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Effective Management Strategies for Spotted Deer at the National Zoo in Bangladesh

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Abstract: This study focused on the care of spotted deer (*Axis axis*) at the Bangladesh National Zoo, with an emphasis on their rearing and management practices. The research spanned a year, from January 15th to December 15th, 2018, and encompassed the observation of four distinct deer groups: adult males (Stags or bucks), adult females (Does), juveniles, and infants. Special attention was dedicated to the dietary habits of the deer, which comprised a diverse range of foods, including maize fodder, Jambu grass, Gourd Spinach (Kolmi grass), cabbages, cucumbers, gourds, pumpkins, grains, wheat bran, and soybean meal. This diet provided them with a daily intake of 13.63% crude protein (CP) and 14.38 MJ ME. The research yielded valuable insights into the characteristics of the deer population. Male deer, on average, weighed 2.97 kg at birth, whereas females weighed 2.73 kg. Adult males exhibited an average weight of approximately 78.08 kg, while adult females weighed around 60.97 kg. Upon weaning, males weighed 19.05 kg, and females weighed 18.49 kg. The deer were typically weaned at an average age of 5.19 months, with estrous cycles lasting approximately 17.40 days. The age at first fawning was recorded at 14.48 months, and the gestation period averaged 232.69 days. To ensure the health and reproductive success of the spotted deer, adherence to recommended feeding plans and effective management practices at the Bangladesh National Zoo was deemed imperative. These measures guaranteed the provision of appropriate nutrition and care, thereby enhancing the overall well-being, productivity, and reproductive outcomes of the deer population. This research has offered significant insights into the management of captive spotted deer. The findings also hold relevance for the broader domain of wildlife conservation. Through meticulous observation and documentation of various aspects of deer management, these findings can contribute to the effective support and conservation of the deer population within the zoo.

Keywords: Spotted Deer, Dietary Habits, Reproductive Characteristics, Wildlife Conservation

1. Introduction

The distribution of Spotted Deer, scientifically known as *Axis axis*, extends widely across the diverse habitats of the Sundarbans. While their natural distribution is primarily confined to the Indian subcontinent, successful introductions have been documented in other regions [1, 2]. Population estimates for Spotted Deer in the Sundarbans range from 52,600 [3] to 83,000 [4], with variations in relative abundance observed across different habitats. Typically, there is a gradual decrease in deer density from west to east within their range [5]. One critical factor influencing their concentration is access to freshwater, ensuring their habitat remains suitable for their needs [6].

Beyond the Sundarbans, several islands in the Bay of Bengal also support substantial populations of Spotted Deer. The presence of essential elements such as drinking water sources, shaded trees, suitable forage grasses, and rugged terrain all contribute to variations in deer concentration within specific areas. Morpho-physiologically classified as

ruminants, Spotted Deer primarily rely on forest vegetation for their diet, including leaves and fruits of keora, new leaves of passur, gewa, and various grasses. Interestingly, they meet their calcium requirements by chewing fallen deer antlers and consuming other items such as crab and shrimp.

In the context of the Bangladesh National Zoo (BNZ), the facility houses 241 Spotted Deer and 11 barking deer. These animals receive a carefully balanced diet to maintain their nutritional well-being. The provided diet includes green fodders (Maize fodder, Jambu grass, and gourd spinach), vegetables (Cabbage, cucumber, pumpkin), and concentrate feeds (Grain, Soybean meal, wheat bran, vitamin-mineral supplements, and common salt). Spotted Deer are known for their high sensitivity, agility, and strength, making them challenging experimental subjects. However, advancements in captive deer management have simplified their feeding through the development of pelleted rations designed to provide essential nutrients for growth and maintenance. In the future, complete pelleted rations may become expedient for free-roaming deer facing browse shortages and environmental pressures.

Beyond Bangladesh, the global deer industry has experienced substantial growth, with approximately five million deer currently being farmed worldwide, marking a 20% annual growth rate [7]. Countries like New Zealand, China, the United Kingdom (UK), Denmark, and the United States of America (USA) have significant deer farming populations. New Zealand, in particular, is a major producer and exporter of venison, with a significant portion of it being exported to Europe, mainly Germany [8]. Deer farming yields various products, including venison and velvet antlers. Venison is prized for its low-calorie, low-fat, and high-protein content, making it suitable for low-fat diets. It is also rich in polyunsaturated fatty acids [9]. Velvet antlers have been used for over 2000 years in Chinese medicine, believed to offer a range of health benefits, including potential growth effects, immune enhancement, anti-inflammatory properties, and more.

While some studies have examined the spotted deer's feeding, reproduction, and management operations in captivity, systematic studies in this context remain limited. However, information on the population of this species in situ and ex situ can be found in studies conducted by the Sundarban Biodiversity Project [5]. Spotted deer hold ecological significance in the Sundarbans, serving as a prominent attraction for tourism and playing a crucial role as a link between primary production and the densities of apex predators like tigers. Protecting and maintaining deer populations and their habitats is essential for the survival of these predators [10].

To address these diverse aspects, the study established specific objectives, which included studying management practices, examining feeding schedules, assessing habitat conditions, evaluating security measures, and calculating the rearing cost of spotted deer at the Bangladesh National Zoo. Overall, the study aimed to provide valuable insights for improving the management and conservation of spotted deer in various settings.

2. Materials and Methods

2.1. Study Area

The study was conducted with the spotted deer at the Bangladesh National Zoo, also known as the Dhaka Zoo, which is located in Mirpur, Dhaka, Bangladesh. It is situated in the central part of the country. The experiment was carried out from January 15th to December 15th, 2018 for a period of one year.

2.2. Environmental Condition of the Study Area

The production of spotted deer within a zoo, as well as the interactions with tourists, are significantly influenced by the local environmental conditions. Therefore, we conducted an overview of the environmental conditions in the study area. The recorded maximum and minimum temperatures in May and January ranged from 33°C to 15-20°C. The summer season extended from April to June with temperatures ranging between 25-30°C, while winter prevailed from December to February. Rainfall typically began in May and continued through September, with approximately 95% of the annual rainfall occurring during the monsoon season. Humidity levels reached a maximum of 96% from July to September and a minimum of about 45% from January to April, as reported by the BBS in 2000.

2.3. Experimental Animals and Parameters Studied

The essential data for this experiment were obtained from a total of 60 deer at the Bangladesh National Zoo, comprising 15 adult males, 15 adult females, 15 juveniles, and 15 infants. In the context of this study, various parameters were investigated, including feeds and feeding practices, production and reproduction profiles, as well as herd management (Figure 2).

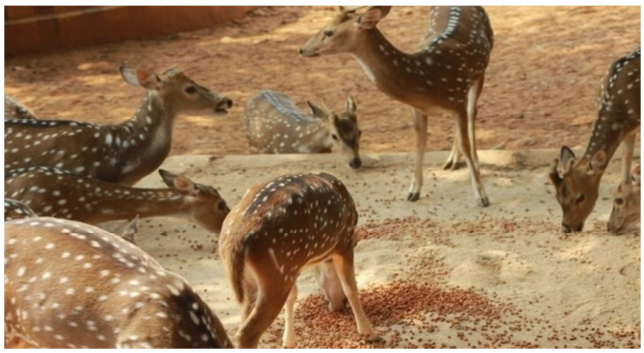

Figure 1. *Concentrate Feeding of Bangladesh National Zoo.*

2.4. Feeds and Feeding

The digestive system of deer is unique, which features a four-chambered stomach. The first chamber, the rumen, serves as a storage facility for food, allowing deer to consume large quantities that are digested gradually through

a process known as "chewing their cud" or "ruminating." Deer are classified as ruminants due to their ability to perform this process. The second stomach chamber, the reticulum, houses microorganisms that aid in breaking down partially digested food through fermentation, making it easier for both the deer and the microorganisms to absorb nutrients. This fermentation process produces methane gas, which deer release regularly. The reticulum's microorganisms play a crucial role in the deer's nutrition. The third chamber, the omasum, primarily facilitates water absorption, while the fourth chamber, the abomasum, continues the digestion process with gastric juices, similar to human stomach acids. The digested food then enters the intestines, where the deer's body absorbs essential nutrients, and any undigested material is expelled as waste (Figure 1).

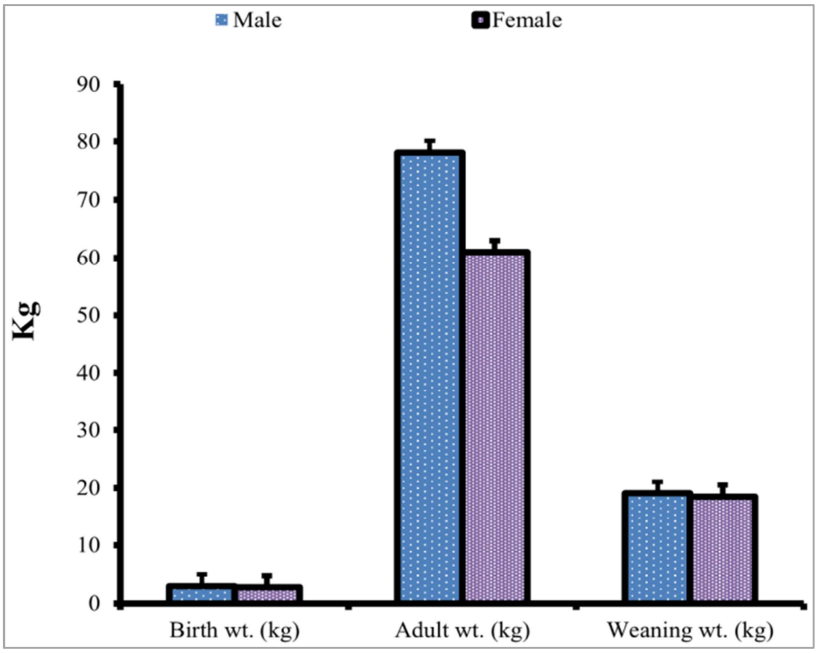

Figure 2. *Body weight of spotted deer at Bangladesh National Zoo.*

2.5. Housing Area Design

Housing emphasized the need for spacious enclosures with tall fences and perimeter fencing to accommodate the flighty nature of spotted deer. The design of holding yards allowed for easy separation of deer into small groups, had concrete floors for cleanliness and included essential features like a deer crush and scales. Adequate ventilation, lighting, power supply, and running water were important considerations. The section also addressed aspects such as spatial requirements, weather protection, substrate materials, bedding, enclosure furnishings, and general husbandry practices, including hygiene, cleaning, pest control, and record-keeping for individual deer.

2.6. Forage Items

Their forage preferences encompass more than 75 plant species, encompassing various plant parts like leaves, stems, fruits, seeds, flowers, and bark. Throughout the year, their diet primarily consists of grasses, often favoring green grasses less than 10cm high. In Texas, for instance, they graze on grasses like peplum, switchgrass, and little bluestem. During spring, they particularly relish sedges. Beyond grasses, they supplement their diet with browse items, including live oak, hackberry, and sumac, providing them with a well-rounded and adaptable feeding strategy.

2.7. Resistant Systems

Manual restraint involves holding the deer by embracing its chest and securing its back against the person's chest, with the option of sitting down to manage the deer more comfortably, while caution is advised for flailing legs or head. Chemical restraint is recommended for complex procedures like electro-ejaculation, intrauterine AI, or embryo transfer, typically administered by a veterinarian. Sedative drugs are employed, with the specific choice determined by the vet. Weighing animals can be done using electronic or mechanical systems, either suspended or platform-based, with the option to integrate the restraint as a weight crate. Alternatively, a separate weigh crate can be placed in a tunnel, allowing for drafting after weighing, preferably with platform scales, to streamline the process.

2.8. Health Management

Health management for deer encompasses various aspects of care. It is essential to prioritize disease control to ensure the overall well-being of these animals. Farmers play a crucial role in maintaining their animals' health and conditioning them to resist infections effectively. Developing a strong rapport with a veterinarian is essential because together, they can create tailored disease control programs to maximize

animal health and productivity. Detecting any unusual behavior in individual animals is a practical method to identify issues early on. To bolster their health and resistance to diseases, it is vital to keep deer well-fed and minimize stress during handling. Diseases in deer can stem from different sources, whether intrinsic flaws, exogenous poisons, or parasitic organisms. Nutritive deficiencies, such as selenium and copper deficiencies, can lead to serious health problems and even death. Excessive selenium use can be toxic. Trauma resulting from inadequate handling facilities and excessive pressure during mustering can result in fractures and mortality. Parasitism, particularly lungworm infections, poses a significant threat to deer, but strategies like pasture rotation and deworming programs can help mitigate these issues. Furthermore, various diseases, including bluetongue, brucellosis, and clostridial infections, can affect deer, underscoring the importance of vaccination and prevention measures. Regular veterinary check-ups and vigilant monitoring are critical for maintaining the health and well-being of deer, especially in a captive environment like the Bangladesh National Zoo, where funding predominantly relies on visitor ticket sales (Figures 3 & 4).

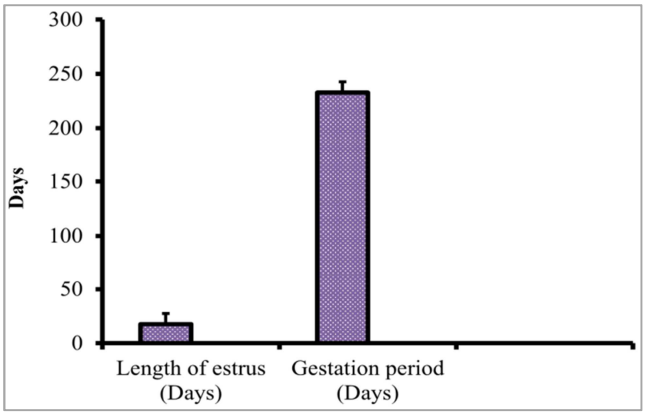

Figure 3. *Length of estrus and gestation period of spotted deer at Bangladesh National Zoo.*

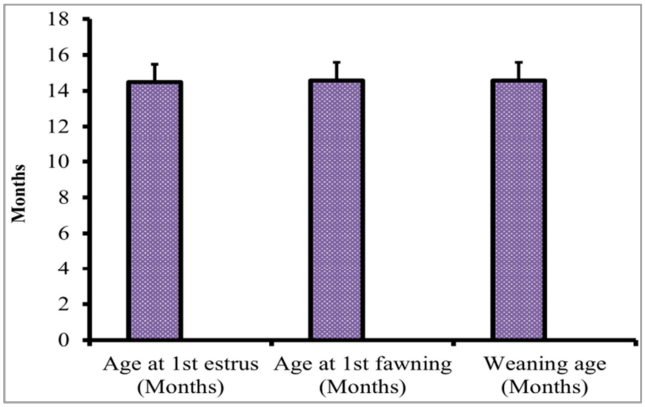

Figure 4. *Age at 1st estrus, fawning and weaning age of spotted deer at Bangladesh National Zoo.*

2.9. Statistical Analysis of Data

The data collected for various parameters were organized and tabulated systematically to facilitate statistical analysis. Using SPSS (Version 20.0), we conducted an analysis that included calculating the mean, standard error of the mean, standard deviation, and variance.

3. Results and Discussion

3.1. Feeds and Feeding

The data presented in Table 1 indicates that the deer at Bangladesh National Zoo (BN Zoo) consumed a total of 8.12 kg of feed on a fresh basis and 2.079 kg on a dry matter basis. Throughout the experimental period, the deer's diet consisted of maize fodder (*Zea mays*), gourd spinach (*Impomoea aquatica*) as leafy vegetables, pumpkin (*Cucurbita moschata*), cucumber (*Cucumis Sativus*) as vegetables, and grain (*Cicer Arietinum*), soybean, and wheat bran as concentrates. This ration supplied to adult deer contained 13.63% crude protein (CP) and 14.38 MJ of metabolizable energy per day (Table 1). While free-ranging spotted deer typically forage on various grasses, creepers, shrubs, tree leaves, and vegetables, the confined deer at BN Zoo had limited access and relied predominantly on the provided feed, with minimal grass browsing. The composition of green fodder, leafy vegetables, and succulent vegetables in their diet varied with the seasons and market availability, including Khira (*Cucumis sativas*), Sasa (*Saha Senanensis*), Misty Cumra (*Cucurbita moschata*), and Cabbage (*Brassica olaracea*) in different seasons. However, it's worth noting that the crude protein content fell below the requirements outlined by Moon et al. (2000), although metabolizable energy levels were relatively close to the requirement [11]. Moon et al. observed that daily dry matter intake (DMI) for adult spotted deer ranged from approximately 2.0% in winter to 2.3% in summer. Similarly, DMI for fallow deer ranged from 2.7% to 3.8% [12]. Adam (1994) reported DMI values of 1.7, 2.0, 2.3, and 3.0 kg/d/hind in autumn, winter, spring, and summer, respectively, and 1.4, 1.3, 2.0, and 2.2 kg/d/growing calves [13]. For maintenance energy, Fennessy (1981) indicated a requirement of 16-18 MJ for adult spotted deer [14], while successful growth, antler development, and reproduction in deer required protein diets in the 13-16% range [15]. Fallow fawns, in particular, benefited from a higher crude protein level of approximately 16% to achieve their target live weights [16]. Adam (1994) specified crude protein requirements as 17, 10, 12-17, 10, 14, 17, and 10, 12% for autumn, winter, spring, and summer in calves, hinds, and stags, respectively [13]. Female fawns (white-tailed deer) required 13% crude protein for maximum growth [17]. Denholm (1984) suggested dietary crude protein requirements for optimum growth ranging from 13 to 15% [18]. According to French et al. (1956), young male fawns (white-tailed deer) needed 13% to 16% crude protein in their diet [19]. The energy concentration for empty body weight was determined to be 17.5 MJ/kg and 21.7 MJ/kg, while the protein content was 150 g/kg and 146 g/kg (ARC, 1980). Referring to Adam's (1994) nutritional requirements for spotted deer [13], it was evident that there was a 4.5%

deficiency in crude protein and a 1.66 MJ per day deficiency in metabolizable energy in the supplied feed (Table 2). This discrepancy implies an imbalance between crude protein and energy supply to the deer at BN Zoo, which could potentially hinder proper growth, development, and reproductive performance. To address these nutritional deficiencies, Table 3 outlines the recommended ration for deer.

Table 1. *Chemical composition of feed consumed by experimental spotted deer at Bangladesh National Zoo.*

Name of feed		% DM	% CP	ME (Kcal/kg)
Local name	**Botanical name**			
Maize fodder / Jambu grass	*Zea mays /sesbania bispinosa*	18	7.91	230
Gourd spinach	*Impomoea aquatica*	15	8.1	131
Cabbage	*Brassica oleracea*	10	1.3	260
Pumkin	*Cucurbita moschata*	14	2.1	430
Gourd	*Lagenaria Siceraria*	14	1.9	420
Cucumber	*Cucumis Sativus*	14.1	1.8	410
Grain	*Cicer Arietinum*	12.51	19.68	720
Soybean meal		88	45	2500
Wheat bran		88	14	1600
Common salt		90	-	-
Vit-min premix	-	-	-	-

Table 2. *Nutrient intakes by the spotted deer at Bangladesh National Zoo.*

Name of feed		Amount supply (kg)/deer	DMI (kg/ deer)	% CP (intake/ deer)	ME (kcal/kg)/ deer
Local name	**Botanical name**				
Maize fodder	*Zea mays / sesbania bispinosa*	3.0	0.54	2.07	690
Gourd spinach grass	*Impomoea aquatica*	2.0	0.3	1.15	262
Cabbage	*Brassica oleracea*	0.5	0.05	0.033	130
Pumkin	*Cucurbita moschata*	0.6	0.084	0.086	258
Gourd	*Lagenaria Siceraria*	0.5	0.07	0.063	210
Cucumber	*Cucumis Sativus*	0.4	0.056	0.048	164
Grain	*Cicer Arietinum.*	0.2	0.177	1.68	144
Soybean meal		0.26	0.229	4.95	650
Wheat bran		0.6	0.528	3.55	960
Common salt		0.05	0.045	-	-
Vit-min premix	-	0.01	-	-	-
Total		8.12	2.079	13.63	14.38 MJ

Table 3. *Recommended rations for spotted deer.*

Name of feed		Amount supply (kg) (kg)/deer	DMI (kg) deer	% CP intake / deer	ME (kcal/kg) / deer
Local name	**Botanical name**				
Maize fodder / Jambu grass	*Zea mays / sesbania bispinosa*	3.00	0.54	2.07	690
Gourd spinach	*Impomoea aquatica*	2.00	0.30	1.15	262
Cabbage	*Brassica oleracea*	0.5	0.05	0.033	130
Pumkin	*Cucurbita moschata*	0.6	0.084	0.086	258
Gourd	*Lagenaria Siceraria*	0.6	0.08	0.066	252
Cucumber	*Cucumis Sativus*	0.5	0.060	0.058	164
Grain	*Cicer Arietinum*	0.3	0.187	1.78	216
Soybean meal		0.3	0.239	0.500	750
Wheat bran		0.7	0.548	3.65	1120
Common salt		0.05	0.045		-
Vit-min premix	-	0.001	-	-	-
Total		8.5	2.088	13.893	15.82 MJ

Table 4. *Body weight of spotted deer at Bangladesh National Zoo.*

Traits	No. of animal	Mean	Standard error of mean (SEM)	Standard deviation (SD)	Maximum	Minimum
Male birth wt. (kg)	15	2.97	0.17	0.67	4.10	1.8
Female birth wt. (kg)	15	2.73	0.17	0.65	3.90	1.70
Adult male wt. (kg)	15	78.08	2.17	8.39	88.90	62.20
Adult female wt. (kg)	15	60.97	1.77	6.87	74.50	51.30
Male weaning wt. (kg)	15	19.05	0.76	2.96	24.30	15.30
Female weaning wt. (kg)	15	18.49	0.58	2.24	22.30	15.20

Table 5. *Reproductive performance of spotted deer at Bangladesh National Zoo.*

Traits	No. of animal	Mean	Standard error of mean (SEM)	Standard deviation (SD)	Maximum	Minimum
Length of estrus (Days)	15	17.40	0.54	2.10	21.10	14.50
Age at 1st estrus (Months)	15	14.48	0.43	1.65	18.30	11.50
Gestation period (Days)	15	232.69	1.48	5.73	241.10	223.70
Age at 1st fawning (Months)	15	14.58	0.43	1.68	18.20	12.00
Weaning age (Months)	15	5.19	0.18	0.68	6.20	4.00

Table 4 depicts the body weight data of spotted deer at BN Zoo. The average birth weight for both male and female spotted deer fawns was approximately 2.97±0.17 kg and 2.73±0.17 kg, respectively. Birth weights displayed some variation, ranging from the highest recorded at 4.10 kg for males to 3.90 kg for females, with the lowest observed at 1.80 kg for males and 1.70 kg for females. These findings align with Mulley's (1984) research, which also reported similar average birth weights of 4.5 kg for males and 4.2 kg for females [20]. Ables (1977) documented average birth weights of 3.5 kg for males and 3.0 kg for females. Typically, fawn birth weight is estimated at around 10% of their mother's weight, as indicated by Kay and Staines (1981) and Mulley et al. (1990) [22]. The study further reveals that adult males averaged 78.08±2.17 kg, while adult females weighed approximately 60.97±1.77 kg. The highest recorded weights were 88.90 kg for males and 74.50 kg for females, whereas the lowest recorded weights were 62.20 kg for males and 51.30 kg for females. These results are in accordance with Ables' (1977) suggestion that adult males and females should ideally attain weights within the range of 85.00 kg and 70.00 kg, respectively [23]. It's important to note that body weight plays a pivotal role in reproduction. Studies have indicated that young hinds weighing less than 60.00 kg during rutting did not successfully produce calves [24]. Therefore, appropriate weight management is essential for ensuring successful reproduction in deer. In Table 5, the average weaning weights for males and females were recorded at 19.05±0.76 kg and 18.49±0.58 kg, respectively. The highest recorded weights were 24.30 kg for males and 22.30 kg for females, while the lowest recorded weights were 15.30 kg for males and 15.20 kg for females. These values are in line with the findings of Mulley (1984), who reported mean weaning weights of 19.4 kg for males and 18.5 kg for females [20]. Typically, weaning occurs at an average weight of 18.00 to 21.00 kg, as noted by Mulley et al. (1990) [22]. In summary, this study provides valuable insights into the body weight, birth weight, and weaning weight of spotted deer at BN Zoo. This information holds significance for effective management and the overall well-being of these animals.

Table 6. *Experimental Deer Disease.*

Identify of Experimental Animals	Deer Disease Name														
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15
Calves (Fawn)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Buck or Stags	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Doe or Hinds	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Pregnant Deer	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Weaning Animals	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×

3.2. Health Status of Experimental Animals

Throughout the examination period, it's worth noting that none of the deer at the Bangladesh National Zoo displayed any signs of illness, as indicated in Table 6. Our observations and efforts to scrutinize their health were meticulous. Nevertheless, it's important to acknowledge that diseases in animals, including deer, can arise due to various factors such as the presence of bacteria, viruses, parasites, and nutritional deficiencies. It's worth highlighting that during the examination, we did not administer any medicines to the deer. This underscores the importance of effective management practices in maintaining the health and well-being of these animals. The absence of disease among the deer during the examination period is a testament to the successful management strategies employed at the zoo, which prioritize the animals' welfare and overall health.

4. Conclusion

In conclusion, this study underscores the critical importance of maintaining balanced nutrition and implementing effective management practices to ensure the overall well-being of spotted deer in captivity. The Bangladesh National Zoo's expansive and natural habitat has been instrumental in providing a secure environment for these animals. Furthermore, the research illuminates the promising economic prospects of commercial deer farming, considering the high demand for deer-related products in the market. This study not only adds valuable insights into the care and conservation of spotted deer but also highlights their significant economic potential within the realm of captive wildlife management.

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Conflicts of Interest

The authors declare no conflicts of interest.

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