ISSN PRINT 2319 1775 Online 2320 7876

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Recent Advances and Future Prospects in the Fish Disease, Diagnosis and their Treatment

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Abstract

Approximately 14 million people are employed in various capacities by India's fisheries and aquaculture industries, which also contribute to agricultural exports and provide nutritional security for the food basket. Due to its varied aquatic resources, the nation has consistently increased its fish production since gaining its independence. This industry, which accounts for 6.3% of the world's fish production, makes up 1.1% of the GDP and 5.15 percent of the GDP from agriculture. In recent years, there has been an increase of emerging and re-emerging diseases that result in significant economic losses for various global aquaculture industries. Rapid identification, characterization, and diagnosis of the causal agents and risk factors are essential for the development of efficient management methods aimed at reducing the detrimental effects of these disorders. Although the rapid development of advanced molecular techniques in aquaculture has diverted consumers' and researchers' attention from fundamental characterization methods, the latter remain extremely important. It is believed that diseases and epizootics represent significant obstacles to sectoral development and aquaculture production growth. The sector is currently dealing with global illness challenges as a result of a number of reasons. These consist of the subsequent items: (a) heightened commerce and market globalization; (b) intensification of fish farming methods through the movement of aquaculture species, feed, and related products; (c) introduction of new or alien species for the development of aquaculture.

Keywords:-Fish disease, Antibiotics; Anti-parasitic; Aquaculture; Chemicals; Feed supplements; Fish health management; Fish vaccine.

Introduction

In recent years, aquatic products have played an essential role in the global food supply chain [1], which has a significant impact on the economy and the social development of developing countries. Fish, as an important source of protein, have a balanced nutrition ratio of essential elements required for the human body [2], continuously increasing the consumption of fish products [3]. With the increase in density and intensive development of aquatic fish farming, fish health has become a top issue of concern for consumers [4]. In addition, according to studies, fish disease is considered a major factor causing about 50% of overall production loss. The common outbreak and rapid spread of diseases result in large-scale fish infections in a relatively short period. This could cause massive fish death and water pollution [5]. Worse yet, it is not

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only parasites that can have harmful effects on human health through contact with diseased fish [6], but fish with bacteria can also infect humans with diseases such as Salmonella [7].

In addition, late identification of fish disease could result in the extinction of the whole farmed fish populations. Therefore, it is necessary to develop modern, non-destructive, fast, real-time, and automatic fish disease prediction and diagnosis techniques to keep fish healthy and safe to prevent and control disease transmission in aquaculture.

Fish disease identification is an indispensable part of modern aquaculture, and rapid and real-time diagnosis is an essential part of the early and precise treatment of diseases. However, the farmed fish will be affected by viruses, bacteria, parasites, metal pollution, and fishing damage [8]. Fish diseases are caused by a combination of different pathogens. Conventional methods involve detection via fish tissue dissection, which is destructive, time-consuming, and costly [9]. The direct diagnosis of diseased fish underwater requires a high level of technology, while the large-scale and rapid spread of fish diseases have to limit the required time for diagnosis. The diversity and heterogeneity of fish diseases increase the difficulty of diagnosis, and the accuracy of diagnosis using these various physiological indicators is low. In recent years, image-based disease-diagnosis techniques have been widely used in the diagnosis of fish diseases.

Traditional fish disease diagnosis methods are mainly based on expert systems, and great achievements have been made in fish disease diagnosis [10]. However, the diagnostic accuracy and speed highly depend on the ability and experience of the experts [11]. With the rapid development of image-processing technology, features such as texture, shape, and color from disease images could be indicators for fish disease diagnosis [12]. The use of camera images, microscopic images, spectral images, ultrasound images, and fluorescence images has been shown to provide feasibility for fish disease diagnosis, and the combination of image-processing technology and computer vision can provide non-destructive, automatic, rapid, real-time diagnosis of fish diseases, and low-cost, simple operation, high sustainability, and no pollution to water bodies [13,14,15]. However, the accuracy of disease diagnosis is generally low due to the diversity of fish species, the complexity of survival conditions, and the difficulty of obtaining high-definition images of diseased fish [16]. This has become a great challenge for accurately identifying and diagnosing fish diseases.

With improvements in automatic disease diagnosis for increasing fish production, farming efficiency and safety, and reducing the impact of diseases on humans, fish, and the environment, there have been extensive studies on fish disease identification in recent decades [5,17]. This article aims to provide a review of the techniques and methods used in recent years for the automatic identification and diagnosis of fish diseases. The application of image-processing technology in aquaculture for host and pathogen identification and diagnosis are reviewed, and indirect identification of pathogens using electrochemical genetic sensors is also discussed. Finally, the article discusses and summarizes the potential techniques for the applications of fish disease identification and diagnosis.

Review

The exponential growth of the human population has markedly increased the global demand for food, particularly protein sources from an animal such as fish. However, continuous harvesting of wild fish has led to overexploitation of the wild stock and resulted in a great loss of fish species [18]. Aqua culturing was introduced to prevent overfishing from reducing the depleting wild fish stock. Fishes are bred in a controlled environment where they are subjected to routine feeding and are closely monitored to ensure longevity [19]. The aquaculture industry is driven by an ever-increasing demand for fish by most consumers from

ISSN PRINT 2319 1775 Online 2320 7876

 UGC CARE Listed (Group -I) Journal Volume 13, Iss 03, 2024

developed countries [20]. Proper management and established breeding technology are essential for the fish industry to fulfill the demand [21].

One of the most challenging challenges in sustainable aquaculture is managing and controlling infectious diseases [22]. Fish exposure to pathogens is even more severe and direct than non-aquatic organisms, considering that there are approximately one million bacteria and ten million viruses per milliliter of seawater. Fish are exposed to pathogens immediately after hatching and are continually affected during their mouth and gut opening stages, especially during the onset of their feeding [23]. They are also exposed to unknown pathogens when they migrate from freshwater to saltwater and during climatic change, including the non-migratory species [24]. Furthermore, fish disease outbreaks can be driven by extreme stress from the aquaculture environment and management procedures [**25**]. Despite monitoring the health of the fish stock due to the development and advancement of aquaculture, a continuous supply of fish products could not be supplied globally, primarily due to disease outbreaks [**26**].

Fish such as groupers with a high market value and are reared mainly in fish farms are exceptionally susceptible to infection [**27**]. The main pathogen that infects marine species is bacteria, which comprises 54.9% of the total infection followed by virus infection (22.6%), parasites (19.4%), and fungi (3.1%) [**26**,**29**,**30**]. The outbreak of these infections' diseases in the large-scale fish farms will cost the farmers their revenue and offsets their business. While more money is churned out to rectify the disease, the turnover rate of the farm is being affected due to the decreased production of fish. However, as in all vertebrates, fish have cellular and humoral immune responses and organs as a defense against various pathogenic and non-pathogenic attacks [**31**,**32**]. Unlike mammals, fish are more dependent on the non-specific, innate defense system [**33**]. They are equipped with natural barriers that act as protective mechanisms: their skin and scales and the lytic proteins present in the mucus and sera [**34**]. While the innate defense system responds faster than the adaptive immunity of the species towards any foreign attack [**35**], the adaptive response of fish is essential for long-term immunological memory despite being implemented with a slight delay [**36**].

This overview explains different fish infections and fish reactions to these attacks. In addition, a brief discussion was held regarding the multi-omics methods, the existing omics technologies employed to address this issue, and the ways in which these developing technologies can be effectively utilized to tackle different fish illnesses. The paper also emphasizes the identification of biomarkers and the possible progress they portend in enhancing the omics approach.

Fish Pathogens

The three primary pathogens that do the most harm to the aquaculture sector by being responsible for a large number of fish deaths are viruses, bacteria, and parasites. In cultured groupers in Brunei Darussalam, Malaysia, Taiwan, Indonesia, Kuwait, Thailand, Singapore, and the Philippines, vibriosis, also known as hemorrhagic septicemia, is a common infection [19]. Vibrio parahaemolyticus, Vibrio alginolyticus, Vibrio vulnificus, Vibrio carchariae, Vibrio anguillarum, Vibrio ordalii, Vibrio harveyi, Vibrio mimicus, and many other members of the Vibrionaceae family are among the Gram-negative bacteria that cause vibriosis [16,20, 21].

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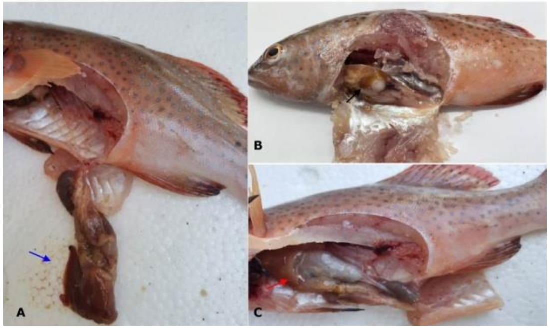
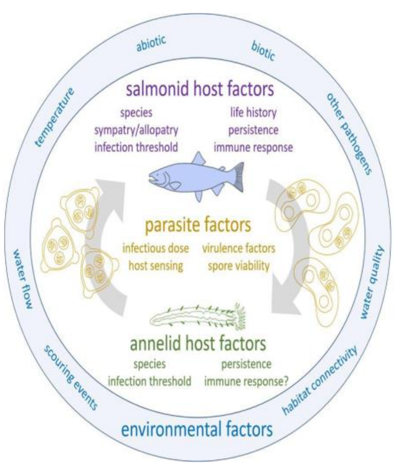
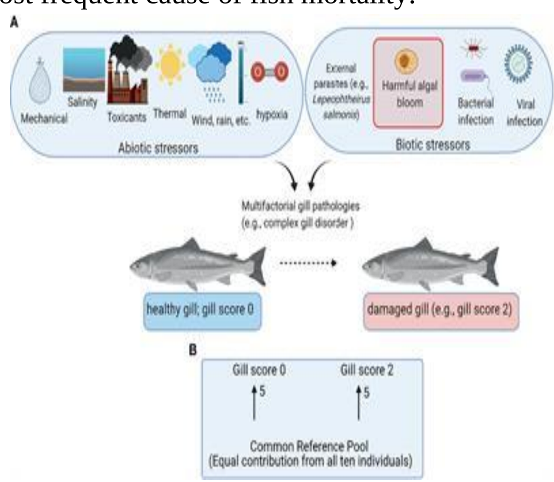


The absence of research on vibriosis caused by other rare Vibrio species may hinder future efforts to control and prevent vibriosis in aquaculture [22]. Numerous species of fish raised in cages and the production of shellfish globally have been severely impacted by this disease, which has had a major negative impact on the aquaculture sector [23, 24]. According to reports, the mortality rate of mariculture groupers has increased due to vibriosis [25]. Numerous significant outbreaks of vibriosis have been documented in Asia, including one in Vietnam where farmed barramundi contracted V. harveyi, which led to up to 40% mortality [26]. V. harveyi produced an outbreak of vibriosis in Asian seabass on a nearby farm in Sabah, Malaysia [27]. Other fish species, including grouper, Epinephelus awoara [28], sole, Solea tauvina [29], gilthead seabream, redbanded seabream, and European seabass [30], have experienced occurrences of vibriosis. The disease's earliest signs and symptoms include lethargy, appetite loss, fish color darkening, loss of balance, and irregular swimming behavior. Additional clinical indicators and symptoms of vibriosis include septicemia hemorrhage and skin, fin, and tail ulcers [12, 22, 32]. Numerous fish species are susceptible to various bacterial infections, although vibriosis is the most frequent cause of fish mortality.





The furunculosis infection caused by the Gram-negative, non-motile rod bacterium Aeromonas salmonicida, which mostly affects salmonid species such as trout, charr, and grayling, is a common bacterial infection. Furunculosis epidemics are frequently brought on by stressors like as contaminated water, crowded living quarters, and abrupt temperature swings [33]. The majority of pathological findings verified that exophthalmia, skin hemorrhages, lethargy, darker skin, irregular swimming, ulcers and liver muscle hemorrhages, and necrosis lesions that formed from furuncles and boil on the skin are common indications of furunculosis [34, 35].

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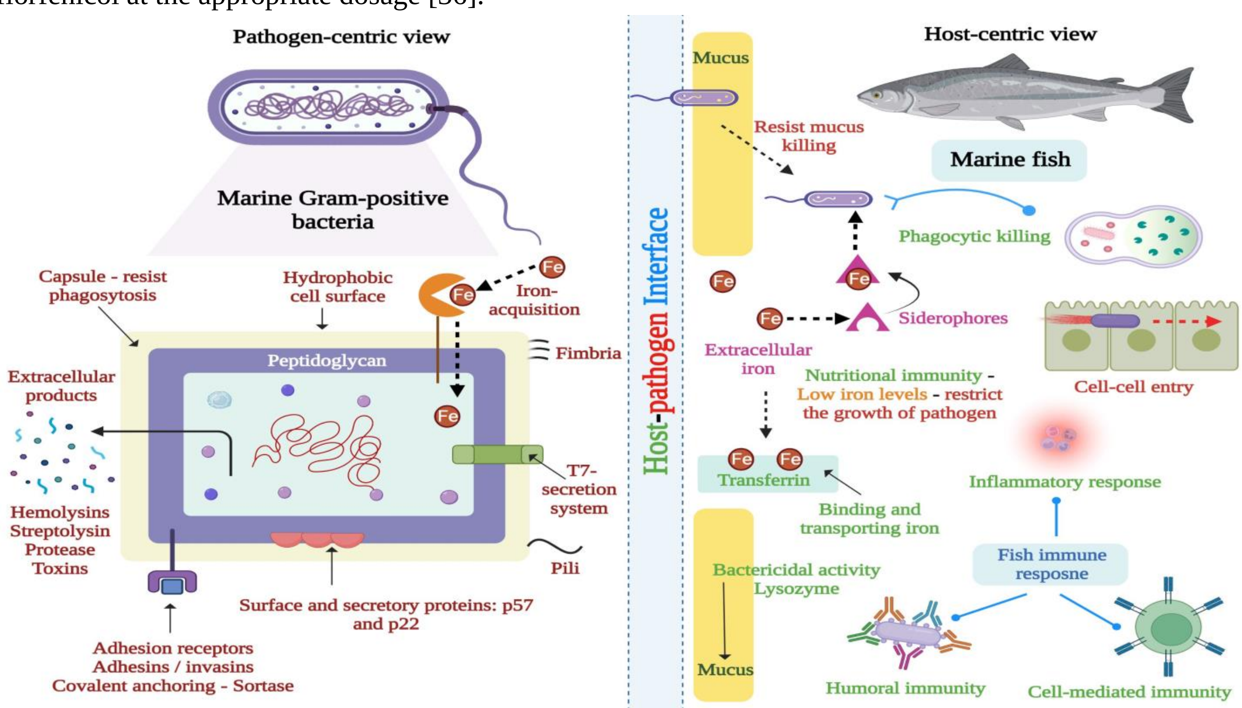
Prior research has examined the presence of furunculosis in a number of species, including non-salmonid species like halibut (Hippoglosus hippoglosus) and turbot (Scophthalmus maximus) as well as salmonid species like Atlantic salmon (Salmo salar) and rainbow trout (Oncorhynchus mykiss) [36,37,38, 39]. Hemorrhagic septicemia infected Atlantic salmon (S. salar) with A. salmonicida resulted in substantial mortality rates, particularly in young and adult fish. Hemorrhagic septicemia is reported to be virtually always deadly after two or three days of exposure [38, 40]. After three weeks of A. salmonicida post-infection, rainbow trout immunized with subunit salmonicida strain A449 demonstrated reduced mortalities [39]. Similar to this, turbot was treated for furunculosis by giving a bacteriostatic antibiotic called florfenicol at the appropriate dosage [36].



Pasteurellosis is another bacterial infection caused by the halophilic bacteria Photobacterium damselae subsp. piscicida. A large variety of fish species, including seabass, cobia, yellowtail, seabream, and others, are impacted by the Gram-negative bacteria [41]. Countries in the Mediterranean, America, Europe, and

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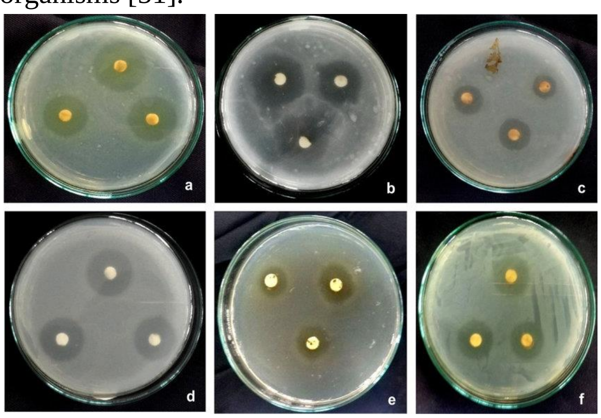
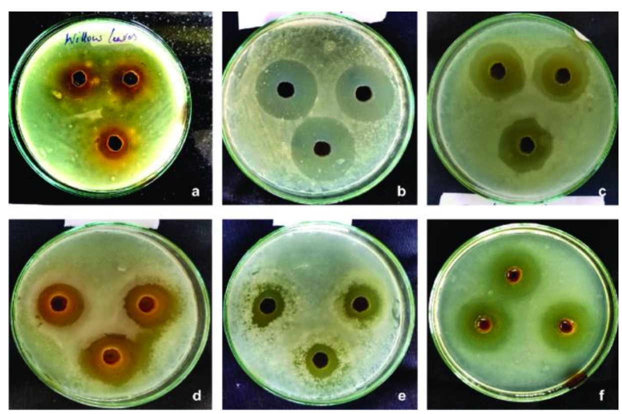
Japan are frequently affected by the illness [42]. According to reports, the sickness typically manifests itself when the water temperature exceeds 20 °C [43]. The white tubercles or granulomas made up of bacterial accumulation in the internal organs are indicative of the presence of this infection [42].

A high death rate from the pasteurellosis outbreak might result in significant financial losses.

In addition to bacterial diseases, viruses are a major contributor to the elevated death rate of fish kept in aquaculture. Since viruses are the most common marine lifeform, they account for the majority of genetic diversity [44]. It is sufficient evidence of their pervasiveness that viral infections cannot be prevented. Viral nerve necrosis (VNN), often called viral encephalopathy and retinopathy (VER), is the virus that marine fish species are most vulnerable to [45]. Globally, VNN is known to have infected many different fish species. These primarily consist of grouper species, such as Epinephelus coioide and Epinephelus fuscoguttatus, that are particularly vulnerable to VNN infection [46, 47]. Not just groupers, but a variety of other marine species are also vulnerable to VNN, including Anguilla (Anguillidae), Gadus morhua (Gadidae), and Umbriana cirrosa (Sciaenidae). Owing to its extensive geographic and species range, VNN has a very negative economic impact on the marine aquaculture sector [48]. The Piscine nodavirus, belonging to the genus Betanodavirus, is commonly recognized as the causal agent of VNN or VER [49, 50]. It is well known that members of the Betanodavirus genus can withstand harsh conditions in the aquatic environment and, once infected, are thought to act as virus reservoirs, spreading the infection to nearby organisms [51].





Lesions in the brain and retina are among the clinical indicators of VNN, and these lesions eventually result in fatigue, discolouration, visual problems, atypical movement, and appetite loss [48]. A similar chronic viral illness that affects people worldwide and throughout a wide range of water temperatures is fish lymphocystis disease (FLD) [52]. In marine net cages in Guangdong, China, Epinephelus bruneus, Epinephelus malabaricus, and Epinephelus chlorostigma were found to have this disease, as was E. fuscoguttatus in Malaysia [53]. Fish lymphocystis disease virus (FLDV) is the iridovirus that causes it [54]. Fish with the infection have unusual hypertrophied lymphocystis cells on their skin, fins, and/or mouths that resemble tiny nodules that resemble pearls and can occur in clusters or singly. The enlargement of the diseased tissues disproportionately results in the apparent nodules. Tumor-like nodules on infected fish make them less valuable on the market. These nodules also prevent the fish from eating, which slows down the fish's pace of growth [55, 56].

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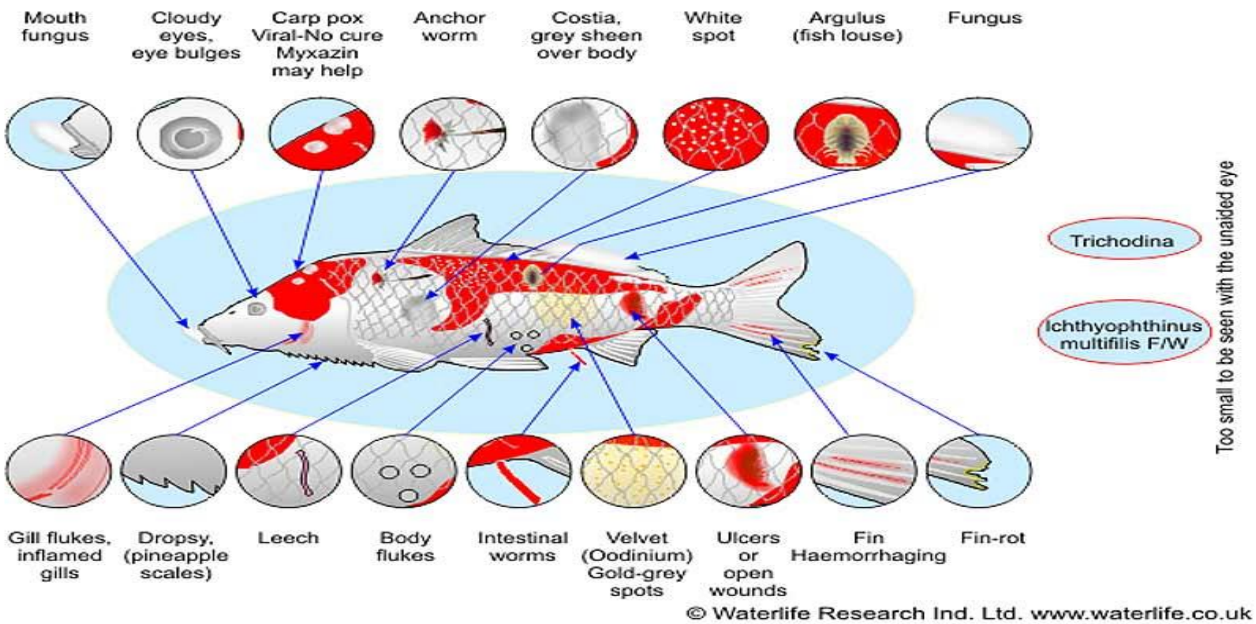

In contrast to viruses, which are obligate hosts, parasites are free-living invertebrate species that are recognized as opportunistic diseases. These parasites are free-living and do not always need a host in order to thrive and procreate. Obedient parasites are those that require hosts in order to live and procreate. Fish species are infested by both obligate and free-living parasites; however, the high death rate in fish is caused by the obligate parasite infestation [57]. Large-scale fish farms are not immune to parasitic diseases. Due to the development of grey patches on the host's skin and gills, the dinoflagellate Amyloodinium ocellatum, which causes amyloodioniosis (velvet sickness), is one of the parasite infections that is most obvious [58]. The disease, which affects Epinephelus species and Cromileptes altivelis, has been documented in Malaysia and Indonesia.

Table:-1 Seasonal variation in fish disease

Diseases	**Species affected**	**Stage of fish**	**Seasonal distribution**		
			Summer	Rainy	Winter
Aeromoniasis	Freshwater fishes	All stages	Yes	Yes	Yes
Red disease	Freshwater fishes	Grow out and Adult	Yes	Yes	Yes
Edwardsellosis	All freshwater and some brackish water fishes	Mostly fry and fingerlings	No	Yes	Yes
Bacterial gill disease	All freshwater fishes	Grow out and Adult	No	No	Yes
Columnaris disease	All freshwater fishes	All stages	Yes	No	No
Vibriosis	Freshwater prawn and shrimps	All stages	Yes	Yes	No
B. Viral diseases					
Whites pot disease	*Penaeus monodon, P. vennamei*	All stages	Yes	Yes	Yes
White tail disease	*Macrobrachium rosenbergii*	Post larvae and juvenile	Yes	Yes	Yes

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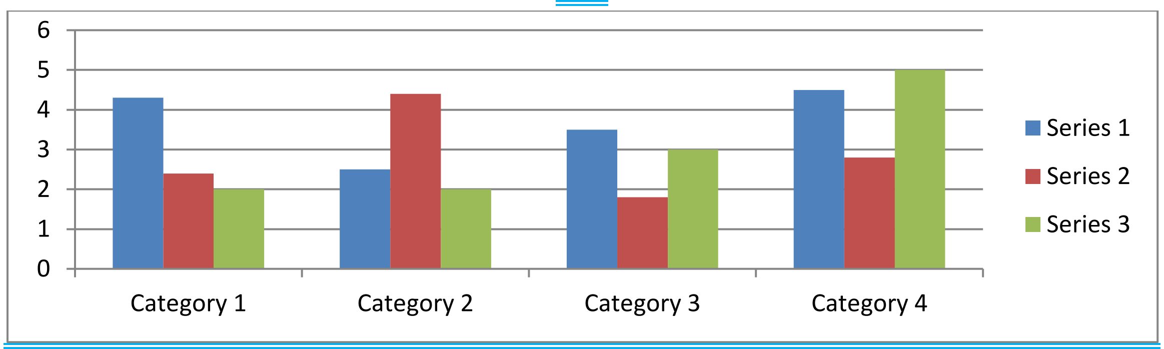
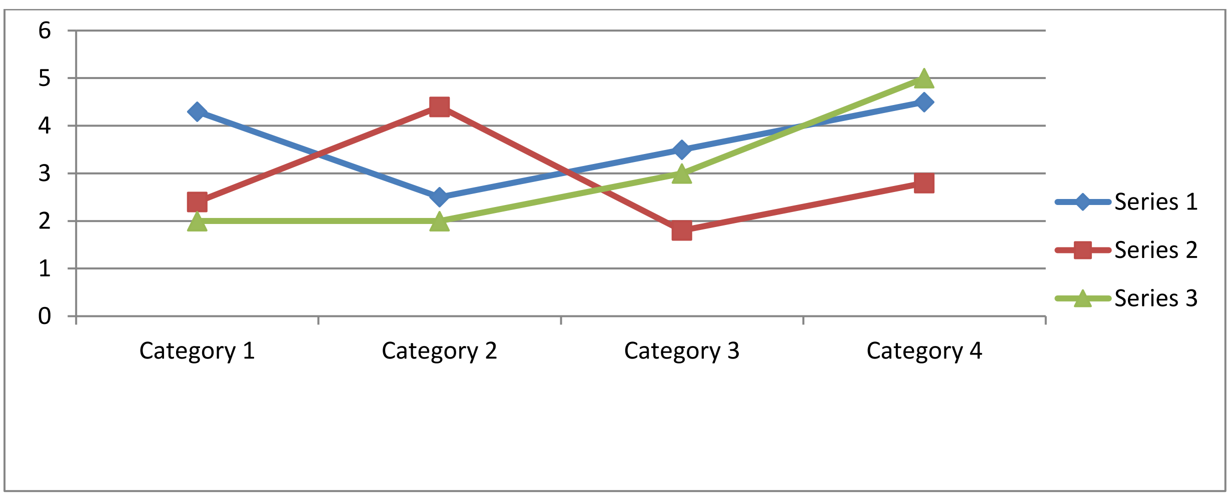
C. Fungal diseases					
Saprolegniasis	All freshwater fishes	All stages	No	No	Yes
Argulosis	All freshwater fishes with scales are affected. *Labeo rohita* more susceptible	Adult	No	Yes	Yes
Lernaeasis	All freshwater fishes	Adult and Juveniles	No	Yes	Yes
Myxosporidiasis	All freshwater fishes	All stages	Yes	Yes	Yes
Dactylogyrosis	All freshwater fishes	Adult	No	Yes	Yes

C-A





G-B

Cryptocaryonosis is another parasite illness that has been documented to afflict cultivated fish in Asian nations [59]. Large yellow croakers, Larimichthys crocea, are notoriously recognized to be negatively impacted by this disease in the sustainable development sector [60]. Due to the whitish or greyish spots that are Cryptocaryon irritans nests observed on the body surface and gills of the affected fish, it is widely known as the "white spot disease" [59]. Although diseases in marine aquaculture are not always harmful, it is undeniable that something needs to be done to stop the rising mortality rate of different fish species, particularly those that support national economies. Thus, numerous initiatives have been made to stop this growing issue of fish mortality.

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DIAGNOSIS OF DISEASE AND THEIR CONTROL

Emerging illnesses affecting aquatic animals have had significant effects on the security of millions of people's livelihoods and have affected national or regional economies The most severe output loss with societal ramifications was seen in India's shrimp aquaculture sector between 1995 and 1998, which nearly caused the sector to collapse. Thus, the development and implementation of appropriate diagnostic and control strategies to counteract disease occurrence in fish and shellfish culture have taken on relevance in many aquaculture-producing nations in order to reduce production loss. The management of the culture unit to lower disease predisposing factors is the most crucial strategy for the disease control program.

Realistic stocking densities, guarding against pathogen introduction into culture systems or hatcheries, maintaining appropriate water quality parameters, minimizing stress, and giving cultured animals enough nutrients are the best ways to do this. A few years ago, diseases affecting aquatic organisms were not seen as a major issue in our nation because the financial losses associated with fish farming were unknown. Attention has been drawn to this aspect due to the recent occurrences of several developing diseases. Consolidate funds, however, are required to address these issues in order to maintain sustainable aquaculture and avoid output losses.

Recent Advancements in Infectious Fish Disease and their possible Treatment

Despite the fact that aquaculture has a lot of room to grow and only uses about 40% of India's available resources at the moment due to access to markets and technological difficulties, data show this. Acknowledging the enormous potential for growth in aquaculture and fisheries, the Indian government reorganized the Central Plan Scheme under the auspices of the "Blue Revolution." In order to increase fish production and productivity from aquaculture and fisheries resources of the inland and marine fisheries sector, including deep sea fishing, the government approved the restructured Central Sector Scheme on Blue Revolution, called Integrated Development and Management of Fisheries (CSS).

Through the full potential utilization of water resources for fisheries development in a sustainable manner, keeping in mind bio-security and environmental concerns, Blue Revolution, the Neel Kranti Mission, aims to achieve economic prosperity for the nation, fishers, and fish farmers as well as contribute to food and nutritional security. A specific goal under the Blue Revolution project is to increase fish production by about 150 lakh tonnes by 2020, up from the current level of 107.95 lakh tonnes. It would result in an increase in export revenue, which would help fishermen and fish growers both directly and indirectly by almost doubling their income.

Current Advancements

The most important thing that farmers can do to reduce fish losses is to control fish disease. This has proven to be difficult because the mortality rate of fish raised in aquaculture is elevated by multiple infections. Pesticides, chemotherapeutic drugs, and antibiotics have all been widely used by fish producers to combat pathogenic illness [61, 62]. Although each of these tactics has benefits, in the long run, the drawbacks outweigh the benefits. Fish health has not improved even though a variety of techniques are being used continuously. Prior to anything else, it is imperative to comprehend the basic biological system that is involved in fish infections. What kind of disease has the fish contracted?

How does the infection get started? What propels the course of the illness? How does the fish fend off the illness? It is possible to answer these intricate concerns by first learning about and comprehending molecular regulatory networks [63]. Advances in fish immunity have led to the development of numerous

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successful disease prevention strategies in recent times. Vaccination and natural compounds with immunostimulatory qualities are two examples of these [64]. This portion of the article provides an overview of the current management strategies for the infectious disease problem affecting farmed fish. It does this by highlighting a few commonly utilized approaches.

IMMUNIZATION (Active & Passive)

Via defense mechanisms triggered by a cascade of immunological responses, organisms protect themselves against infection. Tolerance to the infection allows the host to mount foreign antibodies that momentarily trigger their immune system, a process known as passive immunity, which helps fish survive when the organism is already infected [65,66]. In the meanwhile, one of the most well-known methods for boosting host immunity and protecting fish from current and potential diseases is vaccination, also referred to as active immunity.

Pathogens	Antigen Gene Insert	Host	Route
	RNA Viruses		
Spring viremia of carp virus (SVCV)	pEGFP-G	Common carp (*Cyprinus carpio*)	Immersion & intramuscular
Viral Hemorrhagic Septicemia virus (VHSV)	pcDNA3-vhsG (DK-3592b, genotype Ia & BC-99-292, genotype IVa)	Pacific Herring (*Clupea pallasii*)	Intramuscular
Infectious hematopoietic necrosis virus (IHNV)	Glycoprotein	Rainbow trout (*Oncorhynchus mykiss*)	Intramuscular
	DNA Virus		
Channel catfish virus (CCV)	DNA vector expressing CCV ORF6	Channel catfish	Intramuscular
Iridovirus of Taiwan (TGIV)	TGIV major capsid protein (MCP)	Pearl gentian grouper	Immersion
Koi herpesvirus (KHV)	ORF25 (glycosylated protein)	Koi	Intramuscular
	Bacterial		
Vibrio alginolyticus	Lipopolysaccharides, whole-cell bacterin	Silver sea bream (*Sparus sarba*)	Intramuscular, immersion & oral
Vibrio anguillarum	Outer membrane proteins (OmpK)	Flounder (*Paralichthys olivaceus*)	Intramuscular
Vibrio harveyi	TssJ antigen from T6SS of *V. harveyi*	Golden pompano	Intramuscular

Vaccinations comprising whole pathogens are referred to be first-generation vaccinations. Attenuated pathogens and live vaccines can elicit humoral as well as cellular immune responses; the aquaculture sector now uses both of these vaccinations [67].

Fish Vaccines

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Fish infections remain a major financial problem in commercial aquaculture globally, despite numerous attempts to create novel treatments. While fish diseases can be treated with antibiotics or chemotherapeutics, these approaches have clear drawbacks, including drug resistance and issues with consumer and environmental safety. Vaccination helps to ensure that aquaculture output is sustainable on a worldwide scale in terms of the environment, society, and economy by preventing a wide range of bacterial and viral illnesses . Numerous vaccinations that have been produced since the first reports in the 1940s have significantly lessened the impact of fish infections with bacteria and viruses. Currently, millions of fish are immunized annually, and worldwide, there has been a move away from the use of different antibiotics and toward immunization.

Commercial Fish Vaccines

Large-scale fish farming operations presently use a number of vaccinations that have been developed, including DNA, live-attenuated, and inactivated vaccines. In order to prevent vibriosis and enteric redmouth disease, the first effective commercial bacterial vaccination was created and released in the US in the late 1970s. It was created using whole-cell inactivation as the basis, and immersion techniques were used to administer it. Since 1990, the development of fish vaccines worldwide has proceeded in a manner akin to that of human and veterinary vaccines, involving close collaboration between R&D, the pharmaceutical industry, and regulatory organizations in relevant regions. The leading manufacturers of fish vaccines are Schering-Plough Animal Health (USA), Pharmaq (Norway), Intervet International (The Netherlands), Novartis Animal Health (Switzerland), and Bayer Animal Health (Bayotek)/Microtek, Inc (Germany/Canada).

Due to the introduction of new vaccination technology advancements, a thorough evaluation of the state of the fish vaccine industry is required. Worldwide, more than 26 approved fish vaccines are accessible for use in a variety of fish species (Table 2). The United States Department of Agriculture (USDA) has granted licenses for the majority of developed vaccinations to be used in various aquaculture species. These vaccines are primarily made using conventional production techniques, which entail the growth of particular targeted pathogens. The USDA reports that 77 different species of fish are presently immunized against over 22 distinct bacterial species and six virus pathogenic species.

Fish vaccines have been licensed and made available for purchase by a number of nations, including Korea and Japan. Nine pharmaceutical companies in Japan manufacture fish vaccines for the domestic market; since 2018, 29 vaccine formulations have received approval. More than 13 different kinds of fish species are protected by authorized vaccines against eight bacterial and two viral species. For ten different fish pathogen species, 29 vaccinations have been licensed and made accessible for purchase in Korea.

Fish vaccince

Disease	Pathogen	Vaccine Type	Deliveryy Methods	Country/Region	Make
Vibriosis	*Vibrio anguillarum; Vibrio ordalii; Vibrio salmonicida*	Inactivated	IP or IMM	USA, Canada, Japan, Europe, Australia	Merck Animal Health
Furunculosis	*Aeromonas salmonicida*, subsp. *Salmonicida*	Inactivated	IP or IMM	USA, Canada, Chile, Europe, Australia	MSD Animal Health

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Disease	Pathogen	Vaccine Type	Deliveryy Methods	Country/Region	Make
Bacterial kidney disease (BKD)	*Renibacterium, salmoninarum*	Avirulent live culture	IP	Canada, Chile, USA	Renogen
Enteric septicemia of catfish (ESC)	*Edwarsiella ictaluri*	Inactivated	IP	Vietnam	Pharmaq
Columnaris disease	*Flavobacterium columnaris*	Attenuated	IMM	USA	Merck Animal Health
Pasteurellosis	*Pasteurella piscicida*	Inactivated	IMM	USA, Europe, Taiwan, Japan	Pharmaq AS
Lactococcosis	*Lactococcus garvieae*	Attenuated	IP	Spain	hipara
Streptococcus infections	*Streptococcus spp.*	Inactivated	IP	Taiwan Province of China, Japan, Brazil, Indonesia	Aquavac-vaccines

Current study on fish vaccine

Effective vaccinations for many bacterial infections have not yet been researched and produced, despite the fact that numerous bacterial vaccines are available for use in aquaculture enterprises on a commercial basis. The production of various vaccinations, such as subunit vaccines, plasmid DNA vaccines, recombinant live vector vaccines, and recombinant protein vaccines, which have been tested in fish experiments and approved for commercialization, has been made possible by developments in molecular biology, biotechnology, and reverse vaccinology.

Subunit vaccines against fish nocardiosis in the largemouth bass (Micropterus salmoides) were developed using a reverse vaccinology survey of potent antigenic target contents of specific pathogens. The results showed that, despite showing differential effects, the vaccines were highly promising for nocardial prophylaxis. Under a variety of experimental settings, a multicomponent vaccine was shown to protect trout against three pertinent bacterial diseases (furunculosis, vibriosis, and yersiniosis). This suggests that the vaccine promotes particular antibody responses to distinct bacterial antigens and controls the effective expression of different genes involved in the immune response.

CONCLUSION

With more recently developed adjuvants, microcarriers, and nanocarrier-based precisely targeted vaccines, it is possible to develop multiple next-generation vaccines against a variety of infectious pathogens, particularly bacteria, and produce higher protective immunity in cultured fish species. These vaccines may soon be made available for the aquaculture industry. The creation of a fish vaccine that is effective against most bacterial illnesses will be aided by research on vaccine formulations that include the best antigenic components and field trial trials that support laboratory results. In addition to reducing the effects of environmental pollution brought on by traditional antibiotics and chemical-based treatments, this will support the economy's sustainable growth.

With a wide range of aquatic resources and potential, fishing is a growing business in India that employs over 14.50 million people at the primary level and many more across the value chain. Fish production increased from 7.5 lakh tonnes in 1950–1951 to 107.95 lakh tonnes in 2015–2016 as a result of the fisheries sector's transformation from traditional to commercial scale. In the same period, the sector's export revenues

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were estimated to be around 33,441 crore (US$ 5.51 billion) in 2014. India consistently ranks second after China in the world's fish production. Although India has increased its fish output to 7.2 million tons and plans to double it by 2020, there is still room to grow the amount of fish produced in inland water bodies such as reservoirs, wetlands, lakes, and canals. These kinds of water bodies could benefit from the use of cage culture, and the outcomes at Jharkhand's Chandil Reservoir are promising.

Effective fish immunizations led to significant drops in the use of antibiotics. The true problem with the fish vaccination, however, still lies in merging all the variables that obstruct development into a ministration technique. There are very few authorized vaccines for fish diseases that are available on the market to protect against diseases in commercially significant fish, despite multiple excellent results in research and experimental trials with a moderate to high market potential.

For sustainable fisheries production in the region, it is essential to have a thorough understanding of the prevalence of diseases, utilize local technologies for disease prevention and control, develop an appropriate economic biosecurity program, and implement farm-level BMPs and husbandry practices.

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