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[5] Diseases Caused By Viral Pathogens

メタデータ	言語: eng 出版者: 公開日: 2016-05-13 キーワード (Ja): キーワード (En): 作成者: 中井, 敏博, 佐野, 元彦, 吉水, 守, 笠井, 久会, 伊丹, 利明, Sudhakaran,, Raja メールアドレス: 所属:
URL	https://oacis.repo.nii.ac.jp/records/1270

3. Salmon and Trout Viral Diseases

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3.1. Synopsis

Transmissible diseases of socio-economic importance must be controlled within national boundaries. Salmon and trout viral diseases such as infectious hematopoietic necrosis (IHN), infectious salmon anemia (ISA) and viral hemorrhagic septicemia (VHS) are listed as diseases notifiable to the World Organization for Animal Health (OIE). Formerly *Oncorhynchus masou* virus disease was also listed. For prevention and treatment of diseases, see “*Prevention and Treatment of Diseases Caused by Fish Pathogens*”.

3.2. Introduction

Salmonid fish including chum salmon (*Oncorhynchus keta*), pink salmon (*O. gorbuscha*), sockeye (*O. nerka*), Chinook (*O. tshawytscha*), coho (*O. kisutch*) and masu salmon (*O. masou*) are important species that are hatchery reared and released fish in to the North Pacific Ocean. Atlantic salmon (*Salmo salar*), and rainbow trout (*O. mykiss*) are important for aquaculture. Viral diseases such as infectious pancreatic necrosis (IPN), infectious hematopoietic necrosis (IHN), viral hemorrhagic septicemia (VHS), *Oncorhynchus masou* virus disease (OMVD), infectious salmon anemia (ISA), erythrocytic inclusion body syndrome (EIBS), pancreas disease (PD), sleeping disease (SD), viral wiring disease (VWD), and viral erythrocytic necrosis (VEN) limit successful propagation and aquaculture of these species. Here, we discuss the characteristics, genome size, serological classification, molecular classification and pathogenesis of representative viruses, outlined in the OIE manual of diagnostic methods for aquatic animals (OIE Manual of diagnostic tests for aquatic animals), AFS-FHS blue book (2010), and fish diseases and disorders (Patrick and Bruno, 2011).

3.3. Representative Viral Diseases and their Characteristics

3.3.1. Infectious Pancreatic Necrosis

Infectious pancreatic necrosis (IPN) is an acute contagious systemic birnavirus disease of fry and fingerling trout. The disease most characteristically occurs in rainbow trout, brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and Atlantic salmon. However IPNV and IPN-like birnaviruses have been isolated from a variety of non-salmonid fishes and invertebrates from freshwater, estuarine, and marine environments. IPNV (and IPN-like birnaviruses) is among geographically dispersed groups of viruses.

3.3.1.1 Disease Agent

IPNV is the type species of the genus *Aquabirnavirus* within the viral family designated *Birnaviridae* by the International Committee on Taxonomy of Viruses (ICTV) (King et al, 2012). The IPNV virion is non-enveloped, single shelled and measures approximately 60 nm in diameter. The viral genome consists of a bi-segmented, double-stranded RNA. Aquatic birnavirus including IPNV is classified into two serogroups (A and B).

Serogroup A isolates are divided into nine serotypes, termed A1-A9. Serogroup B contains only one serotype, but this is based on a limited number of isolates. Aquatic birnavirus including IPNV was classified into seven genogroup by sequence analysis of the VP2/NS junction region.

3.3.1.2 Diagnostic Methods

In salmonid fry, symptoms of infection include anorexia and a violent whirling pattern. Non-specific external symptoms include darkening of the skin, abdominal swelling, exophthalmia, pale gills and petechial hemorrhages. IPN exhibits marked pancreatic necrosis and severe lesions in the intestinal mucosa. Pancreatic lesions can vary from small foci to extensive acinar cell necrosis, with nuclear pyknosis, karyorrhexis and basophilic cytoplasmic inclusions. Virological examination coupled with serological or molecular identification is required for confirmation of clinical or subclinical infection with IPNV. Cell cultures of blue gill fry (BF-2), Chinook salmon embryo (CHSE-214), or rainbow trout gonad (RTG-2) are commonly used for evaluation of clinical materials for detection of IPNV in salmonid fishes. Confirmatory identification of IPNV can be accomplished using immunologic-based or molecular-based assay formats.

3.3.1.3 Control

Most IPN epizootics have been linked to the importation of infected eggs or fry. Selection of pathogen free eggs and broodstock is important. IPNV is tolerant to low pH but not alkaline conditions (pH 12). It takes hours to inactivate IPNV using heat, unless the temperature is well above 70°C. Although iodophors are relatively effective against IPNV *in vitro*, it is insufficient for use as a disinfection procedure for IPNV contaminated eggs. Chemotherapy is not available. Promising vaccines have been tested in field trials, and mixed vaccine against five pathogens including recombinant IPNV protein is commercially available in Norway.

3.3.2. Infectious Hematopoietic Necrosis

Infectious hematopoietic necrosis (IHN) is an acute, systemic, and usually virulent rhabdoviral disease that occurs in the wild, but is more typically seen in epizootic proportion among young trout and certain Pacific salmon under husbandry in coastal North America from California to Alaska, Europe, and the Far East. The disease most affects rainbow/ steelhead trout, cutthroat trout (*Salmo clarki*), brown trout, Atlantic salmon, and Pacific salmon including Chinook, sockeye/ kokanee, chum, masu/ yamame and amago salmon (*O. rhodurus*). Under experimental conditions, infections have been reported in non-salmonids like pike fry, sea bream and turbot.

3.3.2.1 Disease Agent:

IHNV is the type species of the genus *Novirhabdovirus* within the viral family designated *Rhabdoviridae* by the ICTV (King et al, 2012). IHNV virion is bullet-shaped and measures 170×70 nm. Its viral genome consists of complementary, single-stranded RNA. IHNV isolates are not classified serologically but can be grouped into three genetic types by sequence analysis of viral glycoprotein gene.

3.3.2.2 Diagnostic Methods

Moribund fish are lethargic, swim high in the water column, and are anorexic. They exhibit exophthalmia, darkening of body color, abdominal distension, pale gills, and hemorrhages at the bases of fins. Fecal casts trailing from the vent have been reported but are not always observed. Necrosis of splenic hematopoietic tissue and of the endocrine and exocrine tissue of the pancreas is diffuse, but the liver can have areas of focal necrosis. Virological examination coupled with serological or molecular identification is required for confirmation of clinical or subclinical infection with IHNV. Cell cultures of BF-2, CHSE-214, RTG-2 or Epithelioma papulosum cyprini (EPC) are commonly used for evaluation of clinical materials for detection of IHNV in salmonid fishes. Confirmatory identification is same as IPNV.

3.3.2.3 Control

Most IHN epizootics have been linked to the importation of infected eggs or fry. Eggs should be disinfected with an iodophor solution, and virus-free water should be used to incubate eggs and raise fry (see *Prevention and Treatment of Diseases Caused by Fish Pathogens*). IHNV is readily inactivated by most common disinfectants. In addition, this virus can be inactivated by drying, or by heating to 60°C for 15 minutes. Chemotherapy is not available. Promising vaccines have been tested in field trials, and DNA vaccines are commercially available in Canada.

3.3.3. Viral Hemorrhagic Septicemia

Viral hemorrhagic septicemia (VHS) is an important source of mortality for cultured and wild fish in freshwater and marine environments in several regions of the northern hemisphere. Over 60 species of freshwater and marine fish are currently known to be natural hosts of VHSV but rainbow trout are especially susceptible.

3.3.3.1 Disease Agent

VHSV is classified to the genus *Novirhabdovirus* within the viral family designated *Rhabdoviridae* by the ICTV (King et al, 2012). VHSV virion is bullet-shaped and measures 180-200×75 nm. The viral genome is complementary, single-stranded RNA. VHSV was classified into three serogroups, however there was considerable overlap of strains within and between these serotypes. VHSV can be grouped into four genetic types by sequence analysis. These genotypes show a geographic basis for their distribution rather than host specificity.

3.3.3.2 Diagnostic Methods

External clinical signs of disease can include exophthalmia, abdominal distention, darkened coloration, anemia, lethargy, hyperactivity, and hemorrhages in the eyes, skin, gills, and at the base of fins. Internally, visceral mesenteries can show diffuse hemorrhage, the kidneys and liver can be hyperemic, swollen, and discolored, and hemorrhages can occur in skeletal muscle. In the liver, kidney and spleen, focal to extensive necrotic changes can occur. Virological examination is same as IHNV. Confirmatory identification is same as IPNV.

3.3.3.3 Control

Same as IHNV. Promising vaccines have been tested in field trials, but no vaccines are commercially available.

3.3.4. Oncorhynchus Masou Virus Disease

Oncorhynchus masou virus disease (OMVD) is an economically significant disease of farmed salmonid fish in Japan. This infection also occurs in wild fish. The disease most characteristically occurs in kokanee, coho, masu salmon and rainbow trout. Surviving salmon often develop cutaneous tumors, particularly around the mouth.

3.3.4.1 Disease Agent

OMV is taxonomically known as *Salmonid herpesvirus 2*; SalHV-2. This virus is classified to the genus *salmonivirus* within the viral family designated *Alloherpesviridae* by the ICTV (King et al, 2012). Diameter of the OMV virion is 200-240 nm and the diameter of the icosahedral nucleocapsid formed with 162 capsomeres is 115 nm. The viral genome is double stranded DNA. OMV isolates are not classified serologically.

3.3.4.2 Diagnostic Methods

External clinical signs in infected fish include appetent exophthalmia, and petechiae on the body surface, especially beneath the lower jaw. Agonal or abnormal swimming behavior has not been observed. Internally, the liver shows white spot lesions, and in advanced cases the whole liver becomes pearly white. In some cases the spleen is found to be swollen. Necrosis of epithelial cells and kidney were observed in the young one-month old moribund specimens while partial necrosis of the liver, spleen and pancreas was seen in older moribund specimens. Virological examination coupled with serological or molecular identification is required for confirmation of clinical or subclinical infection with OMV. Cell cultures of CHSE-214 or RTG-2 are commonly used for evaluation of clinical materials for detection of OMV in salmonid fishes. Confirmatory identification is same as IPNV.

3.3.4.3 Control

Same as IHNV. Chemotherapy using anti-herpesvirus agents is effective but commercially unavailable for fish. Promising vaccines have been tested in field trials, but no vaccines are commercially available.

3.3.5. Infectious Salmon Anemia

Infectious salmon anemia (ISA) is one of the most important viral diseases of farmed Atlantic salmon. Sea-run brown trout, rainbow trout, and Atlantic herring (*Clupea harengus*) are potential asymptomatic carriers of the virus. Infectious salmon anemia has been found in Norway, the Faroe Islands, and the United Kingdom (Scotland and Shetland Islands). Infectious salmon anemia outbreaks occur periodically in Norway and Chile, as well as in a limited region of North America shared by the U.S. and Canada.

3.3.5.1 Disease Agent

ISAV is classified as the type species of the genus *Isavirus* within the viral family designated *Orthomyxoviridae* by the ICTV (King et al, 2012). ISAV is a pleomorphic enveloped virus, 100-130 nm in diameter, with 10-12 nm surface projections. The viral genome consists of eight single-stranded RNA segments of negative polarity. ISAV has been divided into two major clusters or genotypes, called the North American and the European, and the third genotype may exist.

3.3.5.2 Diagnostic Methods

ISA should be a consideration in Atlantic salmon with increased mortality and signs of anemia, or lesions consistent with this disease. It should always be investigated if the hematocrit is less than 10%. External clinical signs in infected fish are pale gills and muscle, petechial hemorrhage, dark liver and spleen, ascites are all present. The presence of renal interstitial hemorrhaging, and tubular epithelial degeneration, necrosis, and casting within the posterior kidney have all been noted. Liver sections show multifocal to confluent hemorrhagic hepatic necrosis, focal congestion, and dilatation of hepatic sinusoids.

3.3.5.3 Control

Same as IHNV. Mixed vaccines are commercially available in Norway.

6) Other diseases

Erythrocytic inclusion body syndrome (EIBS), pancreas disease (PD), sleeping disease (SD), viral wiring disease (VWD) and viral erythrocytic necrosis (VEN) are reported. In case of EIBS, erythrocytic inclusions and typical virus particles have been detected in spawned adult salmon, but in fresh water the disease seems to be limited to juvenile and smolting fish. In salt water, EIBS has been diagnosed in fish as large as 500 g and has caused problems in netpen culture. Naturally occurring infections have been demonstrated in coho, Chinook and Atlantic salmon. The agent that causes EIBS has neither been isolated nor fully characterized. PD and SD are infectious diseases of farmed Atlantic salmon and rainbow trout, respectively. Salmonid alphaviruses are recognized as pathogen. The main pathological lesions are similar in PD and SD, with extensive loss of pancreatic acinar cells during the viraemic phase, concurrent cardiomyocytic degeneration and inflammation and subsequent skeletal muscle degeneration and fibrosis. VWD was first recognized in coho salmon in Japan (Oh et al, 1995). VEN is a condition characterized by the presence of viroplasmic inclusion bodies within the cytoplasm of affected erythrocytes. The causative agent is tentatively placed in the *Iridoviridae*.

4. Shrimp Diseases

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4.1. Synopsis

Penaeid shrimp culture is an important industry in Asia and Americas. The total annual production in 2010 reached over 3.7 million tons in the world (FAO, 2012). However,