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Aquatic species susceptible to diseases listed in Directive 2006/88/EC [1]

Scientific Opinion of the Panel on Animal Health and Welfare (AHAW)

(Question No EFSA-Q-2008-074)

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SUMMARY

Following a request from the European Commission, the Panel on Animal Health and Welfare was asked to deliver a scientific opinion on aquatic animal species susceptible to the diseases listed in the Council Directive 2006/88/EC. More specifically, the question was to establish which species other than those listed in Part II of Annex IV to Directive 2006/88/EC that could be considered as susceptible; and which of the species currently listed as susceptible in Part II of Annex IV to Directive 2006/88/EC that cannot be considered as susceptible. This was achieved through comprehensive literature review with considerations for: i) reflection of natural pathways provided by the experimental design of reported studies, ii) compliance with four objective criteria pertaining to susceptibility to infection, and iii) thorough identification of the causative agent. The four criteria used to assess susceptibility of host species were: evidence of replication or growth of the organism (A), presence of a viable organism (B), presence of specific clinicopathological changes (C), and specific location of the pathogen (D). This led to identification of two main groups: Group I, host species for which the quality of the data provided clear support for susceptibility, and Group II, host species for which incomplete or unclear data prevented a clear conclusion or the only available data was obtained from invasive experiments. Group I (susceptible species) contains i) traded and non-traded species, ii) species belonging to several genera, and iii) many were susceptible to several of the specified pathogens, so may represent different levels of risk. Within Group I, species were identified that currently are not listed in Directive 2006/88/EC and those species are recommended to be considered for possible inclusion. Partial evidence suggesting susceptibility was obtained for a large number of host species (Group II). Several host species, including some currently listed in Directive 2006/88/EC, were identified as potentially non-susceptible but it was not possible to confirm this status firmly due to the quality of the data. Further scientific studies are required to resolve the uncertainty concerning the susceptibility of the host species identified in this group. Such studies should apply clear criteria, such as those used in this opinion, to assess susceptibility of host species and clear identification of the pathogen and affected host(s). In addition, the opinion noted that the lack of clear case definition for some of the specified pathogens compromised assessment of the susceptibility of some host species. Finally, the application of the taxonomic relatedness of host species and the broad taxonomic spread of affected hosts as guiding principles to susceptibility of host species needs to be assessed to determine their robustness and to clarify how they can be applied. This approach could be useful for the numerous species for which data is lacking and also avoid unnecessary experimental studies in the target hosts. This Scientific Opinion should be updated and reviewed regularly.

Key words: Aquatic Diseases, Listed Diseases, Susceptible Species, Infection, Fish, Molluscs, Crustaceans, EUS, EHN, VHS, ISA, IHN, KHV, *Bonamia*, *Mikrocytos*, *Marteilia*, *Perkinsus*, TSV, YHV,WSSV.

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BACKGROUND AS PROVIDED BY THE EUROPEAN COMMISSION

The Council of the European Union adopted on 24 October 2006 a new Directive on animal health requirements for aquaculture animals and products thereof, and on the prevention and control of certain diseases in aquatic animals (2006/88/EC). The Directive lists in Part II of Annex IV certain diseases and the list of susceptible species to those diseases.

The Commission requested EFSA to issue a scientific opinion on vector species and live stages of susceptible species not transmitting disease as regards certain aquatic animal diseases[2]. The scientific opinion identified a relevant issue not strictly included in the terms of reference: new scientific evidence may suggest the existence of species not listed in Annex IV to Directive 2006/88/EC that could be considered as susceptible to the diseases listed in the same Annex. Furthermore, the scientific opinion includes a list of non-listed species that could be considered as susceptible.

If these possibly susceptible species become infected with a listed pathogen, there would be a risk of transmission of a disease agent. This circumstance may affect disease control measures.

Directive 2006/88/EC defines susceptible species as "any species in which infection by a disease agent has been demonstrated by natural cases or by experimental infection that mimics the natural pathways". However, several problems with the practical applicability of this latter definition have been raised. These problems are:

- When classifying one species as susceptible, there are difficulties to scientifically demonstrate whether an experimental infection under certain conditions mimics the natural pathways or not;
- In certain circumstances, it is difficult to assess whether an infection by a disease agent is actually an infection or whether it is only a contamination.

These problems as regards the definition of susceptible species may hamper the listing of one species as susceptible.

Therefore, it is necessary to define a set of scientific criteria for the assessment of host species susceptibility. The set of criteria should take into account the specificity of natural pathways or experimental pathways that mimic the natural ones for infection of fish, molluscs and crustaceans and the different types of pathogens (virus, bacteria, fungus or parasites) and the different types of host (fish, crustaceans and molluscs).

The set of criteria should be applied to the species currently listed in Annex IV to Directive 2006/88/EC and to other possible susceptible species in order to determine which species could be considered as susceptible to the listed diseases.

In applying the set of criteria, special emphasis should be put on those species farmed or imported in the EU.

TERMS OF REFERENCE AS PROVIDED BY THE EUROPEAN COMMISSION

In view of the above, and in accordance with Article 29 of Regulation (EC) 178/2002, the Commission asks EFSA, in the light of the new scientific evidence, to give scientific advice on:

[2] Possible vector species and live stages of susceptible species not transmitting disease as regards certain fish diseases: http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178661772108.htm
Possible vector species and live stages of susceptible species not transmitting disease as regards certain mollusc diseases: http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178675503540.htm
Possible vector species and live stages of susceptible species not transmitting disease as regards certain crustacean diseases:http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1178672822550.htm

- which species other than those listed as susceptible species in Part II of Annex IV to Directive 2006/88/EC could be considered as susceptible, with special focus on those species farmed in and/or imported into the EU;

- which of the species presently listed as susceptible species in Part II of Annex IV to Directive 2006/88/EC cannot be considered as susceptible.

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ASSESSMENT

1. Scope and objectives

The diseases of aquatic animals as listed in the Annex IV to Council Directive 2006/88/EC and amended by Commission Directive 2008/53/EC are the scope of this report.

The objectives of this report were to: i) identify host species that are currently listed although there is no scientific evidence to support their susceptibility to listed pathogens, and ii) identify host species that are not currently listed while scientific evidence exists that demonstrate they are susceptible to infection with listed pathogens.

This was achieved through comprehensive literature search and paper review in light of objective criteria for host susceptibility.

Despite known and foreseen areas of uncertainty in the available and accessible scientific information, it was agreed between the European Commission and the AHAW panel not to proceed with risk assessment at this stage.

In absence of a list of fish and shellfish species that are farmed in Europe or imported to Europe, qualification of host species in terms of trade and farming is considered to be part of risk management. It was therefore agreed not to give consideration to farming and trading of host species. This report provides an assessment of susceptibility for all host species for which information was available and accessible in the scientific literature.

2. Methodological approach

2.1. Definitions and conceptual framework

A susceptible species is defined by Council Directive 2006/88/EC as any species in which infection by a disease agent has been demonstrated by natural cases or by experimental infection that mimics the natural pathways. According to this definition, a susceptible species is primarily susceptible to infection. This is the working definition for this report. A susceptible species is a species that can support replication of an agent or an infestation, which may lead to the development of disease.

Definitions are inherently subjected to interpretation; in order to avoid any subsequent difficulty arising from possible misinterpretation of working definitions, the scientific information was assessed with considerations for: i) reflection of natural pathways provided by the experimental design of reported studies, ii) compliance with four objective criteria pertaining to susceptibility to infection, and iii) thorough identification of the causative agent.

2.2. Natural pathways of infection

The natural pathways, i.e. the transmission of the disease agent to a susceptible aquatic species in their environment, are largely unknown for most of the listed diseases. However, biology of the host species may provide valuable indications on possible routes of transmission. Specific characteristics and traits, such as frequent aggression and fights, cannibalism, etc., provide insights in interpretation of experimental data based on exposure to the agent through various routes of transmission. /modes of transmission. Such considerations are summarised in Table 1 Injection and/or abrasion may be seen as acceptable natural modes of transmission for crustaceans as well as certain species of fish or for certain diseases of fish (e.g. EUS).

Experimental data could generally be treated in two ways for interpretation based on the level of invasiveness of the experimental protocols that were applied during the reported study. Experimental data were consequently classified as "invasive" or "non invasive". Natural cases constitute a third category of data. Cohabitation, bath, and oral dosing (see Table 1) are three modes of exposure that were accepted as a basis for non-invasive experimental data; that perhaps mimics natural pathways most closely.

The pathogen itself also must be considered. For example, in the case of *Aphanomyces invadans*, skin lesions (mechanical lesion or intercurrent infection) are necessary to complete experimental transmission. In fact, such lesions do occur naturally and are commonly accepted as part of the natural pathway that would be rather "invasive" by itself. Bearing this in mind, invasive experimental challenge was accepted as a valid route mimicking natural infection for *A. invadans*.

This shows the inherent difficulty to interprete the concept of natural pathway in light of experimental data. Susceptible species largely are from areas in which the pathological agent is endemic or to which it has been introduced. In some cases however, experimental work has been undertaken to test the susceptibility of animals native to a region not previously exposed to a particular disease agent. Injection is an invasive treatment that nevertheless demonstrates the potential susceptibility of a species. Experimental data based on injection should not be ignored; they represent a separate category of data.

Table 1: Experimental infection and natural pathways of infection in aquatic animals

Mode of experimental transmission	Accepted as "mimicking natural pathways"			Rationale
	Finfish	Molluscs	Crustaceans	
Cohabitation	yes	yes	yes	Cohabitation is very close to natural routes of transmission. It may or may not include direct contact with fish that are the source for the pathogen. It always includes water exposure.
Bath	yes	yes	yes	Although this mode may artificially increase the infectious load, it respects natural primary line of defences and immune response.
Oral dosing	yes	no	yes	Cannibalism may be a natural route of transmission, particularly for shrimp as well as for some fish species.
Injection	generally no	no	yes	Shrimp often use their rostrum to attack other individuals; wounds are very common, especially in recently molted animals and loss of legs or parts of legs is very common. Skin lesions participate in the natural pathway of *Aphanomyces invadans*.

2.3. Criteria for host species susceptibility

Four criteria were used to assess susceptibility of host species: evidence of replication or growth of the organism (A), presence of a viable organism (B), presence of specific clinicopathological changes (C), and specific location of the pathogen (D). Importantly these criteria enable discrimination of actual infection from mechanical carriage.

Type of scientific data supporting criteria A – D varies according to the pathogen under consideration and some examples ot these are illustrated in Table 2 for the specific diseases under the scope of this report. Scientific literature was screened for these data.

For example, evidence of replication can be provided by different sets of scientific data. For viruses, the presence of intracellular proteins, RNA [for DNA viruses], non-structural proteins, viral inclusion bodies and TEM demonstrating virions would constitute evidence for replication. For parasites, the presence of different developmental stages as shown in histopathology would support parasite multiplication.

The presence of a viable organism may be inferred from culture of the pathogen on artificial media or cell lines. Similarly successful transmission to specific pathogen free (SPF) susceptible host brings evidence of pathogen viability.

Detection of characteristic clinicopathologic changes associated with a specific infection is an important consideration in the assessment of host susceptibility. Presence of the pathogen itself is regarded as a primary deviation from normal situation.

The anatomic location of the pathogen is important also to exclude potential passive contamination of the host. This information can be obtained by techniquess such as histology, immuno-histochemistry, or in-situ hybridisation; target organ dissection and isolation followed by specific detection method (PCR, cell culture) is an alternative approach in certain instances.

A species would be regarded as infected and therefore susceptible by interpretation of combinations of A, B C, and D. These combinations would depend on the host species and pathogen. Criterion B alone would not be enough to identify a species as susceptible because it does not exclude mechanical contamination.

Table 2: Examples of data applied to the listed diseases to support criteria A - D

Disease[3]	A: replication	B: viability	C: pathology	D: location
EUS	Replication cannot be demonstrated for A. invadans following the definitions provided in section	Isolation by culture	Granulomatosis or necrosis of muscle tissue associated with invasive infection with fungal like structures	Muscle tissue
EHN	Sequential virus titration showing increase in viral titres TEM showing virions in host cells Products of virus replication detected	Isolation by cell culture Cohabitation with passage to a susceptible host	Tropism for vascular endothelium and haematopoietic necroses Perivascular mononuclear inflammatory response in liver	Gills, cardiovascular system, kidney, liver

[3] Epizootic Ulcerative Syndrome (EUS), Epizootic Haematopoietic Necrosis (EHN), Viral Haemorrhagic Septicaemia (VHS), Infectious Salmon Anaemia (ISA), Koi carp Herpes Virus Disease (KHVD), Infectious Hematopoietic Necrosis (IHN), Infection with *Bonamia ostreae* (IBO), Infection with *Bonamia exitiosa* (IBE), Infection with *Marteilia refringens* (IMR), Infection with *Perkinsus marinus* (IPM), Infection with *Mikrocytos mackini* (IMM), Taura Syndrome (TS), Yellow Head Disease (YHD), White Spot Disease (WSD).

	Serial passage from individual to individual			
VHS	Isolation by cell culture Virus titration showing a growth curve TEM showing virions in host cells Products of virus replication detected Serial passage from individual to individual	Isolation by cell culture Cohabitation with passage to a susceptible host	Lethargy or abnormal swimming, skin darkening, exophthalmia, anaemia, haemorrhages, peritoneal oedema. Petechial haemorrhages. necrotic kidney, moderately swollen spleen, pale liver. Gastro-intestinal tract is empty Primarily endothelial cells in the vascular system are affected. The kidney, liver and spleen show extensive focal necrosis and degeneration. Haemorrhages in skeletal muscle bundles and fibres.	Recover virus from internal organ PCR from internal organ
ISA	Virus titration showing a growth curve TEM showing virions in host cells Products of virus replication detected Serial passage from individual to individual	Isolation by cell culture Cohabitation with passage to a susceptible host	Pale gills, exophthalmia, distended abdomen, and petechia in the eye chamber, possibly with abdominal skin haemorrhages and scale oedema. Internally, darkening of the liver, swollen kidney and haemorrhages within the intestinal wall. Associated mortality. Haemorrhagic liver necrosis, renal interstitial haemorrhage and tubular necrosis. Haematocrit <10 in end stages may be observed	Samples for virus isolation from Internal organs
KHVD	Serial passage from individual to individual TEM observation virions in target cells Intranuclear inclusion bodies (histo)	Isolation by cell culture Cohabitation with passage to a susceptible host	White patches on gill and enophthalmia Necrosis of gill epithelium Intranuclear inclusion bodies Enopthalmia	During course of infection the virus is most abundant in gill, spleen, and kidney
IHN	Virus titration showing a growth curve TEM IFAT Serial passage from	Isolation by cell culture Cohabitation with passage to a susceptible host	Lethargy interspersed with bouts of frenzied, abnormal activity, darkening of the skin, pale gills, ascites, distended abdomen, exophthalmia, and petechial haemorrhages	Samples for virus isolation from Internal organs PCR from internal organ

	individual to individual Products of virus replication detected		internally and externally. Internally, fish appear anaemic and lack food in the gut. Liver, kidney and spleen are pale. Degenerative necrosis in haematopoietic tissues, and digestive tract. Reduced haematocrit, leukopenia, degeneration of leukocytes and thrombocytes.	
IBO	Binucleated plasmodia in TEM or impression smears	Purification and cell viability test Cohabitation with passage to a SPF susceptible host	Focal to disseminated haemocytic infiltration of the connective tissues, Intracellular parasite present in haemocytes	Systemic
IBE	Binucleated plasmodia in TEM or impression smears	Cohabitation with passage to a SPF susceptible host	Focal to disseminated haemocytic infiltration of the connective tissues, Intracellular parasite present in haemocytes	Systemic
IMR	Presence of different stages of the parasite that include tertiary cells	Purification and cell viability test Spore viability in faeces Experimental transmission to intermediate host	Possible haemocytic infiltration, intercellular parasite observed in epithelia of target organs	Gills, palps and digestive tract
IPM	Presence of different stages of the parasite	Isolation on Ray Fluid Thioglycolate Medium Cohabitation with passage to SPF susceptible species	Disseminated haemocytic infiltration, intra or intercellular parasite	All connective tissues and digestive epithelia
IMM	Presence of different stages of the parasite in TEM	Cohabitation with passage to SPF susceptible species Parasite purification and viability assessment	Focal haemocytic infiltration, possible necrosis, intracellular parasite in connective tissue cells, haemocytes and firoblasts, digestive gland epithelial cells	Connective tissues of all organs, adductor muscle, digestive gland epithelium
TS	Presence of characteristic inclusion bodies and positive labelling of inclusion bodies by ISH or IFAT Serial passage from individual to SPF individual	Passage bioassay to a SPF susceptible host	Characteristic inclusion bodies, with pycknosis and karyorrhectic nuclei in target tissues and no haemocytic infiltration	Cells of tissues of ectodermic and endodermic origin
YHD	Presence of characteristic inclusion bodies and positive labelling of inclusion bodies by ISH or IFAT Presence of virions in inclusions bodies by TEM	Passage bioassay to a SPF susceptible host	Characteristic inclusion bodies, with pycknosis and karyorrhectic nuclei in target tissues and no haemocytic infiltration	Haemocytes, heart , lymphoid organ and sinuses, connective tissue

	Serial passage from individual to SPF individual			
WSD	Presence of characteristic intranuclear inclusion bodies Presence of virions in inclusions bodies by TEM Positive labelling of inclusion bodies by ISH or IFAT Serial passage from individual to SPF individual	Passage bioassay to a SPF susceptible host	Eosinophilic inclusions within nuclei of target organs and tissues	Cells of tissues of ectodermic and endodermic origin

2.4. Disease case definition and pathogen identification

For the purpose of this report, it was agreed that default case definitions for diseases under consideration and description of their causative agents are those provided by the OIE Aquatic Manual (2006). Table 3 summarises this information.

Table 3: Definition of the causative agents for diseases listed in CD 2006/88/EC

Disease4	Causative agent	Comment
EUS	Aphanomyces invadans (syn. A. piscicida)	*Aphanomyces invadans* (*A. piscida*) is recognized to be the primary cause for EUS (Baldock et al., 2005); a single clone of *A. invadans* is broadly distributed (Lilley et al., 1997). Aphanomyces invadans is an oomycete. Although long regarded to be fungi because of their characteristic filamentous growth, the Oomycetida are not a member of the Eumycota but are classified with diatoms and brown algae in a group called the Stramenopiles or Chromista. Identification of the pathogen is either based on morphology of the pathogen in pure culture down to genus level, with good evidence that the isolate might be *A. Invadans*, on the results of a specific PCR, or on isolation followed by successful challenge of susceptible species (experimental invasive).
EHN	EHN virus (EHNV)	EHNV is a member of the genus Ranavirus (Iridoviridae) with the European catfish virus (ECV), and European sheatfish virus (ESV). ECV and ESV are isolates of the same virus. EHNV and ECV are distinct viruses that can be differentiated by analysis of major capsid protein gene sequences.
VHS	VHS virus (VHSV) synonym: Egtved virus	VHSV is a rhabdovirus, genus Novirhabdovirus. Neutralisation by polyclonal and monoclonal antibodies suggests a single serotype consisting of three subtypes of VHSV; nucleic acid sequence analysis suggests four major genotypes. Isolates of VHSV have genetic differences that appear to be most strongly related to geographical location and not to year of isolation or to host species. Data from natural outbreaks of disease and also experimental infections have demonstrated variations in the virulence and host preference of VHSV strains.

[4] Epizootic Ulcerative Syndrome (EUS), Epizootic Haematopoietic Necrosis (EHN), Viral Haemorrhagic Septicaemia (VHS), Infectious Salmon Anaemia (ISA), Koi carp Herpes Virus Disease (KHVD), Infectious Hematopoietic Necrosis (IHN), Infection with *Bonamia ostreae* (IBO), Infection with *Bonamia exitiosa* (IBE), Infection with *Marteilia refringens* (IMR), Infection with *Perkinsus marinus* (IPM), Infection with *Mikrocytos mackini* (IMM), Taura Syndrome (TS), Yellow Head Disease (YHD), White Spot Disease (WSD).

ISA	ISA virus (ISAV)	ISAV is an orthomyxovirus. Sequence analysis of various gene segments has revealed differences between isolates both within and between defined geographical areas. Presence of two major groups of ISAV isolates, one European and one North American group. The European group may further be divided into three major groups.
KHVD	KHV (Syn. carp interstitial nephritis and gill necrosis virus (CNGV), cyprinid herpesvirus 3 (CyHV-3))	KHV is a member of the family Herpesviridae. Other cyprinid herpesviruses exist: CyHV-1 (carp pox virus, fish papilloma) and CyHV-2 (goldfish haematopoietic necrosis virus). Sequence analysis of genes coding for 4 major proteins have shown that KHV is closely related to CyHV-1 and CyHV-2, and distantly related to channel catfish virus virus (Ictalurid herpesvirus: IcHV-1). Comparisons of the genomes of KHV isolates from different geographical areas have shown them to be highly similar.
IHN	IHN virus (IHNV)	IHNV is a rhabdovirus, genus Novirhabdovirus. The type strain of IHNV is the Western Regional Aquaculture Center (WRAC) strain available from the American Type Culture Collection (ATCC VR-1392). The GenBank accession number of the entire genomic sequence of the WRAC strain is L40883. Isolates of IHNV have genetic differences that appear to be most strongly related to geographical location and not to year of isolation or to host species. Data from natural outbreaks of disease and also experimental infections have demonstrated variations in the virulence and host preference of IHNV strains
IBO	*Bonamia ostreae*	*Bonamia ostreae*, no strain identified
IBE	*Bonamia exitiosa*	*Bonamia exitiosa*, no strains identified
IMR	*Marteilia refringens*	*Marteilia refringens*; includes *M. maurini*
IPM	*Perkinsus marinus*	*Perkinsus marinus*, all strains
IMM	*Mikrocytos mackini*	*Mikrocytos mackini*, no strains identified
TS	TS Virus (TSV)	TSV is an unassigned species in the Family Dicistroviridae. At least three geographic genotypic groups have been identified based on the sequence of a structural protein gene sequence.
YHD	YH Virus (YHV)	YHV (genotype 1) is one of six known genotypes in the YH complex of viruses and is the agent most commonly associated with yellowhead disease outbreaks in farming situations. Gill-associated virus (GAV) is generally considered less pathogenic to penaeids than YHV though testing on non-penaeids has not been reported. GAV is designated as genotype 2 within the complex. Four other known genotypes in the complex (genotypes 3-6) occur commonly in healthy Penaeus monodon in East Africa, Asia and Australia and are rarely or never associated with disease in this species though their virulence has not been routinely tested in non-penaeids. YHV and other genotypes in the yellowhead complex are classified as a single species in the genus Okavirus.
WSD	WSD Virus (WSDV)	viral species White spot syndrome virus 1, as defined in Vlak et al. 2004

2.5. Review of the scientific literature

The scientific literature was searched and screened with priority given to peer-reviewed articles published in English. Publications in other languages (German, French, Spanish, Italian, and Japanese, essentially) were also consulted; however no formal translation was performed. Where non peer reviewed literature (reports, official data, web-information) or personal

communication were used, the information was thoroughly reviewed and weighted by the working group experts.

The bibliography included in this report is not exhaustive. The scientific literature was searched and reviewed to obtain the necessary data. Subsequently only subsets were used to assess the susceptibility of a species to a given pathogen.

Host species are given by Latin binomial denomination. This does not reflect any particular position of the working group with regards to taxonomy of hosts. It was noted that host species taxonomy was not always well established. With time, synonymy is recognised for taxonomic groups that had initially been affiliated to different species within a single genus or even throughout different genera. This may obviously hamper data tracking and database accuracy.

3. Listed diseases and their susceptible species

The information and scientific data were scrutinised for relevance with: i) natural pathways or experimental design reflecting the natural pathways of infection, ii) support to criteria A – D, and iii) identification and characterisation of the pathogen.

The tables included in the annexe of this report present the detailed results of the literature review and assessment against the criteria mentioned above (See Table 8 to 21 in annex). These assessments are summarised in Tables 4 and 5.

3.1. Epizootic Ulcerative Syndrome

The following genera*: Catla, Channa, Labeo, Mastacembelus, Mugil, Puntius* and *Trichogaster* are listed for their susceptibility to *Aphanomyces invadans* in the Directive 2006/88/EC. Over 200 potential host species belonging to more than 120 genera were identified. Some of the records have identified the host species to the genus level only. The relevant scientific literature was reviewed. Detail review of scientific literature is presented in Table 8. Scientific data are available to support susceptibility of 32 species belonging to 29 genera. There are scientific data suggesting susceptibility of another 190 species approximately, with however uncertainty on pathogen identification and or insufficient information to thouroghly assess susceptibility with regards to criteria A to D. Information obtained by experimental invasive modes was considered to be acceptable for EUS (see section 2.2).

3.2. Epizootic Hematopoietic Necrosis

Rainbow trout (*Oncorhynchus mykiss*) and redfin perch (*Perca fluviatilis*) are listed as species susceptible to EHN virus in the Directive 2006/88/EC. A total of 19 potential host species were initially identified and relevant scientific literature was reviewed. Detail review of scientific literature is presented in Table 9. Scientific data are available to support susceptibility of 7 species (*Perca fluviatilis, Oncorhynchus mykiss, Gambusia affinis, Galaxias olidus, Maqauria australasica, Bidyanus bidyanus, Esox lucius*). There are scientific data suggesting susceptibility of *Carassius auratus* with however uncertainty on pathogen identification. Information on *Retropinna semoni, Carassius auratus, Macullochella peeli, Maquaria novemaculeata, M. ambigua, Lates calcarifer, Capoeta tetragona, Paratya australiensis, Daphnia carinata, Cherax destructor* was considered insufficient to scientifically assess susceptibility with regards to criteria A to D. Scientific data suggesting susceptibility of *Salmo salar* are essentially experimental and invasive.

3.3. Viral Haemorrhagic Septicaemia

Herring (*Clupea* spp.), whitefish (*Coregonus* sp.), pike (*Esox lucius*), haddock (*Gadus aeglefinus*), Pacific cod (*G. macrocephalus*), Atlantic cod (*G. morhua*), Pacific salmon (*Oncorhynchus* spp.), rainbow trout (*O. mykiss*), rockling (*Enchelyopus cimbrius* [=*Onos mustelus*]), brown trout (*Salmo trutta*), turbot (*Psetta maxima* [*Scophthalmus maximus*]), sprat (*Sprattus sprattus*) and grayling (*Thymallus thymallus*) are listed as species susceptible to VHS virus in the Directive 2006/88/EC. Over 100 potential host species were initially identified and relevant scientific literature was reviewed. Detail review of scientific literature is presented in Table 10. Scientific data are available to support susceptibility of 44 species. Also, hybrids of *O. mykiss* x *O. kisutch, O. mykiss* x *S. fontinalis* triploid, and *O. mykiss* x *S. alpinus* triploid demonstrate susceptibility. For many of the species identified information was considered insufficient to scientifically assess susceptibility with regards to criteria A to D. There are scientific data suggesting susceptibility of *Oncorhynchus keta, Coregonus clupeaformis, Dorosoma cepedianum, Microgadus proximus, Lota lota, Parophrys vetula, Ictalurus nebulosus, I. punctatus, Oncorhynchus nerka, Micropterus salmoides, M. dolomieu, Lepomis macrochirus, Pomoxis nigromaculatus, L. gibbosus, Perca flavescens, Sander vitreus, Morone chrysops, Morone americana, Aulorhychus flavidus, Moxostoma anisurum, Moxostoma macrolepidotum, Pimephales notatus, Notropis atherinoides, N.s hudsonius, Percopsis omiscomaycus, Carassius auratus and Salvelinus fontinalis* with however uncertainty on pathogen identification as well as insufficient data regarding criteria A-D. In addition, scientific data suggest susceptibility of *Seriola quinqueradiata, Oncorhynchus aguabonita, Acanthopagrus schlegeli, Epinephelus akaara, Sebastes schlegeli and Pagrus major.*

3.4. Infectious Salmon Anaemia

Rainbow trout (*Oncorhynchus mykiss*), Atlantic salmon (*Salmo salar*), and brown and sea trout (*S. trutta*) are listed as species susceptible to ISA virus in the Directive 2006/88/EC. Twelve potential host species were identified. Detailed review of scientific literature is presented in Table 11. Scientific data are available to support susceptibility of *Salmo salar, S. trutta, Oncorhynchus kitsutch, O. mykiss, Clupea harengus*. There are scientific data suggesting susceptibility of *Alosa pseudoharengus, Salvelinus alpinus, Pollachius virens* with however uncertainty on pathogen identification. Information on *Anguilla anguilla, Gadus morrhua, Alosa pseudoharengus, Salvelinus alpinus, Oncorhynchus keta, Pollachius virens* was considered insufficient to scientifically assess susceptibility with regards to criteria A to D. Scientific data suggesting susceptibility of *Salvelinus alpinus,* and *Oncorhynchus keta* are essentially experimental and invasive.

Work by Skår and Mortensen (2007) indicates that mussels, *Mytilus edulis*, are not likely to be a reservoir of ISAV. Following experimental accumulation of virus, PCR results indicated that viral RNA persisted for 96 hours. Homogenate of mussel tissue taken 24 hours after challenge only resulted in infection in one out of 25 salmon (following injection). Therefore, it was concluded that mussels are not relevant as a reservoir host or vector species for ISAV (EFSA, 2007a).

3.5. Infectious Hematopoietic Necrosis

Chum salmon (*Oncorhynchus keta*), coho salmon (*O. kisutch*), Masou salmon (*O. masou*), rainbow or steelhead trout (*O. mykiss*), sockeye salmon (*O. nerka*), pink salmon (O. *rhodurus*) Chinook salmon (*O.tshawytscha*), and Atlantic salmon (*Salmo salar*) are currently listed as species susceptible to IHN virus in the Directive 2006/88/EC. Twenty five potential host species were identified. Detail review of scientific literature is presented in Table 12. Scientific data are available to support susceptibility of *Oncorhynchus nerka* (including landlocked form),

O. mykiss, O. tshawytscha, O. kisutch, O. keta, O. rodurus, O. masou, O. masou (including landlocked form), *O. clarki, Salmo salar, S. namaycush, Salvelinus fontinalis, S. alpinus, S. leucomaenis, Clupea pallasii, Cymatogaster aggregata, Aulorhynchus flavidus, Plecoglossus altivelis, Gadus morhua, Acipenser transmontanus, Esox lucius*. There are scientific data suggesting susceptibility of *Anguilla anguilla* with however uncertainty on pathogen identification; in addition, information on this species was considered insufficient to scientifically assess susceptibility with regards to criteria A to D. Scientific data suggesting susceptibility of *Dicentrarchus labrax, Sparus aurata, Psetta maxima* are essentially experimental and invasive.

3.6. Koi Herpes Virus Disease

Common carp and koi carp (*Cyprinus carpio*) are currently listed as species susceptible to KHV in Annex IV to Directive 2006/88/EC. Review of literature with regards to criteria for susceptibility is presented in details in Table 13. Scientific data are available to support susceptibility of *Cyprinus carpio* to KHV. There are scientific data suggesting susceptibility of *Carassius auratus* and hybrids of *Cyprinus carpio* x *Carassius auratus*; however, available data do not provide full scientific support for susceptibility. In addition, KHV DNA has been detected by PCR in other cyprinid species such as grass carp and crucian carp; However, these data are unpublished, and were not available to the Working Group for thorough review and assessment.

3.7. Infection with *Bonamia ostreae*

Australian mud oyster (*Ostrea angasi*), Chilean flat oyster (*O. chilensis*), Olympia flat oyster (*O. conchaphila*), Asiatic oyster (*O. denselammellosa*), European flat oyster (*O. edulis*), and Argentinian oyster (*O. puelchana*) are currently listed as species susceptible to *Bonamia ostreae* in Annex IV to Directive 2006/88/EC. Eight potential host species were identified. Detail review of scientific literature is presented in Table 14. Scientific data are available to support susceptibility of *Ostrea edulis* and *Crassostrea ariakensis* to infection with *Bonamia ostreae*. There are scientific data suggesting susceptibility of *Ostrea angasi, Ostrea puelchana* and *Ostrea chilensis*; however, some uncertainty on parasite identification and taxonomic affiliation hampers full scientific support for susceptibility to *Bonamia ostreae*. Information on *Ostrea denselamellosa* and *Crassostrea angulata* was considered insufficient to scientifically assess susceptibility. In addition, available data do not support susceptibility of *Ostrea conchaphila*.

Lynch *et al.* (2007) have investigated the presence of *Bonamia ostreae* DNA using polymerase chain reaction (PCR) in benthic macro invertebrates and zooplankton. *Bonamia ostreae* was detected in eight benthic macroinvertebrates and nineteen grouped zooplankton samples. Among them, *Actina equine* (Anthozoa) and *Ascidiella aspersa* (Ascidiacea) were found attached to *Ostrea edulis* shells. No *in situ* hybridisations and histological examinations were performed in order to confirm and localise the parasite in the host tissues. However, transmission of *B. ostreae* was effective to two naïve oysters cohabiting with the brittle star, *Ophiothrix fragilis*. Those species of invertebrates and zooplankton do not qualify against the definition for vector as well as susceptible species as laid down by Directive 2006/88/EC. However, the EFSA scientific opinion on vector species has highlighted the potential for commercial bivalve species to act as collateral vectors because of fouling and aggregates on the shells (EFSA, 2007b).

The EFSA scientific opinion on vector species has identified a moderate likelihood for clams, cockles and scallops to be vectors for *Bonamia ostreae* (EFSA, 2007b). Recent data suggest that *B. ostreae* may be detected by PCR from various mollusc species (*Haliotis tuberculata*,

Crassostrea gigas, and *Pecten maximus*) which have previously been considered not to be susceptible (Culloty S., pers. com.).

3.8. Infection with *Bonamia exitiosa*

Australian mud oyster (*Ostrea angasi*) and Chilean flat oyster (*O. chilensis*) are listed as susceptible to *Bonamia exitiosa* in Annex IV to Directive 2006/88/EC. Seven potential host species were identified. Detail review of scientific literature is presented in Table 15. Scientific data are available to support susceptibility of *Ostrea chilensis, O. angasi, O. edulis, Saccostrea glomerata*. Despite scientific data suggesting susceptibility of *Ostrea conchaphila, O. puelchana,* and *Crassostrea ariakensis*, uncertainty on parasite identification and taxonomic affiliation hampers full scientific support.

The taxonomy of *B. exitiosa* is quite unsetteled. Sequences of SSU rDNA gene suggest that *B. exitiosa* and *Mikrocytos roughleyi* share a common ancestor following divergence of their lineage from that of *B. ostreae* – and possibly following divergence of the microcells into northern and southern hemispheric forms. The exact relationship with closely related isolates of *Bonamia* sp. from Chile and Argentina is still under investigation. Obviously, this has consequences on the potential range of susceptible species (see paragraph above).

Cupped oysters have previously been identified as potential vectors for *Bonamia exitiosa* with a moderate likelihood (EFSA, 2007b). It should be note that *Saccostrea glomerata* is considered as susceptible species in this report and *Crassostrea ariakensis* could also possibly be recognised as susceptible (Table 15). This would contradict previous conclusions from a previous EFSA opinion (EFSA 2007b) on the ground of Directive 2006/88/EC definitions.

3.9. Infection with *Perkinsus marinus*

Pacific oyster (*Crassostrea gigas*) and Eastern oyster (*C. virginica*) are listed as species susceptible to *Perkinsus marinus* in Annex IV to Directive 2006/88/EC. Seven potential host species were identified. Detailed review of scientific literature is presented in Table 16. Scientific data are available to support susceptibility of *Crassostrea virginica, C. gigas, C. ariakensis, C. corteziensis, Mya arenaria,* and *Macoma balthica*. There are scientific data suggesting susceptibility of *C. rhizophoreae* with however some uncertainty on parasite identification.

3.10. Infection with *Mikrocytos mackini*

Pacific oyster (*Crassostrea gigas*) and Eastern oyster (*C. virginica*), Olympia flat oyster (*Ostrea conchaphila*), and European flat oyster (*O. edulis*) are listed as species susceptible to *Mikrocytos mackini* in Directive 2006/88/EC. Five potential host species were identified. Detailed review of scientific literature is presented in Table 17. Scientific data are available to support susceptibility of *Crassostrea gigas, C. virginica,* and *Ostrea edulis*. There are scientific data suggesting susceptibility of *Ostrea conchaphila,* and *Crassostrea angulata* with existing uncertainty on parasite identification.

3.11. Infection with *Marteilia refringens*

Australian mud oyster (*Ostrea angasi*), Chilean flat oyster (*O. chilensis*), European flat oyster (*O. edulis*), Argentinian oyster (*O. puelchana*), blue and Mediterranean mussels (*Mytilus edulis, M. galloprovincialis*) are currently listed as species susceptible to *Marteilia refringens* in the Directive 2006/88/EC. Twenty potential host species were identified. Detailed review of scientific literature is presented in Table 18. Scientific data are available to support

susceptibility of *Ostrea edulis, Mytilus edulis, M. galloprovincialis, Solen marginatus, Chamelea gallina,* and *Acartia grani*. There are scientific data suggesting susceptibility of *Ostrea denselamellosa, O. angasi, O. puelchana, O. chilensis, Crassostrea gigas, C. virginica, Cardium edule, Ruditapes decussatus, R. philippinarum, Tapes rhomboides, T. pullastra, Ensis minor, Scrobicularia piperata, Saccostrea cucullata* with however uncertainty on parasite identification. Information on *Ostrea angasi, O. puelchana, O. denselamellosa,* and *Crassostrea gigas* was considered insufficient to scientifically assess susceptibility with regards to criteria A to D.

In a previous report, clams and cockles were identified as a group of mollusc species being potential vectors for *Marteilia refringens* with a moderate likelihood (EFSA, 2007b). Here, the assessment of scientific data available tends to show that indeed several species of molluscs (not only clams and cockles but also cupped oysters) would be susceptible to infection with *M. refringens*.

Technically, copepods do not qualify as vectors or even as susceptible species with regards to definitions of Directive 2006/88/EC given that they are not farmed nor traded. However, Audemard *et al*. (2002) has identified *Acartia grani* as an intermediate host in the life cycle of *Marteilia refringens* and intermediate hosts can propagate infection. More recently, new candidates were identified on the basis of PCR positive results: 3 Calanoida, *Acartia discaudata, A. clausi*, and *A. italica*; 1 Cyclopoida, *Oithona* sp.; 1 Harpacticoida, *Euterpina acutifrons* and zoea larval stages of Brachyuran decapods (Carrasco *et al*., 2007). In the case of *Acartia grani*, this species is recognised as susceptible species according the criteria in use for this report.

3.12. Taura Syndrome

Gulf white shrimp (*Penaeus setiferus*), Pacific blue shrimp (*P. stylirostris*), and Pacific white shrimp (*P. vannamei*) are currently listed as species susceptible to TS virus in the Directive 2006/88/EC. Ten potential host species were identified. Detail review of scientific literature is presented in Table 19. Scientific data are available to support susceptibility of *Penaeus vannamei, P. duorarum, P. monodon, P. setiferus, P. chinensis, P. stylirostris, P. aztecus,* and *Metapenaeus ensis*. There are scientific data suggesting susceptibility of *Penaeus schmitti* with however uncertainty on pathogen identification. Information on *Penaeus schmitti,* and *P. japonicus* was considered insufficient to scientifically assess susceptibility with regards to criteria A to D. Scientific data suggesting susceptibility of *Penaeus japonicus* are essentially experimental and invasive.

3.13. Yellow Head disease

Gulf brown shrimp (*Penaeus aztecus*), Gulf pink shrimp (*P. duorarum*), Kuruma prawn (*P. japonicus*), black tiger shrimp (*P. monodon*), Gulf white shrimp (*P. setiferus*), Pacific blue shrimp (*P. stylirostris*), and Pacific white shrimp (*P. vannamei*) are currently listed as species susceptible to YH virus in the Directive 2006/88/EC. Eighteen potential host species were identified. Detail review of scientific literature is presented in Table 20. Scientific data are available to support susceptibility of *Penaeus monodon, P. merguiensis, P. vannamei, P. setiferus, P. aztecus, P. duorarum, Metapenaeus brevicornis, M. affinis, Palaemon styliferus*. There are scientific data suggesting susceptibility of *Penaeus esculentus, P. japonicus, P. stylirostris, Metapenaeus ensis,* and *M. bennettae* with uncertainty on virus identification. Information on *Penaeus esculentus, Metapenaeus ensis, M. bennettae,* and *Macrobrachium lanchesteri* was considered insufficient to scientifically assess susceptibility with regards to criteria A to D. Scientific data suggesting susceptibility of *Macrobrachium lanchesteri, M. sintangense,* and *Palaemon serrifer* are essentially experimental and invasive.

3.14. White Spot Disease

Currently, all decapods are listed as susceptible to WSD virus in the Directive 2006/88/EC. A total of 98 potential host species or genera were identified from the scientific literature. Detailed review is presented in Table 21. Scientific data are available to support susceptibility of 67 species. However, for 20 species information was considered insufficient to scientifically assess susceptibility with regards to criteria A to D.

Numerous aquatic organisms, including rotifers (Yan *et al*., 2004), bivalves, polychaete worms (Vijayan *et al*., 2005) and non-decapodal crustaceans, such as *Artemia salina* and copepods were reported as potential mechanical vectors for WSSV, as well as aquatic arthropods, such as *Isopoda* and *Euphydradae* insect larvae (see Table 4 in EFSA, 2007b). In fact, any insect or living organism present in a WSSV infected pond may become a mechanical vector of the disease by surface or gut contamination with the viral particles. Most of these species are here regarded as potential susceptible species (Table 21).

4. Discussion

Data quality

This report represents the first time that an objective methodological approach has been used to assess susceptibility of host species. It has resulted in a strict review of the scientific literature, accessing and analysing the specific information supporting compliance with four objective criteria, thorough identification of the causative agent, and consideration of natural pathways for experimental studies. For each and every pathogen under consideration, application of these criteria allowed the identification of two main groupings. Group I contained those host species for which the quality of the data provided clear support for susceptibility (Table 4). A second group, Group II, contained a number of potential host species that were disqualified based on the uncertainty of the required information e.g. incomplete or unclear data prevented a clear conclusion or the only available data was obtained from invasive experiments. Table 5 summarises this situation and shows that for certain pathogens, this number is rather high (e.g. EUS, VHS, WSD). For many species the assessment could not be completed because of data not being available, or reports providing data of poor quality.

Identification of the pathogen as well as identification of the host species was often lacking or unclear. From this point of view, the three groups of host species (finfish, mollusca, crustaceans) and their pathogens were not equal (see Table 5). Lack of pathogen identification was a major source of uncertainty for mollusc diseases as well as for EUS, which is probably due to the fact that molecular DNA based tools for diagnosis have only recently been developed for these pathogens. Pathogen identification was usually given for fish and shrimp viruses, although there was some uncertainty for the definition for some pathogens e.g. *Bonamia exitiosa*, YHV. This issue would need to be addressed for those specified pathogens having an unclear definition in order to better delineate a group of susceptible species.

A number of reports identified the host species at the genus level only (see detailed Tables in annex); this obviously hampered listing of host species. On several occasions, it was noted that common names and Latin nomenclature were not matching, with common names being used for different scientific names. In addition to this, there were examples where the taxonomy of the host remained unclear (e.g. *Channa marulia* = *Ophicephalus marulius*, *Crassostrea glomerata* = *Saccostrea commercialis*) and synonyms were used to search literature (e.g. *Cirrhinus reba*, syn *Cirrhinus ariza*, syn. *Labeo ariza*).

In many instances, data pertaining to replication or growth of the pathogen, its viability, associated histopathology, and tissue location were extracted from peer reviewed papers that

were published initially for a different purpose. For example, sequence analysis of a shrimp virus isolate may provide information on organs or tissues from which the nucleic acid was originally amplified. Often, several papers were necessary to gather the requested information.

On the other hand, it happened (although rarely) that a single report, from a single case, and even sometimes corresponding to a single isolate fully satisfied the criteria (e.g. VHS in *Trisopterus minutus*). This would only appear in the detailed assessment and summary Tables, which list such species along with others for which the evidence stems from various sources. Similarly, some papers indicated a relatively low susceptibility; however, in this report the level of susceptibility was not considered and host species are not ranked by different degrees of susceptibility.

A number of entries in the assessment tables are based on non-peer reviewed sources or personal communication. For example, the outbreak of VHS in the Great Lakes in North America has generated a flow of official reports with no formal publication in scientific format. This type of information was checked with the primary investigators, when possible, and additional information requested for the assessment. However, it would be recommendable to publish those data in peer-reviewed journals. Such papers would probably benefit from taking into account the criteria and considerations presented here (section 2).

Lack of evidence and true resistance

For the majority of host species, absence from the list of susceptible species does not reflect true resistance but arises from a number of reasons, such as lack of published evidence, no opportunity for exposure and conflicting reports.

For example, levels of resistance to infection with *Bonamia ostreae* have been demonstrated for some mollusc species, e.g. *Crassostrea gigas, Mytilus edulis, M. galloprovincialis,* etc. (Culloty et al., 1996). However, no particular status is given to these species compared to those for which exclusion is solely based on absence of evidence. Similarly, for EUS and despite the broad spectrum of affected hosts, few species have been demonstrated experimentally to be refractory.

Further, there are some conflicting experimental studies where one research group finds a species susceptible and another does not (e.g. Follett et al. 1997 find brook trout susceptible to IHNV in contradiction to results obtained by La Patra et al. 1993). This could reflect issues pertaining to strain of virus or fish group, age or strain, or other unidentified experimental factors. Therefore, positively demonstrated susceptibility was preferred in this assessment and, where only limited experimental studies have been conducted, it has generally been stated that the status is unproven rather than non-susceptible.

The question of infectious dose is certainly one facet of this. Infectious dose used in experimental challenges has not been considered when designing the criteria for assessment of susceptibility. This could however be considered in further assessment.

Among the numerous species excluded from the list of susceptible hosts, many never actually encounter the pathogen, naturally or experimentally. When this encounter occurs, data may come to widen the host range of the pathogen. This is the case with recent outbreaks of VHS in the Great Lakes region in North America and also EUS in the Chobe-Zambesi River System in Africa. For disease agents that have a broad range of susceptible species, it would appear likely that species from currently unaffected geographic regions will also be susceptible. Bearing this in mind, the concept of taxonomic spread in host range (see below) would be of great potential.

Therefore, it has to be born in mind that the list of susceptible species is likely to be incomplete. The list is likely to grow whenever the disease agent is being introduced into a new geographic area.

Furthermore, in cases such as EUS, a large number of host species has been reported in publications as being susceptible. In some cases the reports did not include sufficient detail for those species to fulfil criteria for category I or II of the susceptible species list provided here.

A large number of host species have been identified as susceptible to EUS. Considering the broad range of hosts, it is likely that other species not yet reported might also be susceptible.

Therefore, it is suggested that - for those pathogens with a broad spectrum of susceptible species - the report presented here is followed up by a risk assessment. Such a risk assessment would take into consideration the geographical origin of the live aquatic animal consignment and the species range found to be susceptible to this pathogen. This risk assessment would quantify the risk that live aquaculture animals kept under normal farming conditions may spread the agent in question and under which circumstances this might take place.

Listing by species vs genus or higher taxonomic group

In reviewing susceptibility of aquatic hosts to pathogens, it may be useful to consider the taxonomic range over which susceptible hosts exist. Such an approach may be used to better inform risk assessors and risk managers for the importation of potentially susceptible hosts compared to a fixed list of susceptible species for which exclusion is often based on lack of evidence rather than true resistance (see relevant section of the discussion above).

Susceptibility to the crustacean viral pathogens TSV, YHV and WSSV may illustrate this point.

In contrast to the apparently rather limited susceptible host ranges for TSV and YHD, Directive 2006/88/EC lists susceptibility to WSD (WSSV) in 'all decapods'. The Decapoda comprise over 20,000 species across 2 suborders (Dendrobranchiata and Pleocyemata). Members of both suborders Dendrobranchiata and Pleocymata have been shown to be susceptible. This higher-level taxonomic diversity in WSD susceptibility demonstrated by representation across these two suborders is likely the basis for the statement that 'all decapods' are susceptible to WSSV but it should be taken into account that most of the Families within the two suborders have not been tested.

To illustrate this point, only three families (Penaeidae, Solenoceridae, Sergestidae) of the seven families in the Suborder Dendrobranchiata have been studied in this context. Similarly, of the approximately 94 families that comprise the various Infraorders and Superfamilies of the Suborder Pleocyemata, only 24 have been demonstrated to be naturally or experimentally susceptible (or to act as carrier/vector). Furthermore, within the Suborder Pleocyemata, of the 8 Infraorders (Anomura, Astacidea, Brachyura, Caridea, Palinura, Palinuridea, Stenopodidea and Thalassinidea), only 5 have been demonstrated to contain susceptible or vector species (exceptions being the Infraorders Palinuridea, Stenopodidea and Thalassinidea).

Nevertheless, WSSV appears to have a wide host range compared to TSV and YHD. In addition, all decapod crustaceans from marine and brackish or freshwater sources that have been subjected to experimental infection trials have been successfully infected.

An understanding of taxonomic spread in host range is therefore a new concept in addressing susceptibility and will undoubtedly highlight the variation in virulence strategies for the pathogens listed in Directive 2006/88/EC. As stated above, a risk assessment based upon taxonomic range may also by-pass the potential for rapid outdating of lists of susceptible species (as new literature becomes available) and would allow a precautionary principle to be applied to those species within a potentially susceptible taxonomic group that for various of reasons have never been rigorously tested for susceptibility.

A major question remains to know if the concept of taxonomic spread in host range should be restricted to risk assessment and, if not, how it could and should be applied to other diseases

(e.g. EUS, VHS) for listing purpose. Certainly one should expect consistency in the approach for listing susceptible species.

Pathogen definition and strain differentiation

Section 2.4 of this report provides working definitions for the listed diseases on the basis of the OIE Aquatic Code and its interpretation by the experts of the working group. These definitions have a direct impact on the span of the literature review and the outputs of the performed assessments.

Clear definitions of pathogens and differentiation of strains are fundamental to assessment of susceptibility of host species as any change in these definitions would have an impact on their host and geographic ranges.

This issue is illustrated well by the Yellowhead complex viruses. Currently the literature categorises the complex into two distinct viruses: Yellow Head Virus (YHV) and Gill Associated Virus (GAV). GAV is synonym of Lymphoid Organ Virus (LOV). Although both are found strongly associated with the lymphoid organ of *P. monodon*, LOV is considered to be relatively asymptomatic and GAV subsequently reported as its more pathogenic relative. Via sequencing, LOV and GAV are 98.9% similar (Cowley et al. 2000), indicating that they are likely the same virus. In addition, GAV has between 83% and 85.1% similarity to YHV based on sequencing of different amplicons and therefore GAV was reported to be a closely related 'topotype' of YHV. Both of these studies however used only the sequences of relatively few clones (see Cowley et al. 1999). Owing to the small number of clones sequenced and the small size of the sequenced regions, these findings could not consider the potential variation in mutants within the clones that result from so-called quasi-species within a population in addition to possible natural genomic variation within these viruses. Based upon the ICTV definition of a virus species as '…(a) polythetic class of viruses that can constitute a replicating lineage and occupy a particular ecological niche', Van Regenmortel (2000) lists the following characteristics for discriminating between virus species: relatedness of genome sequence, natural host range, cell and tissue tropism, pathogenicity and cytopathology, mode of transmission, physicochemical properties of virions and antigenic properties of virions. Owing to GAV and YHV sharing the above characteristics and with a genome matching 491 out of a compared 577bp, combined with the fact that the viruses are morphologically indistinguishable and cause the same gross disease, Munro and Owens (2007) consider that GAV and YHV are the same virus and term them 'Yellow head-like virus' (YHLV) in their recent review.

In the case of *Bonamia exitiosa*, SSU rDNA gene sequences suggest that *Mikrocytos roughleyi* and several American isolates of *Bonamia* sp. may be conspecific. Again, the application of a broad definition of *B. exitiosa* has a direct impact on its host and geographic range. It would add three more species to the list of susceptible hosts, two of which are outside the genus *Ostrea* (see discussion above on taxonomic spread in host range). Cupped oysters would be considered as susceptible species in this context.

Vectors and susceptible species opinions

By and large, no major inconsistencies have been noted between this report and the previous EFSA opinions on vector species (EFSA 2007 a, b, and c).

However, there are some areas where the assessments from the current report have refined those of the previous EFSA opinions. For example, clams and cockles were identified as a group of potential mollusc vectors for *Marteilia refringens* with a moderate likelihood (EFSA, 2007b). The current report has provided clear evidence that indeed several of these species (not only clams and cockles but also cupped oysters) are susceptible to infection with *M. refringens*.

The EFSA opinions on vectors pointed to a need to properly assess the list of susceptible host species. The assessment undertaken in the current report indicates that the tables included in the annexes A1, A2 and A3 of the EFSA opinions on vector species for fish diseases (EFSA 2007a) should be updated. The impact of the current report on these tables is presented further by Table 6, that illustrates the additional non-listed susceptible species. The situation ranges from no additional susceptible species (e.g. KHV, infection with *Mikrocytos mackini*), to several additional species (EHN, IHN), and many species to be included (VHS, EUS).

Another point to consider here is the impact of the decision made by the risk manager on the Group II species (see Table 5). Depending on whether or not a conservative approach is taken, the number of species considered as susceptible may vary despite some lack of scientific data to support susceptibility. This decision will have a considerable impact on the EFSA vector opinions. Those opinions may consequently need to be reviewed.

Evidence coming from invasive approach only

This point has been also addressed in section 2 of the report.

The definition of a susceptible species in Directive 2006/88/EC is based partially on 'experimental infection that mimics natural pathways'. However, the working group considered that data from invasive treatments e.g. intraperitoneal or intramuscular injection, provided valuable information on the potential susceptibility of a host species and offered a rigorous assessment of non-susceptibility.

In fact, there was a number of examples where the only evidence stemmed from invasive experiments but these were relatively limited (Table 5).

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Application of objective criteria of susceptibility allowed the identification of two main groups; Group I, those host species for which the quality of the data provided clear support for susceptibility (Table 4) and Group II, those host species for which incomplete or unclear data prevented a clear conclusion or the only available data was obtained from invasive experiments (Table 5).
2. Group I (susceptible species, Table 4) contains: i) traded and non-traded species, ii) species belonging to several genera, and iii) many were susceptible to several of the specified pathogens, so may represent different levels of risk.
3. Within Group I, many species were identified that currently are not listed in Directive 2006/88/EC (Table 6). Some were susceptible to more than one of the specified pathogens.
4. Partial evidence suggesting susceptibility was obtained for a further large number of host species (Group II, Table 5).
5. Several host species, including some listed currently in Directive 2006/88/EC, were identified as potentially non-susceptible but it was not possible to confirm this status firmly due to the quality of the data (Table 7).
6. The lack of clear case definitions for some of the specified pathogens compromised assessment of the susceptibility of some host species. This conclusion reinforces that of the previous EFSA scientific opinions on vector species and life stages of susceptible species not transmitting disease as regards certain aquatic diseases (EFSA, 2007).

Table 4: Species for which scientific evidence supports susceptibility [Group I]

Disease	Host species
Epizootic Ulcerative Syndrome	*Acanthopagrus australis*,, *Alosa sapidissima*, *Ameiurus melas*, *Archosargus probatocephalus*, *Bairdiella chrysoura*, *Brevoortia tyrannus*, *Carassius auratus auratus*, *Carassius carassius*, *Channa striata* (= *Ophicephalus striatus*), *Cirrhinus mrigala*, *Clarias batrachus*, *Colisa lalia*, *Cyprinus carpio*, *Fundulus heteroclitus*, *Fundulus majalis*, *Glossogobius giurus*, *Ictalurus punctatus*, *Labeo rohita*, *Lepomis macrochirus*, *Micropterus salmoides*, *Mugil curema*, *Mugil cephalus*, *Oncorhynchus mykiss*, *Oreochromis niloticus*, *Plecoglossus altivelis*, *Pogonias cromis* , *Puntius schwanenfledi*, *Rutilus rutilus*, *Sillago ciliata*, *Silurus glanis*, *Trichogaster trichopterus*, *Tridentiger obscurus obscurus*
Epizootic Haematopoietic Necrosis	*Perca fluviatilis*, *Oncorhynchus mykiss*, *Gambusia affinis*, *Galaxias olidus*, *Maqauria australasica*, *Bidyanus bidyanus*, *Esox lucius*
Viral Haemorrhagic Septicaemia	*Oncorhynchus mykiss*, *O. tshawytscha*, *O. kisutch*, *Salmo salar*, *S. trutta*, *Thymallus thymallus*, *Coregonus lavaretus*, *Esox masquinongy*, *E. lucius*, *Clupea harengus*, *C. pallasii*, *Sprattus sprattus*, *Sardinops sagax*, *Gadus morhua*, *Trisopterus minutus*, *Merlangius merlangus*, *Micromesistius poutassou*, *Trisopterus esmarkii*, *Theragra chalcogramma*, *Enchelyopus cimbrius*, *Merluccius productus*, *Limanda limanda*, *Platichthys flesus*, *Pleuronectes platessa*, *Reinhardtius hippoglossoides*, *Scophthalmus maximus*, *Paralichthys olivaceus*, *Argentina sphyraena*, *Hypomesus pretiosus*, *Ammodytes hexapterus*, *A. personatus*, *Pomatoschistus minutus*, *Neogobius melanostomus*, *Cymatogaster aggregata*, *Aplodinotus grunniens*, *Scomber japonicus*, *Gasterosteus aculeatus*, *Lampetra fluviatilis*, *Dicentrarchus labrax*, *Plecoglossus altivelis*, *Salvelinus namaycush*, *O. mykiss* x *O. kisutch*, *O. mykiss* x *S. fontinalis* triploid, *O. mykiss* x *S. alpinus* triploid
Infectious Salmon Anaemia	*Salmo salar*, *S. trutta*, *Oncorhynchus kitsutch*, *O. mykiss*, *Clupea harengus*
Koi carp Herpes Virus Disease	*Cyprinus carpio*
Infectious Hematopoietic Necrosis	*Oncorhynchus nerka* (including landlocked form), *O. mykiss*, *O. tshawytscha*, *O. kisutch*, *O. keta*, *O. rodurus*, *O. masou*, *O. masou* (including landlocked form), *O. clarki*, *Salmo salar*, *S. namaycush*, *Salvelinus fontinalis*, *S. alpinus*, *S. leucomaenis*, *Clupea pallasii*, *Cymatogaster aggregate*, *Aulorhychus flavidus*, *Plecoglossus altivelis*, *Gadus morrhua*, *Acipenser transmontanus*, *Esox lucius*
Infection with *B. ostreae*	*Ostrea edulis*, *Crassostrea ariakensis*
Infection with *B. exitiosa*	*Ostrea chilensis*, *O. angasi*, *O. edulis*
Infection with *M. refringens*	*Ostrea edulis*, *Mytilus edulis*, *M. galloprovincialis*, *Solen marginatus*, *Chamelea gallina*, *Acartia grani*
Infection with *P. marinus*	*Crassostrea virginica*, *C. gigas*, *C. ariakensis*, *C. corteziensis*, *Mya arenaria*, *Macoma balthica*
Infection with *M. mackini*	*Crassostrea gigas*, *C. virginica*, *Ostrea edulis*
Taura Syndrome	*Penaeus vannamei*, *P. duorarum*, *P. monodon*, *P. setiferus*, *P. chinensis*, *P. stylirostris*, *P. aztecus*, *Metapenaeus ensis*
Yellow Head Disease	*Penaeus monodon*, *P. merguiensis*, *P. vannamei*, *P. setiferus*, *P. aztecus*, *P. duorarum*, *Metapenaeus brevicornis*, *M. affinis*, *Palaemon styliferus*
White Spot Disease	*Penaeus aztecus*, *P. duorarum*, *P. chinensis*, *P. indicus*, *P. merguiensis*, *P. setiferus*, *P. stylirostris*, *P. vannamei*, *P. japonicus*, *P. monodon*, *P. penicillatus*, *P. semisulcatus*, *Metapenaeus dobsonii*, *M. ensis*, *M. conoceros*, *Trachypenaeus curvirostris*, *Crangon crangon*, *Exopalaemon orientalis*, *Palaemon adspersus*, *Macrobrachium idella*, *M. lamerrae*, *M. rosenbergii*, *Panulirus homarus*, *P. longipes*, *P. ornatus*, *P. penicillatus*, *P. polyphagus*, *P. versicolor*, *Homarus gammarus*, *Scyllarus arctus*, *Astacus leptodactylus*, *Cherax destructor*, *C. quadricarinatus*, *Pacifastacus leniusculus*, *Procambarus clarkia*, *Orconectes limosus*, *Atergatis integerrimus*, *Calappa philarigus*, *Cancer pagurus*, *Carcinus maenas*, *Charybdis annulata*, *C. feriatus*, *C. granulata*, *C. lucifera*, *C. natator*, *Demania splendida*, *Doclea hybrida*, *Grapsus albolineatus*, *Halimede ochtodes*, *Liagore rubronaculata*, *Liocarcinus depurator*, *L. puber*, *Lithodes maja*, *Matuta miersi*, *Menippe rumphii*, *Paradorippe granulata*, *Paratelphusa hydrodomous*,

	Paratelphusa pulvinata, Parthenope prensor, Phylira syndactyla, Podophthalmus vigil, Portunus pelagicus, P. sanguinolentus, Scylla serrata, S. tranquebaricca, Thalamita danae, Uca pugilator

Table 5: Species for which scientific data partially supports susceptibility [Group II]

Disease	Host species - incomplete data with regards to criteria A – D	uncertainty related to pathogen identification and/or taxonomic affiliation	Invasive experimentale evidence only
Epizootic Ulcerative Syndrome	*Acanthogobius flavimanus, Acanthopagrus berda, Acheilognathus lanceolatus, Aeathopagurus australia, Ambassis agassiz, A. nalua, Amblypharyngodon mola, Amniataba percoides, Amphipnous cuchia, Anabas escanden, A. testudineus, Anguilla bicolor, A. nebulosa, Arius sp., Arramphus sclerolepis, Badis badis, Barbus* sp., *Belone cancilla, Bidyanus bidyanus, Bunaka* sp., *Caranx* spp., *Channa gachua, C. maculate, C. marulia, C. micropeltes, C. orientalies, Chrysichthys nigrodigitatus, Cinetodus froggatti, Cirrhinus juillieni, Clarias gariepinus, C. teysmanni brachysoma, Colisa fasciatus, Cyclocheilichtys enoplos, Datnioides quadrifasciatus, Elecheronema tetradactylum, Epinephelus tauvina, Esomus danrica thermoicos, Etroplus suratensis, Fluta alba, Gerdes ovatus, Glossamia aprion, Glossogobius* spp., *Hexanematichthys danielsi, H. latirostris, H. lentaspis, Hyporhamphus gaimardi, Johnius belengeri, Kurtus gulliveri, Labeo boga, L. porcellus, Lates calcarifer, Leiopotherapon unicolor, Leiostomus xanthunus, Liza ceramensis, L. diadema, L. dussumieri, L. macrolepis, Lobotes surinamensis, Lutjanus argentimaculatus, Macrognathus pancalus, M. aculeatus, Macrones keletius, Macrones vittatus, Mastacembelus armatus,*	*Acanthogobius flavimanus, Acanthopagrus berda, Acheilognathus lanceolatus, Aeathopagurus australia, Alosa mediocris, Ambassis agassiz, A. nalua, Amblypharyngodon mola, Ameiurus nebulosus, Amniataba percoides, Amphipnous cuchia, Anabas escanden, A. testudineus, Anguilla bicolor, A. nebulosa, Arius* sp., *Arramphus sclerolepis, Badis badis, Barbus* sp., *Belone cancilla, Bidyanus bidyanus, Bunaka* sp., *Caranx* spp., *Catla catla, Channa argus, C. gachua, C. maculate, C. marulia, C. micropeltes, C. orientalies, Chrysichthys nigrodigitatus, Cinetodus froggatti, Cirrhinus juillieni, Clarias gariepinus, C. teysmanni brachysoma, Colisa fasciatus, Cyclocheilichtys enoplos, Cynoscion arenarius, C. regalis, Datnioides quadrifasciatus, Elecheronema tetradactylum, Epinephelus tauvina, Esomus danrica thermoicos, Etroplus suratensis, Fluta alba, Fundulus grandis, Gerdes ovatus, Glossamia aprion, Glossogobius* spp., *Heteropneustes fossilis, Hexanematichthys danielsi, H. latirostris, H. lentaspis, Hyporhamphus gaimardi, Johnius belengeri, Kurtus gulliveri, Labeo boga, L. porcellus, Lagodon rhomboides, Lates calcarifer, Leiopotherapon unicolor, Leiostomus xanthunus, Liza ceramensis, L. diadema, L. dussumieri, L. macrolepis,*	Not applicable (see 2.2)

	Mastacembelus zebrinus, Melanotaenia splendida, Microphis boaja, Morone saxatilis, Morulius calbasu, Mystus cavasiu,, M. nemurus, M. tengara, Nandus marmoratus, N. nandus, Nemantolosa erebo, Notopterus notopterus, Ompole bimaculatus, Oreochromis mossambica, Osteobrama cotio cotio, Oxyeleotris lineolatus, O. marmoratus, Parmambassic gulliveri, Platycephalus fuscus, Polydactylus sheridani, Priopidchtyus gymnocephalus, Pristolepis fasciatus, Psettodes sp., *Puntius ticto, P. altus, P. amphibious, P. chola, P. dorsalis, P. filamentosus, P. orphoides, P. sarana, P. vittatus, Rasbora danicornius, R. myersi, Rhynehobdella* sp., *Rothee boelengeri, Sarcocheilichthys variegates, Scardinius erythrophthalmus, Scatophagus argus, Scleropages jardini, Scutengraulis seratchlevi, Selenotoca multifasciata, Siganus* sp., *Sillago* sp., *Spheroides* sp., *Strongylura kreffti, Symbranchus, Tetrodon sp., Tilapia mossambica, Toxotes chatareus, T. lorentzi, Trichogaster chuna, T. fasciata, Trichopsis vittatus, Trinectes maculates, Tylosurus* sp., *Upeneus bansai*	*Lobotes surinamensis, Lutjanus argentimaculatus, L. griseus, Macrognathus pancalus, M. aculeatus, Macrones keletius, Macrones vittatus, Mastacembelus armatus, Mastacembelus zebrinus, Melanotaenia splendida, Microphis boaja, Micropogonias undulatus, Morone saxatilis, Morulius calbasu, Mystus cavasius, M. nemurus, M. tengara, M. vittatus, Nandus marmoratus, N. nandus, Nemantolosa erebo, Notopterus notopterus, Ompole bimaculatus, Oreochromis mossambica, Osteobrama cotio cotio, Oxyeleotris lineolatus, O. marmoratus, Paralichthys albigutta, P. lethostigma, Parmambassic gulliveri, Platycephalus fuscus, Polydactylus sheridani, Pomatomus saltatrix, Priopidchtyus gymnocephalus, Pristolepis fasciatus, Psettodes* sp., *Puntius ticto, P. altus, P. amphibious, P. chola, P. dorsalis, P. filamentosus, P. gonionotus, P. orphoides, P. sarana, P. sophore, P. vittatus, Rasbora danicornius, R. myersi, Rhynehobdella sp., Rothee boelengeri, Sarcocheilichthys variegates, Scardinius erythrophthalmus, Scatophagus argus, Sciaenops ocellatus, Scleropages jardini, Scutengraulis seratchlevi, Selenotoca multifasciata, Siganus* sp., *Sillago* sp., *Spheroides* sp., *Strongylura kreffti, Symbranchus, Tetrodon sp., Therapon sp., Tilapia mossambica, Toxotes chatareus, T. lorentzi, Trichogaster chuna, T. fasciata, T. pectoralis, Trichopsis vittatus, Trinectes maculates, Tylosurus* sp., *Upeneus bansai, Valamugil* sp., *Wallago attu*	
Epizootic Haematopoietic Necrosis	*Retropinna semoni, Carassius auratus, Maquaria novemaculeata, M. ambigua, Lates*	-	*Maquaria novemaculeata, Salmo salar*

	calcarifer, Capoeta tetrazona, Paratya australiensis, Daphnia carinata, Cherax destructor, Agraptocorixa sp.		
Viral Haemorrhagic Septicaemia	*Anguilla anguilla, Sparus aurata, Solea senegalensis, Chondrostoma polylepis, Oncorhynchus keta, , Coregonus clupeaformis, Dorosoma cepedianum, Gadus macrocephalus, Melanogrammus aeglefinus, Microgadus proximus, Lota lota, Parophrys vetula, Ictalurus nebulosus, I. punctatus, Thaleichthys pacificus, Micropterus salmoides, M. dolomieu, Lepomis macrochirus, L. gibbosus, Pomoxis nigromaculatus, Ambloplites rupestris, Perca flavescens, Sander vitreus, , Morone chrysops, Morone saxatilis, Morone Americana, Anoplopoma fimbria, Sebastes inermis, Fundulus heteroclitus, Aulorhynchus flavidus, Moxostoma anisurum, Moxostoma macrolepidotum, Barbus graellsii, Pimephales notatus, Notropis atherinoides, Notropis hudsonius, Percopsis omiscomaycus, , , Danio rerio, Carassius auratus, O. mykiss x S. namaycush triploid, O. mykiss x O. kisutch triploid, Salvelinus fontinalis, Perca fluviatilis, Oncorhynchus nerka*	*Oncorhynchus keta, Coregonus clupeaformis, Dorosoma cepedianum, Microgadus proximus, Lota lota, Parophrys vetula, Ictalurus nebulosus, I. punctatus, Oncorhynchus nerka, Micropterus salmoides, M. dolomieu, Lepomis macrochirus, Pomoxis nigromaculatus, L. gibbosus, P. flavescens, Sander vitreus, Morone chrysops, Morone americana, Aulorhychus flavidus, Moxostoma anisurum, Moxostoma macrolepidotum, Pimephales notatus, Notropis atherinoides, Notropis hudsonius, Percopsis omiscomaycus, Carassius auratus, Salvelinus fontinalis*	*Seriola quinqueradiata, Oncorhynchus aguabonita, Acanthopagrus schlegeli, Epinephelus akaara, Sebastes schlegeli, Pagrus major* In addition, the following species for which infection trials (invasive and/or non-invasive) have not given any partially support to susceptibility are: *Rutilis rutilis, Squalius cephalus, Cyprinus carpio, Tinca tinca, Salvelinus alpinus, Pleuronectes yokohama,, Oncorhynchus gorbuscha*
Infectious Salmon Anaemia	*Anguilla anguilla, Gadus morrhua, Alosa pseudoharengus, Salvelinus alpinus, Oncorhynchus keta, Pollachius virens, Mytilus edulis*	*Alosa pseudoharengus, Salvelinus alpinus, Pollachius virens*	*Salvelinus alpinus, Oncorhynchus keta*
Koi carp Herpes Virus Disease	*Carassius auratus, hybrids of Cyprinus carpio x Carassius auratus*	-	-
Infectious Hematopoietic Necrosis	*Anguilla anguilla*	*Anguilla anguilla*	*Dicentrarchus labrax, Sparus aurata, Psetta maxima*
Infection with *B. ostreae*	*Ostrea angasi, O. puelchana, O. denselamellosa, O. concaphila, Crassostrea angulata*	*Ostrea angasi, O. puelchana, O. chilensis, O.denselamellosa, O. concaphila and Crassostrea angulata*	-

Infection with *B. exitiosa*	*Ostrea concaphila,*	*Ostrea conchaphila, O. puelchana, Crassostrea ariakensis, Saccostrea glomerata*	-
Infection with *M. refringens*	*Ostrea angasi, O. puelchana, O. denselamellosa, Crassostrea gigas, Ruditapes decussatus*	*Ostrea denselamellosa, O. angasi, O. puelchana, O. chilensis, Crassostrea gigas, C. virginica, Cardium edule, Ruditapes decussatus, R. philippinarum, Tapes rhomboides, T. pullastra, Ensis minor, Scrobicularia piperata, Saccostrea cucullata*	-
Infection with *P. marinus*	-	*Crassostrea rhizophoreae*	-
Infection with *M. mackini*	*Crassostrea angulata* -	*Ostrea concaphila, Crassostrea angulata*	-
Taura Syndrome	*Penaeus schmitti, P. japonicus*	*Penaeus schmitti*	*Penaeus japonicus*
Yellow Head Disease	*Penaeus esculentus, Metapenaeus ensis, M. bennettae, Macrobrachium lanchesteri*	*Penaeus esculentus, P. japonicus, P. stylirostris, Metapenaeus ensis, M. bennettae*	*Macrobrachium lanchesteri, M. sintangense, Palaemon serrifer*
White Spot Disease	*Metapenaeus brevicornis, Parapenaeopsis stylifera, Solenocera indica, Alpheus lobidens, Alpheus brevicristatus, Astacus astacus, Squilla mantis, Orconectes punctimanus, Calappa lophos, Charybdis cruciata, Charybdis japonicus, Gelasimus marionis nitidus, Helice tridens, Macrophthalmus sulcatus, Matuta planipes, Metapograpsus messor, Pseudograpsus intermedius, Sesarma oceanica, Branchiopoda Cladocera, Artemia salina*	-	-

Table 6: Non listed species that should be considered as susceptible.

Disease	Host species
Epizootic Ulcerative Syndrome	*Acanthopagrus australis, Alosa sapidissima, Ameiurus melas, Archosargus probatocephalus, Bairdiella chrysoura, Brevoortia tyrannus, Carassius auratus auratus, Carassius carassius, Cirrhinus mrigala, Clarias batrachus, Colisa lalia, Cyprinus carpio, Fundulus heteroclitus, Fundulus majalis, Glossogobius giurus, Ictalurus punctatus, Lepomis macrochirus, Micropterus salmoides, Oncorhynchus mykiss, Oreochromis niloticus, Plecoglossus altivelis, Pogonias cromis, Rutilus rutilus, Sillago ciliata, Silurus glanis, Tridentiger obscurus obscurus*
Epizootic Haematopoietic Necrosis	*Gambusia affinis, Galaxias olidus, Maquaria australasica, Bidyanus bidyanus, Esox lucius*
Viral Haemorrhagic Septicaemia	*Oncorhynchus tshawytscha, O. kisutch, Salmo salar, Esox masquinongy, Sardinops sagax, Trisopterus minutus, Merlangius merlangus, Micromesistius poutassou, Trisopterus esmarkii, Theragra chalcogramma, Enchelyopus cimbrius* [= *Onus mustela*], *Merluccius productus, Limanda limanda, Platichthys flesus, Pleuronectes platessa, Reinhardtius hippoglossoides, Paralichthys olivaceus, Argentina*

	sphyraena, Hypomesus pretiosus, Ammodytes hexapterus, Ammodytes personatus, Pomatoschistus minutus, Neogobius melanostomus, Cymatogaster aggregata, Aplodinotus grunniens, Gasterosteus aculeatus, Lampetra fluviatilis, Acanthopagrus schlegeli, Epinephelus akaara, Sebastes schlegeli, Pagrus major, Dicentrarchus labrax, Plecoglossus altivelis, Salvelinus namaycush, O. mykiss x O. kisutch, O. mykiss x S. fontinalis triploid, *O. mykiss x S. alpinus* triploid
Infectious Salmon Anaemia	*Oncorhynchus kitsutch, Clupea harengus*
Koi Herpes Virus Disease	None
Infectious Hematopoietic Necrosis	*Oncorhynchus clarki, Salmo namaycush, Salvelinus fontinalis, S. alpinus, S. leucomaenis, Clupea pallasii, Cymatogaster aggregate, Aulorhychus flavidus, Plecoglossus altivelis, Gadus morrhua, Acipenser transmontanus, Esox lucius*
Infection with *B. ostreae*	*Crassostrea ariakensis*
Infection with *B. exitiosa*	*Ostrea edulis*
Infection with *M. refringens*	*Solen marginatus, Chamelea gallina, Acartia grani*
Infection with *P. marinus*	*Crassostrea ariakensis, C. corteziensis, Mya arenaria, Macoma balthica*
Infection with *M. mackini*	None
Taura Syndrome	*Penaeus duorarum, P. monodon, P. chinensis, P. aztecus, Metapenaeus ensis*
Yellow Head Disease	*Penaeus merguiensis, Metapenaeus brevicornis, M. affinis, Palaemon styliferus*
White Spot Disease	All decapods are currently listed. Full scientific evidence exists for: *Penaeus aztecus, P. duorarum, P. chinensis, P. indicus, P. merguiensis, P. setiferus, P. stylirostris, P. vannamei, P. japonicus, P. monodon, P. penicillatus, P. semisulcatus, Metapenaeus dobsonii, M. ensis, M. conoceros, Trachypenaeus curvirostris, Crangon crangon, Exopalaemon orientalis, Palaemon adspersus, Macrobrachium idella, M. lamerrae, M. rosenbergii, Panulirus homarus, P. longipes, P. ornatus, P. penicillatus, P. polyphagus, P. versicolor, Homarus gammarus, Scyllarus arctus, Astacus leptodactylus, Cherax destructor, C. quadricarinatus, Pacifastacus leniusculus, Procambarus clarkia, Orconectes limosus, Atergatis integerrimus, Calappa philarigus, Cancer pagurus, Carcinus maenas, Charybdis annulata, C. feriatus, C. granulata, C. lucifera, C. natator, Demania splendida, Doclea hybrida, Grapsus albolineatus, Halimede ochtodes, Liagore rubronaculata, Liocarcinus depurator, L. puber, Lithodes maja, Matuta miersi, Menippe rumphii, Paradorippe granulata, Paratelphusa hydrodomous, Paratelphusa pulvinata, Parthenope prensor, Phylira syndactyla, Podophthalmus vigil, Portunus pelagicus, P. sanguinolentus, Scylla serrata, S. tranquebaricca, Thalamita danae, Uca pugilator*

Table 7: Listed species whose susceptibility lacks scientific support

Disease	Host species with unsufficient scientific evidence
Epizootic Ulcerative Syndrome	No specific species is listed currently but following genera: *Catla, Channa, Labeo, Mastacembelus, Mugil, Puntius* and *Trichogaster.* No species from *Catla* and *Mastacembelus* listed in Table 4.
Epizootic Haematopoietic Necrosis	None
Viral Haemorrhagic Septicaemia	*Gadus aeglefinus, G. macrocephalus, Onos cimbrius*
Infectious Salmon Anaemia	None
Koi Herpes Virus Disease	None
Infectious Hematopoietic Necrosis	None
Infection with *B. ostreae*	*Ostrea conchaphila, O. angasi, O. puelchana, O. chilensis, O. denselamellosa*
Infection with *B. exitiosa*	None
Infection with *M. refringens*	*Ostrea angasi, O. puelchana, O. chilensis*
Infection with *P. marinus*	none
Infection with *M. mackini*	*Ostrea concaphila*
Taura Syndrome	None
Yellow Head Disease	*Penaeus stylirostris*
White Spot Disease	No specific species is listed currently but all decapods. There is lack of scientific evidence for: *Metapenaeus brevicornis, Parapenaeopsis stylifera, Solenocera indica, Alpheus lobidens, Alpheus brevicristatus, Astacus astacus, Squilla mantis, Orconectes punctimanus, Calappa lophos, Charybdis cruciata, Charybdis japonicus,*

	Gelasimus marionis nitidus, Helice tridens, Macrophthalmus sulcatus, Matuta planipes, Metapograpsus messor, Pseudograpsus intermedius, Sesarma oceanica, Branchiopoda Cladocera, Artemia salina

RECOMMENDATIONS

1. All of the host species identified in Table 6 should be considered for possible inclusion in Directive 2006/88/EC.
2. Further scientific studies are required to resolve the uncertainty concerning the susceptibility of the host species identified in Tables 5 and 7.
3. All further studies should apply clear criteria, such as those used in this opinion, to assess susceptibility of host species and clear identification of the pathogen and affected host(s).
4. The application of the taxonomic relatedness of host species and the broad taxonomic spread of affected hosts as guiding principles to susceptibility of host species needs to be assessed to determine their robustness and to clarify how they can be applied. This approach could be useful for the numerous species for which data is lacking and also avoid unnecessary experimental studies in the target hosts.
5. This Scientific Opinion should be updated and reviewed regularly.
6. The lack of uniformity in the definition of listed diseases and their causative agents, and the imprecision arising from the wide variation in pathogenicity of their many strains should be addressed.

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APPENDICES

Legend to Tables: I = host species for which the quality of the data provided clear support for susceptibility; II = host species for which incomplete or unclear data prevented a clear conclusion or the only available data was obtained from invasive experiments; - = not applicable, nda = no data available; X = yes; ? = most likely however available information is not clear.

APPENDIX A

Diseases of fish

Epizootic Ulcerative Syndrome

Table 8: Host species susceptible to *Aphanomyces invadans*

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Acanthogobius flavimanus	Natural	-	nda	nda	nda	High susceptibility reported by Kumamaru 1973, cited by Hatai in Baldock et al. 2005 (p. 558). Original reference in Japanese	Nda	II
Acanthopagrus australis	Natural	-	X	Nd	X	A, B, and D. Fraser et al., 1992 B, ID Phadee et al. 2004 (Australian isolate)	Yes (PCR)	I
Acanthopagrus berda	Natural	-	nda	nda	Nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	Nda	II
Acheilognathus lanceolatus	Natural	-	nda	nda	nda	High susceptibility reported by Kumamaru 1973 cited by Hatai in Baldock et al. 2005 (p. 558). Original reference in Japanese; no info on histology	Nda	II
Aeathopagurus australia	Natural	-	nda	nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Australia	Nda	II
Alosa sapidissima	Natural	-	x	X	X	C & D. Sosa et al., 2007	Yes (PCR)	I
Alosa mediocris	Natural	-	nd	X	X	C & D. Sosa et al., 2007	Nda	II
Ambassis agassiz	Natural	-	nda	Nda	nda	Pearce 1990 (p. 30) Diagnosis likely to be based on clinical symptoms and epizootic trait of the disease.	Nda	II
Ambassis nalua	Natural	-	Nda	Nda	Nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	Nda	II
Ambassis sp.	Natural	-	Nda	Nda	Nda	listed by Tonguthai 1985 as species affected in outbreaks in Australia and Burma	Nda	II
Amblypharyngodon mola	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	Nda	II

Ameiurus nebulosus	Natural	-	nd	X	X	C & D. Sosa et al., 2007	nd	II
Ameiurus melas	Natural	-	X	X	X	A-D&ID. Hawke et al., 2003	Yes	I
Amniataba percoides	natural	-	Nda	Nda	Nda	Pearce 1990 (p. 30) ; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II
Amphipnous cuchia	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	Nda	II
Anabas ascanden	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	Nda	II
Anabas testudineus		-	Nda	Nda	Nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Sri Lanka) Tonguthai, 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Thailand) Khan et al., 2001, cited by Lilley et al. 2001 Roberts et al., 1994 refers to Roberts et al. 1986 Reantaso, 1991, cited by Liulley et al. 1998	Nda	II
Anguilla bicolor	Natural	-	Nda	Nda	Nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Sri Lanka) Tonguthai, 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Thailand)	Nda	II
Anguilla nebulosa	Natural	-	Nda	Nda	Nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II

Archosargus probatocephalus	Natural	-	nd	X	X	C & D. Sosa et al., 2007	Yes (PCR)	I
Arius sp.	Natural	-	nd	nda	nda	Pearce 1990 (p. 30) Diagnosis likely to be based on clinical symptoms and epizootic trait of the disease.	Nda	II
Arramphus sclerolepis	Natural	-	Nda	Nda	Nda	listed by Tonguthai 1985 as species affected in outbreaks in Australia	Nd	II
Badis badis	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	nd	II
Bairdiella chrysoura	Natural	-	nd	X	X	Noga et al. 1991 C, D and ID. Sosa et al., 2007	Yes (PCR)	I
Barbus sp.	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be suscpetible in disease outbreaks in Burma	Nda	II
Belone cancilla.	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	Nda	II
Bidyanus bidyanus	nda	-	Nda	Nda	Nda	Callinan unpublished, cited in Lilley et al., 1998	nda	II
Brevoortia tyrannus	Natural	-	X	X	X	B. Blazer et al., 1999 C & D, Noga et al. 1988 B and ID Phadee et al. 2004 (isolate from USA)	Yes (PCR)	I
Bunaka sp.	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nda	II
Caranx spp.	Natural	-	Nda	Nda	Nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II

Carassius auratus auratus	Natural Experimental invasive	-	X	X	X	C-D: Miyazaki & Egusa 1972, 1973a, cited by Hatai in Baldock et al. 2005 Experiments by Hatai, 1980, cited by Hatai in Baldock et al. 2005 B-D: Phadee et al. 2004 exp. c., PCR	Yes (PCR)	I
Carassius carassius	Natural, experimental invasive	-	nda	x	x	C-D: Miyazaki & Egusa, 1973b or c, cited by Hatai in Baldock et al. 2005 (p. 558); species is referred to as "crucian carp, Carassius auratus" (latin species name does not fit the common name). The same confusion about latin and common name is found in Lilley et al., 1998, who refers to a paper by Miyazaki, 1994, which supposedly reports both "Carassius auratus (crucian carp)" and "Carassius carassius auratus (goldfish)" as susceptible; given that both species are covered, one can conclude that Carassius carassius was one of the animals found to be susceptible; Hatai in Baldock et al. 2005 also reports to have undertaken challenge experiments, published by Hatai 1980, which have shown that both goldfish (Carassius auratus auratus) and crucian carp (no latin name provided) were susceptible to artificial infection;	yes	I
Catla catla	Experimental invasive	-	nd	X	X	C&D Ahmed & Hoque 1999	nda	II
Channa = Ophicephalus		-	Nda	Nda	Nda	Phan Thi Van unpublished, cited in Lilley et al., 2001	nda	II
Channa argus	Natural	-	Nda	X	X	Miyazaki & Egusa 1973, cited by Hatai in Baldock et al. 2005	Nda	II
Channa gachua= Ophicephalus gachua	Natural	-	Nda	Nda	Nda	Tonguthai 1985, lists the species as affected in disease outbreaks in Burma	nda	II

Channa maculata =Ophicephalus maculatus	nda	-	Nda	Nda	Nda	Miyazaki, 1994, cited in Lilley et al., 1998	nda	II
Channa marulia = Ophicephalus marulius	Natural	-	Nda	Nda	Nda	Khan et al., 2001, (cited in Lilley et al., 1998) Tonguthai 1985, lists the species as affected in disease outbreaks in Burma	Nda	II
Channa micropeltes = Ophicephalus micropeltes	nda	-	Nda	Nda	Nda	Chinabut unpublished, cited in Lilley et al., 1998	nda	II
Channa orientalies	nda	-	Nda	Nda	Nda	Khan et al., 2001	nda	II
Channa pleurophthalmus=ophicephalus pleurophthalmus	Natural	-	nd	X	X	C&D. Histopathological and macroscopic lesions Hanjavanit et al., 1997	Check	
Channa punctata = Ophicephalus punctatus	nda	-	x	nda	nda	B Lilley & Roberts, 1997 (the authors used an isolate from Bangladesh); Dahal unpublished, cited in Lilley et al., 2001	yes	II
Channa striata = Ophicephalus striatus	Natural	-	X	X	X	B-D and ID. Callinan et al., 1995 B, C, and D. Roberts et al., 1993 B&ID Willouboughby & Roberts C. Chinabut et al., 1995. B&ID Phadee et al. 2004 (isolate from Thailand)	yes	I
Chrysichthys nigrodigitatus	nda	-				OIE, 2006c Source?	Insufficient data	II
Cinetodus froggatti	Natural	-	Nda	Nd	nda	listed by Tonguthai 1985 as species affected in outbreaks	nda	II

				a		in Papua New Guinea		
Cirrhinus juillieni	Natural	-	Nda	Nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II
Cirrhinus mrigala	Natural	-	X	X	X	C & D. Roberts et al., 1993 B&ID Phadee et al. 2004 (isolate from Bangladesh)	Yes (PCR)	I
Cirrhinus reba, syn Cirrhinus ariza, syn. Labeo ariza	Natural	-	X	Nda	nda	B. in Miles et al., 2003; species listed as source of isolation of isolate used in the study	yes	II
Clarias batrachus	Natural	-	x	x	x	B-D and ID. Callinan et al., 1995 Tonguthai 1985 : Diagnosis based on clinical symptoms and epizootic trait of the disease ; species also listed as found to be suscpetible in disease outbreaks in Burma	Yes (non-sexually reproducing Aphanomyces sp.)	I
Clarias gariepinus	nda	-	Nda	Nda	Nda	Khan et al., 2001 Callinan unpublished, cited in Lilley et al., 2001	Nda	II
Clarias teysmanni brachysoma	Natural	-	Nda	Nda	Nda	Costa & Wijeyaratne 1989 : Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Colisa fasciatus	nda	-	Nda	Nda	Nda	Khan et al. (2001)	Nda	II
Colisa lalia	Natural	-	X	x	x	B-D Rha et al., 1996, cited by Hatai in Baldock et al. 2005; B Hatai et al., 1992 (isolate from Colisa lalia was used to challenge ayu and goldfish), ID Phadee et al. 2004 B&ID Phadee et al., 2004 (isolate from Singapore)	Yes (PCR)	I
Cyclocheilichtys enoplos	Natural	-	Nda	Nda	Nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II

Cynoscion regalis	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Cynoscion arenarius	Natural	-	nd	X	X	C & D. Sosa et al., 2007	nd	II
Cyprinus carpio	Experimental invasive, natural	-	nda	x	x	Wada et al. 1996, experimental invasive, C&D and ID : carp were only moderately susceptible Tonguthai 1985; listed as cultured species found to be susceptible in Burma	yes	I
Datnioides quadrifasciatus	Natural	-	Nda	Nda	Nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nd	II
Elecheronema tetradactylum	Natural	-	Nda	Nda	Nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nd	II
Epinephelus tauvina	Natural	-	Nda	Nda	Nda	Costa & Wijeyaratne 1989 ; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Sri Lanka) Tonguthai, 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Thailand)	nd	II
Epinephelus sp.	Natural	-	nd	X	X	Vishwanath et al., 1997a	nd	II
Esomus sp.	Natural	-	nd	x	x	Vishwanath et al. 1997b, 1998	nd	II
Esomus danrica thermoicos	Natural	-	nda	Nda	Nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Etroplus suratensis	Natural	-	nda	Nda	Nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Etroplus sp.	Natural	-	nd	x	x	Vishwanath et al. 1997b, 1998	nd	II
Fluta alba	nda	-	nda	Nda	Nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II

						Chinabut (unpublished), cited in Lilley et al., 1998, 2001)		
Fundulus grandis	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Fundulus heteroclitus	Experimental invasive	-	nd	x	x	Johnson et al., 2004	yes	I
Fundulus majalis	Experimental invasive	-	nd	X	X	Johnson et al., 2004	yes	I
Gerdes ovatus	Natural	-	Nda	Nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Australia	nd	II
Glossamia aprion	nda	-	Nda	Nda	nda	Pearce 1990 (p. 30) ; Diagnosis likely to be based on clinical symptoms and epizootic trait of the disease	nda	II
Glossogobius giurus	Natural	-	x	x	x	B-D and ID. Callinan et al., 1995 C&D Ahmed & Hoque 1999	Yes (non-sexually reproducing Aphanomyces sp.)	I
Glossogobius spp.	Natural	-	nd	X	X	Vishwanath et al. 1997b, 1998	nda	II
Heteropneustes fossilis	Natural	-	nd	X	X	C & D. Pathiratne & Jayasinghe, 2001, C&DVishwanath 1997b listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nd	II
Hexanematichthys lentaspis	Natural	-	Nda	Nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	Nda	II
Hexanematichthys danielsi	Natural	-	Nda	Nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	Nda	II
Hexanematichthys latirostris	Natural	-	Nda	Nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	Nda	II

Hyporhamphus gaimardi	Natural	-	Nda	Nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II
Ictalurus punctatus	Natural	-	X	X	X	B-D&ID. Hawke et al., 2003 C & D. Sosa et al., 2007	Yes	I
Johnius sp.	nda	-	Nda	Nda	nda	Reantaso, 1991 Lilley et al., 1998	nda	II
Johnius belengeri	Natural	-	Nda	Nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nd	II
Kurtus gulliveri	Natural	-	Nda	Nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nd	II
Labeo boga	Natural	-	Nda	Nda	nda	Tonguthai 1985; listed as species found susceptible in outbreaks in Burma		II
Labeo porcellus	Natural	-	Nda	Nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Labeo rohita	Natural	-	X	X	X	C & D. Roberts et al., 1993 B and ID. Willouboughby & Roberts, 1994	Yes	I
Labeo sp.	Natural	-	Nda	Nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	nd	II
Lates calcarifer	Natural	-	nd	nda	nda	Pearce 1990: p80: Pearce studied the progression of skin lesions in large Barramundi. Pearce mentions that large feral fish (as were used in the study) usually do not develop ulcerated lesions with deep fungal invasion. In reverse, the author seems to suggest that this type of lesion would have been expected from a smaller sized Barramundi and in consequence says that this is what	nda	II

						they have observed in small Barramundi. One of 5 Barramundi in the study developed granulomatous keratitis associated with fungal hyphae in the eye. (OIE, 2006c) Pearce 1989, cited by Roberts, 1994; citation suggests that Barramundi is susceptible Costa & Wijeyaratne 1989 list Lates calcarifer as susceptible, based on clinical symptoms and epizootic trait of the disease Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease (Thailand, Papua New Guinea and Burma)		
Lagodon rhomboides	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Leiopotherapon unicolor	Natural	-	nd	x	x	Pearce 1990 describes skin ulcers (p34) and mycotic granuloma (Fig 6.12)	nda	II
Leiostomus xanthunus	Natural	-	nd	x	x	Noga et al., 1991	nd	II
Lepomis macrochirus	Natural	-	X	X	X	C & D. Sosa et al. 2007 A-D&ID. Hawke et al., 2003	Yes	I
Liza diadema	nda	-	nd	nda	nda	Pearce 1990 (p. 30); Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II
Liza dussumieri	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	nda	II
Liza macrolepis	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical	nd	II

						symptoms and epizootic trait of the disease		
Liza ceramensis	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Liza sp.	nda	-	nda	nda	nda	Vinoba, unpublished; cited in Lilley et al., 2001	nda	II
Lobotes surinamensis	Natural	-	nda	nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nd	II
Lutjanus griseus	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Lutjanus argentimaculatus	Natural	-	nd	?	?	Pearce 1990 (p. 30) Listed as susceptible species. Diagnosis likely to be based on clinical symptoms and epizootic trait of the disease.	Insufficient data	II
Lutjanus sp.	Natural	-	nda	nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nda	II
Macrognathus aculeatus	nda	-	nda	nda	nda	Khan et al., 2001 (cited in Lilley et al., 2001)	Nda	II
Macrognathus (Mastacembelus) pancalus	nda	-	nda	nda	nda	Khan et al., 2001 (cited in Lilley et al., 2001)	nda	II
Macrognathus siamensis	Natural	-	x	Nda	nda	ID: Phadee et al., 2004 (isolate from Thailand) Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease (report from Thailand)	yes (PCR)	II
Macrones keletius	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Macrones vittatus	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical	nd	II

						symptoms and epizootic trait of the disease		
Mastacembelus armatus	nda	-	nda	nda	nda	Chinabut unpublished (cited by Lilley et al., 1998, 2001)	nda	II
Mastacembelus zebrinus	natural	-	nda	nda	nda	Tonguthai 1985 : species listed as found to be suscpetible in disease outbreaks in Burma	nd	II
Melanotaenia splendida	Natural	-	Nda	x	x	Pearce 1990, describes dermatitis and mycotic granuloma in muscle tissue (p 69)	nda	II
Microphis boaja	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II
Micropterus salmoides	Natural	-	x	X	X	C & D. Sosa et al., 2007	Yes, (PCR)	I
Micropogonias undulatus	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Morone saxatilis	nda	-	Nd	Nd	nd	Noga et al., 1991 Info insufficient. Ulcers found in 1 fish with aseptate hyphae found, no histo.	nd	II
Morulius calbasu	nda	-	nda	nda	nda	Khan et al., 2001, cited in Lilley et al. 2001	nda	II
Mugil curema	Natural	-	nd	X	X	Sosa et al., 2007	Yes (PCR)	I
Mugil cephalus	Natural	-	X	X	X	B&D. Fraser et al., 1992 B-D and ID. Sosa et al. 2007 B&IDPhadee et al. 2004 (Australian isolate)	Yes (PCR)	I
Mugil sp.	Natural	-	X	X	X	B. Callinan et al., 1995 C&D Vishwanath 1997b, 1998	Yes (non-sexually reproducing Aphanomyces sp.)	I
Mystus cavasius		-	nda	nda	nda	Khan et al., 2001	nda	II
Mystus nemurus	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II

Mystus tengara		-	nda	nda	nda	Khan et al., 2001	nda	II
Mystus vittatus	Natural	-	Nda	X	X	C & D. Pathiratne & Jayasinghe, 2001	nda	II
Mystus sp.	nda	-	nda	X	X	C&D : Vishwanath et al. (1998) Tonguthai 1985; listed as species found susceptible in outbreaks in Burma	nda	II
Nandus marmoratus	Natural	-	nda	nda	nda	Tonguthai 1985; listed as species found susceptible in outbreaks in Burma	nd	II
Nandus nandus	nda	-	nda	nda	nda	Khan et al., 2001 (cited in Lilley et al., 2001)	nda	II
Nematalosa sp.	Nda	-	nda	nda	nda	Vinoba, unpublished; cited in Lilley et al., 2001	nda	II
Nemantolosa erebi *Bony bream*	Nda	-	nda	nda	nda	Pearce 1990 (p. 30) Listed as susceptible species. Diagnosis likely to be based on clinical symptoms and epizootic trait of the disease.	nda	II
Notopterus notopterus	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease Chinabut unpublished, and Khan et al., 2001 (cited in Lilley et al., 1998, 2001)	Nda	II
Notopterus sp.	Natural	-	nda	nda	nda	Tonguthai 1985; listed as species found susceptible in outbreaks in Burma	nda	II
Ompole bimaculatus	Natural	-	nda	nda	nda	Tonguthai 1985; listed as species found susceptible in outbreaks in Burma	nda	II
Opicephalus sp.	Natural	-		X	X	C&D. Vishwanath 1997b	nda	II
Opicephalidae see also under *Channa* spp.	?	-	?	?	?		?	II

Oncorhynchus mykiss	Experimental invasive	-	X	X	X	Khan et al., 1998 Oidtmann et al. 2008	Yes (PCR)	I
Oreochromis mossambica	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II
Oreochromis niloticus	Experimental invasive	-		X	X	C&D. Khan et al., 1998 limited growth of A. invadans in host tissues – low susceptibility	yes	I (low susceptibility)
Osphronemus gouramy	Natural	-	X			B. Miles et al., 2003; authors used strain isolated from this species; isolate provided by V. Panyawachira	Yes (mAB)	II
Osteobrama cotio cotio	Nda	-	nda	nda	nda	Khan et al. 2001 (cited in Lilley et al. 2001)	nda	II
Oxyeleotris lineolatus	Natural	-	nda	nda	nda	Pearce 1990 (p. 30) Listed as susceptible species. Diagnosis based on clinical symptoms and epizootic trait of the disease.	nda	II
Oxyeleotris marmoratus	Natural	-	nda	nda	nda	ID: Lilley & Roberts, 1997 report that EUS was diagnosed in this species, but provide no detail on what grounds (table 1 of public.) Tonguthai 1985: Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II
Oxyeleotris sp.	Natural	-				Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nda	II
Paralichthys albigutta	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Paralichthys lethostigma	Natural	-	nd	X	X	Noga et al. 1991 C & D. Sosa et al. 2007	nd	II

Parmambassic gulliveri	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nda	II
Platycephalus fuscus	Nda	-	nda	nda	nda	Callinan, unpublished (cited in Lilley et al., 1998)	nda	II
Platycephalus sp.	Nda	-		x	X	Vishwanath et al., 1998	nda	II
Plecoglossus altivelis	Experimental invasive	-	X	X	X	C & D. Hatai 1980, cited in Baldock et al. 2005 B & ID Phadee et al. 2004 (isolate from Japan)	yes	I
Pogonias cromis	Natural	-	nd	X	X	C & D. Sosa et al., 2007	Yes (PCR)	I
Polydactylus sheridani	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nda	II
Pomatomus saltatrix	Nda	-	nda	X	X	Noga et al., 1991: fungal myositis (histo) found in 1 fish with ulcers and aseptate hyphae.	Nd	II
Priopidchtyusgymnocephalus	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea ; species name not found on fishbase	Nda	II
Priopidicthys sp.	Natural	-	nda	nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Australia, species name not found on fishbase	Nda	II
Pristolepis fasciatus	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II
Psettodes sp.	Nda	-	nda	nda	nda	Reantaso, 1991 (cited in Lilley et al., 1998)	nda	II
Puntius altus	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II

Puntius amphibius	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II
Puntius chola	Nda	-	nda	nda	nda	Dahal (unpublished) cited in Lilley et al., 2001	Nda	II
Puntius dorsalis	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nd	II
Puntius filamentosus	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Puntius gonionotus	Natural	-	nda	X	X	C & D. Roberts et al., 1993	nda	II
Puntius orphoides	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II
Puntius sarana	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Puntius sophore	natural	-	Nda	x	x	Ahmed & Hoque, 1999	nd	II
Puntius schwanenfledi	Experimental invasive	-	?	X	X	C & D. Khan et al., 1998	yes	I
Puntius ticto	Nda	-	X	Nda	nda	Khan et al., 2001 B Phadee et al. 2004 (isolate from Bangladesh)	nda	?
Puntius vittatus	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nda	II
Puntius sp.	Natural	-	nda	X	X	C&D Vishwanath, 1997b, 1998 (India) C&D Mohan & Shankar, 1995 (India)	nda	II
Rasbora danicornius	Natural	-	nda	nda	nda	Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II

Rasbora myersi	Natural	-	nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	nd	II
Rhodeus ocellatus	Experimental invasive	-	nda	X	X	C & D. Hatai, 1980, cited in Baldock et al. 2005	yes	?
Rhynehobdella sp.	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	nd	II
Rothee boelengeri	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Burma	nd	II
Rohtee sp.	nda	-	nda	nda	nda	Chinabut unpublished ; cited in Lilley et al., 1999. This is probably identical with Osteobrama cotio cotio (keti)	Nda	II
Rutilus rutilus	Experimental invasive (IM injection)	-		X	X	C. & D. Khan et al., 1998 limited growth of A.invadans in host tissues – low susceptibility	yes	I
Sarcocheilichthys variegates	Natural	-		Nda	nda	High susceptibility reported by Kumamaru 1973 cited by Hatai in Baldock et al. 2005; original source in Japanese, no info on histology	Nda	II
Scardinius erythrophthalmus	nda	-	Nda	Nda	nda	Marginally susceptible; Experiments by Hatai, 1980 cited in Lilley et al., 1998	nda	II
Scatophagus argus	Natural (P)	-	nda	nda	nda	Pearce 1990 (p. 30): Listed as susceptible species. Diagnosis based on clinical symptoms and epizootic trait of the disease. Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea Reantaso, 1991, cited in Lilley et al. 1998	Nda	II

Scatophagus sp.	Natural	-		x	x	Vishwanath, 1997b, 1998	Nda	II
Sciaenops ocellatus	Natural	-	nd	X	X	C & D. Sosa et al. 2007	nd	II
Scleropages jardini	Natural	-	nda	nda	nda	Pearce 1990 (p. 30) : Listed as susceptible species. Diagnosis based on clinical symptoms and epizootic trait of the disease.	Nda	II
Scutengraulis seratchlevi	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nda	II
Selenotoca multifasciata	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea	Nda	II
Siganus sp.	nda	-	nda	nda	nda	Vinoba, unpublished; cited in Lilley et al., 2001	Nda	II
Sillago ciliata	Natural Experimental invasive	-	X	X	X	B, D and ID. Natural : Fraser et al., 1992 C. experimental by Catap & Munday 2002	Yes	I
Sillago sp.	Natural	-	-	x	x	Vishwanath, 1997b, 1998	Nda	II
Silurus glanis	Experimental invasive (O)	-	X	X	X	Oidtmann et al. 2008	Yes (PCR)	I
Spheroides sp.	Natural	-	nda	nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Australia	nd	II
Strongylura kreffti	Natural	-	nda	nda	nda	Pearce 1990 (p. 30) ; Listed as susceptible species. Diagnosis based on clinical symptoms and epizootic trait of the disease.	Nda	II
Symbranchus	Natural	-	nda	nda	nda	listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nd	II
Tetrodon sp.	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible	nd	II

						in outbreaks in Burma		
Therapon sp.	Natural	-	nda	x	x	Vishwanath, 1997a, b, 1998	Nda	II
Tilapia mossambica, identical with *Oreochromis mossabicus*	Natural	-	nda	nda	nda	Tonguthai 1985; species listed as found to be susceptible in outbreaks in Papua New Guinea;	Nd	II
Trinectes maculatus	Experimental invasive (J) Natural (N)	-	nda	nda	nda	Johnson et al., 2004, info insufficient. No histology. Noga et al., 1991 : Info insufficient. Ulcers found in 1 fish with aseptate hyphae found, no histo.	Nda	II
Toxotes chatareus	natural	-	nda	nda	nda	Pearce 1990, p 30; Info insufficient; Listed under susceptible species. Diagnosis based on clinical symptoms and epizootic trait of the disease (OIE, 2006c) listed by Tonguthai 1985 as species affected in outbreaks in Papua New Guinea	nda	II
Toxotes lorentzi	Natural	-	nda	nda	nda	Pearce 1990 (p. 30) Listed as susceptible species. Diagnosis based on clinical symptoms and epizootic trait of the disease.	Nda	II
Trichogaster chuna	nda	-	nda	nda	nda	Khan et al., 2001	Nda	II
Trichogaster fasciata	Natural	-	nda	nda	nda	Tonguthai 1985; listed as species found susceptible in outbreaks in Burma	Nda	II
Trichogaster pectoralis	Natural	-	nd	X	X	C & D. Pathiratne & Jayasinghe, 2001	nd	II
Trichogaster trichopterus	Natural, experimental invasive (O)	-	X	X	X	A&B. Callinan et al., 1995 C&D. Histopathological and macroscopic lesions Hanjavanit et al., 1997 B &ID Phadee et al. 2004 (isolate from Japan); C,D & ID	yes	I

						Oidtmann et al. (2008) PCR		
Trichopsis vittatus	natural	-	Nda	nda	nda	Tonguthai 1985; Diagnosis based on clinical symptoms and epizootic trait of the disease	Nda	II
Tridentiger obscurus obscurus	Natural	-	Nda	X	X	Miyazaki & Egusa 1973, cited by Baldock et al. 2005	yes	I
Tylosurus sp.	nda	-	Nda	nda	nda	Vinoba, unpublished; cited in Lilley et al., 2001	Nda	II
Upeneus bansai	nda	-	Nda	nda	nda	Reantaso, 1991, cited in Lilley et al., 1998	Nda	II
Valamugil sp.	Natural	-	Nda	x	x	Vishwanath, 1997b, 1998	Nda	II
Wallago attu	Natural	-	Nda	X	X	Vishwanath et al., 1998	Nda	II
Xenentodon cancila	Natural	-	X	nda	nda	B and ID Willoughby & Roberts 1994 (isolate from Bangladesh – fish shows ulcers but no detailed information re granulomas) Costa & Wijeyaratne 1989; Diagnosis based on clinical symptoms and epizootic trait of the disease	yes	II

Epizootic Hematopoietic Necrosis

Table 9: Host species susceptible to EHNV

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Perca fluviatilis	Natural Experimental, non-invasive and	X	X	X	X	A: Inclusion bodies B: virus isolation from viscera Transmission via IP of supernatant from infected cells C: Kidney, liver, spleen, heart, swimbladder, pancreas, gills D: Immunoperoxidase staining ass w lesions.	Original virus isolation (Langdon et al. 1986)	I

						Langdon et al., 1986 Langdon and Humfrey, 1987 Langdon et al.,1989 Reddacliff and Whittington 1996		
Oncorhynchus mykiss	Natural Experimental, non-invasive:	X	X	X	X	A: Inclusion bodies B: Virus isolation from kidney, liver, spleen and brain. C: Liver, spleen, kidney, brain, gastrointestinal epithelium, heart, swimbladder and gills. D: Virus recovered from internal organs Experimental infection (bath): re-isolation from one individual. Langdon et al., 1988 Reddacliff and Whittington 1996 Whittington et al., 1999	Yes	I
Salmo salar	Experimental, invasive	nd	X	X	X	B+D: Virus isolation from brain and kidney, but not from liver and spleen. C: Depression, extreme darkening, apperent blindness, cessation of feeding, severe vacuolating encephalopathy of the optic lobe and lesser degrees of focal vacuolation in the cerebellar fibre tracts and in the optic nerve, small foci of hepatocellular necrosis. No mortality. Langdon et al., 1986	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Retropinna semoni	Experimental, non-invasive	nd	nd	nd	nd	B: no reisolation of virus C: no disease or mortality Cohabitation and bath Langdon et al.,1989	Original virus isolation (Langdon et al. 1986) used in infection trial	II
Carassius auratus	Experimental, invasive and non-invasive	nd	nd	nd	nd	B: no reisolation of virus C: no disease or mortality Langdon et al.,1989	Original virus isolation (Langdon et al. 1986) used in infection trial	II
Gambusia affinis	Experimental, non-invasive	nd	X	X	X	B: virus isolation from nine affected fish C: Some clinical sign consistent with EHNV lesions and mortality D: Virus isolation from internal organs Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	I
Galaxias olidus	Experimental, non-invasive	nd	X	X	X	B: Virus isolated from all exposed fish. C: haematopoietic necrosis D: Virus isolation from internal organs	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used	I

						Clinical signs and mortality Langdon et al.,1989	in infection trial	
Macullochella peeli	Experimental, non-invasive and invasive	nd	X	X	X	B: Virus isolation from 2/4 fish after 24 days post bath exposure. (Viscera of all inocluated fish - IP) C: No clinical signs from bath (pancreas and liver – IP) D: Virus isolation from internal organs Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Maqauria australasica	Experimental, non-invasive and invasive	nd	X	X	X	B: Virus isolation from viscera from all exposed fish (and all inoculated – IP) C: kidney, liver spleen, pancreas D. Virus isolation from internal organs Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	I
Bidyanus bidyanus	Experimental, non-invasive and invasive	nd	X	X	X	B: Virus isolation from 10 dead / 26 total bath. Virus isolation from all inoculated fish C: Kidney bath Pancreas and kidney - IP D: Virus isolation from internal organs Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	I
Maqauria novemaculeata	Experimental, non-invasive and invasive	nd	?	?	nd	B: No (virus isolation from 1 moribund IP)) C: No (1/4 survivors spleen, kidney, liver- IP) D: Virus isolation from internal organs (IP) Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Maqauria ambigua	Experimental, non-invasive and invasive	nd	?	?	nd	B: No – Bath. (Yes –IP) C: No (Spleen Kidney liver – IP) Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Lates calcarifer	Experimental, non-invasive and invasive	nd	nd	nd	nd	B: no reisolation of virus C: no disease or mortality Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Capoeta tetrazona	Experimental, non-invasive	nd	nd	nd	nd	B: no reisolation of virus C: no disease or mortality Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Esox lucius	Experimental, non-invasive	nd	X	X	X	A: B: virus isolation on cell culture	Yes	I

						C+D: Infected cells showed hypertrophy, vacuolization and pyknotic nuclei or karyorrhexis in liver, heart, kidney, spleen and gills. Degenerative changes consistent with loss of function were most prominent in the kidneys where the structure of the sinusoids was hard to define as a result of destruction and haemorrhaging. In the gills, the most common lesions were hydropic changes and karyorrhexis in the epithelial cells. D: virus isolation from pool of kidney/spleen/heart. Britt Bang Jensen, pers.com.		
Paratya australiensis	Experimental, non-invasive	nd	nd	nd	nd	Not susceptible to EHNV when cohabited with EHNV-infected *Perca fluviatilis*. They remained healthy and it was not possible to reisolate virus. Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Daphnia carinata	Experimental, non-invasive	nd	nd	nd	nd	Not susceptible to EHNV when cohabited with EHNV-infected *Perca fluviatilis*. They remained healthy and it was not possible to reisolate virus. Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Cherax destructor	Experimental, non-invasive	nd	nd	nd	nd	Not susceptible to EHNV when cohabited with EHNV-infected *Perca fluviatilis* or by immersion. They remained healthy and it was not possible to reisolate virus. Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II
Agraptocorixa sp.	Experimental, non-invasive	nd	nd	nd	nd	Not susceptible to EHNV when cohabited with EHNV-infected *Perca fluviatilis*. They remained healthy and it was not possible to reisolate virus. Langdon et al.,1989	Original virus isolation from *Perca fluviatilis* (Langdon et al. 1986) used in infection trial	II

Viral Haemorrhagic Septicaemia

Table 10: Host species susceptible to VHSV

Host species	Natural/experimental Invasive/Non-invasive	A	B	C	D	Asessment	Pathogen ID	Group
Oncorhynchus mykiss	Natural	nda	X	X	X	B+D) Isolation in cell culture from spleen and kidney (Jensen, 1963 & 1965) C. Outbreak, 30% mortality (Jensen, 1965). A description of the pathology is given by Wolf (1988) based on personal observations and published literature.	Yes: F1, first isolation of VHSV	I
	Experimental, non-invasive	X	X	nda	X	A+B+D) Rainbow trout infected with VHSV strain F1 (not necessarily the original F1, but a serologically similar virus!) by immersion were catherisized at day 1 with an indwelling catheter connected to the urinary bladder. Virus could be isolated from blood and urine from day 3 with titres up to $10^{8.5}$ $CCID_{50}$/ml in blood and 10^{5} $CCID_{50}$/ml in urine. The fish were tested by virological and serological examinations before entering into the experiment and found free of VHSV. The reisolated virus was verified as VHSV by neutralisation test (Neukirch, 1984)		
Oncorhynchus tshawytscha	Natural	nda	X	nda	X	B+D) Cell culture from internal organs (Hopper, 1989)	Virus identified by EM of cell culture, protein profiling, serum neutralization test, FAT, Western blot (Winton et al, 1989)	I
	Experimental, non invasive	nda	nda	nda	nda	Juvenile Chinook salmon, exposed to effluent from infected adult coho salmon were sampled and found to be positive for VHSV (Brunson et al., unpublished in Amos, 1998) Refractory to the tested isolates, no virus re-isolation (Follett et al., 1997).	Known VHSV isolate used in infection trials (Follett et al. 1997)	
Oncorhynchus kisutch	Natural	nd	X	nd	X	B) Cell culture from internal organs (Brunson et al, 1989), spawning fluids (Brunson et al, 1989; Eaton et al, 1991) D) Internal organs (Brunson et al, 1989), and spawning fluids (Brunson et al, 1989; Eaton et al, 1991,)	Virus identified by EM of cell culture, protein profiling, serum neutralization test, FAT, Western blot (Winton et al, 1989) and by	I

	Experimental non invasive	nd	nd	nd	nd	Juvenile Chinook salmon, coho salmon, and steelhead exposed to effluent from infected adult coho salmon were sampled and found to be positive for VHSV (Brunson et al., unpublished in Amos et al, 1998). Refractory to the tested isolates, no virus reisolation (Follett et al., 1997).	neutralization assay and immunoblot (Eaton et al, 1991)	
Oncorhynchus keta	Natural	nd	nd	nd	nd	Marty, Karreman & Jones, abstract, Victoria meeting 2006. VHSV by PCR only, cell culture not performed.	Insufficient data	II
Oncorhynchus nerka	Natural	nd	nd	nd	nd	Marty, Karreman & Jones, abstract, Victoria meeting 2006. VHSV by PCR only, cell culture not performed.	Insufficient data	II

	Experimental, non-invasive	nd	nd	nd	nd	Refractory to the tested isolates, no virus reisolation (Follett et al. 1997).	Known VHSV isolated used in infection trial.	
Oncorhynchus gorbuscha	Experimental, non-invasive	nd	nd	nd	nd	Refractory to the tested isolates, no virus reisolation (Follett et al. 1997).	Known VHSV isolated used in infection trial.	II
Salmo salar	Natural	nd	X	?	nd	B) Not stated how the virus was isolated or from which organs. C) VHSV isolated from farmed Atlantic salmon in 1995 (Traxler, 1995), 1998, 1999 and 2002 in BC, Canada. The isolations occurred in winter/spring period, often coinciding with herring spawning in the close to the farm site. Losses were in one case chronic, eventually reaching 10%, and in another were 2% per week (Traxler, personal communication).	VHSV verified by DNA probe	I
		nd	nd	?	nd	C) The fish had ceased eating and clinical signs in some moribund fish suggested an infectious agent. Abnormal mortality levels were not observed. Fish were submitted for histopathology and tissue culture – VHSV was isolated, but by histopath or tissue culture not stated. (Amos & Thomas, 2002)	Insufficient data	
		nd	X	nd	X	B+D) Isolation in cell culture from internal organs (Noygayrede 1988)	?	
	Experimental, non invasive	nd	X	nd	X	B+D) Cell culture from internal organs (King et al, 2001)	Known VHSV isolates used in infection trial. Reisolations verified by ELISA.	
		nd	X	nd	X	B+D) Cell culture from internal organs up to 10^3 dilution Fish checked virologically before start of experiment. Bath 5x 10^4 PFU/ml. Neutralizing antibodies produced by survivor fish, checked at day 79 post infection (de Kinkelin & Castric, 1982)	Known VHSV isolates used in infection trial.	

	Experimental, invasive	?	X	X	X	A) Effluent from IP infected salmon induced mortality in rainbow trout at day 8-30 after IP injection B+D) Cell culture from internal organs up to 10^6 dilution. C) Histology and gross. Fish checked virologically before start of experiment. Injected 1x 10^3 PFU/fish. Neutralizing antibodies produced by survivor fish, checked at day 79 post infection. (de Kinkelin & Castric, 1982).	Known VHSV isolates used in infection trial.	
Salmo trutta	Natural	nd	X	X	?	B+D) Cell culture from internal? organs. C) Histology and gross lesions comparable with VHS. (Bovo et al. 1982)	Virus identified by immunoflouresence but not stated which antibody they used.	I
		nd	X	X	X	B+D) Cell culture from internal organs. C) Histology and gross lesions comparable with VHS. (de Kinkelin & le Berre, 1977)	Virus identified by seroneutralization test?	
		nd	X	X	X	B+D) Cell culture from internal organs. C) Exophthalmia, periocular haemorrhages, haemorrhages in the muscle and at the fin bases. (Schlotfeldt & Ahne, 1988)	Identified by neutralization test and IFAT.	
		nd	X	nd	nd	P.E.V. Jørgensen, unpublished. VHSV isolated from brown trout from a Danish trout farm. Not possible to find further information in the old protocols.	nd	
		nd	X	?	?	B) Virus isolation in cell culture. C) Fish found dead. D) Gill + visceral organs pooled together. (Gagné et al. 2007)	VHSV verified by RT-PCR and sequencing (genotype IVb)	
		?	nd	nd	nd	Antibodies in feral brown trout, virus isolation not attempted. Of 608 sera tested, 27% were positive (min 0%, max 60%), sampled in 16 different waters. (Enzmann et al. 1993)		
	Experimental, non-invasive	nd	X	X	nd	B. Re-isolation of virus. C VHS-like symptoms and mortality up to 79% Negative controls included. (Jørgensen, 1980)	Known VHSV isolates used. Re-isolations verified by IFAT	

		nd	X	?	X	B+D) Re-isolation of virus from organs. C) Limited mortality. (Glass et al, 1991)	Known VHSV isolate used.	
	Experimental, non-invasive	nd	X	nd	X	A+B+D) Rainbow trout analysed and found free for VHSV. Stated that brown trout were free of VHSV, but no testing stated. Virus transferred from infected RT to BT (cohab at day 5), verified by isolation of VHSV from blood samples from day 4 after cohabitation. VHS developed in RT with severe symptoms and high virus titers. BT showed no symptoms and virus titers low. No negative control fish stated. (Enzmann et al, 1993)	Known VHSV isolate used.	
Thymallus thymallus	natural	nd	X	X	?	B+D. isolation in cell culture (whole fish or organs not stated) C) vereinzelt spiral swimming und gelegentlich blutungen in bereich der rückenflossenbasis beobachtet. Der verlus bertrug etwa 50%. Histologically, blutungen ausgedehnte necroses in the liver, the haematopoietic part of the kidney and in pancreas. Vacuolar degeration of the intestinal epithelium was observed in all parts of the intestine. (Wizigmann et al. 1980)	VHSV verified by neutralization test and IFAT	I
	Natural	nd	X	X	?	B) Virus isolated on cell culture C) Two independent outbreaks in grayling fry resulting in mortalities up to 100% within few days. Most affected individuals floated listlessly on the surface and showed pronounced signs of a haemorrhagic septicaemia. D) Not stated from which tissues virus was isolated. (Meier & Wahli 1988)	VHSV verified by serum-neutralization and IFAT	

	Experimental, non-invasive	nd	X	X	X	B) Virus re-isolation in cell culture from infected fish, not from negative controls C) High mortality rate (56-100%) in infected groups, mortality rate for negative control group not stated. Gross: listless fish floating on one side, erratic swimming, tiny subcutaneous haemorrhages, exophthalmus, pale gills. Histology: focal necrosis in the liver, spleen intestinal mucosa D) Whole fish or kidney/liver/spleen used for virus isolation Negative control fish included, experiment. carried out twice (Meier & Wahli 1988)	VHSV verified by serum-neutralization and by IFAT	
Coregonus lavaretus	Experimental, invasive and non-invasive	nd	X	X	nd	B) Virus re-isolated from the majority of fish (IP and immersion) C) Darkening of the body, exophthalmia, haemorrhage in the skin and eyes, mortality immersion 20%, mortality IP 100%). Control fish showed no signs. D) Whole fish examined (Skall et al. 2004)	Re-isolations verified as VHSV by ELISA	I
Coregonus spp.	Natural	?	X	X	X	A) Antibodies to VHSV detected in 45% of tested sera from 120 fish caught in Lake Constance (test not validated) (Enzmann et al. 1993). B) Virus isolation from a pool of internal organs or whole fish on cell culture. Virus identified by neutralization test (Ahne & Thomsen 1985) or 50%PNT (Meier et al. 1986). C) Limited gross lesions (Ahne & Thomsen 1985). Septicaemia, haemorrhages and mortality up to 50% (Meier et al. 1986) D) virus isolation from a pool of kidney, liver and spleen (Ahne & Thomsen 1985)	VHSV verified by neutralization test or 50%PNT	I

	Experimental, non-invasive	X	X	X	X	A) Virus re-isolation from internal organs with a titre of $10^{6.8}$ $TCID_{50}$/g B) Virus re-isolation from internal organs with a titre of $10^{6.5}$ $TCID_{50}$/g C) Mortality: 9/25 dead on day 6. Bleedings in the base of the fins D) Virus re-isolation from a pool of internal organs Not stated if the fish were tested for VHSV before start of the experiment. No negative controls included. (Ahne & Thomsen 1985)	Known VHSV isolate used.	
Coregonus clupeaformis	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	nd	II
Esox masquinongy	Natural	nd	X	?	X	B+D) Virus isolation in cell culture from kidney-spleen-swim bladder tissue C) Congestion of internal organs, the inner wall of the swim bladder was thichkened and contained numerous budding, fluid-filled vesicles – caused by VHSV? 4 of 27 fish examined positive (Elsayed et al. 2006)	VHSV identified by EM, RT-PCR and sequencing (genotype IVb, GenBank ac. No. DQ401193)	I
Esox lucius	Natural	nd	X	X	nd	B) isolation in cell culture (whole fish or organs not stated) C) the diseased fish went to the water surface, zeigten blutungen in the musculature, vor allem in höhe des afters, und starben innerhalb weniger stunden. Finally they died. Histologically, blutungen ausgedehnte necroses in the liver, the haematopoietic part of the kidney and in pancreas. Bei den hechten fiel vor allem die fast complete necrosis in the Langerhans islands. Furthermore did the excretory part of the kidney show a vacular degeneration of the tubulus epithel as well as ablagerunge eiweissreicher, hyaline amorph mass in the tubulus lumina Wizigmann et al. 1980)	VHSV verified by neutralization test and IFAT	I

		X	X	X	?	A) EM demonstrated rhabdoviral particles within capillary endothelial cells of the anterior kidney (Meier, 1981). B) Isolation of VHSV in cell culture, verified by IFAT and 50%PNT (Meier & Jørgensen 1979, Meier 1980). C) Mortality close to 100%, widespread haemorrhages in the skin and muscles and exopthalmus, pale gills, histologically necroses were seen in liver, spleen and pancreas (Meier & Jørgensen 1979; Meier 1980, 1981). D) Whole fish or internal organs used for virus isolation (Meier & Jørgensen 1979).		
		nd	nd	?	nd	C) VHS outbreak in 23 of 45 farms, how diagnosis made is not stated but stated that exact laboratory diagnosis is necessary, two forms recognized: the hydrocephalus form and the haemorrhagic form VHSV antibodies detected in 34% of 127 sera (min 0%, max 68%) from fish caught in 12 different waters (Enzmann et al. 1993)		
	Experimental, non-invasive	X	X	nd	X	A+B+D) Rainbow trout and pike analysed and found free for VHSV. No negative control fish stated. Virus transferred from infected RT (day 6 after RT infection) to pike, verified by isolation of VHSV from blood samples from day 2 after cohabitation and onwards. At day 14 the pike were transferred to a tank with RT, VHSV isolated from RT 4 days after transfer from blood samples (Enzmann et al. 1993)		
Clupea harengus	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs (Dixon et al. 1997, King et al 2001, Mortensen et al. 1999, Skall et al. 2005, Skall pers.com.) 89 isolates	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I

Clupea pallasii	Experimental, non invasive (SPF fish)	X	X	X	?	A) Titers in fish raised over time from not detectable to up til $10^{7.7}$ PFU/ml. Virus shedding in water was examined, and the fish did excrete virus in high amounts, on average $10^{6.5}$ PFU/h/fish. B) VHSV reisolated from infected fish by cell culture. C) Clinical disease, mortality approaching 100%, generally 1-2 mm haemorrhagic areas on the lower jaw and isthmus and around the eye but 2 of 130 fish showed extensive cutaneous haemorrhaging, histopathology showed multifocal eoagulative necrosis of hepatocytes, diffuse necrosis of interstitial haematopoietic tissues in the kidney, diffuse necrosis of the spleen epidermis and subcutis, and occasional necrosis of pancreatic acinar cells. D) Midportion of fish examined for presence of virus. (Kocan et al. 1997)	Yes, VHSV verified by DNA probe or RT-PCR.	I
	Natural	nd	X	X	X	B+D) Virus isolation by cell culture from internal organs. C) Epizootic mortality, moribund fish no apparent external lesions, behaved lethargic, floating upside down and swimming in circles. VHSV confirmed by PCR, DNA probe. (Meyers et al. 1999)		
		nd	X	nd	X	B+D) Virus isolation in cell culture from kidney-spleen samples (Kent et al. 1998, Marty et al. 1998) VHSV confirmed by DNA probe (Kent el al. 1998). No statement how virus was identified as VHSV (Marty et al. 1998). 40 isolations.		
		X	X	nd	X	A) VHSV not detected in water in pounds before introduction of herring (day 0) with up to 700 PFU ml-1 after 8 days of confinement. B) Isolation in cell culture, up to 10^{8} PFU g^{-1}. C. Virus isolations from both moribund and non-moribund fish, pathology not described. D. Isolation from pools of kidney-spleen. VHSV verified by RT-PCR (Hershberger et al. 1999)		
Sprattus sprattus	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal	VHSV verified by ELISA	I

						organs (Mortensen et al. 1999, Skall et al. 2005, Skall pers.com.). 44 isolates	and sequencing (Snow et al. 2004).	
Sardinops sagax	Natural	?	X	X	X	A) Titers for pooled kidney-spleen tissue in sardine and herring ranged from 1.2 x 10^2 to 1.6 x 10^6 PFU/g. B) Isolation in cell culture from diseased and healthy looking fish. C) British Columbia: mass mortality episode, in some sardines external signs similar to those describe in Pacific herring, which signs not reported. VHSV isolations from 95 of 163 sardines. California: healty sardines. D) Gill?-kidney-spleen samples for virus isolation from BC. From healthy sardines the isolation came from kidney-spleen samples. (Hedrick et al. 2003, Hedrick, pers.com.)	VHSV verified by RT-PCR and sequencing (Hedrick et al. 2003)	I
Dorosoma cepedianum	Natural	nd	?	?	?	B+D) PCR and cell culture performed without stating for which samples what was done. C) Clinical disease stated without further information (DeHaven, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Gadus morhua	Natural	nd	X	?	X	B+D) Virus isolation in cell culture from pools of internal organs and/or skin lesions. (Mortensen et al. 1999, Skall et al. 2005, Skall pers.com.) 7 isolates, 4 from internal organs, 3 from skin samples	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
		nd	X	?	X	B) Virus isolation in cell culture (Smail 2000, King et al. 2001). C) Ulcer, caused by VHSV? (Smail 2000). Skin lesion (King et al. 2001). D) Isolated from skin sample with ulcer/lesion (Smail 2000, King et al. 2001). No isolation from corresponding organ material (King et al. 2001). 3 isolates		
Gadus macrocephalus	Natural	nd	X	?	?	B) VHSV isolated from 2 cods caught in 2 different years. Confirmed by EM, PNT, dotblot, T1 ribosomal fingerprinting (Meyers et al. 1992). VHSV isolated from sport-caught cod (Meyers et al. 1994).	VHSV confirmed by DNA probes	II

						C+D) VHSV isolated from wounds. No typical VHS gross lesions. Attempted isolation from kidney-spleen from 1 fish failed (Meyers et al. 1992). VHSV isolated from gut-liver pool and from skin sample from sport-caught fish (Meyers et al. 1994).		
Melanogrammus aeglefinus	Natural	nd	X	?	?	B) Virus isolation in cell culture. C) Deep petechial haemorrhaging on the tail, caused by VHSV? D) Virus isolated from alcohol-swabbed skin sample. 2 isolates. (Smail, 2000)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	II
Trisopterus minutus	Natural	nd	X	nd	X	B+D) Isolation in cell culture from a pool of internal organs. 1 isolates (King et al. 2001)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Merlangius merlangus	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs. 3 isolates (King et al. 2001, Mortensen et al. 1999)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Micromesistius poutassou	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs. 2 isolates. (Brudeseth et al. 2002, Mortensen et al. 1999)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Trisopterus esmarkii	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs. 19 isolates (Brudeseth et al. 2002, King et al. 2001, Mortensen et al. 1999)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Theragra chalcogramma	Natural	X	X	X	X	A) 3.16 x 10^6 $TCID_{50}$ ml^{-1} of original organ material. B+D) Virus isolation from internal organs by cell culture in 2/2 fish. C) Epizootic mortality, moribund fish, no apparent external lesions, behaved lethargic, floating upside down and swimming in circles. Several histological changes that may or may not be caused by VHSV. (Meyers el al. 1999)	VHSV confirmed by PCR, DNA probe.	I
Microgadus proximus	Natural	nd	X	nd	nd	B. tissue not described (P. Reno, unpublished in Meyers et al. (1999))	nd	II

Enchelyopus cimbrius	Natural	nd	X	nd	X	B) Isolation in cell culture from a pool of internal organs. 1 isolate. (Mortensen et al. 1999)	Yes - VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Lota lota	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Merluccius productus	Natural	X	X	X	X	A) up to 3.16 x 10^5 $TCID_{50}$ ml^{-1} of original organ material. B) Virus isolation by cell culture in 10/10 fish. C) Epizootic mortality, moribund fish, no apparent external lesions, behaved lethargic, floating upside down and swimming in circles. Several histological changes that may or may not be caused by VHSV. D) Viral isolation from internal organs. (Meyers et al. 1999)	VHSV confirmed by PCR, DNA probe.	I
Limanda limanda	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs. 7 isolates. (Skall et al. 2005, Skall pers.com.)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Platichthys flesus	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs. 6 isolates. (Skall et al. 2005)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Pleuronectes platessa	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs. 2 isolates. (Skall et al. 2005)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Parophrys vetula	Natural	nd	X	nd	?	Single isolation from wild fish (Hershberger, pers.com.) Hershberger & Kocan, unpublished, referred in Hershberger et al. (1999).	Insufficient data	II
Reinhardtius hippoglossoides	Natural	nd	X	nd	X	B) Virus isolation in cell culture from spleen/kidney (15/30 fish) at second passage. (Dopazo et al. 2002)	VHSV verified by immunodot, EM, no reaction with MAb IP5B11 in IFAT. As all other VHSV isolates to day reacts with IP5B11, isolates were tested in ELISA at the CRL-fish	I

							using IP5B11 with positive result.	
Scophthalmus maximus	Natural	nd	X	X	X	B) Isolation in cell culture (Ross et al. 1994, Schlotfeldt et al. 1991). C) Sudden mortality, exophthalmia, skin and liver haemorrhages (Schlotfeldt et al. 1991). Increasing mortality, exophthalmia, distended abdomen, ascites, pale liver, white colouration of the kidney, lower intestine and heart, visceral haemorrhage, body swelling due to fluid retention, focal haemorrhaging behind the retina and within the musculature (Ross et al. 1994, Munro, 1996). Histology revealed widespread collapse and necrosis of cardiac muscle, widespread necrosis of hepatocytes, highly vacuolated kidney tubules (Ross et al. 1994). D) Isolated from a pool of internal organs (Schlotfeldt et al. 1991). Probably internal organs, but not directly stated (Ross et al. 1994).	VHSV verified by EM, 50%PNT, IFAT (Schlotfeldt et al. 1991) VHSV verified by ELISA, neutralisation test (Ross et al. 1994). Verified by sequencing (Snow et al., 2004).	I
Paralichthys olivaceus	Natural	nd	X	nd	X	B+D) Virus isolation on cell culture from head kidney-brain pools. Wild fish, 18 isolates. (Takano et al. 2000, 2001)	Isolates verified as VHSV by neutralization tests, IFAT	I
		X	X	X	X	A. TEM of infected cardiac muscle, necrotic haematopoietic tissue and spleen showed virus particles. B. Virus isolation on cell culture. C. Gross: cumulative mortality up to 70%, dark body colouration, expanded abdomen due to ascites, pale gills, congested liver, splenomegaly, swollen kidney, haemorrhage in the lateral musculature. Microscopically: necrotic heart muscle fibres, necrosis in the haemotopoietic tissues. D. Virus isolation from spleen. Immunohistochemical staining of necrotic heart muscle fibres and spleen .(Isshiki et al. 2001)		
		nd	X	nd	X	B) Virus isolation on cell culture. D) Head, kidney and brain tissue used for isolation. (Watanabe et al. 2002)		
Ictalurus nebulosus	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList	Insufficient data	II

						.pdf		
Ictalurus punctatus	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Argentina sphyraena	Natural	nd	X	nd	X	B+D) Isolation in cell culture from a pool of internal organs. 1 isolate. (Mortensen et al. 1999)	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I
Thaleichthys pacificus	Natural	nd	X	nd	?	B) virus isolation in cell culture from 6 of 15 pooled samples of 5 fish (Hedrick et al. 2003; Kaufman & Holt, 2001) C) Healthy in appearance {Hedrick et al. 2003; Kaufman & Holt, 2001) D) Virus isolation from a pool of kidney-spleen {Hedrick et al. 2003), gill-kidney-spleen {Kaufman & Holt, 2001). It is the same samples mentioned in the 2 references!	VHSV verified by RT-PCR and sequencing (Hedrick et al. 2003)	II
Hypomesus pretiosus	Natural	X	X	X	?	A) 4.2 x 10^4 – 1.4 x 10^6 PFU g^{-1} tissue. B) Isolated on cell culture. C) Natural outbreak in captivity, 60 of 60 dead or moribund fish VHSV positive. D) Gill?-kidney-spleen samples used for virus isolation. (Hedrick et al. 2003)	VHSV verified by RT-PCR and sequencing (Hedrick et al. 2003)	I
Ammodytes hexapterus	Natural, laboratory conditions	X	X	X	?	A) 3 x 10^5 – 4 x 10^6 PFU g^{-1} tissue B) Isolation on cell culture. C) Disease outbreak. D) Midportion of whole fish. (Kocan et al. 2001)	Virus identified as VHSV by DNA (Kocan et al. 2001)	I
Ammodytes spp.	Natural	nd	X	nd	X	B+D) Isolation in cell culture from a pool of internal organs (Skall et al. 2005, Skall pers.com.). 1 isolate	VHSV verified by ELISA	I
Ammodytes personatus	Natural	nd	X	nd	X	B) Virus isolation on cell culture. D) head kidney and brain tissue used for isolation. 1 isolation. Wild fish. (Watanabe et al. 2002)	VHSV was verified by IFAT	I
Pomatoschistus minutus	Natural	nd	X	nd	X	B+D) Isolation in cell culture from pools of internal organs (Skall et al. 2005, Skall pers.com.) 3 isolates	VHSV verified by ELISA and sequencing (Snow et al., 2004).	I

Neogobius melanostomus	Natural	nd	X	X	X	B) Virus isolation on cell culture, C&D) Large scale fish kill, all the fish examined showed a wide range of signs indicative of a haemorrhagic disease. Most notable were signs of anaemia indicated by pale colouration to the gill lamellae and pale liver. Haemorrhagic areas were seen in many organs, in particular the omentum, abdominal fat, gonads, liver, muscle tissue, skin and fins. None of the fish had food in their gastrointestinal tracts. Affected hepatocytes appeared severly vacuolated with occasional pyknotic and karyolitic nulei. The posterior renal tissue was similarly affected with evidence of scattered individual cell necrosis. Severe splenic parenchymal necrosis and depletion characterized by individual cell necrosis. (Groocock et al, 2007)	VHSV verified by RT-PCR and sequencing (genotype IVb, GenBank ac.no. EF564588	I
Cymatogaster aggregata	Natural	nd	X	nd	X	B) Virus isolation in cell culture. C) Clinically normal fish. D) kidney-spleen sample used for isolation 10 isolations (Kent et al. 1998)	VHSV confirmed by DNA probe (Kent et al. 1998, Hedrick et al. 2003)	I
		nd	X	?	?	B) Isolation in cell culture. C) Submitted in connection with a mass mortality episode predominantly involving *Sardinops sagax*. D) Isolation from a pool of gill?-kidney-spleen. (Hedrick et al. 2003)		
Micropterus salmoides	natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
	Natural	nd	X	?	nd	B) Not stated how the virus was isolated. C) Mortality (co-infection with *Aeromonas salmonicida*). (de Kinkelin et al. 1999 (POSTER))		

	Experimental, non-invasive	?	X	X	?	A) Co-habitation trial LMB → RT B) Not stated how the virus was re-isolated. C) Mortality. Gross clinical signs discrete, histological lesion observed were foci of necrosis in lymphoid tissue in kidney Negative control fish included, VHSV not isolated from these. (de Kinkelin et al. 1999 (POSTER))		
Micropterus dolomieu	Natural	nd	X	?	nd	B) PCR and cell culture performed without stating for which samples what was done. C. Clinical disease stated without further information. (DeHaven, 2006; Evans, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Lepomis macrochirus	Natural	nd	X	?	nd	B. PCR and cell culture performed without stating for which samples what was done. C. Clinical disease stated without further information (Evans, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Pomoxis nigromaculatus	Natural	nd	X	?	nd	B) PCR and cell culture performed without stating for which samples what was done. C) Clinical disease stated without further information (Evans, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Ambloplites rupestris	Natural	nd	x	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Lepomis gibbosus	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Aplodinotus grunniens	Natural	X	X	X	X	A+D) TEM heart. B) Virus isolation in cell culture. C) Disease outbreak, with histology and gross lesions. (Lumsden et al. 2007)	VHSV verified by ELISA, RT-PCR and sequencing, genotype IVb (Lumsden et al. 2007)	I
Perca flavescens	Natural	nd	X	nd	nd	B) PCR and cell culture performed without stating for which samples what was done. C) Clinical disease stated without further information. (DeHaven, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList	Insufficient data	II

						.pdf		
Sander vitreus	Natural	nd	X	nd	nd	B) PCR and cell culture performed without stating for which samples what was done. C) Clinical disease stated without further information. (DeHaven, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Scomber japonicus	Natural	nd	X	?	X	B) Virus isolation in cell culture. C) Apparently healthy mackerel. D) Virus recovered from a pool of spleen-kidney tissue. (Hedrick et al. 2003 and pers.com.)	VHSV verified by RT-PCR and sequencing {Hedrick, 2003)	I
Morone chrysops	Natural	nd	X	?	nd	B. PCR and cell culture performed without stating for which samples what was done {DeHaven, 2006) C. Clinical disease stated without further information (DeHaven, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Morone saxatilis	Natural	nd	X	?	?	B) Virus isolation in cell culture. C) Sampled due to mortality. D) Visceral organs + gill used for isolation. 2 isolations. (Gagné et al. 2007)	VHSV confirmed by RT-PCR and sequencing (genotype IVb)	II
Morone americana	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Anoplopoma fimbria	Natural	nd	X	?	?	B) Isolation in cell culture. C) Dying/dead fish in connection with mass mortality in *Sardinops sagax*. D) Tissue homogenates used for cell culture, not stated which tissues. (Traxler et al. 1999)	VHSV verified by PCR and DNA probe (Traxler et al. 1999). VHSV detected by PCR (Hedrick et al. 2003).	II
		nd	nd	?	nd	C) Dead fish, positive PCR (Hedrick et al. 2003).		
Sebastes inermis	Natural	nd	nd	nd	nd	Natural outbreak in cultured fish, caused by genotype IV (Personal communication, Dr. Nakajima) Unpublished, in Isshiki et al (2003).	genotype IV	II

	Experimental, invasive	nd	X	X	X	B) Virus re-isolation on cell culture. C) Ascites and internal haemorrhaging. D) Virus re-isolation from kidney. 20 fish in one tank, mortality 95%, IP-injection; negative control fish included but data on mortality and virus re-isolation not stated. (Ito et al. 2004)		
Anguilla anguilla	Natural	nd	X	nd	nd	B) Virus isolation on cell culture (Castric et al. 1992, Jørgensen et al. 1994). C) Routine virological examination (Castric et al. 1992) D) Elver supernatant used for virus isolation (Castric et al. 1992)	1 isolate, GenBank accession no.: AY546618, genotype III	II
	Experimental, non-invasive	nd	nd	nd	nd	B) No VHSV was reisolated from elvers. It is not stated whether the fish were examined for VHSV before start of experiment.. Wild caught and farmed elvers were used in the experiments. (Hill & Williams, 1984)		
Fundulus heteroclitus	Natural	nd	X	?	?	B) Virus isolation in cell culture. C) Sampled following report of thousands of dead fish. D) Organs + gills pooled together. (Gagné et al. 2007)	VHSV confirmed by neutralization, RT-PCR and sequencing (type IVb, GenBank ac. No. EF079895)	II
Gasterosteus aculeatus	Natural	nd	X	?	?	B) Virus isolation in cell culture. C) Sampled following report of thousands of dead fish. D) Organs + gills pooled together. (Gagné et al. 2007)	VHSV confirmed by RT-PCR and sequencing	I
		nd	X	nd	X	B+D) Isolation in cell culture from kidney-spleen samples. C. Clinically normal fish VHSV confirmed by DNA probe. 6 isolations. (Kent et al. 1998)		
Aulorhynchus flavidus	Natural	nd	X	nd	nd	No information on how and from what the virus was isolated! (Traxler et al. 1995)	Insufficient information	II
	Experimental, invasive and non-invasive	nd	nd	?	nd	Losses caused by both exposure methods, no further information given (Traxler et al. 1995)		

Moxostoma anisurum	Natural	nd	X	?	nd	B) PCR and cell culture performed without stating for which samples what was done. C) Clinical disease stated without further information. (DeHaven, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Moxostoma macrolepidotum	Natural	nd	X	?	nd	B) PCR and cell culture performed without stating for which samples what was done. C) Clinical disease stated without further information. (DeHaven, 2006) http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Insufficient data	II
Barbus graellsii	Natural	nd	X	nd	nd	No information on how and from what tissue the virus was isolated (Basurco & Coll, 1989)	Serum neutralization test.	II
Pimephales notatus	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Notropis atherinoides	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Notropis hudsonius	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Percopsis omiscomaycus	Natural	nd	X	nd	nd	http://dnr.wi.gov/fish/documents/vhs_fedorderModList.pdf	Nd	II
Sparus aurata	Natural	nd	X	nd	X	B) Isolation in cell cultures using extended incubation up to 30-45 days. C) No external or internal pathology were observed, histology was not performed. D. Isolation from kidney-spleen samples. (Isabel Bandin, pers.com.)	Isolate (1) sequenced and genotyped as III (López-Vázquez et al. 2003 (poster))	I or II?
Solea spp.	Natural	nd	X	nd	X	B) Isolation in cell cultures using extended incubation up to 30-45 days. C) No external or internal pathology were observed, histology was not performed. D. Isolation from kidney-spleen samples. (Isabel Bandin, pers.com.)	Isolate (1) sequenced and genotyped as III (López-Vázquez et al. 2003 (poster))	I or II?
Solea senegalensis	Natural	nd	X	nd	X	B) Isolation in cell cultures using extended incubation up to 30-45 days. C) No external or internal pathology were observed, histology was not performed.	Isolate (1) sequenced and genotyped as III {Isabel Bandin pers.com.)	I or II?

						D. Isolation from kidney-spleen samples. (Isabel Bandin, pers.com.)		
Chondrostoma polylepis	Natural	nd	X	nd	X	B) Isolation in cell cultures using extended incubation up to 30-45 days. C) No external or internal pathology were observed, histology was not performed. D. Isolation from kidney-spleen samples. (Isabel Bandin, pers.com.)	Isolate (1) sequenced and genotyped as Ia (López-Vázquez et al. 2003 (poster))	I or II?
Lampetra fluviatilis	Natural	nd	X	nd	X	B+D) Isolation on cell culture from internal organs. (Tuija Gadd, pers.com)	VHSV has been verified by RT-PCR and sequencing	I
Acanthopagrus schlegeli	Experimental invasive	nd	X	X	X	B) Re-isolation on cell culture. C) Gross lesions and pathology. D) Virus recovered from internal organs. Only 10 fish, infection method IP, mortality 90%, no mortality or re-isolation of virus from negative control fish. (Isshiki et al. 2003)	Re-isolations verified as VHSV by IFAT.	II
Epinephelus akaara	Experimental invasive	nd	X	X	X	B) Re-isolation on cell culture. C) Gross lesions and pathology. D) Virus recovered from internal organs. Only 10 fish, infection method IP, mortality 70%, no mortality or re-isolation of virus from negative control fish. (Isshiki et al. 2003)	Re-isolations verified as VHSV by IFAT.	II
Sebastes schlegeli	Experimental invasive	?	X	X	X	A) Neutralizing antibodies in survivors. B) Re-isolation on cell culture. C) Gross lesions and pathology D) Virus recovered from internal organs. Only 10 fish, infection method IP, mortality 10%, no mortality or re-isolation of virus from negative control fish. (Isshiki et al. 2003)	Re-isolations verified as VHSV by IFAT.	II
Pagrus major	Experimental invasive	nd	X	nd	X	B) Re-isolation of virus in cell culture. D) Virus recovered from kidney. 20 fish, infection method IP, and mortality 75%; negative control fish included but data on mortality and virus re-isolation not stated. (Ito et al. 2004)	Known VHSV isolate used in infection trial.	II

	Experimental invasive	nd	nd	nd	nd	Only 10 fish, infection method IP, mortality 0%, no mortality or re-isolation of virus from fish, no neutralizing antibodies in survivors (Isshiki et al. 2003)		
Pleuronectes yokohamae	Experimental invasive	nd	nd	nd	nd	Only 10 fish, infection method IP, mortality 0%, no mortality or re-isolation of virus from fish, no neutralizing antibodies in survivors (Isshiki et al. 2003)	Known VHSV isolate used in infection trial.	II
Seriola quinqueradiata	Experimental invasive	nd	X	nd	X	B+D) Virus re-isolation on cell culture from kidney. 20 fish, infection method IP, mortality 97.5%; negative control fish included but data on mortality and virus recovery not stated. (Ito et al. 2004)	Known VHSV isolate used in infection trial.	II
Dicentrarchus labrax	Experimental, non-invasive	X	X	X	X	A) > 10^8 PFU/g organ, neutralizing antibodies in survivors. B+D) Re-isolation of virus from internal organs. C) Mortality up to 50%, clinical and histological signs suggestive of VHS. 5 fish tested and found free of VHSV before start of the experiment. No replicates for each test, 50 fish/test, negative controls included. (Castric & de Kinkelin, 1984)	Known VHSV isolates used in infection trial.	I
Oncorhynchus aguabonita	Experimental, invasive	?	X	X	X	A) Organ pool 3.8 log10 $TCID_{50}$/0.1ml, ascites 6.2 log10 $TCID_{50}$/0.1ml, 6.2 log10 $TCID_{50}$/0.1ml). B+D) Re-isolation in cell culture from organ pools (organs not stated). C) Typical VHS symptoms observed A subsample of the fish were tested before start and found negative for VHSV. Only 10 fish, 80 g, infection method IP (10^6 $TCID_{50}$/fish), mortality 90%. Negative control fish included, no mortality. (Ahne et al. 1976)	Known VHSV isolate used in infection trial.	II
Danio rerio	Experimental, invasive and non-invasive	nd	nd	X	X	C) Gross: erratic swimming behaviour, distended visceral cavity, exophthalmia and petechial haemorrhages. Histology: small haemorrhages in liver and muscle. D) Liver, kidney, muscle, gills and brain (by RT-PCR, IP injected fish, 24 h after injection). (Novoa et al. 2006)	Known VHSV isolate used in infection trial.	II

Plecoglossus altivelis	Experimental, non-invasive, invasive and co-habitation	nd	X	nd	X	B) Re-isolation of virus in cell culture from few (1-3 fish) from each group, respectively. D) Re-isolation from brain and kidney-liver-spleen pools. (Bowden, 2003)	Known VHSV isolate used in infection trial. Re-isolations verified by ELISA.	I
Carassius auratus	Experimental, non-invasive	nd	?	?	nd	Immersion trial using liver extract and cell culture supernatant. Not stated how many fish used, which VHSV isolate used or how it was verified that it was VHSV. The infected fish were tested as whole fish on cell culture with development of CPE. The author concludes that the infection trial was successful. (Pfitzner, 1966)	Insufficient data	II
Salvelinus namaycush	Natural?	nd	nd	nd	nd	Suspect case of VHS. (Klingler, unpublished in Ghittino (1972)).	Nd	I
	Experimental, non-invasive	nd	X	X	X	B) Virus was easily recovered from dead fish on cell culture, not stated how the verification as VHSV was done. C) Moribund lake trout displayed clinical signs of VHS, including exopthtalmia and haemorrhages. D) Recover of virus from head-kidney-spleen pool. (Dorson et al. 1991)	Known VHSV isolates used in infection trial.	
O. mykiss x S. namaycush triploid	Experimental, non-invasive	nd	nd	?	nd	C) Mortality of test tanks: 20%, negative control 0% (Dorson et al. 1991)	Known VHSV isolates used in infection trial.	II
O. mykiss x O. kisutch triploid	Experimental, non-invasive	nd	nd	?	nd	C) Mortality in test tanks (mortality in negative controls): 6(4), 5(4), 6(0), 36(18), 22(3), 10(0). (Dorson et al. 1991)	Known VHSV isolates used in infection trial.	II
O. mykiss x O. kisutch	Experimental, non-invasive	X	X	X	X	A) 4 x 10^5 PFU/g organ material (2 immersion infections 24 h apart). 10^7 PFU/g organ material (Immersion infections on day 0, 1, 6 and 8). B+D) Virus re-isolation on cell culture from kidney-spleen pools. C) Haemorrhagic lesions and exopthalmia were found in all dead fry. (Ord et al. 1976)	Known VHSV isolates used in infection trial. Not stated how virus re-isolation was verified as VHSV.	I
O. mykiss x S. fontinalis triploid	Experimental, non-invasive	nd	X	X	X	B) Virus recovery on cell culture from fish with clinical signs, not stated how the verification as VHSV was done. C) Mortality in test tanks (mortality in negative controls): 0% (0%), 34% (0%), 60% (14%). Clinical	Known VHSV isolates used in infection trial.	I

						signs. D) Recover of virus from head-kidney-spleen pool. (Dorson et al. 1991)		
Salvelinus fontinalis	Experimental, non-invasive	nd	nd	nd	Nd	B) No virus re-isolated. {Dorson, 1991 C) Mortality of test tanks: 6%, 10%, negative control 10%. (Dorson et al. 1991)	Known VHSV isolates used in infection trials (Dorson et al. 1991). Insufficient data (Rasmussen 1965)	II
	Experimental, co-habitation	nd	nd	nd	nd	Artificially infected rainbow trout were used as disease carriers (injection of liver material from VHS diseased fish). Not written how it was verified that it was actually VHS, could be based only on the clinical symptoms. Mortality among the brook trout did not occur until 9 weeks after the beginning. All brook trout had died with characteristic disease symptoms by the end of the 15th week. (Rasmussen, 1965}		
Salvelinus alpinus	Experimental, non-invasive	nd	nd	nd	nd	Mortality of test tanks: 6%, negative control 11% - Mortality of test tanks: 38%, negative control 39%. (Dorson et al. 1991)	Known VHSV isolates used in infection trial.	II
O. mykiss x S. alpinus triploid	Experimental, non-invasive	nd	X	X	X	B) Virus re-isolation on cell culture from all moribund fish. C) Mortality of test tanks: 31%, 43%, negative control 7% Mortality of test tanks: 18%, negative control 0%. D) Recover of virus from head-kidney-spleen pool. (Dorson et al. 1991)	Known VHSV isolates used in infection trial.	I
Tinca tinca (Tinca vulgaris)	Experimental, invasive	nd	nd	nd	nd	IM injection with VHSV isolate grown on cell culture in tench. Rainbow trout were injected with blood from the tench 3 months p.i.. The tench did not develop disease, neither did the rainbow trout. Not stated how the virus used was verified as VHSV. (Zwillenberg et al. 1968)	Insufficient data	II
Perca fluviatilis	Natural	nd	X	?	X	B+D) Virus isolation from pool of organs, but mechanical contamination of the sample from VHSV infected rainbow trout sampled at same time cannot be excluded. C) High mortality in fish (Giuseppe Bovo, pers.com.)	VHSV verified by ELISA.	II

	Experimental, invasive	nd	nd	nd	nd	IM injection with VHSV isolate grown on cell culture in perch. Rainbow trout were injected with blood from the perch at day 29. The perch did not develop disease, neither did the rainbow trout. Not stated how the virus was verified as VHSV. (Zwillenberg et al. 1968)	Insufficient data	
	Experimental, non-invasive	nd	nd	nd	nd	Preliminary infection trial by bath and cohabitation with no mortality evidence (Giuseppe Bovo, pers.com.).	Insufficient data	
Cyprinus carpio	Experimental, invasive	nd	nd	nd	nd	IM injection with blood from IP injected rainbow trout with VHS symptoms in carp. The carp did not develop disease, neither did the rainbow trout. Not stated how the virus was verified as VHSV. (Zwillenberg et al. 1968)	nd	II
Squalius cephalus	Experimental, invasive	Nd	Nd	Nd	nd	IP injection of organ material from diseased fish. No verification that the material did actually contain VHSV, as the experiment was performed before it was realised that the disease is caused by a virus. No mortality in test fish (Tack, 1959)	nd	II
Rutilus rutilus (Leuciscus rutilus)	Experimental, invasive	Nd	Nd	Nd	nd	IP injection of organ material from diseased fish. No verification that the material did actually contain VHSV, as the experiment was performed before it was realised that the disease is caused by a virus. No mortality in test fish (Tack, 1959)	nd	II

Infectious Salmon Anaemia

Table 11: Analysis of evidence for susceptibility to ISAV

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Salmo salar	Natural and experimental	X	X	X	X	A The virus has been shown to replicate in vascular endothelial cells of a range of tissues. B Virus has been isolated in cell culture from field cases in farmed Atlantic salmon and detected by RT-PCR in wild Atlantic salmon and successfully transmitted experimentally	yes	I

						by co-habitation. C Definitive host, with infected fish showing clinical signs, histopathological lesions and mortalities. D Virus isolated from internal organs Thorud and Djupvik 1988, Hovland et al. 1994 Raynard et al., 2001, Rodger et al. 2001, Snow et al. 2001a, Moneke et al. 2003, Plarre et al.,2005		
Salmo trutta	Natural and intra-peritoneal injection	X	X	nd	X	A Experimental infections with i.p. challenge have shown the virus to be capable of replication with persistence indicative of a carrier state. B Virus isolation in cell culture. D Detection of ISAV by RT-PCR in brown trout and sea trout (individual or pooled kidney, with isolation of virus from sea trout (pooled heart kidney, liver and spleen. Nylund and Jakobsen 1995, Devold et al. 2000, Nylund et al. 1995, Raynard et al. 2001, Plarre et al., 2005	yes	I
Oncorhynchus kitsutch	Natural and intra-peritoneal injection	X	X	X	X	A. Experimental i.p. challenge with high, medium and low doses was only successful in establishing infection with the high dose. B. Virus isolated in cell culture. C. Disease and associated clinical signs and mortality in farmed fish with D Detection of virus by RT-PCR and virus isolation from pools of kidney, spleen and pyloric caecae. Kibenge et al., 2001; Rolland and Winton, 2003	yes	I
Anguilla anguilla	Natural and Experimental Invasive and non-invasive	nd	X	nd	X	B. Single report of ISAV isolated in cell culture from internal organs a single wild-caught eel (Stagg et al., 2001, Dr. R. Raynard, personal communication). Neukirch et al. 1985 reported islation of a haemagglutinating orthomyxovirus-like virus from eels (A. anguilla), but no further characterization is available. In experimental studies, no disease was seen in eels following ip injection of 20g eels or in co-habiting Atlantic salmon, and virus was not isolated from either. When 20g eels were cohabited with ip injected salmon, a cpe in SHK cells was obtained on two occasions from eels on days 9 and 43 post cohabitation. However the cpe was not confirmed as due to ISAV, and skin was included in the inoculum, raising the possibility of surface contamination rather than true infection (Dr. O.	yes	II

						Haenen, personal communication). D. Single virus isolation from a wild caught eel from internal organs. Two potential isolates in co-habitation study included skin the the samples (Dr. R. Raynard, Dr. O. Haenen, personal communications).		
Gadus morrhua	Natural and Experimental Invasive	?	nd	nd	?	A. Susceptible to i.p. (but not cohabitant) challenge with RT-PCR positives in multiple tissues for 45 days and increasing levels of ISAV RNA in brain in the absence of morbidity or mortality (Grove et al 2007) Snow and Raynard (2005) found no onward transmission to cohabitant fish following initial i.p. challenge and no RT-PCR signal when spleen and kidney tested at 42 days post-infection (brain not examined), concluding that cod were not susceptible to ISA disease. D. One report of a positive RT-PCR signal in gill from wild cod (MacLean 2003).	yes	II
Alosa pseudoharengus	Natural	nd	nd	nd	nd	Rolland, 2004 reports single positive RT-PCR in wild fish. Wrong reference in the PhD thesis. No further details.	Probably (PCR)	II
Salvelinus alpinus	Experimental Invasive Intraperitoneal	nd	nd	nd	?	D. No morbidity or mortality following i.p. challenge. No virus cultured but 10% still positive by RT-PCR 40 days post challenge (pools of kidney, liver, spleen, heart). Snow et al., 2001b	Probably (experimental challenge)	II
Oncorhynchus mykiss	Non invasive experimental: bath and cohabitation	X	X	X	X	A Infection established by cohabitation of trout in seawater with i.p. infected Atlantic salmon and transmission of infection from i.p. infected trout to cohabitant Atlantic salmon (Snow et al. 2001a). Virus was isolated in high titre from serum and tissues (Biacchesi et al. 2007). Replication occurs in vascular endothelium (Nylund et al. 1997), B Virus isolated in cell culture. C. In freshwater, bath challenge resulted in morbidity and mortality D. Virus isolated from serum and tissues.	yes	I
Oncorhynchus keta	Experimental invasive: Intraperitoneal	nd	X	nd	X	B No morbidity or mortality following i.p. challenge with low, moderate or high doses. Virus reisolated in cell culture from high dose challenge only, 13 days post infection. D Virus isolated from internal organs- kidney, spleen, liver. Rolland and Winton, 2003 Only IP data	yes	II
Clupea harengus	Experimental	nd	nd	X	X	C. Significant decrease in haematocrit with mortalities in	Yes	I

	non-invasive: Bath					challenge group only. D. RT-PCR positive kidney material following bath challenge. Nylund et al., 2002		
Pollachius virens	Natural and experimental, invasive (intra-peritoneal) and non-invasive (co-habitation)	nd	nd	nd	nd	ISAV was not detected by RT-PCR in any fish sampled following i.p. injection with ISAV or following cohabitation with ISAV-infected Atlantic salmon. Virus was not isolated and no histological changes indicative of ISAV infection were noted. No evidence of infection was detected by RT-PCR and virus culture in co- habiting Atlantic salmon (Snow et al. 2002). Kidney tissue from 93 pollock living with ISA-infected salmon in sea cages were all tested negative for ISAV by RT-PCR (McClure et al. 2004)	no	II
Mytilus edulis	Experimental non-invasive (bath)	nd	nd	nd	nd	ISAV was detected by real time RT-PCR in hepatopancreas up to 72 hours after bath exposure of actively filtering mussels. Fish challenged with mussel homogenate prepared 96 h after exposure were ISAV negative. Mussels sampled from a tank with experimentally infected salmon demonstrating clinical signs and mussels collected on net pen cages during outbreaks in Atlantic salmon were all ISAV negative. It was concluded that ISAV is rapidly inactivated in mussels and that mussels are not a likely reservoir host for ISAV. Skår C. K. & Mortensen S. (2007).	yes	II

Infectious Hematopoietic Necrosis

Table 12: Host species susceptible to IHNV

Host species	natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Oncorhynchus nerka	Natural and experimental non-invasive (bath)	X	X	X	X	A Virus isolated to high titre (106-109TCID50/ml from pooled ovarian fluid or kidney/spleen of adult fish. B Virus isolated in cell culture C Morbidity and mortality in natural and experimental	yes	I

						infections. D Virus isolation from spleen, reproductive fluids with isolation of virus from kidney, spleen or reproductive fluids. Experimental transmission by bath with morbidity and mortality. Amend et al. 1969, Garver et al. 2006, Rudakova et al. 2007		
Oncorhynchus nerka (landlocked form)	Natural and experimental non-invasive (bath)	nd	X	X	X	B Virus isolated in cell culture C Morbidity and mortality with bath challenge. Histopathology in gut with necrosis in natural infection. D Virus isolated from tissue pools Isolation of virus from tissue pools of wild fish. Experimental transmission by bath with morbidity and mortality Kimura and Awakura 1977, Sano et al. 1977, Follett, et al. 1987, Yamazaki and Motonishi 1992, Garver et al. 2005, Garver et al. 2006	yes	I
Oncorhynchus mykiss	Natural and experimental non-invasive (bath)	X	X	X	X	A Virus replication demonstrated by increasing titres in a range of internal organs and TEM. B Virus isolated in cell culture C Morbidity and mortality in natural and experimental infections, D Virus isolated from internal organs with isolation of virus. Experimental transmission by bath with morbidity and mortality with re-isolation of virus from internal organs. Amend et al. 1969, Yamamoto and Clermont 2000, Bergmann et al. 2003, Garver et al. 2005, 2006	yes	I
Salvelinus fontinalis	Natural and experimental non-invasive (bath)	X	X	X	?	A Virus replication to high titre with bath challenge of fry (typically above 10^5pfu/g) . Bootland et al. 1994 B Virus isolation following bath challenge C Bath challenge resulted in morbidity and mortality with typical clinical signs Bootland et al. 1994. Field outbreaks also described. Yamazaki and Motonishi 1992 D Isolated from whole fry	yes	I
Salvelinus alpinus	Non-invasive experimental (immersion challenge)	X	X	X	?	A High titre of virus isolated 10^2-10^6pfu/g. McAllister et al. 2000. B Isolation of virus in cell culture. McAllister et al. 2000. C Immersion challenge resulted in morbidity and mortality	yes	I

						with recovery of virus and establishment of carrier fish. McAllister et al. 2000. D. Whole fry or viscera and kidney used for isolation		
Oncorhynchus tshawytscha	Natural and non-invasive experimental (bath)	X	X	X	X	A Transmission of virus to co-habitant Atlantic salmon bath exposure and isolation of high titres of virus following bath exposure (up to 10^8 pfu/ml) B Virus isolated in cell culture C Morbidity and mortality in natural outbreaks and bath challenge D. Virus isolated from kidney/spleen, gills and ovarian fluids. Follett, et al. 1987, Arkush et al. 2004, St. Hilaire 2001b	yes	I
Oncorhynchus kisutch	Natural and non-invasive experimental (bath)	nd	X	X	X	B Isolation of virus in cell culture. C Pathology associated with bath exposure. D Isolation of virus from internal organs and ovarian fluid of naturally infected fish. La Patra et al. 1989, Basurco et al. 1993, Helmick et al. 1995, Kelley et al. 2007	yes	I
Salmo salar	Natural and non-invasive experimental (bath))	?	X	X	X	A. Experimental infection by bath challenge with reisolation of virus from kidney and seroconversion. B. Isolation in cell culture. C. Morbidity and mortality in farmed Atlantic salmon with typical histopathology. D. Isolation of IHNV from kidney. Amstrong et al. 1993, St. Hilaire 2001a, 2002.	yes	I
Oncorhynchus keta	Natural	nd	X	X	X	B Virus isolated from field outbreaks C Natural outbreak associated with morbidity and mortality D Virus isolated from ovarian fluids Virus isolated from natural outbreak in fish with morbidity and mortality and from ovarian fluids of adult fish. Sano et al. 1977, Follett et al. 1987, Yoshimizu et al. 1993, Nishizawa et al. 2006	yes	I
Oncorhynchus rodurus	Natural	X	X	X	X	A. Virus titre more than 10^6 B Virus isolated in cell culture C. Typical clinical signs and mortality. D Virus isolated from kidney Sano et al. 1977, Yamazaki and Motonishi 1992, (Professor M. Yoshimizu, personal communication).	yes	I
Oncorhynchus masou	Natural	X	X	X	X	A. Virus isolated to high titre (over 10^6 pfu/g from kidney) B Isolation of virus from fry and adult fish	yes	I

						C Mortality with typical clinical signs during field outbreaks. D Virus isolated from whole fish homogenates during outbreak of disease in hatchery fry with typical signs of IHN, from kidney of larger fish and from ovarian fluids of adult fish. Yamazaki and Motonishi (1992), Park et al. 1993, Nishizawa et al. 2006, Professor M. Yoshimizu, personal communication		
Oncorhynchus masou (landlocked form)	Natural	X	X	X	X	A. Virus isolated to high titre (over 10^6 pfu/g from kidney) B. Virus isolated in cell culture. C. Reported epizootic of IHN and significant losses of fry and fingerlings. Disease outbreaks in cultured fish. Typical clinical signs. D. Virus isolated from kidney. Kimura and Awakura 1977, Sano et al. 1977, Yamazaki and Motonishi 1992. (Professor M. Yoshimizu, personal communication).	Yes	I
Oncorhynchus clarki	Experimental non-invasive Bath	nd	X	X	X	B Virus isolated in cell culture C Low level of mortality D. Virus isolated from internal organs La Patra et al. 1994	Yes	I
Salvelinus leucomaenis	Natural	nd	X	nd	X	B Virus isolated in cell culture D Virus isolated from kidney Yamazaki and Motonishi 1992, (Professor M. Yoshimizu, personal communication).	Yes	I
Oncorhynchus gorbuscha	Non-invasive experimental (Bath)	nd	X	nd	nd	B Low titre virus (101pfu/g) recovered from single whole fry following bath challenge (Follett et al. 1997). However absence of virus in field situations where challenge likely. (Follett et al. 1987)	yes	II
Clupea pallasii	Natural	nd	X	nd	X	B Virus isolated in cell culture from one of 162 fish of this species caught off-shore in a wild fish survey. Kent et al. 1998 D. Virus was isolated from pooled kidney and spleen and its identity confirmed by DNA probe and neutralization. Kent et al. 1998.	Yes	I
Cymatogaster aggregata	Natural	nd	X	nd	X	B Virus isolated in cell culture from one of 307 of this species caught near net-pens in a survey of wild fish. Kent et al. 1998 D. Virus isolated from pooled kidney and spleen and its	Yes	I

						identity confirmed by DNA probe. Kent et al. 1998.		
Aulorhychus flavidus	Natural	nd	X	nd	X	B Virus isolated isolated in cell culture from two of 72 of this species caught near net-pens in a in survey of wild fish. Kent et al. 1998 D. Virus isolated from pooled kidney and spleen and its identity confirmed by DNA probe. Kent et al. 1998.	Yes	I
Anguilla anguilla	Natural	nd	X	nd	?	B. Reports challenge study with IHNV isolated from an eel. No further details given. Bergmann et al. 2003. Jorgensen et al. (1994) failed to recover IHNV from 2092 pools of elvers and eels in Europe.	?	II
Plecoglossus altivelis	Natural	nd	X	nd	X	B. Nishizawa et al. 2006 report partial nucleotide sequence data for IHNV isolated from ayu. Virus was isolated from fish downstream of an outbreak in rainbow trout. C. No clinical signs D. Virus isolated from kidney. (Professor M. Yoshimizu, personal communication).	Yes	I
Gadus morrhua	Natural	nd	X	nd	X	B. Enzmann et al. 2005 reports partial nucleotide sequence data for IHNV isolated from cod from north American Pacific. D The virus was isolated from internal organs of wild cod in the absence of clinical signs. Histopathology was not performed (Professor Peter-Joachim Enzmann, personal communication.)	Yes	I
Salmo namaycush	Non-invasive Bath	X	X	X	nd	A. Viral titres of 105 to 107 pfu/g in dead fish B Virus isolated following bath challenge. Follet et al., 1997 C Clinical signs and mortalities following bath challenge. Follet et al., 1997 Follet et al., 1997	Yes	I
Acipenser transmontanus	Non-invasive. Bath	X	X	X	?	A Virus replication following bath challenge of larval fish with viral concentrations above 105pfu/g. LaPatra et al., 1995 B. Challenge virus was reisolated. LaPatra et al., 1995 C. Bath challenge of larval fish resulted in morbidity and mortality, while seroconversion was detected in older fish in the absence of clinical signs LaPatra et al., 1995 D- Virus isolated from whole larvae	Yes	I
Sparus aurata	Experimental, invasive.	X	X	X	?	A virus replication following intra-peritoneal injection up to 109 pfu/g. Castric and Jeffroy, 1991	yes	II

	Intra-peritoneal injection Natural route not confirmed					B Virus was reisolated in cell culture. Castric and Jeffroy, 1991 C Morbidity with signs consistent with IHN and mortality (43%) in challenged fish but not in controls D Virus isolated from organs (no further details given)		
Esox lucius	Experimental non-invasive Bath	?	X	X	?	B. Virus isolated in cell culture. C. Haemorrhages, exopthalmus and mortality (≥40%) in young pike following bath infection. These were absent in controls D. Virus isolated from whole fish/trunk. Dorson et al., 1987	yes	I
Dicentrarchus labrax	non-natural route. Invasive Intra-peritoneal injection	X	X	nd	X	A Virus replication following intra-peritoneal injection up to 109 pfu/g without clinical signs. B. Virus was reisolated in cell culture following intraperitioneal injection. Castric and Jeffroy, 1991 D Virus isolated from organs (pool of kidney and spleen)	yes	II
Psetta maxima	Intra-peritoneal injection	X	X	X	X	A virus replication following intra-peritoneal injection up to 109 pfu/g.. Castric and Jeffroy, 1991 B Re-isolation in cell culture following intra-peritoneal injection. Castric and Jeffroy, 1991 C Morbidity with signs consistent with IHN and mortality (87%) following intra-peritoneal injection in challenged fish but not in controls. Castric and Jeffroy, 1991 D Virus isolated from organs (no further details given)	yes	II

Koi Herpes Virus Disease

Table 13: Host species susceptible to KHV

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Cyprinus carpio	Natural Experimental (Bath and co-habitation)	X	X	X	X	A. Detection of virons by EM in organs (Hedrick et al. 2000) B. Isolation of virus by cell culture (Hedrick et al. 2000). Bath exposure of carp to KHV and subsequent exposure of naïve fish by cohabitation (St-Hilaire et al. 2005). C. Nuclear inclusion observed in epithelial cells, and	Yes	I

						leukocytes of the gills, and cells in spleen and kidney (Hedrick et al. 2000). D. Isolation of virus from gills and kidney-spleen extract (Hedrick et al. 2000).		
Cyprinus carpio x Carassius auratus	Experimental invasive (IP injection)	?	nd	nd	X	Experimental injection of (koi) carp, goldfish and hybrids. KHV DNA detected by PCR in carp and hybrids, not in goldfish. (Hedrick et al. 2006)	Yes	II
Carassius auratus	Natural Experimental (co-habitation)	nd	nd	?	?	C. Goldfish kept at same facility with koi during KHV outbreak showed clinical signs (with inter-current infections) and tested positive for KHV DNA by PCR (Sadler et al. 2008) Co-habitation of infected koi with goldfish. Detection of KHV DNA by PCR in pooled organs of goldfish (El-Matbouli et al. 2007)	Yes	II

APPENDIX B

Diseases of molluscs

Infection with *Bonamia ostreae*

Table 14: Host species susceptible to *Bonamia ostreae*

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Ostrea edulis	Natural	X	X	X	X	A. EM observation of uninucleated and binucleated stages of B. ostreae in naturally infected O. edulis (Pichot et al. 1980). B. Viable parasites can be purified from infected oysters (Mialhe et al., 1988). C & D. Systemic infiltration of infected haemocytes observed in naturally infected O. edulis (Balouet et al., 1983).	SSU sequence available (Cochennec et al., 2000)	I
Ostrea angasi	Natural (Exposure of first generation from introduced O. angasi by rearing in B. ostreae endemic waters)	nd	nd	nd	X	Insufficient data. Bonamia was detected in histological sections and tissue imprints at low prevalence (Bougrier et al., 1986).	No identification	II
Ostrea chilensis	Natural (direct exposure of O. chilensis by rearing in B. ostreae endemic waters)	X	nd	X	X	A. various stages of the parasite in histological sections (Grizel et al. 1983) B. no data C. Bonamia gross lesions were observed (Grizel et al. 1983). D. Bonamia was detected by histology and EM (Grizel et al., 1983)	No thorough characterisation of the parasite	II
Ostrea conchaphila	Natural and experimental non invasive	nd	nd	?	?	Katkansky (1969) and Farley et al. (1988) describe a microcell parasite in O. conchaphila from Oregon, USA. Experimentally O. conchaphila could not be infected by cohabitation with infected O. edulis (I. Arzul personal comm.)	Microcell species ID uncertain	II
Ostrea denselamellosa	Natural (direct exposure of first generation from	nd	nd	nd	nd	Le Borgne & Le Pennec 1983. the paper does not mention Bonamia ostreae	No identification	II

	introduced animals by rearing in B. ostreae endemic waters)							
Ostrea puelchana	Natural (direct exposure of first generation from introduced animals by rearing in B. ostreae endemic waters).	nd	nd	nd	X	A. no data B. no data C. no data D. Bonamia was detected in histological sections and tissue imprints (Pascual et al. 1991)	No identification	II
Crassostrea angulata	Natural	nd	nd	nd	nd	Microcells observed in C. angulata after exposure to infected O. edulis (Katkansky et al. 1969).	No identification	II
Crassostrea ariakensis	Natural	nd	nd	X	X	A. no data B. no data C & D. Detection of Bonamia sp. by histology and EM in C. ariakensis from a quarantine facility with inlet water from a B. ostreae endemic area (Cochennec et al. 1998).	Bonamia species later confirmed by DNA sequencing (Arzul, pers. com.).	I

Infection with *Bonamia exitiosa*

Table 15: Host species susceptible to *Bonamia exitiosa*

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Ostrea chilensis	Natural	X	nd	X	X	A. EM observation of uninucleated and binucleated stages of B. ostreae in naturally infected O. chilensis (Dinamani et al. 1987; Hine et al. 2001). C. Observation of Bonamia within the haemocytes (Dinamani et al. 1987). D. Systemic infiltration of Bonamia infected haemocytes (Dinamani et al. 1987).	18S rDNA sequence available (Hine et al. 2001).	I
Ostrea angasi	Natural	nd	nd	X	X	C and D. Intracellular and extracellular parasites in focal areas of haemocytosis located in connective tissue and gills (Heasman et al., 2004)	Species ID: The 18S and ITS sequences of Bonamia sp. show a very close genetic similarity with B. exitiosa (Corbeil et al. 2006)	I

Ostrea conchaphila	Natural	nd	nd	?	?	Katkansky (1969) and Farley et al. (1988) describe a microcell parasite in O. conchaphila from Oregon, USA.	Microcell species ID is uncertain	II
Ostrea edulis	Natural	X	nd	X	X	A. Binucleated stages of B. ostreae and B. exitiosa-like observed in histological sections (Abollo et al., 2008). C. & D. Two types of microcells observed within haemocytes in different organs of O. edulis (Abollo et al. 2008).	Species ID: Presence B. exitiosa confirmed by PCR-RFLP and sequencing (Abollo et al. 2008)	I
Ostrea puelchana	Natural	nd	nd	X	X	C & D. Bonamia sp. detected by histology within haemocytes of O. puelchana (Kroeck & Montes 2005). Species ID: Sequencing 18S rDNA confirms relationship with B. exitiosa-like group (unpublished observation I. Arzul)	Bonamia species ID is uncertain	II
Crassostrea ariakensis	Natural	nd	nd	X	X	C & D. Bonamia sp. detected by histology within haemocytes in different tissues of C. ariakensis (Burreson et al. 2004).	Bonamia species ID is uncertain. B. exitiosa-like confirmed by sequencing 18S rDNA (Burreson et al. 2004).	II
Saccostrea glomerata	Natural	nd	nd	X	X	Insufficient evidence. C & D. Mikrocytos roughleyi observed within haemocytes, associated focal lesions in gill, connective and gonadal tissue. Pathology different from B. exitiosa infections in O. chilensis.	18S rDNA sequence data very closely related to B. exitiosa (Cochennec et al., 2003). Parasite described as Bonamia roughleyi	II

Infection with *Perkinsus marinus*

Table 16: Host species susceptible to *Perkinsus marinus*

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Crassostrea virginica	Natural	X	X	X	X	A: Connective tissue of all organs harbours different parasite stages (Mackin, 1951; Ray & Chandler, 1955) B. Isolation by RFTM and clonal culture possible from infected oysters (La Peyre et al., 1993). Direct transmission possible (Ray &	Molecular characterization was done and existence of strains have been reported (Reece et al., 2001)	I

						Chandler, 1955) C. Pale appearance of the digestive gland, reductions in condition index, severe emaciation, gaping, shrinkage of the mantle, reduced gonadal development and/or retardation of growth, mortalities and sometimes the presence of abcesses (Mackin, 1951; Ray & Chandler, 1955). Proliferation of the parasite causes systemic disruption of connective tissue and epithelial cells and is associated with massive haemocytic infiltration (Mackin, 1951; Ray & Chandler, 1955) D. Parasites occur within gut gill labial palp and mantle epithelium, connective tissue of all organs, and haemocytes (Mackin 1951; Ray & Chandler, 1955).		
Crassostrea gigas	Natural and non invasive experimental	nd	X	X	X	A.. not documented B. & D. Detection of the parasite by RFTM culture from rectal, mantle and gill tissue (no detection by histology). Mainly low level of infection reported (Meyers et al. 1991; Calvo et al. 1999). C. was confirmed (C. Audemard pers com).	Experimental data are based on ID confirmed parasite	I
Crassostrea ariakensis	Natural and non invasive experimental Laboratory (oysters maintained in lab facilities with non-filtered water coming from infected area) and field studies	X	X	X	X	A. Detection of different parasite stages in connective tissue of many organs by histology (Moss et al., 2006) B. Detection of the parasite by RFTM culture. Most of the time low level of infection reported (Calvo et al., 2001). C. Disruption of connective tissue and epithelial cells with massive haemocytic infiltration observed in some individuals maintained in the laboratory by histology (Moss et al., 2006) D. Parasites observed in the visceral mass by histology (Moss et al., 2006) and detected by RFTM culture from rectal, mantle and gill tissue (Calvo et al. 2001).	Molecular characterization was done in oysters maintained in laboratory facilities and confirmed parasite affiliation i.e. P. marinus (Moss et al., 2006)	I

Crassostrea rhizophoreae	Natural and experimental (non invasive - inoculation in the palleal cavity and bath exposure)	X	X	nd	X	A Injection of Perkinsus marinus in SPF oysters. RFTM showed high level of infection for 16 weeks (D. Busheck pers com) B & D Detection of the parasite by RFTM culture from mantle tissue or whole oysters (no detection by histology). (Busheck et al. 2002; Littlewood 2000) Mortality reported but not associated with the infection (Littlewood, 2000). .	Experimental data are based on ID confirmed parasite	II
Mya arenaria	Experimental (non invasive - Mantle cavity inoculation)	X	X	X	X	A. Observation of proliferating parasite cells by histology (Dungan et al. 2007) B. Isolation of the parasite by RFTM culture (Dungan et al. 2007) C & D. Lesions and parasites found in gill epithelia and in connective tissues of mantle (Dungan et al. 2007)	Molecular characterization was done (Dungan et al. 2007)	I
Macoma balthica	Experimental (non invasive - mantle cavity inoculation)	X	X	X	X	A. Observation of proliferating cells by histology (Dungan et al. 2007) B. Isolation of the parasite by RFTM culture (Dungan et al. 2007) C & D. Lesions and parasites found in gill, mantle epithelial and connective tissues, and in visceral, kidney, nervous connective tissues (Dungan et al. 2007)	Molecular characterization was done (Dungan et al. 2007)	I
Crassostrea corteziensis	Natural	X	nd	X	X	A & D. Observation of different stages of the parasite with different levels of infection in the connective tissue of different organs (Caceres Martinez et al., 2008). C. Haemocytic infiltration associated with infection and in advanced cases macroscopic lesions (Caceres Martinez et al., 2008)	Comfirmatory molecular characterization was done	I

Infection with *Mikrocytos mackini*

Table 17: Host species susceptible to *Mikrocytos mackini*

Host species	Natural or experimental5	A	B	C	D	Assessment	Pathogen ID	Group
Crassostrea gigas	Natural	X	X	X	X	A. TEM characterization showed binucleated cells and different parasite stages (Hine et al. 2001) B. Direct transmission from host to host possible (Hervio et al. 1996) C. Green pustules on the surface of the body and mantle are often observed in infected individuals. Foci of haemocyte infiltration in the mantle, labial palps and adductor muscle. Tissue necrosis may occur at the centre of the lesion (Bower et al. 1994). D. Target organs and infected tissue: connective tissue of all organs, adductor muscle fibres, haemocytes and epithelium of the digestive gland (Histology Bower et al. 1994; In situ hybridization Bower et al. 2005, Meyer et al. 2005).	Molecular confirmation (Carnegie et al. 2003)	I
C. virginica	Invasive experimental (Inoculation in adductor muscle) Natural (field studies)	X	X	X	X	A. TEM characterization showed different parasite stages (Hine et al. 2001) B. Parasites isolated from experimentally infected C. virginica were infective to exposed oysters (Bower et al. 1997). C. Moribund oysters – characteristic tissue lesions (Bower et al. 1997) D. Detection by imprints and or histology in target organs and tissues (Bower et al. 1997).	TEM characterization (Hine et al. 2001)	I
Ostrea edulis	Invasive experimental (Inoculation in adductor muscle) Natural (field studies)	X	X	X	X	A. TEM characterization showed different parasite stages (Hine et al. 2001) B. Parasites isolated from experimentally infected O. edulis were infective to exposed oysters (Bower et al. 1997). C. Moribund oysters characteristic tissue lesions (Bower et al. 1997) D. Detection by imprints and or histology in target organs and tissues (Bower et al. 1997).	TEM characterization (Hine et al. 2001) Molecular characterization (Carnegie et al. 2003)	I

[5] Natural, non invasive experimental, or invasive experimental.

Ostrea concaphila	Invasive experimental (Inoculation in adductor muscle) Natural (field studies)	nd	nd	X	X	C. Moribund oysters characteristic tissue lesions (Bower et al. 1997) D. Detection by imprints and or histology in target organs and tissues (Bower et al. 1997)	Molecular characterization of the parasite was not done but experimental data are based on ID confirmed parasite	II
Crassostrea angulata	Natural	nd	nd	nd	nd	Microcells observed in C. angulata after exposure to infected O. edulis (Katkansky et al. 1969).	No identification	II

Infection with *Marteilia refringens*

Table 18: Host species susceptible to *Marteilia refringens*

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Ostrea edulis	Natural	X	X	X	X	A. Observation of all stages of the parasite (Grizel et al., 1974). B. Successful transmission from oysters to copepods Acartia grani (Audemard et al. 2002). C. Typical histological features. Poor condition index, discolouration of the digestive gland, cessation of growth, tissue necrosis, and mortalities (Grizel et al. 1974). D. Typical location (Grizel et al. 1974).	Molecular characterization was done (Le Roux et al. 2001). Two types have been reported, type M and type O (Le Roux et al. 2001) and detected in flat oysters (Le Roux et al. 2001; Lopez-Flores et al. 2004; Novoa et al. 2005)	I
Mytilus edulis	Natural	X		X	X	A. Observation of all stages of the parasite in digestive gland of mussels by histology (Comps et al., 1975; Poder et al. 1983). C. & D. Intercellular parasite observed in epithelia of target organs. Necrosis of digestive epithelia in some advanced infection (Comps et al., 1975).	Molecular characterization was done (Le Roux et al. 2001). Two types have been reported, type M and type O (Le Roux et al. 2001) and detected in Mytilus edulis (Le Roux et al., 2001)	I
Mytilus galloprovincialis	Natural	X	X	X	X	A. &D. Observation of all the stages of the parasite in digestive gland of mussels by histology, TEM and ISH (Comps et al. 1982, Villalba et al. 1993a, Znrcic et al. 2001) B. Successful transmission from mussels to copepods Acartia grani (Carrasco et al., 2005) C. & D Intercellular parasite observed in	Molecular characterization was done (Le Roux et al. 2001). Two types have been reported, type M and type O (Le Roux et al. 2001) and detected in Mytilus galloprovincialis (Le Roux et	I

						epithelia of target organs. Negative impact of the parasite on condition index and development of the gonad (Camacho et al. 1997; Villalba et al. 1993b)	al. 2001; Lopez-Flores et al. 2004; Novoa et al. 2005)	
Ostrea angasi	Natural	nd	nd	nd	X	Oysters produced in French hatchery were placed in a known infected environment (Bougrier et al. 1986). A and C is not documented D. Observation of parasites in the digestive gland of the oyster by digestive gland imprint.	Molecular characterization of the parasite was not done	II
O. puelchana	Natural	nd	nd	nd	X	Oysters produced in a French hatchery were placed in a known infected environment (Pascual et al., 1991). A and C is not documented D. Observation of parasites in the digestive gland of the oyster. Molecular characterization of the parasite was not done	Molecular characterization of the parasite was not done	II
Ostrea chilensis	Natural (Oysters originating in Chiloe Island, Chile, were directly placed in a known infected environment)	X	nd	X	X	A. Observation of different stages of the parasite in digestive gland of oysters by histology C. & D. intercellular parasite observed in epithelia of target organs. (Grizel et al., 1983).	Molecular characterization of the parasite was not done	II
O. denselamellosa	Natural	nd	nd	nd	X	Oysters produced in a French hatchery were placed in an endemic area (Ifremer report 1993). A. and C. is not documented D. Observation of parasites in the digestive gland of the oysters.	Molecular characterization of the parasite was not done	II
Crassostrea gigas	Natural	nd	nd	X	X	A. & D. Detection of early stages (primary stages and sometimes secondary stages) in the epithelia of the stomach but mature stage has never been observed (Cahour, 1979; Montes et al. 1998; Riera et al. 1993) meaning that there is no really multiplication. C. No lesion associated with presence of the parasitic cells.	Molecular characterisation of the parasite was not conclusive. However description is inside known range of M. refringens	II

Crassostrea virginica	Natural	X	nd	X	X	A. & D. Detection of different stages (from primary stages to tertiary stages) in the epithelia of the digestive gland of one individual. No report of mature spore (Renault et al., 1995). C. Hemocytic infiltration of connective tissue and epithelia where parasites were located (Renault et al., 1995).	Molecular characterization of the parasite was not done	II
Cardium edule	Natural	X	nd	X	X	A. & D. Detection of different stages of the parasite (from primary to tertiary cells) but not mature spore in digestive gland by histology and TEM (Comps et al., 1975; Poder et al. 1983). C. Not documented	Molecular characterization of the parasite was not done	II
Ruditapes decussatus	Natural	nd	nd	X	X	A. and B.. is not documented C. & D. Observation of parasites in the stomach and digestive diverticula of the clams (Villalba et al. 1993c).	Molecular characterization of the parasite was not done. Description is inside known range of M. refringens.	II
Ruditapes philippinarum	Natural	X	nd	X	X	A & D. Detection of different stages including spores of Marteilia in the epithelium of digestive gland of one individual (Itoh et al., 2005). C. No host reaction associated (Itoh et al. 2005)	Molecular characterization of the parasite was not done. Description is outside known range of refringens. Maybe a different species?	II
Tapes rhomboides	Natural	X	nd	X	X	A, C & D. Detection of different stages of the parasite including spores with refringent granules in the epithelium of the digestive gland (Poder et al. 1983; Villalba et al. 1993c)	Molecular characterization of the parasite was not done However inside known range of refringens.	II
Tapes pullastra	Natural	X	nd	X	X	A, C & D. Detection of different stages of the parasite including spores with refringent granules in the epithelium of the digestive gland (Poder et al. 1983; Villalba et al. 1993c)	Molecular characterization of the parasite was not done However inside known range of refringens	II
Ensis minor	Natural	nd	nd	X	X	C & D Detection of advanced stages of the parasite in the epithelium of the digestive gland (Ceschia et al. 2001)	Molecular characterization of the parasite was not done	II
Solen marginatus	Natural	X	nd	X	X	A, C & D. Detection of different stages of the	Molecular characterization of	I

						parasite including mature spores (with refringent granules) in the epithelium of the digestive gland (Lopez & Darriba, 2006; Lopez-Flores et al. 2008)	the parasite was done (Lopez-Flores et al. 2008)	
Chamelea gallina	Natural	X		X	X	A, C & D. Detection of different stages of the parasite including mature spores (with refringent granules) in the epithelium of the digestive gland (Lopez-Flores et al. In press)	Molecular characterization of the parasite was done (Lopez-Flores et al. In press)	I
Scrobicularia piperata	Natural	X	nd	X	X	A., C. & D. Detection of different stages of the parasite including spores in the epithelium of the digestive gland by histo and TEM (Comps 1985) Ultrastructural observations suggest that this parasite species is distinct from M. refringens (= M. christenseni) (Comps 1985).	Parasite ID uncertain. No parasite ID. However molecular characterization of the parasite was not done However description is inside the known range of Marteilia refringens	II
Saccostrea cucullata	Natural	X	nd	X	X	A., C. & D. Detection of different stages of the parasite (primary and secondary) in the epithelia of the stomach and digestive gland by histology (Comps 1976).	Molecular characterization of the parasite (= M. lengehi) was not done (originated from Persic Golfe) (Comps, 1976). Description outside known range of M. refringens.	II
Acartia grani	Natural, and non invasive experimental exposure (cohabitation with infected mussels and oysters)	X	nd	X	X	A. C & D. Observation of different stages of the parasites in the digestive epithelium and in the ovocytes of the female copepods by histology and in situ hybridization (Audemard et al. 2002 ; Carrasco et al. 2008)	Molecular characterization of the parasite was done	I

Other species including the cnidaria *Cereus pedunculatus*, the cyclopoida *Oithona* sp. and an indeterminate harpaticoida species have been shown to be infected by *Marteilia refringens* by PCR (Audemard et al. 2002; Carrasco et al. 2007a and b).

APPENDIX C

Diseases of crustaceans

Taura Syndrome

Table 19: Host species susceptible to TSV

Species	Natural/experimental Invasive/Non-invasive	A	B	C	D	Assessment	Pathogen ID	Group
Penaeus vannamei	Natural and Experimental (Non-invasive and Invasive)	X	X	X	X	A. Presence of characteristic inclusion bodies and labelling by ISH. TEM of virions. MAb labelling in haemolymph. Serial passage from infected animals to to SPF P. vannamei demonstrated (Brock et al. 1995; Lightner et al. 1995; Hasson et al., 1995, 1999; Poulos et al. 1999). B. Passage bioassay to SPF P. vannamei (Brock et al., 1995; Hasson et al., 1995) C. Typical histological changes (Lightner et al. 1995; Hasson et al. 1995, 1999). D. Target organs involved (Lightner et al. 1995; Hasson et al. 1995, 1999) Pathogen characterised by: Sequencing of VP1 (structural protein) gene..	Genotype of pathogen: Over 20 isolates reported in the literature. Several accessions in GenBank.	I
Penaeus duorarum	Experimental (Invasive and Non-invasive)	X	X	X	X	A. Presence of characteristic inclusion bodies only observed in a few individuals. ISH not used to confirm (Overstreet et al., 1997) A & B. Passage bioassay to SPF P. vannamei after 79 days survival following TSV exposure (Overstreet et al., 1997). C. Typical histological changes but only in a small proportion of the affected population (Overstreet et al., 1997). D. Target organs involved but only in a small number of specimens (Overstreet et al., 1997).	Pathogen characterised by: Not reported Genotype of pathogen: Not reported Sucrose-gradient purified Ecuadorian isolate of TSV collected during 1993	I

Penaeus schmitti	Natural	?	?	?	?	Note: Personal communication stating this species as 'highly prone' to TS from Regis Bador (Colombia) in Brock et al. 1997)	no scientific data available	II
Penaeus monodon	Natural and Experimental (Invasive)	XN	X	X	X	A. Presence of characteristic inclusion bodies and labelling by ISH (Srisuvan et al., 2005). B. Passage bioassay to SPF P. vannamei and confirmed TS negative P. monodon (Srisuvan et al., 2005). C. Typical histological changes (Srisuvan et al., 2005) D. Target organs involved (Srisuvan et al., 2005). Pathogen characterised by: Sequencing of VP1 (structural protein) gene.	Genotype of pathogen: Several isolates from across South east Asia reported in the literature. Several accessions in GenBank.	I
Penaeus setiferus	Natural and Experimental Invasive and Non-invasive	X	X	X	X	A. Presence of characteristic inclusion bodies and confirmation of TS by ISH (Overstreet et al., 1997) B. Passage bioassay to SPF P. vannamei after 79 days survival following initial exposure (Overstreet et al., 1997). C. Typical histological changes (Overstreet et al. 1997) D. Target organs involved (Overstreet et al., 1997). Genotype of pathogen: Not reported	Pathogen characterised by: Not reported Sucrose-gradient purified Ecuadorian isolate of TSV collected during 1993	I
Penaeus chinensis	Experimental (Invasive)	X	nd	X	X	A. Presence of characteristic inclusion bodies but ISH or IFAT not used to confirm TS (Overstreet et al., 1997) B. No scientific data available C. Typical histological changes. Co-infection with the parvovirus HPV (Overstreet et al., 1997) D. Target organs involved. Co-infection with the parvovirus HPV (Overstreet et al., 1997)	Pathogen characterised by: Not known Genotype of pathogen: Sucrose-gradient purified Ecuadorian isolate of TSV collected in 1993 (Overstreet et al., 1997)	I
Penaeus japonicus	Experimental (Invasive)	X	nd	nd	?	A. No histopathological data or ISH/IFAT data available though semi-quantitative replication estimates provided using Q-PCR (Chang et al. 2004)	Pathogen characterised by: Sequencing of VP1 (structural protein) gene Genotype of pathogen: Ch-5 isolate with GenBank accession from China (Nielsen et al. 2005). Also, two Taiwanese isolates (Tw2KMeTSV from	II

							Metapenaeus ensis and Tw2KPmTSV from Penaeus monodon) passaged to SPF P. japonicus (Chang et al. 2004). Challenge of P. japonicus was by i.m. injection (Chang et al. 2004) of juvenile (1-2g) shrimps.	
Metapenaeus ensis	Natural	?	X	X	?	A. Gross signs but no histopathological data or ISH/IFAT data available. Gills and pleopods PCR positive (Chang et al., 2004). B. Tissue preparation from specimen showing gross signs and PCR positivity for TS injected into P. japonicus. Q-PCR detection from P. japonicus tissues following bioassay (Chang et al., 2004). C. Gross signs but no histopathological data D. PCR confirmation of TS in gills and pleopods though no specific localisation of pathogen presented (Chang et al., 2004). Live, farmed M. ensis bought from a market showing external signs of TS. Died 2 days after arrival at the lab, gills and 2 pleopods removed and analysed for virus infection by nested PCR (not QPCR).	Pathogen characterised by: Sequencing of VP1 (structural protein) gene (Chang et al. 2004) Genotype of pathogen: Taiwanese isolates Tw2KMeTSV from Metapenaeus ensis	I
Penaeus stylirostris	Natural and experimental (Invasive and Non-invasive)	X	X	X	X	A. Presence of characteristic inclusion bodies. Confirmation of TS positivity by ISH in P. stylirostris from particular geographic locations (Robles-Sikisaka et al., 2002). B. Passage bioassay to SPF P. vannamei (Erickson et al. 2002) C. Typical histological changes (Robles-Sikisaka et al., 2002) D. Target organs involved (Robles-Sikisaka et al., 2002)	Pathogen characterised by: Sequencing of VP1 and VP2 (structural protein) genes (Erickson et al., 2002; Robles-Sikisaka et al. 2002) Genotype of pathogen: Mexican isolates MX99TSV and SON2KTSV, both isolated from P. stylirostris in 1999 and 2000 respectively (Erickson et al. 2002). GenBank accessions available. A separate range of isolates (>20) reported by	I

							Robles-Sikisaka et al. (2002) in Mexican and Taiwanese P. stylirostris. Structural protein gene sequences reported in paper.	
Penaeus aztecus	Experimental (Invasive and Non-invasive)	X	X	X	X	A. Presence of characteristic inclusion bodies only observed in a few specimens. Confirmed as TS positive by ISH (Overstreet et al., 1997) B. Passage bioassay to SPF P. vannamei after 79 days survival following initial exposure (Overstreet et al., 1997) C. Typical histological changes up to 3 days post exposure (Overstreet et al. 1997) D. Target organs involved up to 3 days post exposure (Overstreet et al. 1997).	Pathogen characterised by: Not reported Genotype of pathogen: Not reported	I

Yellow Head disease

Table 20: Host species susceptible to YHV

Species	Natural/Experimental Invasive/Non-invasive	A	B	C	D	Assessment	Pathogen ID	Group
Penaeus monodon	Natural and Experimental Invasive and non-invasive	X	X	X	X	A. Presence of characteristic inclusion bodies and presence of virions associated with inclusion bodies by TEM (Boonyarapatalin et al. 1993; Chantanachookin et al. 1993). Labelling of inclusion bodies with Mabs (Sithogorngul et al. 2000) B. Passage bioassay to healthy P. monodon (Boonyarapatalin et al. 1993). Passage bioassay by injection, feeding and cohabitation with "healthy" P. monodon (Flegel et al. 1995). C. Typical histological changes (Boonyarapatalin et al. 1993; Chantanachookin et al. 1993) D. Target organs involved ((Boonyarapatalin et al. 1993; Chantanachookin et al. 1993).	Pathogen characterised by: Sequence comparisons of structural protein genes (ORF2 and ORF3), intergenic regions (IGRs) and the long 3'-UTR (Walker et al. submitted) Genotype of pathogen: 6 genotypes reported from natural and farmed P. monodon. G1 (YHV), G2 (GAV), G3-6 (asymptomatic in P. monodon). Considers	I

						Passage bioassay to healthy P. monodon from ponds where Yellowhead 'had not been reported' (Boonyarapatalin et al. 1993). Passage bioassay by injection, feeding and cohabitation with "healthy" adult P. monodon (Flegel et al. 1995; Longyant et al. 2006) and by bath exposure of YHV free PL (Walker et al. 2001). Difficult to find an example where SPF is stated. Kiatpathomchai et al. (2004) passaged YHV to RT-PCR YHV-free P. monodon adults	G1 as the most pathogenic (associated with severe YHD), G2 (less severe than G1, associated with MCMS). Walker et al. (submitted).	
Penaeus esculentus	Natural and Experimental Invasive*	nd	nd	nd	nd	A. No scientific data available though external signs observed (in Munro & Owens, 2007) and 82 % mortality occurred following injection with GAV (Spann et al. 2000)*.	Pathogen not characterised * *Note: Natural infections with YHV reported from P. esculentus co-cultivated with P. monodon (Munro & Owens, 2007) while Spann et al. (2000) report mortality of P. esculentus following injection with a pathogenic strain of GAV	II
Penaeus japonicus	Natural and Experimental (Invasive*)	X	nd	X	X	A. Presence of characteristic inclusion bodies and presence of virions associated with inclusion bodies by TEM (Wang et al. 1996). B. No scientific data available* C. Typical histological changes (Wang et al. 1996) D. Target organs involved (Wang et al. 1996)	Pathogen not characterised * *Note: Spann et al. (2000) report mortality of P. japonicus following injection with a pathogenic GAV isolate	II
Penaeus merguiensis	Natural (YHV) and Experimental (Invasive see GAV)	?		X	X?	A. Mortalities in P.merguiensis when injected with virus (reported anecdotally in Chantanachookin et al. (1993). I am ok with this Franck but it really depends on how these different genotypes would be considered by the Cion under the heading of 'YHD' (i.e. are we considering that all genotypes are of concern…I think yes, they may not). C. Histology (Withyachumnarnkul and Boonsaeng, pers.com. in Flegel 1997). Also, presence of characteristic inclusion bodies when injected with pathogenic isolate of GAV* (Spann et al.	Pathogen characterized. Note: Spann et al. (2000) report mortality of P. merguiensis following injection with a pathogenic GAV isolate … yes if Spann's virulent GAV is YHV	I

						2000). Typical histological changes when injected with GAV (Spann et al. 2000)* D. Target organs involved when injected with GAV (Spann et al. 2000)		
Penaeus vannamei	Natural and Experimental Invasive and Non-invasive	X	X	X	X	A. Presence of characteristic inclusion bodies (Lightner et al. 1998; Pantoja & Lightner 2003) and labelling with ISH probe (Tang & Lightner, 1999). B. Passage bioassay to healthy P. vannamei (Lightner et al. 1998). Shrimp for experimental challenges were obtained as PL from 2 sources and reared at the UofA. SPF PL of Mexican strain P. vannamei from the OI, Hawaii. C. Typical histological changes (Lightner et al. 1998; Pantoja & Lightner 2003) D. Target organs involved (Lightner et al. 1998; Pantoja & Lightner 2003)	Pathogen characterised by: ID of pathogen: Thai isolate 6 from infected P monodon. Reference number UAZ93-28 (Lightner et al. 1998) Although not stated as G1, the isolate came from a source in Thailand in 1993. Presume YHV (i.e. Group 1)	I
Penaeus stylirostris	Natural and Experimental Invasive	X	nd	X	X	A. Presence of characteristic inclusion bodies and presence of virions associated with inclusion bodies by TEM (Lu et al. 1994) B. No scientific data available C. Typical histological changes (Lu et al. 1994) D. Target organs involved (Lu et al. 1994)	No ID	II
Penaeus setiferus	Natural* and Experimental Non-invasive	X	nd	X	X	A. Presence of characteristic inclusion bodies (Lightner et al. 1998) although no confirmation by TEM or ISH B. No scientific data available C. Typical histological changes (Lightner et al. 1998) D. Target organs involved (Lightner et al. 1998)	Pathogen characterised by: Not reported Genotype of pathogen: Thai isolate from infected P monodon. Reference number UAZ93-28 (Lightner et al. 1998) *Note: natural YHV infections of farmed P. setiferus reported by Lightner et al. 1997. YHV observed as co-infection with WSSV (Lightner, 1996).	I
Penaeus aztecus	Experimental (Non-invasive)	X?	nd	X	X	A. Presence of characteristic inclusion bodies (Lightner et al. 1998) but no confirmation by TEM or ISH. I am ok with this staying as an 'X' B. No scientific data available	Pathogen characterised by: Not reported Genotype of pathogen: Thai isolate from infected P	I

						C. Typical histological changes (Lightner et al. 1998) D. Target organs involved (Lightner et al. 1998)	monodon. Reference number UAZ93-28 (Lightner et al. 1998)	
Penaeus duorarum	Experimental Non-invasive	X?		X	X	A. Presence of characteristic inclusion bodies (Lightner et al. 1998) but no confirmation by TEM or ISH. B. No scientific data available C. Typical histological changes (Lightner et al. 1998) D. Target organs involved (Lightner et al. 1998)	Pathogen characterised by: Not reported Genotype of pathogen: Thai isolate from infected P monodon. Reference number UAZ93-28 (Lightner et al. 1998)	I
Metapenaeus ensis	Experimental (Invasive)	nd	nd	nd	nd	A. Gross clinical signs and mortalities in M. ensis when injected with YHV virus (reported anecdotally in Chantanachookin et al. 1993). B. No scientific data available C. Standard histopathology data not presented despite clinical signs and mortalities (In: Chantanachookin et al. 1993) D. Target organs involvement not reported (In: Chantanachookin et al. 1993)	Insufficient evidence Pathogen characterised In this case we have descriptions of morts and pathology though not presented as data. Due to morts and ability to infect and kill other species in the genus (see below), would say susceptible but possibly a group II	II
Metapenaeus bennettae	Experimental* Invasive	nd	nd	nd	nd	No scientific data available	Pathogen not characterised Listed as an experimental infection in 'Natural and Experimental Host Range' table in recent review by Munro & Owens (2007) and previously by OIE (2006) and Walker et al. (2005). Walker et al. record an absence of GAV (by nested RT-PCR) in natural populations but ability to infect experimentally with GAV (though data not reported). ISH data not available (Pers Comm. Peter Walker, YHV OIE reference	II

							laboratory, Australia) GAV data may be available from Walker report	
Metapenaeus brevicornis	Experimental (Invasive*)	X	nd	X	X	A. Presence of characteristic inclusion bodies and labelling with MAb Y18, Y19 and to a lesser extent V3-2B (Longyant et al. 2006) B. No scientific data available C. Typical histological changes (Longyant et al. 2006) D. Target organs involved (Longyant et al. 2006)	Virus isolate from infected P. monodon (Longyant et al. 2006). *Transmission not successful via feeding (Longyant et al. 2006).	I
Metapenaeus affinis	Experimental (Invasive and non-invasive)	X	nd	X	X	A. Presence of characteristic inclusion bodies and labelling with MAb Y18, Y19 and to a lesser extent V3-2B (Longyant et al. 2006) B. No scientific data available C. Typical histological changes (Longyant et al. 2006) D. Target organs involved (Longyant et al. 2006)	Virus isolate from infected P. monodon (Longyant et al. 2006).	I
Macrobrachium lanchesteri	Experimental Invasive	?	nd	nd	nd	A. Insufficient data although presence of Y18, Y19 and V3-2B immuno-positive material is reported at 3 days following injection. Standard histopathology data not presented (Longyant et al. 2005), though see comment below C. Standard histopathology not presented and despite labelling, typical histological changes not demonstrated (Longyant et al. 2005) D. Target organs involvement not convincing due to lack of histological material presented (Longyant et al. 2005) Insufficient data although presence of Y18, Y19 and V3-2B immuno-positive material is reported at 3 days following injection. Standard histopathology data not presented (Longyant et al. 2005). Note: there is a confusion with figure labeling in paper where I assume pathology figures labeled as M. lancesteri are actually showing pathology in M. sintangense and other species	Genotype of pathogen: Virus isolate from infected P. monodon (Longyant et al. 2005).	II
Macrobrachium sintangense	Experimental (Invasive)	X	nd	X	X	A. Presence of Y18, Y19 and V3-2B immuno-positive material at 3, 10 and 30 days following injection. Mortalities c.70%. Standard histopathology data not	Virus isolate from infected P. monodon (Longyant et al. 2005).	II Possible a I if we consider that

						presented (Longyant et al. 2005). Though see comment below C. Standard histopathology not presented though labelling is pronounced (Longyant et al. 2005) D. Target organs involvement not convincing due to lack of histological material presented though labelling provides some evidence (Longyant et al. 2005) Note: as above, there is a confusion with figure labeling in the paper where I assume pathology figures labeled as M. lancesteri are actually showing pathology in M. sintangense. If so, pathology data can be used to accept criteria A, C and D		pathology in Longyant paper is actually for this species and not for M. lanchesteri as labelled
Palaemon styliferus	Natural and Experimental (Invasive)	X	X	X	X	A. In situ hybridisation (Flegel, 1997). Presence of Y18, Y19 and V3-2B immuno-positive material. Mortalities high (c. 70%) over 30 day trial. Standard histopathology data not presented (Longyant et al. 2005) B. SPF P. monodon contracted YHV after eating P. styliferus fed on YHV-infected P. monodon (Flegel et al., 1995). C. Standard histopathology H&E and in situ (Flegel, 1997). Immunolabelling is pronounced (Longyant et al. 2005) D. Target organs involvement (Flegel et al., 1997)	Virus isolate from infected P. monodon (Longyant et al. 2005).	I
Palaemon serrifer	Experimental (Invasive).	X	nd	X	X	A. Presence of Y18, Y19 and V3-2B immuno-positive material. Mortalities low (5%) over 30 day trial. Standard histopathology data not presented (Longyant et al. 2005), though see comment below C. Standard histopathology not presented though labelling is pronounced (Longyant et al. 2005) D. Target organs involvement not convincing due to lack of histological material presented though labelling provides some evidence (Longyant et al. 2005) Note: as above, there is a confusion with figure labeling in the paper where I assume pathology figures	Virus isolate from infected P. monodon (Longyant et al. 2005	II Possible a I if we consider that pathology in Longyant paper is actually for this species and not for M. lanchesteri as labelled

						labeled as M. lancesteri are actually showing pathology for either M. sintangense, P. styliferus and P .serirfer If so, pathology data can be used to accept criteria A, C and D		
Acetes sp.	Experimental	nd	X	nd	nd	B. Anecdotal reports that farmers using frozen krill (Acetes sp.) as shrimp feed experienced YHV mortalities 10 days after feeding and that injection of extracts of krill (Acetes sp.) collected from YHV affected shrimp ponds into laboratory held P. monodon caused disease (In: Flegel et al. 1995).	No Pathogen not characterised OK	II

White Spot Disease

Table 21: Host species susceptible to WSV

Host species	Natural or experimental	A	B	C	D	Assessment	Pathogen ID	Group
Penaeus aztecus	Experimental non invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Lightner et al. 1998) C. Typical histological changes (Lightner et al. 1998) D. Target organs involved (Lightner et al. 1998)	Yes - experimental	I
Penaeus duorarum	Experimental non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Lightner et al. 1998) C. Typical histological changes. (Lightner et al. 1998) D. Target organs involved. (Lightner et al. 1998)	Yes - experimental	I
Penaeus chinensis	Natural and experimental invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Lu et al. 1997) and virions by TEM (Zhan et al 1998) B: Transmission to SPF crayfish (Huang et al 2001) or SPF P. monodon (Zhan et al 1998) C. Typical histological changes (Lu et al., 1997 and Zhan et al., 1998) D. Target organs involved (Lu et al., 1997and Zhan et al 1998).	Yes - experimental	I
Penaeus indicus	Natural and experimental (invasive)	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al., 1999 and Sahul Hameed et al., 2000) and virions by TEM (Rajan et al 2000).	Yes experimental	I

						B: ”Healthy” P. monodon (Rajendran et al., 1999) C. Typical histological changes (Rajendran et al. 1999 and Sahul Hameed et al 2000) D. Target organs involved (Rajendran et al. 1999 Sahul Hameed et al 2000 and Rajan et al. 2000)		
Penaeus merguiensis	Natural	X	X	X	X	A: inclusion bodies by histology and ISH (Lo, pers. com. in Flegel 1997) B: transmission to P. monodon C. histology D. Target organs involved. Immuno blot of target organs (Barnett et al., 2006)	Yes?	
Penaeus setiferus	Experimental non invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies. Lightner et al. 1998 C. Typical histological changes. Lightner et al. 1998 D. Target organs involved. Lightner et al. 1998	yes	I
Penaeus stylirostris	Natural and experimental invasive	X	nd	X	X	A. Presence of characteristic inclusion bodies. Lightner et al. 1998 and Lu et al. 1997 C. Typical histological changes. Lightner et al. 1998 and Lu et al. 1997 D. Target organs involved. Lightner et al. 1998and Lu et al. 1997	yes	I
Penaeus vannamei	Natural and experimental (non-invasive)	x	nd	x	x	A. Presence of characteristic inclusion bodies. Lightner et al. 1998 and Lu et al. 1997 C. Typical histological changes. Lightner et al., 1998 and Lu et al., 1997 D. Target organs involved. Lightner et al. 1998and Lu et al. 1997	yes	I
Penaeus japonicus	Natural and experimental (invasive and non-invasive)	x	nd	x	x	A. Presence of characteristic inclusion bodies (Lu et al. 1997, Wang et al. 1998b, Chou et al 1998) and virions by TEM (Zhan et al. 1998), reaction by ISH (Wang et al. 1998b) C. Typical histological changes. (Lu et al. 1997, Wang et al. 1998b, Chou et al 1998) D. Target organs involved,	yes - detection by PCR of target tissues (Lu et al. 1997, Wang et al. 1998b, Chou et al 1998, Wang et al. 1998a and Lo et al. 1996)	I
Metapenaeus brevicornis	Natural	nd	nd	nd	x	D. Detection by PCR of target tissues (Hossain et al 2001a)	PCR testing of target organ. Likely to be susceptible	II
Metapenaeus dobsonii	Natural and experimental invasive and non-	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al 1999), observation of virions by TEM (Rajan et al 2008)	yes - detection by PCR of target tissues (Hossain et al 2001)	I

	invasive					B: Transmission to ”healthy” P. monodon (Rajendran et al., 1999) C. Typical histological changes. (Rajendran et al 1999) D. Target organs involved (Rajendran et al 1999 Rajan et al 2008 and(Hossain et al 2001)		
Metapenaeus ensis	Natural and experimental non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Wang et al. 1998b), detection by ISH (Wang et al. 1998b and Chang et al. 1998) C. Typical histological changes. (Wang et al. 1998b) D. Target organs involved (Chang et al. 1998, Wang et al. 1998a, Wang et al. 1998b)	yes - detection by PCR of target tissues (Wang et al. 1998a)	I
Metapenaeus monoceros	Natural or experimental invasive and non-invasive	nd	x	nd	x	B: transmission to ”healthy” monodon (Rajendran et al. 1999) D: detection by PCR of target tissues (Hossain et al. 2001a)	yes	I
Penaeus monodon	Natural and experimental invasive and non-invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Sahul Hameed et al 2000, Wang et al. 1998b and Rajendran et al. 1999) and virions by TEM (Zhan et al. 1998 and Rajan et al 2008), reaction by ISH (Wang et al. 1998b) B: transmission to spf shrimp (Lightner 1999) C. Typical histological changes. (Sahul Hameed et al., 2000, Wang et al., 1998b and Rajendran et al. 1999) D. Target organs involved (Wang et al. 1998b, Wang et al. 1998a and Lo et al. 1996)	yes - detection by PCR of target tissues (Kou et al 1998, Lo et al. 1996 and Wang et al 1998a)	I
Penaeus penicillatus	Natural and experimental invasive and non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Chou et al, 1998) C. Typical histological changes. (Chou et al 1998) D. Target organs involved. (Chou et al 1998, Wang et al. 1998a and Lo et al. 1996)	Yes - detection by PCR in target tissues (Lo et al. 1996 and Wang et al 1998a)	I
Penaeus semisulcatus	natural & experimental (non invasive)	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999), observation of viral particles by TEM (Rajan et al 1998) B: Transmission to ”healthy” P. monodon (Rajendran et al. 1999) C. Typical histological changes. (Rajendran et al. 1999) D. Target organs involved (Rajendran et al. 1999, Wang et al 1998a, Lo et al 1996)	yes - detection by PCR in target tissues (Lo et al. 1996 and Wang et al 1998a)	I
Parapenaeopsis stylifera	natural	nd	nd	nd	x	D. Detection by PCR in target tissues & organs	Detection by PCR in target	II

						(Hossain et al. 2001b) Organism coming from the wild. PCR testing of target organ. Difficult to be a contamination Likely to be susceptible	tissues & organs (Hossain et al. 2001b)	insufficient evidence
Solenocera indica	natural	nd	nd	nd	x	D. Detection by PCR in target tissues. (Hossain et al. 2001b)	PCR detection	II
Trachypenaeus curvirostris	natural experimental oral (non invasive)	X	nd	nd	X	A. Detection by ISH (Chang et al, 1998) D. Target organs involved. (Chang et al, 1998 Wang et al. 1998a, Wang et al. 1998b)	yes - PCR in target tissues (Wang et al. 1998a, Wang et al. 1998b)	I
Crangon crangon	Experimental invasive	x	nd	nd	x	A. Detection by IIF (V. Alday personal comunication) D. Target organs involved. (V. Alday pers. com.)	Yes - experimental	I
Alpheus lobidens	Natural	nd	nd	nd	nd	No scientific information found but positive PCR (not mentioned if sampled target tissues) Takahashi et al., 2003	Yes - PCR	II
Alpheus brevicristatus	Natural	nd	nd	nd	nd	No scientific information found but positive PCR (not mentioned if sampled target tissues) Takahashi et al., 2003	Yes - PCR	II
Callianassa sp.	natural	nd	nd	nd	nd	PCR Lo et al. 1996	PCR	II
Exopalaemon orientalis	Experimental non-invasive	x	nd	nd	x	C. No scientific information found D. Target organs involved (Chang et al. 1998 and Wang et al 1998a)	yes - detection by PCR in target tissues (Wang et al 1998a)	I
Palaemon sp.	natural	nd	nd	nd	x	D. Organism coming from an infected pond. Detection by PCR in target tissues (Lo et al. 1996)	PCR	II
Palaemon adspersus	Experimental invasive	x	nd	nd	x	A. Observation of viral particles by TEM (Corbel et al. 2001) reaction by ISH (Corbel et al. 2001) D. Target organs and detection by PCR (Corbel et al. 2001)	Yes – PCR & experimental	I
Macrobrachium idella	Experimental invasive and non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999) C. Typical histological changes (Rajendran et al. 1999) D. Target organs involved (Rajendran et al. 1999)	Yes experimental	I
Macrobrachium lamerrae	Experimental invasive and non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Sahul-Hameed et al. 2000) C. Typical histological changes (Sahul-Hameed et al. 2000) D. Target organs involved (Sahul-Hameed et al. 2000)	Yes experimental	I
Macrobrachium rosenbergii	natural and experimental	x	x	x	x	A. Presence of characteristic inclusion bodies (Sahul Hameed et al 2000 and Rajendran et al. 1999) and	Yes experimental	I

	invasive and non-invasive					detection by PCR of target tissues (Hossain et al 2001 and Lo et al. 1996) B: Transmission to ”healthy” P. Monodon (Rajendran et al. 1999) C. Typical histological changes. (Sahul Hameed et al 2000 and Rajendran et al. 1999) D. Target organs involved. (Sahul Hameed et al Hossain et al 2001 and Lo et al. 1996)		
Panulirus homarus	Experimental non invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999 B: Transmission to ”healthy” P. monodon (Rajendran et al. 1999) C. Typical histological changes (Rajendran et al. 1999) D. Target organs involved (Rajendran et al. 1999)	Yes - experimental	I
Panulirus longipes	natural and experimental invasive and non-invasive	x	x	x	x	A:Presence of characteristic inclusion bodies (Rajendran et al. 1999) B: Transmission to ”healthy” P. Monodon (Rajendran et al. 1999) C. Typical histological changes. (Rajendran et al. 1999) D. Target organs involved (Rajendran et al. 1999 and Wang et al 1998a)	yes - detection by PCR in target tissues (Wang et al 1998a)	I
Panulirus ornatus	natural and experimental invasive and non-invasive	x	x	x	x	A:Presence of characteristic inclusion bodies (Rajendran et al. 1999) B: Transmission to ”healthy” P. Monodon (Rajendran et al. 1999) C. Typical histological changes. (Rajendran et al. 1999) D. Target organs involved (Rajendran et al. 1999 and Wang et al 1998a).	yes - detection by PCR in target tissues (Wang et al 1998a)	I
Panulirus penicillatus	Experimental non invasive	x	nd	nd	x	A:Detection by ISH (Chang et al. 1998) D. Target organs involved (Chang et al. 1998 and Wang et al 1998a). and detection by PCR of target tissues (Wang et al 1998a)	Yes – PCR & experrimental	I
Panulirus polyphagus	natural and experimental invasive and non-invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999 B: Transmission to ”healthy” P. Monodon (Rajendran et al. 1999) C. Typical histological changes (Rajendran et al. 1999)	Yes - experimental	I

						D. Target organs involved (Rajendran et al. 1999)		
Panulirus versicolor	Experimental non-invasive	X	nd	nd	X	A:Detection by ISH (Chang et al. 1998) D. Target organs involved (Chang et al. 1998 and Wang et al 1998a))	yes - detection by PCR in target tissues (Wang et al 1998a	I
Homarus gammarus	Experimental non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (G Stentiford pers. com.), observation of viral particles by TEM (G Stentiford pers. com.) C. Typical histological changes. (G Stentiford pers. com.) D. Target organs involved	yes - detection by PCR in target tissues (G Stentiford pers. com.)	I
Scyllarus arctus	Experimental invasive	x	nd	nd	x	A. Detection by ISH and dot blot hybridization (Corbel et al. 2001), observation of viral particles by TEM (Corbel et al. 2001) D. Target organs involved	yes - detection by PCR of target tissues (Corbel et al. 2001)	I
Astacus astacus	Experimental invasive and non-invasive	nd	nd	nd	x	D. Target organs involved and detection by PCR in target tissues (Jiravanichpaisal et al. 2004)	Yes - PCR	II
Astacus leptodactylus	Experimental invasive	x	nd	nd	x	A. Detection by ISH and dot blot hybridization (Corbel et al. 2001), observation of viral particles by TEM (Corbel et al. 2001) D. Target organs involved	yes - detection by PCR in target tissues (Corbel et al. 2001)	I
Cherax destructor	Experimental invasive	x	nd	x	x	A. Detection by histology and dot blot hybridization (Edgerton, 2004) C. Typical histological changes (Edgerton, 2004) D. Target organs involved (Edgerton, 2004)	Yes - experimental	I
Cherax quadricarinatus	Experimental invasive	x	nd	x	x	A. Detection of the characteristic inclusion bodies by histology and ISH (Shi et al. 2000) and observation of viral particles by TEM (Shi et al. 2000) C. Typical histological changes (Shi et al. 2000) D. Target organs involved (Shi et al. 2000)	Yes - experimental	I
Pacifastacus leniusculus	Experimental invasive and non-invasive	x	nd	x	x	A. Detection of the characteristic inclusion bodies by histology and ISH (Jiravanichpaisal et al., 2001) C. Typical histological changes (Jiravanichpaisal et al. 2001) D. Target organs involved (Jiravanichpaisal et al. 2001)	Yes - experimental	I
Squilla mantis	Natural	nd	nd	nd	x	D. Detection PCR in target tissues and organs involved (Hossain et al 2001b)	PCR testing of target organ.	II

Procambarus clarkii	Experimental invasive and non-invasive	x	nd	nd	x	A. Detection by ISH (Chang et al. 1998), by TEM (Huang et al. 2001) D. Target organs involved ISH (Chang et al. 1998, Huang et al. 2001, Wang et al. 1998a, Huang et al. 2001 and Du et al. 2008)	Yes experimental and PCR of target tissues (Wang et al. 1998a, Huang et al. 2001 and Du et al. 2008)	I
Orconectes punctimanus	natural	nd	nd	nd	x	D. Detection by dot blot hybridization from target tissues and organs involved (Lo et al. 1999)	The virus DNA was extracted and analyzed by PCR with specific primers and restriction fragmental length polymorphism.	II
Orconectes limosus	Experimental injection	x	nd	nd	x	A. Detection of inclusion bodies by ISH Corbel et al. 2001), observation of viral particles by TEM (Corbel et al. 2001) D. detection by PCR and dot blot hybridization (target tissues and organs) (Corbel et al. 2001)	Yes - experimental	I
Atergatis integerrimus	Experimental invasive and non-invasive	x	nd	x	x	A. Detection of the characteristic inclusion bodies by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. Target organs involved	Yes - experimental and PCR of target tissues (Sahul-Hameed et al. 2003)	I
Calappa philarigus	Natural Experimental invasive and non-invasive	x	nd	x	x	A. Detection of the characteristic inclusion bodies by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. Target organs involved	yes - PCR of target tissues (Sahul-Hameed et al. 2003 and Kou et al. 1998)	I
Calappa lophos	Experimental non-invasive	nd	nd	nd	x	D. viral DNA detected by PCR in target organs (Wang et al. 1998a)	yes - PCR	II
Cancer pagurus	Experimental invasive	x	nd	nd	x	A. Detection of characteristic inclusions by ISH (Corbel et al. 2001), observation of viral particles by TEM (Corbel et al. 2001) D. Target organs involved	yes - detection by PCR and dot blot hybridization in target tissues (Corbel et al. 2001)	I
Carcinus maenas	Experimental invasive	x	nd	nd	x	A. Detection of characteristic inclusions by ISH, observation of viral particles by TEM (Corbel et al. 2001) D. Target organs involved	yes - detection by PCR and dot blot hybridization of target tissues (Corbel et al. 2001)	I
Charybdis annulata	Natural Experimental invasive and non-	x	nd	x	x	A. Detection of characteristic inclusion bodies by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al.	yes - PCR in target tissues (Sahul-Hameed et al. 2003 and Hossain et al. 2001)	I

	invasive					2003) D. Target organs involved		
Charybdis cruciata	Natural	nd	nd	nd	x	D. Target organs involved and detection by PCR in target tissues (Hossain et al. 2001b)	Yes - PCR	II
Charybdis feriatus	Natural and Experimental non-invasive	x	nd	nd	x	A. Detection of inclusions by ISH (Kou et al. 1998) D. Target organs involved	yes - PCR in target tissues (Kou et al. 1998, Lo et al. 1996 and Wang et al. 1998a)	I
Charybdis granulata	Experimental non-invasive	x	nd	nd	x	A. Detection of characteristic inclusion bodies by ISH (Chang et al. 1998) D. Target organs involved	yes - PCR of target tissues (Chang et al. 1998 Wang et al. 1998a)	I
Charybdis japonicus	Natural	nd	nd	nd	?	D. PCR positive, but it is not mentioned if target organs were selected (Takahasi et al 2003)	Yes - PCR	II
Charybdis lucifera	Natural Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003 and Lo et al. 1999)	Yes – see D	I
Charybdis natator	Natural Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003), ISH (Kou et al. 1998) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003 and Kou et al. 1998)	Yes – see D	I
Demania splendida	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes – see D	I
Doclea hybrida	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes – see D	I
Gelasimus marionis nitidus	Natural	nd	nd	nd	x	D. Target organs involved (Hossain et al. 2001b)	yes - detection PCR in target tissues (Hossain et al. 2001)	II
Grapsus albolineatus	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. target tissues (Sahul-Hameed et al. 2003)	Yes - PCR of target tissues (Sahul-Hameed et al. 2003)	I
Halimede ochtodes	Experimental	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003)	yes - PCR of target tissues	I

	invasive and non-invasive					C. Typical histological changes (Sahul-Hameed et al. 2003) D. target tissues	(Sahul-Hameed et al. 2003)	
Helice tridens	Natural	nd	nd	nd	x	D. Detection by PCR of target tissues (Lo et al 1996 and Kou et al. 1998)	Yes - PCR (Lo et al 1996 and Kou et al. 1998)	II
Liagore rubronaculata	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes, see D	I
Liocarcinus depurator	Experimental invasive	x	nd	nd	x	A. Detection by ISH and dot blot hybridization (Corbel et al. 2001), observation of viral particles by TEM (Corbel et al. 2001) D. detection by PCR of target tissues (Corbel et al. 2001)	Yes - PCR	I
Liocarcinus puber	Experimental invasive	x	nd	nd	x	A. Detection by ISH and dot blot hybridization (Corbel et al. 2001), observation of viral particles by TEM (Corbel et al. 2001) D. detection by PCR of target tissues (Corbel et al. 2001)	yes	I
Lithodes maja	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes see D	I
Macrophthalmus sulcatus	Natural	nd	nd	nd	x	D. Detection by PCR of target tissues (Hossain et al. 2001b)	Yes - PCR	II
Matuta miersi	Experimental	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes see D	I
Matuta planipes	Natural	nd	nd	nd	x	D. Detection by PCR of target tissues (Otta el al 1999)	Yes - PCR	II
Menippe rumphii	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes - PCR	I
Metapograpsus sp.	Experimental invasive and non invasive	x	x	x	x	A. Detection by histology (Rajendran et al. 1999) B: Transmission to ”healthy” P. monodon C. Typical histological changes (Rajendran et al. 1999) D. Target organs involved (Rajendran et al. 1999)	yes	I

Metapograpsus messor	Natural	nd	nd	nd	x	D. Detection by PCR in target tissues (Hossain et al. 2001b)	yes - PCR	II
Paradorippe granulata	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes - PCR	I
Paratelphusa hydrodomous	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes - PCR	I
Paratelphusa pulvinata	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes - PCR	I
Parthenope prensor	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes - PCR	I
Phylira syndactyla	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	yes	I
Podophthalmus vigil	Experimental invasive and non-invasive	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)	Yes, see D	I
Portunus pelagicus	Natural, Experimental invasive and non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Supamattaya et al. 1998), detection by ISH (Supamattaya et al. 1998 and Kou et al. 1998) and virions by TEM (Supamattaya et al. 1998) C. Typical histological changes bodies (Supamattaya et al. 1998) D. Target organs involved bodies (Kou et al. 1998 and Supamattaya et al. 1998)	Yes - experimental	I
Portunus sanguinolentus	Natural, Experimental invasive and non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Sahul-Hameed et al. 2003), detection by ISH (Chang et al. 1998 and Kou et al. 1998) C. Typical histological changes bodies (Sahul-Hameed	Yes - PCR in target organs	I

						et al. 2003) D. detection by PCR in target organs (Lo et al. 1996, Sahul-Hameed et al. 2003 and Wang et al. 1998b)		
Pseudograpsus intermedius	Natural	nd	nd	nd	x	D. Detected by PCR in target organs (Hossain et al. 2001a)	yes	II
Sesarma sp.	Experimental invasive and non-invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999 and Kanchanaphum et al. 1998), detection by ISH (Kanchanaphum et al. 1998) B: Transmission to PCR negative P. monoon (Kanchanaphum et al. 1998) and ”healthy” P. Monodon (Rajendran et al. 1999) C. Typical histological changes bodies (Rajendran et al. 1999 and Kanchanaphum et al. 1998) D. detection by PCR in target organs (Kanchanaphum et al. 1998)	Yes – see A, D	I
Sesarma oceanica	Natural	nd	nd	nd	x	D. Detection by PCR in target organs (Otta el al 1999)	Yes - PCR	II
Scylla serrata	Natural, Experimental invasive and non-invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999, Sahul-Hameed et al. 2003 and Kanchanaphum et al. 1998), and viral particles by TEM (Supamattaya et al. 1998), detection by ISH (Kanchanaphum et al. 1998, Supamattaya et al. 1998) B: Transmission to PCR negative P. monodon (Kanchanaphum et al. 1998) and ”healthy” P. monodon (Rajendran et al. 1999) C. Typical histological changes bodies (Rajendran et al. 1999 and Kanchanaphum et al. 1998) D. detection by PCR in target organs (Lo et al. 1996, Kanchanaphum et al. 1998 and Sahul-Hameed et al. 2003)	Yes - D	I
Scylla tranquebaricca	Experimental invasive and non-invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Rajendran et al. 1999 B: Transmission to ”healthy” P. monodon (Rajendran et al. 1999) C. Typical histological changes bodies (Rajendran et al. 1999) D. Target organs involved bodies (Rajendran et al. 1999)	Yes - experimental	I
Thalamita danae	Experimental invasive and non-	x	nd	x	x	A. Detection by histology (Sahul-Hameed et al. 2003) B: No scientific information found	Yes – PCR and expe	I

	invasive					C. Typical histological changes (Sahul-Hameed et al. 2003) D. PCR of target tissues (Sahul-Hameed et al. 2003)		
Uca pugilator	Experimental invasive	x	x	x	x	A. Presence of characteristic inclusion bodies (Kanchanaphum et al. 1998), detection by ISH (Kanchanaphum et al. 1998) B: Transmission to PCR negative P. monondon (Kanchanaphum et al. 1998) C. Typical histological changes bodies (Kanchanaphum et al. 1998) D. detection by PCR in target organs (Kanchanaphum et al. 1998)	Yes – PCR and experimental	I
Sergestoidea Acetes sp.	Experimental invasive and non-invasive	x	nd	x	x	A. Presence of characteristic inclusion bodies (Supamattaya et al. 1998), and viral particles by TEM (Supamattaya et al. 1998), detection by ISH (Supamattaya et al. 1998) C. Typical histological changes bodies (Supamattaya et al. 1998) D. Target organs involved bodies (Supamattaya et al. 1998)	Yes - experimental	I
Cirripedia Balanus sp.	Natural, Experimental	nd	nd	nd	nd	Detection by PCR (Ramírez-Douriet et al. 2005)	Yes - PCR	II
Branchiopoda Cladocera	Natural	nd	nd	nd	nd	Detection by PCR (Ramírez-Douriet et al. 2005)	Yes - PCR	II
Artemia salina	Natural	nd	nd	nd	nd	Positive PCR reaction of whole organism (Otta et al 1999)	Yes - PCR	II
Copepoda	Natural	nd	nd	nd	nd	Psitive PCR reaction of whole organism (Lo et al, 1996, Ramírez-Douriet et al. 2005)	Yes - PCR	II
Chaetognata	Natural	nd	nd	nd	nd	Positive PCR reaction of whole organism (Ramírez-Douriet et al. 2005)	Yes - PCR	II
Rotifera	Natural	nd	nd	nd	nd	Positive PCR reaction of whole organism (hatched organism and resting egg) and dot blot hybridization (Yan et al. 2004). Rotifers were washed and disinfected prior testing. Washing water was negative	Yes – PCR and dot-blot	II
Polychaeta Marphysa sp.	Natural, experimental non-invasive	nd	nd	nd	nd	Positive PCR reaction of whole organism (Vijayan et al. 2005). The paper assumes that there is no infection but acts as a mechanical vector. However, this is not demonstrated nor a reference is mentioned	Yes – PCR and dot-blot	II
Coleoptera (Ephydridae)	Natural,	nd	nd	nd	nd	Positive PCR reaction of whole organism (Lo et al,	Yes – PCR and dot-blot	II

						1996)		

ABBREVIATIONS

BE	*Bonamia exitiosa*
BO	*Bonamia ostreae*
CD	Council Directive
DG	Digestive gland
DNA	Deoxyribonucleic acid
ELISA	Enzyme-linked immunosorbent assay
FISH	Fluorescent *in situ* hybridization
IFAT	Indirect fluorescent antibody test
ISH	*in-situ* hybridization
MM	*Mikrocytos mackini*
MR	*Marteilia refringens*
MSX	Multinucleate sphere X (*Haplosporidium nelsoni*)
OIE	World Organization for Animal Health
PCR	Polymerase chain reaction
PM	*Perkinsus marinus*
QPX	Quahog parasite unknown
RFLP	Restriction fragment length polymorphism
RNA	Ribonucleic acid
RT-PCR	Reverse transcriptase polymerase chain reaction
SEM	Scanning electron microscopy
ATCC	American Type Culture Collection
BIV	Bohle virus
CNGV	Carp interstitial nephritis and gill necrosis virus
CPE	Cytopathogenic effect
DNA	Deoxyribonucleic acid
ECV	European catfish virus
EHN	Epizootic haematopoietic necrosis
EHNV	Epizootic haematopoietic necrosis virus
ELISA	Enzyme-linked immunosorbent assay
ESV	European sheatfish virus
EUS	Epizootic ulcerative syndrome
FV3	Frog virus 3
GIT	Gastro-intestinal tract
IFAT	Indirect fluorescent antibody test
IHN	Infectious hematopoietic necrosis
IHNV	Infectious hematopoietic necrosis virus
IPN	Infectious Pancreatic Necrosis
ISA	Infectious salmon anaemia
ISAV	Infectious salmon anaemia virus
ISH	In-situ hybridization
KHV	Koi carp herpes virus
LAMP	Loop Mediated Isothermal Amplification
MCP	Major capsid protein
OIE	World Organization for Animal Health

PCR	Polymerase chain reaction
PFU	Plaque forming unit
RFLP	Restriction fragment length polymorphism
RNA	Ribonucleic acid
RT-PCR	Reverse transcriptase polymerase chain reaction
SEM	Scanning electron microscopy
SVC	Spring viraemia of carp
SVCV	Spring viraemia of carp virus
SE	Sensitivity
SHK-1	
SP	Specificity
SS	Susceptible species
SSO	Sea side organism (*Haplosporidium costale*)
TEM	Transmission electron microscopy
VHSV	Viral haemorrhagic septicaemia virus
VHS	Viral haemorrhagic septicaemia