

## Advances in the study of nodavirus

### ABSTRACT

Nodaviruses are small bipartite RNA viruses which belong to the family of Nodaviridae. They are categorized into alpha-nodavirus, which infects insects, and beta-nodavirus, which infects fishes. Another distinct group of nodavirus infects shrimps and prawns, which has been proposed to be categorized as gamma-nodavirus. Our current review focuses mainly on recent studies performed on nodaviruses. Nodavirus can be transmitted vertically and horizontally. Recent outbreaks have been reported in China, Indonesia, Singapore and India, affecting the aquaculture industry. It also decreased mullet stock in the Caspian Sea. Histopathology and transmission electron microscopy (TEM) are used to examine the presence of nodaviruses in infected fishes and prawns. For classification, virus isolation followed by nucleotide sequencing are required. In contrast to partial sequence identification, profiling the whole transcriptome using next generation sequencing (NGS) offers a more comprehensive comparison and characterization of the virus. For rapid diagnosis of nodavirus, assays targeting the viral RNA based on reverse-transcription PCR (RT-PCR) such as microfluidic chips, reverse-transcription loop-mediated isothermal amplification (RT-LAMP) and RT-LAMP coupled with lateral flow dipstick (RT-LAMP-LFD) have been developed. Besides viral RNA detections, diagnosis based on immunological assays such as enzyme-linked immunosorbent assay (ELISA), immunodot and Western blotting have also been reported. In addition, immune responses of fish and prawn are also discussed. Overall, in fish, innate immunity, cellular type I interferon immunity and humoral immunity cooperatively prevent nodavirus infections, whereas prawns and shrimps adopt different immune mechanisms against nodavirus infections, through upregulation of superoxide anion, prophenoloxidase, superoxide dismutase (SOD), crustin, peroxinectin, anti-lipoplysaccharides and heat shock proteins (HSP). Potential vaccines for fishes and prawns based on inactivated viruses, recombinant proteins or DNA, either delivered through injection, oral feeding or immersion, are also discussed in detail. Lastly, a comprehensive review on nodavirus virus-like particles (VLPs) is presented. In recent years, studies on prawn nodavirus are mainly focused on *Macrobrachium rosenbergii* nodavirus (MrNV). Recombinant MrNV VLPs have been produced in prokaryotic and eukaryotic expression systems. Their roles as a nucleic acid delivery vehicle, a platform for vaccine development, a molecular tool for mechanism study and in solving the structures of MrNV are intensively discussed.

**Keyword:** Diagnosis; Immunology; Nodavirus; Vaccines; Virus-like particles