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Flock size dynamics: Its impact on production, sale and consumption of duck meats and eggs in the coastal areas of Bangladesh

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ABSTRACT

Touhiduzzaman, Md., Hasan, A.T.M.M., Rahman, Md.M., Islam, S., Akter, N. and Hossain, Md.E. 2024. Flock size dynamics: Its impact on production, sale and consumption of duck meats and eggs in the coastal areas of Bangladesh. Indian Journal of Poultry Science, 59(02): 93-104.

The study aimed to determine whether a larger flock size enhance the production, sale, and consumption of household duck eggs and duck meats in the coastal regions of Bangladesh. A cross-sectional survey was conducted over three months, from April 15 to June 15, 2021, in three villages within the Tala upazila of Satkhira. Results indicated that the percentage of Khaki Campbell (88.9%) was the highest followed by Jinding (6.7%) and Desi (4.4%) ducks in the existing flocks. The Desi, Jinding and Khaki Campbell started laying at an average age of 6.5, 6.7 and 6.2 months, respectively. Annual egg production (no.) was the highest in Khaki Campbell (176) followed by Jinding (173) and Desi (140). Mongoose was the leading predator followed by jackal, wild cat, dog, crow and muskrat. None of the farmers practiced vaccination and deworming. Overall reported disease incidence was 57.8% which appeared to be the main challenge for duck raising. Mortality was high in Khaki Campbell (12.4%) followed by Desi (10.0%) and Jinding ducks (9.5%). Shelter for the ducks was the primary need of the farmers. An increased flock size was associated with increased annual egg production which ultimately increased net annual family income. Further, an increased annual egg production concomitantly increased annual egg and duck sale. Accordingly, increased annual duck and egg production increased annual household consumption of duck egg and duck meat. An increased sale of duck was associated with reduced consumption of duck egg and duck meat. It was concluded that production and consumption duck egg and duck meat as well as family income could be optimized by increasing rearing of household ducks.

Keywords: Duck, Coastal, Consumption, Egg, Flock size, Sale

INTRODUCTION

Poultry production plays a vital role in the global livestock farming system, significantly contributing to the achievement of various sustainable development goals. It has emerged as the fastest-growing sector within the livestock industry worldwide (Hennessey *et al.*, 2021). As a species next to chicken, duck contributes major sources of animal protein as an integral component of the mixed farming system to play substantial role in the economy of the developing country (Ahmed *et al.*, 2021). The Food and Agricultural Organization report indicates that Bangladesh ranks 11th in duck meat production and 4th in duck egg production among Asian countries. (Begum *et al.*, 2020). Practice of raising chicken and duck or both are traditional in Bangladesh. Duck production has some special features 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 foragers so requires less feed than the chicken (Hossain *et al.*, 2020, 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 (Soren *et al.*, 2009; Tamizhkumaran *et al.*, 2013; Giri *et al.*, 2014). However, the availability of these feed resources is affected by their locations, habitats and seasons (Hossain *et al.*, 2020). 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 build their farms near the water bodies. 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,

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snails, insects and fallen grains which especially suitable for household duck rearing (Anitha *et al.*, 2012).

Most of the poultry researches done in Bangladesh are primarily focused on chicken and not on duck (Hossain *et al.*, 2020). 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 impact of flock size of household duck on annual egg production, egg sale, consumption and their subsequent effects on socio-economic status of the duck owner, challenges and prospects of raising ducks in the coastal areas of Bangladesh are scant. The study, 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 of Bangladesh.

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 of Satkhira district on the basis of some clearly defined specific criterion for the selection of households.

Study area

Satkhira, located in southwestern Bangladesh, is part of the Khulna Division. It is bordered by Jessore district to the north, the Bay of Bengal to the south, Khulna District to the east, and the 24 Pargana district of West Bengal, India, to the west. The geographical coordinates of Satkhira are 22°43′6.55"N latitude and 89°4′13.72"E longitude. The district experiences an annual average maximum temperature of 35.5°C (95.9°F) and a minimum of 12.5°C (54.5°F), with annual rainfall averaging 1710 mm. Soil electrical conductivity is slightly saline at 5.93 dS/m during the dry season and non-saline at 0.61 dS/m during the wet season (Kumar *et al.*, 2019).

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 having 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

A fourth-year veterinary student from CVASU, under the guidance of a CVASU academician, was trained in survey and interview methodologies at CVASU. Interviews with farmers were conducted at their respective locations. To ensure thoroughness, each interviewer spoke with only one farmer per day, dedicating approximately two hours to each session, which included a 30-minute break. During the farm visits, an observation checklist was also filled out. Institutional approval for the interviews with duck-keeping households was granted by CVASU.

Data collection

Prior to the field survey, a structured questionnaire and a detailed survey protocol were designed to meet the specific objectives of the study. Respondents were briefed on the interview's goals, and their verbal and written consents were obtained. Interviewers received printed guidelines at least a week before the interview. Additionally, they underwent further training during pilot testing conducted by a senior faculty member. The questionnaire was pre-tested on 5% of duck-keeping households, leading to the elimination of unclear, unnecessary, or lengthy questions. Feedback from respondents during this phase was used to refine and update the questionnaire to suit field conditions. Data collected through face-to-face interviews included information on age, flock size, housing and feeding systems, vaccination, deworming, types of treatments, egg production numbers, predators, necessary items, and the socio-economic conditions of the farmers.

Statistical analysis

The raw data were compiled using Microsoft Excel Professional 2020 (Microsoft Corporation, USA). Outliers were identified using the interquartile range test, and multicollinearity was assessed through variance inflation factors. The Shapiro-Wilk test was utilized to check the normality of the response variable. Profile plots were employed to examine interactions among covariates. Data analysis included Fisher's exact test and one-way ANOVA. The Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were used to evaluate the dataset's suitability for principal component analysis (PCA). Heatmaps of multiple orthogonal contrasts were generated to identify latent trends, dimensionality, and the strengths of the covariates. Test variables were standardized and compared against two PCA components, represented on the x and y axes, based on maximum eigenvalues. Significant statistical effects ($p<0.05$) were further analyzed using Duncan's New Multiple Range Test (DMRT) to compare means. All statistical analyses were performed using Stata 14.1 SE (Stata Corp LP, College Station, Texas, USA). The following model was employed to estimate the effects of the predictors on dependent variables:

$$Y_{ijkln} = \mu_{0+} \alpha_{ij} + \beta_{ik} + \gamma_{il} + \ldots\ldots \omega_{in+} \varepsilon_{ijlkn}$$

Where,

Y_{ijkln} = The observed effect of the trait 'i' at the 'j^{th}' level of the predictor 'α', the 'k^{th}' level of the predictor 'β', 'l^{th}' level of the predictor 'γ'……and the 'n^{th}' level of the predictor 'ω';

μ_0= The intercept of the regression model;
α_{ij}= The slope of the regression model for the trait 'i' at 'j^{th}' level of the predictor 'α' observed on Y_{ijkln};
β_{ik}= The slope of the regression model for the trait 'i' at 'k^{th}' level of the predictor 'β' observed on Y_{ijkln};
γ_{il}= The slope of the regression model for the trait 'i' at 'l^{th}' level of the predictor 'γ' observed on Y_{ijkln};
ω_{in}= The slope of the regression model for the trait 'i' at 'n^{th}' level of the predictor 'ω' observed on Y_{ijkln};
ε_{ijkln}= The random sampling error of the trait 'i' at the 'j^{th}' level of the predictor 'α', the 'k^{th}' level of the predictor 'β', 'l^{th}' of the predictor 'γ'……the 'n^{th}' level of the predictor 'ω' which are distributed as $\varepsilon_i \sim NID(0,\sigma^2)$.

RESULTS

Socio-economy of the duck farmers

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%). 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%).

Flock structure

Three types of duck breeds, i.e., Desi, Jinding and Khaki Campbell were reared in the study areas. The percentage of Khaki Campbell (88.9%) was the highest followed by Jinding (6.67%) and Desi (4.44%) ducks. Average flock size of Desi, Jinding and Khaki Campbell ducks were 5.00, 7.00 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 planktons 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 Desi, Jinding and Khaki Campbell ducks, respectively (Table 3).

Performance parameters

The study showed that Desi, 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 Desi (140) (Table 3). Overall, type of breed, annual egg production and duck consumption were the principal eigenvectors controlling variability of the performance parameters of the ducks.

Production, sale and consumption

There was a strong relationship among flock size, annual egg and duck production, sale and consumption

Table 1: Socio-economic conditions of the duck farmers

Variables	Type of breed			Total	P-value
	Desi	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)	

Table 2: Overall management practices of the local, Jinding and Khaki Campbell ducks

Variable	Type of breed			Total	P-value
	Desi	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)	1.000
No	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	
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)	0.058
3	0.00 (0)	4.44 (2)	42.2 (19)	46.7 (21)	
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)	0.643
No	4.44 (2)	4.44 (2)	73.3 (33)	82.2 (37)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (40)	
Age at first laying					
6 months	2.22 (1)	2.22 (1)	73.3 (33)	77.8 (35)	0.089
7 months	2.22 (1)	4.44 (2)	15.6 (7)	22.2 (10)	
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)	0.006
Medium (151-175)	0.00 (0)	4.44 (2)	46.7 (21)	51.1 (23)	
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)	1.000
No	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	
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)	0.782
No	2.22 (1)	4.44 (2)	35.6 (16)	42.2 (19)	
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)	1.000
No	4.44 (2)	6.67 (3)	84.4 (38)	95.6 (43)	
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)	1.000
No	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
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)	1.000
No	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	
Total	4.44 (2)	6.67 (3)	88.9 (40)	100 (45)	

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†			SEM	P-value
	Desi	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 (%)	10.0	9.52	12.4	0.16	0.837

†SEM= Standard error of the means

of duck egg and duck and their subsequent effects on annual income (Fig. 1). An increased annual duck and egg production increased annual household consumption of duck egg and duck meat (Fig. 2). Accordingly, an increased annual egg production concomitantly increased annual egg and duck sale (Fig. 2). Further, an increased sale of duck was associated with reduced consumption and sale of duck egg and duck meat and the vice versa (Fig. 2-3). An increased flock size was associated with increased annual egg production which ultimately increased net annual family income (Fig. 4). Principal component analysis revealed that component 1 was strongly influenced by flock size, consumption of duck egg, duck meat, disease incidence and duck mortality indicating 18.9% variability while availability of scavenging land, annual egg production and annual income influenced component 2 reflecting 17.9% variability (Fig. 5).

Predation

Mongoose was the leading predator followed by

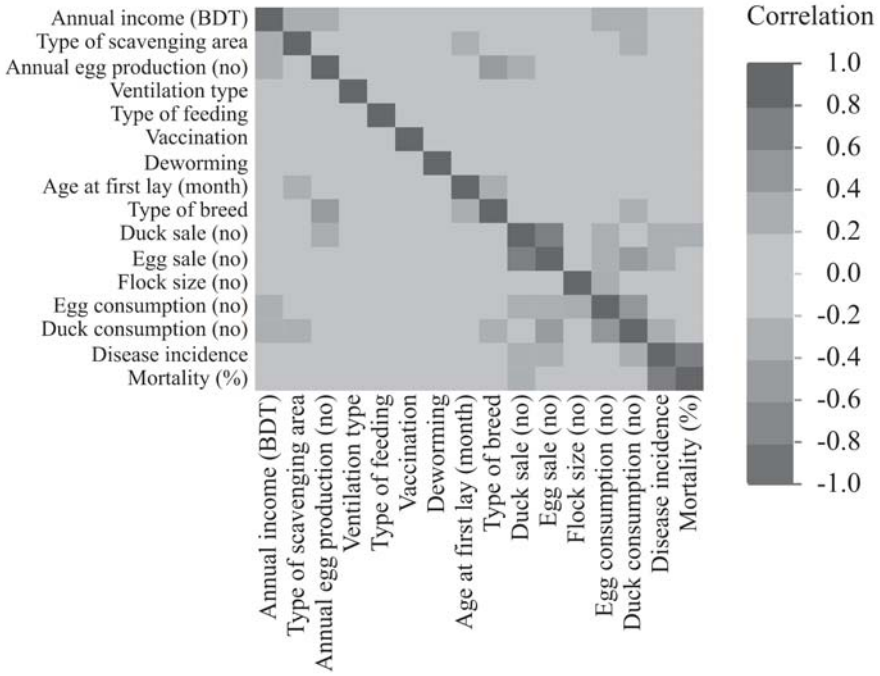

Fig. 1: Heatmap showing orthogonal contrasts of the relationships among performance parameter, management system, flock size, annual income, production, sale and consumption of ducks and duck eggs in the Satkhira district, Bangladesh (N=322)

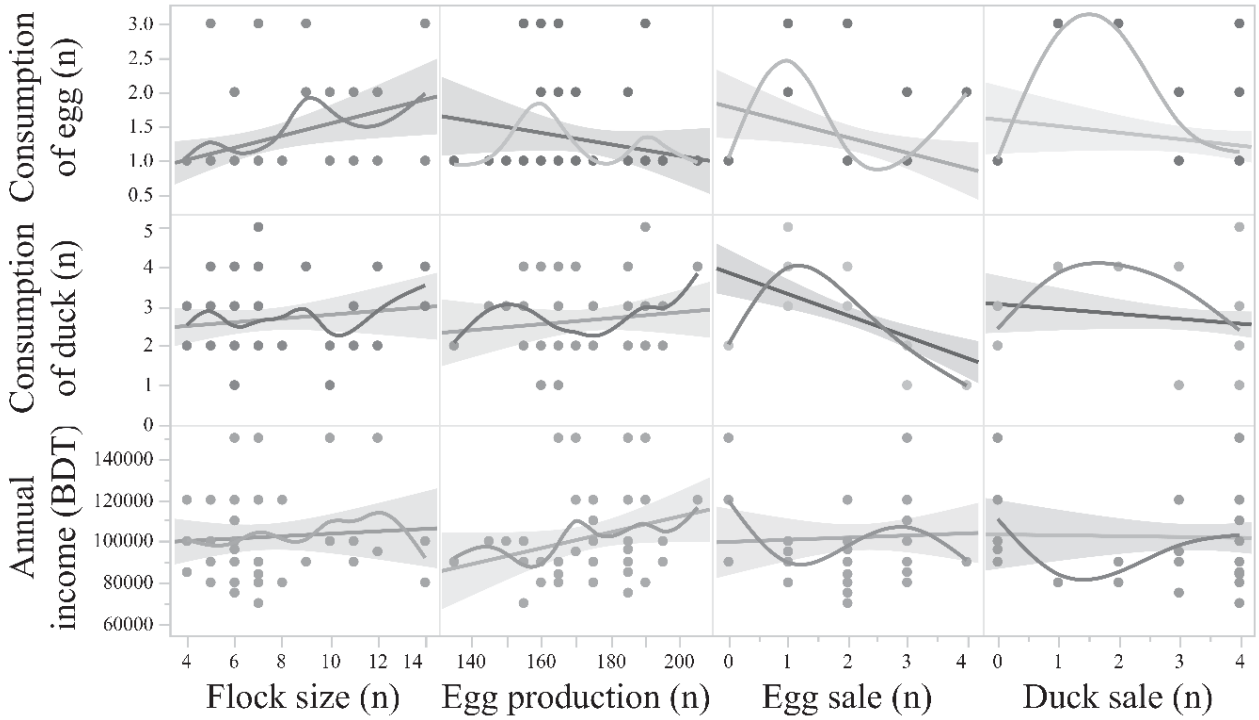

Fig. 2: Trendlines with 95% confidence band and scatterplot smoothing indicating relationship of flock size, egg production, egg sale and duck sale with annual income, consumption of duck and duck egg in Satkhira district, Bangladesh (N=322)

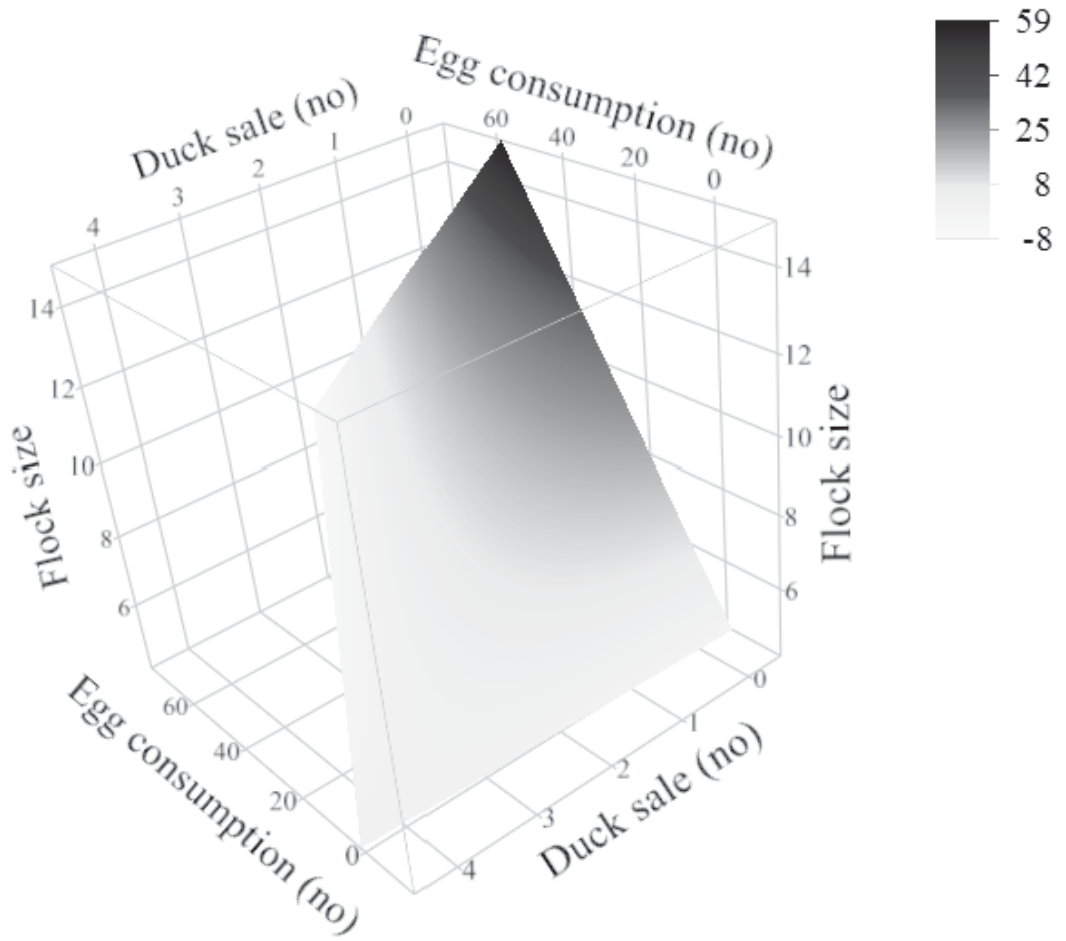

Fig. 3: A response surface model to predict the influence of flock size and duck sale on annual egg consumption of the household ducks in the Satkhira district, Bangladesh (N=322)

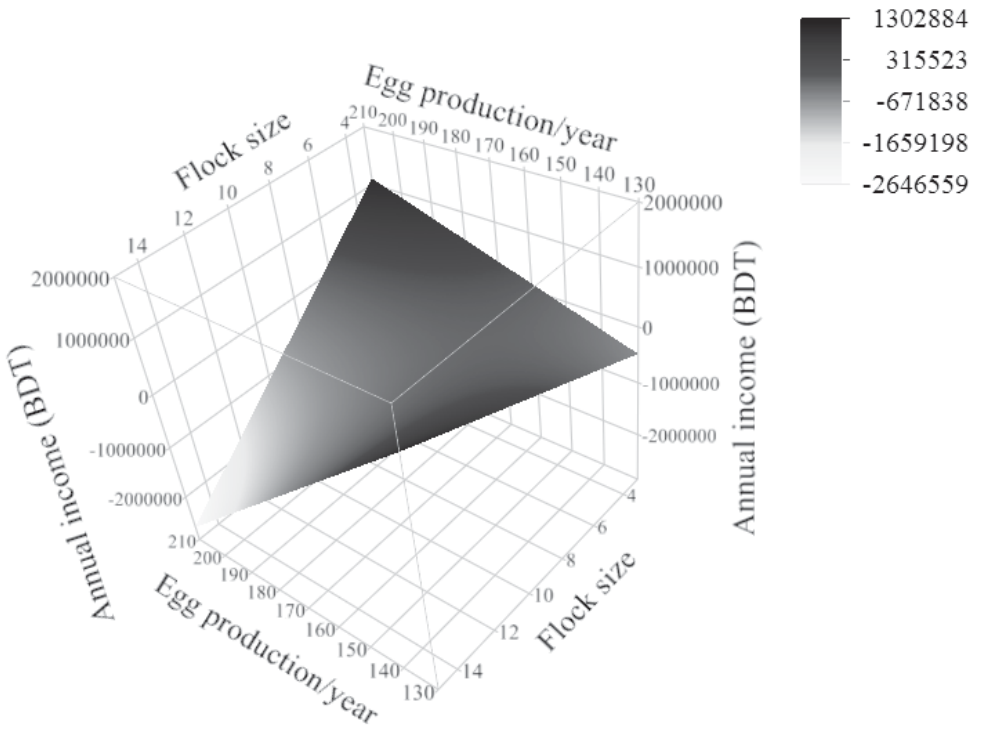

Fig. 4: A response surface model to predict the influence of flock size and annual egg production on annual income of the duck owners (N=322)

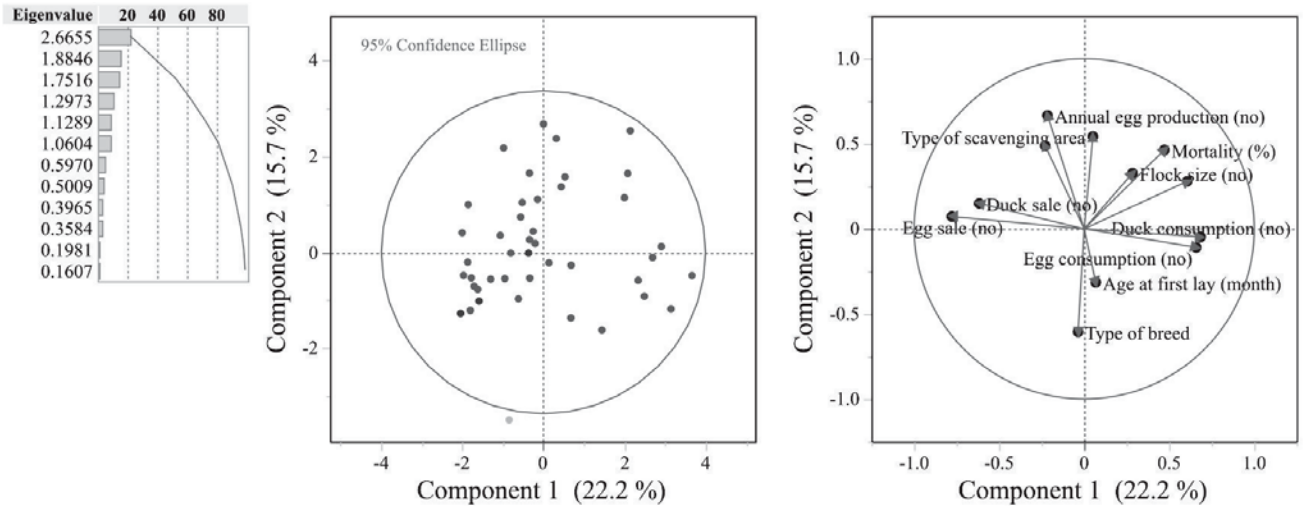

Fig. 5: Biplot indicating eigenvector loadings of the principal components affecting flock size, annual income, production, sale and consumption of ducks and duck eggs in the Satkhira district, Bangladesh (N=322)

jackals, wild cats, dogs, crows and muskrats. 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 (Fig. 6).

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 Desi (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 (Fig. 7).

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 (Fig. 8).

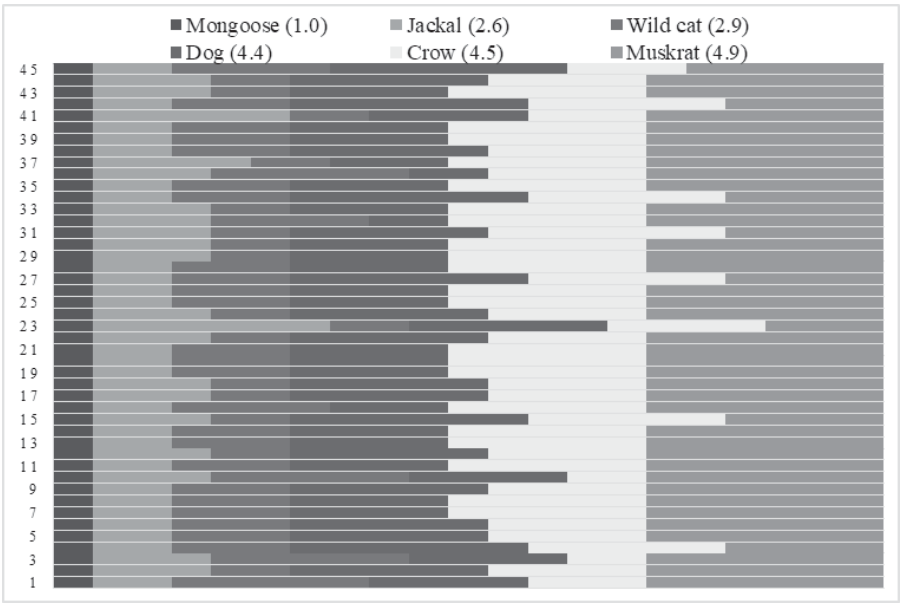

Fig. 6: Stacked bar diagram showing mean ranking (where least score indicates the most important predator) of the existing predators in the Satkhira district of Bangladesh (N=322)

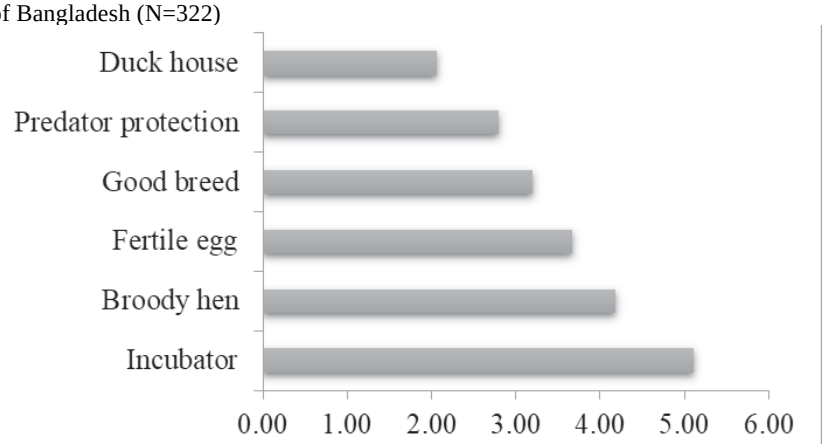

Fig. 7: Mean priority ranking (in a 1-6 scale where least score indicates the most important predictor and the vice versa on 'x' axis) of the self-perceived items needed for household duck production in the study areas (N=322)

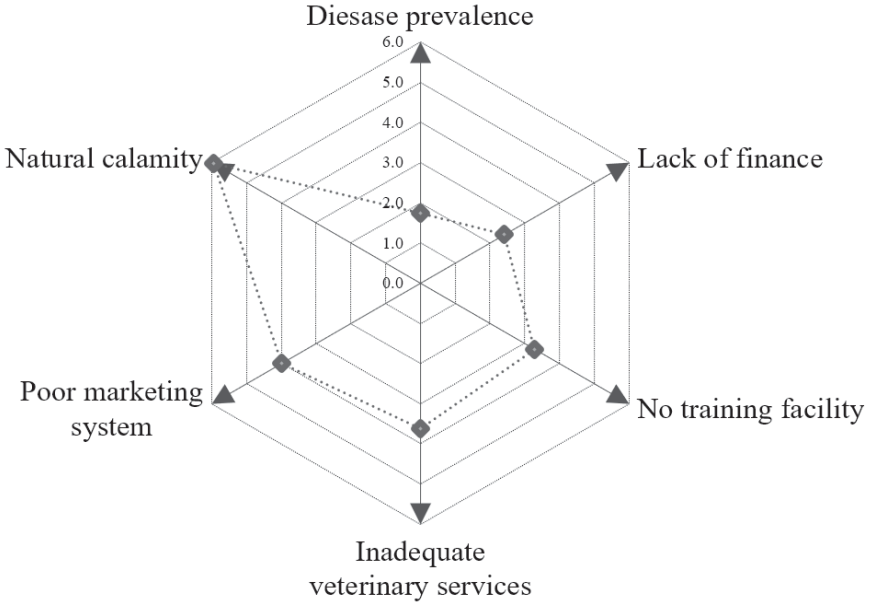

Fig. 8: Radar chart showing mean priority ranking (in a 1-6 scale where least score indicates the most important predictor and the vice versa on 'x' axis) exhibited by different poles of the existing challenges for household duck production in the study areas (N=322)

DISCUSSION

Socio-economy

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 appeared close to the study of Rahman *et al.* (2020) who reported that 46.0% of the duck farmers were middle aged (>40 years). All of them were woman and housewives. 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 housewives, 23.0% businessmen and 10.0% were service holders 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 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, Desi and Jinding ducks were reared in the study areas. Khaki Campbell held the top position (88.9%). The reason was the availability of the ducklings of Khaki Campbell by the retailer in 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 the two breeds, with Khaki Campbell outperforming Jinding. Additionally, Jinding consumed significantly more feed than Khaki Campbell, resulting in higher production costs and significantly lower returns compared to Khaki Campbell. Overall, in waterlogged areas, Khaki Campbell proved to be the optimal breed for rearing, offering high economic benefits (Hossain, 2020). However, Jinding ranked second due to its remarkable ability to tolerate saline coastal water. Research from India has shown that, under rural conditions, the Khaki Campbell duck outperformed local breeds (Uddin *et al.*, 2020). Flock size varied from location to location like our study which showed flock size of Desi, Jinding and Khaki Campbell ducks were average 5.00, 7.00 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 Desi 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 intervals. 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 (Anitha *et al.*, 2009). 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 were rich sources of protein, vitamins, and minerals, which helped meet the diverse nutrient requirements needed by ducks to enhance 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 areas 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 parameters were age of sexual maturity and annual egg production. It was manifested that age at sexual maturity varied with the type of breed, i.e., Desi, Jinding and Khaki Campbell ducks attained their sexual maturity an average 6.50, 6.67 and 6.18 month, respectively. These findings were consistent 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) reported that Khaki Campbell ducks reached sexual maturity at 195-210 days of age. Annual egg production in the Desi, 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 Desi, Jinding and Khaki Campbell ducks were 150, 173 and 176. But higher than Debnath *et al.* (2020) showed annual production in Desi duck was 75-95 and in Khaki Campbell 120-140 in India. Uddin *et al.* (2020) reported that average production was 200-220 in Sylhet. Egg production may vary from study to study due to variation of location, management and feed ingredients provided to the ducks.

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 egg 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.,* 2020). Moreover, eggs and meat produced from scavenging ducks are considered to be organic (Zaman *et al.*, 2009), 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 meat. Surplus eggs, growing drakes and spent ducks were sold either to the neighbors or doorstep farmers or to the local traders (Hossain, 2020). Egg production was the primary reason behind rearing household ducks. 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 accordance with our findings (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 and attack the ducks when condition becomes favorable. Repeated attack by the predators on duck flock has a great negative impact on performance and behavior of duck 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 (Anitha *et al.,* 2009). Farmers claimed that anorexia, depression, gradual weight loss and decreased production were the common signs of the escaped ducks due to predation threat (Nadim *et al.,* 2020).

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 plague, duck cholera and food poisoning were 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; Al *et al.,* 2019; Patil *et al.,* 2021). 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 ailing ducks 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 Livestock Service Provider, 33.3% from non-government organization 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 Desi and Jinding ducks. The mortality rate ranged from 9.52-12.4%. These results support some previous studies which reported that the mortality was higher in Khaki Campbell than the other duck breeds and mortality of ducks was on average 15.2% (Islam *et al.*, 2016).

Farmer's need

Most of the farmers said 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 be made 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 required. 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 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 ailing 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 the 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 of duck egg and duck meat and the vice versa. It was concluded that production and consumption duck egg and duck meat as well as family income could be optimized by increasing rearing of household ducks.

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