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Assessing the Productivity of BLRI-Developed Native Ducks at the Community Level Compared to Indigenous Ducks in Conventional Farming Systems

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ABSTRACT

Duck farming is a profitable business in low-lying areas of Bangladesh. The present study aimed to disseminate Bangladesh Livestock Research Institute (BLRI) developed native ducks BLRI-1(Rupali) and BLRI-2 (Nageswari) and validate their production ability compared to indigenous ducks under existing farming conditions in Bhanga upazila of Faridpur. An experiment was done at the community level where 45 farmers were selected based on their duck type. Data on the productive potentials of BLRI-developed native ducks were recorded and compared with the local germplasm of ducks. Among 45 duck-rearing farmers, with an average age of 38.58 years and farming experience of 12.38 years. Ducks were raised under scavenging conditions where 82.2% of farmers used separate duck houses and regular house cleaning was practiced by 68.89% of farmers. Ducks were consistently fed paddy, rice, and rice bran whereas 82.2% of farmers provided supplement feed with duckweed, and 15.6% supplied ready-made feed. The highest growth performance was observed for Rupali ducks growing to 1505.62 g by 24 weeks, compared to 1486.07 g for Nagesawri ducks. The highest egg production was 192.00 ± 5.70 eggs in Nageswari ducks followed by 181.33 ± 7.55 eggs for Rupali. Statistically significant differences were observed in adult male and female weights, eggs per clutch, and egg weight among the three breeds. Most of the farmer (84.4%) vaccinate their duck, against Duck Plague and Duck Cholera. The highest incidences of Duck Plague and Duck Cholera were observed in Native duck farms in comparison to BLRI-developed duck farms. Farmers obtained the highest Net income 8149.00 BDT (68.04 USD) and Benefit-Cost Ratio (BCR) of 1.60 in Rupali ducks compared to the Indigenous ducks at 1.30 whereas the overall BCR in duck rearing was 1.49. Major constraints regarding duck farming were disease outbreaks (73.3%) and high feed prices (64.4%). Thus, the study highlighted the significant variations in the performance and economic viability of ducks and emphasized farmers' training and breed-specific management strategies such as improved housing; feeding, and disease management practices to boost the profitability of duck farming.

Keywords: Benefit-cost ratio, BLRI duck, Disease outbreak, Growth performance, Native duck, Profitability

INTRODUCTION

Raising poultry plays a crucial role in livestock farming providing nutrition and a source of household earnings for small-scale, marginal, and landless poor farmers (Rahman et al., 2020). Many farmers who cannot afford to keep large animals such as cattle and goats can more easily raise poultry. Duck is one of the second largest poultry species that is raised in the southern and harbor regions of Bangladesh. The environment and climate of Bangladesh are favorable to duck rearing. Duck raising is popular worldwide, but more than 75% of the ducks were reared in Asia (Ahmed et al., 2021). The total duck population in Bangladesh was 68.261 million and is the second in number among poultry species in Bangladesh (DLS, 2024). The population of ducks is increasing in Bangladesh. According to the Food and Agricultural Organization (FAO), Bangladesh reared a lot of ducks and obtained positions 11th and 4th in duck meat and egg production among Asian countries (Pingle, 2011). Native duck germplasm has been reared in Bangladesh for both meat and egg purposes. Duck rearing in the traditional way has been practiced for different centuries in Asia (Parvez et al., 2020; Jalaludeen and Churchil, 2022).

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Ducks are reared in rice fields, canals, and rivers to access their feeds (Khatun et al., 2020). Duck plays a crucial role in income generation, nutrition supplement, and job opportunity creation for the people living in low-lying areas of Bangladesh. Ducks offer several benefits, including strong disease resistance, exceptional foraging skills in wetland environments, and natural flocking tendencies. Native duck germplasm has been reared in Bangladesh for both meat and egg purposes (Ahmed et al., 2021). To empower small farmers and landless laborer families through a holistic and self-sufficient strategy that not only improves income, employment, and nutrition but also promotes community development, gender equality, and environmental protection, all within the broader scope of rural development, where ducks serving as a key resource (Caron et al., 2009). Duck farming is an important part of sustainable livelihood development for poor rural communities and also an additional source of household income (Islam et al., 2023). The growth performance of ducks is higher than chickens (Das et al., 2020). Duck farming can play a significant role in increasing egg and meat production in Bangladesh. The backyard duck is a greater source of human resource development in low-lying areas of Bangladesh. However, duck farming in Bangladesh decreased due to several reasons such as shrinking water bodies, pollution of grazing fields, difficulty in obtaining inputs like ducks, feed, and medications, difficulties with marketing, and disease outbreaks (Sheheli et al., 2023). Furthermore, Bangladesh Livestock Research Institute (BLRI) initiated two native ducks BLRI-1 (Rupali) and BLRI-2 (Nageshwari) by phenotypic, productive, and reproductive characteristics improvement through selective breeding of high-yielding native germplasm (Khatun et al., 2020). These duck breeds have been improved to meet the demand for eggs and meat in Bangladesh. Several studies suggest that exotic ducks are not well-suited and not showed always better performance (Ali, 2020; Ali and Islam, 2021). However, BLRI-improved ducks are much suited to Bangladeshi climatic conditions. This developed duck had a higher growth rate and egg production in comparison to local duck breeds. Many studies have been done at one station to identify the productive, reproductive, and phenotypic characteristics of the BLRI-1 and BLRI-2 ducks under intensive farming conditions (Islam et al., 2014; Khatun et al., 2020). No studies were carried out at the field level to evaluate the growth, productivity, and reproductive performance along with the profitability of farmers in BLRI-developed duck rearing compared to native ducks. *This study aims to compare the productivity and adaptability of BLRI-developed native ducks (BLRI-1 and BLRI-2) with indigenous ducks in conventional farming systems.* This study was undertaken with the following objectives: a) To know the socioeconomic conditions of farmers along with duck farming and health management at the community level; b) To know the growth and productive performance of BLRI improved native ducks in comparison to local germplasm; c) To know the profitability and constraints of duck farming in the selected community.

MATERIAL AND METHODS

Study areas and duration

The study was conducted at BLRI Technology Village, Jandi; a low-lying area of Bhanga upazila under Faridpur district in Bangladesh from June 2022 to July 2024. Bhanga Upazila is located at 23.3971°N (latitude) and 90.0036°E (longitude) where the average annual rainfall is 2000-2500 mm the temperature ranges from 12 to 40^0C and the humidity ranges between 55-75%. This is a low-lying area of Bangladesh where BLRI established a technology at Jandi village to disseminate BLRI-developed technologies. Duck farming is very suitable in the selected area.

Experimental design

The experiment was performed by categorizing the duck into 3 distinct groups: Rupali, Nageswari, and Indigenous duck. Each group was formed with 15 duck farmers. A total of 10 Rupali and 10 Nageswari ducks were distributed to each farmer where each farmer got 8 female and 2 male ducks. In this study, the local native duck-rearing farmers were considered the control group farmers with at least 10 ducklings. All ducks were reared under the scavenging system, and the farmers provided two times a day minimal feed or no supplemental feed (Figure 1). The experimental design was utilized with a completely randomized design.

Data recording

Experimental data was recorded by regular observation and other data was collected through a pretested questionnaire. Data were recorded on socioeconomic conditions, duck rearing, feeding and management system, productive and reproductive performance, health and operational biosecurity, and constraints of farmers in duck rearing. Both experimental and descriptive data were collected to highlight the farming system and productivity of farms in low-lying areas of Bangladesh.

Figure 1. Scavenging of ducks in water bodies and farmers' feed supplementation, Bhanga, Bangladesh

Data analysis

Collected data were entered, sorted, compiled, tabulated, and organized into a Microsoft Excel sheet (MS Excel, 2021). Then data were statistically analyzed by Statistical Package for the Social Sciences (SPSS, Version-25). One-way ANOVA was done by the Duncan method to know the significance at the 5% level. All data was then tabulated using descriptive statistics such as frequency distribution, percentage, mean, and standard error value for further interpretation.

The net return was calculated by using the following formula:

Net return = GR-GC

Where GR is Gross return and GC is Gross cost.

GC = TFC+TVC

Where TFC is Total fixed cost and TVC is Total variable cost.

To calculate the benefit-cost ratio the formula was as follows:

$$\text{Benefit-Cost ratio} = \frac{\text{Gross return (GR)}}{\text{Gross cost (GC)}}$$

The benefit-cost ratio was a relative measure used to compare benefit per cost. It helped to analyze the financial efficiency of the farms. The multiple regression model was used to determine the effects of key variables in overall duck farming. The relationship between Y and X was established through regression analysis, where the variation in Y due to changes in X was estimated using a Linear Multiple Regression model, which is represented as follows:

$$Y = a + b1X1 + b2X2 + b3X3 + b4X4 + b5X5 + \ldots\ldots\ldots\ldots\ldots + b11X11 + e \ldots\ldots\ldots\ldots\ldots$$

Where, Y: Profit of Duck-rearing farmers (BDT/year), a: Constant b: Regression coefficient, X1: Hatched duckling value (BDT/year), X2: Bought duckling value, X3: Bought duck value, X4: Stock value of duck, X5: Feed value, X6: Treatment cost, X7: Labor cost, X8: Housing cost with 10% depreciation, X9: Miscellaneous Cost, X10: Age, X11: Family size, e: Error term. Along with different costs, age, and family size have a great impact on production and profitability in duck farming.

To simplify the estimation of the above equation, it is converted into a multiple linear form by applying the logarithm. The logarithmic version of the equation is as follows:

$$\text{Log } Y = \text{Log } a + b1 \log X1 + b2 \log X2 + \ldots b6 \log X6 + e$$

The multi-collinearity is an important component of multiple regression analysis. The multi-collinearity test examines the correlation among independent variables (X1, X2, X3, …, X11). Multi-collinearity is indicated when the correlation coefficients between these variables exceed certain thresholds (typically 0.85). If the correlation is less than or equal to 0.60, it suggests no significant multi-collinearity (Wantasen et al., 2024).

RESULTS

Socio-economic status of the farmer

In the present study, the average age of a farmer was 38.58 ± 1.72 years. The typical family size was 4.91 ± 0.21 members, and the average number of earning members per family was 1.31 ± 0.12. Additionally, the farmers had an average of 12.38 ± 1.44 years of farming experience (Table 1). The educational levels of farmers showed that 8.9% are illiterate, while 42.2% have completed primary education (Table 1). Additionally, 33.3% have an education level below the Secondary School Certificate (SSC), 13.3% have completed SSC, and only 2.2% have completed the Higher Secondary Certificate (HSC). Concerning occupation, it was revealed that all the duck-rearing farmers were housewives.

Housing and feeding management

The data on housing facilities for ducks in Table 2 reveals that 82.2% had separate duck houses. 97.8% of the farmers utilized wood for duck house construction purposes, while 2.2% used mud. Regarding floor type for duck housing, 95.6% of the farmers used wood, while 4.4% used mud indicating a strong preference for wooden flooring among the selected farmers, likely due to its practicality and durability in maintaining hygienic conditions for ducks. In the case of wooden floored houses, farmers used plastic bags as litter and could easily clean the floor. The wooden floor had less chance of damping and prevented the duck from contact with soil-borne disease organisms such as *Pasturella multocida* which causes duck cholera disease. In this study, 100% of farmers reared their ducks under scavenging. Farmers revealed the house cleaning practices that 55.56% used brooms for cleaning, while 33.33% used water and 11.11% used disinfectant. Poor cleaning practices increase the susceptibility to diseases. The study revealed that all farmers (100%) consistently fed their ducks with paddy, rice, and rice bran (Table 2). Additionally, 82.2% of the farmers supplemented the ducks' diet with duckweed, 53.3% included snails, and 15.6% provided ready-made feed which indicates that farmers did not provide balanced feed to their ducks and they take nutritional feed mainly from the environment during scavenging.

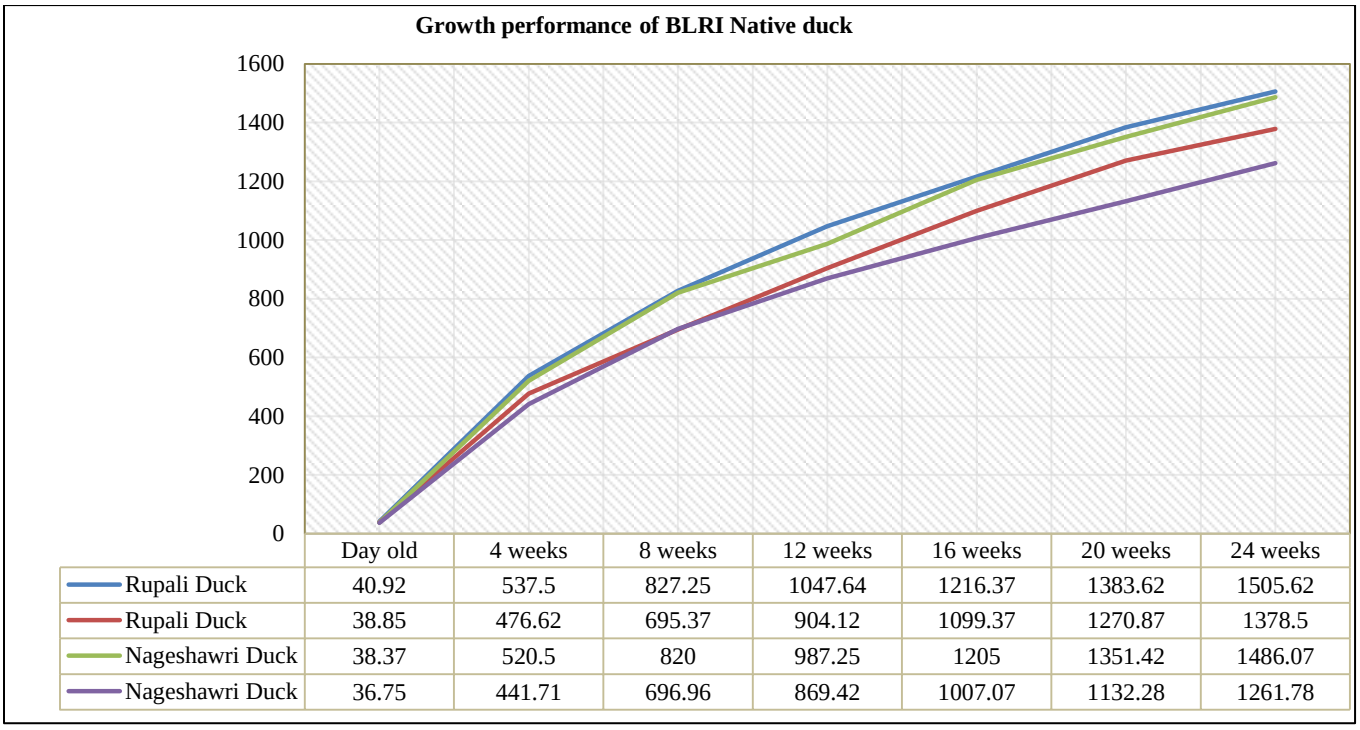
Table 1. Family status of duck-rearing farmer in the community of Bhanga, Bangladesh in 2024

Family Status of Farmers	Mean ± S. E. (n=45)	Parameter	Percent (n)
Age of farmer	38.58 ± 1.72	**Occupation:** Housewife	100.0 (45)
Family size	4.91 ± 0.21	**Training Facilities Received**	
Earning member	1.31 ± 0.12	DLS	4.4 (2)
Farming Experience	12.38 ± 1.44	BLRI	73.3 (33)
Education level	**Percent (n)**	**Total trained**	77.8 (35)
Illiterate	8.9 (4)	No training	22.2 (10)
Primary	42.2 (19)	**Purpose of duck earing**	
Below SSC	33.3 (15)	Extra Income	4.4 (2)
SSC	13.3 (6)	Family needs and extra income	95.6 (43)
HSC	2.2 (1)	Total	100.0 (45)
Total	100.0 (45)	-	-

S. E: Standard error, n: Number, SSC: Secondary school certificate, HSC: Higher secondary school certificate, DLS: Department of livestock services, BLRI: Bangladesh livestock research institute

Table 2. Housing facility and management system of duck in the community of Bhanga, Bangladesh during 2022-2024

Parameter	Percent (n)	Parameter	Percent (n)
Housing facility		**Floor-type**	
Separate duck house	82.2 (37)	Wood	95.6 (43)
Duck and chicken at the same house	17.8 (8)	Mud	4.4 (2)
System of rearing: Scavenging	100.0 (45)	**House cleaning practice**	88.89 (40)
Housing material		Cleaned by using a Broom	68.89 (31)
Mud and wood	2.2 (1)	Cleaned by Water	55.56 (25)
Wood and Tin	97.8 (44)	Cleaned by Disinfectant	33.33 (15)
Feed Ingredients			
Paddy	100 (45)	Duckweed	82.2 (37)
Rice	100 (45)	Snail	53.3 (24)
Rice bran	100 (45)	Ready feed	15.6 (7)



	Day old	4 weeks	8 weeks	12 weeks	16 weeks	20 weeks	24 weeks
Rupali Duck	40.92	537.5	827.25	1047.64	1216.37	1383.62	1505.62
Rupali Duck	38.85	476.62	695.37	904.12	1099.37	1270.87	1378.5
Nageshawri Duck	38.37	520.5	820	987.25	1205	1351.42	1486.07
Nageshawri Duck	36.75	441.71	696.96	869.42	1007.07	1132.28	1261.78

Figure 2. Growth performance of Rupali and Nageshwari duck at the community level of Bhanga, Bangladesh in 2022

The growth performance of BLRI improved native duck

The growth performance of BLRI-improved native ducks (Rupali and Nageshawri ducks) was documented across various stages of development in Figure 2. At day old, Rupali ducklings weighed 38.85 g and 40.92 g for females and males, respectively, while Nageshawri ducklings weighed 36.75 g and 38.37 g. By 24 weeks, Rupali male ducks reached an average weight of 1505.62 g, whereas Nageshawri male ducks weighed slightly less at 1486.07 g and then Rupali females were 1378.50 g and Nageshwari females were 1261.78 g, respectively. This data indicates that the Rupali duck had a higher growth rate than the Nageshwari duck.

Productive and reproductive performance of ducks at the community level

In the present study, it was examined adult female weights as 1.57 ± 0.06 kg for Rupali, 1.37 ± 0.06 kg for Nageswari, and 1.25 ± 0.11 kg for Indigenous Deshi ducks. Adult male weights averaged 1.78 ± 0.05 kg for Rupali, 1.56 ± 0.04 kg for Nageswari, and 1.45 ± 0.05 kg for Indigenous Deshi ducks (Table 3). Age at first laying was 210.00 ± 4.88, 205.33 ± 6.23, and 225.33 ± 5.70 days for Rupali, Nageswari, and Indigenous Deshi ducks respectively (Table 3, $p < 0.05$). Egg production per clutch was highest in Nageswari ducks with 36.73 ± 1.59 eggs, followed by Rupali with 34.33 ± 1.68 eggs and Indigenous Deshi with 26.67 ± 1.16 eggs. Overall egg production was highest in Nageswari ducks at 192.00 ± 5.70 eggs, followed closely by Rupali at 181.33 ± 7.55 eggs. Egg weight was significantly different among breeds, with Rupali eggs weighing 64.93 ± 0.67 g, Nageswari eggs 61.53 ± 0.58 g, and Indigenous Deshi eggs 62.06 ± 0.62 g ($p < 0.05$). Age at first laying and total egg production exhibited statistically significant differences ($p < 0.05$) where the adult boy weight of male and female ducks along with their egg production per clutches was significant at a 1% level ($p < 0.05$). These findings underscore the distinct performance characteristics observed among the different duck breeds. This variation was due to the improved variety of native ducks had higher performance than local germplasm.

Health, diseases, and biosecurity management of duck

The study documented the vaccination and deworming practices among duck farmers, revealing that 84.4% of farmers vaccinated their ducks overall, with 80.0% specifically vaccinating against Duck Plague and 40.0% against Duck Cholera. The majority of farmers (64.4%) administered vaccines every 6 months, while

20.0% opted for an annual schedule (Table 4). Additionally, 77.8% of duck farmers practiced deworming of ducks, primarily at 6-month intervals (71.1%). As all farmers didn't practice vaccination and deworming at regular intervals, disease outbreaks at a higher rate were observed during the study. Therefore, an awareness program needs to be applied to improve health management practices. Further study will be conducted to know the impact of vaccination and deworming on the health status of ducks.

Table 3. Productive and reproductive performance of different ducks at the community of Bhanga, Bangladesh in 2022-2024

Parameters	Rupali (Mean ± S.E.)	Nageswari (Mean ± S.E.)	Indigenous Deshi (Mean ± S.E.)	Overall (Mean ± S.E.)	Significant Level
Adult female weight	1.57 ± 0.06	1.37 ± 0.06	1.25 ± 0.11	1.39 ± 0.03	<0.001$^{(***)}$
Adult male weight	1.78 ± 0.05	1.56 ± 0.04	1.45 ± 0.05	1.59 ± 0.03	<0.001$^{(***)}$
Age at first laying	210.00 ± 4.88	205.33 ± 6.23	225.33 ± 5.70	213.55 ± 3.42	0.04$^{(**)}$
Weight at laying	1.64 ± 0.05	1.58 ± 0.08	1.64 ± 0.38	1.63 ± 0.13	0.98$^{(NS)}$
Egg per clutch	34.33 ± 1.68	36.73 ± 1.59	26.67 ± 1.16	32.58 ± 1.06	<0.001$^{(***)}$
Total egg production	181.33 ± 7.55	192.00 ± 5.70	168.00 ± 9.71	180.44 ± 4.66	0.11$^{(NS)}$
Egg weight	64.93 ± 0.67	61.53 ± 0.58	62.06 ± 0.62	62.84 ± 0.41	0.01$^{(**)}$

Different superscript letters in the same row differ significantly, $p < 0.05$; ***$p < 0.01$: Significant at 1% level; **$p < 0.05$: Significant at 5% level; NS > 0.05: Non-significant.; S.E: Standard error

Table 4. Vaccination and deworming practiced by community farmers of Bhanga, Bangladesh during 2022-2024

Parameter	Percent (n)	Parameter	Percent (n)
Vaccination practice	84.4 (38)	Deworming practice	77.8 (35)
Duck plague vaccination	80.0 (36)	**Deworming interval**	
Duck cholera vaccination	40.0 (18)	3 months	4.4 (2)
Vaccination interval		4 months	2.2 (1)
6 months	64.4 (29)	6 months	71.1 (32)
1year	20.0 (9)	-	-

Outbreak of diseases and biosecurity management

The experiment investigated disease outbreaks in duck farms shown in Table 5 revealing that the highest outbreak of duck plague (73.33%) and duck cholera (53.33%) was found for Native ducks while duck plague affected 46.66% and duck cholera affected 26.67% of Nageswari Duck farms. Moreover, 40.00% of duck plague and 33.33% of duck cholera outbreaks were observed in Rupali duck farms during the respective periods. In the study, farmers responded that the highest percentage of disease outbreaks predominantly occurred during winter (66.67%) in Nageswari Duck and were reduced in frequency during the following year, with outbreaks occurring in summer (13.33%) both in Nageswari and Native Duck. Additionally, the highest disease occurrence was about 60% or more in Nageshwari and local duck farms during the winter seasons whereas in Rupali duck farm 40% of disease outbreaks were observed during the summer month. The study examined biosecurity practices and management strategies for diseased and deceased ducks among farmers (Table 5). Results indicated that 97.8% of farmers reported that duck contact with wild birds was common due to rearing in a scavenging system. Moreover, the majority (91.1%) of farmer isolated and kept their diseased ducks in separate sheds. Regular cleaning of excrement was practiced by 57.8% of farmers. For deceased ducks, burial (53.3%) was the most common management method, followed by disposal in fields (26.7%), water (17.8%), and incineration (2.2%). Though the Department of Livestock Services was the main extension service worker to provide treatment facilities, the veterinarians from research teams provided treatment facilities to this selected community at a free cost to develop a livestock technology village. Their service rate was high in this community. That is why BLRI provides treatment support at 75.6%, with additional care provided

by quacks/ village doctors (33.3%), veterinary hospitals (4.4%), and farmers themselves (37.8%).

The benefit-cost ratio in duck farming

The study analyzed economic parameters across different duck breeds, revealing significant variations in financial metrics (Table 6). Rupali ducks demonstrated the highest net income of 8149.00 BDT (68.04 USD), with a Benefit-Cost Ratio (BCR) of 1.60, while Nageswari ducks showed a net income of 8048.47 BDT (67.20 USD) and a BCR of 1.59. Indigenous Deshi ducks exhibited a net income of 4303.67 BDT (35.93 USD) and a BCR of 1.30. The total average income of farmers from Rupali, Nageswari, and Indigenous Deshi ducks were 21721.33 BDT (181.37 USD), 21624.67 BDT (180.56 USD), and 18742.00 BDT (156.49 USD), respectively. The overall net income and BCR of the duck-rearing farmers were 6833.71 BDT (57.06 USD) and 1.49 in the chosen areas. These findings underscored the economic viability and profitability of duck farming, highlighting breed-specific differences in financial performance and efficiency.

Table 5. Diseases outbreak and biosecurity management by community duck farmers of Bhanga, Bangladesh in 2022-2024

Parameters (%)	**Rupali % (n)**	**Nageswari % (n)**	**Native duck % (n)**
Duck Plague	40.00 (6)	46.66 (7)	73.33 (11)
Duck Cholera	33.33 (5)	26.67 (4)	53.33 (8)
Season of disease outbreak			
Summer	40.00 (6)	20.00 (3)	26.67 (4)
Rainy	20.00 (3)	13.33 (2)	13.33 (2)
Winter	40.00 (6)	66.67 (10)	60.00 (9)
Parameters	**Percent (n)**	**Parameters**	**Percent (n)**
Overall Biosecurity management		**Diseased duck management**	
Contact with wild bird	97.8 (44)	Keep in the same shed	8.9 (4)
Cleaning of Excrement	57.8 (26)	Keep it in a separate shed	91.1 (41)
Death duck management		**Treatment facilities for duck**	
Throw in Field	26.7 (12)	By Veterinary Hospital	4.4 (2)
Buried	53.3 (24)	By Researcher of BLRI	75.6 (34)
Burnt	2.2 (1)	By Quack	33.3 (15)
Throw in Water	17.8 (8)	By Own self	37.8 (17)

Table 6. Benefit cost ratio in different types of duck farming in the community of Bhanga, Bangladesh during 2022-2024

Parameters	**Rupali**	**Nageswari**	**Indigenous Deshi**	**Total**
Hatched duckling value (BDT.)	753.33	826.67	913.33	831.11
Bought duckling value (BDT.)	580.00	503.33	673.33	585.56
Bought duck value (BDT.)	130.00	232.00	93.33	151.78
Stock duck value (BDT.)	1726.67	2253.33	3540.00	2506.67
Feed cost (BDT.)	4554.33	4608.87	3411.00	4191.40
Veterinary cost (BDT.)	860.00	483.33	473.33	605.56
Housing cost (10% depreciation) (BDT.)	318.00	280.67	275.33	291.33
Family labor cost (BDT.)	4346.67	4133.33	4780.00	4420.00
Other cost (BDT.)	303.33	254.67	278.67	278.89
Gross cost (BDT.)	13572.33	13576.20	14438.33	13862.29
Family needs duck value (BDT.)	2003.33	2123.33	2640.00	2255.56
Sold duck value (BDT.)	3753.33	4200.00	5373.33	4442.22
Stock duck value (BDT.)	4096.67	4533.33	4261.33	4297.11
Family needs egg value (BDT.)	7741.33	6550.67	4118.67	6136.89
Sold egg value (BDT.)	4126.67	4217.33	2348.67	3564.22
Gross income (BDT.)	21721.33	21624.67	18742.00	20696.00
Net Income (BDT.)	8149.00	8048.47	4303.67	6833.71
Benefit cost ratio (BCR)	1.60	1.59	1.30	1.49

Production function analysis (multiple regression test)

The results of the estimation of the model for multiple regression analysis on Duck rearing are shown in Table 7.

Interpretation of the estimated model

The analysis of the production function indicated that the values of hatched ducklings, feed costs, and labor expenses significantly affected the gross returns and profits from Duck production.

Value of hatched ducklings (X_1)

It was found that the regression coefficient for the value of hatched ducklings was estimated at 0.527 for Ducks, which is significant at the 1% probability level. This indicates a positive relationship between the value of hatched ducklings and gross returns (Table 7).

Feed value (X_5)

In the case of feed cost, the regression coefficient was 0.444 for the duck farmers which was significant at a 1% probability level. As a result, a positive relationship was found between feed value and gross returns.

Labor cost (X_7)

The estimated coefficient for labor costs was 0.262 for farmers raising ducks, and this result was significant at the 1% probability level.

Value of R^2

The R^2 value of 0.732 suggests that 73.2% of the total variation in gross returns among native duck-rearing farmers is accounted for by the variables included in the model which means that 26.8% of the variation remains unexplained, likely due to other factors that were not included in the model.

Value of adjusted R^2

The adjusted R^2 value of 0.643 is shown in Table 7 which indicates that 64.3% of the total variation in total income from native duck farming is explained by the variables in the model.

F-change

The F change of the model derived was 8.200. This value was significant at a 1% probability level implying that all the explanatory variables included in the model were important for explaining the variation in total return and profit for duck farming.

Multi-collinearity test of independent variables included in the regression analysis

The results presented in Table 8 revealed that all correlation coefficients were below 0.85, which represents that there is no multi-collinearity and no significant relationships among the independent variables.

Constraints of farmers in duck rearing

The study detected several constraints encountered by the farmers in duck rearing shown in Table 9. These included the outbreak of diseases was the highest ranking, affecting 73.3% of farmers, and high feed prices were the second-ranked, which were a concern for 64.4% of farmers. Other significant challenges included lack of training (28.9%), vaccine shortages (28.9%), and attacks by predatory animals (hawks, foxes, Mongoose, and other wild animals) 22.2%. Additionally, high duckling prices (17.8%), poor veterinary services (15.6%), and theft (11.1%) were reported as constraints. A smaller proportion of farmers cited lack of quality ducklings (13.3%), unavailability of ducklings (2.2%), and uncertainty in profitability (2.2%) as challenges in duck rearing.

Table 7. Profit-function analysis in duck farming through multiple regression in Bhanga, Bangladesh

Parameters	Regression coefficients	t-value	Significant level
(Constant)	1927.275	0.428	0.672
Hatched duckling value (X_1)	0.527	4.276	0.001***
Bought duckling value (X_2)	0.005	0.051	0.959
Bought duck value (X_3)	0.141	1.368	0.181
Stock value of duck (X_4)	0.010	0.099	0.922
Feed value (X_5)	0.444	4.560	0.001***
Treatment cost (X_6)	0.033	0.320	0.751
Labor cost (X_7)	0.262	2.488	0.018**
Housing cost with depreciation (X_8)	0.171	1.238	0.225
Other cost (X_9)	0.088	0.883	0.383
Age (X_{10})	-0.121	-1.071	0.292
Family size (X_{11})	-0.080	-0.763	0.451
R Square	0.732		
Adjusted R square	0.643		
F Change	8.200		0.001***

Different superscript letters in the same row differ significantly, $p < 0.05$; ***$p < 0.01$: Significant at 1% level; **$p < 0.05$: Significant at 5% level; NS > 0.05: Non- significant.

Table 8. Multi-collinearity analysis of independent variables included in the regression analysis

	X1 Log	X2 Log	X3 Log	X4 Log	X5 Log	X6 Log	X7 Log	X8 Log	X9 Log	X10 Log	X11 Log
X1 Log	0.00	0.03	0.59	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00
X2 Log	0.01	0.31	0.00	0.00	0.00	0.35	0.00	0.00	0.00	0.00	0.00
X3 Log	0.01	0.25	0.22	0.15	0.00	0.16	0.00	0.00	0.00	0.00	0.00
X4 Log	0.18	0.08	0.03	0.30	0.04	0.01	0.00	0.00	0.00	0.01	0.00
X5 Log	0.24	0.18	0.02	0.24	0.00	0.31	0.00	0.07	0.00	0.00	0.01
X6 Log	0.21	0.00	0.01	0.05	0.00	0.00	0.01	0.26	0.00	0.11	0.01
X7 Log	0.02	0.01	0.00	0.03	0.68	0.02	0.03	0.00	0.08	0.01	0.01
X8 Log	0.00	0.00	0.00	0.02	0.02	0.03	0.19	0.02	0.23	0.13	0.12
X9 Log	0.26	0.06	0.00	0.14	0.12	0.02	0.04	0.06	0.27	0.02	0.56
X10 Log	0.07	0.01	0.02	0.04	0.04	0.08	0.64	0.56	0.06	0.54	0.26
X11 Log	0.00	0.07	0.11	0.01	0.09	0.01	0.08	0.03	0.37	0.17	0.02

Table 9. Constraints of farmers in duck rearing at Bhanga, Bangladesh in 2022-2024

Parameters	Percent (n)	Ranking	Parameters	Percent (n)	Ranking
Outbreak of disease	73.3 (33)	I	Poor Veterinary Service	15.6 (7)	VI
High feed price	64.4 (29)	II	Lack of Quality Duckling	13.3 (6)	VII
Lack of training	28.9 (13)	III	Theft	11.1 (5)	VIII
Vaccine shortage	28.9 (13)	III	Profit not guaranteed	2.2 (1)	IX
Attacked by predatory animal	22.2 (10)	IV	Unavailability of Duckling	2.2 (1)	IX
High duckling price	17.8 (8)	V	-	-	-

DISCUSSION

The age of the farmers in the study area was similar to the farmer's mean age found by Jha et al. (2015) and Afrin et al. (2016). Jha et al. (2015) reported that 52% of farmers were young and the literacy rate was 48% that were closely similar to the present study. A literacy rate of 57% was reported by Parvez et al. (2020) which seemed to be lower but a higher value for family size was also recorded than the present study. Afrin et al. (2016) presented the average family size was 5.8 of duck rearing farmers along with a higher literacy rate of 94% in the Kishoreganj district which was close to the present study. Afrin et al. (2016) presented that the majority (73%) of the farmers had not received any training. However, a higher percentage of trained farmers was observed in the study area. The dissimilar results were due to farmers being trained by the research team before on BLRI native duck farming and management.

It was observed that most of the farmer used separate housing for their ducks which was made of tin and wood. The study of Rahman et al. (2009) mentioned that most of the duck farmers (93.5%) provide separate duck houses. They also narrate that the duck house was constructed with tin and wood was 65.5%. These data were strongly supported by the present study. A comparatively higher percentage of wood and tin-made duck is seen in the current study areas than in the findings of Jha et al. (2015), where they mentioned that 50% of houses were built with tin and wood. It was observed that duck houses made of tin and wood were durable and long-lasting with relatively low costs involved. On the contrary, Alam et al. (2014) reported that 55% of farmers housed their poultry (chicken and duck) in the same house in their living premises whereas 45% used shelters made of wood and tin or soil and tin or a combination of soil bamboo and wood. Rahima et al. (2023) expressed that most of the poultry houses were constructed from tin and bamboo (88.82%) which was strongly aligned with the current study. All farmers in this study reared their ducks in a scavenging system. The study of Jha et al. (2015) was slightly related to the present study where they stated during the rainy

season, ducks were raised only on natural feed resources under a scavenging management system. The current study was consistent with the outputs of Rahman et al. (2009), who stated that most of the farmers (67.5%) mainly utilized ponds as the scavenging place for ducks. A study carried out by Rahima et al. (2023) revealed that a maximum of 97.64% of farmers raised their poultry in semi-scavenging conditions under a backyard poultry production system. 88.89% farmer practiced their duck house cleaning. The findings of Rahman et al. (2009) were slightly lower than the present study where they mentioned that approximately 45% of duck-rearing farmers followed cleaning practices of their duck houses 2 to 3 times a month while only 10.50% performed daily cleaning practices. Jha et al. (2015) stated that a maximum of 35.50% of farmers regularly cleaned the duck house and a few portions (14%) of farmers never followed cleaning practices in their farms. Alam et al. (2014) also reported that 50-60% percent of farmers cleaned their poultry houses daily and 30% followed house cleaning once a week. 73.53% of farmers usually cleaned poultry houses reported by Rahima et al. (2023). Those studies were more or less related to the results of the current study. Rahman et al. (2009) indicated that 62% of farmers provide additional feed ingredients like rice polish, broken rice, and wheat bran which was closely supported by the present findings. Jha et al. (2015) reported 53.50% and Parvez et al. (2020) found 50% of farmers provided additional supplement feed to optimize the egg production of their ducks. The report of Rahima et al. (2023) mentioned that farmers supplied different additional feeds nearly supported the present study. The variations in output were observed due to the locations of the study, financial capability, knowledge of daily requirements and supply of supplemented feed were different in the present study. Therefore, farmers selected locally available feed ingredients and used them as supplemented feed for duck rearing in the studied area.

The body weight at eight weeks of age in different ducks at the community level was lower than the finding of Khatun et al. (2016), which presented higher live weights of Rupali, and Nageswari ducks because of providing a balanced supplementary diet. For Rupali and Nageswari ducks, the mean live weights at day old were nearly similar to the report of Morduzzaman et al. (2015) but higher at 4 weeks and 8 weeks of age, where the body weight gain was lower at 12 weeks of age. After 8 weeks of age farmer didn't provide supplementary feed to their duck and ducks take feed only from natural sources as a result poor growth was observed after that time. By the way, Rupali and Nageswari ducks had higher body weight gain in comparison to the study of Islam et al. (2012), who found poor growth rates of Indigenous Deshi ducks. In the study of Islam et al. (2014), it was stated that the mean body weights of BLRI-1 (Rupali) and BLRI-2 (Nageswari) ducks at day old 34.69 g, 34.54 g while 378.95 g and 359.22 g in 4th weeks of age that was lower than present study but slightly similar to the body weight at 8th weeks 846.71 g and 844.43 g whereas higher body weight at 12th weeks of 1399.91 g and 1313.05 g, respectively compared to the present findings. However, the higher adult body weight (1690 g) was indicated by Alam et al. (2014) concerning native ducks in the Mymensingh district. A comparatively lower average body weight of duck (1.22 ± 0.19 kg) than the current findings was observed by Rahima et al. (2023) in the Jhenidah district.

The study report is slightly different from the study report of Khatun et al. (2016), who reported first egg production age was 154, 147, and 161 days with the weight at first egg laying of 1437 g, 1455 g, and 1435 g for Rupali, Nageswari and Local ducks reared with supplementary feeding at farmer's level. The egg weights of the Rupali and Native ducks in the study of Khatun et al. (2016), were nearly similar but lower for the Nageswari duck in comparison to the current study. According to the study of Khatun et al. (2020), the average annual egg production of Rupali and Nageswari ducks was relatively higher than the present findings because they conducted their experiment under an intensive management system. They also stated the higher egg weight than the current outputs in Rupali and Nageswari duck. Moreover, higher egg weight was reported by Sharma et al. (2002) in Nageswari duck. According to Momu and Hossain (2022), Deshi black ducks got quick sexual maturity at a younger age compared to Deshi white ducks. Islam et al. (2014) reported a lower average age at sexual maturity for BLRI-1 ducks and BLRI-2 ducks than the present study. In the studies of Morduzzaman et al. (2015), the average egg production of a single Nageshwari duck was 140 to 160 per year which was lower than the present findings. Zaman et al. (2005) reported that Nageswari ducks had a relatively lower annual egg production compared to the present study findings. Alam et al. (2014) conducted a study with locally available ducks (Deshi, Khaki Campbell, and Jending) in the Mymensingh district where they found comparatively lower results than the current study in terms of the average age at sexual maturity, annual egg production and egg weight. Rahima et al. (2023) observed a lower average egg production and egg weight compared to the current study. The differences in

results may have arisen due to farmers rearing different ducks under scavenging conditions. Ducks consumed feed from natural sources and farmers were not to provide any definite supplementary feed to their ducks.

In the case of vaccination and deworming 84.4% and 77.8% of farmers practiced, however, all of them did not follow the vaccination schedule. A different result was observed in the study of Rahman et al. (2009) where they reported that most of the respondents (85.5%) did not provide vaccines to ducks. Approximately, 86% of farmers did not practice vaccination for their poultry (Chicken and Duck) owing to a lack of sufficient knowledge and facilities for vaccination reported by Alam et al. (2014). In addition, Jha et al. (2015) indicated that 65% of farmers were not aware of the importance of vaccination; they did not even vaccinate their ducks. Conversely, 30.50% of farmers did not regularly practice the scheduled vaccination and 14.50% followed the regular vaccination schedule whereas only 8.82% of farmers vaccinated their poultry under backyard poultry production stated by Rahima et al. (2023). These variations may have arisen due to the difference in location and year of the study conducted with duck-rearing farmers. Vaccination and deworming reduced the outbreak of disease but due to irregular vaccination and deworming practices, farmers faced some challenges of disease outbreak. So further research and extension work is necessary to know the impact of vaccination and deworming along with minimization of challenges regarding disease outbreaks.

Duck plague is the most prevalent disease reported by Khan et al. (2018) similar to current findings. The finding of seasonal outbreaks of disease was contrary to Khan et al. (2018), where authors found a higher incidence of diseases in the rainy season. The variation may occur due to different agroecological locations, climatic circumstances, animal-raising methods, housing systems, and also variations in sample numbers. Rahman et al. (2009), reported that duck plague and duck cholera outbreaks were the frequently observed diseases of ducks which supports the present study. However, Rahman et al. (2009) announced that the maximum outbreak of diseases was found at 34.18% in summer. 49% of farmers responded to duck cholera, 22% to duck plague, and 18% responded to no disease outbreak in their duck in the Mymensingh district (Alam et al., 2014). In addition, Jha et al. (2015) stated that the majority of the farmers (65%) had incomplete ideas about duck diseases. They also reported that the inadequate nutrient supply and poor management practices were the main reasons behind the elevated occurrence of diseases during summer followed by the other two seasons. A similar result was seen in the case of Rupali and Nageswari ducks where Rahima et al. (2023) reported that Duck plague (45.50%) and duck cholera (22.82%) were the more frequent diseases in ducks. The present study showed differences in results from the above findings because the study locations and sample size were different among those studies. Although, duck plague and duck cholera were causal diseases in different ducks but winter season was more susceptible to disease outbreaks for ducks due to drastically falling temperatures, cold weather and lack of sufficient nutrient consumption were challenging for ducklings and grower ducks to adapt to the ambient temperature during the winter season. This outbreak of several diseases around the year reduced the willingness of farmers to duck farming. That is why duck farming at the community level has declined.

In the case of biosecurity practices, contact with wild birds is the major source of duck plague (Henning et al., 2009; Elmberg et al., 2017). The dissimilar results in treatment were observed according to the findings of Rahman et al. (2009), where they obtained that only 7.25% of farmers isolated and medicated their diseased ducks. They also reported that 92.75% followed the traditional treatment method and only 7.25% practiced the modern mode of treatment. Furthermore, it was reported that only 9.75% of farmers followed the burring of dead ducks whereas 90.25% of farmers directly brought down dead ducks somewhere else which caused environmental hazards. The difference in results in the recent study indicated the gradual increase in of awareness the sick and dead duck management practices among farmers in the study area. It was a common practice that, very few farmers usually reported to the health center and utilized the treatment facilities until the situation became severe with a risen mortality rate (Debnath et al., 2020). These findings underscore the diverse approaches to biosecurity and disease management in duck farming communities.

In terms of net income, the present findings were consistent with the results of Khatun et al. (2016). Parvez et al. (2020) reported a lower net return of 6735 BDT (56.33 USD) from duck rearing with a BCR of 1.30. Comparatively higher net income and BCR were observed because of the variations in study location, year, and number of respondents considered for the current study than that of the above studies. In the present study, the overall BCR of duck-rearing farmers was lower than the outputs of Afrin et al. (2016), where they reported the BCR was 2.03.

The present study indicated several challenges encountered by the farmers in duck rearing. These findings were related to Alam et al. (2014), who reported that conventional rearing methods, feed scarcity, poor housing facilities, disease outbreaks, inadequate access to vaccines and medicine, and attacks of predatory animals indicated as the major constraint for backyard poultry (chicken and duck) farming in Mymensingh district. On the other hand, Rahman et al. (2009) indicated that almost 100% of duck owners stated that the outbreak of diseases and higher prices involved in getting quality feed (97%) emerged to be notable constraints for duck-rearing farmers which strongly supported the present study. They also reported that due to a lack of proper knowledge and training facilities, the majority of the farmers (95.7%) were not aware of taking special care of ducklings. However, a lower percentage (28.9%) of farmers reported that they faced challenges due to a lack of training in the present study. Additionally, they identified issues such as theft (37%), the attacks of predatory animals (23%), and major potential to harm the paddy fields (16%) as social problems. The most common constraints of disease outbreaks (54.12%) followed by a lack of adequate knowledge and predatory animal attack for poultry rearing in backyard systems reported by Rahima et al. (2023).

CONCLUSION

In the current study, ducks were raised under scavenging conditions with locally available feed supplements. However, 82.2% of farmers used separate duck houses whereas regular house cleaning was practiced by 68.89% of farmers was not satisfactory. In the case of growth rate, it was observed that Rupali male ducks weigh about 1505.6 g and females 1378.5 g compared to Nagesawri male ducks 1486.07 g and females 1262.8 g at 24 weeks. The highest egg production was 192 eggs in Nageswari ducks followed by 181 eggs in Rupali and the lowest 168 eggs in local indigenous ducks which indicates BLRI native ducks had higher productivity than local ducks. About 84.4% of farmers vaccinated their ducks against the Duck Plague and Duck Cholera due to the regular vaccination program continued by BLRI in this community. However, the biosecurity practice was not at an acceptable level. The BCR in duck farming was in Rupali 1.60 and Nageshwari 1.59 which was almost similar but lower in local ducks at 1.30 due to poor productivity. The overall BCR in duck farming was 1.49. This BCR will be improved if it is possible to mitigate the challenges mentioned by duck-rearing farmers like outbreaks of disease, high feed price, poor knowledge, and unavailability of improved duck/duckling variety. After all, duck farming is a profitable business in waterlogged low-lying areas of Bangladesh. The growth performance of the BLRI-1 native duck (Rupali) was better than BLRI-2 Native duck (Nageswari) and Indigenous duck breeds where the egg production of the Nageswari duck was better than Rupali and Indigenous duck. From this study, it can be concluded that the socioeconomic status of farmers along with housing, feeding, breeding, health, and biosecurity management is not satisfactory. Therefore, extension service along with technical intervention through the identification of research gaps is very necessary to mitigate the challenge in duck farming. Future research should be imposed on technology-based duck farming improvement in lowland areas of Bangladesh.

DECELERATIONS

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Competing interests

There is no competing of interest.

Availability of data and materials

The data are available upon request from the corresponding author.

Ethical considerations

For this article to be published with scientific research standards in the Journal of the World's Poultry Research, all authors have ruled and agreed on ethical issues, including fabrication of data, double publication and submission, redundancy, plagiarism, consent to publication, and misconduct.

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Authors' contributions

This study was carried out in collaboration among all authors. Syidul Islam and Md. Ashraful Islam

conceptualized and designed the study, did the experiment in the community, and wrote the protocol and manuscript. Syidul Islam and Sharmin Sultana wrote the methodology, completed the formal analysis, and wrote the manuscript. Rezwanul Islam helped in data collection. Md Habibur Rahman helped to write the original manuscript. Syidul Islam, Md Ashraful Islam, and Sharmin Sultana edited the manuscript for final submission. Razia Khatun provided guidelines for writing the manuscript and financial support for the manuscript. All Authors read and agreed to publish the last edition of the manuscript.

REFERENCES

Afrin H, Begum R, Ahmed MJU, Rahman MA, and Haque S (2016). Profitability analysis and gender division of labour in duck rearing: A case of Kishoreganj district in Bangladesh. Progressive Agriculture, 27(4): 482-489. DOI: https://www.doi.org/10.3329/pa.v27i4.32138

Ahmed S, Sumon MSA, Famous M, Hossain MT, Zonayet M, and Hossain N (2021). A report on problems and prospects of duck rearing system at Jaintiapur Upazila, Sylhet, Bangladesh. Journal of Global Agriculture and Ecology, 11(2): 25-35. Available at: https://ikprress.org/index.php/JOGAE/article/view/6624

Alam MA, Ali MS, Das NG, and Rahman MM (2014). Present status of rearing backyard poultry in selected areas of Mymensingh district. Bangladesh Journal of Animal Science, 43(1): 30-37. DOI: https://www.doi.org/10.3329/bjas.v43i1.19382

Ali MZ (2020). Common respiratory diseases of poultry in Bangladesh: A review. SAARC Journal of Agriculture, 18(1): 1-11. DOI: https://www.doi.org/10.3329/sja.v18i1.48377

Ali MZ and nIslam MM (2021). Characterization of β-lactamase and quinolone resistant Clostridium perfringens recovered from broiler chickens with necrotic enteritis in Bangladesh. *Iranian journal of veterinary research*, 22(1): 48. DOI: https://www.doi.org/10.22099/ijvr.2020.36848.5376

Caron P, Craufurd P, Martin A, Mc Donald A, Abedini W, Afiff S, Bakurin N, Bass S, Hilbeck A, Jansen T, and Lhaloui S (2009). Impacts of AKST on development and sustainability goals. International assessment of agricultural knowledge, science and technology for development (AASTD), global report, chapter 3, pp. 145-253. Available at: https://agritrop.cirad.fr/550581/1/550581.pdf

Das S, Rahman S, Das S, Kalita G and Tolenkhomba T (2020). A socio-economic analysis of the duck farmers of Tripura. International Journal of Livestock Research, 10: 144-151. Available at: https://www.doi.org/10.5455/ijlr.20200623072018

Debnath J, Sarkar D, and Das TK (2020). Socio-economic status of duck farmers and duck rearing system in India: A review. Journal of Entomology and Zoology Studies, 8(6): 1262-1266. Available at: https://www.entomoljournal.com/archives/2020/vol8issue6/PartQ/8-5-378-437.pdf

Department of Livestock Services (DLS) (2024). Livestock economy at a glance 2023-2024, Ministry of Fisheries and Livestock, Bangladesh. Available at: https://dls.gov.bd/site/page/22b1143b-9323-44f8-bfd8-647087828c9b/Livestock-Economy

Elmberg J, Berg C, Lerner H, Waldenström J, and Hessel R (2017). Potential disease transmission from wild geese and swans to livestock, poultry, and humans: a review of the scientific literature from a One Health perspective. Infection Ecology & Epidemiology, 7(1): 1-21. DOI: https://www.doi.org/10.1080/20008686.2017.1300450

Henning KA, Henning J, Morton J, Long NT, Ha NT, and Meers J (2009). Farm-and flock-level risk factors associated with Highly Pathogenic Avian Influenza outbreaks on smallholder duck and chicken farms in the Mekong Delta of Viet Nam. Preventive Veterinary Medicine; 91(2-4): 179-188. DOI: https://www.doi.org/10.1016/j.prevetmed.2009.05.027

Islam MA, Khan MJ, Debi MR, and Rahman MM (2012). Growth performance of three genotypes of ducks in coastal region of Bangladesh. Bangladesh Journal of Animal Science, 41(1): 19-23. DOI: https://www.doi.org/10.3329/bjas.v41i1.11971

Islam MS, Khatun H, Islam MN, Faruque S, and Sarker MS (2014). Study on the productive and reproductive performances of BLRI-1 and BLRI-2 ducks in Bangladesh. A Scientific Journal of Krishi Foundation, The Agriculturists, 12(1): 10-14. DOI: https://www.doi.org/10.3329/agric.v12i1.19485

Islam R, Hussain J, Sarma M, Mahanta JD, Sapcota D, and Saharia AAJ (2023). Duck production and management practices in the rural areas of Assam. The Pharma Innovation Journal, 12(11S): 1671-1675. Available at: https://www.thepharmajournal.com/special-issue?year=2023&vol=12&issue=11S&ArticleId=24204

Jalaludeen A and Churchil RR (2022). Duck production: An overview. Duck production and management strategies, pp. 1-55. DOI: https://www.doi.org/10.1007/978-981-16-6100-6_1

Jha B, Hossain MM, Baishnab PC, Mandal PK, and Islam MR (2015). Socio-economic status of duck farmers and duck farming in haor areas of Sylhet district in Bangladesh. International Journal of Natural Sciences, 5(2): 73-79. DOI: https://www.doi.org/10.3329/ijns.v5i2.28615

Khan KA, Saha S, Hossain MT, Haque ME, Haq MM, and Islam MA (2018). Epidemiological investigation of recurrent outbreaks of duck plague in selected Haor (wetland) areas of Bangladesh. Journal of Advanced Veterinary and Animal Research, 5(2): 131-139. DOI: http://www.doi.org/10.5455/javar.2018.e256

Khatun H, Islam MN, Bhuyan AA, Hasan MN, and Islam MS (2016). Performance of BLRI developed native duck under farmer's condition with supplementary feeding. Bangladesh Journal of Livestock Research, 19(1-2): 18. DOI: https://www.doi.org/10.3329/bjlr.v19i1-2.26423

Khatun H, Sultana S, Faruque S, Sumon MRA, Sarker MSK, and Sarker NR (2020). Laying performance of 5th generation of BLRI improved native duck. Bangladesh Journal of Livestock Research, 7(1): 15-23. DOI: https://www.doi.org/10.3329/bjlr.v27i1.55166

Momu JM and Hossain MA (2022). Morphometric measurements, productive and reproductive performance of Deshi black and Deshi white duck. Emerging Animal Species, 4: 100009. DOI: https://www.doi.org/10.1016/j.eas.2022.100009

Morduzzaman M, Bhuiyan AKFH, Rana M, Islam MR, and Bhuiyan MSA (2015). Characterization of Nageswari Duck of Bangladesh. Bangladesh Journal of Animal Science, 44(2): 92-99. DOI: https://www.doi.org/10.3329/bjas.v44i2.26007

Parvez S, Miah MY, and Khan MH (2020). Smallholder duck farming: A potential source of livelihood in haor women in Bangladesh. Asian Journal of Medical and Biological Research, 6(1): 73-80. DOI: https://www.doi.org/10.3329/ajmbr.v6i1.46481

Pingle H (2011). Waterfowl production for food security. Lehman Information, 46: 34-37. Available at: https://d-nb.info/1016624441/34

Rahima FF, Jalil MA, Hossain MR, and Rahman MS (2023). Management system and productivity of backyard poultry in Jhenidah district of Bangladesh: A survey. Asian Journal of Medical and Biological Research, 9(1): 1-8. DOI: https://www.doi.org/10.3329/ajmbr.v9i1.62846

Rahman KM, Jamal Hossain M, and Shihab Rana M (2020). Livestock and poultry rearing by smallholder farmers in haor areas in Bangladesh: Impact on food security and poverty alleviation. Bangladesh Journal of Agricultural Economics, 41.1: 73-86. DOI: https://www.doi.org/10.22004/ag.econ.304171

Rahman MM, Khan MJ, Chowdhury SD, and Akbar MA (2009). Duck Rearing System in Southern Coastal Districts of Bangladesh. Bangladesh Journal of Animal Science, 38(1&2): 132-141. DOI: https://www.doi.org/10.3329/bjas.v38i1-2.9922

Sharma SS, Zaman G, Goswami RN, Roy TC, and Mahanta, JD (2002). Physical characteristics of Nageswari duck eggs of Assam. Indian Journal of Animal Science, 72: 77-1178. Available at: https://epubs.icar.org.in/index.php/IJAnS/article/view/38154

Sheheli S, Mithun S, Alom MN, and Banik S (2023). Profitability and Problems of Farmers in Duck Farming: A Study on Haor Areas in Bangladesh. International Journal of Agricultural Science, Research & Technology, 13(3): 195-202. Available at: https://journals.iau.ir/article_707547_7c4d3da0e25a6d65bb3a091eb852ae24.pdf

Wantasen E, Umboh SJK, and Leke JR (2024). Profit analysis of native chicken farming business in Kakas District, Regency of Minahasa, Indonesia. IOP Conference Series: Earth and Environmental Science, 1341(1): 012110. DOI: https://doi.org/10.1088/1755-1315/1341/1/012110

Zaman G, Goswami RN, Aziz A, Nahardeka N, Roy TC and Mahanta JD (2005) Farming system of Nageswari ducks in North-Eastern India (Assam). World's Poultry Science Journal, 61: 687-693. DOI: https://www.doi.org/10.1079/WPS200579