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Theory of Tilapia Lake Virus (TiLV)

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Abstract

As the world's population grows, aquaculture is becoming increasingly important in meeting the global demand for high-quality protein. Tilapia, a resilient and adaptable fish species, is widely cultivated for its nutritional value. However, the emergence of Tilapia Lake Virus (TiLV) is a serious threat to the world's tilapia trade, with substantial financial consequences. Addressing the challenge of TiLV is crucial for ensuring the long-term sustainability of tilapia production and maintaining food security for the growing population. This article emphasizes the significance of aquaculture in addressing food security challenges and the urgent need to mitigate the impact of TiLV on the tilapia fisheries sector.

Keywords: Antinutrients; Undomesticated; Legume Vigna Racemosa; Processing

Abbreviations

TiLV: Tilapia Lake Virus; SHT: Syncytial Hepatitis of Tilapia; ORFs: Open Reading Frames; ICTV International Committee on Taxonomy of Viruses; MMCs: Melanomacrophage Centers; BPL: β-Propiolactone.

Introduction

By 2050, it is expected that there will be more than 9 billion people on the planet, resulting in an astounding 70% surge in the worldwide demand for food, feed, and fiber. This population growth is closely intertwined with significant shifts in lifestyle and consumption patterns, primarily driven by the rapid urbanization taking place. As a consequence of these trends, it is expected that the consumption of grains and pulses will decrease, while there will be a substantial increase in the consumption of vegetables, fruits, meat, dairy, and fish. Aquaculture, a well-established industry, stands out as a pivotal source of high-quality protein for humanity [1]. As our global population continues to expand, the challenges of resource scarcity and environmental degradation are becoming increasingly evident. The needs of our society are changing, and land resources alone can no longer meet them. Consequently, our oceans are emerging as a new frontier for human sustenance and development, with fish playing a central role as a source of high-quality protein and a fundamental dietary staple [2]. Over the past few decades, aquaculture has emerged as the fastest-growing sector within agriculture. Since 2013, its production has even surpassed that of wild fisheries [3]. Fisheries and aquaculture play a critical role in enhancing food security and livelihoods on a global scale. Fish remains a vital nutritional source for nearly 3 billion individuals, providing essential minerals, while supplying over 50% of animal protein to 400 million people in the world's most economically disadvantaged regions. In developing countries, the sustenance of over 500 million people is either directly or indirectly connected to fisheries and aquaculture remarkably, the aquaculture sector has gained remarkable momentum, boasting an impressive annual growth rate of 7% and fish products constitute more than 37% of internationally traded food production by volume. Aquaculture stands out as the fastest-growing sector that provides highly protein-rich foods. Globally, the average fish consumption per capita is approximately 20.2 kg [4].

Tilapia, often colloquially referred to as “aquatic chicken,” is a popular choice among major cultivable species. Its annual global production ranges from 0.7 to 0.9 million tonnes per year [4]. Asia serves as the main centre for the production of tilapia aquaculture, with Africa and the Americas contributing additional production. Notably, China leads the world in tilapia production, followed by Indonesia and Egypt [4]. Nevertheless, it’s essential to underscore that disease represents a significant concern in tilapia production. Various pathogens, including bacteria, parasites, and viruses, are prevalent worldwide, posing a substantial challenge for the sustainable growth of the sector. Tilapia is renowned for its resilience in suboptimal water quality and its ability to withstand many diseases that affect other farmed fish. However, the emergence of Tilapia Lake Virus (TiLV) has posed a significant threat to the global tilapia industry, marking the first major disease epidemic in tilapia aquaculture. In 2011, a new virus called TiLV was discovered in Israel [5] with scientific reports of the disease surfacing in 2013. Subsequent research revealed that the virus linked to syncytial hepatitis of tilapia (SHT) bears a close genetic resemblance to TiLV [5]. Categorized as an OIE-listed disease, TiLV is highly contagious and endangers tilapia farming. Since its discovery in 2014, TiLV has drawn widespread attention within the aquaculture industry due to its association with substantial fish mortality and the severe consequences for the tilapia aquaculture sector. It has now been reported in 16 countries and the number continues to rise, thanks to improved diagnostic techniques and expanded surveillance efforts around the world. It poses a major threat to the tilapia aquaculture industry, with reported mortality rates reaching as high as 90%. The economic losses suffered by fish farmers due to TiLV are substantial and directly linked to the occurrence of this disease.

Materials and Methods

Aetiological Agent

Tilapia lake virus is a novel enveloped, negative strain single-stranded RNA virus. They can contain capsid virion with multiple aggregates that are dense in electrons [6]. It composed of 10 segments each of which encode a protein [5]. The diameter is between 55 to 100 nm [7]. The ten segments each contain open reading frames (ORFs), which could encode 14 different proteins [8]. According to the Baltimore classification system, the tilapia lake virus belongs to group V, the monotypic genus tilapia virus, which is the sole genus in the Amnoonviridae family and can contain only one species of tilapia virus. The new unassigned genus Tilapinevirus, which includes the new species Tilapia tilainevirus, has been proposed taxonomically to the International Committee on Taxonomy of Viruses (ICTV, 2020).

Global Distribution of Tilapia Lake Virus

There have been reports of the tilapia lake virus in 16 countries [9]. Some Asian countries included are Thailand [10]. Chinese Taipei [11,12], Malaysia [13] India [14], Indonesia [15], the Philippines [16], and Bangladesh[17]. The disease has also been reported in Colombia [18], Mexico [19], the USA [20], Peru [21] and African countries like Egypt [22], Tanzania and Uganda (Area of Lake Victoria) [23,24]. In India, the tilapia lake virus was first spread in two states, namely Kerala and Kolkata [14].

Mode of Transmission

Tilapia lake virus is transmitted in various ways; some routes are horizontal and some are vertical transmission. Direct horizontal transmission has been shown in co-habitation studies to be an important mode of transmission. The presence of TiLV in the gonads of breeders and fry at 2, 5, and 10 days post-hatching suggests that TiLV may be transmitted vertically [25].

Host Factor

The tilapia lake virus was infected with wild and farm tilapia, which they have observed in numerous nations. Red tilapia (O. sp.), Nile tilapia, and hybrid tilapia (Oreochromis niloticus × O. aureus) have all been shown to be susceptible to TiLV [5,7,10,26].

Disease sign at farm, tank, or pond level

The tilapia species exhibits general symptoms at the farm, pond, and tank, with symptoms like anorexia, abdominal swelling, loss of appetite, scale protrusion, several anemias, skin abrasion and congestion, poor body condition, and bilateral exophthalmia [26,27].

Gross Sign

Gross symptoms appeared within a month after the fingerlings were placed in the grow-out facilities. and mortality typically begins The gross signs may include bleeding at the fins and opercula bases, skin erosion, scale protrusion and loss, abdominal distension due to ascites, skin darkening, gill pallor, and swelling of the abdomen in addition to ocular changes such as exophthalmia ("pop-eye") and severe cases presenting with shrinkage of the eyeball (phthisis bulbi) and lens opacity. Additionally, fish exhibit abnormal behaviors including Lethargy, loss of appetite, surface swimming, and loss of balance are some abnormal behaviors that fish display [5,7]. TiLVD-related deaths can range widely from 10% to 90%. Internally, the TiLV exhibits some abnormal conditions, fish with symptoms like watery, pale, and necrotic liver. In certain cases, liver tissue looks green or dark; other symptoms show enlargement of the skin and accumulation of watery fluid from the gall bladder in the abdominal cavity and intestines.

Microscopic Pathological Sign

The targeted organs of the Tilapia Lake virus are the spleen, kidney, liver, and brain. In the histopathological analysis, the most typical findings in the livers of infected fish include the formation of syncytial cells and massive hepatocellular necrosis with pyknotic and karyolitic nuclei [18,14]. The fish with TiLV infection had capillary congestion, proliferative glial cells, edema and multifocal hemorrhages in their brains [12,18]. Increased melanomacrophage centers (MMCs) were seen in the anterior kidney along with numerous necrotic foci, and melanin granule dispersion was seen in the spleen [25].

Different Diagnostic Methods

Virus isolation and cell culture

TiLV sensitivity was seen in the multiple-cell line.		
1	E-11	Eyngor, et al. [5] Tsofack, et al. [18]
2	OmB	Tsofack, et al.[18]
3	TmB	

Table 1: TiLV sensitivity was seen in the multiple-cell line.

Other cell lines for the detection of TiLV		
1	CHSE-214	Eyngor, et al. [5]
2	BF-2	
3	BB	
4	EPC	
5	KE-1	
6	RTG-2	
7	FHM	

Table 2: Other cell lines for the detection of TiLV.

Molecular methods

There are numerous molecular TiLV tests available.

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1	RT-PCR	· Using a particular primer, it's the first reverse transcription polymerase chain reaction (RT-PCR).	Eyngor, et al. [5]
2	Nested RT-PCR	· Assay for nested RT-PCR with reportedly improved sensitivity.	Kembou Tsofack, et al. [18]
		· Able to identify TiLV in diseased fish samples that are preserved as well as fresh.	
		· Tenfold higher sensitivity than one RT-PCR.	
3	Semi- nested RT-PCR	· It is alternative semi-nested RT-PCR assay.	Dong, et al. [28]
		· A maximum of 7.5 copies for detection	
		· capable of identifying TiLV in clinically healthy fish	
4	RT-qPCR	· A recently created reverse transcription quantitative PCR (RT-qPCR) technique based on SYBR green.	Tattiyapong, et al. [27]
		· Two viral copies per microliter is the detection threshold.	

Table 3: molecular TiLV tests.

Results and Discussion

Prevention and Control

It is mandatory to use drugs prior to a disease outbreak in order to prevent it.

Vaccination

For controlling fish diseases, vaccines can be used as an effective prophylactic measure. A vaccine is an antigenic material that induces adaptive immunity against a specific pathogen. Interest in creating tilapia vaccines has increased recently as tilapia culture has grown exponentially and large-scale production has become common. TiLV vaccine development is ongoing in China, Thailand, and Israel. Tilapia can produce anti-TiLV antibodies in seven to ten days, according to research on humor's defense against TiLV [29]. After being exposed to the virus. The majority of the time, an increase in antibodies happened within two weeks after the fish were re-exposed to TiLV (through IP injection). These demonstrated that tilapia maintained humoral memory and generated anti-TiLV antibodies to shield fish from further exposure. The TiLV has recently been created using β-propiolactone (BPL) inactivation [30]. Montanide IMS 1312 adjuvant, combined with the inactivated vaccine, has an apparent high efficacy survival rate of 85.7%.

Immunostimulants

Immunostimulants are substances that stimulate one or more immune pathways, increasing the body's ability to fight antigens. Unlike vaccines, which target particular pathogens, immunostimulants act to improve the immune system's overall response. It is a broad-spectrum activity and very common compared to the vaccines. There are different immunostimulants on the market. That can contain β-glucans, which are most commonly used in aquaculture. These immunostimulants bolster the immune system both adaptive and innate by enhancing the humoral complements, phagocytes, and lysozyme activities. Additionally, they may be useful for antibody responses [31]. β-glucans, effective against viral and bacterial diseases.

Probiotics

Live microorganisms known as probiotics, which are mainly bacteria and yeasts found in fishes, normal pond environments or intestinal microflora, are beneficial to health. Probiotics may be added to feed, given to boost immune responses, or added to ponds to enhancing the water quality [32]. Probiotics are used in aquaculture to combat pathogens, including bacteria and viruses. It has been demonstrated that probiotic bacteria can influence fish immunity (innate and adaptive) directly by increasing lysozyme levels, phagocytic activities, cytokine production, and complement responses [33]. The probiotic Bacillus subtilis C-3102 has been demonstrated to enhance the adherence of beneficial bacteria to the mucosal surfaces of the stomach of hybrid tilapia (O. aureus × O. niloticus) and enhance the intestinal production of cytokines such as TGF-β, IL-1b, and TNF. In a TiLV challenge bioassay, probiotic supplementation was shown to have a reduced mortality rate of 25% compared to tilapia that were not fed the probiotic diet, which had a higher mortality rate of 32% [34].

Virus Free Tilapia

The majority of tilapia farmers utilize SPF animals that are TiLV-free. The biosecurity facilities where the SPF tilapia are raised allow for constant monitoring of their health status through the use of standardized diagnostic techniques [35-41].

Conclusion

As the world's population continues to grow and food demands change, the growing demand for high-quality protein is anticipated to be largely met by aquaculture. Among the various fish species, tilapia stands out as a popular choice due to its resilience and adaptability. However, the tilapia industry worldwide faces a serious threat from the emergence of Tilapia Lake Virus (TiLV), which could result in large financial losses. Addressing the challenge of TiLV is essential for ensuring the long-term sustainability of the tilapia sector and maintaining food security for billions of people worldwide.

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