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Original Article

Culture practices and health management issues in selected aquafarms of Rajbari, Bangladesh: A preliminary study

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A B S T R A C T

The current study was conducted to determine the existing fish culture systems and health management practices in the selected aquafarms of Rajbari District, Bangladesh. Data were collected from 50 fish farmers from October 2019 to February 2020 using questionnaire interview, focus group discussion and crosscheck interview. It was found that most of the aqua farmers had 11 to 15 years' experience of fish farming and more than 30% had their own ponds. The farmers used to prepare ponds for stocking by several steps like pond drying, bottom mud removal, dyke construction, liming, fertilizer application, and finally stocking. Only 20% fish farmers stocked single fish species like pangas and tilapia, whereas other used to stock two to eight types fish species. Most of the fish farmers sell the harvested fishes either in the local or in city markets. Major fish health problems in the study area were infectious and non-infectious diseases occurred due to bacteria, virus, fungus, parasites, unfavorable water quality and malnutrition. Majority (94%) of the farmers did not have water quality measurement tools. However, the major health problems of fish were ranked by the farmers on the basis of critical condition where fish disease, poor water quality, fish killing as a part of enmity, entrance of wild animal and hamper due to fish eating birds were ranked as 1st, 2nd, 3rd, 4th and 5th utmost constraints, respectively. Forty-four percent and 20% respondents received training on different aquaculture techniques from Government and non-government organizations, respectively. While during disease outbreak, most of them received technical assistance from the culture fellows. The fish farmers of the study area were not aware of good aquaculture practice maintaining biosecurity. The present study revealed that there is a lack of scientific knowledge of the fish farmers in the studied areas which demands further improvements of the existing condition.

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Introduction

Aquaculture is one of the fastest-growing sectors of fisheries of the Bangladesh economy, which provides protein-rich meal, employment opportunity and foreign currency (Jahan *et al.*, 2015; Hossain and Hasan, 2017). Aquaculture provides about 50% fish for direct human consumption in Bangladesh. Traditionally, the people of Bangladesh stock fish in their homestead pond for family consumption. But now, a large number of fish farmers are involving in aquaculture for commercial purpose and the sector provides income and livelihood for more than 10% of the existing population (Shamsuzzaman *et al.*, 2017). Studies showed that, the geographical location and topography of Bangladesh is appropriate for fish farming particularly in high density. In last ten years Bangladesh is blessed with 5.4% growth in fisheries, whereas 8.2% in aquaculture (Shamsuzzaman *et al.*, 2020). Inland aquaculture comprises more than 80% of the total recorded aquaculture production in Bangladesh, and is presently dominated by carps, pangas and tilapia (Shamsuzzaman *et al.*, 2017).

The rapid growth and intensification of aquaculture for enhancing yield create several health problems in fish like outbreak of both infectious and non-infectious diseases, environmental pollution and sudden death of the stock. These problems have become major challenges for the aquaculture entrepreneurs and the fish farmers (Shirin *et al.*,

2020; Mishra *et al.*, 2017). Fish requires more attention in order to monitor their health than the terrestrial farm animals and crop like cattle, poultry and plants as fish lives in a dynamic environment under water (Giri, 2018). Similarly, both fish feeding and death are well hidden under water in the pond culture system (Bondad-Reantaso *et al.*, 2005). Sudden change in their ecosystem can cause massive death even loss of the whole culture system (Serfling, 2015). Snieszko (1974) stated that, fish diseases in aqua farms occurred by the outcomes of a number of linked events involving the interactions of fish, the environment, and the pathogen present in the water. Moreover, fish nutrition is also an important consideration in all the aqua farms as proper growth and innate immunity of fish depend on balanced diet (Raja and Jithendran, 2015). Faruk *et al.* (2004) stated that, the amount of economic loss was about US$ 344 per hectare in each year in the local fish farms for disease occurrence in Bangladesh. Generally, the fish farmers used to apply different aqua drugs after disease outbreak to minimize the loss, but their impact on fish as well as water-body is also considered negatively at present (Faruk *et al.*, 2017; Ahmed *et al.*, 2015; Kamaruddin and Baharuddin, 2015). Therefore, prevention before the onset of fish disease and keeping sound environment for fish is required (Serfling, 2015). In addition, biosecurity is important for disease prevention and control of diseases and reducing loss in aquaculture production (Mahagamage and Jayakody, 2020; Rahman *et al.*, 2019). Similarly, identification of possible health hazard for fish is a part of good health management practices.

Fish is a common meal item for the inhabitants of Rajbari District and the aquaculture production of this region is increasing gradually (BBS, 2011). Study on regional culture practice is important to identify the fish health problems from the root level. Every step in aquaculture is important for fish health and successful production like pond size, pond preparation steps, fish stocking, feeding, water quality monitoring and harvesting. Several studies on fish culture practices, health management and biosecurity in different areas have been carried out previously (Hassan *et al.*, 2019; Faruk *et al.*, 2017; Hasan *et al.*, 2013), but no research has been done in Rajbari District. Considering the situation, the present study was conducted to determine the existing fish culture system with health management practices of the fish farmers located in selected upazilas under Rajbari District.

Materials and Methods

Two sub-districts of Rajbari namely, Rajbari Sadar and Pangsha (Figure 1) were selected for the present study for five months from October 2019 to February 2020. Fundamental data were collected using questionnaire interview, focus group discussion (FGD) and crosscheck interviews with key informants (KI) such as Upazila Fisheries Officer (UFO) and NGOs staffs. A total of 50 fish farmers; 25 from Rajbari Sadar and 25 from Pangsha were randomly chosen for interview. Six FGD sessions of the participants were performed where each group contained 7 to 9 members. The questionnaire was based mainly on farming experience, manpower, steps of fish culture, fish health management practices, fish health problems, seasonality of diseases, clinical signs of fish diseases, and source of technical assistance of the fish farmers. Moreover, Priority Index (P.I.) of major health problems was identified to understand the degree of the problems faced by the participants. The P.I. of constraints is explained below according to Roy and Basu (2020) and Mozahid *et al.* (2018).

$$P.I.=\sum s_i f_i/n,\ (0\leq P.I.\leq 1)$$

Where,
P.I. = Priority Index
S_i = Scale value of i^{th} priority
F_i = Frequency of i^{th} priority
N = Total number of observations

In the study, the scale value of P.I. ranged from 1 to 0 with priority 1^{st} to 5^{th}, correspondingly.

Collected data on aquaculture system were analyzed using Microsoft Excel 2013 and SPSS Software (version 20.00) and results were presented in textual, tabular and graphical format. Moreover, geographical location of the markets were pointed and presented using ArcGIS software (Version 10.5) (Figure 1).

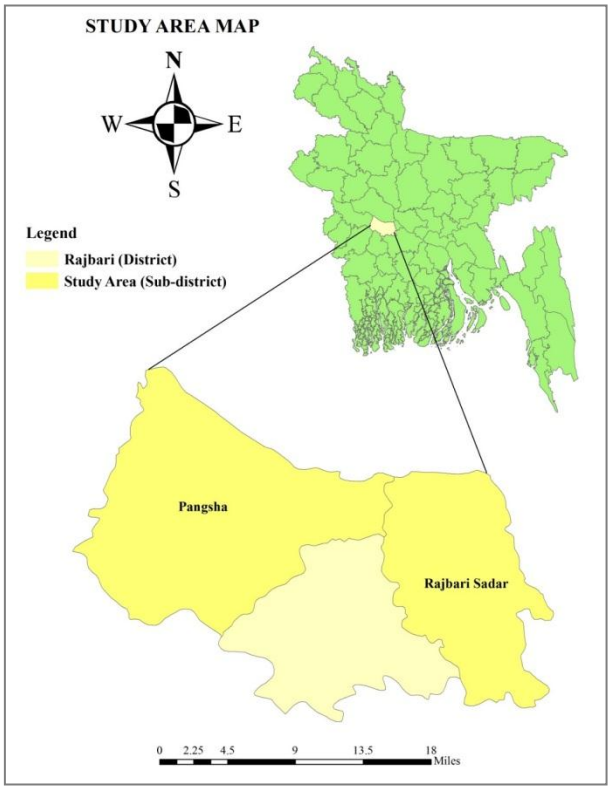


Figure 1. Geographical map of the study area

Results and Discussion

Farming experience and ownership

Most of the commercial farmers in the study areas started rearing fish by considering it as a profitable occupation. The fish farmers were divided into five sub-groups based on their experiences. It was found that, 30% respondents had 11 to 15 years of fish farming experience. Moreover, 12, 20, 24 and 14% aqua farmers were in 1-5, 6-10, 16-20 and above 20 years' experience groups, respectively (Figure 2). Roy *et al.* (2020) stated that, experience is positively correlated to age of the individuals which also influenced the production. It indicates that, the more the experience increased the more practical knowledge on pond farming increased which is important for successful aquaculture. In the study area, above 32% farmer cultured fish in their own pond (Figure 2) while 38% share pond with others and the rest (30%) took ledge ponds for farming fish.

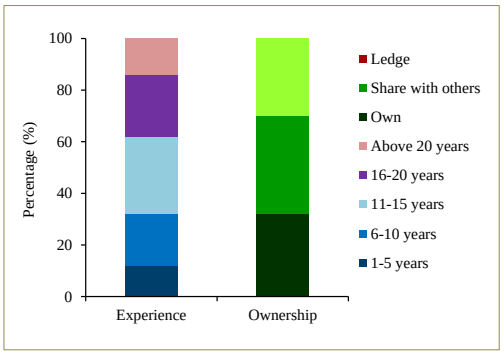


Figure 2. Experience and ownership of the fish farmers in the study area

Generally, for larger farm and ponds, farmers used to hire labor for pond preparation, seed stocking management and harvesting. In the study area, more than 50% farmers used to hire labor for taking care of ponds (Table 1). Moreover, some of them had fixed labor and others used to hire labor occasionally when the pressure of culture activities increases. The respondents also stated that, the manpower related to fish farming did not wear any disinfected and farm specific clothing. Schwarz *et al.* (2010) opined that, personnel access from one unit to another unit within same aqua farm should be restricted for maintaining good aquaculture practice.

Table 1. Variables of aquaculture influencing fish health in the study area

Variables	Categories	Percentage (%)
Farm boundary	Brick wall	5
	Fence	15
	Absent	80
Connection between ponds	Present	56
	Absent	44
Frequency of pond preparation	Bi-annually	26
	Annually	46
	Two years interval	28
Aerator	Yes	12
	No	88
Water quality testing tools	Yes	6
	No	94
Harvesting time	Early morning	74
	Morning	26
Season of disease	Summer	34
	Rainy	10
	Winter	56
Training source	No training	36
	Government organization	44
	Non-government organization	20

Farm boundary

In case of aquaculture, boundary plays a great role in ensuring biosecurity by preventing easy access of pathogen transmitting vectors in the fish farm (Islam *et al.*, 2019). It was found that, only 5% farms were surrounded by boundary made of brick and cement and 15% were surrounded by fence boundary (Table 1). Most of the farms had no boundary and it might be due to less awareness of the farmers regarding biosecurity and for not being interested in paying extra money for boundary construction.

Pond number and size

The number of pond varied among the respondents where, 34% had 1 to 3 ponds, 36% had 4 to 6 ponds and the rest of the fish farmers (30%) had above 6 ponds (Figure 3). In the sampled area, average pond size of 60% farmers was 0.20-1.5 acres and only 10% farmers had pond size of above 2.5 acres (Figure 3). Most of the farmers (42%) reported that, average pond depth was 1-2 m; whereas, 28% reported above 2 m water depth (Figure 3). Hassan *et al.* (2019) reported that, in the selected farms of Cumilla the range of pond area and depth were 1.7-8.5 ha and 1.82-2.35 m, respectively. Pond size and depth plays a vital role in case of pond management as well as production potential and suitable pond is also required for specific fish stock. However, specific pond size is not maintained in most of the areas of Bangladesh (Islam *et al.*, 2019).

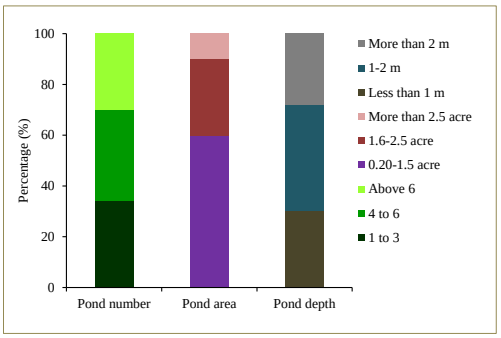


Figure 3. Average pond number and size in the study area

Pond water

All the fish farmers used ground water in the ponds and rain water is also added naturally during rainy season. Moreover, the respondents reported that, Rajbari is a flood prone area and every year almost all the ponds are inundated with flood water. But through the flood water, pathogen carrying water or fish can be passed from one farm to another one. Ponds of most of the farmers (56%) were connected with the other ponds of the same farm (Table 1). Moreover, it was observed that, there was no connection of water from one farm to another farm and few fish farmers used to share water within their farm boundary when needed. Similar result was found by Islam *et al.* (2019). Pietrak *et al.* (2010) stated that, ground water as a source of fish farming should be contamination free as water is the main medium for the survival of fish.

Culture species

Selection of culture species is one of main considerations in commercial aqua farming. From the study, it was found that 80% fish farmers practiced polyculture in their ponds combining two to eight species and rest of the farmers stocked single species (monoculture) culture in ponds (Figure 4). In polyculture system, they used to stock rui (*Labeo rohita*), kalibaos (*L. calbasu*), bata (*L. bata*), catla (*Catla catla*), mrigal (*Cirrhinus cirrhosus*), silver carp (*Hypophthalmichthys molitrix*), bighead carp (*H. nobilis*), grass carp (*Ctenopharyngodon idella*), mirror carp (*Cyprinus carpio* var. *specularis*), carpio (*C. carpio*), sarpunti (*Barbodes gonionotus*), tilapia (*Oreochromis nilotica*), shol (*Channa striatus*), koi (*Anabas testudineas*), shing (*Heteropneustes fossilis*), magur (*Clarias batrachus*), pangas (*Pangasianodon hypophthalmus*) and pabda (*Ompok pabda*). In case of monoculture, they used tilapia, shing, magur, koi

and pangas separately. They have reported that, on the basis of market demand they try to select species for culture. Faruk *et al.* (2017) reported that, average 86.7% tilapia farmers practiced polyculture system.

Integrated aqua farming and horticulture

In the study area, 16% fish farmers practiced integrated aquaculture combining fish culture with poultry farming or duck farming. More than 85% fish farmers reported that, they used to plant vegetables and fruit trees on the pond embankments (Figure 4). Common horticulture plants were tomato, cucumber, brinjal, bottle gourd, sponge gourd, bitter gourd, pumpkin, snake gourd, potato, cabbage, cauliflower, pea, okra, bean, spinach, red amaranth, onion, garlic and chilli. And other fruit plants were banana, lemon, mango, papaya, guava, jujube and coconut. The finding is close to the results of Jahan *et al.* (2015). Though the utilization of dyke for other crop and animal facilitates extra income, but such integration has potentiality to affect the fish health. Chicken and duck contaminate the culture area and water becomes contaminated by the movement of the poultry stock as well as wastage (Schwarz *et al.*, 2010). Moreover, inorganic fertilizers, insecticides and pesticides used in horticulture are harmful for fish health which can be mixed in the pond water by flood or rain.

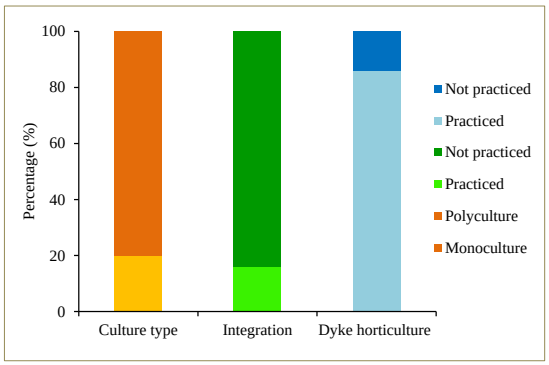


Figure 4. Culture system categories in the study area

Pre-stocking pond management

Major steps reported by the farmers were pond drying, removal of unwanted species, removal of bottom mud, tilling, lime and fertilizer application, dyke construction, water input and finally fish stocking (Figure 5). It was found that 26, 46 and 28% pond farmers prepared their pond bi-annually, annually and at two years interval, respectively (Table 1). The pond preparation steps are in accordance with the findings of Faruk *et al.* (2017) and Jahan *et al.* (2015). Schwarz *et al.* (2010) stated that, it is necessary to remove pond bottom mud at regular interval as dead fish, toxic chemicals, toxic gases and organics matters are embedded in the mud. Moreover, regular water exchange with contamination free water is also necessary for fish health (Islam *et al.*, 2019), which was not practiced in the study area.

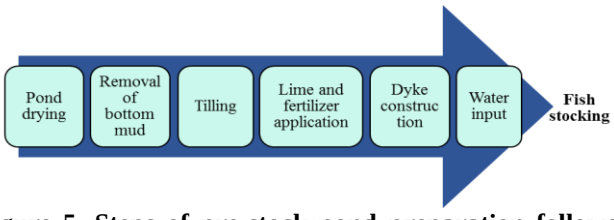


Figure 5. Steps of pre-stock pond preparation followed by the participants

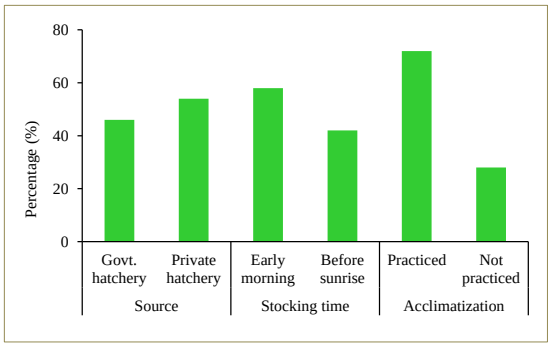
Stocking of fish seed

More than 50% respondents collected fish seed from private hatchery and rest of them (46%) used to collect from government hatchery (Figure 6a). Most of the farmers (72%) used to acclimatize seed before stocking which is very important for adjusting the fish seeds with the new environment of culture pond. Faruk *et al.* (2017) reported that, 73.3% tilapia farmers collected their fry from other hatchery while 26.7% farmers had their own hatchery.

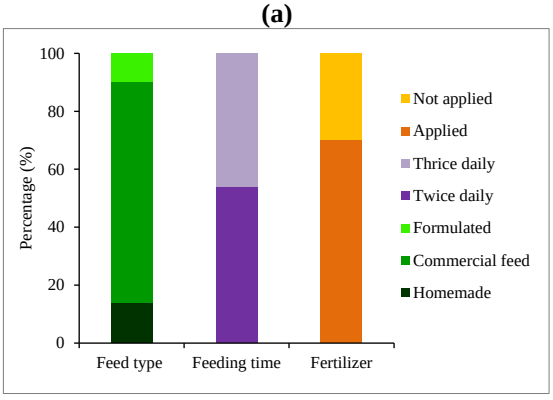
The stocking density of fish was categorized into four groups namely not specific, low (below 20000 fish ha^{-1}), medium (20000-40000 fish ha^{-1}) and high (above 40000 fish ha^{-1}); whereas, the fish size was considered 7-12 cm (Table 2). Specific stocking density and stocking size of fish were not followed by the 8% and 5% fish farmers in case of polyculture and monoculture systems, respectively. It was found that, most of the polyculture farmer stocked fish at high density while 65% monoculture farmers stocked fish at medium density. The stocking density of the present study was much higher than the finding of Faruk *et al.* (2017) and Jahan *et al.* (2015) which might be due to the backdated culture practice with poor awareness about the problems occurring from over density. However, prior to stocking, quarantine of the seed is necessary for the disease prevention (Schwarz *et al.*, 2010). But there was no facility for quarantine in the studied farms and it is a common scenario of majority aqua farms in Bangladesh (Islam *et al.*, 2019; Faruk *et al.*, 2017).

Table 2. Fish stocking densities in polyculture and monoculture in the study area

Categories	Polyculture (%)	Monoculture (%)
Not specific	8	5
Low (below 20000 fish ha^{-1})	10	12
Medium (20000-40000 fish ha^{-1})	31	65
High (above 40000 fish ha^{-1})	51	18



(a)



(b)

Figure 6 (a). Fish seed stocking and 6 (b) feeding practices in the study area

Application of feed and fertilizer

Commercial feed was used by most of the farmers (76%) (Figure 6b); whereas, 14% farmers used homemade feed and the rest 10% used formulated feed for culture purposes. Faruk *et al.* (2017) found that, 26.7% fish farmers of Mymensingh had their own feed mill or machine. On the other hand, Hossen *et al.* (2020) reported that, in Barishal Sadar 12% fish farmers depended on natural sources of feed. It was noticed that, 54 and 46% fish farmers applied feed twice and thrice daily, respectively (Figure 6b). Balanced diet, ration size and feeding period are important consideration in aquaculture for avoiding malnutrition. While in the study area, specific amount of feeding was not maintained and farmers were not aware of the necessity for balanced diet. In case of both traditional and semi-intensive system, the presence of natural feed like phytoplankton and zooplankton was regarded as good source of feed by the respondents and 70% farmers apply fertilizer for the production of such plankton (Figure 6b).

Artificial aeration

In the study area, only 12% farmers had aerators (Table 1) to agitate the surface water. In case of aqua farming with high stocking density, natural aeration is insufficient which results in health problem for the fish stock (Tanveer *et al.*, 2018) but, mechanical aeration enhances the fish production and maintain suitable quality for fish (Sultana *et al*., 2017). Most of the respondents of the investigated areas could not facilitate the culture system with sufficient aeration due to the higher cost of the paddle wheel aerator.

Water quality test

Only 6% farmers have instruments for testing water quality (Table 1) including dissolved oxygen meter and pH meter. Rest of the farmers did not have facility for water quality test. Moreover, they lacked knowledge regarding the importance of regular monitoring of water quality. Sometimes different government and non-government organizations test the water quality of the farms during investigation of different projects. Regular monitoring of water quality parameters are important for avoiding environmental stress which lead to different diseases. Parvin (2011) found that, most of the commercial farms used to keep different instruments for measuring water quality like measuring temperature, dissolved oxygen, transparency, pH, ammonia and alkalinity. In the study area, most of the fish farmers were small scale and they recognize the water quality problems on the basis of farming experience.

Harvesting of fish

The present survey revealed that, all the fish farmers sold their harvested fish to intermediaries and they used to sell the fish in the local markets within same district. About 70% farmers harvested fish in the morning whereas, 26% harvested at the early morning (Table 1). Different mesh sized cast nets are used for harvesting. Farmers usually share their harvesting tools each other without disinfecting them. In the view of biosecurity, farming tools can be potential source of pathogen contamination from one farm to another farm (Islam *et al.*, 2019). Moreover, they also reported that, when severe disease outbreak occurred they harvest all the fish stock. Hossen *et al.* (2020) found that, pond farmers of Barishal Sadar harvest all the year round but the peak season is post-monsoon.

Diseases

Most of the farmers monitor the health of fish either weekly or monthly. Large-scale loss of production occurs due to massive fish death. Reason behind such mortality is either infectious pathogens or drastic change in water quality (Giri, 2018). According to the survey, common fish diseases in the study area were pop eye, swollen belly, tail and fin rot, red spot, gill rot, fish lice, white spot, anal protrusion, haemorrhagic eyes, fungal attack, epizootic ulcerative syndrome (EUS) and malnutrition (Table 3). More or less similar diseases were reported by Islam *et al.* (2019), Hassan *et al.* (2019) and Faruk *et al.* (2017). They used to recognize the disease on the basis of their experience and clinical sign. They hardly know about the causative agents of the infectious diseases except macroscopic parasites like fish lice. The degree of problems after the occurrence of diseases was studied using three scales like less critical, critical and very critical. Moreover, 68, 65, 55 and 50% fish farmers reported that, fungal infection, gill rot, EUS and tail and fin rot create very critical condition after the onset, respectively (Figure 7). Whereas, 77% considered malnutrition problem creating less critical condition as fish can get remedy by maintaining proper diet. Delabbio *et al.* (2004) stated that, regular removal of dead and moribund fish is important consideration for maintaining biosecurity in aquaculture. Labor and other personnel entering into culture system should wear disinfected clothing and boots to prevent horizontal transmission of infectious pathogens (FAO, 2007). From the study, it was revealed that, 56% farmers faced fish disease problems during winter, while only 34% faced such problems in summer (Table 1). Some farms also noticed disease after heavy rainfall (10%) and during summer (3.4%). Faruk *et al.* (2017) reported that, near 38% aqua farmers faced fish disease problems during winter whereas, 13% faced occurrence of disease before onset of winter.

Table 3. Common fish health problems in the study area

Problems	Major clinical sign
Pop eye	Eye protrusion, opaqueness of eye
Swollen belly	Distended and reddened abdomen
Tail and fin rot	Lesion at the base of fins
Red spot	Haemorrhage throughout the skin
Gill rot	Gill lesion, anorexia, breathing problem
Fish lice	Abnormal movement, presence of *Argulus*
White spot disease	Whitish spot on body surface, fin and gill
Anal protrusion	Swelling and reddening of anus
Haemorrhagic eyes	Reddened eye
Fungal disease	Cotton like white to grey growth on the skin, gills, fins and eye; scale loss
EUS	Red spots, ulcer on body skin, eye, fin
Oxygen depletion	Fish gasping for air
Temperature problem	Swim erratically, stop feeding, lethargy
Toxicity	Anorexia, cloudy pond water, fish death
Turbidity	Turbid water, excessive aquatic vegetation
Malnutrition	Skeletal deformation, anorexia, abnormal and larger head

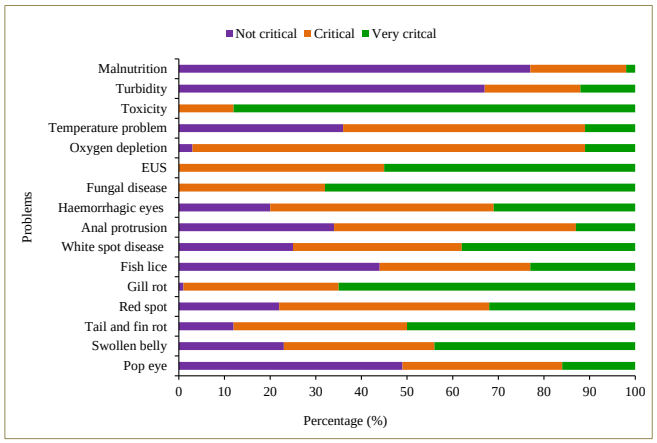


Figure 7. Degree of disease problems faced by the fish farmers in the study area

Water quality problems

The common water quality problems were temperature fluctuation, oxygen depletion, turbidity, acidity and excessive growth of aquatic weed. The farmers reported that, due to excessive hot and cool temperature as well as sudden fluctuation, fish cease feeding and can't grow properly which ultimately cause health problems or even death of fish. Water parameters are important for fish as parameters beyond optimum level creates stress in fish population which eventually led to possibility of different infectious diseases. But due to oxygen depletion, massive death of fish in the culture system takes place and water toxicity is also considered for such losses (Robert, 2012). Besides, the presence of large aquatic plants limits the space for free movement of fish and block light penetration which prevents photosynthesis by microscopic plants and causes fish death. Giri (2018) also stated that, turbidity occurs due to excessive algal growth and aquatic weed. To solve the problem, weeds are manually removed by the fish farmers or labor in the study areas. In addition, farmers also stock extra grass carp, silver carp, black carp and common carps to control the weed as they are herbivore on nature. Major sign and symptoms of fish health problems consideration of the respondents are given in Table 3.

Aquatic bird

In the study area, 86% farmers reported the presence of aquatic bird eating fish from the pond (Figure 8). Kite bird, little black cormorant, herons, kingfisher and water fowls were commonly found around farms. These birds act as carriers of disease to other farms as birds can transmit pathogen through droppings and transferring fish from one farm to another farm (Getchis, 2014; Robert, 2012; Sadler and Goodwin, 2007). Moreover, more than 60% farmers used net over the pond to protect the fish from the birds (Figure 8). Farmers tried to control predatory birds by hanging polythene rope over the ponds and covering pond with net. Faruk *et al.* (2017) also found that, in Mymensingh few farmers covered their pond with threads for protection.

Wild and domestic animal

Eighty-two percent farmers confirmed the availability of wild animal in the culture area or farm including- cat, dog, fox, hen, duck, snack and frog (Figure 8). Fifty-six percent farmers used net around the pond for the protection from animals. These animals may also act as vector for infectious fish diseases and in case of many trematodes such animals become intermediate host (Palić and Scarfe, 2018; Robert, 2012).

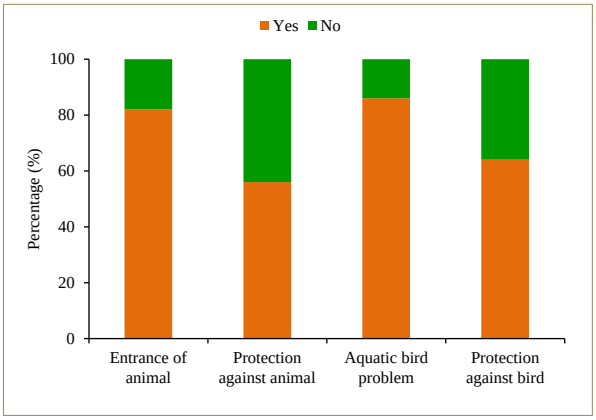


Figure 8. Problems of wild and domestic animal and protection in the study area

Poison application and poaching

The study revealed that, the farmers suffered from losses for poisoning and poaching due to enmity, family conflicts, jealousy and social conflicts. Heavy mortalities took place due to poison application in the ponds. For avoiding such loss, the owners of large aqua farm occasionally recruit night guard as both poisoning and poaching occurs at night.

Ranking of major health problems

The problems related to fish health were ranked by the pond farmers and according to their responses; fish disease problem was ranked 1st with 0.94 priority index (Table 4). Thus 2nd, 3rd, 4th and 5th ranked problems were poor water quality, poison application and poaching due to enmity, hamper due to wild animal and aquatic birds, respectively. The problems are in line with the findings of Hossen *et al.* (2020), Faruk *et al.* (2017) and Jahan *et al.* (2015).

Table 4. Ranking of the health problems by the fish farmers in the study area

Fish health problems	1st (S= 1)	2nd (S= 0.75)	3rd (S= 0.50)	4th (S= 0.25)	5th (S= 0)	P. I.	Rank
Disease	40	8	2	0	0	0.94	1
Poor water quality	4	32	10	4	0	0.68	2
Poison application and poaching	3	4	26	12	5	0.44	3
Wild animal	2	3	9	25	11	0.3	4
Aquatic bird	1	3	3	9	34	0.14	5

Technical assistance

The current result revealed that, 44% farmer participated in training program organized by government organization, while 36% received no training (Table 1). Dissimilar result was found by Hossen *et al.* (2020) and they reported that, 84% fish farmer of Barishal Sadar sub-district were trained by non-government organizations. Jahan *et al.* (2015) reported that, friends and neighbors practicing fish farming

were the main source of knowledge and information about aquaculture technologies among sample farmers.

Conclusion

The present investigation provided recent status of fish culture and health management practices in some aquafarms of Rajbari District which reflects traditional pattern of aquaculture practice in the studied areas. Due to knowledge gap, farmers usually try to solve the farm management related problems either based on their own experience or taking minimal assistance from others. Further improvements of farmer's knowledge on modern and scientific fish farming through training and workshops is highly recommended.

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