Research Article

BIOMEDICAL Journal of Scientific & Technical Research

ISSN: 2574 -1241

DOI: 10.26717/BJSTR.2021.40.006413

Pathology of Epizootic-Infectious Diseases of Fishes in Aquaculture

Firew Admasu[1,2]* and Mulugeta Wakjira[2]

[1]*Dilla University, College of Natural Sciences, Department of Biology, Dilla, Ethiopia*

[2]*Jimma University, College of Natural Sciences, Department of Biology, Jimma, Ethiopia*

***Corresponding author:** Firew Admasu, Dilla University, College of Natural Sciences, Department of Biology, Dilla, P. O. Box 419, Ethiopia

ARTICLE INFO

Received: November 10, 2021

Published: November 24, 2021

Citation: Firew Admasu, Mulugeta Wakjira. Pathology of Epizootic-Infectious Diseases of Fishes in Aquaculture. Biomed J Sci & Tech Res 40(2)-2021. BJSTR. MS.ID.006413.

Keywords: Disease Pathology; Epizootic Necrosis; Infectious Diseases; Pathogenic Organisms

ABSTRACT

This article was developed for seminar presentation of PhD study in Aquaculture and fishery management.

Background: Epizootic disease occasion in an animal population cause serious economic and health issues in various products. It primarily affects livestock, and may extend to humans from infected animals. Necrosis is the death of body tissue due to a lack of blood supply that occurs by injury or chemicals. Many of fish diseases occur as a result of stress, poor water quality, overcrowding and failure to quarantine. Management practices of fish health in aquaculture designed to prevent fish disease rather than treatment.

Objectives: The main objective of this study is to assess pathology of infectious diseases of fish in aquaculture.

Methods: Relevant information were collected from secondary sources such as published articles like researches, reviews, books, etc. and organized following standard scientific writing methods.

Result and conclusion: Fish pathology deals with causes and nature of diseases, parasites that affect fish normality, involve examination of tissues, organs, host-pathogen relationships, pathophysiology, diagnostic methods, epidemiology, descriptions of new diseases, etc. Fish diseases are grouped in to infectious and non-infectious diseases. Infectious diseases caused by parasitic, bacterial, viral, or fungal; and non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic cases. Epizootic infectious necrosis is caused by pathogens and characterized as necrosis on liver, spleen, kidney, etc. of fish organs. It discard via urine, sexual fluids and mucus, whereas liver, kidney, spleen, and other internal organs are the most abundant sites. Invertebrates may act as vectors such as insects, annelids, crustaceans, etc. The affected fish sign include mottled red gills, skin darkening, swim at the surface, show respiratory distress, end of feeding, abdominal swelling, enlargement of liver and spleen, eyes bulging, gills fading, etc. Pathogens transmitted from infected to normal fishes via direct contact or close contact with infected water and infected fishes, and may the survive fishes become carriers. Effective prevention and control measures includes preventing infected fish movement between watersheds, reducing bird activity around aquaculture, cleaning and appropriate disinfection, vaccination, antibiotics, reduce physiological stressors, adequate nutrition, etc. No specific treatment so far, however, chemotherapy, antibiotics, bath, etc. are some of treatments. In general, the potential of such infectious pathogens are the main causes for fish mortality at the rates of 80–100% of fish species. Therefore, strict isolation, evasion of overpopulation, environmental hygiene, including water quality and temperature, oxygen, pH, salinity, turbidity, algal blooms, human activity and biosecurity management of aquaculture are basic activities for prevention and controlling methods of diseases of fishes.

Introduction

Geographically, aquaculture is mainly present in tropical and sub-tropical climatic regions. Elements of climate change that impact aquaculture, forecasts include global warming, sea level rise, changes in ocean productivity and circulation pattern, water stress, changes in monsoon patterns and occurrence of extreme weather events [1]. All aquaculture animal species farmed for human consumption, so it is argued that aquaculture flexibility, adaptability and cultured species diversity able to respond to climate change impacts and emerge as an alternative livelihood [1]. Evolvement of aquaculture as a climate smart adaptation and mitigation strategy is essential to examine how aquatic animal pathogens respond to climate change, changed situation and such pathogens interact with their farmed hosts [2]. Therefore, there must be concern about climate change that may further increase the risk to aquaculture posed by diseases through alterations in the distribution, prevalence and pathogens. Aquaculture has been the fastest growing food production sector [Tveterås et al., 2012], being one of the most promising farming activities to meet near-future world food needs [Kobayashi et al., 2015]. Fisheries play a great role in food security, a source of income and social development in developing countries [3].

Total production of aquaculture [FAO, 2015] reveal an annual increment in global production of 6%, which is expected to provide up to 63% of global fish consumption by 2030 [4], for an estimated population of nine billion people in 2050. Almost all fish produced from aquaculture is for human consumption [3]. 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 [5]. 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 [5]. Some of the most important of these fish diseases is caused by bacterial, viral, fungal [6]. The major impact is on farms that rear young fish where cumulative mortality can reach 90–100% [7,8]. 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 [9]. Therefore, identification of pathogens, prevention and control strategies are important to reduce diseases that causes damage of aquaculture production. Fish pathology deals with the diseases and parasites that affects fish normal living, include host-pathogen relationship (Figure 1), 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, and so involving both infectious and non-infectious processes. Infectious diseases are contagious diseases caused by parasites, bacteria, viruses, or fungi. Non-infectious diseases are generally categorized as environmental, nutritional, or genetic cases, and these problems corrected by changing management practices [Ruth, 2005].

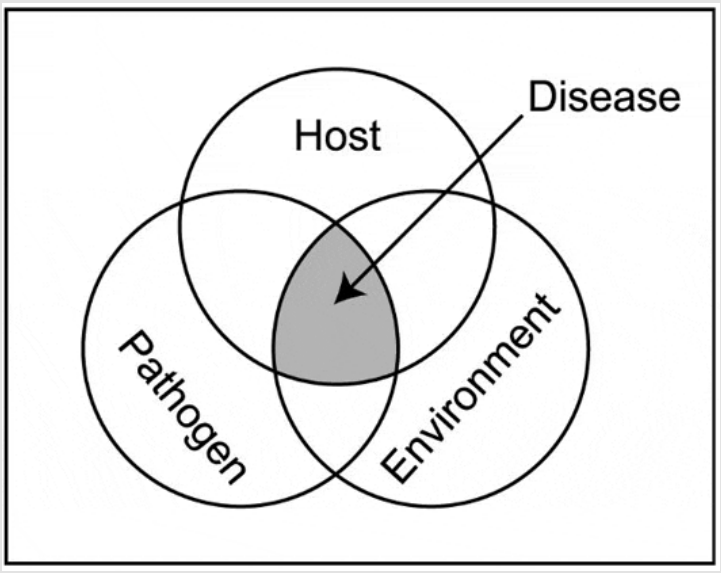

Figure 1: Fish disease with pathogens, environment and host relationship [Ruth, 2005].

The species most widely cultured in aquaculture include oysters, mussels, clams, marine shrimps, freshwater prawns, salmonid fish, cyprinids, tilapias, catfishes, snakeheads, milkfish, eels, cod, sea bass, sea bream, groupers, and redfish. The diseases of one group are usually different to other groups, and the causes of diseases include micro parasites (bacteria, fungi, viruses, and protozoan parasites), macro parasites such as ecto parasitic lice, or endo parasitic nematode worms, and non-infectious agents, such dietary or environmental chemical agents [FAO, 2018]. Epizootic disease is the outbreaks of disease cause serious economic and community health issues [Onstad et al., 2006], and primarily affects livestock and other domestic animals, and often it may extend to humans who are exposed to diseased animals. In addition, necrosis is the death of body tissue due to a lack of blood supply that occurs by injury, chemicals, radiation, and the condition is called gangrene.

Infectious diseases is a disease primarily caused by bacteria, viruses and parasites in aquaculture. Many disorders and diseases are occur in fish as a result of stress, poor water quality, overcrowding, and failure to quarantine and minimized by appropriate care and good hygiene. Specific defenses are specialized responses to particular pathogens recognized by the fish's body as adaptive immune responses [10,11]. Fish disease is a substantial source of monetary loss to aqua culturist. Production costs are increased by fish disease outbreaks because of the investment lost in dead fish, cost of treatment, and decreased growth during convalescence. Parasites and bacteria may be of minimal significance under natural conditions, but can cause substantial problems when animals are crowded and stressed under the culture conditions [Ruth, 2005]. Disease is rarely a simple association between a pathogen and a host fish. Management practices directed at limiting stress are likely to be most effective in preventing disease outbreaks. Therefore, thus why this study focus on pathology of infectious diseases and biosecurity management practices of fish health in aquaculture.

Pathology of Infectious Diseases of Fishes in Aquaculture

There are various fish diseases in aquaculture which caused by bacteria, viruses, parasites, fungi, environmental problems, nutritional deficiencies, etc. The appearance of a disease in aquaponics systems can be even more devastating. Infectious diseases are the diseases that caused by pathogenic organisms. In contrast, non-infectious diseases are caused by environmental problems, nutritional deficiencies, or genetic conditions [Ruth, 2005]. However, both infectious and non-infectious disease are causes effects including direct mortalities, losses of productivity due to reduced growth, fecundity, product quality and social factors and costs of control measures. Therefore, assessing the pathology of infectious diseases is important to develop biosecurity management of fishes in aquaculture for prevention and control methods of diseases.

Infectious Diseases of Fish: Infectious diseases are contagious diseases that caused by different microbial pathogens transmitted either from the environment such as bacteria, viruses, parasites, fungi or carried by other fish. Such pathogens can be transmitted horizontally (between the fish) or vertically by external or internal factors [Winton 2002; Mc Loughlin and Graham 2007]. The capability of a pathogen to cause clinical disease depends on the interrelationship of six major components related to fish and their living environment (physiological status, host, husbandry, environment, nutrition and pathogen) [Plumb and Hanson 2011]. So, fishes are encountered by pathogens like parasites, bacteria, virus, fungus, etc. as explained below.

Parasitic Diseases of Fishes: Parasitic diseases of fishes are caused by small microscopic organisms called protozoa which live in the aquatic environment, and a variety of protozoans which infest the gills and skin of fish causing irritation, weight loss, and eventually death. Most protozoan infections are relatively easy to control using standard fishery chemicals such as copper sulfate, formalin, or potassium permanganate [Ruth, 2005]. The disease incidences are being grouped as per the pathogen types, seasonality, size and species [12]. Similarly, the parasitic diseases are opportunistic and obligate. The major parasitic diseases of fish include protozoan, crustacean and helminthic diseases. Based on their habitats, most crustaceans are external parasites causing harsh diseases while protozoans cause either external or internal diseases. The majority of monogeneans and annelids are external parasitic diseases, while the majority of digeneans cause internal parasitic diseases. Nematode, acanthocephalan and cestodes infestations are internal parasitic diseases. A number of parasites with larval stages in fresh water fish have a piscivorous mammalian carnivore as their normal final host and are able to infect humans because of low host specificity at adult stage [13]. Table 1. Type of parasitic infections with their examples of affected freshwater fish species.

Table 1: Parasitic infections with examples of affected freshwater fish species [13].

Type of parasitic infections	Examples of affected fish species
Ectoparasites, *Trypanosome*, Encysted metacercariae, monogenea,	African catfish, *Morymyrus kanumme, Bagrus bajad* and Nile tilapia
Ectoparasites, metacercariae	African catfish, Nile tilapia
Ectoparasites, monogenea, helminthes	Freshwater fishes
Ectoparasites, Metacercariae, fluke trematodes and Cestodes	Nile tilapia, blue tilapia, *Tilapia zillii*, African catfish and common carp
Ectoparasites - Cleidodiscus aculeatus	*Oreochromis* spp., *Clarias lazera*, silver carp, black carp and common carp

Bacterial Diseases of Fishes: Bacterial diseases of fishes are often internal infections and require treatment with medicated feeds containing approved antibiotics by Food and Drug Administration (FDA). Typically fish infected with a bacterial disease will have hemorrhagic spots or ulcers along the body wall and around the eyes and mouth, and also have an enlarged, fluid-filled abdomen, and protruding eyes. Bacterial diseases can also be external, resulting in erosion of skin and ulceration [Ruth, 2005]. In recent years, the number of infections caused by many species of Gram-positive bacteria, two of them are of particular importance in pathology of bacterial diseases of fish: Lactococcus garviae and Streptococcus iniae. Both bacterial species cause serious health disorders in different species of freshwater and marine water fish species, such as rainbow trout and other salmonids from Oncorhynchus family, eels, and fish belonging to the Ictaluridae (catfish) and Cichlidae (tilapia) families [14]. Although bacteria might be present in the environment and in fish, and also disorders occur during summer when the water temperature increases and reaches optimal values in the range of 18ºC–25ºC. Therefore, it is assumed that the temperature and sanitary of aquatic environment are the most important factors conducive to the occurrence of disease symptoms [14] [15] reported on the modern threats of bacterial infections in freshwater fish, water is an environment in which other aquatic organisms live besides fish, including many species of saprophyte bacteria inhabiting sediments and plants, phytoplankton and zooplankton. Some of them are colonize on the skin, gills, digestive tract of fish and living as commensals, supporting digestion and beneficial effect on the immune system of these animals.

The development of disease is dependent on bacteria being capable of causing disorders, immune status of fish, environmental conditions and virulence of disease agent [16]. There are various species of bacteria implicated in fish diseases, and the common fish pathogenic bacteria species belong to the genera Vibrio, Aeromonas, Flavobacterium, Yersinia, Edwardsiella, Streptococcus, lactococcus, Renibacterium, and Mycobacterium. However, there is growing indications that the pathogenic species spectrum as well as the geographic and host range is widening among fish pathogens [17,18], leading to the emergence of new pathogens. Some examples of the bacterial infections, such as Aeromonas species, Acinetobacter spp. etc. are explained as follows. Aeromonas spp. are commonly found in various environments including water, and therefore fish are constantly exposed to bacteria. Interaction with bacteria is especially dangerous under conditions of stress, include unfavorable environmental conditions and human intervention in catching, sorting, and transporting of the fish [19].

Skin infection (Figure 2) with Aeromonas sobria in carp (Cyprinus carpio L.) [20]. Similarly, Acinetobacter spp., is widely dispersed in nature, including the aquatic environment. Disease results depigmentation of the skin, loss of scales, and exophthalmia with congestion of the eye, haemorrhages in skin and gill congestion observed in fish species, and accompanied by mortalities, ranging from 5% to 20% [21]. Infection with Acinetobacter spp. in carp (Cyprinus carpio L.) [20] (Figure 2). The health disorders in cultured fish were noted mainly in spring, when water temperature rose to 7ºC–10ºC [22]. Clinical signs, prevalently lethargy, darkening of the skin, skin lesions, and ulceration, have been observed in infected fish. In post-mortem examination hemorrhage in the kidneys and spleen was noticed. The range of mortality varied from 40% to 85% in different fish species [23,24] (Figure 2).

Figure 2: Fish species infected by d/t pathogenic bacteria [15].

Viral Diseases of Fishes: Viral pathogens of fish are found among many families of vertebrate viruses that include pathogens of humans or domestic livestock. However, there are significant differences between the ecology of viral diseases of fish, humans or other terrestrial vertebrates. There are various viral diseases of fishes which distinguish with special laboratory tests, difficult to diagnose and no available specific medications or vaccines to cure infections of fish [Ruth, 2005]. The degree of social and economic impact of epizootic ulcerative syndrome and white-spot disease of fishes in rural aquaculture [25]. Proper monitoring and intense surveillance of viral diseases of fishes such as cyprinid herpes virus [26], carp edema virus [27], tilapia lake virus [27], rana virus [28],

etc. Viral diseases caused mainly due to close contact aquaculture with surrounding water [29]. In addition, management options of viral diseases of fish are limited but vary depending on the type and pathogenicity of the virus, and species susceptibility. Viral infections cause negative impacts on economy of fish production, and some virus families have been identified on the cultured fishes. Though, there is little information about viruses infecting fish such as Epizootic infectious haematopoietic necrosis virus (EIHNV), infectious haematopoietic necrosis virus (IHNV), infectious pancreatic necrosis virus (IPN), viral haemorrhagic septicaemia (VHS), spring viremia virus (SVV), etc on freshwater fishes [30,31].

The viral disease may cause variable range of mortality and infects juveniles and adults within a temperature range of 11-17 °C [32]. The viral diseases transmitted via feces, urine, sexual fluids, mucus and direct contact or close contact with surrounding water, and also can entry into fish at the base of the fins [33]. Such viruses can affect a range of fish species such as red fin perch (Perca fluviatilis), rainbow trout (Oncorhynchus mykiss), sockeye salmon (O. nerka), chinook (O. tshawytscha), chum (O.keta), yamame (O. masou), amago (O. rhodurus), coho (O. kisutch), Atlantic salmon (Salmo salar), Macquarie perch (Macquaria australasica), mosquito fish (Gambussia affinis), silver perch (Bidyanus bidyanus) and mountain galaxias (Galaxias olidus) [34,35]. In addition, the infected fish show distended abdomen, darkened skin, petechial haemorrhages at the base of fins, ulcerative dermatitis, swim bladder edema and haemorrhages in gills, the infected fish show swollen kidney and spleen [36] (Figure 3). However, there is no vaccine available for such viral diseases and hence, biosecurity management practices can reduce physiological stressors and play vital role in preventing this disease.

Figure 3: Infected fish showing enlargement with white spots on liver tissue [DPINSW, 2013].

Fungal Diseases of Fishes: The mycotic infections among freshwater fish species are commonly caused by straminipilous organisms, and pathogens can infect eggs, fry, fingerlings, and adult fish. Stress factors such as mechanical injury after handling, exposure to extreme levels of pH, prolonged exposure to low water temperatures, lack of food, and presence of other microbial infections such as bacterial and viral, and increase the susceptibility of fish to fungal infections. Fungal spores are common in the aquatic environment, but do not usually cause disease in the healthy fish. When fish are infected with an external parasite, bacterial infection, or injured by handling, the fungi can colonize damaged tissue on the exterior of the fish. These areas appear to have a cottony growth or may appear as brown matted areas when the fish are removed from the water. Formalin or potassium permanganate are effective against most fungal infections. Since fungi are usually a secondary problem it is important to diagnose the original problem and correct it as well [Ruth, 2005]. Fungal diseases of fish, like moulds, cause mycoses are microscopic organisms producing filamentous coatings on substrates. Moulds are fungi, heterotrophic organisms nutritionally dependent on organic substrate, and infestation of fishes is largely a secondary phenomenon. However, there is evidence that fungi may affect healthy fish in certain circumstances. Mycoses hinder the function of organs and kill the fish on mass. Fish infestation by Saprolegnia, saprolegniasis, occurs in all types of waters all over the world and is one of the most widespread diseases of inland fishes in ponds and in water courses. The spores most easily and most frequently penetrate into the fish body when surface of the skin or gills is damaged (mechanically or by a parasite or bacterial infection).

Epizootic ulcerative syndrome or EUS is an infection caused by an oomycete fungi known as Aphanomyces invadans or A. piscicida. Aphanomyces is a member of a group of organisms formerly commonly known as water moulds; they are currently recognized as belonging to the group of heterokonts or stramenopiles [37]. EUS is an epizootic condition affecting wild, farmed freshwater and estuarine finfish. EUS is also known by other names such as red spot disease (RSD), mycotic granulomatosis (MG), and ulcerative mycosis (UM) and in 2005 it was suggested to rename EUS as epizootic granulomatous aphanomycosis (EGA) [38] [FAO, 2018]. EUS causes ugly lesions in affected fish, lesions can range from small

pinpoint red spots, hemorrhagic spots, localized swelling, localized raised areas on the body surface, protruding scales, scale loss, skin erosion, reddened areas of the skin under the scales, exposure of underlying musculature, and ulceration (Figure 4). Ulcers can be found over a broad area with the center of the lesions being necrotic. Lesions are observed most often in the lateral surface but can also occur on any part of the body.

Figure 4: Infected fish showing enlargement with white spots on liver tissue [DPINSW, 2013].

Pathology of Diseases of Fish

Pathology of medical science mainly focus on the cause, origin, nature, and diagnose of disease result obtained from laboratory examination of tissues, organs, bodily fluids and autopsies (Table 2). The vast majority of fish diseases are restricted to fish and pose no risk to handlers or consumers [39]. The pathogenesis, after waterborne exposure, epizootic enters a fish through the gills, skin, fin bases, mouth and esophagus/cardiac/stomach regions and then the pathogens replicates in epidermal cells [40,41]. Due to no efficient treatment exist for viral diseases, it is better to apply prevention and control measure on aquaculture and the surrounding environment properly. Thus, focus needed on the pathology of diseases of fishes, include symptom and diagnosis, transmission, prevention and control, and advisable treatments in aquaculture are explained below.

Table 2: Identification methods of sick and healthy fish [AFCD, 2008].

	Sick Fish	Healthy fish
Activity	Swimming slowly; sluggish response	Swimming actively; sharp and responsive
Body colour	Dull, dark or discoloured	Bright and glossy
Body Surface	White layered patches	Intact
Body Shape	Thin	Normal size
Feed Intake	Poor appetite	Good appetite
Organs	Different fish disease cause damage to different organs	Internal organs are healthy and normal

Symptoms and Diagnosis of Diseases of Fish: Early recognition of diseased fish is important in maintaining health of the aquaculture system. The gills of affected fish sign become mottled red, central whitish (watery) spots, skin darkening, turn into lethargic, swim at the surface, show respiratory distress, end of feeding, abdominal swelling, focal blood clots, bulging of the eyes, fading of the gills, etc. are suspect for the infection. Disease signs at the farm, tank or pond level are mass of small dead fish found on the water body**,** large numbers of fish-eating birds (like seagulls) at the water surface**,** loss of appetite**,** pinpoint hemorrhages at the base of the fins and gills, enlargement of internal organs. Microscopic pathological signs are necrosis lesion of internal organs [42,43]. A preliminary diagnosis of the disease can be increased mortality and clinical signs of the disease that include lethargy, dark coloration of the body (skin), distended abdomen, exophthalmia ('pop eye'), pale gills, and mucoid opaque faecal casts. Infected fish commonly hemorrhage around the mouth, behind the head, pectoral fins and muscles near the anus. Necrosis is common in the kidney and spleen, and sometimes in the liver. Mortality is very high in young fish and some fish become covert carriers of the pathogens if they survive infection [42,43]. Necropsy may reveal liver and spleen enlargement or focal pale spots on the liver [44-50]. The affected fish lesions can range from small pinpoint red spots, hemorrhagic spots, localized swelling, protruding scales, scale loss/skin erosion, reddened areas of the skin under the scales and ulceration (Figure 5) [35] [1]. In addition, diagnostic for fish diseases include lethargy, aggregation in still areas of the pond with periodic bursts of erratic swimming and loss of equilibrium [32]. 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, hemorrhaging at the base of the fins, on operculum and around the eye, weakened swimming capability, bleeding at base of fins, a white discharge from the anus (Figure 6). The kidney, spleen, brain and digestive tract are the sites where pathogen most abundant [39].

 DOI: 10.26717/BJSTR.2021.40.006413

Figure 5: Infected finfish abdominal distension, liver and spleen enlargement, a range of lesions and mass mortality [34,45,37].

Figure 6: The infected fishes with white discharge from anus, weakened swimming capability, darkening of the skin, pale gills [38].

Transmission of Fish Diseases: Pathogens can be transmitted both horizontally through fish-to-fish contact, and vertically associated with egg. However, disease is transmitted mostly by fish to fish through direct contact or through water. Horizontal fish-to-fish transmission through water is the primary route through which pathogens spreads in the wild and in aquaculture operations. Although, it occurs primarily in fry and fingerlings in aquaculture facilities, young and older fishes are also susceptible to the pathogens. The transmission occurs via water as the pathogens are present in all the secretions and excretions of infected fish. Blood-sucking parasites and fish eating birds may transfer to new areas [31]. Transmission mode is infected fish spread the disease by shedding with faeces, urine, spawning fluids and mucus secretions, include 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.

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. Some of the key elements of prevention of fish disease include knowledge on the transmission of pathogen, discovery on the carriers of disease, development of effective preventive methods of pathogens entry into the cultured fish and the capacity to provide environmental conditions to good fish health. Activities measures including prevention of infected fish movement between watersheds, reducing bird activity around aquaculture, destocking, cleaning and appropriate disinfection. However, **s**ome of the effective prevention and control plans are vaccination, antibiotics, biological and chemical methods, and reduce physiological stressors play vital role. Some example of vaccines in fish include killed vaccines, attenuated vaccines, DNA vaccines, recombinant technology vaccines, and synthetic peptide vaccines [40]. Good preventive medical practices include quarantine, routine observation, vaccination, and the use of immune stimulants, probiotics, and diagnostics for disease management. Quarantine is the procedure by which an individual or population is isolated, acclimated, observed and, if necessary, treated for specific diseases before its release onto the farm [41].

In avoidance of disease, effective measures in preventing exposure to physical, chemical and biological disease agents, and other vital elements of management of fish health such as water supplies, environmental manipulation, nutrition and feeding, genetic resistance to disease, vaccination, etc. and rapid progress on the immune responses of fish [51-54]. Sanitation measures and disinfection to reduce the risk of recontamination [55-66]. Protection of aquaculture facilities under appropriate disinfection of equipment and intake water [33]. In addition, control measures including destocking, cleaning and disinfection using appropriate treatments will assist in eradication from an aquaculture facility; for example, sodium hypochlorite at 200 mg/L and other treatments, such as heating to 60°C [48]. Advancing vaccination is one of the most important approaches to prevention and control of infectious disease of fish [42].

Some of the improvements of fish vaccination include immunization of large stock at a time and the development of multivalent vaccines [42]. Vaccination is widely in use in almost all food producing animals. In aquaculture, it reduces the use of antibiotics and protects fish from infectious diseases, and also avoids the risk of drug resistance [42]. The few important considerations before application of vaccination in fish include fish species to be vaccinated, status of the immune system of 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), farming technology (handling and mechanization), environment (temperature and salinity), stress factors, nutrition, and cost benefit [43].

Treatment of Diseases of Fish: Prevention measures are advisable due to no established treatment so far. However, **s**ome of the effective control measures are vaccination, antibiotics, biological and chemical methods. Parasitic diseases of fish are most frequently caused by a variety of protozoans which causing irritation, weight loss, and eventually death. However, most protozoan infections are relatively easy to control using standard fishery chemicals such as copper sulfate, formalin, or potassium permanganate [Ruth, 2005]. Bacterial diseases are often internal infections and require treatment with medicated feeds containing antibiotics which are approved for use in fish by the Food and Drug Administration. Viral diseases are distinguish from bacterial diseases with special laboratory tests, difficult to diagnose and no specific medications available to cure viral infections of fish. Fungal diseases are common in the aquatic environment, but do not usually because disease in healthy fish, unless the fish infected with external parasite, bacterial, or injured by handling, then the fungi can colonize on tissue of the fish, appear to have a cottony growth or brown matted areas. So, formalin or potassium permanganate are effective against most fungal infections. Since fungi are usually a secondary problem it is important to diagnose the original problem and correct it as well [Ruth, 2005].

Successful control measures of fish diseases involves a careful management of fish health that removes infected stocks, prevents from re-infection, reduces stress, providing a good environment and adequate nutrition can greatly reduce. However, chemotherapy, antibiotics, bath treatment, etc. are some of the treatments of diseases. The first successful chemical was probably salt, used as a dip treatment to reduce pathogens on external surfaces. Antibiotics are very useful additions to a fish health manager's. Drug bath is a major course of treatment for fish diseases [AFCD, 2008]. Bath treatment involves varying in duration, depending on the chemical and concentration used, often used on brood stock and effective in highly stressful. After treatment, fish should be rinsed in clean water before returned to avoid the transfer of chemical to the tank. Before antibiotics are even considered, sources of stress such as poor water quality, nutrition, genetics, and handling or transport must be removed or reduced. In addition, attacks by predators

may be the primary cause of disease, and contacting a fish health specialist helps to identify stresses and the rate of bacterial infection reducing losses [Ruth, 2005; AFCD, 2008].

Conclusion and Recommendations (future directions): In general, the potential of such infectious pathogens are the main causes for fish mortality at the rates of 80–100% of cyprinid, common carp, etc. of finfish species. Therefore, prevention, strict isolation, 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, evasion of overpopulation are the basic activities for prevention and controlling the diseases that affecting the fishes in aquaculture.

Conclusion

Infectious and non-infectious disease of fishes effects including direct mortalities and serious economic losses due to reduced growth, fecundity, product quality and social factors, and costs of control measures. The outbreak of a disease is caused by the combination factors, such as the presence of a pathogen and unfavorable environmental conditions which will reduce the immune capacity of the fish. 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. Diseases are emerging pathogens that are widespread in a diverse range of environments and hosts restricted to insects and ectothermic vertebrates. Pathogens are the focus of biosecurity controls because the threat to native fish populations with an expanded geographic distribution would have severe impacts on aquaculture production. However, there is a risk that aquaculture operations in tropics will experience higher cumulative mortalities and faster progression of diseases in the future, and this will most likely be exacerbated 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, threatening a significant part of the global supply of nutritious animal sources foods. How disease outbreak dynamics can be mediated by climate driven changes are of paramount importance. There are various factors that can cause fish disease such as adding new fish in the system, environment or poor water quality, fish stress, a poor or unbalanced diet, equipment used in the system is not suitable for the fish, etc.

Animals with disease may show one or more of these signs, but the pathogen may still be present in the absence of any signs. Disease signs at fish farm includes hundreds or thousands of small dead fish**,** large numbers of fish-eating birds around the farm**,** loss of appetite**,** juveniles swimming at the surface**,** swollen abdomen, darkened skin color, hemorrhages at the base of the fins and gills, enlargement of the kidney, liver and spleen; white to yellow liver lesions, coagulative or liquefactive necrosis of the liver, kidney and spleen; necrotic lesions in the heart, pancreas, gastrointestinal tract and gills; No treatment had yet proven to be effective to prevent the disease, 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. Some of the effective key practice used strategies are vaccination, antibiotics, bathing, quarantine, etc. methods. Administration techniques of vaccines in fish include oral, injection, or immersion methods. Antibiotics are also in use in aquaculture despite their side effects in the development of drug resistance by microorganisms.

Recommendations (Future Directions)

For disease prevention and control, certain measures are recommended to reduce risk factors. These are administer commercial vaccines against various fish viral and bacterial pathogens, and most common routes of application are by injection, by immersion or via food. Avoid high stocking density, which causes stress and may increase the incidence of disease even if other environmental factors are acceptable, and also, 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), and dead or dying fish 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, and 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. Segregate fish by age and species for disease prevention, since susceptibility to certain pathogens varies with age, and certain pathogens are specific to some fish species, due to young fish are more susceptible to pathogens than older fish. The vaccines for controlling viral diseases infecting the fishes have limited application and effectiveness. There is also a need for further development of safe and efficacious vaccine(s) that are acceptable within the current regulatory framework.

The development of oral vaccine using a live attenuated strain(s) would fill this gap and should be a priority for future vaccine research, and probably be most desirable considering the low cost, protection efficacy and ease of administration. Developing oral vaccines is a possibility now that a reverse genetic system

for pathogens has been established. Obviously, the next several years will be quite exciting in research as the molecular tools to manipulate viral genomes are advanced, the genome sequences of fish become available and the fish immune system is better understood. 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 viral diseases are being reported in many counties, there has been no systematic study conducted to estimate economic losses. However, the obvious economic importance of viral diseases in aquaculture give good reason for greater efforts to strengthen the research, quarantine, and surveillance systems. Finally, there are various recommended methods used to prevent diseases of fishes such as purchase healthy fish from a reliable and reputable fish supplier; quarantine new fish in a separate fish tank before introducing them into an established fish tank; feed the fish with a proper, varied, and well-balanced diet; keep the water quality clean at all times and ensure that it is within the key water quality parameters of pH, ammonia, nitrites, nitrates, and temperature of fish; ensure enough aeration to keep DO as high as possible; remove uneaten fish food from the tank; ensure that the water is from a good source, clean and free of chlorine; make sure that the fish tank is in an excellent shaded place; follow the standard hygiene procedure by washing hands and using clean gears or equipment; and treat the disease as soon as it is identified.

References

1. De Silva SS, Soto D (2009) Climate change and aquaculture: potential impacts, adaptation and mitigation. FAO Fisheries Technical Paper 530: 137-215.
2. Walker PJ, Mohan CV (2009) Viral disease emergence in shrimp aquaculture: origins, impact and the effectiveness of health management. Reviews in Aquaculture 1(2): 125-154.
3. (2016) FAO. State of World Fisheries and Aquaculture, Contributing to food security and nutrition for all, Food and Agriculture Organization of the United Nations, Rome, Italy.
4. (2014) FAO. Small-scale aquaponic food production: integrated fish and plant farming. FAO, Rome
5. Leung TLF, Bates AE (2013) More rapid and severe disease outbreaks for aquaculture at the tropics: Implications for food security. Journal of Applied Ecology,50(1): 215-222.
6. Walker PJ, Winton JR (2010) Emerging viral diseases of fish and shrimp. Veterinary Research 41(6): 51.
7. Bergmann SM, Fichtner, Skall HF, Hans-J**ü**rgen Schlotfeldt, Niels J**ø**rgen Olesen (2003) Age- and weight-dependent susceptibility of rainbow trout Oncorhynchus mykissto isolates of infectious haematopoietic necrosis virus (IHNV) of varying virulence. Diseases of Aquatic Organisms 55(3): 205-210.
8. Purcell M, Lapatra S, Woodson J, Kuratah, G ,Winton J (2010) Early viral replication and induced or constitutive immunity in rainbow trout familes with differential resistance to infectious hematopoietic necrosis virsus (IHNV). Fish and Shellfish Immunology 28(1): 98-105.
9. MacKinnon, Hawley Traxler G, Morrison D, Salonius K (2008) Efficient IHN vaccine in Atlantic salmon subjected to an IHNV challenge simulating natural and/or e challenges. American Fisheries Society - Fish Health section, Annual Meeting.
10. Hartman KH (2004) "Koi Herpes Virus (KHV) Disease". Fact Sheet VM-149. University of Florida Institute of Food and Agricultural Sciences.
11. Cipriano RC (2009) «Furunculosis and other diseases caused by aeromonas salmonicida". Fish Disease Leaflet 66, US Department of the Interior.
12. Sahoo PK, Paul A, Sahoo MK, Pattanayak S, Rajesh Kumar P, et al. (2020) Incidences of Infectious Diseases in Freshwater Aquaculture Farms of Eastern India: A Passive Surveillance based Study from 2014-2018. 11(1): 579.
13. Salah Mesalhy Aly (2013) A Review of Fish Diseases in Aquaculture Sector. Research program on livestock and fish.
14. Austin B, and Austin DA (2016) Bacterial fish pathogens. Disease of farmed and wild fish. (6th Edn.)., Springer International Publishing Switzerland.
15. Pękala et al. (2015) Agnieszka (2018) Francis-Floyd (2005) Introduction to Fish Health Management. Department of Large Animal Clinical Sciences and Department of Fisheries and Aquatic Sciences, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.
16. Johnson PJ, Paull SH (2011) The ecology and emergence of diseases in fresh waters. Freshwater Biol 56(4): 638-657.
17. Birkbeck TH, Laidler LA, Grant AN, Cox DI (2002) Pasteurella skyensis sp. nov., isolated from Atlantic salmon (Salmo salar L.). International Journal of Systematic and Evolutionary Microbiology 52(3): 699-704.
18. Michel C , Bernardet JF, Daniel P, Chilmonczyk S, Urdaci M, et al. (2002) Clinical and aetiological aspects of a summer enteritic syndrome associated with the sporulating segmented filamentous bacterium *"Candidatus Arthromitus"* in farmed rainbow trout, Oncorhynchus mykiss (Walbaum),". Journal of Fish Diseases 25(9): 533-543.
19. Agnieszka Pękala-Safińska (2018). Contemporary Threats of Bacterial Infections in Freshwater Fish. J Vet Res 62(3): 261-267.
20. Kozińska A, Paździor E, Pękala A, Niemczuk W (2014) Acinetobacter johnsonii and Acinetobacter lwoffii - the emerging fish pathogens. Bull Vet Inst Pulawy 58: 193-199.
21. Pękala A, Kozińska A, Paździor E, Głowacka H (2015) Phenotypical and genotypical characterization of Shewanella putrefaciens strains isolated from diseased freshwater fish. J Fish Dis 38(3): 283-293.
22. Qin L, Zhang X, Bi K (2012) A new pathogen of gibel carp Carassius auratus gibelio-Shewanella putrefaciens. Wei Sheng Wu Xue Bao 52(5): 558-565.

23. Mohan CV, Bhatta R (2002) Social and economic impacts of aquatic animal health problems on aquaculture in India: 63-75. In: Arthur JR, Phillips MJ, Subasinghe RP, Reantaso MB, MacRae IH (Eds.)., Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development. FAO Fisheries Technical Paper, pp. 406.

24. Sahoo PK, Swaminathan TR, Abraham TJ, Kumar R, Pattanayak S, et al. (2016) Detection of goldfish haematopoietic necrosis herpes virus (Cyprinid herpesvirus-2) with multi-drug resistant Aeromonas hydrophila infection in goldfish: Acta Trop 161: 8-17.

25. Behera BK, Pradhan PK, Swaminathan TR, Sood N, Paria P, et al. (2018) Emergence of Tilapia Lake Virus associated with mortalities of farmed Nile Tilapia Oreochromis niloticus (Linnaeus 1758) in India. Aquaculture 484: 168-174.

26. George MR, John KR, Mansoor MM, Saravanakumar R, Sundar P, et al. (2015) Isolation and characterization of a ranavirus from koi, Cyprinus carpio L, experiencing mass mortalities in India. J Fish Dis 38(4): 389-403.

27. ECRLFD, NRL (2009) Infectious Haematopoietic Necrosis Virus and EPIZONE viral diseases in aquaculture. The European Community Reference Laboratory for Fish Diseases (ECRLFD), and National Reference Laboratories (NRL).

28. Tarabili M, Shahidy M, Diab S, Aly S, Refaee A (2000) Establishment of Primary Fish Tissue Culture for Isolation of Some Fish Viruses in Egypt. In: Proceedings of the 9th Scientific Meeting of the Faculty of Medical Veterinary Sciences.

29. Ebrihim ME (2002) The Role of Some Ecological Factors in Virus Infection in Fishes in Egypt. Unpublished M. V. Sc. thesis, Faculty of Veterinary Medicine, Cairo University.

30. (2007) AGDAFF-NACA. Aquatic animal diseases significant to Asia-Pacific: identification field guide. Australian Government Department of Agriculture, Fisheries and Forestry.

31. (2000a) OIE. Diagnostic Manual for Aquatic Animal Diseases, Third Edition, 2000. Office International des Epizooties, Paris, France, pp. 237.

32. Whittington RJ, Becker JA, Dennis MM (2010) Iridovirus infections in finfish critical review with emphasis on ranaviruses. J Fish Dis 33(2): 95-122.

33. Foot J, Free D, McDowell T, Arkush K, Hedrick R (2006) Infectious hematopoietic necrosis virus transmission and disease among juvenile Chinook salmon exposed in culture compared to environmentally relevant conditions. San Francisco Estuary Watershed Science 4: 1-16.

34. Baldock FC, Blazer V, Callinan R, Hatai K, Karunasagar I, et al. (2005) Outcomes of a short expert consultation on epizootic ulcerative syndrome (EUS). Fish Health Section, Asian Fisheries Society, Manila, pp. 555-585.

35. Harmache A, LeBerre M, Droineau S, Giovannini M, Brémont M (2006) *''Bioluminescence Imaging of Live Infected Salmonids Reveals that the Fin Bases are the Major Portal of Entry for* Novirhabdovirus". Journal of Virology 80 *(7): 3655*-3659.

36. (2000b) OIE. Regional Aquatic Animal Disease Yearbook 1999 (Asian and Pacific Region). OIE Representation for Asia and the Pacific. Tokyo, Japan, p. 40.

37. Whittington R, Humphrey J (2019) Epizootic haematopoietic necrosis (EHN), and also known as infection with epizootic haematopoietic necrosis virus (EHNV) from Aquatic animal diseases significant to Australia: identification field guide (5th Edn.).,

38. Peter Dixon, Richard Paley, Raul Alegria-Moran, Birgit Oidtmann (2016) Epidemiological characteristics of infectious hematopoietic necrosis virus (IHNV). Veterinary Research volume 47(1): 63.

39. Ayalew Assefa, Fufa Abunna (2018) Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish.

40. Roy PE Yanong, Claire Erlacher-Reid (2012) Biosecurity in Aquaculture, Part 1. Southern Regional Aquaculture Center. SRAC Publication No. 4707.

41. Plant KP, La Platra SE (2011) Advances in fish vaccine delivery. Developmental and Comparative Immunology 35(12): 1252-1256.

42. Adams A (2016) Fish Vaccines (1st Edn.)., Springer Science+Business Media, Basel, Switzerland.

43. Arnold L, Lentnek MD (2009). Diphyllobothrium: Diphyllobothriasis; Anisakiasis: Symptoms of Anisakiasis; and Chlonorchiasis: Clonorchis sinensis, Public Health Agency of Canada.

44. Ayalew Assefa, Fufa Abunna (2018) Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish.

45. Blazer V, Bondad-Reantaso MG, Callinan RB, Chinabut S, Hatai K, et al. (2005) Aphanomyces invadans (A. piscicida): A Serious Pathogen of Estuarine and Freshwater Fishes, pp. 24-41. Sheperdstown, West Virginia. Michigan State University, East Lansing, Michigan.

46. Bondad-Reantaso MG, Subasinghe RP, Richard Arthur J, Ogawa K, Chinabut S, et al. (2005) Disease and health management in Asian aquaculture. Vet Parasitol. 132(3-4): 249-272.

47. Bryan LK, Baldwin CA, Gray MJ, Miller DL (2009) Efficacy of select disinfectants at inactivating Ranavirus. Dis. Aquat. Org. 84(2): 89-94.

48. Carbone D, Faggio C (2016) "Importance of prebiotics in aquaculture as immunostimulants. Effects on immune system of Sparus aurata and Dicentrarchus labrax," Fish and Shellfish Immunology, 54: 172-178.

49. Crane M, Hyatt A (2011) Viruses of fish: an overview of significant pathogens. Viruses. 3(11): 2025-2046.

50. Dadar M, Dhama K, Vakharia V N (2016) "Advances in Aquaculture Vaccines against Fish Pathogens: Global Status and Current Trends,"Reviews in Fisheries Science & Aquaculture, 25(3): 184-217.

51. Enzmann P, Kurath G, Fichtner D, Bergmann SM (2005) *''Infectious Hematopoietic Necrosis Virus: Monophyletic Origin of European Isolates from North American Genogroup M''. Diseases of Aquatic Organisms.* 66(3): 187-195.

52. Erazo-Pagador GE (2001) In G. D. Lio-Po, C. R. Lavilla, & E. R. Cruz-Lacierda (Eds.), Health management in aquaculture (pp. 75-81). Tigbauan, Iloilo, Philippines: Aquaculture Department, Southeast Asian Fisheries Development Center.

53. Fiorenza Evan A, Wendt Catrin A, Dobkowski Katie A, King Teri L, Pappaionou, et al. (2020) *''It's a wormy world: Meta-analysis reveals several decades of change in the global abundance of the parasitic nematodes and* Pseudoterranova SPP. In marine fishes and invertebrates". Global Change Biology. 26(5): 2854-2866.

54. Francis, Lloyd R (2010) Sanitation Practices for Aquaculture facilities. Institute of Food and Agriculture Sciences, University of Florida Extension Leaflet VM 87.

55. Hill B (2002) National and international impacts of white spot disease of shrimp. Bull Eur Assoc Fish Pathol 22: 58-65.

56. (2007) IPCC. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [IN: Core Writing Team, Pachauri, R.K. and Reisinger, A. (Eds.).,]. IPCC, Geneva, Switzerland, pp. 104.

57. Kube cka D, Boukal S, Cech M (2016) "Ecology and ecological quality of fish in lakes and reservoirs," Fisheries Research 173: 1-3.

58. Maqsood S, Singh P, Samoon MH, Munir K (2011) "International Aquatic Research Emerging role of immunostimulants in combating the disease outbreak in aquaculture," International Aquatic Research 3: 147-163.

59. Mastan SA (2015) "Use of immunostimulants in aquaculture disease management," Int J Fish Aquat Stud 2(4): 277-280.

60. Nishizawa T, Kinoshita S, Kim WS, Higashi S, Yoshimizu M (2006) *"Nucleotide Diversity of Japanese Isolates of Infectious Hematopoietic Necrosis Virus (IHNV) Based on the Glycoprotein Gene". Diseases of Aquatic Organisms* 71(3): 267-272.

61. Oidtmann BC, Thrush MA, Denham KL, Peeler EJ (2011) "International and national biosecurity strategies in aquatic animal health," Aquaculture 320(1-2): 22-33.

62. (2006) OIE. Manual of Diagnostic Tests for Aquatic Animal Diseases. Office International des Epizootics, Paris.

63. Rico A, Satapornvanit K, M Haque M (2012) "Use of chemicals and biological products in Asian aquaculture and their potential environmental risks: A critical review," Reviews in Aquaculture 4(2): 75-93.

64. Rogers C, Basurco B (2009) "Antimicrobial agents in aquaculture: Practice, needs and issues," CIHEAM 59: 41-59.

65. Rudakova SL, Kurath G, Bochkova EV (2007) *"Occurrence and Genetic Typing of Infectious Hematopoietic Necrosis Virus in Kamchatka, Russia". Diseases of Aquatic Organisms* 75 *(1): 1*-11.

66. Sharifuzzaman SM, Austin B (2017) "Probiotics for Disease Control in AquacultureShellfish 1st," in Diagnosis and Control of Diseases of Fish and Shellfish (1st Edn.)., B. Austin, A. Newaj-Fyzul (Eds.)., Wiley & Sons, Ltd, Oxford, pp. 189-222.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2021.40.006413

Firew Admasu. Biomed J Sci & Tech Res

Submission Link: https://biomedres.us/submit-manuscript.php