Chapter 1: Introduction

Poultry production is considered a crucial part of global development contributing to the achievement of several sustainable development goals and has become the fastest growing livestock sector worldwide (Hennessey et al., 2021). As a species next to chicken, duck contributes major sources of animal protein and it is an integral component of the mixed farming system to play substantial role in the economy of the developing country (Ahmed et al., 2021). According to the report of Food and Agricultural Organization the position of Bangladesh in respect to duck meat and egg production is 11^{th} and 4^{th} respectively among the Asian countries (Begum et al., 2020). Practice of raising chicken and duck or both are traditional in Bangladesh. Duck production has some focal points that they have more disease resistance capability than other poultry species, management system is simple, longer egg production life, they do not need elaborate housing, they naturally control pests and snails and they are great forager so requires less amount feed (Hossain et al., 2020a, 2021). Hence, duck production is increasing steadily in Bangladesh and has increased from 36.62 million in 2014-15 to 42.21 million in 2020-21 (DLS, 2021).

Household duck farming, mostly handled by women, is an important means of reducing poverty in the poor coastal households with low income and poor livelihood conditions (Parvez et al., 2020). There are different types of duck raising systems which can be classified as free range, semi-intensive and intensive. Household ducks forage snail, duck weed, fish and phytoplankton from nearby scavenging lands such as ditches, ponds, marshes and rivers to fulfill their nutritional requirements. However, the availability of these feed resources is affected by their locations, habitats and seasons (Hossain et al., 2020a). Satkhira district is the coastal area located at Southwestern part of Bangladesh near the Bay of Bengal and Sundarbans having many rivers and larger areas of waterbodies. There are many small-scale duck farmers who built their farms near to water bodies. Households duck rearing system practiced throughout this district as marshy lands are available. Tala upazila under Satkhira district occupies large areas of low-lying water reservoirs where water stands throughout the year. These water reservoirs contain plankton, small fishes, snails, insects and fallen grains which especially suitable for household duck rearing.

Most of the poultry researches done in Bangladesh are primarily focused on chicken and not on duck (Hossain et al., 2020a). There are some sporadic studies highlighting the potentiality,

productivity and profitability of duck rearing in the coastal and haor regions of Bangladesh (Begum et al., 2020; Kabir et al., 2020; Rahman et al., 2020; Ahmed et al., 2021). However, systematic studies related to the impacts of flock size of household duck on annual egg production, egg sale, consumption and their sub-sequent effects on socio-economic status of the duck owner, challenges and prospects of raising ducks in the coastal areas of Bangladesh are scant. We, therefore, aimed to investigate the current status, management systems, self-perceived prospects and challenges of raising household ducks and their contribution on income generation, sale and consumption of duck eggs and duck meat in the coastal areas of Satkhira district Bangladesh.

Chapter 2: Materials and Methods

Study design

A cross-sectional survey was carried out for 3 months from 15 April to 15 June, 2021. The study areas were randomly selected from 3 villages (Alipur, Nagarghata and Panchpara) under the Tala upazila in Satkhira on the basis of some well-defined specific criterions for the selection of households.

Study area

Satkhira is a district in southwestern Bangladesh and is part of Khulna Division. It is bordered to the north by Jashore District, on the south by the Bay of Bengal, to the east by Khulna District and to the west by 24 Pargana District of West Bengal, India. Satkhira has a latitude of 22°43'6.55"N and a longitude of 89°4'13.72"E. The annual average maximum temperature reaches 35.5 °C (95.9 °F) and minimum 12.5 °C (54.5 °F). The annual rainfall is 1710 mm. Electrical conductivity value of soil is slightly saline (5.93 dS/m) in dry season and non-saline (0.61 dS/m) in wet season (Kumar et al., 2019).

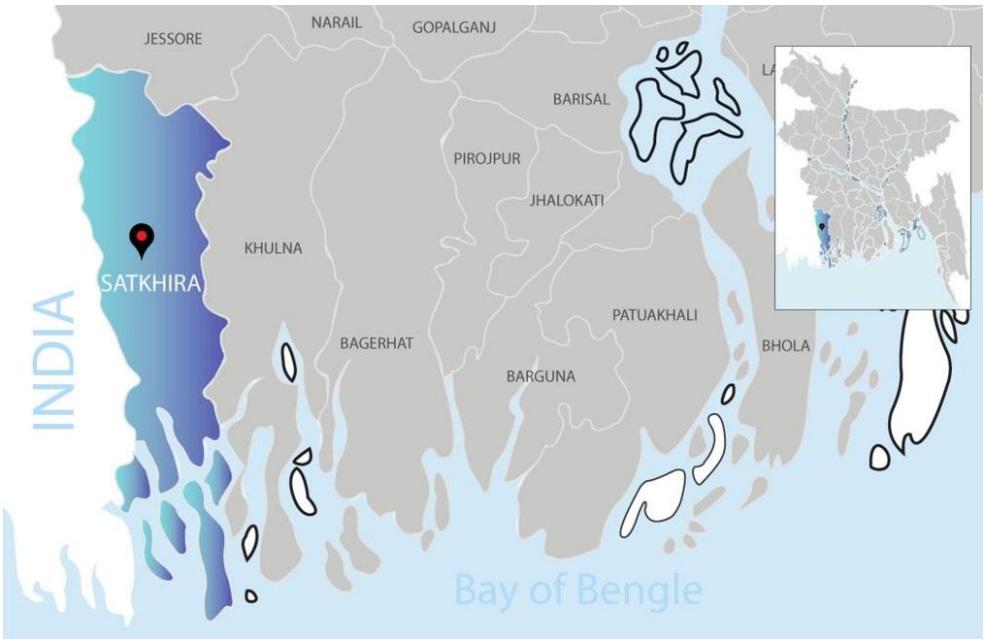

Figure 1. Map of the study areas

Farm selection

A total of 45 duck households were selected randomly from three villages under Tala upazila. Simple random sampling technique was followed for selecting the households. Households having five years as the minimum duck rearing experience, currently present at least one duck and one drake, availability of surrounding water body with scavenging feeds for ducks were selected for the study.

Farmer's interview

One interviewer (fourth year veterinary student from CVASU under supervision of CVASU academician) was trained in surveying and interviewing techniques at CVASU. Farmers were interviewed in their own premises. In order to get in depth, one interviewer interviewed only two farmers per day. It took around two hours to interview a respondent. A break of 30 minutes was taken between two subsequent interviews. An observation list was also completed during the farm visit. Institutional approval for conducting interviews with the duck households was obtained from CVASU.

Data collection

Before, the field survey, a structured questionnaire (Appendix I) and a survey protocol were developed to achieve targeted objectives. After briefing the objectives of the interview, verbal and written consents of the respondents were taken. At least one week before interview, the interviewer was given printed materials as guidelines for the survey. The interviewer was further trained up during the pilot testing by the senior faculty member. The questionnaire was pre-tested on 5% of duck households. Unwanted, ambiguous and long questions were eliminated through pilot-testing. Finally, comments and suggestions made by the respondents were incorporated to improve and update the questionnaire under the field conditions. Age, flock size, housing system, feeding system, vaccination, deworming, types of treatment, number of egg production, predators, required items and socio-economic conditions of the farmers were recorded in the data sheet through face to face interview.

Statistical analysis

Raw data were compiled into Microsoft excel professional 2020 (Microsoft corporation, USA). Outliers and multicolliniarity in the data set were tested by inter quartile range test and variance inflation factors. Normality of the response variable was checked by Shapiro Wilk test. Profile plots were used to measure the interactions of the covariates. The data were analyzed by Fisher's exact test and one way ANOVA. Kaiser-Meyer-Olkin measures of sampling adequacy and Bartlett's test of sphericity were applied to test the suitability of the dataset for the principal component analysis (PCA). Heatmap of multiple orthogonal contrasts were produced to check the latent trends, dimensionality and strengths of the co-variates. Based on maximum 'eigen' values, the test variables were standardized and contrasted against two PCA components labeled on 'x' and 'y' axes. When statistical effects were deemed significant ($p<0.05$), the Duncan's New Multiple Range Test (DMRT) was used to compare the means. All statistical tests were performed by using Stata 14.1 SE (Stata Corp LP, College Station, Texas, USA).

Chapter 3: Results

Socio-economy of the duck farmer

Age of the duck farmers were stratified into three principal categories, i.e., young (15-25 y), middle age (26-40 y) and old (>40 y). Majority of the respondents (53.3%) belonged to middle aged group followed by old (37.8%) and young (8.89%) respectively. All of them were women and housewives (Table 1).

The level of education of the farmers were also classified into three categories, e.g., illiterate, primary and secondary. Majority of the farmers obtained secondary level of education (46.7%) followed by primary education (42.2%) while the rest of them were illiterate (11.1%) (Table 1).

Annual income of the respondent farmers ranged from BDT 75,000 to 1,50,000. Depending on the level of income, the farmers were divided into three classes, i.e., low, medium and high income group. The most of the farmers (64.4%) belonged to the medium income group followed by high (31.1%) and low (4.44%) (Table 1)

Table 1. Socio-economic conditions of the duck farmers (N=322)

Variables	Type of breed			Total	P-value
	Deshi	Jinding	Khaki Campbell		
Age group (years)					
15-25	0.00 (0)	0.00 (0)	8.89 (4)	8.89 (4)	
26-40	2.22 (1)	6.67 (3)	44.4 (20)	53.3 (24)	0.616
41-65	2.22 (1)	0.00 (0)	35.6 (16)	37.8 (17)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Education					
None	0.00 (0)	2.22 (1)	8.89 (4)	11.11 (5)	
Primary	2.22 (1)	4.44 (2)	35.6 (16)	42.2 (19)	0.312
Secondary	2.22 (1)	0.00 (0)	44.4 (20)	46.7 (21)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Annual income (BDT)					
Low (<75,000)	0.00 (0)	0.00 (0)	4.44 (2)	4.44 (2)	
Medium (75000-1,00,000)	4.44 (2)	4.44 (2)	55.6 (25)	64.4 (29)	1.000
High (>1,00,000)	0.00 (0)	2.22 (1)	28.9 (13)	31.1 (14)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	

Flock structure

Three types of duck breed, i.e., Deshi, Jinding and Khaki Campbell were reared in the study areas. The percentage of Khaki Campbell (88.9%) was highest followed by Jinding (6.67%) and Deshi (4.44%) ducks. Average flock size of Deshi, Jinding and Khaki Campbell ducks were 5, 7 and 7.28, respectively (Table 3).

Housing systems

The farmers used a variety of materials for duck housing. The majority of them (88.9%) used brick-cemented house while 8.9% and 2.22% of them used earthen and wooden houses. None of them used any litter material. Few of them (29.0%) practiced integrated farming where both the ducks and chickens were reared (Table 2).

Feeding systems

All of the duck farmers reared their ducks in semi-scavenging system. They supplied insufficient, imbalanced feed, so, ducks largely relied upon scavenging feeds, i.e., snail, duck weed, earthworm, crab, frog, small fish and plankton for other essential nutrients. Very few of them (17.8%) supplied additional commercial poultry feed to their ducks. Average feeding frequency was 2.00, 3.33 and 2.53 for Deshi, Jinding and Khaki Campbell ducks, respectively (Table 3).

Table 2. Overall management practices of the Deshi, Jinding and Khaki Campbell ducks (N=322)

Variable	Type of breed			Total	P-value
	Deshi	Jinding	Khaki Campbell		
Type of housing					
Brick-cemented	4.44 (2)	6.67 (3)	77.8 (35)	88.9 (40)	1.000
Earthen	0.00 (0)	0.00 (0)	8.89 (4)	8.89 (4)	
Wooden	0.00 (0)	0.00 (0)	2.22 (1)	2.22 (1)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Use of litter materials					
Yes	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	1.000
No	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	101 (45)	
Share of chicken house with duck					
Yes	0.00 (0)	0.00 (0)	28.9 (13)	28.9 (13)	0.580
No	4.44 (2)	6.67 (3)	60.0 (27)	71.1 (32)	

Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Availability of scavenging lands					
Yes	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
No	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	1.000
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Frequency of feeding (no)					
2	4.44 (2)	0.00 (0)	44.4 (20)	48.9 (22)	
3	0.00 (0)	4.44 (2)	42.2 (19)	46.7 (21)	0.058
4	0.00 (0)	2.22 (1)	2.22 (1)	4.44 (2)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Use of commercial feed					
Yes	0.00 (0)	2.22 (1)	15.6 (7)	17.8 (8)	
No	4.44 (2)	4.44 (2)	73.3 (33)	82.2 (37)	0.643
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (40)	
Age at first laying					
6 month	2.22 (1)	2.22 (1)	73.3 (33)	77.8 (35)	
7 month	2.22 (1)	4.44 (2)	15.6 (7)	22.2 (10)	0.089
Total	4.44 (2)	6.67 (3)	88.89 (40)	100 (45)	
Annual egg production (no)					
Low (up to150)	4.44 (2)	0.00 (0)	2.22 (1)	6.67 (3)	
Medium (151-175)	0.00 (0)	4.44 (2)	46.7 (21)	51.1 (23)	0.006
High (176-200)	0.00 (0)	2.22 (1)	40.0 (18)	42.2 (19)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Regular cleaning of shed					
Yes	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
No	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	1.000
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Disease incidence					
Yes	2.22 (1)	2.22 (1)	53.3 (24)	57.8 (26)	
No	2.22 (1)	4.44 (2)	35.6 (16)	42.2 (19)	0.782
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Practice of quarantine					
Yes	0.00 (0)	0.00 (0)	4.44 (2)	4.44 (2)	
No	4.44 (2)	6.67 (3)	84.4 (38)	95.6 (43)	1.000
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Practice of deworming					1.000
Yes	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	
No	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	1.000
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Practice of vaccination					1.000
Yes	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	
No	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	1.000
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	

Performance parameters

The study showed that Deshi, Jinding and Khaki Campbell ducks started laying at an average age of 6.50, 6.67 and 6.18 months, respectively. Annual egg production was high in Khaki Campbell (176) followed by Jinding (173) and Deshi (140) (Table 3).

Table 3. Comparative performance of the three genotypes of household duck in the Satkhira district of Bangladesh reared under semi-intensive system (N= 322)

Breed	Comparative performance†			SE	P-value
	Deshi	Jinding	Khaki Campbell		
Flock size (no)	5.00	7.00	7.28	0.38	0.473
Feeding frequency (no/d)	2.00	3.33	2.53	0.09	0.023
Age at first laying (m)	6.50	6.67	6.18	0.06	0.091
Annual egg production (no)	140	173	176	2.20	0.001
Mortality (%)	10.00	9.52	12.37	0.16	0.837

†SE = Standard error of the means

Production, sale and consumption

An increased flock size was associated with increased annual egg production (Figure 2) which ultimately increased net annual family income (Figure 3). Further, an increased annual egg production concomitantly increased annual egg (Figure 4) and duck (Figure 5) sale. Accordingly, increased annual duck and egg production increased annual household consumption of duck egg (Figure 6) and duck meat (Figure 7). The heatmap indicates the graphical multiple correlation matrix among flock size, annual egg and duck production, sale and consumption and their association with annual income. An increased sale of duck is associated with reduced consumption and sale of duck egg and duck meat and the vice versa (Figure 8).

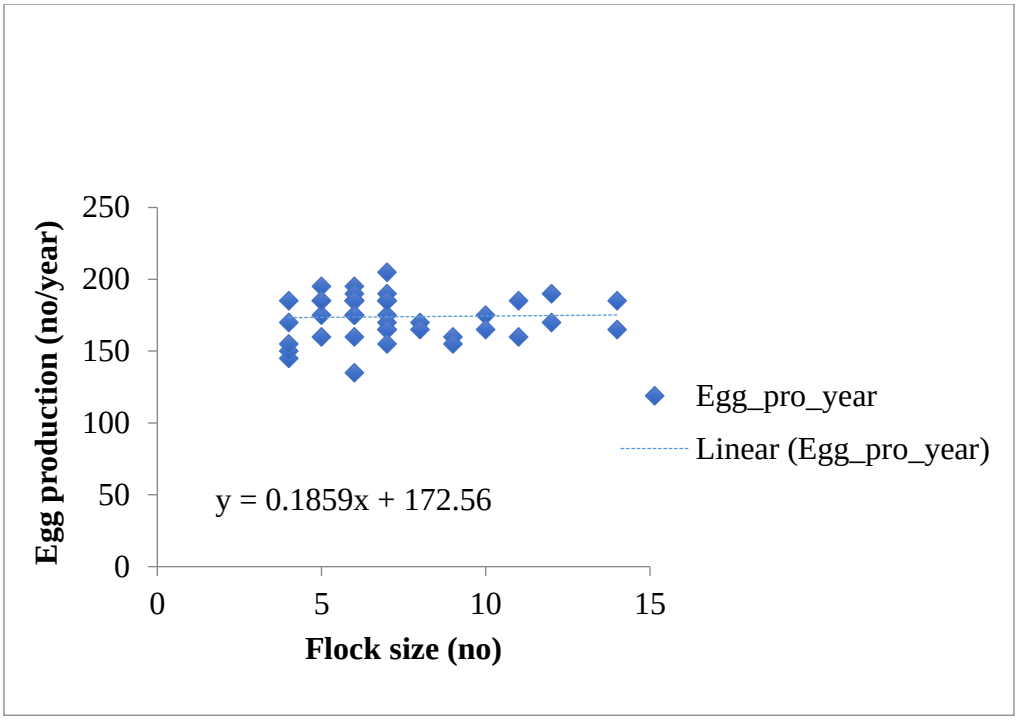

Figure 2. Association between flock size and annual egg production (N=322)

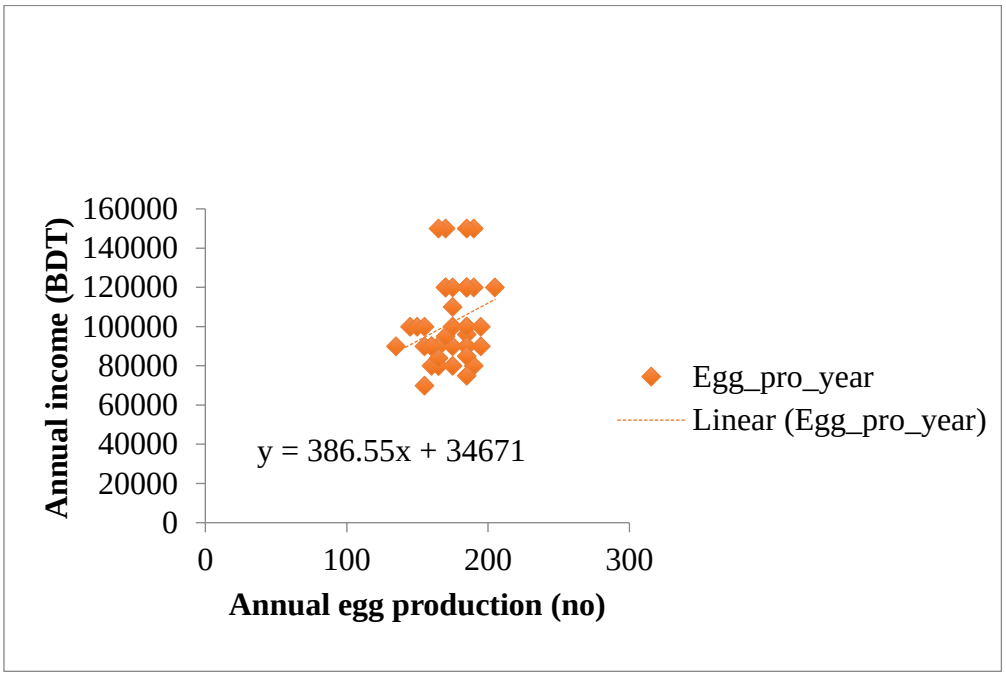

Figure 3. Association between annual egg production and annual income (N=322)

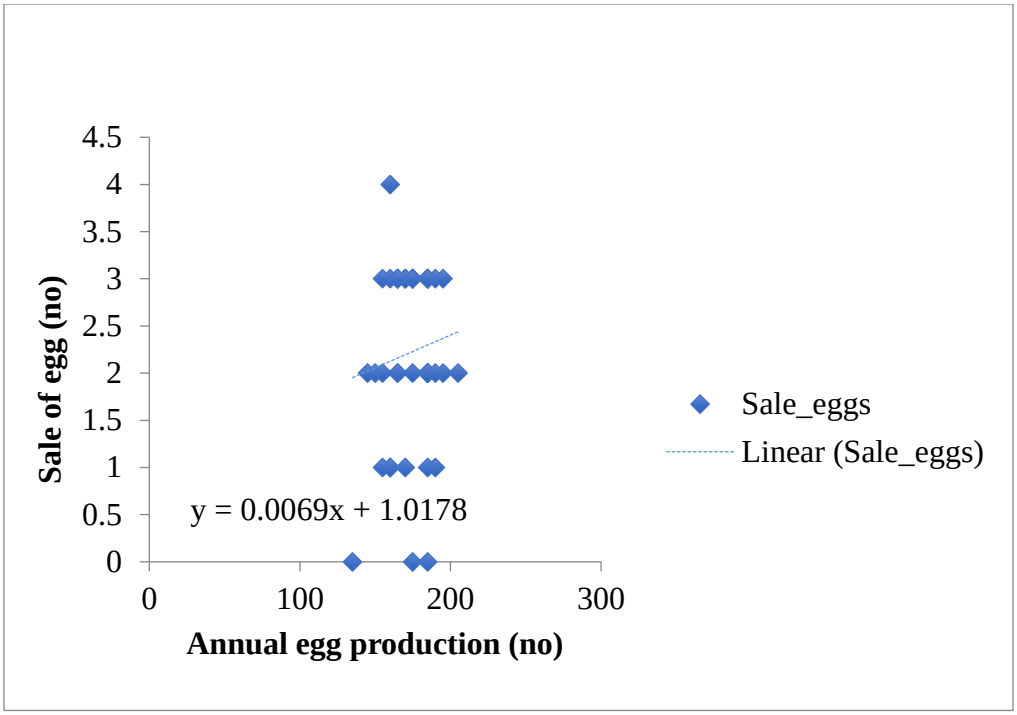

Figure 4. Association between annual egg production and sale of egg (N=322)

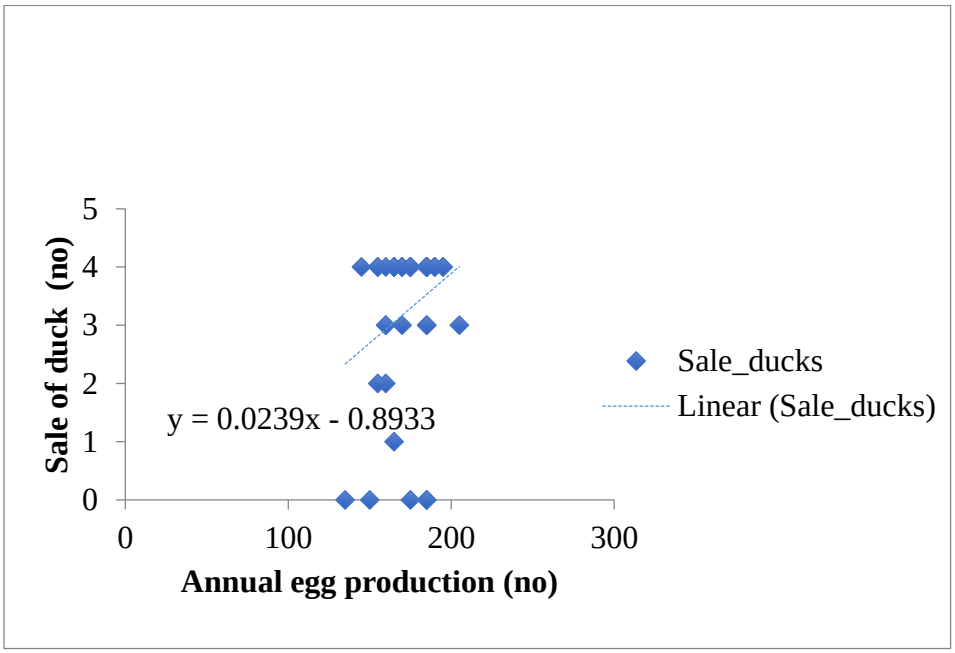

Figure 5. Association between annual egg production and sale of duck (N=322)

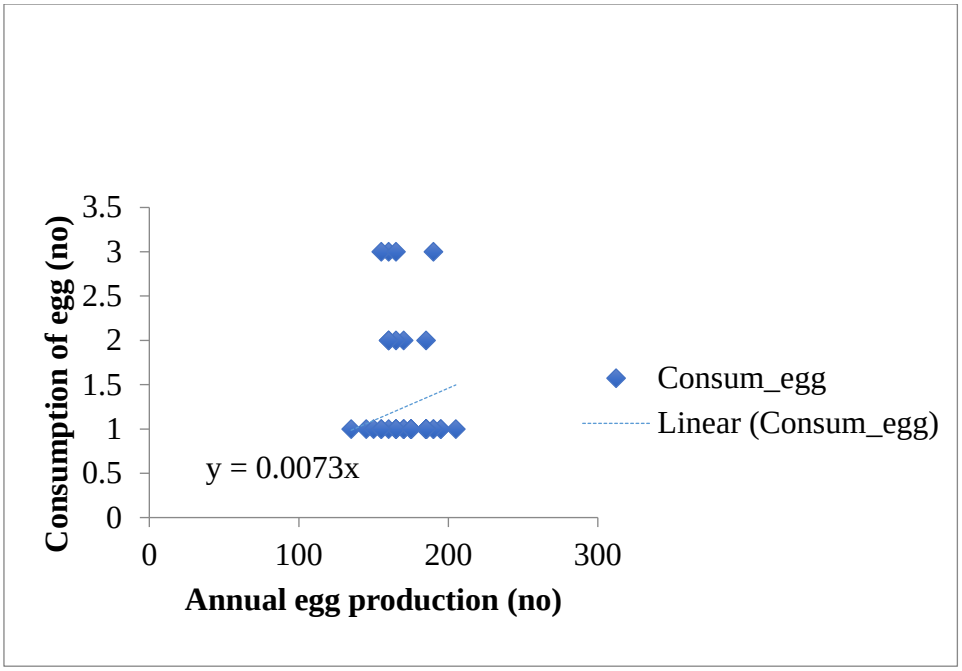

Figure 6. Association between annual egg production and consumption of egg (N=322)

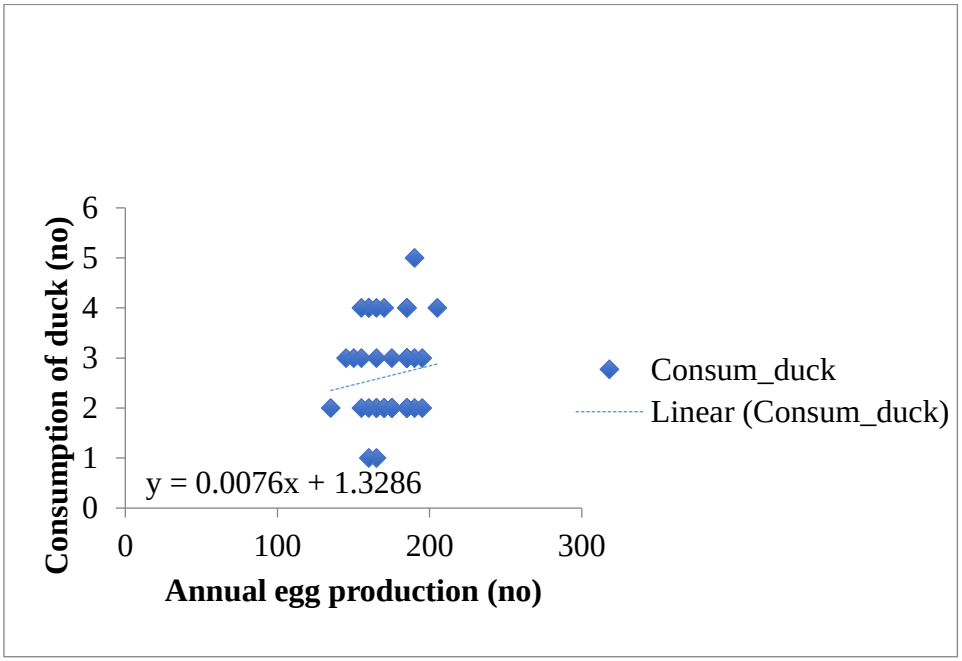

Figure 7. Association between annual egg production and consumption of duck (N=322)

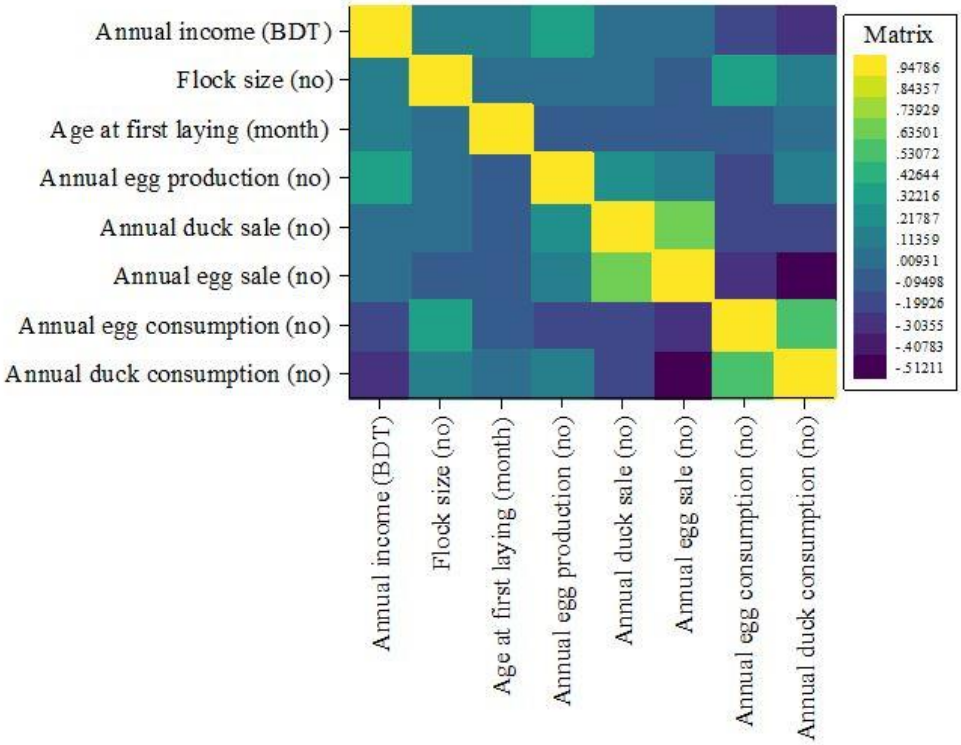

Figure 8. Orthogonal contrasts of the factors affecting flock size, annual income, production, sale and consumption of ducks and duck eggs in Satkhira, Bangladesh (N=322)

Predation

Mongoose was the leading predator followed by jackal, wild cat, dog, crow and muskrat. Muskrat and crow were reported terrific for the ducklings. Jackals, wild cats and dogs were major threats for ducks of all ages along with mongooses (Figure 9).

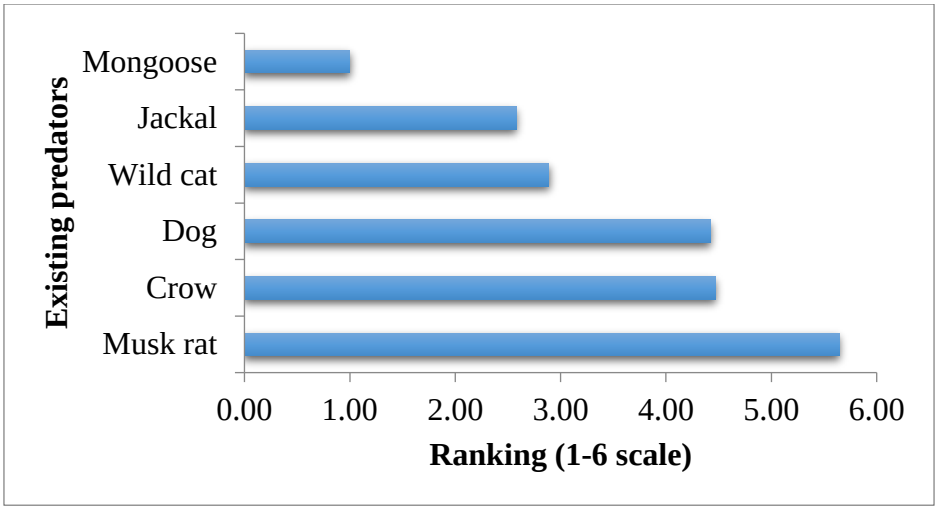

Figure 9. Mean ranking (in a 1-6 scale where least score indicates the most important predictor and the vice versa) of the existing predators in the descending order of importance for household duck production in the Satkhira district of Bangladesh (N=322)

Health

None of the farmers practiced vaccination and deworming. Overall incidence of disease was 57.8% which appeared to be the main challenge for duck raising. Very few of them (4.44%) had quarantine facilities for the affected ducks. Mortality was also high in Khaki Campbell (12.4%) followed by Deshi (10.0%) and Jinding ducks (9.52%) (Table 3).

Farmers' need

Shelter for the ducks was the primary need of the farmers followed by protection from predation, availability of day old duckling of high yielding breeds, increased fertility, broody hens and incubators to hatch the eggs (Figure 10).

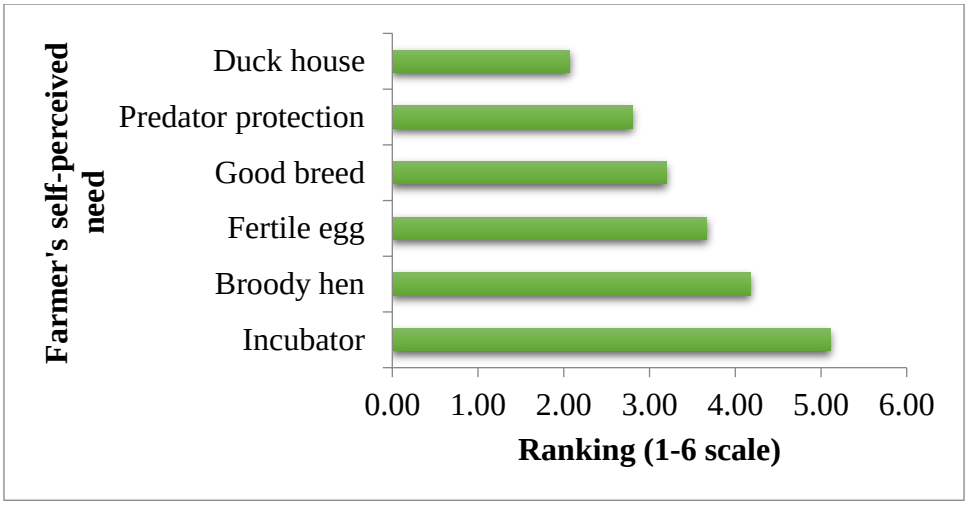

Figure 10. Mean priority ranking (in a 1-6 scale where least score indicates the most important predictor and the vice versa) of the self-perceived items needed for household duck production in the study areas (N=322)

Challenges

Disease incidence was the most challenging factors followed by lack of finance, lack of training, insufficient veterinary services, poor marketing system and natural calamity in the study areas (Figure 11).

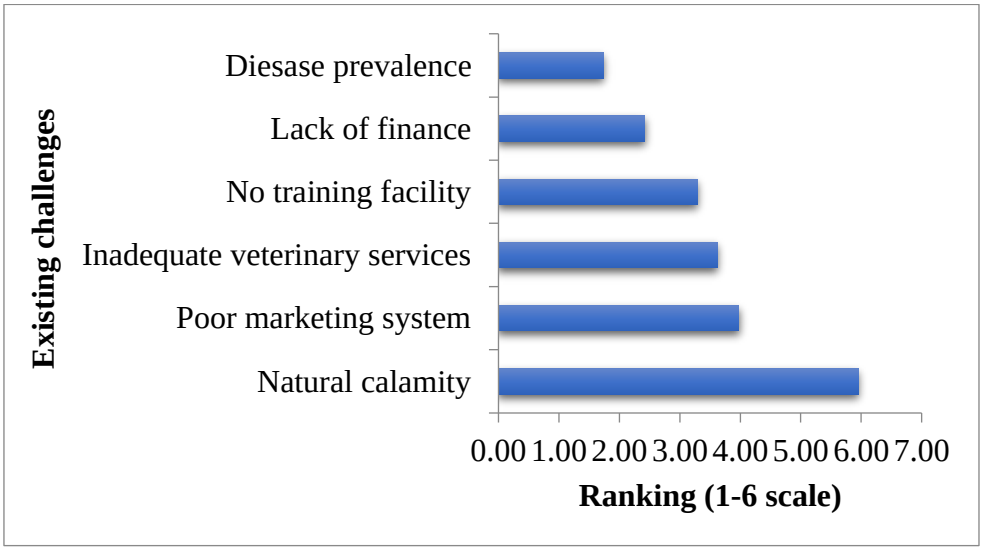

Figure 11. Mean priority ranking (in a 1-6 scale where least score indicates the most important predictor and the vice versa) of the existing challenges for household duck production in the study areas (N=322)

Chapter 4: Discussion

Socio-economy of the duck farmer

The study was undertaken in the rural areas of the Satkhira district, Bangladesh. Duck farmers of different ages participated in the study where most of them were middle aged (53.3%). About 38.0% of them were 40 years old which resembles close to the study of Rahman et al. (2020) who reported 46.0% of the duck farmers to be middle aged (>40 years). All of them were woman and housewife. Similar findings were demonstrated by Begum et al. (2018) who mentioned that the majority of the housewives (90.0%) took care of the duck. This report, however, differs with Rahman et al. (2020) who reported that 67.0% of the respondents were housewife, 23.0% businessman and 10.0% were service holder along with agriculture as basic component of their subsistence farming system.

Educational qualifications of the farmers were identified through face to face interview in the study areas. The level of education of the farmers varied from primary to secondary although only 11.0% of them were illiterate. Hence, the state of education was satisfactory in the study areas. In a previous study, Parvez et al. (2020) reported that the iliiteracy rate was twenty 25.0% in Haor areas of Sylhet. Another study showed, in Assam, one third of the duck rearers were illiterate and others studied up to primary level (Debnath et al., 2020). The difference in literacy rate may be due to lack of facilities for education in those areas. Annual income of the respondent farmers varied from BDT 75000-150000 and most of them (64.4%) were partitioned into medium income category.

Flock structure

Khaki Campbell, Deshi and Jinding ducks were reared in the study areas. Khaki Campbell held the top position (88.9%).The reasoning was the availability of the ducklings of Khaki Campbell by the retailer to the study areas. Production performance of Khaki Campbell also satisfied the farmers as it is globally the best egg producer (Hossain et al., 2021). Khaki Campbell ducks were also better meat producer with good feed efficiency (Begum et al., 2018). Daily egg production varied between two breeds where the Khaki Campbell showed better performance than the Jinding. Likewise, the Jinding took significantly more feed than the Khaki Campbell which incurred high production cost and significantly low return that the Khaki Campbell. Overall, at water logged area Khaki Campbell was the unique breed that could be reared with high economic strands (Hossain, 2020). However, Jinding ranked

second position because of their extraordinary capacity to tolerate saline coastal water. Research from India indicated that under rural conditions, the Khaki Campbell duck had better performance than the local breeds (Uddin et al., 2020). Flock size varied from location to location like our study which showed flock size of Deshi, Jinding and Khaki Campbell ducks were average 5, 7 and 7.28 in number although Debnath et al. (2020) demonstrated that the flock size varied from 2 to 9 where average flock size was 5.3 ducks per household. In Odisha, flock size of Deshi ducks varied from 9 to 30. However, in Assam flock size ranged from 20-50.

Housing systems

The duck farmers used variety of locally available cheap materials, i.e., bamboo, wood, mud, mat, polythene, tin, wire net and brick for preparing duck houses to protect their ducks from bad weather and predators. However, most of the houses were brick cemented (88.9%). Closely similar results were reported in previous studies where farmers used tin, wood, bamboo and wire net for preparing duck house (Ahmed et al., 2021) although majority (90.0%) of the houses were made of tin and bamboo (Rahman et al., 2020). The reason behind making brick-cemented houses may be its durability. As the ducks scavenge in water, wooden houses are damaged easily through dampness. Moreover, brick-cemented houses provide more comfortable environment than the houses made with tin. Brick-cemented houses were also preferable by the farmers because it was more sustainable comparative to other houses from cyclone as Satkhira is a coastal district where cyclone is very common at regular interval. Bamboo baskets or mosquito nets were used to protect ducklings from predators since they were strong enough to accompany and protect the older flocks.

Feeding systems

In the study areas, ducks were mostly reared in the semi-scavenging system. Marshy lands were available close to the households. Although farmers used to provide some homemade concentrate feeds but they were not sufficiently balanced. Hence, ducks in the study areas largely relied on scavenging feeds for other essential nutrients. A wide range of scavenging feeds such as snail, duck weed, earthworm, crab, frog, small fish and phytoplankton were noticed to have been available in those marshy lands (Hossain, 2020). All these feeds are rich

sources of protein, vitamins and minerals that helped meeting different types of nutrient requirements needed by ducks to increase their productivity (Uddin et al., 2020).

Very few of the farmers (17.8%) supplied readymade commercial feed to their ducks. However, for better growth and immunity at earlier stages commercial feeds were supplied to the duckling and again during laying stages for better egg production (Hossain, 2020). Some farmers used to supply earthworm and snails to the duckling along with broken rice, boiled rice and rice bran. In the morning, ducks were released from the houses and farmers provided traditionally mixed paddy, rice, rice bran and water and allowed their ducks to scavenge up to evening. But some of the ducks eventually returned to their houses one or more times before evening for taking additional feeds when natural feeds in the scavenging area were declined. Similar results were reported in a previous study where main supplemental feeds were paddy, mixture of boiled and broken rice and hardly rice polish with wheat bran (Parvez et al., 2020). The level of supplementation in those areas varied from 30-110 g/duck/d depending on socio-economic condition of the farmers (Uddin et al., 2020).

Performance parameter

In our study, performance parameter was age of sexual maturity and egg production/duck/year. It was manifested that age of sexual maturity varied with the breeds such as Deshi, Jinding and Khaki Campbell ducks attained their sexual maturity an average 6.50, 6.67 and 6.18 month of ages respectively. These findings were more or less similar with the results of Basnet et al. (2021) who reported the days for sexual maturity varied from 184 to 210 and Islam et al. (2016) stated that age at sexual maturity of duck varied from 180 to 210 days with an average of 183.6 days but Vignesh et al. (2020) reported that age at sexual maturity of duck varied from 140 to 180 days with an average of 153.12 days and Debnath et al. (2020) indicated that Khaki Campbell ducks reached sexual maturity at 195-210 days of age. Annual egg production in Deshi, Jinding and Khaki Campbell ducks were 140, 230 and 220/duck/year respectively which were lower than Hamid. (2020) who reported annual egg production in Deshi, Jinding and Khaki Campbell ducks were 150, 173 and 176/duck/year respectively but higher than Debnath et al. (2020) showed annual production in Deshi duck was 75-95 and in Khaki Campbell 120-140 in India. Uddin et al. (2020) reported average production rate was 200-220 egg/duck/year in Sylhet. Egg production level varied study to study may be due to location, management procedure and provided feed ingredients to duck. Uddin et al. (2020) reported that non genetic factors like poor nutrition had much greater

effect on production parameters than the genetic influence for the improvement of ducks under scavenging system of rearing.

Production, sale and consumption

In the study area, most of the households used to rear two or more ducks for sale and consumption of duckling, duck egg and live duck. The cost of duck eggs as well as meat appeared higher than the egg and meat of hen. Higher price of the ducks might be due to its exceptional taste and higher nutritional value (Hossain et al., 2020b). Moreover, Eggs and meat produced from scavenging ducks are considered to be organic, nutritious and completely free from hormones and antibiotics (Uddin et al., 2020). Globally, in preparation of different traditional delicious cuisines, various items are being made from duck eggs and meats. Surplus eggs, growing drakes, spent ducks are sold either to the neighbors or doorstep farmers or to the local traders (Hossain., 2020). Egg production was the primary reason behind rearing household duck. The study identified a proportional relationship among flock size, egg production, sale and consumption of duck eggs and meat. It was demonstrated that increased flock size linearly increased egg production, sale and consumption of duck eggs and meat which eventually increased their annual income and thus food safety and health (Hossain et al., 2021). Series of previous studies are closely in accord (Adzitey and Adzitey, 2011; Ndiweni, 2013; Jha and Chakrabarti, 2017; Wong et al., 2017).

Predation

The most prevalent predators available in the study areas were mongoose (*Herpestes edwardsi)*, jackal (*Canis aureus*), wild cat (*Felis chaus)*, dog (*Canis familiaris)*, crow (*Corvus macrorhynchos)* and muskrat (*Ondatra zibethicus*). Majority of the respondents reported that the predators had a great impact on duck production. Predators usually conceal themselves to the nearby bushes of the scavenging areas of ducks and attack the ducks when condition becomes favorable. Repeated attack by the predators on duck flock has a great negative impact on their performance and behavior since either the predator succeeded or not the effect of predators' fear may alter the behavioral changes of the prey duck specially their scavenging behavior, growth and stage of laying eggs (Nadim et al., 2020). Farmers claimed that anorexia, depression, gradual weight loss and decreased production were the common signs of the escaped ducks.

Health

Vaccination and deworming were not practiced by the household duck farmers in the study areas which appeared contrasting with Rahman et al. (2020) who reported that 90.0% of the farmers followed the vaccination program regularly. Begum et al. (2018) further reported that 90.0% of the ducks were vaccinated and 94.0% were dewormed. Hence, the disease incidence was very common in study areas and it was reported as the self-perceived main challenge. Duck plaque, duck cholera and food poisoning were also noticed as the most common diseases of ducks in Bangladesh along with duck viral hepatitis, coccidiosis, salmonellosis, avian influenza and intestinal helminthiasis (Habib et al., 2018; Sabuj et al., 2019; Patil et al., 2021b). Ducklings were more susceptible to the infectious diseases than the adults. Most of the farmers reported that the ducks were affected mostly in the winter season although Debnath et al. (2020) demonstrated that the majority of the ducks were affected in the monsoon season. They usually slaughtered the sick duck instead of treatment because they could not diagnose the diseases.

Treatment was given mostly by the pharmacy owner without postmortem examination and confirmatory diagnosis. This treatment protocol appeared sharply contrasting with Rahman et al. (2020) who noticed that 56.7% of the farmers received treatment from LSP (Livestock Service Provider), 33.3% from NGO workers and 10.0% from upazila veterinary hospital. Oxytetracycline and ciprofloxacin were used as preliminary treatment in the study areas. Very few farmers had quarantine facilities for affected ducks which was a risk factor for frequent disease outbreak. Biosecurity was not maintained in the houses which eventually resulted repeated disease outbreak in the study areas. In present study, mortality was high in Khaki Campbell followed by Deshi and Jinding ducks. The mortality rate ranged from 9.52-12.4%. These results supported by some previous studies. Uddin et al. (2020) reported that the mortality was higher in Khaki Campbell than the other duck breeds and Islam et al. (2016) stated mortality of ducks were on average 15.2%.

Farmer's need

Most of the farmers told that shelter for ducks was the primary requirement for expanding the flock size. Protection from predation was also an alarming issue. Along with Khaki Campbell, day old chicks of other high yielding breeds need to make available. Training was necessary to all of the duck farmers for better feeding and management of duck to get better

production. Knowledge about vaccination and its advantages in preventing duck diseases were warned. The farmers had sufficient fertile duck eggs and some farmers used broody hen to incubate them. Similar conditions were also found in other studies, i.e., Islam et al. (2016) reported that the farmers incubated their duck eggs under broody hen. The reasons behind it could be that the broody hen acted as a good mother to incubate, brood and protect the ducklings from predations. Table eggs and fertile eggs were sold at the same price. Availability of small incubator was expected by the some farmers.

Challenges

Almost all of the household duck owners reported that the disease incidence was their top priority problem for the continuation of duck rearing. Financial problems were also considerable. They had limited knowledge on scientific farm management. They were not aware of and could not identify the diseases. Being coastal areas, veterinary services were inadequate. Hence, mortality rate was high and to compensate mortality some farmers used to consume sick ducks in the early stages of showing clinical signs. The farmers claimed that they did not receive optimum price of duck egg and meat due to lack of organized marketing system. Natural calamity was also great challenge as the study areas were in coastal region.

Conclusion

An increased flock size is associated with increased annual egg production which ultimately increases net annual family income. Further, an increased annual egg production concomitantly increases annual egg and duck sale. Accordingly, increased annual duck and egg production increases annual household consumption of duck egg and duck meat. The sale of duck is associated with reduced consumption and sale of duck egg and duck meat and the vice versa.

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Appendix I

Questionnaire for household duck farming

1. Owner's details

- Name: …… Age: …..…… Sex: ……
- Mobile No: …… Address: …….....
- Educational backgrounds of farmer:

None☐	Primary☐	Secondary☐	More☐

- Occupation: …… Income (Family):……..……. /year

2. History of duck

- Flock size: …….. Duck……. Drake: ….……..
- Age:

0-2months	2-9 months	>9 months

- Species: Indigenous / Hybrid (Indian Runner/Khaki Campbell /Jinding)/Crossbred

3. Information on housing

- Rearing system: Free range/Intensive/Semi-intensive/Other……
- Elements of house: Bamboo/straw/tin/polyethylene /mud/wood/others….
- Location of duck house: ☐Next to the house ☐Near the scavenging area
- Cleaning of shed: Daily/Weekly/Monthly/Other…….
- Litter used: Yes/No. If Yes: ……..
- Ventilation facilities: Yes/No
- Have any quarantine facilities: Yes /No
- Do duck and chickens share same house or shelter? Yes/No

4. Feeding history

- Type of feeding: natural/artificial/both.
- Name of ingredients: Rice/Rice polish/Snail/Broken rice/……..
- Any commercial feed? Yes/No. If yes: …….
- If scavenging, what type of feed? .....
- Feed for duckling: …….
- Feed for laying duck: …… Feed for meat duck: ……
- How much times offer the feed per day: 1 Time/2 Times/More
- Presence of marshy land: Yes/no. If yes, what type: haor / pond / river?

5. Disease management

- Any diseases occur in previous/current? Yes/No. If Yes……

Sign	Possible diagnosis	Season	Treatment	Mortality

- Regular vaccination-Yes/no If yes type of vaccine: ……..
- Regular deworming-Yes/no If yes type of anthelmintic: …….

6. Information on laying of duck

- Age at 1st laying: …. ….
- Egg production/year: ……..
- What are your the main reasons for duck rearing? Cash income/Egg/Meat /Home cleanliness/other…

7. Tell me the main PROSPECTS to duck production

Reasons	**Ranking**
A. Sale of ducks (live, slaughtered)	
B. Sale of eggs	
C. Consumption of ducks eggs	
D. Consumption of duck meat	
E. To earn money that can be invested or used for payments	
F. Others (Specify): ……..	

8. If predator exists, what do you think are the main predators in your area?

Name of predators	**Ranking**
Mongoose	
Crow	
Jackal	
Wild cat	
Dog	
Others (Specify): ……..	

9. What do you think are the main ITEMS YOU NEED for your successful duck production?

Name of needs	**Ranking**
Broody hen	
Rice husk incubator	
Good breed	
To purchase eggs for hatching and duckling	
Duck sheds and crate	
Protection from predator	
Others (Specify): ……..	

10. What do you think are the main CHALLENGES for your duck production?

Name of challenges	**Ranking**
Lack of finance	
No training in duck production	
Inadequate veterinary service	
Poor marketing facility	
Disease and predation	
Natural calamity	
Others (Specify): ……..	

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Biography

The author, Md. Touhiduzzaman, son of Late Abdul Karim Gazi and Samnunnahar was born on March 6, 1997 at Tala, Satkhira. He passed Secondary School Certificate examination from Nagarghata Kabi Nazrul Bidyapith in 2013 followed by Higher Secondary Certificate examination from Kalaroa Govt. College in 2015. He is now enrolled in year-long internship programme for completion of Doctor of Veterinary Medicine (DVM) degree in CVASU, Chattogram, Bangladesh.