Quantitative Analysis of Biosecurity Levels in Ornamental Fish Farms Based on a Scoring System. A Case Study in Sri Lanka

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ABSTRACT

The importance of biosecurity levels vary, as every pathway of disease transmission is not the same. The risk based quantitative assessment, which is more insightful, compared to general qualitative assessment, and therefore, could be considered as the ideal way to identify the gaps in different biosecurity measures in detail. All the possible ways of transmitting pathogens and the relevant preventive measures in fish farms have been included in the analysis used in the study and it has been further sub divided into external and internal biosecurity. In this, relative importance of different biosecurity aspects has been taken into account and accordingly, the final score is weighted in developing the risk based weighted scoring system. The biosecurity score obtained was indicated after the completion of the questionnaire and the scores at each subcategory can be compared by the farmer or the field veterinarian. A study carried out using a sample of 91 ornamental fish farmers in Gampaha District, revealed that there is a vast variation in the scores of biosecurity level in fish farms, ranging from 63% to 5% and this implies that many biosecurity measures have not been adequately implemented in these farms and there exists more room for improvement.

Key Words: Biosecurity, Scoring system, Risk Based, Ornamental

INTRODUCTION

Performance, thus the profitability suffers greatly of the business entities that operate in ornamental fish industry whenever there is an outbreak of a disease. In case of an outbreak of an epidemic disease, the entire production system gets disrupted and the infected has to be placed under quarantine (Carey et al.,2005). Improper environmental factors, inadequate farm management, uncontrollable movements in aquatic animals have been cited as the major factors that result in outbreak of disease. In controlling the aquatic diseases, the relationship between host, pathogen and the environment should be thoroughly understood (Subasinghe et al., 2012).

This is the place where biosecurity plays a pivotal role in ornamental fish farming in preventing outbreak of disease, rather than in curing them. As a result, biosecurity is defined as all the measures taken in to consideration to prevent the introduction and spread of infectious agents within the farm in order to keep the fish healthy and also to limit the spread of pathogens in the environment (Barcelo et al., 1998).

Biosecurity management can be categorized into two, namely external and internal biosecurity management (Laanen,2013). External biosecurity is related to the measures that prevent pathogens entering the farms while internal biosecurity is related to the measures used to minimize the pathogens within the farm.

Therefore, careful identification of gaps in each level of farm management practices is worthwhile along with good evaluation of biosecurity systems in each farm. Hence, there should frequent assessment of the

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biosecurity management practices for compliance as there is always the risk of exotic or endemic disease spreading into the farm (Gelaude et al.,2014).

More often checklists based on qualitative assessment indicators are used to assess the biosecurity levels in farms. Recently most scientists have identified that the importance of biosecurity levels is not the same as every pathway of disease transmission is not equally efficient. Therefore, method of risk based quantitative assessment developed paving the way for more insightful assessment, compared to general qualitative assessment. Under the said system, different weights will be given for each biosecurity measure to calculate the final score. This helps in identifying the gaps in different biosecurity measures in detail. Quantitative assessment tools of biosecurity levels for pig herds and poultry flocks have been extensively used in most of the developed countries (Dewulf et al.,2012; Wei et al.,2012). A large number of risk factors related to biosecurity measures in different livestock and poultry productions systems have been identified in scientific literature but the available scientific facts specific for biosecurity in ornamental fish farms are very few, (Kouwenhoven et al., 1978; Wolgemuth, 1989; Kapperud et al., 1993; Liljebjelke et al., 2005; McQuiston et al., 2005; Capua and Marangon, 2006; Hermans and Morgan, 2007). There is no such quantitative risk assessment system available in Sri Lanka for ornamental fish farms, not to the knowledge of the researchers of this study.

To develop a quantitative biosecurity assessment system to assess the biosecurity status of ornamental fish farms in Sri Lanka is the major objective of this study.

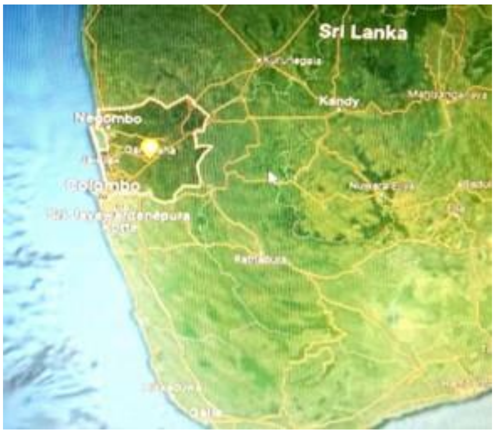
METHODOLOGY

Selection of Farms

Ornamental fish farms in Gampaha district were selected for the study as it is considered as one of the districts consisting higher number of ornamental fish farms in Sri Lanka (Heenatigala,2009) and as the district having the highest number of fish farmers that engaged in export activities.

As reliable data that had been recorded previously on fish farmers could not be obtained, all the ornamental fish exporters (31) currently engaged in export activities and officially registered in Animal Quarantine Station, Department of Animal Production and Health, Sri Lanka within the sample area were included in the study. In the absence of official registry of ornamental fish farms, farms were first located with the help of the exporter using snow ball technique. (Manager of the each export establishment assisted the researchers in identifying the fish farmers supplying fish for the exporter and the process continued until the whole area is covered). Face to face interview between the researcher and the ornamental fish farm owner, personal observations and instructions provided by the researcher were used in carrying out the questionnaire survey.

Figure 1: Study Area within 6.90902 ^{0} – 7.33031^{0} and 79.842^{0}– 80.211019^{0})- Gampaha District, Sri Lanka



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Development of the questionnaire

The questionnaire developed aims at describing the complete biosecurity situation at an ornamental fish farm. Questions were asked on each relevant aspect of biosecurity measure considering the disease transmission routes in ornamental fish to determine whether a preventive measure is applied or to identify whether a specific situation is present or absent. The questionnaire was developed after a thorough literature servey on disease transmission in ornamental fish, based on the information obtained from the Biocheck. UGent tool for pigs, poultry biosecurity measures (Laanen et al., 2013) and the biosecurity questionnaires available in the web sites, WOAH (Former O.I.E) and FAO.

Accordingly, the scoring system is separated into 2 main categories, external and internal biosecurity, and the questionnaire comprised of questions on different biosecurity measures. The questionnaire has been prepared with a view to extracting information on biosecurity measures in detail. External biosecurity and internal biosecurity are comprised of all the measures that prevent the introduction of off-farm pathogens and each is divided into 7 subcategories and 3 sub-catogeries respectively. Under each subcategory the number of measures included, ranged from 3 to 7.

Figure 2: Risk Matrix Used to calculate the sub category measure scores.

Severity	s5= Very high	5	10	15	20	25
	s4= High	4	8	12	16	20
	s3= Modarate	3	6	9	12	15
	s2= Low	2	4	6	8	10
	s1= Very low	1	2	3	4	5
		L1= Very low	L2= Low	L3= Modarate	L4= High	L5= Very high
		Likelihood				

Development of biosecurity score form and validation

Biosecurity Scoring System

A technical scoring system was developed taking the risk of biosecurity measures into account. The prioritization and weighing of various biosecurity measures and (sub) categories have been done by ornamental fish experts, each with their own area of expertise. Weight of each measure was derived by taking the mean of each weight given by the panel of experts and further supported by the literature survey.

The method described by Gelaude (2014) was considered in quantifying the effect of a specific biosecurity measure.

Total of sixty seven marks was allocated for all external biosecurity measures and each subcategory (measure) was divided into several sub measures. Subsequently, total of thirty three marks were allocated for internal biosecurity measures by the panel of experts. Each sub measure was allocated maximum of 25 marks using the risk matrix considering the likelihood of spreading a disease by the transmission route and the severity of disease.

The procedure followed in obtaining the final score of the internal and external biosecurity began with the allocation of a score between 0 and 1 for each question, 0 for total absence of preventive measure or full presence of risk and 1 for full presence of preventive measure or total absence of risk. To obtain the relative result of the question, the said score was then multiplied by the weightage given to the specific question.

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This was followed by summation of the results of each question under the given subcategory and then dividing it by the maximum score obtained in the said subcategory. To derive the subcategory score, the above calculated proportional result of the subcategory was multiplied by the weightage assigned to the given subcategory and the final score of the internal and external biosecurity is the sum of the scores obtained by each subcategory of internal and external biosecurity. This method was adhered to ensure that the scoring system is risk-based and weights are included both at the level of the subcategories as well as at the level of the individual questions.

Different Disease Transmission routes and Biosecurity Strategies

Literature survey reveals that there are several biosecurity strategies practiced in different countries to cover the disease transmission risks at different transmission routes.

Table 1. Literature references of different external biosecurity strategies against different pathogen transmission routes.

Transmission route	Different strategies of biosecurity	Citation
External Biosecurity consideration 1.purchasing new fish to the farm. 2.Feed and Water Supply	Bringing from the same farms. Purchasing new animals. Quarantine facilities and all in all out system. Disinfection of transport vehicle. Frequency of purchasing new fish. Storage facility to fish feed. Water storage facility. Water supply from a clean source. Quality feed.	Hege et al.,2002 Villarroel et al., 2007 a Yanong et al.,2012 Shimaa et al.,2012 Baraitareanu et al.,2020 Yanong et al.,2012 Shimaa et al.,2012 Villarroel et al., 2007 a. Villarroel et al.,2007 a. Villarroel et al., 2007 a.
3.Removal of waste water and dead fish	Water disposal to a pit. Gutters always clean without accumulation of water. Proper disposal of dead fish.	Damianns et al.,2020 a.

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4.Visitors and farm workers hygiene	Visitor should make a prior notification to enter the farm. All farm workers and the owner abide by the rules accessing the farm. Farm specific clean clothes and shoes are available. Hand disinfection facility. Visitor access limited. Workers not rearing fish at home. Separate workers for each section.	Noremarket et al., 2014 Baraitareanu et al., 2020 Kapperud et al.,1993 Refegier- Petton et al., 2001
5.Supply of materials 6.Biological vector	Materials shared with farms. Shared materials disinfected. Access of fish to outside of the farm. Feed stored securely to prevent rodents and other pests accessing. Prevent Wild birds enter the fish farm. Bird and vermin proof air inlets. Fenced farms. Pet access is prevented.	Amass Baysinger, 2006 Yanong et al.,2021 Baraitareanu et al., 2020
7. Location of the farm	Water is not stagnant. Distance between the nearest farm is more than 500m. Wind or waste water not coming from other farms.	Truscutt et al., 2008 Bradburry et al., 2008

Table 2: Literature references for different internal biosecurity strategies against pathogen transmission routes.

Transmission Route	Biosecurity Strategy	Citation
Internal Biosecurity Consideration 1.Disease management	Acceptable Stocking density Prophylactic treatment Health management programs	Sims ,2007

2.Cleaning and disinfection	Disinfection cleaning after each production cycle Foot bath available Clean cloths available Clean boots available Vehicle bath available Hand washing facility	Meroz ,1995 Félix et al., 2020 Shimaa et al., 2020
3.Materials and utensils between compartments	Materials disinfected between compartments Protocol for disinfection is available Clearly recognizable material code between compartments	Shimaa et al.,2020

Collection of Data.

All data were collected between June 2021 and June 2022 through a personal interview at the farm. All fish farms were visited by the researcher with a view to minimize interviewer bias and to ensure inter farm comparability. After the interview was conducted and the questionnaire was filled in, all sections were visited and photographs were taken.

RESULTS OF THE SCORING SYSTEM

Different Biosecurity Scores in average

Table 3: Average scores of participant farmers for different biosecurity measures.

	Average Score of the Farmer	Standard Score
External Biosecurity		
1.Purchasing new fish to the farm	3.81(26%)	15
2.Feed and water	4.3 (35.8%)	12
3.Removal of waste water and dead fish	1.16 (16.57%)	7
4.Visitors and farm workers	1.15 (12.7%)	9
5.Material Supply	3.58 (51.1%)	7
6.Biological vectors	2.73 (45.5%)	6
7.Location of the farm	3.5 (31.81%)	11

Internal Biosecurity		
1.Disease management	5.42 (41.69%)	13
2. Cleaning and disinfection	3.05 (25.41%)	12
3. Materials and measures between compartments	2.5 (31.25%)	8

Within the category of external biosecurity, the following 3 subcategories had the lowest average scores acquired by ornamental fish farmers: visitor and workers hygiene, waste water and dead fish removal and purchasing of new fish. In the subcategories of the external biosecurity, material supply, feed and water supply and biological vector control obtained the highest average scores. Within internal biosecurity, disease management obtained the highest score, whereas cleaning and disinfection had the lowest score comparing the standard scores of each category. Even considering the highest average values obtained by the farmers, which are far lower than the standard scores.

When comparing the average scores obtained by the farmers for the each category, internal biosecurity scores have reached closer to the standard values of each category.

The obtained results allowing rapid visual identification of any bottlenecks in the biosecurity management at the farm. The maximum biosecurity score acquired by the farmer is 63% while the minimum is 5%. According to the results, farmers having higher education level acquired highest scores in biosecurity levels where as the farmers with lower levels of education gained lower scores.

DISCUSSION AND CONCLUSION

Since the Sri Lankan ornamental fish industry concentrates mainly on export market, production is mainly determined by the legal and private requirements of the importing country. So far the domestic exporters have been successful in providing good quality and healthy fish to the world with zero complaints. As the sector is still growing and in competing with other exporters in the world, it is important to take every possible step to mitigate the threat of spreading endemic or exotic diseases, which could have a detrimental impact on the whole industry. As the findings of this study suggests, there is more room for most of the biosecurity measures to be improved, this innovative tool will allow the farmers to observe their farm biosecurity levels, in a quantitative manner. While Health standards, hygiene, traceability, social and environmental requirements are comparatively new, marketing standards for ornamental fish for the EU market have been in place since the early 1970s and the new conditions were imposed in 2014 for Australian exports. Other countries also tend to amend the health standards, hygienic requirements, and traceability, social and environmental standards with the time to overcome different issues faced by the people engaged in live animal international trade.

According to the knowledge of researchers, Sri Lankan ornamental fish industry biosecurity levels in the ornamental fish industry in Sri Lanka have not been systematically studied at the national level, also biosecurity scores at the national level have not yet been calculated. Thus, the biosecurity assessment tool developed in this study can be used to calculate the national average of biosecurity standards of the ornamental fish farms in Sri Lanka. This should be further followed up through the modification or expansion of the existing measures at farm level. Managing protocols must be evaluated and described at each step together with the training of the farm staff and the professionals that serve in this sector. If the biosecurity scoring system is used throughout the country, the biosecurity level could be mapped out and high risked areas in which the risk of epidemic disease outbreaks can be identified thus making target surveillance possible.

This is a very important issue to be consider as the exporters who do not breed ornamental fish tend to purchase fish for their buyers on demand and they collect fish from different suppliers scattered all over the country. This study has developed a risk based scoring tool for the quantitative evaluation of biosecurity levels of above mentioned ornamental fish farms. The system could identify the biosecurity status as well as biosecurity gaps present in the farm in a standardized and reproducible manner. The scoring system which could help the veterinarian and eventually farmer to identify the gaps as well as to implement the biosecurity measures in the farm considering almost all the aspects of biosecurity levels.

This innovative tool allows not only to study the biosecurity levels at farms, in a quantitative manner, but also the relationship between biosecurity, health, and production characteristics, similar to the way this has been used for pig production, poultry and dairy production systems in other countries (Laanen et al., 2013; Daamians et al., 2020).

Significant variation in biosecurity scores was found between different farms indicating that there is ample room in this sector for improvements. In general, the internal biosecurity scores were higher than the external biosecurity scores in studies conducted in dairy sector (Gelaude,2014), opposing to the porcine and livestock industry where external biosecurity scores (65/100) are on average higher than the internal biosecurity scores (52/100) (Laanen et al., 2013).

A study conducted by Limbergen (2018) on European Conventional Broiler Production found internal biosecurity score (mean 76.6) to be better than external biosecurity score (mean 68.4). There was a variation between the mean biosecurity scores for different member states, ranging from 59.8 to 78.0 for external biosecurity and from 63.0 to 85.6 for internal biosecurity (Limbergen et al., 2018). Sub category of visitors and staff scored the lowest biosecurity levels compared to the standard scores which suggested that better education of broiler farmers and the staff will help to improve the broiler farm biosecurity in Europe.

Similar study conducted by Daamians,2020 to assess the biosecurity in veal, beef and dairy farms in Europe found that, for all production systems both internal and external biosecurity to be at lower level. The Bio Check tool was used to assess the scores and this resulted in lower mean total biosecurity scores of 39.7 points for veal 44.3 for beef, and 48.6 points for dairy farms, out of a maximum of 100 points. “Health Management “subcategory was observed as the lowest subcategory in all three production systems. This evaluation was important in benchmarking and in comparing all three types of farms in the area and in providing herd specific advices for improvement of biosecurity loopholes.

Based on the views of experts and the literature survey carried out, the external biosecurity score weightage is higher than the internal biosecurity score weightage in the ornamental fish industry in Sri Lanka. The average scores obtained by the farmers were far lower than the weighted standard scores and the internal biosecurity scores were comparatively higher than the external biosecurity scores on average. This difference between the external and internal biosecurity scores resulted due to the fact that there are less preventive measures for internal biosecurity when compared with the external biosecurity at ornamental fish farms in Sri Lanka. Therefore, high scores reaching the maximum score of 100 (hundred out of hundred) can be more easily obtained for internal biosecurity category in Sri Lankan ornamental fish farms.

As the biosecurity has become an essential element of intensive farming systems, avoidance of the introduction of new pathogens and effectively controlling of their spread will contribute to increase the wellbeing of fish industry too. A better knowledge of the epidemiology of the fish diseases will contribute towards designing better biosecurity programs like quantitative assessment methods. Findings of a study of this nature is immensely important to the stakeholders of the industry as this has produced an objective quantitative assessment methods to permit precise selection of biosecurity measures and thereby to carry out proper evaluation of their impact in preserving the health of fish in Sri Lanka. It is suggested a collaborative approach with other branches of science like sociology and psychology to implement a better biosecurity plan in a farm.

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