Assessment of Tilapia Cage Farming Practices in Relation to the Occurrence of Fish Mortality along the Fish Cage Belt at Magat Reservoir, Philippines

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ABSTRACT

The present study was conducted in Magat Reservoir, Philippines, to determine the profile and practices of tilapia cage farmers in relation to the occurrence of fish mortality. Eight stations were established: Station 1 (Baligatan), Station 2 (Namnama), Station 3 (Halag 1), Station 4 (Halag 2), Station 5 (Halag 3), Station 6 (Taliktik), Station 7 (Dallaw) and Station 8 (Isla Berde). A total of 80 households were interviewed from December 2016 to May 2017. Results showed that most incidents of fish mortality in cages occurred during the summer season (March to June). Farmers perceived the primary causes of fish mortality in Magat Reservoir to include fluctuating temperature (91.25%), water quality (83.75%), pollution and predation by birds (each 76.25%), parasite infestation (56.25%) and diseases (50%). Reduced feeding, isolation of the infected fish and proper stocking are the major activities conducted by the fish farmers to prevent the occurrence of fish mortality at Magat Reservoir.

Keywords: Fish cage culture, Fish mortality, Magat Reservoir, Tilapia

INTRODUCTION

Cage farming is the most common method of fish culture practiced in lakes, reservoirs and marine waters of most of the developing countries in South East Asia (Kashindye *et al*., 2015). This farming system provides competitive and sustainable production (Roriz *et al*., 2017), benefits local economies by generating additional employment and income along the entire aquaculture production chain (Ross *et al*., 2011), and requires lower investment compared to ponds and raceways (Rojas and Wadsworth, 2007). However, proliferation of fish cages in some bodies of water has resulted in negative impacts to the aquatic ecosystem (Garcia *et al*., 2014; Li *et al*., 2014). To minimize these risks, there is a need to conduct planning, legislate compliance, manage and monitor environmental quality of the fish farms (Nyanti *et al*., 2012, Ling *et al*., 2013, Ramos *et al*., 2013), and also provide best management techniques and public policies that contribute to the sustainability of this fish farming system (Garcia *et al*., 2014) to further increase fish production through reduction of the incidence of fish mortality. Therefore, the effective success of production in aquaculture depends on site selection, fish health management, and environmental carrying capacity, which involves important water quality parameters and maintenance of water resources (Costa-Pierce, 2002).

Magat Dam Reservoir is located in the northern part of the Philippines and is one of the largest reservoirs in Asia, covering a surface area of 11,700 ha and with maximum water depth of 193 m. It is a multi-purpose dam with a storage

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capacity of 1.08 billion·m^{-3} providing irrigation to 95,000 ha of rice fields and hydroelectric power generation (360 megawatts) (Elazegui and Combalicer, 2004). Cage culture of Nile tilapia (*Oreochromis niloticus*) in enclosures has become industrialized and a major source of income for fish farmers around the reservoir (Baleta and Bolaňos, 2016), and cage farming has significantly developed and increased every year. Consequently, declines in fish harvest in the reservoir have been observed by fish cage farmers, and have been attributed to the occurrence of parasites and the spread of infectious fish diseases, pollution, and other environmental factors. The lack of technical support and regulatory guidelines for the farmers and professionals, as well as the absence of national strategies for controlling the introduction and spread of diseases in aquatic animals, still represent an important bottleneck for the sustainable growth of the aquaculture industry (Georgiadis *et al*., 2001; Oidtmann *et al*., 2011).

Data obtained from this study will provide baseline information on the different culture practices in fish cage farms in Magat Reservoir, Philippines, and can be used by fish cage farmers and stakeholders to define proper cage culture practices. Understanding these practices could give a possible explanation of the occurrence of mortalities at tilapia cage farms. In addition, policy makers may use these data in formulating policies and regulations to promote sustainable aquaculture by increasing awareness of water quality, pollution and risk of mortality in aquaculture farms. Hence, this study was conducted to assess tilapia cage farming practices in relation to the occurrence of fish mortality in Magat Reservoir.

MATERIALS AND METHODS

Study area

The field study was carried out from December 2016 to May 2017 at eight sampling stations within Magat Reservoir, (16° 46'79" N latitude, 121° 23'00.48" E longitude), Philippines: Station 1 (Baligatan), Station 2 (Namnama), Station 3 (Halag 1), Station 4 (Halag 2), Station 5 (Halag 3) Station 6 (Taliktik), Station 7 (Dallaw) and Station 8 (Isla Berde) (Fig. 1).

Research methods, design and instrument

Before the study was conducted, the researchers discussed the planned sampling activities with the Barangay chairman and local administrators, and prior informed consent was granted. This research used a stratified random sampling method to determine the demographic profile, types of operation, stocking practices, feed and feeding management, health management of the cultured tilapia and harvesting practices, using a combination of interviews and survey questionnaires. Prior to the survey proper, a questionnaire was prepared and was pre-tested with college students to test the clarity of the questions to the target respondents. The respondents at each station were interviewed following the corrected survey questionnaire. Validations were done through personal interviews and ocular inspection at the fish cage farms.

Respondents

The respondents in this research were randomly selected from the fish cage operators among the different stations at Magat Reservoir. The main fish cage operators in every station were identified for interviews. In each of the eight stations, ten fish cage operators were selected for interviews, for a total of eighty respondents. The purpose and mechanics of the survey were first explained to the respondents, and then they were allowed to speak spontaneously to minimize feeling pressure. Other relevant information was obtained from the Municipality of Ramon Isabela, Philippines.

Statistical analysis

Answers to each question were tabulated and calculated using a frequency distribution. Graphical presentation of data was conducted based on the percentage of respondents to each question. Descriptive analysis was used for the interpretation of all the data gathered in the study. Correlational (Pearson's r) analysis was also conducted using statistical software (SPSS, version 23) to determine the correlation of each factor with probable causes of fish mortality.

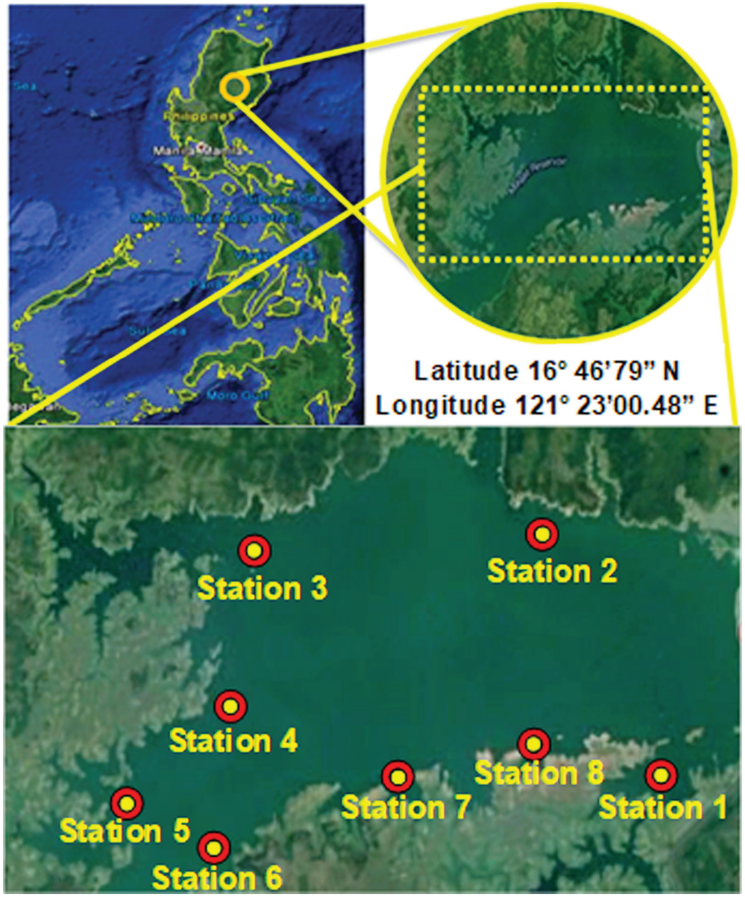

Figure 1. Map showing the study area in Magat Dam Reservoir, Philippines.

RESULTS

General information about the respondents

A profile of the respondents' mean age, sex, civil status, number of members in the household and educational attainment is presented in Table 1 and Fig. 2. The mean age of respondent tilapia cage farmers in Magat Reservoir was 41.71, with a range of 22 to 80 years old. Of the farmers, 78.75% were male, while 21.25% were female. With regards to their civil status, 93.75% of the respondents were married; while very few were single. The mean number of members per household of respondents was 4.77 persons. In terms of their educational attainment, half of the respondents reached an elementary level of education, 40% reached high school, 7.14% entered college, and 2.86% took vocational programs.

Sites of operation and stocking practices

The sites of operation and stocking practices of fish cage farmers at the different stations in Magat Reservoir are shown in Figs 3-4. The mean number of cages used by tilapia farmers in Magat Reservoir was 9.92 units, with 2 units being the smallest and 35 units being the largest. The mean stocking density practiced by tilapia cage farmers within Magat Reservoir was 9.29 fish·m^{-3}; the highest density was 14.1 fish·m^{-3} at Halag 1, and the lowest was 7.2 fish·m^{-3} at Dallaw.

Table 1. Respondents' profile (sex and civil status data as percentage) from eight stations at Magat Reservoir (n=80).

Stations	Mean Age	Sex		Civil Status		Number of Household Members
		Male	Female	Single	Married	
Baligatan	44.4	70	30	0	100	4.7
Namnama	34.9	60	40	0	100	4.3
Halag I	35.8	90	10	20	80	4.1
Halag II	41.2	100	0	10	90	3.5
Halag III	37.9	70	30	0	100	5.4
Taliktik	44.5	70	30	20	80	5.8
Dallaw	46.8	90	10	0	100	5
Isla Berde	48.2	80	20	0	100	5.4
Mean ±SD	41.71±5.06	78.75±13.5	21.25±13.5	6.25±7.33	93.75±9.16	4.77±0.77

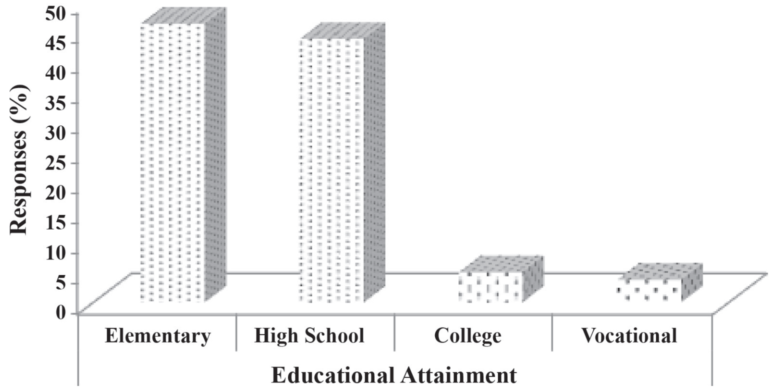

Figure 2. Educational attainment of tilapia cage operators at Magat Reservoir, Philippines.

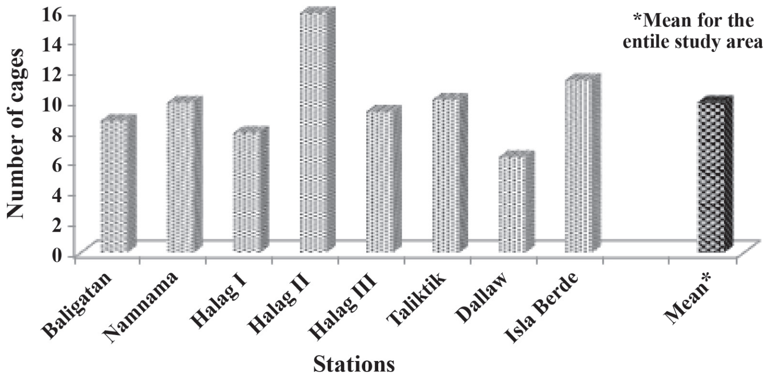

Figure 3. Number of cages used by tilapia fish farmers at different sites in Magat Reservoir and the overall mean.

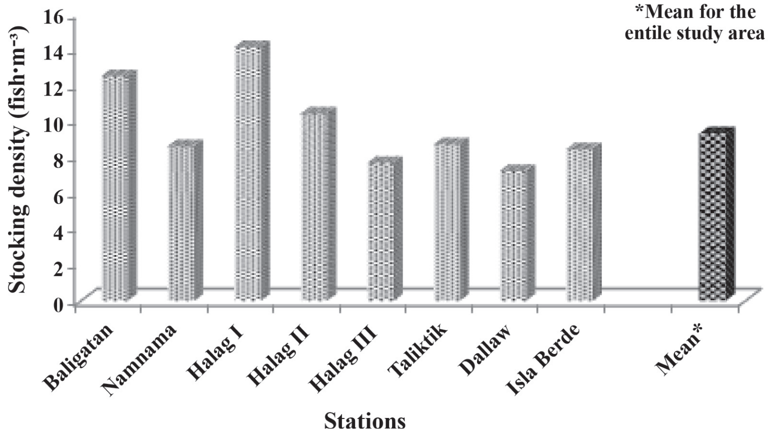

Figure 4. Stocking densities of tilapia fingerlings used by farmers at different sites in Magat Reservoir and the overall mean.

Feeds and feeding management

The feeding frequency, types of feed given and feeding regimes by fish cage operators at Magat Reservoir are presented in Figs. 5-6. The majority (65%) of the respondents said that they fed the tilapia three times a day (morning, midday, and afternoon). The time of feeding ranged from 7:00-9:00 a.m. in the morning, 11:00 a.m.-1:00 p.m. during midday and 2:00-4:00 p.m. in the afternoon. Moreover, approximately half of the farmers (56.25%) claimed that they follow a feeding guide. On the other hand, some respondents identified "ad libitum" and restricted feeding as their feeding regime. With regards to the type of feeds given to cultured stock, the majority of farmers (78.75%) utilized commercial feeds for their cultured fish. Only a few administered rice bran (7.5%) or powdered corn (2.5 %) as supplemental feed.

Health management for tilapia cage culture

The occurrence of fish mortality by season at Magat Reservoir is shown in Fig. 7. Most (87.14%) incidents of mortality occurred during the summer season (March to June), while during rainy season fish mortality occurs mostly in October (5.71%). The mean percentage of mortality for the entire culture period was also determined (Fig. 8). Respondents claimed that they experienced an average of 41-60% mortality of the fish stock by the end of the culture period.

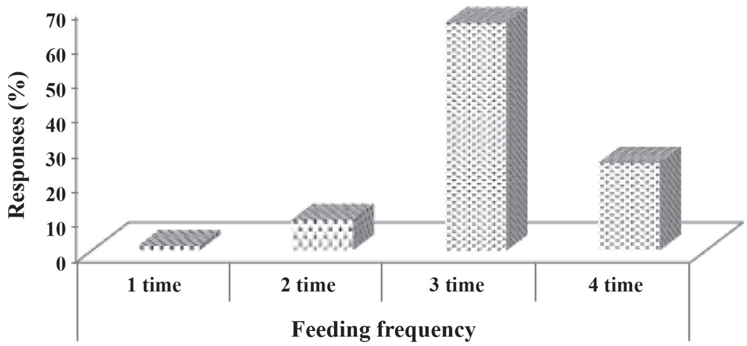

Figure 5. Percentage of farmers practicing different daily tilapia feeding frequencies at Magat Reservoir.

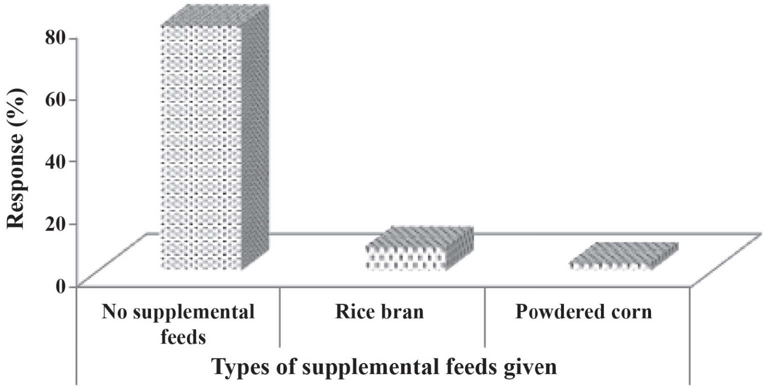

Figure 6. Percentage of farmers using different types of supplemental feeds given to farmed tilapia in Magat Reservoir.

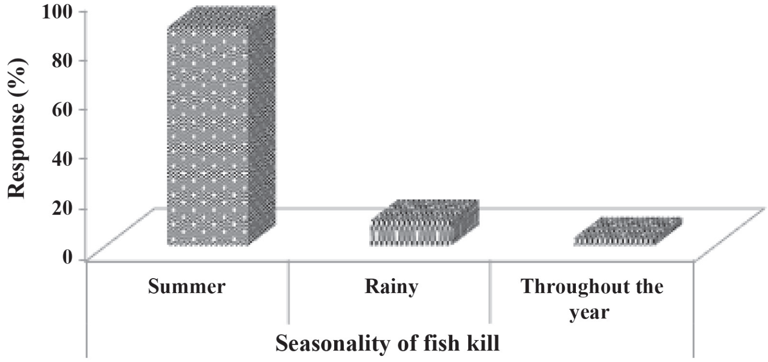

Figure 7. Percentage of farmers facing tilapia mortality by season at Magat Reservoir.

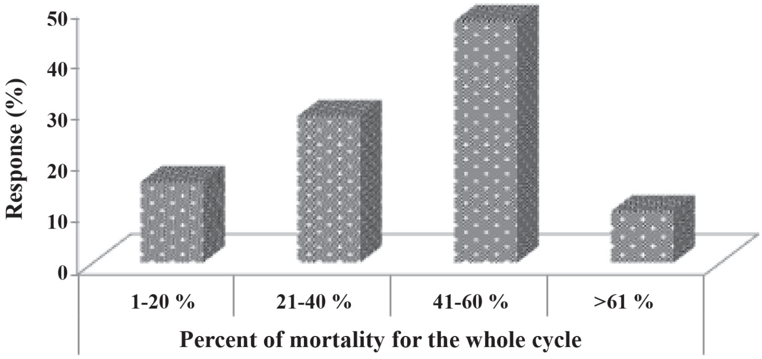

Figure 8. Percentage of farmers facing different percentage of fish mortality over the entire tilapia culture period.

The majority of respondents claimed that they observed signs, symptoms or clinical manifestations of disease in their farmed tilapia: eye opacity and skin lesions (both 67.14%), sluggishness (65.71%), enlargement of abdominal cavity (64.28%), followed by red spots in the operculum, loss of scales, exophthalmia, skin discoloration, loss of appetite and erratic swimming behaviour (Fig. 9). Only a few identified gasping at the surface of the water or rotten fins.

Almost all of the respondents identified fluctuating temperature (91.25%) and water quality (83.75%) as the most probable causes of mortality, followed by pollution and predation by birds (each 76.25%), parasite infestation (56.25%) and diseases (50%). Less than half of the respondents identified stress (46.25%) or overfeeding (38.75%), while only a few identified competitors (33.75%), or high stocking density (21.25%) as probable causes of mortality (Fig. 10).

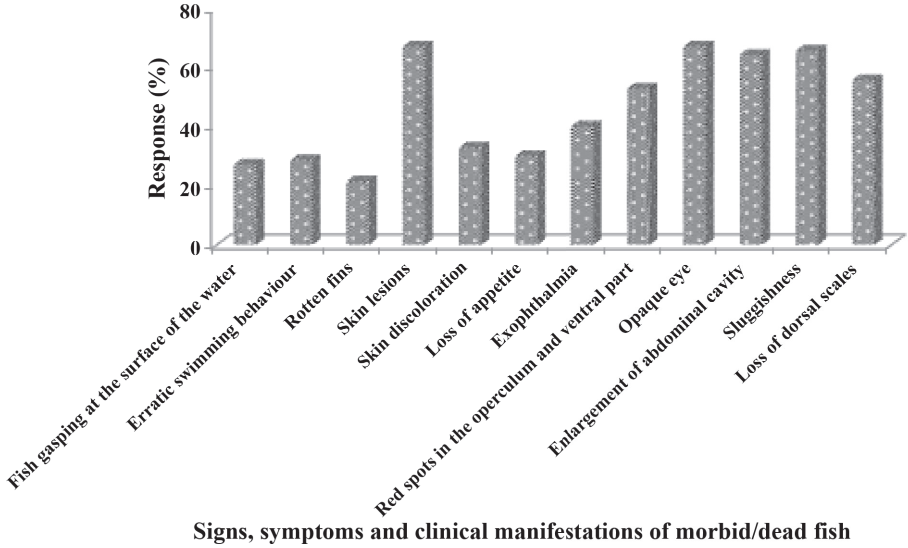

Figure 9. Percentage of farmers experienced different signs, symptoms, and clinical manifestations of moribund or dead farmed tilapia at Magat Reservoir.

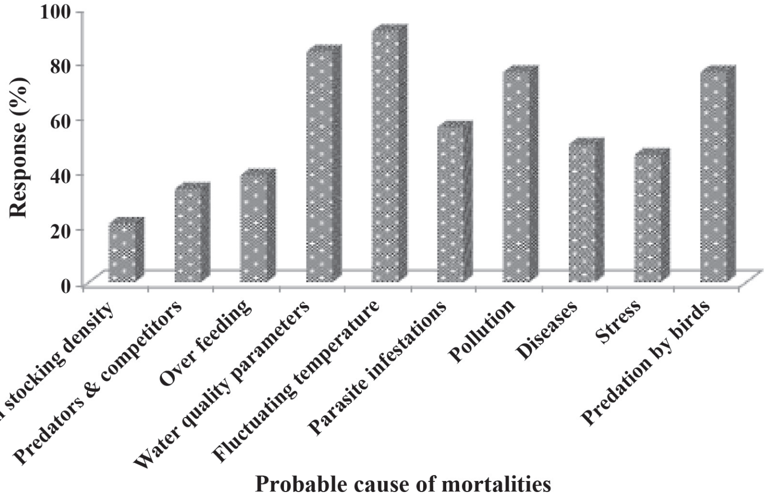

Figure 10. Percentage of farmers experienced probable causes of tilapia mortality at Magat Reservoir.

Pollution was one of the most probable causes suggested by the farmers for fish mortality. Almost half (40%) of the respondents claimed that dogs were near their cages while 37.14% of the respondents claimed that they had no animals near their cages. A few respondents raised chickens or rats (both 5.71%), pigs or ducks (both 4.28%), or cats (2.85%) at the floating house near their fish-rearing cages (Fig. 11).

Respondents from Magat Reservoir identified the presence of caged birds as the most probable or potential source of contamination of the water (72.5%), followed by the presence of domesticated animals (63.75%). Other contaminants that the respondents identified include aquatic macrophytes and human feces floating around the cage (Fig. 12).

Correlations between factors influencing the occurrence of fish mortality

The correlation analysis of probable causes of mortalities included the following variables; high stocking density (HSD), predators and competitors (PC), over-feeding (OF), water quality parameters (WQP), fluctuating temperature (FT), parasite infestations (PI), pollution (POL), diseases (DIS), stress (STR) and predation by birds (PB) (Table 2). Significant positive correlations were found between HSD and STR, between OF and POL and between PI and DIS.

Table 2. Correlation matrix of probable causes of fish mortalities at Magat Reservoir.

Parameters	HSD	PC	OF	WQP	FT	PI	POL	DIS	STR	PB
HSD	1									
PC	.281	1								
OF	.367	.084	1							
WQP	-.036	.095	.298	1						
FT	.385	-.147	.484	.157	1					
PI	-.483	-.398	-.362	-.278	-.139	1				
POL	.568	.378	.745*	.636	.211	-.638	1			
DIS	-.514	-.179	-.098	-.404	-.086	.752*	-.520	1		
STR	.761*	.388	-.014	.162	.159	-.255	.432	-.279	1	
PB	.611	.542	.626	-.262	.043	-.386	.537	-.095	.255	1

Correlations between parameters are shown by correlation coefficient (r) values; *significant ($p < 0.05$); Blank – not significant

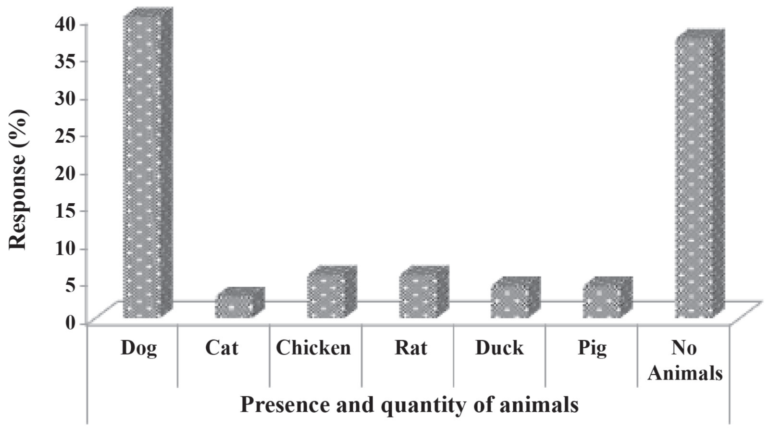

Figure 11. Percentage of farmers experienced domesticated animals present near the tilapia cages of Magat Reservoir.

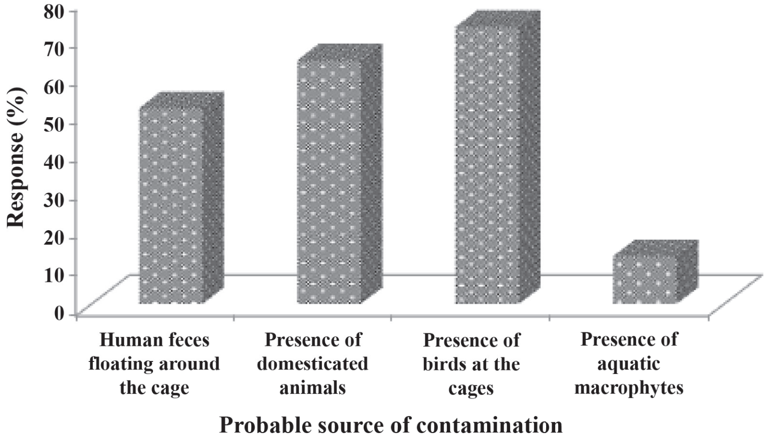

Figure 12. Percentage of farmers suggested probable sources of water contaminants at Magat Reservoir.

DISCUSSION

In the present investigation, the mean age of respondent tilapia cage farmers in Magat Reservoir was similar to a study by Syandri *et al*. (2011), who reported that the majority of Nile tilapia fish farmers at Maninjano Lake, Indonesia, ranged in age from 41-50 years old. Also, the majority of fish farmers in lakes and rivers were men (Syandri *et al*., 2011). With regards to their civil status, majority of the respondents were married, while very few were single. The findings of the present study were more or less similar to the findings of Syandri *et al*. (2015). In terms of their educational attainment, half of the respondents in this study reached an elementary level of education, 40% reached high school, 7.14% entered college, and 2.86% took a vocational course. In a study by Singh *et al*. (2015), most of the fish farmers interviewed were senior high school graduates (38%) or junior high school graduates (22%), which is similar to the present investigation.

With regards to site of operation and stocking practices, the mean number of cages being used by tilapia farmers in Magat Reservoir was similar to that from a previous study (Syandri *et al*., 2015). Meanwhile, the mean stocking density practiced by tilapia cage farmers within Magat Reservoir was 9-10 fish·m^{-3}. Stocking rates or densities are dependent on species, cage volume and mesh size, water surface area, and availability of aeration (Masser, 1997). In another study by Schmittou *et al*. (1998), the authors recommended stocking at a rate of 80 fish·m^{-3} for 15-g tilapia fingerlings, which is in contrast to our results. This difference might be due to management strategies practiced by the tilapia cage operators in Magat Reservoir to avoid mass mortalities.

In the present study, the majority of the respondents said that they feed their tilapia three times a day (morning, midday, and afternoon). Moreover, approximately half of the fish cage farmers claimed that they follow feeding guidelines. Tilapia are fed a ratio which varied along the rearing period from 1.5 to 11% of the body weight, given 2 to 5 times per day, and re-adjusted daily, weekly or every two weeks based on fish growth or according to weather or environmental conditions (McGinty and Rakocy, 1994). With regards to the types of feed given to cultured stock, the majority of the farmers utilized commercial feeds for their cultured fish. Similarly, the majority of farmers in a tropical Reservoir in Brazil used commercial feed (Roriz *et al*., 2017), while 94% of fish farmers in Egypt used commercial feed (Eltholth *et al*., 2015).

Caged-fish farming is dependent on the environment to provide a wide range of environmental goods and services, including the steady supply of dissolved oxygen and the removal and assimilation of wastes (Beveridge *et al*., 1997). Fish farmers interviewed in this study experienced highest mortalities in summer, specifically during the months of March to June, and this confirms the previous findings by O'Hearn and McAteer (2016). Lakes and reservoirs in summer are subject to much higher surface temperatures, decreasing the physical ability of water to hold oxygen. Many lakes are also stratified during the summer making it difficult for oxygen to diffuse to greater depths. In addition, during the summer period natural or human-induced limnological changes in these productive lakes can cause algal or aquatic plant populations to collapse or reduce oxygen levels, which has the potential to cause a fish kill (Hoyer *et al*., 2009). Moreover, the respondents claimed that they experience an average of 41-60% fish mortality of the stock over the entire culture period. Similar results were observed by Kampayana *et al*. (2016), who reported that the majority of tilapia cage operators in all lakes in Rwanda recorded greater than 60% fish mortality due to bad weather conditions or sporadic natural calamities such as heavy rains, strong winds, or low dissolved oxygen of water.

The majority of respondents claimed that they observed the signs, symptoms or clinical manifestations of disease in the cultured fish in Magat Reservoir. Generally, fish cage operators at Magat Reservoir practiced intensive culture of tilapia, based on the density of stocking and feeding regime. Intensive culture systems, either in ponds or in cages, have always led to epizootic disease problems. Various fish diseases may lead to high fish mortality in any aquaculture farm (Nofal and Abdel-Latif, 2017). However, almost all of the respondents identified fluctuating temperature and water quality as the most probable causes of mortality, followed by pollution and predation by birds, parasite infestation and fish diseases. Fluctuating water parameters, most notably temperature and dissolved oxygen level, are major contributors to the stress of fish. This is consistent with findings of Roriz *et al*. (2017), who reported that the primary causes of fish mortality in the reservoir were water temperature and water level (72%), fingerling quality (31%) and improper feed management (24%). The main contributing factor appears to be higher water temperatures, and consequently lower dissolved oxygen levels and lower water levels in freshwater systems (Lugg, 2000). In addition, the natural occurrence of fish kills can be related to physical processes, including sudden or excessive temperature changes or rapid fluctuations in temperature, pollution, toxic algal blooms, turnover of the water column, water chemistry changes such as low dissolved oxygen or oxygen depletion and/or changes in pH. Fish kills can also be biological in nature such as infections by viruses, bacteria or parasites (Hoyer *et al*., 2009), which was confirmed by the present investigation. Moreover, birds are known to be vectors of diseases, while parasites and bacterial pathogens are opportunists, as they attack the system especially when fish are in a stressful condition. In addition, ectoparasites might act as a portal of entry for secondary bacterial invaders which, together with poor water quality caused mortality of cultured fishes at Al-Manzala fish farms (Nofal and Abdel-Latif, 2017).

Pollution is one of the most probable causes of fish mortality. In the present investigation, almost half of the respondents claimed that dogs were moving around their cages while 37% of the respondents claimed that they had no animals near their cages. As water pollution increases, populations of disease-causing organisms, such as bacteria and parasites, also increases. In addition, pollutants such as suspended solids can prevent oxygen uptake by fish and can damage the functioning of gills, and thus may cause fish kills (Kibria, 2014). Human activities are also responsible for pollution of water leading to fish mortality, for example, accidental oil spills, drainage discharge of pesticides and herbicides from agricultural land, presence of domesticated animals and improper disposal of human waste (Kibria, 2014).

In the present study, high stocking density showed significant positive correlation with stress. Disease is usually an effect of secondary infection and the primary precursor to disease is stress from physical or chemical factors such as lowered water temperature, rapid changes in salinity, chronic pollution or crowded conditions (Lugg, 2000). High stocking density might exceed carrying capacity of a water body resulting in increased fish stress, disease and mortality, reduced feed conversion efficiency, low growth rate and loss of profit (Schmittou *et al*., 1998). In Magat Reservoir, the environmental parameters fluctuate widely and fish become more susceptible to diseases. When any diseases occur in cages, they are almost impossible to be controlled or treated (Tonguthai and Leong, 2000).

CONCLUSION

Fish mortality generally occurs in the summer during the hottest months at Magat Reservoir, and depends on the water level, fish health and water quality status. Pollution, predation by birds, fluctuating temperature, water quality, parasite infestation and fish diseases are major contributory factors to the stress of cultured stocks resulting in fish mortality. A lack of technical assistance and undiagnosed diseases are also important factors. Hence, the fish farmers apply different management strategies including proper stocking, proper nutrition and feeding management, and proper health management. In addition, reduced feeding, application of salt and madre de cacao extract and other chemicals, isolation of infected fish and proper stocking are the major activities conducted by the fish farmers to prevent the occurrence of fish mortality at Magat Reservoir. It is necessary to adopt mitigation measures for protecting water quality in the reservoir from deterioration, while monitoring important water parameters may give early warning of the possible occurrence of fish mortality in Magat Reservoir.

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