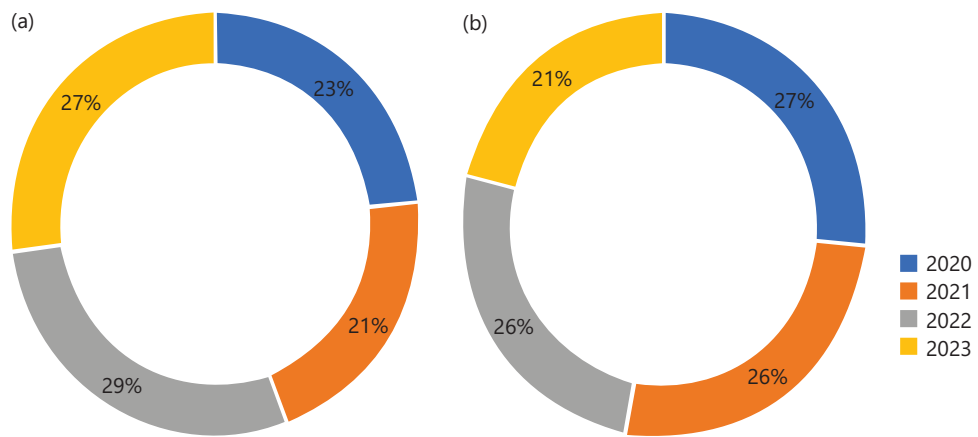

Fig. 3(a-b): Prevalence of buffalo's parasitic diseases at five Upazila in Sylhet District from 2020 to 2023, (a) Prevalence of gastro-intestinal parasitic infection and (b) Prevalence of ectoparasitic diseases infection

prevalence peaked in 2022 (29%) and the lowest prevalence was observed in 2021 (21%). Ectoparasitic infections the highest prevalence occurred in 2020 (27%).

Figure 4 shows the prevalence of different non-infectious diseases in buffaloes across five Upazilas in Sylhet District from 2020 to 2023. It is divided into three concentric circles representing various disease categories Inner Circle (Nutritional Deficiency Diseases) whose prevalence is generally low but stable across the years, with a slight increase or decrease depending on the year. Middle Circle (Metabolic Disorders) whose prevalence shows fluctuations, with the highest percentage in 2023 (3.75%). Outer Circle (Hormonal or Non-infectious Reproductive Diseases): These diseases are the most prevalent compared to the other categories. The highest prevalence was seen in 2020 (3.40%), but it declined slightly in the following years.

Occurrence of different diseases of buffaloes in the study area during the study period: Investigation of different disease occurrences over a period studied and recorded (Table 7). The table summarizes the occurrence and prevalence of various diseases in buffaloes (n = 300) across 5 Upazilas of Sylhet during the study period. Infectious diseases accounted for 27.3% of the prevalence, with FMD (3%) and
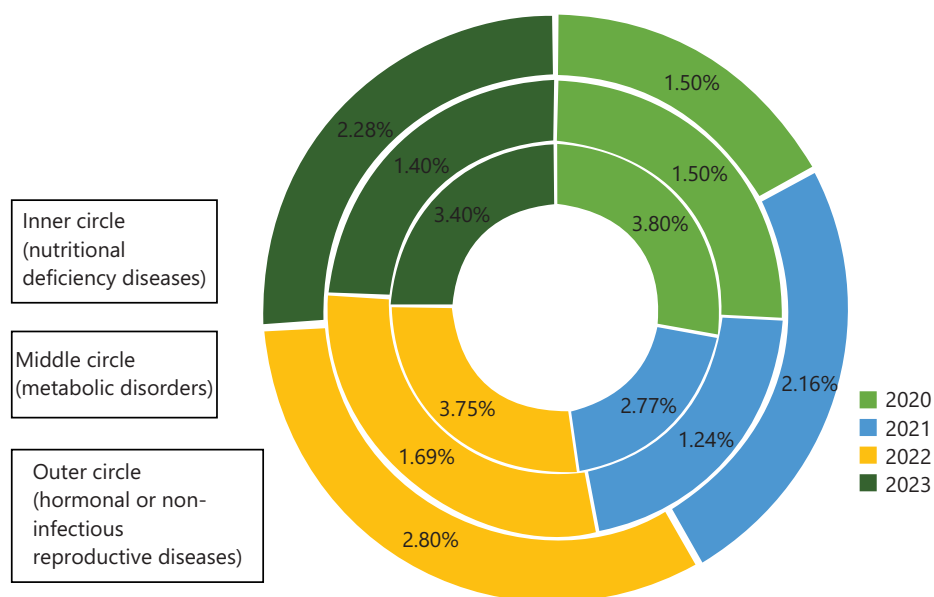
Fig. 4: Prevalence of buffalo's non-infectious diseases at five Upazila in Sylhet District from 2020 to 2023

Table 7: Occurrence of diseases of buffaloes during the study period at the haor and bordered areas (5 Upazila) of Sylhet (n = 300)

Disease category	Name of the diseases	Total number of buffaloes examined	Number of identified cases	Prevalence (%)	Prevalence (%) by category	Overall disease occurrence (%)
Infectious diseases	Anthrax	300	0	0	27.3	76.33
	Black quarter		1	0.33		
	Hemorrhagic septicemia		5	1.66		
	Mastitis		0	0		
	Pneumonia			0		
	FMD		9	3		
	Rabies		0	0		
	Ephemeral fever		0	0		
	LSD		0	0		
	Ringworm		5	1.66		
	Dermatophytosis		2	0.66		
Parasitic infestation	Helminthes's parasitic disease		93	31	65.9	
	Hemoprotozoa disease		0	0		
	Ectoparasite		99	33		
Non infectious disease	Nutritional deficiency disease		7	2.33		
	Metabolic disease/disorder's		3	1	6.8	
	Hormonal or non-infectious reproductive disease		5	1.66		
	Poisoning/toxicity		0	0		
	Surgical affections		0	0		
Total			229	76.33	100	

hemorrhagic septicemia (1.66%) being notable. Parasitic infestations were predominant (65.9%), with ectoparasites (33%) and helminthic infections (31%) being the most common. Non-infectious diseases contributed 6.8%, primarily due to nutritional deficiencies (2.33%). Overall disease occurrence was 76.33%.

Table 8: Overall prevalence of different parasitic infestations in buffaloes of haor and bordered area of Sylhet District of Bangladesh

Helminths group	Species	Total number of samples examined	No. of the positive sample	Prevalence (%)
Trematode	*Fasciola* spp.	200	41	20.5
	Paramphistomum spp.		19	9.5
	Eurytrema pancreaticum		27	13.5
	Schistosoma spp.		3	1.5
	Subtotal		90	45
Nematode	*Toxocara* spp.		15	7.5
	Haemonchus spp.		17	8.5
	Oesophagostomum spp.		11	5.5
	Syngamus laryngeus		3	1.5
	Subtotal		46	23
Cestode	*Avitellina centripunctata*		19	9.5
	Subtotal		169	77.5
	Mixed infestation		87	43.5
	Total		256*	118*

*Total number of animals affected is less than the summation of individual infestation because the same animal was infected by more than one type of gastro-intestinal parasite

Investigation of diseases of buffaloes by laboratory examination

Blood: The blood was taken from sick or sick animals and shifted to the Field Disease Investigation Laboratory (FDIL) for hemoprotozoa disease investigation and all the results were found negative.

Feces: The 200 fecal samples were examined in the laboratory and the results are given below.

Overall prevalence of parasitic infestation in buffaloes: One or more species of gastrointestinal parasites was present in all 200 fecal samples that were examined for this investigation. Among buffaloes, fascioliasis was the most prevalent (20.5%) parasitic infestation, with an overall prevalence of 84.5% (Table 8).

Upazila-wise prevalence of parasitic infestation in buffaloes: The level of parasite infestation varied throughout the five haor and adjacent areas of Sylhet; Jaintapur had the highest level (85%) and Zakiganj had the lowest (65%). Out of the three helminth categories, Gowainghat had the highest prevalence of trematode (31.25%) and cestode (28.12%), while Kanaighat had the highest (51.72%) prevalence of nematode infestation (Table 9).

DISCUSSION

The survey encompassed 200 buffalo farmers, with 47.5% identified as landless, 34% as marginal and 13.3% as major farmers, respectively. Buffalo farming in Bangladesh is influenced by climate, soil and socioeconomic variables, with several farmers integrating livestock with crop production[8]. A recent survey in Lalpur Upazila indicated that more than 80% of farmers had 2-5 acres, whereas 47.5% of farmers in our study are landless. Moreover, most farmers in Lalpur are under 30 years of age, in contrast to the 40-50 age range in Sylhet's hilly region. The 55% of farmers were educated (with 5% illiterate) and 58.8% were reliant on agriculture[10]. According to 2020 research conducted in a coastal region, 85% of owners were men, 47.5% were between the ages of 31 and 45, 76.25% were reliant on agriculture and 51.25% had only completed primary school. However, only 0-3.75% of them started raising buffalo due to government or non-profit training[11,12].

The study revealed that 87% of buffaloes were raised in extensive or free-range systems, while only 13% were reared in semi-intensive systems. A recent study in Sylhet and Noakhali's haor areas found that farmers raised dairy buffalo freely in Bathan but lacked winter care[11,13]. In various regions, night shelter practices for buffaloes vary. In one study, 67% of buffaloes were housed in cattle sheds, 10% in separate

Table 9: Upazila-wise prevalence of different helminth's parasitic infestation buffaloes of haor and bordered area of Sylhet District of Bangladesh

Upazila name	Total fecal sample	No. and Helminth positive sample (%)	Avg. and Helminth positive samples (%)	No. of trematode-positive samples	Trematode positive sample (%)	No. of cestode-positive samples	Cestode positive samples (%)	No. of Nematode-positive samples	Nematode positive samples (%)
Jaintapur	40	34 (85)	29.8 (74.5)	10	29.41	8	23.52	16	47.05
Kanaighat	40	29 (72.5)		8	27.58	6	20.68	15	51.72
Gowainghat	40	32 (80)		10	31.25	9	28.12	13	40.62
Companiganj	40	28 (70)		8	28.57	7	25	13	46.42
Zakiganj	40	26 (65)		8	30.76	6	23.07	12	46.15
Total	200	100		44		36		69	

*Total number of animals affected is less than the summation of individual infestation because the same animal was infected by more than one type of gastro-intestinal parasite

houses and 23% on verandas. With an overall adoption rating of 53.8%, the majority of buffalo farm owners in Surat, Gujarat's peri-urban regions had modest adoption levels of better buffalo husbandry techniques[14]. In coastal Bangladesh, 77.5% of farmers provided no specific housing[15]. Additionally, winter care for buffaloes was largely neglected. Seasonal grazing patterns revealed that during the dry season, buffaloes were kept in Bathan, while in the wet season, they grazed wetlands extensively[6].

Seasonal variation influences the feeding practices and diet of buffaloes. During the dry season, buffaloes were exclusively fed green grass, while in the wet season, 87.3% received green grass alone, 9.4% were given green grass with roughage and 3.3% received green grass, roughage and concentrated feed. Commercial feed was not used and only 3 and 6% of buffaloes were given a balanced diet in the dry and wet seasons, respectively. During lactation and pregnancy, 42.8% of buffaloes in the wet season and 19.6% in the dry season received additional diets. In the dry season, 80% had water provided, while no water provision was recorded during the wet season. Only 11.6 and 20.3% received mineral supplements. A study in Bangladesh's haor area indicated limited access to balanced diets and mineral supplements across seasons[13], aligning with findings that buffaloes lacked water access in the dry season but not in the wet season.

The study found that all farmers relied on natural mating due to the availability of local buffalo bulls, with no use of Artificial Insemination (AI). Only 10% of farmers showed high knowledge of calf management, while most had moderate awareness and only 15% understood calf mortality causes, with 50% reporting losses. Approximately 50% of buffalo owners were well-informed on common diseases. In Bangladesh, 91.6% of small-scale farmers used natural services, while AI was common on commercial farms[16]. Research in Bangladesh highlights gaps in practices like navel cord disinfection, timely colostrum feeding, deworming and vaccination. Calf mortality rates are high, from 14.5 to 79.5%, often due to inadequate management and limited owner knowledge[16,17].

The study found that buffalo products make up only 10-15% of the local market, yet 65-85% of consumers have a positive attitude toward buffalo milk and meat. Furthermore, 35-70% of consumers recognize the nutritional benefits of buffalo products compared to cow products. However, more data on knowledge, attitudes and practices regarding buffalo milk and meat in rural and border regions of Bangladesh is needed. Despite their potential, buffalo production faces challenges, with buffaloes contributing just 2% to milk and 0.94% to meat production[18,19].

The survey revealed that most buffalo owners have limited to moderate knowledge about infectious and bacterial diseases such as anthrax, black quarter and hemorrhagic septicemia. Similarly, awareness of viral infections is low, with only 18% showing good to excellent knowledge of foot and mouth disease. Just 11% of owners are familiar with vaccination practices and regular vaccination programs have not been established. While 33% of owners are aware of parasitic diseases, only 23% practice deworming, with only 3% administering it twice a year. Additionally, 59, 13 and 2% of owners know about liver fluke, fungal infections and non-infectious diseases, respectively. Despite nearly all owners being aware of veterinary services, only 29% seek government veterinary assistance. Studies indicate significant knowledge gaps regarding animal diseases, with deworming practices ranging from 60-94% and vaccination rates at 40-45%. Challenges such as feed shortages and limited technical knowledge persist, but buffalo farming has the potential to improve farmers' socioeconomic status[1,13,20]. Further research is needed to improve practices and exploit buffalo farming's potential in Bangladesh.

From 2020 to 2023, the prevalence of diseases in buffaloes across five upazilas in Sylhet District varied, with infectious diseases ranging from 27 to 28%, parasitic diseases from 65 to 68% and non-infectious diseases from 6 to 7% (Fig. 3). In Bangladesh, the prevalence of infectious diseases in buffaloes and other ruminants varies by pathogen and region. For example, gastrointestinal helminthiasis is highly prevalent

in buffaloes in Sylhet, with a reported infection rate of 78%. In Lower Dir Khyber Pakhtunkhwa, Pakistan, it turns out that 64.2% of buffaloes had one or more gastrointestinal parasite infections[20]. Though limited, studies on metabolic and non-infectious diseases in buffaloes suggest that these conditions are a significant health concern in ruminants in Bangladesh, as seen in cattle in Chittagong, where metabolic diseases accounted for 3.18% of diagnosed cases[21].

The prevalence of various infectious diseases in buffaloes included 0.5 to 3% for Black quarter, 2.1 to 3.7% for hemorrhagic septicemia, 1.7 to 4% for pneumonia, 8.8 to 14% for foot and mouth disease (FMD), 1 to 2.1% for ephemeral fever, 3.5 to 5.7% for ringworm and 0.4 to 0.7% for dermatophilosis, FMD, which is endemic in Bangladesh, poses significant economic challenges, with 58.3% of buffaloes affected on small-scale farms[22]. Additionally, respiratory diseases like pneumonia, particularly in young goats[23], are concerning, although data specific to buffaloes is limited.

Non-infectious diseases like nutritional deficiencies, metabolic disorders and hormonal or reproductive disorders were observed in buffaloes, with nutritional deficiencies (3.1 to 3.7%) being less common than in cattle, where malnutrition was recorded at 0.26%[24]. Parasitic infections, particularly gastrointestinal (23.9 to 32.8%) and ectoparasitic infestations (33 to 41.2%), were widespread. Common parasites included trematodes (*Fasciola* sp.), nematodes (*Toxocara vitulorum*) and protozoa (*Balantidium coli*). The prevalence of these infections varies with season, age, sex and deworming practices[19]. Ectoparasite infestations, such as ticks and lice, were more prevalent in younger buffaloes[25] and vary with environmental factors and seasons. The findings underscore the need for improved disease management strategies to address the widespread health challenges faced by buffaloes in Bangladesh.

This study examined 200 fecal samples of buffaloes from the Sylhet District's bordered and haor areas, revealing that all samples contained one or more species of gastrointestinal (GI) parasites, with an overall prevalence of 77.5%. This prevalence aligns with previous studies (65-74%)[26,27] but differs significantly from another study has much lower infection rates of 9.8 and 13.18%, respectively. The variations in prevalence may stem from differences in sampling methods, sample sizes, stocking density, environmental conditions, grazing, housing, deworming practices and overall husbandry[28].

The study identified nine different species of gastrointestinal parasites, including four nematodes, one cestode and four trematodes, with mixed-species infections being common. Trematode infections were notably more prevalent (45%) than nematode infections (23%), in Guwahati, Asam India which is very nearest to our study areas and close to Meghalaya hill tracts. The higher trematode prevalence may be attributed to the presence of intermediate hosts such as snails, fish and grasshoppers in the study area, as these vectors are influenced by local climatic factors like moisture, humidity and geography.

Fascioliasis was observed in 20.5% of buffaloes, which is similar to a study of Singh *et al.*[29] and Biswas *et al.*[30]. Furthermore, the study confirmed higher parasite prevalence in adult buffaloes compared to calves[31] and found higher infection rates in younger animals. The variation in age-based susceptibility may be due to differences in immune status and parasite-specific age preferences.

The prevalence of *Eurytrema pancreaticum*, a trematode of zoonotic importance, was found to be 13.5%. Adult buffaloes were more susceptible to this infection than younger animals. This finding is consistent with study of Chang *et al.*[32] and Tung *et al.*[33], which documented similar infections in cattle. The high prevalence of *Eurytrema* in Sylhet may be linked to the availability of its intermediate hosts and shared geographical conditions with neighboring India.

Regarding sex-based prevalence, no significant difference was found between male and female buffaloes[30]. However, higher parasite prevalence in females, possibly due to immunosuppression during pregnancy and lactation[26]. These differences warrant further research to understand the factors influencing parasitic disease outbreaks in buffaloes.

CONCLUSION

Haor and border areas are very suitable for buffalo rearing ecologically or zoo geographically. As peoples of these areas are continuously suffering or facing natural calamities, losing their crops, therefore buffalo rearing might be profitable, as well as a co-income source of cow food (when food scarcity occurs) and veterinary technical services (as haor and bordered areas are prone to parasites) are ensured. Buffalo rearing and production can be increased by the motivation of the farmers through proper education and training. The controlled breeding program of buffalo through artificial insemination may be an effective tool for 2014 increased buffalo rearing as well as milk and beef production, which are an important protein source and might play a crucial role in the improvement of the livelihood of the marginal farmers in the haor and bordered areas of Bangladesh and ultimately may contribute in national sustainable development goal.

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