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REPORT OF THE MEETING OF THE OIE *AD HOC* GROUP ON SUSCEPTIBILITY OF FISH SPECIES TO INFECTION WITH OIE LISTED DISEASES[1]

Paris, 28–30 November 2017

The OIE *ad hoc* Group on Susceptibility of fish species to infection with OIE listed diseases (the *ad hoc* Group) met for their third meeting at OIE Headquarters from 28 to 30 November 2017.

The list of participants and the Terms of Reference are presented in Annex I and Annex II, respectively.

Dr Stian Johnsen, Standards Department, welcomed members to this meeting and thanked the *ad hoc* Group for their ongoing work on this important topic.

The Chair of the *ad hoc* Group, Dr Mark Crane, clarified that the purpose of this meeting was to finalise the assessment started at their previous meeting of infection with koi herpesvirus (KHV) and start applying the criteria for listing on infection with salmonid alphavirus (SAV), spring viraemia of carp virus (SVCV), red bream iridoviral disease virus (RSIV) and infectious haematopoietic necrosis virus (IHNV). During this meeting the *ad hoc* Group applied the criteria on five diseases, of which the assessments of KHV, SAV and SVCV were finalised.

The *ad hoc* Group applied the three-stage approach, outlined in Article 1.5.3. of the *Aquatic Animal Health Code (Aquatic Code)* to assess susceptibility of a species, described as shown below:

1) criteria to determine whether the route of transmission is consistent with natural pathways for the infection (as described in Article 1.5.4.);

2) criteria to determine whether the pathogenic agent has been adequately identified (as described in Article 1.5.5.);

3) criteria to determine whether the evidence indicates that presence of the pathogenic agent constitutes an infection (as described in Article 1.5.6.).

Stage 1: criteria to determine whether the route of transmission is consistent with natural pathways for the infection (as described in Article 1.5.4.)

Route of infection Key

N: Natural infection.

E: Experimental (non-invasive).

EI: Experimental (invasive).

For most references that reported invasive experimental procedures as the route of transmission these were not progressed past Stage 1 (i.e. Article 1.5.4.). In other cases the stage 3 criteria A-D indicated that the species were non-susceptible to infection.

[1] Note: This *ad hoc* Group report reflects the views of its members and may not necessarily reflect the views of the OIE. This report should be read in conjunction with the February 2018 report of the Aquatic Animal Health Standards Commission because this report provides its considerations and comments. It is available at http://www.oie.int/en/international-standard-setting/specialists-commissions-groups/aquatic-animal-commission-reports/meeting-reports/

Stage 2: criteria to determine whether the pathogenic agent has been adequately identified (as described in Article 1.5.5.)

Accurate pathogen identification might not have been carried out in older publications because molecular typing techniques were not available at the time. In these circumstances a weight of evidence approach using combined data from relevant studies were considered used to assess susceptibility.

Stage 3: criteria to determine whether the evidence indicates that presence of the pathogenic agent constitutes an infection (as described in Article 1.5.6.)

There was evidence of infection with the pathogenic agent in the suspect host species in accordance with criteria A to D in Article 1.5.6. Evidence to support criterion A alone was sufficient to determine infection. In the absence of evidence to meet criterion A, satisfying at least two of criteria B, C or D were required to determine infection.

A. The pathogenic agent is multiplying in the host, or developing stages of the pathogenic agent are present in or on the host;

B. Viable pathogenic agent is isolated from the proposed susceptible species, or infectivity is demonstrated by way of transmission to naïve individuals;

C. Clinical or pathological changes are associated with the infection;

D. The specific location of the pathogen corresponds with the expected target tissues.

Hosts that were classified as susceptible species (as described in Article 1.5.7.) were proposed for inclusion in Article 10.X.2. of the relevant disease-specific chapter of the *Aquatic Code.*

Hosts that were classified as species for which there is partial evidence for susceptibility (as described in Article 1.5.8.) were proposed for inclusion in a new Section 2.2.2. *Species with incomplete evidence for susceptibility* of the relevant chapter of the *Aquatic Manual*.

The detailed assessments for each specific pathogenic agent assessed by the *ad hoc* Group are provided in Annexes III to V.

Disease	**Annex Number**
KHV	III
SAV	IV
SVCV	V

The *ad hoc* Group wished to note the following:

1. The *ad hoc* Group recommended including a list of species with strong evidence of non-susceptibility in each of the disease-specific chapters of the *Aquatic Manual*.

2. The *ad hoc* Group agreed to commence work electronically on VHSV, IHNV and RSIV.

3. The *ad hoc* Group requested that another physical meeting be held in 2018 to finalise the assessments on RSIV and IHNV and to start applying the criteria to the remaining OIE listed fish diseases.

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…/Annexes

Annex I

REPORT OF THE MEETING OF THE OIE *AD HOC* GROUP ON SUSCEPTIBILITY OF FISH SPECIES TO INFECTION WITH OIE LISTED DISEASES

Paris, 28–30 November 2017

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Annex II

REPORT OF THE MEETING OF THE OIE *AD HOC* GROUP ON SUSCEPTIBILITY OF FISH SPECIES TO INFECTION WITH OIE LISTED DISEASES

Paris, 28–30 November 2017

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Terms of reference

Background

A new Chapter 1.5. *Criteria for listing species as susceptible to infection with a specific pathogen* was introduced in the 2014 edition of the *Aquatic Code*. The purpose of this chapter is to provide criteria for determining which host species are listed as susceptible in Article X.X.2. of each disease-specific chapter in the *Aquatic Code.* The criteria are to be applied progressively to each disease-specific chapter in the *Aquatic Code*.

These assessments will be undertaken by *ad hoc* groups and the assessments will be provided to Member Countries for comment prior to any change in the list of susceptible species in Article X.X.2. of the disease-specific chapters in the *Aquatic Code.*

For species where there is some evidence of susceptibility but insufficient evidence to demonstrate susceptibility through the approach described in Article 1.5.3, information will be included in the relevant disease-specific chapter in the *Aquatic Manual.*

Purpose

The *ad hoc* Group on Susceptibility of fish species to infection with OIE listed diseases will undertake assessments for the ten OIE listed fish diseases.

Terms of Reference

1. Consider evidence required to satisfy the criteria in Chapter 1.5.

2. Review relevant literature documenting susceptibility of species for OIE listed fish diseases.

3. Propose susceptible species for OIE listed diseases for fish based on Article 1.5.7.

4. Propose susceptible species for OIE listed diseases for fish based on Article 1.5.8.

Expected outputs of the *ad hoc* Group

1. Develop a list of susceptible species for inclusion in the relevant Article X.X.2. of fish disease-specific chapters in the *Aquatic Code.*

2. Develop a list of species with incomplete evidence for susceptibility for inclusion in Section 2.2.2. of the *Aquatic Manual.*

3. Draft a report for consideration by the Aquatic Animals Commission at their February 2018 meeting.

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ASSESSMENT OF HOST SUSCEPTIBILITY TO INFECTION WITH KOI HERPES VIRUS (KHV)

Criteria for susceptibility to infection with KHV are detailed in Table 1 (as per Article 1.5.6. of the *Aquatic Code*). This table includes Replication (A), Viability/Infectivity (B), Pathology/Clinical Signs (C) and Location (D). Hosts were considered to be infected with KHV if they fulfilled either criterion A, or at least two of criteria B, C and D (as per point 3 of Article 1.5.7. of the *Aquatic Code*).

Table 1. *Criteria for susceptibility to infection with KHV* (Stage 3)

A: Replication	B: Viability / Infectivity	C: Pathology / Clinical signs	D: Location
Sequential virus titration showing increase in viral titres; OR Demonstration of increasing copy number over time by qPCR with confirmatory PCR/sequencing; OR TEM showing virions in host cells; OR Products of virus replication detected e.g. demonstration of viral antigen by specific immunoassay of tissue imprints or fixed tissue sections.	Isolation by cell culture OR Passage to a susceptible host with infection confirmed by PCR/sequencing and demonstrating at least two of the following: i. clinical signs, with or without associated mortality, ii. Histopathology, iii. Re-isolation of virus in cell culture.	White patches on gill, enophthalmia, necrosis of gill epithelium and intranuclear inclusion bodies. Erosion of primary gill lamellae, fusion of secondary lamellae, and swelling at the tips of the primary and secondary lamella. Inflammation and necrosis of gill tissues is a consistent feature. Gills also exhibit hyperplasia and hypertrophy of branchial epithelium, and fusion of secondary lamellae and adhesion of gill filaments. Gill necrosis, ranging from small areas of necrotic epithelial cells of secondary lamellae to complete loss of the lamellae. Branchial epithelial cells and leucocytes may have prominent nuclear swelling, margination of chromatin to give a 'signet ring' appearance, and pale diffuse eosinophilic intranuclear inclusions are commonly observed. Inflammation, necrosis and nuclear inclusions have been observed in kidney, spleen, pancreas, liver, brain, gut and oral epithelium.	Gill, intestine, kidney, and spleen are the organs in which KHV is most abundant during the course of an overt infection.* Brain is the target organ for chronic disease.

* Where gills and intestine are used surface contamination should be ruled out.

ASSESSMENT FOR HOST SUSCEPTIBILITY

The assessment for host susceptibility to infection with KHV is provided in Table 2.

Table 2. *Outcome of assessment for host susceptibility to infection with KHV*

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C	D		
Cyprinus	*carpio*	Common carp	N	Culture + subsequent sequencing	Y	Y	Y	Y	1	Aoki *et al.,* 2007; Hedrick *et al.,* 2000; St-Hilaire *et al.,* 2005; McColl *et al.,* 2016; Sano *et al.,* 2004; Rahmati-Holasoo *et al.,* 2016
Cyprinus	*carpio koi*	Koi carp	N	Culture + subsequent sequencing	Y	Y	Y	Y	1	
(e.g. Cyprinus carpio x *Carassius auratus)*		Common carp hybrids	E	PCR	N	N	Y	Y	1	Bergmann *et al.,* 2010b; Kempter *et al.,* 2009
crucian carp x *koi carp hybrids*		Common carp hybrids	E	PCR	N	N	Y	Y	1	Bergmann *et al.,* 2010b
Carassius	*auratus*	Goldfish	N	PCR (PCR nested/sequence)	Y	N	N	N	2*	Bergmann *et al.,* 2009

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C	D		
Carassius	*auratus*	Goldfish	E	PCR	Y	N	N	N		Bergmann *et al.,* 2010a
			E	PCR	N	N	N	N		El-Matbouli *et al.,* 2007
			E	PCR	N	N	N	N		Matbouli *et al.,* 2011
			N	PCR	N	N	N	N		Sadler *et al.,* 2008
			EI	PCR	N	N	N	N		Hedrick *et al.,* 2006
			E	PCR	N	N	N	N		Yuasa *et al.,* 2013
Carassius	*carassius*	Syberian crucian carp	N	PCR	N	N	N	Y	2	Cho *et al.,* 2014
Ctenopharyngodon	*idellus*	Grass carp	N	PCR nested/sequence	Y	N	N	N	2	Bergmann *et al.,* 2009; Kempter *et al.,* 2012; Radosavljevič *et al.,* 2012

Annex III (contd)

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C	D		
Oncorhynchus	*mykiss*	Rainbow trout	E	PCR	N	Y	N	N	3**	Bergmann *et al.,* 2016
					N	N	N	N		McColl *et al.,* 2016
Leuciscus	*idus*	Blue back ide	N	PCR nested/sequence	N	N	N	N	3	Bergmann *et al.,* 2009
Acipenser	*gueldenstaedtii*	Russian sturgeon	N	PCR	N	N	N	N	3***	Kempter *et al.,* 2009
Acipenser	*oxyrinchus*	Atlantic sturgeon	N	PCR	N	N	N	N	3***	Kempter *et al.,* 2009
Anodonta	*cygnea*	Swan mussel	N	PCR nested	N	N	N	N	3	Kielpinski *et al.,* 2010
Gammarus	*pulex*	Scud (crustacean)	N	PCR nested	N	N	N	N	3	Kielpinski *et al.,* 2010
Rutilus	*rutilus*	Common roach	E	PCR nested	N	N	N	N	3	Kempter *et al.,* 2012

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C	D		
Perca	*fluviatilis*	European perch	E	PCR nested	N	N	N	N	3	Kempter *et al.,* 2012
Tinca	*tinca*	Tench	E	PCR nested/N	N	N	N	N	3	Fabian *et al.,* 2013; Fabian *et al.,* 2016; Kempter *et al.,* 2012; Radosavljevič *et al.,* 2012
Hypophthalmichthys	*molitrix*	Silver carp	E	PCR nested	N	N	N	N	3	Kempter *et al.,* 2012; Radosavljevič *et al.,* 2012
Gymnocephalus	*cernuus*	Eurasian ruffe	E	PCR nested	N	N	N	N	3	Kempter *et al.,* 2012
Rutilus	*rutilus*	Roach	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Gasterosteus	*aculeatus*	Three-spined tickleback	N	N	N	N	N	N	3	Fabian *et al.,* 2013; Fabian *et al.,* 2016
Barbatula	*barbatula*	Stone loach	E	nested PCR	N	N	N	N	3	Popichal *et al.,* 2016

Annex III (contd)

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Hybrid Acipenser ruthenus x Huso huso		Hybrid sterlet x beluga	E	nested PCR	N	N	N	N	3	Pospichal *et al.,* 2016
Abramis	*brama*	Common bream	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Carassius	*gibelio*	Prussian carp	N	N	N	N	N	N	3	Fabian *et al.,* 2013, Radosavljevič *et al.,* 2012, Kempter *et al.,* 2012
Gobio	*gobio*	Gudgeon	N	N	N	N	N	N	3	Fabian *et al.,* 2013; Fabian *et al.,* 2016
Leucaspius	*delineatus*	Sunbleak	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Squalius	*cephalus*	European chub	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Leuciscus	*leuciscus*	Common dace	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Scardinius	*erythrophthalmus*	Rudd	N	N	N	N	N	N	3	Fabian *et al.,* 2013; Fabian *et al.,* 2016

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Ictalurus	*nebulosus*	Brown bullhead	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Gymnocephalus	*cernuus*	Ruffe	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Sander	*lucioperca*	Pike-perch	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Esox	*lucius*	Northern pike	N	N	N	N	N	N	3	Fabian *et al.,* 2013
Chondrostoma	*nasus*	Common nase	E	N	N	N	N	N	3	Fabian *et al.,* 2013; Fabian *et al.,* 2016
Leuciscus	*idus*	Ide	E	N	N	N	N	N	3	Fabian *et al.,* 2013; Fabian *et al.,* 2016
Bidyanus	*bidyanus*	Silver perch	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Maccullochella	*peelii*	Murray cod	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Macquaria	*ambigua*	Golden perch	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016

Annex III (contd)

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Galaxias	*maculatus*	Common galaxias	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Anguilla	*australis*	Short finned eel	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Neoarius	*graeffei*	Salmon cat fish	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Tandanus	*tandanus*	Eel-tailed catfish	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Retropinna	*semoni*	Australian smelt	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Melanotaenia	*duboulayi*	Crimson spotted rainbowfish	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Mugil	*cephalus*	Sea mullet	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Hypseleotris sp.		Carp gudgeon	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Ambassis	*agassizii*	Olive perchlet	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Nematalosa	*erebi*	Bony bream	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016
Mordacia	*mordax*	Short headed lamprey	E	qPCR and RT-PCR	N	N	N	N	4	McColl *et al.,* 2016

Route of infection Key

N: Natural infection.

E: Experimental (non-invasive).

EI: Experimental (invasive).

Evidence of infection Key

Y: Demonstrates criterion is met.

N: Criterion is not met **or** was not assessed.

Criterion A alone is sufficient to determine infection. Otherwise at least two of criteria B/C/D.

Outcome Key

1: Meets the criteria for susceptibility.

2: Some but not all of the criteria have been met.

3: Criteria have not been met (e.g. PCR-positive on gills or intestines and no other evidence; studies with questionable methodology or inconsistent results).

4: Evidence of non-susceptibility (e.g. Experimental [invasive] studies with no evidence of infection.

Additional information relevant to assessments for KHV

Grass carp – The *ad hoc* Group agreed that this species meets the criteria for susceptibility, but should be included in the OIE *Aquatic Manual* only because this was the first report for this species and therefore needs corroboration.

Goldfish* – The *ad hoc* Group noted that there was insufficient evidence in the scientific literature demonstrating goldfish are susceptible to infection with KHV. In addition, there is evidence of non-susceptibility from two independent laboratories. Therefore, the *ad hoc* Group recommended that Goldfish not be listed as susceptible until further evidence is provided, which indicates otherwise.

Rainbow trout** – The *ad hoc* Group assessed two papers with outcomes scores of '2' and '4' and agreed not to include this species in the *Aquatic Manual* because of conflicting evidence in the literature. The outcome "2" status was based on single paper only, the first report of susceptibility in rainbow trout, and it was not consistent with herpes virus species specificity. Further, gill was included in the "organ" sample for PCR testing, which makes it difficult to determine whether the samples were environmental contaminants. Further, this was a single paper with a new unusual species reporting; therefore, we felt it required corroboration. The second paper demonstrated non-susceptibility.

*** There was only one study on this species so the *ad hoc* Group recommended the findings be corroborated by an independent laboratory.

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ASSESSMENT OF HOST SUSCEPTIBILITY TO INFECTION WITH SALMONID APLHAVIRUS (SAV)

Criteria for susceptibility to infection with SAV are detailed in Table 1 (as per Article 1.5.6. of the *Aquatic Code*). This table includes Replication (A), Viability/Infectivity (B), Pathology/Clinical Signs (C) and Location (D). Hosts were considered to be infected with SAV if they fulfilled either criterion A, or at least two of criteria B, C and D (as per point 3 of Article 1.5.7. of the *Aquatic Code*).

Table 1. *Criteria for susceptibility to infection with SAV (Stage 3)*

A: Replication	B: Viability/Infectivity	C: Pathology/Clinical signs	D: Location
Sequential virus titration showing increase in viral titres; OR Demonstration of increasing copy number over time by qPCR with confirmatory PCR/sequencing; OR TEM showing virions in host cells; OR Products (e.g. antigens) of virus replication detected.	Isolation by cell culture. OR Passage to a susceptible host with infection confirmed by PCR/sequencing and demonstrating at least two of the following: i. clinical signs, with or without associated mortality, ii. Histopathology, iii. Re-isolation of virus in cell culture.	Severe loss of exocrine pancreatic tissue, cardiomyocytic necrosis and inflammation, skeletal muscle inflammation and degeneration. Necrosis of exocrine pancreatic tissue and a variable inflammatory reaction in the peripancreatic fat. Heart muscle cell degeneration and necrosis develops before the inflammation response in the heart. In a proportion of fish, severe fibrosis of the peri-acinar tissue may occur.	Systemic disease with SAV found in brain, gills, cardiovascular system, pancreas, kidney, liver and skeletal muscle.

ASSESSMENT FOR HOST SUSCEPTIBILITY

The assessment for host susceptibility to infection with SAV is provided in Table 2.

Table 2. *Outcome of assessment for host susceptibility to infection with SAV*

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C	D		
Salmo	*salar*	Atlantic salmon	E/N	PCR/Sequence	Y	Y	Y	Y	1	Cano *et al.,* 2015; Jansen *et al.,* 2010; Graham *et al.,* 2011; Hjortaas *et al.,* 2013; Taksdal *et al.,* 2015
Oncorhynchus	*mykiss*	Rainbow trout	N/E	PCR/Sequence	Y	Y	Y	Y	1	Borzym *et al.,* 2014; Schmidt-Posthaus *et al.,* 2014; Villoing *et al.,* 2000; Graham *et al.,* 2003
Limanda	*limanda*	Common Dab	N	PCR/Sequence	Y	Y	N	Y	1	Bruno *et al.,* 2014; McCleary *et al.,* 2014; Simons *et al.,* 2016; Snow *et al.,* 2010
Hippoglossoides	*platessoides*	Long rough Dab	N	PCR/Sequence	N	N	N	Y	2	Snow *et al.,* 2010
Pleuronectes	*platessa*	Plaice	N	PCR/Sequence	N	N	N	Y	2	McCleary *et al.,* 2014; Snow *et al.,* 2010
Salmo	*trutta*	Brown trout	EI	PCR/Sequence	N	Y	N	N	3	Boucher *et al.,* 1995
Labrus	*Bergylta*	Ballan wrasse	E/EI	PCR/Sequence	N	N	N	N	3	Røsæg *et al.,* 2017

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Pollachius	*virens*	Saithe	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Merlangius	*merlangus*	Whitting	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Myoxocephalus	*octodecemspinosus*	Sculpin sp.	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Gadus	*morhua*	Cod	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Trisopterus	*esmarkii*	Norway Pout	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Glupea	*harengus*	Herring	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Melanogrammus	*aeglefinus*	Haddock	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Merluccius	*hubbsi*	Argentine hake	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Platichthys	*flesus*	European flounder	N	qPCR	N	N	N	N	3	Snow *et al.,* 2010
Lepeophtheirus	*salmonis*	Salmon louse	N	PCR/Sequence	N	N	N	N	3	Petterson *et al.,* 2009

Route of infection Key

N: Natural infection.

E: Experimental (non-invasive).

EI: Experimental (invasive).

Stage 3 Criterion A alone is sufficient to determine infection. Otherwise at least two of criteria B/C/D.

Outcome Key

1: Meets the criteria for susceptibility.

2: Some but not all of the criteria have been met.

3: Criteria have not been met (e.g. PCR- positive on gills or intestines and no other evidence; studies with questionable methodology or inconsistent results).

4: a) no evidence of susceptibility or b) evidence of non-susceptibility.

Additional information relevant to assessments for SAV

The *ad hoc* Group recommended to remove brown trout from the *Aquatic Code* and *Aquatic Manual* because the route of infection described in available studies are only experimental through injection, not by natural route. SAV is a recently discovered pathogenic agent so there are few studies, especially for Salmonid species. More research on these species is recommended.

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ASSESSMENT OF HOST SUSCEPTIBILITY TO INFECTION WITH SPRING VIRAEMIA OF CARP VIRUS

Criteria for susceptibility to infection with spring viraemia of carp virus (SVCV) are detailed in Table 1 (as per Article 1.5.6. of the *Aquatic Code*). This table includes Replication (A), Viability/Infectivity (B), Pathology/Clinical Signs (C) and Location (D). Hosts were considered to be infected with SVCV if they fulfilled either criterion A, or at least two of criteria B, C and D (as per point 3 of Article 1.5.7. of the *Aquatic Code*).

Criteria for susceptibility to infection with SVCV

Stage 1: Natural infection (e.g. disease outbreak) or experimental transmission by cohabitation, immersion, feeding (injection not appropriate).

Stage 2: Virus isolation followed by serological test using validated antisera (serum neutralisation test) or RT-PCR + sequencing.

OIE definition of confirmed case:

The presence of SVCV should be **suspected** *if at least one of the following criteria are met:*

- *Presence of rapid and significant mortalities in susceptible fish species;*
- *Presence of typical clinical signs of the disease in susceptible fish species;*
- *Presence of typical histopathology;*
- *Virus isolation with typical CPE.*

The presence of SVCV should be considered as **confirmed** *if the following criteria are met:*

Virus isolation with typical CPE and positive for serological tests using validated antisera;

OR

Virus isolation with typical CPE and positive for RT-PCR using extracted RNA from isolated virus as template and sequencing.

Table 1. *Criteria for susceptibility to infection with SVCV (Stage 3)*

A: Replication	B: Viability/ Infectivity	C: Pathology/Clinical signs	D: Location
Sequential virus titration showing increase in viral titres or high virus titres in organs (>10^5 $TCID_{50}$/g); OR Demonstration of increasing copy number over time by qPCR with confirmatory PCR/sequencing; OR TEM showing virions in host cells; OR Products (e.g. antigens) of virus replication detected.	Isolation by cell culture. OR Passage to a susceptible host with infection confirmed by PCR/sequencing and demonstrating at least two of the following: i. clinical signs, with or without associated mortality, ii. Histopathology, iii. Re-isolation of virus in cell culture.	Typical clinical signs include exophthalmia, pale gills, haemorrhages on the skin, base of the fins and the vent, abdominal swelling, ascites and a protruding vent (anus), often with trailing mucoid faecal casts. Necrosis and degeneration in major organs.	High titre in liver, heart and kidney. Lower titre in spleen, gills and brain. As a systemic infection virus will be located in all tissues.

For this assessment only virus isolates identified as SVCV according to Stone *et al.* 2003 (genotype 1) are regarded as SVCV.

ASSESSMENT FOR HOST SUSCEPTIBILITY

The assessment for host susceptibility to infection with SVCV is provided in Table 2.

Table 2. *Outcome of assessment for host susceptibility to infection with SVCV*

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C	D		
Aristichthys	*nobilis*	Bighead carp	N	Serum neutralization test as the strains of Rhabdovirus carpio. Stone *et al* (2003) confirmed identification of Bighead carp isolates by PCR and sequencing as SVCV.	NA	Y	NA	Y	1	Shchelkunov and Shehelkunova (1989); Stone *et al.,* 2003
Abramis	*brama*	Bream	N	PCR/sequencing	NA	Y	NA	Y	1	Basic *et al.,* 2009
Rutilus	*frisii kutum*	Caspian White Fish	E	SVCV reference strain (isolate 56/70, accession no:Z37505.1) (Stone *et al.,* 2003)	NA	Y	Y	Y	1	Ghasemi *et al.,* 2014; Zamani *et al.,* 2014
Cyprinus	*carpio*	Common carp	E/N	Reference strain from Ahne	Y	Y	Y	NA	1	Haenen and Davidsen, 1993; Shchelkunov and Shehelkunova (1989)
Cyprinus	*carpio*	Ghost carp	N/EI	980619(type 1a/DQ916051(P) AM501515(G))	NA	Y	Y	Y	1	Goodwin, 2002; Miller *et al.,* 2007
Cyprinus	*carpio*	Koi carp	N	Identified by the OIE ref lab (CEFAS)	Y	Y	Y	Y	1	Goodwin, 2002

Annex V (contd)

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Notemigonus	*crysoleucas*	Golden Shiner	E	Culture and RT PCR/sequencing	N	Y	Y	Y	1	Boonthai *et al.,* 2017
Pimephales	*promelas*	Fathead minnow	E	Culture and RT PCR/sequencing	N	Y	Y	Y	1	Boonthai *et al.,* 2017
Carassius	*auratus*	Goldfish	N	Id1 Type (FN178480)122-02	NA	Y	NA	Y	1	Basic *et al.,* 2009; Jorgensen *et al.,* 1989; Miller *et al.,* 2007
Ctenopharyngodon	*idella*	Grass carp	N	Reference strain from Ahne	N	Y	Y	NA	1	Haenen and Davidsen, 1993; Shchelkunov and Shehelkunova, 1989
Silurus	*glanis*	Sheatfish European catfish	N	14286/3(type 1d/Fijan *et al.,* . 1984)	NA	Y	Y	NA	1	Sheppard *et al.,* 2007; Fijan *et al.,* 1984; Jorgensen *et al.,* 1989
Danio	*rerio*	Zebrafish	E	The reference strain of SVCV (ATCCVR-1390)	NA	Y	Y	N	1	Sanders *et al.,* 2003
Rutilus	*rutilus*	Roach	E	Reference strain from Ahne	Y	Y	Y	N	1	Haenen and Davidsen, 1993
Carassius	*carassius*	Crusian carp	N	Sequencing	NA	Y	NA	NA	2	Miller *et al.*. 2007
Esox	*lucius*	Pike	E	Reference strain Fijan *et al.,* (1971)	Y	Y	N	Y	2*	Ahne, 1985
Hypophthalmichthys	*molitrix*	Silver carp	N	M2-78 (1d type)	NA	Y	NA	NA	2	Stone *et al.,* 2003

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Perca	*flavescens*	Yellow perch	E	The first North American isolate of SVCV (Goodwin, 2002)	Y	Y	N	N	2*	Emmenegger *et al.,* 2016
Cynops	*orientalis*	Firebelly newt	N	Cell culture/sequencing	Y	Y	N	Y	2*	Ip *et al.,* 2016
Catla	*catla*	Catla	N	PCR only (cell culture not performed)/sequence do not match with SVCV	NA	N	N	N	3	Haghighi-Khiabanian Asl, 2008
Oncorhynchus	*tshawytscha*	Chinook salmon	EI	The first North American isolate of SVCV (Goodwin, 2002)	Y	Y	N	NA	3**	Emmenegger *et al.,* 2016
Notropis	*atherinoides*	Emerald shiner	EI	HHOcarp06 (Ia; Garver *et al.,* 2007)	Y	NA	Y	NA	3	Misk *et al.,* 2016
Cirrhinus	*merigala*	Merigal	N	PCR only (cell culture not performed)/sequence do not match with SVCV	NA	N	N	N	3	Haghighi-Khiabanian Asl, 2008b
Sarotherodon	*niloticus*	Nile tilapia	N	PCR/histopath EM	NA	NA	NA	NA	3	Soliman *et al.,* 2008
Oncorhynchus	*mykiss*	Rainbow trout	N	Serum neutralisation	N	Y	N	N	3***	Jeremič *et al.,* 2006
			E	Cell cultivation and PCR	N	Y	N	N		Emmenegger *et al.,* 2016; Stone *et al.,* 2003
			E	Cell cultivation	N	N	N	N		Haenen and Davidsen, 1993

Annex V (contd)

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	**B**	**C**			
			N	PCR	N	N	N	N		Haghighi-Khiabanian Asl, 2008a
			EI	Not detected by cell culture, PCR and sequencing	N	N	N	N		Boonthai *et al.,* 2017
Oncorhynchus	*mykiss*	Steelhead trout	EI	The first North American isolate of SVCV (Goodwin, 2002)	Y	Y	Y	NA	3	Emmenegger *et al.,* 2016
Labeo	*rohita*	Rohu	N	PCR only (cell culture not performed)/sequence do not match with SVCV	NA	N	N	N	3	Haghighi-Khiabanian Asl, 2008b
Litopenaeus	*vannamei*	Pacific white shrimp	N	Sequencing. The identity of the virus as SVCV has not been corroborated.	NA	Y	NA	NA	3	Johnson *et al.,* 1999
Oncorhynchus	*nerka*	Sockeye salmon	E/EI	The first North American isolate of SVCV (Goodwin, 2002)	N	N	N	N	3	Emmenegger *et al.,* 2016
Tinca	*tinca*	Tench	N	980548(type 1a/DQ916052(P))SVCV not corroborated	N	Y	NA	NA	3	Miller *et al.,* 2007
Catostomus	*commersonii*	White sucker	EI	HHOcarp06 (Ia; Garver *et al.,* 2007)	N	Y	N	N	3	Misk *et al.,* 2016

Genus	Species	Common name	STAGE 1: Transmission	STAGE 2: Pathogen identification	STAGE 3: Evidence of infection				Outcome	References
					A	B	C			
Sander	*vitreus*	Walleye	EI	Isolate of SVCV (Goodwin, 2002) Not detected by cell culture and RT PCR	N	N	N	N	4	Boonthai *et al.,* 2017
Micropterus	*salmoides*	Largemouth Bass	EI	Isolate of SVCV (Goodwin, 2002) Not detected by cell culture and RT PCR	N	N	N	N	4	Boonthai *et al.,* 2017
Esox	masquinongy	Muskellunge	EI	Isolate of SVCV (Goodwin, 2002) Not detected by cell culture and RT PCR	N	N	N	N	4	Boonthai *et al.,* 2017

* EI only: outcome 3.

** Unusual finding. No conflicting studies but needs corroboration.

*** Appears to be an anomalous result in one fish (two week old) with high viral titre considering decades of surveillance in Rainbow trout not showing susceptibility.

NA: not assessed.

Additional information relevant to assessments for SVCV

For SVCV the *ad hoc* Group was not able to find any reference to orfe (*Leuciscus idus*), the species has only been mentioned in personal communication in Dixon *et al.,* 1994. The *ad hoc* Group recommended the species to be deleted from the *Aquatic Code* and *Aquatic Manual*.

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