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Infectious Myonecrosis Virus (IMNV) – An alarming viral pathogen to Penaeid shrimps

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ABSTRACT

Intensification and diversification of the aquaculture practices made an opening to the emergence of new viral diseases daunting the farmers to achieve a sustained production. Viruses are obligatory parasites abundant in the aquatic environments and are being introduced in the sector directly or indirectly. Infectious Myonecrosis Virus (IMNV) is an emerging shrimp RNA virus causing the disease, infectious myonecrosis (IMN). The disease was reported first from Brazil and currently the geographical locations of infection span in Brazil and Indonesia. Research are centered on the viral pathogenesis, viral entry, disease prevention and epidemiology, diagnostics and molecular pathology. The recent developments in the synthetic and molecular biology techniques have paved way to explore IMNV at its molecular levels, yet further research has to be conducted to fully understand the virus as well as diagnostics of the disease with cause. This review covers all the aspects of the virus, IMNV and the disease IMN, research developments and emphasizes on the current progress and the future prospects of the research in control and prevention strategies.

Contents

1. Introduction

The farming of *Litopenaeus vannamei*, white leg shrimp has positively influenced the global shrimp production and export scenario. Global production of farmed shrimp has increased from 3.4 million tons in 2013 to 3.6 million tons in 2014 (*Aquaculture Culture Asia-Pacific Magazine*). The farmers of Vietnam, Indonesia, and India are shifting from Black tiger shrimp farming to *L. vannamei* culture. As a result,the production of *L. vannamei* in Asia increased from 2.12 million tons in 2013 to 2.37 million tons in 2014 (*FAO, Glob fish, shrimp May-2015*). The culture of monodon was a true sufferer of many havocs like White spot Disease (WSD), Loos Shell Syndrome (LSS) and Monodon Slow Growth Syndrome (MSGS). Today world has moved on to *L. vannamei*

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due to its high productivity, low-cost involvement and availability of SPF seed. The huge production rate of *L. vannamei* has boosted the export of India in 2013–2014 fiscal year by 1,34,372 tons (USD 1.47 billion) compared with 69,565 tons (USD 540.8 million) during the previous fiscal year (Shrimp, 2014). But now *L. vannamei* is no more resistant to diseases like TSV, YHV Type-1, IHHNV, and EMS. The availability of *L. vannamei* SPF stocks for WSSV has reduced the outbreaks of WSSV. But still, it is suffering from new emerging diseases like EMS, IMNV and abdominal segment deformity disease (ASDD) (Sakaew et al., 2008). In this paper, we are reviewing the current research status for IMNV which is an emerging viral disease of *L. vannamei*.

Infectious myonecrosis virus is an emerging novel virus which has affected the Vannamei culture of countries like north-eastern Brazil (Andrade et al., 2007; Lightner et al., 2004a,b, Nunes et al., 2004; Poulos et al., 2006) and in the East Java Island (Senapin et al., 2007) as well as in other South-East Asian countries. The disease is not threatening as other viral diseases viz., WSSV, YHV etc., but there may be high mortality due to adverse environmental conditions. As per the bioassay results there were no mortality until 9 to 13 days after exposure to IMNV (Tang et al., 2005), while significant mortality can occur within 1 to 3 days in bioassays with TSV, YHV, or WSSV (Lu et al., 1995; Overstreet et al., 1997; Tang and Lightner, 2000). Although disease progression is slower in comparison to other viral diseases. There can be a significant economic loss due to the persistent mortality and increased feed conversion efficiency (Lightner et al., 2004b). Cumulative mortalities up to 80% has been reported in Brazil (Poulos et al., 2006). There is a reduction in the market value of survivors with necrotic muscle. The disease was first reported in shrimp farming areas of Brazil in 2004 and by 2006, it was spread to Indonesia, which is due to the improper transportation of live animals. It was responsible for economic losses that valued at approximately US$20 million (OIE, World Animal Health Organization, 2009) in 2003. Hence to develop the awareness and necessary control measures for the emergence of IMNV, it was listed in OIE (International Organization of Epizootics) report during 2005.

1.1. Infectious Myonecrosis Virus (IMNV)

Infectious Myonecrosis Virus (IMNV) is an emerging potential shrimp virus reported to cause a considerable economic loss in shrimp aquaculture (Nunes et al., 2004). The disease was first reported in the State of Piaui, North-East Brazil, 2002 in the Pacific whiteleg shrimp, *Litopenaeus vannamei* and initially was named as Idiopathic Myonecrosis (Lightner et al., 2004a,b). Finally, the disease was renamed as Infectious myonecrosis (IMN) and the etiological agent was identified as a virus, named Infectious Myonecrosis Virus (IMNV) (Poulos et al., 2006; Tang et al., 2008). Apart from naturally susceptible *L. vannamei*, the other species reported to be experimentally susceptible are *Farfantepenaeus subtilis*, Penaeusmonodon, and *Litopenaeus stylirostris*. (Lightner et al., 2004a,b; Tang et al., 2005; Coelho et al., 2009). The virus infects all the life stages of shrimp including post larvae, juveniles, and adult, but the mortality was observed in the juveniles and adult with a cooked appearance (Nunes et al., 2004). The reported survival range during infection is35 to 55% in 12 g shrimp with a stocking density of 60/$m^2$and the economic loss was estimated to be US$20 million in 2003 (Nunes et al., 2004). Till date, the disease was restricted only to Brazil in South America and Indonesia in Asia. (Lightner et al., 2004a, b; Senapin et al., 2007). Losses caused by the disease in 2003 alone were estimated to be 20 million dollars (OIE, 2007). Brazilian shrimp farmers suffered an economic loss of 440 million USD as a result of IMNV outbreak at the end of 2005 (Andrade et al., 2007) and by the end of 2011, an estimate has been reported from both Brazil and Indonesia that the financial loss was increased to >1 billion US$ (Lightner, 2012). Studies reported that the infectious myonecrosis virus can appear as a co-infection with *Macrobrachium rosenbergii* Noda virus (MrNV) and white spot syndrome virus (WSSV) in *Litopenaeus vannamei* (Senapin et al., 2013; Feijó et al., 2013) as well as with *Vibrio harveyi* (Oktaviana and Widanarni, 2014).

1.2. Geographical distribution of the virus

The virus was first reported from the North- East Brazil in South America in 2002. Up to 2007, the disease was restricted only to Brazil. But in 2007, the virus crossed its border and was reported in Indonesia for the first time from an Asian country where it was seen in farms of west Java, Sumatra, Bangka, west Borneo, south Sulawesi, Bali, Lombok and Sumbawa in SouthEast Asia (Sutanto, 2011). Thailand also claimed the infection with IMN virus but further investigation revealed that other than Indonesia, no other Asian countries were infected. (Senapin et al., 2011). Since it was first reported from Brazil, this virus is thought to be South American in origin. It is restricted in geographical distribution. The spread of the disease to new locations like Indonesia is believed to be due to the illegal transboundary movement of the infected or carrier broodstock and postlarvae for aquaculture (Flegel, 2006; Lightner, 2012; Senapin et al., 2007; Walker and Mohan, 2009; Walker and Winton, 2010). Rumors are already existing regarding the presence of virus in Asian countries other than Indonesia say, India, China, Malaysia, Thailand, and Vietnam. But the report by Senapin et al. in 2011, states them false as contamination or muscle cramp syndrome (whitening of the muscle) (Plate 1).

1.3. Host range and strains of IMNV

IMN virus exclusively infects the Penaeid shrimps. Till date, there is no report of any infection among the wild populations (Tang et al., 2005). The virus naturally infects Pacific whiteleg shrimp, *L. vannamei* and Southern brown shrimp, *Farfantepenaeus subtilis* and has been experimentally proving to infect, *Penaeus monodon,* and *L. stylirostris* (Lightner et al., 2004a,b; Tang et al., 2005; Coelho et al., 2009). There have been no reports of death in *P. monodon* due to the infection, but it can be a potential carrier of the virus (Tang et al., 2005). Since the main target tissue of IMNV infection is skeletal muscles and which is not a vital organ, the infection is not that much fatal in comparison with other virulent shrimp viruses like WSSV, YHV, and TSV. Also, the damage initiated to the muscle tissues can be repaired at the early stages of the infection (Tang et al., 2005). Studies have been undertaken for the identification of potential vectors or carriers of the IMNV and recently da Silva et al., 2015 reported that *Artemia franciscana*, aquaculture live feed organism, as a vector for the IMNV infection. But mass mortality of the shrimp *L. vannamei* fed with infected *A. franciscana* were not observed. This is because maybe it act as a source of IMNV in growing out culture ponds (da Silva et al., 2015). Bivalves and polychaete worms are also reported positive to IMNV infection from the infected pond without any reliability to confirm that they are true vectors or carriers. The presence of the virus may be either due to the ingestion of the contaminated tissues or water from the infected area (Andrade and Lightner, 2009). Reported details of the host range of IMNV given as table (Table 1).

To date, four strains of IMNV have been described and nine strains partially sequenced. The first strain (IMNV_Brazil_2006) was reported from Brazil in 2006 (Poulos et al., 2006) followed by the second (IMNV_Indonesia_2006) from Indonesia in 2007 (Senapin et al., 2007). The partial and complete genome of the isolates of these strains is available in Genebank. The following table shows updated information about the genome sequence available in the database (Table 2).

The viral genome sequence of IMNV isolated from Indonesian shrimp farm shows 99.6% similarity with Brazilian sequence (Senapin et al., 2007). Multiple alignments of Brazilian IMNV viral capsid protein coding sequence of 372 bp shows a high degree of similarity with sequences of Brazil and Indonesia (Melo et al., 2014). This analysis suggested that the Brazilian and Indonesia strains are genetically identical