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Non-Infectious diseases and biosecurity management practices of fishes health in aquaculture

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Abstract

This article organized while studying PhD in Aquaculture and fishery management to review non-infectious diseases and biosecurity management of fish in aquaculture. Background: Fish diseases are broadly categorized in to infectious and non-infectious disease. Infectious diseases are caused by pathogenic organisms such as parasitic, bacterial, viral, or fungal, and non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic cases; they are not contagious. Many of the diseases that occur in fish are the result of stress, poor water quality, overcrowding, and failure to quarantine any new or sick fish to avoid spread of disease, and these factors can all be minimized by appropriate care and good hygiene. Aquaculture fish health management practices is important to prevent fish disease which begins with prevention rather than treatment. Objectives: The main objective of this study is to assess non-infectious diseases and biosecurity management practices of fish health in aquaculture. Methods: Statistical data were collected by observation and secondary sources such as published articles like researches, reviews, books, etc and organized following the standard scientific methods. Result and conclusion: Fish pathology deals about the cause and nature of diseases, host-pathogen relationships, diagnostic methods, therapy, epidemiology, etc. Fish diseases are caused by parasitic, bacterial, viral, fungal, environmental problems, nutritional deficiencies, and genetic cases. Fish diseases that associated with physico-chemical properties of water are non-infectious environmental diseases, and caused by adverse environmental conditions, nutritional disorders, genetic defects, results sudden mass mortality. Diseases with physical factors are mainly due to handling, transport, high stocking density and predation, and also secondary factors by pathogenic infection may introduced easily set in once injuries. Thus, fish water physico-chemical management practices in aquaculture are important to prevent such fish disease. However, affected fish symptom and diagnosis become skin darkening, swim at the surface, show respiratory distress, end of feeding, abdominal swelling, enlargement of internal organs, focal blood clots, bulging of the eyes, fading of the gills, etc. Transmitted by direct contact or close contact with surrounding contaminated water and infected fishes spreads the disease in healthy ones, via feces, urine, sexual fluids, and external mucus. Effective prevention and control measures includes preventing infected fish movement among watersheds, reducing bird activity around aquaculture, reduce physiological stressors, good environment and adequate nutrition, etc. Treatments, no established treatment so far, however, chemotherapy, antibiotics, bath, etc are advisable. In conclusion, regularly removing contaminants from water, disinfect all equipment used for tank cleaning, administer dietary additives and immuno-stimulants are important prevention measures. If not, it cause various effects including direct mortalities, losses due to reduced growth, product quality and social factors, and costs of control measures. Therefore, prevention, strict isolation, environmental observations to ponds, including water quality, temperature, oxygen, pH, salinity, turbidity, algal blooms, evasion of overpopulation, human activity and also proper biosecurity management practices of aquaculture are basic recommended activities for controlling diseases of fishes.

Key words: Biosecurity management; Fish diseases; Non-infectious diseases

Introduction

Aquaculture has been the fastest growing food production sector during the last 40 years (Tveterås), and Kobayashi reported as it being one of the most promising farming activities to meet near-future world food needs. Fisheries play a great role in food security, a source of income and social development in developing countries (FAO). Total production of aquaculture reveal an annual increment in global production of 6%, which is expected to provide up to 63% of global fish consumption by 2030 (FAO, 2014), for an estimated population of nine billion people in 2050. Almost all fish produced from aquaculture is for human consumption (FAO). However, huge loss of production in aquaculture is occurring because of many reasons such as diseases. A disease is the most serious constraint that causes damage to the livelihood of farmers, loss of job, reduced incomes, and food insecurity (Leung and Bates). Studies showed that almost 50% of production loss is because of diseases which are more severe in developing countries, and the annual loss of revenues because of disease of fish reaches up to 6 billion dollars (Leung and Bates). The major impact is on farms that rear

young fish where cumulative mortality can reach 90–100% (Bergmann; Purcell). In addition to direct losses due to mortality, the disease has a negative impact on the breeding of endangered fish stocks, causes restrictions on the movement of infected fish or survivors, and so mortality decreased fish production levels and deformities that occur in the survivors (MacKinnon). Therefore, identification prevention and control strategies are important to reduce diseases that causes damage of aquaculture production[1-5].

Fish pathology: Fish pathology deals with the diseases that affects fish normal living, host-pathogen relationship, pathophysiology, diagnostic methods, therapy, epidemiology, and descriptions of new diseases. Many disease outbreaks of captive fish stocks are associated with stressful conditions such as poor water quality, excessive crowding, inadequate nutrition, etc. There are two broad categories of disease that affect fishes, such as infectious and non-infectious diseases. Infectious diseases are contagious diseases caused by pathogens and so, often require some type of medication. However, non-infectious diseases are generally categorized as environmental, nutritional, or genetic cases, and so, these problems are often corrected by changing management practices (Ruth). Many diseases of aquatic animals are caused by organisms that are part of the normal biota of their surrounding environment (FAO). Many disorders and diseases occur in fish are the result of stress, poor water quality, overcrowding, and failure to quarantine any new or sick fish to avoid spread of disease, and these factors can all be minimized by appropriate care and good hygiene. Fish defenses against disease are specific and non-specific. Non-specific defenses include skin and scales, mucus layer secreted by epidermis which used to traps microorganisms and inhibits their growth (Cipriano)[6-9].

Non-infectious diseases of fishes: Based on Parker non-infectious diseases are not caused by pathogens, usually related to environmental factors, inadequate nutrition or genetic defects. Successful fish health management is accomplished through disease prevention, reduction of infectious disease incidence and reduction of disease severity. Avoidance of contact between the susceptible fish and a pathogen should be a critical goal to prevent outbreak of infectious disease. According to the report of Winton, the three main measures to achieve the goal are use of pathogen-free water supply, use of certified pathogen-free stocks, and strict attention to sanitation, as Implementation of these measures decrease fish exposure to pathogenic agents. However, it is practically impossible to define all agents which could cause disease in the aquatic environment and to completely prevent host exposure to pathogens. Certain factors, such as overcrowding, increase fish susceptibility to infection and pathogen transmission, and so, many pathogens which do not cause disease in wild fish can cause disease outbreaks with high mortality rates in high-density fish production systems. Similarly, fish disease is a substantial source of monetary loss to aquaculturist. Production costs are increased by fish disease outbreaks because of the investment lost in dead fish, cost of treatment, and decreased growth during convalescence. In nature, humans are less aware of fish disease problems because sick animals are quickly removed from the population by predators. In addition, fish are much less crowded in natural systems than in captivity. Pathogens may be of minimal significance under natural conditions, but can cause substantial problems when animals are crowded and stressed under the culture conditions (Ruth). Disease is rarely a simple association between a pathogen and a host fish, and therefore, management practices that directed at limiting stress are likely to be most effective in preventing disease outbreaks.

Biosecurity management: Biosecurity is mitigating the risks and impacts on the economy, the environment, social amenity or human health associated with pests and diseases. Resources for biosecurity activities, including prevention, eradication, containment and asset protection, are allocated according to risk, to achieve the greatest reduction in the highest priority risks, and the most cost-effective benefit to the community. Fish health management is used in aquaculture to describe management practices which designed to prevent fish disease, because, if once fish get sick it can be difficult to salvage them, and successful fish health management begins with prevention of disease rather than treatment (Ruth). In addition, biosecurity in aquaculture consists of practices that minimize the risk of introducing an infectious disease and spreading it to animals and the risk that infected animals or infectious agents leave a facility and spread to other sites and to other susceptible species. Good biosecurity minimizes the fishes exposure and susceptibility to pathogens, reduces economic losses from mortalities (Roy and Claire). Therefore, this study focus on non-infectious diseases and biosecurity management of fish in aquaculture to develop prevention and control methods of fish diseases[10-13].

Non-infectious diseases of fishes and biosecurity management in aquaculture

There are various fish diseases which caused by bacteria, viruses, parasites, fungi, environmental problems, nutritional deficiencies, etc that have a negative impact on aquaculture. Such diseases are categorized as infectious and non-infectious diseases. Infectious diseases are the diseases that caused by pathogenic organisms present in the environment. In contrast, non-infectious diseases are the diseases that caused by environmental problems, nutritional deficiencies, or genetic conditions; and they are not contagious and usually cannot be cured by medications (Ruth). However, both infectious and non-infectious disease are causes disease of fishes and some effects including direct mortalities, productivity losses due to reduced growth, fecundity, product quality and social factors, as well as the costs of control measures. Therefore, assessing non-infectious diseases is important to develop biosecurity management of fishes in aquaculture for prevention and control methods of diseases.

Non-infectious diseases of fishes: Non-infectious disease also known as non-genetic or non-communicable diseases are diseases that are not caused by pathogens and cannot be transferred from one host to another. They are emerging and remerging diseases in aquaculture characterized by lesion, deformities, anorexia, anemia, weight loss, suffocation and death when severe. This renders the fish unmarketable because they are regarded as poor quality by processors (Dung). Non-

infectious diseases can be broadly categorized as environmental, nutritional, or genetic cases (Ruth). In general, fish diseases that associated with physico-chemical properties of water are non-infectious environmental diseases. Non-infectious diseases are caused by adverse environmental conditions, nutritional disorders, or genetic defects, and result in sudden mass mortality or death, they are not contagious. Diseases associated with physical factors are mainly due to handling, transport, high stocking density and predation, and also secondary factors such as bacterial, viral, or parasitic infection may easily set in once injuries are introduced. Diagnosis of non-infectious environmental diseases can be done through examination of fish for external/internal disease signs; histopathological/ histochemical analysis; hematological analysis to assess the cellular composition of the blood in response to environmental stress; analysis of physico-chemical characteristics of rearing water; and evaluation of culture operations and management practices. Effects on host can be death due to embolism in blood and emphysema in tissues; edema and degeneration of the gill lamellae; bulging of the cornea; abrupt mass mortalities. So, prevention and control methods includes monitor dissolved oxygen (DO), avoid algal blooms, maintain efficient operation of waterlines and pumps, sufficient water exchange, etc (Erazo-Pagador).

Environmental diseases of fishes: Environmental diseases are the most important in commercial aquaculture. Environmental diseases include low dissolved oxygen, high ammonia, high nitrite or natural or man-made toxins in the aquatic environment. Proper techniques of managing water quality enable producers to prevent most environmental diseases (Ruth)[14-16].

Nutritional diseases of fishes: Nutritional diseases can be very difficult to diagnose. A classic example of a nutritional disease of catfish is "broken back disease," caused by vitamin C deficiency. The lack of dietary vitamin C contributes to improper bone development, resulting in deformation of the spinal column. Another important nutritional disease of catfish is "no blood disease" which may be related to a folic acid deficiency, and the affected fish become anemic and may die. The condition seems to disappear when the deficient feed is discarded and a new feed provided (Ruth). Non-pathogenic disease such as unbalanced nutrition causes fatty-liver disease (Fig.1) (AFCD, 2008).

Figure1: Non-pathogenic disease of unbalanced nutrition causes fatty-liver (AFCD, 2008).

Genetic defects: Genetic abnormalities include conformational oddities such as lack of a tail or presence of an extra tail. Most of these are of minimal significance; however, it is important to bring in unrelated fish for use as brood stock every few years to minimize inbreeding (Ruth).

Pathology of non-infectious diseases: Similar to pathology of infectious diseases, non-infectious diseases have their own or similar symptoms and diagnosis, transmission ways, prevention and control measures, and treatments.

Symptoms and Diagnosis of diseases of fish: Accurate diagnosis and prompt response will stop the spread of disease to other fish, thus minimizing losses. Symptom and diagnosis of the diseases of fishes: skin darkening, turn into lazy, swim at the surface, show respiratory distress, end of feeding, abdominal swelling, enlargement of liver and spleen, focal blood clots, bulging of the eyes, fading of the gills, etc are suspect for the infection. Based on OIE, (2000a) of diagnostic manual for aquatic animal diseases, behavioral changes are not specific to pathogens but may include lethargy, aggregation in still areas of the pond with periodic bursts of erratic swimming and loss of equilibrium. Changes in appearance include dark discoloration of the body, especially in yolk sac fry stages (90-100% mortality). The abdomen can be distended due to accumulation of fluids in the body cavity (dropsy) (AGDAFF, 2007). Infected fish showed darkening of skin, abdomen may be distended, haemorrhaging at the base of the fins, on the operculum and around the eye, weakened swimming capability, bleeding at base of fins, a white discharge from the anus (Fig. 2) (Peter).

Figure2: The infected fishes with white discharge from anus, weakened swimming capability, darkening of the skin, pale gills (Peter).

Transmission of fish diseases: The disease is transmitted mostly by fish to fish through direct contact or through water via faeces, urine, sexual fluids or external mucus. The manifestation of disease depends on the size and age of the fish, the species and strain and the environmental conditions, including water temperature. Horizontal fish-to-fish transmission through water spreads in the wild and in aquaculture operations primarily in fry and fingerlings, young and older fishes are also susceptible. The transmission generally occurs via water as all the secretions and excretions of infected fish present. Blood-sucking parasites and fish eating birds may transfer to new areas (AGDAFF, 2007). Transmission mode is usually spread during shedding with faeces, urine, spawning fluids, mucus secretions, contaminated equipment, eggs from infected fish, and blood sucking parasites (e.g., leeches, Argulus spp.). In general, pathogens are transmitted through various ways such as via feces, urine, sexual fluids, external mucus and by direct contact or close contact with surrounding contaminated water and infected fishes

spreads the disease in healthy ones, the fishes which may survive become carriers[17-19].

Prevention and control of fish diseases: Prevention is the cornerstone of any health protection program and can be as challenging and complex as the actual control of existing diseases. The key elements of disease prevention include knowledge of water quality control methods, pathogen transmission, reliable detection of disease carriers, development of effective methods to limit the entry of pathogens, capacity to provide environmental conditions conducive to good fish health, prevention of infected fish movement between watersheds, reducing bird activity around aquaculture, biological and chemical methods, reduce physiological stressors (Ayalew Assefa and Fufa Abunna). Good preventive medical practices include quarantine, routine observation, vaccination, use of immunostimulants, probiotics, and diagnostics for disease management (Roy and Claire). There are many other important elements of fish health management that should be considered before regulation, such as facilities, water supplies, environmental manipulation, nutrition and feeding, genetic resistance to disease, vaccination, etc and rapid progress has been made in research on the immune responses of fish and in the development of immunization procedures (Plant and LaPatra). Sanitation measures and disinfection to reduce the risk of recontamination (Francis). Protection of aquaculture facilities under these circumstances will require appropriate disinfection of equipment and intake water (Whittington). Control measures include destocking, cleaning and disinfection using appropriate treatments will assist in eradication from an aquaculture facility (Bryan). Advancing vaccination is one of the most important approaches to prevention and control disease of fish (Dadar). Vaccination is widely in use in almost all food producing animals. In aquaculture, it reduces the use of antibiotics to protects fish from diseases and avoids the risk of drug resistance (Plant and LaPatra). The few important considerations before application of vaccination in fish include fish species to be vaccinated, status of the immune system of the fish, production cycle, and life history of the aquaculture system, which diseases need to control in aquaculture, when do these diseases occur (seasonal distribution of diseases in the aquarium), farming technology (handling and mechanization), environment (temperature and salinity), stress factors, nutrition, and cost benefit (Adams).

Treatment of diseases of fish: Based on AFCD, (2008) report, drug bath is a major course of treatment for fish diseases. Prevention measures are advisable due to no established treatment so far. However, some of the effective control measures are vaccination, antibiotics, and bath (Ruth). Successful disease control involves a careful program of fish health management that removes infected stocks, prevents re-infection, reduces stress, and maintains optimal production conditions. If fish are provided with a good environment and adequate nutrition, the risk of infection by pathogens is greatly reduced. However, chemotherapy, antibiotics, bath treatment, etc are some of the treatments of diseases. Chemotherapy is the use of drugs and chemicals for the treatment of infectious disease and against the pathogen without significant adverse effects on the fish host. Antibiotics are very useful additions to a fish health manager's toolbox, but they are only tools and not "magic bullets". Bath treatment involves a short bath treatment varying in duration from a few seconds to 5 min, depending on the chemical and concentration used, often used on brood stock. While effective, they can be highly stressful. After treatment, fish should be rinsed in clean water before being returned to the holding facility to avoid transfer of chemical to the tank. Considerable care on sources of stress such as poor water quality, nutrition, genetics, and handling or transport must be removed or reduced. Contacting a fish health specialist early in a disease outbreak helps identify contributing stresses and the rate of bacterial infection, thereby reducing losses (Ruth)[20-23].

Biosecurity management of fish health in aquaculture: There are various biosecurity management practices that used to reduce the introduction of pathogens and to prevent fishes from infected by diseases in aquaculture. According to Bebak-Williams, the goal of biosecurity is the implementation of practices and procedures which will reduce the risks of introduction of pathogens into the facility, spread of pathogens throughout the facility, and presence of conditions which can increase susceptibility to infection and disease. Quarantine is an important biosecurity component for prevention of contact with infectious agents and is used when fish are moved from one area to another. Fish under quarantine are isolated for a specific period of time before release into contact with a resident population, preferably in a separate area with dedicated equipment as reported by Plumb and Hanson. Based on Somerville report, new fish remain in quarantine until shown to be disease-free, and it is advisable in some cases to quarantine new fish in an isolation tank for 45 days before adding them to the main system. During quarantine, fish are monitored for signs of disease and sampled for presence of infectious agents. Prophylactic treatments may be initiated during the quarantine period in order to remove initial loads of external parasites. Therefore, the following biosecurity measures are very important in biosecurity management of fish health in aquaculture.

Biosecurity measures in aquaculture system can keep the safety of a facility from certain disease-causing agents include strict quarantine measures, sanitation of equipment, egg disinfection, transfer control, water treatments, use clean feed, and disposal of dead appropriately (Ayalew Assefa and Fufa Abunna). Most diseases of aquaculture can be overcome by careful application of biosecurity measures. Stocking density reduction is one of the most important approaches to control diseases of fish in aquaculture. Low stocking densities are a very useful first step measure when ectoparasite infections break out, along with increasing water flow, to achieve a greater flushing effect on the parasites (Oidtmann). However, the aquaculture sector has been facing many constraints and challenges which are sophisticated and multifaceted. Therefore, planning for prevention and control strategy based on globally accepted principles and locally applicable strategies are recommended for such problem. Generally, the use of a combination of immuno-prophylaxis, biosecurity measures, and use of approved antibiotics can result in ultimate health protection of fish in aquaculture. Fish health management is a term used in aquaculture to describe management practices

which are designed to prevent fish disease (Ruth). Once fish get sick it can be difficult to salvage them, and so, successful fish health management begins with prevention rather than treatment of disease. Prevention of fish disease is accomplished through good water quality management, nutrition, and sanitation. Suboptimal water quality, poor nutrition, or immune system associated with stressful conditions allow these potential pathogens to cause disease. Medications used to treat these diseases provide a means of buying time for fish and enabling them to overcome opportunistic infections. Therefore, daily observation of fish behavior and feeding activity allows early detection of problems when they do occur so that a diagnosis can be made before the majority of the population becomes sick.

Conclusion and recommendations (future directions): In general, the potential of such non-infectious diseases are the main causes for fish species mortality. Therefore, prevention, hygiene, and environmental observations to ponds systems, including weather, water temperature, oxygen, pH, salinity, turbidity, algal blooms, human activity and also proper biosecurity management of aquaculture, overpopulation are basic activities for controlling the diseases of fishes.

Conclusion

Non-infectious disease causes direct mortalities, losses due to reduced growth, fecundity, product quality and social factors, costs of control measures. Non-infectious diseases include nutritional diseases, genetic conditions and environmentally-based pathogens. Invariably the outbreak of a disease is caused by a combination of factors, such as the presence of a pathogen and unfavorable environmental conditions which will reduce the immune capacity of the fish. The sources and modes of infection among fish are variable, as fish disease is rarely a simple association between pathogen, a host fish and an environmental problem. Fish stressors, such as poor water quality often contribute to the outbreak of disease and the complexity of the challenge. The transmission of infection to fish occurs through direct and indirect exposure of cultured fish, facilitated by poor fish health management, contaminated water supply, contaminated culture facilities, together with environmental conditions associated with the fish culture practice (air, ponds, soil, equipments, feed, pollutants, etc.)[24].

Proper biosecurity management measures, avoidance of overpopulation and temperature regulation are some of the criteria for controlling the pathogens affecting the fishes. There is a risk that aquaculture operations in the tropics will experience higher cumulative mortalities and faster progression of diseases in the future by climate change leading to varieties of pathogens that have the potential to spread geographically. This can furthermore result in introduction and spread of more pathogens to natural fisheries and aquaculture landscapes has a significant part of the global supply of nutritious animal sources foods. In addition, disease management and biosecurity implementation will be vital to prevent future disease losses that would be associated with aquaculture in lower latitudes. Understanding interaction between climate sensitive aquaculture landscapes along with their aquatic hosts and climate sensitive aquatic animal diseases, mapping of potential risks, identification of suitable adaptation/mitigation intervention strategies should be the focus of future research and development. Similarly, disease signs at the farm, tank or pond level are hundreds or thousands of small dead fish found on the downwind bank of the water body, large numbers of fish-eating birds at the water surface, loss of appetite, juveniles swimming at the surface, swollen abdomen, darkened skin color, haemorrhages at the base of the fins and gills, enlargement of the kidney, liver and spleen; coagulative or liquefactive necrosis of the liver, kidney, spleen, heart, pancreas, and gastrointestinal tract and gills. No treatment had yet proven to be effective to prevent the disease, and so, strict isolation, hygiene, and testing procedures should be in place. However, there are various best approaches of scientific recommendations to prevention and control of infectious disease of fish in aquaculture.

3.2. Recommendations (Future directions): For disease prevention and control, certain measures are recommended to reduce risk factors. These are, administer commercial vaccines against various fish pathogens, and most common routes of application are by injection, by immersion or via food. Take preventive and corrective measures to prevent stress in fish, since multiple stressors are present in every step of aquaponic production, avoidance and management of stress through monitoring and prevention minimize its influence on fish health. Avoid high stocking density, which causes stress and may increase the incidence of disease even if other environmental factors are acceptable, and high stocking density increases the possibility of skin lesions, which are sites of various pathogen entries into the fishes. Regularly remove contaminants from water (uneaten food, faeces and other particulate organics). Dead or dying fish should be removed promptly as they can serve as potential disease sources to the remaining stock and a breeding ground for others, as well as fouling the water when decomposing. Disinfect all equipment used for tank cleaning and fish manipulation. After adequate disinfection, all equipment should be rinsed with clear water. Use of footbaths and hand washing with disinfecting soap at the entrance and within the buildings are recommended, with these steps directly decrease the potential for the spread of pathogens. Administer dietary additives and immuno-stimulants for improvement of health and to reduce the impacts of disease. Such diets contain various ingredients important for improvement of health and disease resistance including natural plant products, immuno-stimulants, vitamins, microorganisms, organic acids, essential oils, prebiotics, probiotics, synbiotics, nucleotides, vitamins, etc. Segregate fish by age and species for disease prevention, since susceptibility to certain pathogens varies with age, due to young fish are more susceptible to pathogens than older fish.

The movement of live fish always carries the risk of introduction of pathogens to a new environment at all levels, from intercontinental translocations, to those within regions, between countries, or even between watersheds. There is no way in which a live fish can be guaranteed to be free of pathogens. A number of conventions have been established for the translocation of fish on pathogen transfer, but the recommendations within these conventions are soundly based and should be rigorously followed, especially for movements of

species between continents or within large regions. Before a movement of fish is made, at whatever level, it is necessary to assess the risk involved for information on known pathogens within the region, country or watershed of origin which might be dangerous to native species, and pathogens within the receiving country/watershed which might be dangerous to the introduced species. Even though fish diseases are being reported in many counties, there has been no systematic study conducted to estimate economic losses. However, the obvious economic importance of fish diseases in aquaculture give good reason for greater efforts to strengthen the research, quarantine, and surveillance systems. Finally, for non-infectious diseases of fishes, water quality, diets, and extreme environmental conditions are factors attributed to non-infectious diseases of fishes. So, It is recommend that farmers constantly monitor the physico-chemical condition of their pond as well as change their pond water when due. Feeding of fish with the right feed as well as further research needed on immune-modulatory diet.

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