Report of the WOAH *ad hoc* Group on susceptibility of mollusc species to infection with OIE listed diseases

Original: English (EN)

November–2 December 2021
& May–June 2022

Table of Content

List of Annexes

World Organisation for Animal Health
Founded as OIE

Standards Department
AAC.secretariat@woah.org

12, rue de Prony
75017 Paris, France

T. +33 (0)1 44 15 18 88
F. +33 (0)1 42 67 09 87
woah@woah.org
www.woah.org

1. Meetings

This report covers the work of the WOAH *ad hoc* Group on Susceptibility of mollusc species to infection with OIE listed diseases (the *ad hoc* Group) who met virtually between November and December 2021 and between May and June 2022.

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

2. Methodology

The *ad hoc* Group applied criteria, as outlined in Chapter 1.5. Criteria for listing species as susceptible to infection with a specific pathogen of the WOAH *Aquatic Animal Health Code* (the *Aquatic Code*), to potential host species in order to determine susceptibility to infection with *Marteilia refringens*. The assessments were conducted using a three-stage approach. Details of the three-stage approach, including additional considerations, are described below:

2.1. 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.):

Table 1 describes the route of transmission for infection with *Marteilia refringens* used by the *ad hoc* Group when applying Stage 1 to assess susceptibility to infection with *Marteilia refringens.*

Table 1: Route of transmission for infection with *Marteilia refringens*

Route of Transmission	Considerations
1. Natural exposure included situations where infection had occurred without experimental intervention (e.g. infection in wild or farmed populations). OR 2. Non-invasive experimental procedures: e.g. cohabitation with infected hosts or faeces of infected hosts (Carrasco *et al*., 2008b); or infection by immersion in seawater enriched with a suspension of parasites (Comps & Joly, 1980).	Non-invasive experiments were considered for copepods and for *Mytilus galloprovincialis* (Comps & Joly, 1980).

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

Table 2 describes the pathogen identification methods used by the *ad hoc* Group when applying Stage 2 to susceptibility to infection with *Marteilia refringens,* as well as some considerations.

Table 2: Pathogen Identification for infection with *Marteilia refringens*

Pathogen Identification (*Marteilia refringens*)	Pathogen Identification (at Type M or Type O level)*	Considerations
Molecular sequence information for Internal transcribed spacer 1 (ITS 1) (Le Roux *et al*., 2001) or intergenic spacer (IGS) (Lopez-Flores *et al*., 2004) regions OR PCR-RFLP (as described in Le Roux *et al*., 2001) OR Multiplex TaqMan Assay to detect *Marteilia refringens* (Carrasco *et al*., 2017) OR Observed parasite and morphology from histology or cytology that was later characterised by linked molecular information from other studies.	Molecular sequence information for ITS 1 (Le Roux *et al*., 2001) or intergenic spaces (IGS) (Lopez-Flores *et al*., 2004) regions OR PCR-RFLP (as described in Le Roux *et al*., 2001) which distinguishes between Type O and Type M OR Multiplex TaqMan Assay to detect *Marteilia refringens* and distinguishes between types Type O and M (Carrasco *et al*., 2017) OR Observed parasite and morphology from histology or cytology that was later characterised by linked molecular information from other studies (Type O and Type M).	Molecular sequence information within the 18S sequence generally does not allow differentiation between Type O, Type M or *Marteilia cochillia* Differences between Type O and Type M are based on the ITS 1 and consistent with the differences defined in IGS Molecular data should be associated with microscopical examination wherever possible to confirm the presence of the pathogen. ISH is currently not sufficiently specific to resolve pathogen identity at the species and type levels. For early studies without molecular information, corroborating evidence from later studies was also considered*.

* In locations where co-occurrences of type O and type M have been reported, the *ad hoc* Group could not necessarily link stage 3 criteria demonstrating the presence of a pathogenic agent that constitutes an infection, to a single genetic type. When a study is not strong enough (limited sample size or representativeness between geographic region, time and host species), the *ad hoc* Group could not exclude the presence of the alternate type of *M. refringens*. In contrast, the *ad hoc* Group could attribute infection to a particular type and rule out co-infection when molecular methods that maximise chance to detect co-infection including multiplex taqman assay and cloning prior PCR-RFLP or sequencing were used.

2.3. 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.):

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. Criteria A to D are presented below:

A. The pathogenic agent is multiplying in the host, or developing stages of the pathogenic agent are present in or on the host[1];

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.

[1] For the purposes of the assessments for susceptibility to infection with *Marteilia refringens*, replication 'on the host' was not considered to apply.

Table 3 describes the evidence of infection with *Marteilia refringens,* Type O and Type M, used by the *ad hoc* Group when applying Stage 3 to susceptibility to infection with *Marteilia refringens,* as well as some considerations.

Table 3: Evidence of infection with *Marteilia refringens*

Evidence of infection			
A: Replication	**B: Viability / Infectivity**	**C** Pathology / Clinical signs**	**D***: Location**
1. Presence of the mature stage (equals presence of tertiary cells) of the parasite demonstrated by: a) Histopathology OR b) Cytology (usually digestive gland imprints) OR c) TEM **OR** 2. For copepods, different parasite stages or the presence of many parasite cells.	1. Transmission via either co-habitation or faeces exposure to copepods **OR** 2. Demonstration of viability of cells isolated from tissues and of spores in faeces by: a) Vital stains OR **b)** Successful infection of copepods.	1. Mortality[2] **OR** 2. Macroscopic lesions such as discolouration of tissue (pale digestive gland) **OR** 3. Rapid loss of condition **OR** 4. Microscopic lesions such as localised haemocyte infiltration in connective tissues around the digestive gland	1. Parasites in the epithelia of digestive gland tissue **OR** 2. Atypical location within hemolymph, or connective tissue of different organs including the gills, and the mantle[3] **OR** 3. For copepods, parasites located in the gonad and/or the digestive tract.

** Pathology/Clinical signs may be non-specific, variable and include some or all of the characteristics listed.
***As demonstrated by histology or *in-situ* hybridisation (ISH) or positive PCR from the digestive gland tissue.

3. Results

The *ad hoc* Group agreed that only three of the six species currently included in Article 11.4.2. as susceptible to infection with *Marteilia refringens,* blue mussel (*Mytilus edulis*), European flat oyster (*Ostrea edulis*) and the Mediterranean mussel (*Mytilus galloprovincialis*) met the criteria for listing as susceptible to infection with *Marteilia refringens* in accordance with Chapter 1.5. of the *Aquatic Code* and were proposed to remain in Article 11.4.2. Three species, the Australian mud oyster (*Ostrea angasi*), Argentinean oyster (*Ostrea puelchana*) and the Chilean flat oyster (*Ostrea chilensis*) did not meet the criteria for listing as a susceptible species and were proposed to be deleted from Article 11.4.2.

Five additional species were found to meet the criteria for listing as susceptible species to infection with *Marteilia refringens*. Dwarf oyster (*Ostrea stentina*), European razor clam (*Solen marginatus*), golden mussel (*Xenostrobus securis*), striped venus (*Chamelea gallina*) and a copepod (*Paracartia grani)*, were proposed to be included in Article 11.4.2.

Two *Ostrea* species, Chilean flat oyster (*Ostrea chilensis*) and Japanese flat oyster (*Ostrea denselamellosa*) and a copepod (*Paracartia latisetosa*) were assessed as having incomplete evidence of susceptibility and were proposed to be included of Section 2.2.2. of Chapter 2.4.4., Infection with *Marteilia refringens*, of the *Aquatic Manual*.

Pathogen-specific positive PCR results had been reported in the following seven species, Cortez oyster (*Crassostrea corteziensis*), Grooved carpet shell (*Ruditapes decussatus*), Pacific cupped oyster (*Magallana gigas* also known as *Crassostrea gigas*) and zooplankton (*Acartia discaudata, Centropages typicus, Euterpina acutifrons, Penilia avirostris)* as well as in unidentified copepods of the genus *Oithona*, but an active infection had not been

[2] It is sometimes difficult to correlate the presence of the pathogen with mortality. In this case, mortality alone was not sufficient when other pathogens were documented to be present.
[3] To date the atypical location in the connective tissues has mostly been reported in mussels (WOAH Reference laboratory information).

demonstrated. These species were proposed to be included in the second paragraph of Section 2.2.2. of Chapte 2.4.4., Infection with *Marteilia refringens*, of the *Aquatic Manual*.

4. Assessments

Species were determined to be susceptible based on the combination of assessment outcomes as outlined in Article 1.5.7.

Table 4 describes the different scores and outcomes of the assessments undertaken by the *ad hoc* Group.

Table 4: Scores and Outcome of assessments

Score	Outcome
1	Species assessed as susceptible (as described in Article 1.5.7.). These species were proposed for inclusion in Article 11.4.2. of Chapter 11.4., Infection with *Marteilia refringens*, of the *Aquatic Code* and Section 2.2.1. of Chapter 2.4.4., Infection with *Marteilia refringens*, of the *Manual of Diagnostic Tests for Aquatic Animals* (the *Aquatic Manual*).
2	Species assessed as having incomplete evidence for susceptibility (as described in Article 1.5.8.) were proposed for inclusion in Section 2.2.2., Species with incomplete evidence for susceptibility of Chapter 2.4.4., Infection with *Marteilia refringens*, of the *Aquatic Manual*.
3	Species assessed as not meeting the criteria or for which there was unresolved or conflicting information. These species were not proposed for inclusion in either the *Aquatic Code* or the *Aquatic Manual*. The exceptions were species where pathogen-specific positive PCR results had been reported but an active infection had not been demonstrated. These species were proposed for inclusion in the second paragraph in Section 2.2.2. Species with incomplete evidence for susceptibility of Chapter 2.4.4., Infection with *Marteilia refringens*, of the *Aquatic Manual*.
4	Species assessed as non-susceptible.
NS	Species not scored due to insufficient or irrelevant information.

Table 5 summarises the assessments for host susceptibility to infection with *Marteilia refringens* together with the outcomes and relevant references.

Table 5: Assessments for infection with *Marteilia refringens*

Family	Scientific name	Common name	Stage 1: Route of transmission	Stage 2: Pathogen identification	Stage 3: Evidence of infection				Outcome *M. refringens* – Paper	Outcome Type M		Outcome Type O		References
					A	B	C	D		Paper	Overall	Paper	Overall	
Score 1														
Bivalves														
Ostreidae	*Ostrea edulis*	European flat oyster	N	IGS and ITS 1 PCR with ITS 1 sequencing	YES	ND	YES	YES	1	I[5]	NS	1	1	Lopez-San Martin *et al.*, 2015
			N	NO (Histology[6])	YES	ND	ND	YES	1	NS		NS		Audemard *et al.*, 2001
			N	NO (Histology and cytology[6])	YES	YES	ND	YES	1	NS		NS		Carrasco *et al.*, 2008b
			N	ITS 1 PCR, RFLP ITS 1 sequencing	ND	ND	ND	YES	2	3		3		Novoa *et al.*, 2005
			N	ITS 1 PCR, RFLP ITS 1 sequencing	ND	ND	ND	YES	2	3		3		Le Roux *et al.*, 2001
Ostreidae	*Ostrea stentina*	Dwarf oyster	N	IGS and ITS 1 PCR, RFLP, ITS 1 and IGS sequencing	YES	ND	I[7]	YES	1	NS	3	1	1	Elgharsalli *et al.*, 2013
			N	IGS and ITS 1 PCR, only ITS 1 sequencing	YES	ND	YES	YES	1	3		3		Lopez-SanMartin *et al.*, 2015
Mytilidae	*Mytilus edulis*	Blue mussel	N	ITS1 RFLP, IGS PCR, sequencing and Histology	YES	ND	YES	YES	1	1	1	NS	NS	Bøgwald *et al.*, 2022
Mytilidae	*Mytilus galloprovincialis*	Mediterranean mussel	N	ITS 1 PCR, IGS, RFLP and sequencing	YES	ND	ND	YES	1	3	1	3	3	Arzul *et al.*, 2014
			N	IGS, ITS 1 PCR and sequencing	YES	ND	NO	YES	1	1		NS		Gombac *et al.*, 2014
			N	IGS PCR and sequencing	YES	ND	ND	YES	1	NS		NS		Carrasco *et al.*, 2007b
Mytilidae	*Xenostrobus securis*	Golden mussel	N	IGS and ITS 1 PCR and sequencing	YES	ND	ND	YES	1	3	3	NS	NS	Pascual *et al.*, 2010

Family	Scientific name	Common name	Stage 1: Route of transmission	Stage 2: Pathogen identification	Stage 3: Evidence of infection				Outcome *M. refringens* – Paper	Outcome Type M		Outcome Type O		References
					A	B	C	D		Paper	Overall	Paper	Overall	
Solenidae	*Solen marginatus*	European razor clam	N	IGS PCR and sequencing	YES	ND	ND	YES	1	3	3	NS	NS	Lopez-Flores *et al.*, 2008a
			N	NO[8] (Histology)	YES	ND	ND	YES	NS	NS		NS		Lopez & Darriba, 2006
Veneridae	*Chamelea gallina*	Striped venus	N	IGS sequence, Histology ISH	YES	ND	I[9]	YES	1	NS	NS	3	3	Lopez-Flores *et al.*, 2008b
Crustacea														
Acartiidae	*Paracartia grani*	No common name	N, E	PCR ITS 1, nested PCR IGS and sequencing	YES	I[10]	YES	YES	1	NS	NS	NS	NS	Boyer *et al.*, 2013
			E	Histology, ISH and TEM[6]	YES	ND	ND	YES	1	NS		NS		Carrasco *et al.*, 2008b
Score 2														
Bivalves														
Ostreidae	*Ostrea chilensis*	Chilean flat oyster	N	Histology[6]	YES	ND	I[11]	YES	1	NS	NS	NS	NS	Grizel *et al.*, 1983
Ostreidae	*Ostrea denselamellosa*	Japanese flat oyster	N	Histology[6]	ND	ND	I[12]	YES	2	NS	NS	NS	NS	Martin, 1993
Crustacea														
Acartiidae	*Paracartia latisetosa*	No common name	N	PCR IGS and sequencing	YES	ND	ND	YES	1	NS	NS	NS	NS	Arzul *et al.*, 2014
Score 3														
Ostreidae	*Magallana gigas* also known as *Crassostrea gigas*	Pacific cupped oyster	N	nested PCR IGS and sequencing	ND	ND	ND[13]	YES	3	3[14]	3	NS	NS	Grijalva-Chon *et al.*, 2015
			N	NO (Histology)	NO	NO	YES	YES	NS	NS	NS	NS	NS	Cahour, 1979
Ostreidae	*Crassostrea corteziensis*	Cortez oyster	N	nested PCR IGS and sequencing	ND	ND	ND[13]	YES	3	NS	NS	3[14]	3	Grijalva-Chon *et al.*, 2015
Veneridae	*Ruditapes decussatus*	Grooved carpet shell	N	ITS 1 PCR and nested PCR IGS and sequencing	NO	ND	NO	YES	3	3[14]	3[14]	NS	NS	Boyer *et al.*, 2013

Family	Scientific name	Common name	Stage 1: Route of transmission	Stage 2: Pathogen identification	Stage 3: Evidence of infection				Outcome *M. refringens* – Paper	Outcome Type M		Outcome Type O		References
					A	B	C	D		Paper	Overall	Paper	Overall	
Crustacea														
Acartiidae	*Acartia discaudata*	No common name	N	PCR targeting IGS and sequencing	ND	ND	ND	ND	3	NS	NS	NS	NS	Carrasco *et al.*, 2007b
Centropagidae	*Centropages typicus*	No common name	N	ITS 1 PCR, IGS, RFLP and sequencing	ND	ND	ND	NO	3	NS	NS	NS	NS	Arzul *et al.*, 2014
Achidiidae	*Euterpina acutifrons*	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	NO	NS	NS	NS	NS	NS	Audemard *et al.,* 2002
			N	PCR targeting IGS and sequencing	ND	ND	ND	ND	NS[16]	NS		NS		Carrasco *et al.*, 2007b
Oithonidae	*Oithona* sp. (FRANCE)	No common name	N	PCR targeting IGS. ISH negative	ND	ND	ND	NO	3	NS	NS	NS	NS	Arzul *et al.*, 2014
Oithonidae	*Oithona* sp. (SPAIN)	No common name	N	PCR targeting IGS and sequencing	ND	ND	ND	ND	3	NS	NS	NS	NS	Carrasco *et al.*, 2007b
Sididae	*Penilia avirostris*	No common name	N	PCR targeting ITS and IGS. RFLP	ND	ND	ND	NO	3	NS	NS	NS	NS	Arzul *et al.*, 2014
Score NS														
Bivalves														
Ostreidae	*Ostrea angasi*	Australian mud oyster	N	NO (Histology and cytology[6])	ND	ND	I[17]	ND	NS	NS	NS	NS	NS	Bougrier *et al.*, 1986
Ostreidae	*Ostrea puelchana*	Argentinean oyster	N	NO (Histology)	ND	ND	ND	ND	NS	NS	NS	NS	NS	Pascual *et al.*, 1991
Ostreidae	*Saccostrea cucullata*	Hooded oyster	N	NO (Histology)	NO	ND	ND	YES	NS	NS	NS	NS	NS	Comps, 1976
Ostreidae	*Crassostrea virginica*	American cupped oyster	N	NO (Histology and TEM)	YES	NO	ND	YES	NS	NS	NS	NS	NS	Renault *et al.*, 1995
Cardiidae	*Cerastoderma edule*	Common edible cockle	N	NO (Histology and TEM)	YES	ND	ND	YES	NS	NS	NS	NS	NS	Comps *et al.,* 1975
			N	NO (Histology)	YES	ND	ND	YES	NS	NS		NS		Poder *et al.*,1983
Veneridae	*Ruditapes philippinarum*	Japanese carpet shell	N	NO (Histology)	YES	ND	NO	YES	NS	NS	NS	NS	NS	Itoh *et al.*, 2005

Family	Scientific name	Common name	Stage 1: Route of transmission	Stage 2: Pathogen identification	Stage 3: Evidence of infection				Outcome *M. refringens* – Paper	Outcome Type M		Outcome Type O		References
					A	B	C	D		Paper	Overall	Paper	Overall	
Veneridae	*Polititapes rhomboides*	Banded carpet shell	N	NO (Histology)	YES	ND	ND	YES	NS	NS	NS	NS	NS	Poder *et al.,* 1983
Veneridae	*Venerupis corrugata*	Corrugated venus	N	NO (Histology)	YES	ND	ND	YES	NS	NS	NS	NS	NS	Poder *et al.,* 1983
Pharidae	*Ensis minor*	Clamdog	N	NO (Histology)	YES	ND	ND	YES	NS	NS	NS	NS	NS	Ceschia *et al.,* 2001
Semelidae	*Scrobicularia plana*	Peppery furrow	N	NO[18] (Histology and TEM)	YES	ND	ND	YES	NS	NS	NS	NS	NS	Comps, 1983
Pectinidae	*Argopecten gibbus*	Calico scallop	N	NO (Histology)	YES	ND	YES	YES	NS	NS	NS	NS	NS	Moyer *et al*., 1993
Cardiidae	*Tridacna maxima*	Elongate giant clam	N	NO (Histology and TEM)	NO	ND	NO	YES	NS	NS	NS	NS	NS	Norton *et al*., 1993
Semelidae	*Abra segmentum*	No common name	N	N (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Crustacea														
Acartiidae	*Acartia clausi*		N	PCR targeting IGS and sequencing	ND	ND	ND	ND	NS	NS	NS	NS	NS	Carrasco *et al*., 2007b
Acartiidae	*Acartia italica*	No common name	N	PCR targeting IGS and sequencing	ND	ND	ND	ND	NS	NS	NS	NS	NS	Carrasco *et al*., 2007b
Canuellidae	*Canuella perplexa*	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Cladocera	*Evadne* sp.	No common name	N	PCR targeting IGS. ISH negative	ND	ND	ND	NO	NS	NS	NS	NS	NS	Arzul *et al*., 2014
Oithonidae	*Oithona* sp. (SPAIN)	No common name	N	PCR targeting ITS and IGS. RFLP	ND	ND	ND	ND	NS	NS	NS	NS	NS	Carrasco *et al*., 2007a
Order: Cyclopoida	ND	No common name	N	N (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Order: Harpacticoida	ND	No common name	N	PCR targeting ITS and IGS. RFLP	ND	ND	ND	ND	NS	NS	NS	NS	NS	Carrasco *et al*., 2007a

Family	Scientific name	Common name	Stage 1: Route of transmission	Stage 2: Pathogen identification	Stage 3: Evidence of infection				Outcome *M. refringens* – Paper	Outcome Type M		Outcome Type O		References
					A	B	C	D		Paper	Overall	Paper	Overall	
Order: Decapoda	ND	Decapod (larvae)	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Order: Decapoda	ND	No common name	N	PCR targeting IGS and sequencing	ND	ND	ND	ND	NS	NS	NS	NS	NS	Carrasco *et al*., 2007b
Class: Ostracoda	ND	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Annelida														
Spionidae	*Streblospio shrubsolii*	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Class: Polychaeta	ND	No common name	N	PCR IGS	ND	ND	ND	NO	NS	NS	NS	NS	NS	Arzul *et al*., 2014
Tunicata														
Molgulidae	*Molgula manhanttensis*	Common sea grape	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Fritillariidae	*Appendicularia* sp.	No common name	N	PCR IGS	ND	ND	ND	NO	NS	NS	NS	NS	NS	Arzul *et al*., 2014
Chaetognatha														
Sagittidae	*Sagitta* sp.	No common name	N	PCR IGS and sequencing	ND	ND	ND	NO	NS	NS	NS	NS	NS	Arzul *et al*., 2014
Cnidarians														
Sagartiidae	*Cereus pedunculatus*	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Nemertea														
Lineidae	*Lineus viridis*	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002
Pisces														
Gobiidae	*Pomatoschistus microps* (juveniles)	No common name	N	NO (PCR 18S with SS2/SAS1 primers[15])	ND	ND	ND	ND	NS	NS	NS	NS	NS	Audemard *et al*., 2002

[5] Type M was not detected but the methodology used may have not been sufficient for its detection.

[6] Morphology from histology was later characterised by linked molecular information from Le Roux *et al*. (2001).
[7] Mortality and hemocytic infiltration was reported. However, it cannot be concluded that the causative pathogenic agent was *M. refringens* as there was a co-infection with *B. exitiosa*.
[8] In Ria de Arousa there are three species of *Marteilia* identified (*M. refringens; M. cochillia; M. octospora*). Without molecular information, it is difficult to conclude which *Marteilia* species is present in the animals sampled.
[9] Animals sampled from a mortality event. However, it cannot be concluded that the causative pathogenic agent was *M. refringens*.
[10] Experimental transmission assay (from copepod to mussels) was unsuccessful but it cannot be concluded that the parasite was non-viable.
[11] Mortality was reported. However, it cannot be concluded that the causative pathogenic agent was *M. refringens* as there was a co-infection with *B. ostreae.*
[12] Mortality was reported. However, there was insufficient information to be confident that it was associated with *M. refringens.*
[13] No histology was completed and samples were from outside mortality event.
[14] Phylogenetic analysis of sequences from the Genbank allowed conclusions on the type.
[15] The 18S SS2/SAS1 primers are not specific enough to confirm *Marteilia refringens.*
[16] PCR positive but the *ad hoc* Group concluded that contamination could not be ruled out.
[17] The mortality that was reported was attributed to a haplosporidium.
[18] Subsequent molecular testing from Le Roux *et al*. (2001) was not used because it did not include any information from this species.

Assessment Table Key

N: Natural infection
E: Experimental (non-invasive)
YES: Demonstrates criterion is met
NO: Criterion is not met
I: Inconclusive
ND: Not determined
NS: Not scored

5. Naming convention for susceptible species

The scientific names of the host species are in accordance with the World Register of Marine Species (WoRMS) https://www.marinespecies.org/index.php.

The common names of mollusc species are in accordance with FAOTERM (http://www.fao.org/faoterm/collection/faoterm/en/). Where the common mollusc name was not found in FAOTERM, the naming was done in accordance with https://www.sealifebase.ca.

6. Comments on the *ad hoc* Group's rationale and decision-making

'Inconclusive' was used to distinguish situations where more information was provided than would have been assessed as 'Non-determined' but the *ad hoc* Group could not conclude that the criterion was met. Each time inconclusive was used within the assessment table, the *ad hoc* Group provided additional information in a footnote. The *ad hoc* Group treated 'Inconclusive' as 'Non-Determined' when making their final assessment.'

Where possible the *ad hoc* Group included information regarding the types but for a variety of reasons the *ad hoc* Group was rarely able to assess susceptibility of species at the type level.

At least three studies (Le Roux *et al*., 2001; Novoa *et al*., 2005; Lopez-Flores *et al*., 2004) provided evidence for the co-occurrence of both types in several locations and within the same individual. Under those conditions, it is impossible to link molecular information regarding the genetic type with morphological and pathological information. These studies used a cloning approach to demonstrate the presence of both genetic types. When cloning is not used, e.g. when direct sequencing is employed, techniques can exclude the detection of one genetic type or the other. The majority of studies did not provide discrimination of the genetic types. The *ad hoc* Group did try to use later studies of the regionally occurring genetic types. However, when combining molecular and morphological and pathological information between studies, the survey designs, even when using cloning, were often not sufficiently representative (limited sample size and extent) to infer consistency of genetic types through time.

6.1. General comments

The *ad hoc* Group agreed to focus on studies published from 2000 onwards, when molecular testing was available. Papers published in earlier years were referred to when necessary to increase confidence of an assessment or when no recent paper was available for the assessment of a specific host species. When necessary to corroborate pathogen identification, the *ad hoc* Group:

(1) contacted authors of the studies to further describe pathogen identification methods, or

(2) utilized molecular information from parallel or subsequent studies on the same source population.

The *ad hoc* Group agreed that while the ideal situation was two papers with a score of '1', a single study scoring '1' with corroborative evidence was also enough to conclude susceptibility of a species in the absence of conflicting evidence. Where sampling strategy was distributed across seasons or locations, and/or where a single paper provided all evidence (molecular with corresponding evidence from histology within the same animals), the *ad hoc* Group considered that one strong paper was sufficient to conclude susceptibility of a species. Consequently, additional studies were still reviewed to check for any supporting or conflicting evidence. When additional papers were identified but the *ad hoc* Group did not feel that they were necessary to assess because the species had already been determined as susceptible by other studies, these studies were included in the list of references.

6.2. Species-specific comments

- *Ostrea chilensis*: only one study was available for assessment. The evidence provided was assessed by the *ad hoc* Group as having met the criteria for susceptibility and was scored as a '1'. However, the *ad hoc* Group was unable to find any additional studies or corroborative evidence within the Grizel *et al*., 1993 study. As a result, the *ad hoc* Group assessed *Ostrea chilensis* as an overall score of '2' and proposed it to be included in Section 2.2.2. of Chapter 2.4.4., Infection with *Marteilia refringens*, of the *Aquatic Manual*.

- *Ostrea puelchana*: the *ad hoc* Group were unable to score *Ostrea puelchana*, despite it being currently listed as susceptible in Article 11.4.2. While it is likely that the parasite identified in the Pascual *et al*., 1991 study is *Marteilia refringens,* due to the location of the study (different from the location for which subsequent molecular data are available in Le Roux *et al*., 2001), the evidence presented in the paper was not sufficient to conclude susceptibility.

- *Ostrea stentina*: in light of new scientific evidence and personal communications, the *ad hoc* Group recognises that *Ostrea stentina* and *Ostrea equestris* are considered distinct species. The *ad hoc* Group also noted that the two species had a different geographic distribution. *Ostrea equestris* is distributed in the Americas (North and South) and the western Pacific (New Zealand), while *Ostrea stentina* is distributed in the eastern Atlantic (Tunisia, Spain). For the purposes of assessment for susceptibility to infection with *Marteilia refringens*, all papers reviewed were located within Tunisia and Spain. Therefore, the *ad hoc* Group concluded that the species was in fact *Ostrea stentina*.

- *Chamelea gallina*: only one study was available for assessment. The evidence provided was assessed by the *ad hoc* Group as having met the criteria for susceptibility and was scored as a '1'. The *ad hoc* Group considered that the diagnostic testing outlined in Lopez-Flores *et al*. (2008b) which included molecular testing and histological evidence, was sufficient to assess it as a susceptible species.

- *Solen marginatus*: only two studies were available for assessment. The evidence provided was assessed by the *ad hoc* Group as having met the criteria for susceptibility and one of the studies was scored as a '1'. The *ad hoc* Group considered that the diagnostic evaluation outlined in Lopez-Flores *et al*. 2008a study which included both molecular pathogen identification and histological review of the same study population, was sufficient to assess it as a susceptible species.

- *Xenostrobus securis*: only one study was available for assessment. The evidence provided was assessed by the *ad hoc* Group as having met the criteria for susceptibility and was scored as a '1'. The *ad hoc* Group considered that the sampling strategy outlined in Pascual *et al.,* 2010 study included multiple years of testing and the molecular testing and histological evidence was sufficient to assess it as a susceptible species.

- *Magallana gigas* also known as *Crassostrea gigas*:

  - To date, there have been no reports of the mature (tertiary) stages of *Marteilia refringens* in *Crassostrea gigas*. If this changes, this assessment would require re-evaluation.

  - According to WoRMS, the accepted name for *Crassostrea gigas* should be *Magallana gigas*. Previously the *ad hoc* Group had maintained the name as *Crassostrea gigas* based on the arguments provided by Bayne *et al*. (2017) and considered that the report by Salvi & Mariottini (2017) was not sufficiently robust to support the proposed taxonomic change. However, the *ad hoc* Group considered new data and peer reviewed publications (Salvi & Mariottini, 2020; Salvi *et al*., 2022; Sigwart *et al*., 2021) on the new name of *Magallana gigas*. Currently *Magallana gigas* is the accepted name in WORMS and *Crassostrea gigas* is considered an alternate representation in order to reflect the contrasting views of Byane *et al*. (2017). To ensure consistency with the approach of ensuring scientific names are in accordance with WORMS while recognising that *Crassostrea gigas* will be widely used, the *ad hoc* Group has agreed to identify Pacific cupped oyster as '*Magallana gigas* also known as *Crassostrea gigas*' within the assessment table. The *ad hoc* Group recommended to the Commission that it be included as such in the *Aquatic Code* and the *Aquatic Manual*.

- *Mytilus edulis*:

  - Several papers reviewed by the *ad hoc* Group for the assessment of *Mytilus edulis* concerned mussels from La Trinité River. All these studies were scored as an outcome of 1. However, none of the studies reviewed by the *ad hoc* Group included the characterisation of the mussel species sampled. The *ad hoc* Group reviewed the geographic distribution of *Mytilus galloprovincialis* and *Mytilus edulis* and considered that this region has cohabitation of both species and hybrids. Bierne *et al*. (2003) showed that hybrids were present in La Trinité River. Therefore, the *ad hoc* Group could not be confident that the species sampled were *Mytilus edulis* and considered them to be mixed populations of *M. edulis*, *M. galloprovincialis* and their hybrids. Consequently these papers were not included in the final assessement of *Mytilus edulis*.

  - Based on Bøgwald *et al*. (2022), the *ad hoc* Group was able to assess *Mytilus edulis* with a score 1. The evidence provided was assessed by the *ad hoc* Group as having met the criteria for susceptibility and was scored as a '1'. The *ad hoc* Group considered that the sampling strategy outlined in this study included multiple years of testing, the molecular testing and histological evidence, and was therefore sufficient to assess it as a susceptible species. In addition, the sampling was completed in an area where only *Mytilus edulis* is found. Michalek *et al*. (2016) provided general information about the distribution of mussel species in Europe.

- *Mytilus galloprovincialis*: based on Michalek *et al*. (2016), the studies reviewed did not raise questions about the species identity of *M. galloprovincialis*.

- *Ruditapes decussatus*: although there was molecular detection of *Marteilia refringens* in conjunction with ISH results, the *ad hoc* Group considered that the intrepretation of the pictures provided within Boyer *et al*. (2013) supported that the clams were not infected with viable parasites. The evidence provided was assessed by the *ad hoc* Group as having met the criteria for a score of 3.

- Zooplankton:

  - Where the authors of studies reviewed did not provide the species name, the *ad hoc* Group stayed at a higher classification level: at the Order or Class level (for example, Order Harpacticoida for Harpacticoid in Carrasco *et al*., 2007a) or at the genus level (for example, Evadne sp. in Arzul *et al*., 2014).

  - If only one sample was positive by PCR then the *ad hoc* Group considered it not to be a score "3" (PCR positive) but instead put it as a "NS" considering that contamination could not be ruled out. In order to assess a species as having met the criteria for a score "3", multiple positives could have come from a single or separate studies (for example, *Euterpina acutifrons*).

  - Only *Paracartia grani* met the criteria to be scored as a "1" and this is based on the molecular information and the ISH results from multiple studies.

  - *Paracartia latisetosa* also had molecular and ISH results but was assessed as a "2" because only two individuals tested positive from a single sampling event. *Paracartia latisetosa* should be reassessed if more information becomes available in the future.

  - *Oithona* sp. from France and Spain (and two geographic locations within Spain) could not be assumed to be conspecific. The *ad hoc* Group assessed the studies individually and proposed them for inclusion in Section 2.2.2. of Chapter 2.4.4., Infection with *Marteilia refringens*, of the *Aquatic Manual* as unidentified copepod species of the genus *Oithona*.

- There are many species where there is no molecular information on the pathogen identification of *M. refringens* and therefore it was not possible to score these species. They were included within the table as NS.

7. Article 1.5.9. Listing of Susceptible species at a taxonomic ranking of Genus or Higher

The *ad hoc* Group considered Article 1.5.9., Listing of susceptible species at a taxonomic ranking of Genus or higher in the *Aquatic Code,* and determined that it was not applicable for the susceptible host species for *M. refringens* identified at this time.

8. References

ARZUL, I., CHOLLET, B., BOYER, S., BONNET, D., GAILLARD, J., BALDI, Y., ROBERT, M., JOLY, J.-P., GARCIA, C. & BOUCHOUCHA, M. (2014). Contribution to the understanding of the cycle of the protozoan parasite *Marteilia refringens*. *Parasitology*, **141(02)**, 227-240.

AUDEMARD, C., LE ROUX, F., BARNAUD, A., COLLINS, C., SAUTOUR, B., SAURIAU, P.-G. DE MONTAUDOUIN, X., COUSTAU, C., COMBES, C. & BERTHE, F.C.J. (2002). Needle in a haystack: involvement of the copepod Paracartia grani in the life cycle of the oyster pathogen *Marteilia refringens*. *Parasitology,* **124(3)**, 315-323.

AUDEMARD, C., BARNAUD, A., COLLINS, C.M., LE ROUX, F., SAURIAU, P.-G., COUSTAU, C., BLACHIER, P. & BERTHE, F.C.J. (2001). Claire ponds as an experimental model for *Marteilia refringens* life-cycle studies: new perspectives. *Journal of Experimental Marine Biology and Ecology*, **257**, 87–108.

BAYNE, B.L., AHRENS, M. ALLEN, S.K., ANGLÈS D'AURIAC, M., BACKELJAU, T., BENINGER, P., BOHN, R., BOUDRY, P., DAVIS, J., GREEN, T., GUO, X., HEDGECOCK, D., IBARRA, A., KINGSLEY, P., KRAUSE, M., LANGDON, C., LAPÈGUE, S., LI, C., MANAHAN, D., MANN, R., PEREZ-PARALLE, L., POWELL, E.N., RAWSON, P.D., SPEISER, D., SANCHEZ, J.-L., SHUMWAY, S. & WANG., H. (2017). The proposed dropping of the Genus Crassostrea for all Pacific cupped oysters and its replacement by a new Genus Magallana: A dissenting view. *Journal of Shellfish Research*, **36 (3)**, 545-547.

BERTHE, F.C.J., LE ROUX, F., PEYRETAILLADE, E., PEYRET, P., RODRIGUEZ, D., GOUY, M. & VIVARES, C.P. (2000). The existence of the phylum Paramyxea Desportes and Perkins, 1990 is validated by the phylogenetic analysis of the *Marteilia refringens* small subunit ribosomal RNA. *Journal of Eukaryotic Microbiology*, **47(3)**, 288–293.

BIERNE, N., BORSA, P., DAGUIN, C., JOLLIVET, D., VIARD, F., BONHOMME, F & DAVID, F. (2003). Introgression patterns in the mosaic hybrid zone between *Mytilus edulis* and *M. galloprovincialis*. *Molecular ecology*, **12**, 447-461.

BØGWALD, M., SKAR, C.K., KARLSBAKK, E., ALFJORDEN, A., FIEST, S.W., BASS, D. & MORTENSEN, S. (2022). Infection cycle of *Marteilia pararefringens* in blue mussels Mytilus edulis in a heliothermic marine oyster lagoon in Norway. *Diseases of Aquatic Organisms*, **148**, 153-166.

BOUGRIER, S., TIGÉ, G., BACHÈRE, E. & GRIZEL H. (1986). *Ostrea angasi* acclimatization to French coasts. *Aquaculture*, **58**,151-154.

BOYER, S., CHOLLET, B. , BONNETA, D. , ARZUL, I., (2013). New evidence for the involvement of *Paracartia grani* (Copepoda, Calanoida) in the life cycle of *Marteilia refringens* (Paramyxea). *International Journal for Parasitology*, **43(14)**, 1089-1099.

CAHOUR, A. (1979). *Marteilia refringens* and *Crassostrea gigas*. *Marine Fisheries Review*, **41**, 19-20.

CARRASCO, N., VOORBERGEN-LAARMAN, M., LACUESTA, B., FURONES, D. & ENGELSMA, M.Y. (2017). Application of a competitive real time PCR for detection of *Marteilia refringens* genotype “O” and “M” in two geographical locations: The Ebro Delta, Spain and the Rhine-Meuse Delta, the Netherlands. *Journal of Invertebrate Pathology*, **149**, 51-55.

CARRASCO, N., ARZUL, I., CHOLLET, B., ROBERT, M., JOLY, J.-P., FURONES, M.D. & BERTHE, F. (2008b). Comparative experimental infection of the copepod *Paracartia grani* with *Marteilia refringens* and *M. maurini. Journal of Fish Diseases*, **31**, 497-504.

CARRASCO, N., LÓPEZ-FLORES, I., ALCARAZ, M., FURONES, M.D., BERTHE, F.C.J. AND ARZUL, I. (2007a). First record of a Marteilia parasite (Paramyxea) in zooplankton populations from a natural estuarine environment. *Aquaculture*, **269**, 63-70.

CARRASCO, N., LÓPEZ-FLORES, I., ALCARAZ, M., FURONES, M.D., BERTHE, F.C.J. AND ARZUL, I. (2007b). Dynamics of the parasite *Marteilia refringens* (Paramyxea) in *Mytilus galloprovincialis* and zooplancton populations in Alfacs Bay (Catalonia, Spain). *Parasitology*, **134(11)**, 1541-1550.

CESCHIA, G., ZANCHETTA, S., SELLO, M., MONTESI, F., ANTONETTI, P., AND FIGUERAS, A. (2001). Presence of parasites in razor clam (*Ensis minor* and *Ensis siliqua*) harvested from coastal areas of the southern Tyrrhenian and Adriatic Seas. *Bollettino Societa Italiana di Patologia Ittica*, **13(30)**, 20-27.

COMPS, M. (1983). Etude morphologique de *Marteilia christenseni sp. n*. parasite du lavignon *Scrobicularia piperata* P. (mollusque pélécypode). *Revue des travaux de l'Institut des pêches maritimes*, **47**, 99–104.

COMPS, M. (1976). *Marteilia lengehi n. sp.,* parasite de l’huître *Crassostrea cucullata* Born. *Revue des travaux de l'Institut des pêches maritimes,* **40**, 347–349.

COMPS, M., GRIZEL, H., TIGE, G., & DUTHOIT, J.L. (1975). Parasites nouveaux de la glande digestive des mollusques marins *Mytilus edulis* L. et *Cardium edule*. *Comptes Rendus de l’Académie des Sciences de Paris*, **281**, 179–181.

COMPS, M. AND JOLY, J.P. (1980). Contamination expérimentale de *Mytilus galloprovincialis* Lmk par *Marteilia refringens*. *Science et Pêche Bulletin d'Information et de Documentation de l'Institut Scientifique et Technique des Pêches Maritimes,* **301**, 19-21.

ELGHARSALLI, R., ALOUI-BEJAOUI, N., SALAH, H., CHOLLET, B., JOLY, J-P, ROBERT, M., COURALEAU, Y. & ARZUL, I. (2013). Characterization of the protozoan parasite *Marteilia refringens* infecting the dwarf oyster *Ostrea stentina* in Tunisia. *Journal of Invertebrate Pathology*, **112(2)**, 175-183.

GOMBAC, M., KUSAR, D., OCEPEK, M., POGACNIK, M., ARZUL, I., COURALEAU, Y. & JENCIC, V. (2014). Marteiliosis in mussels: a rare disease?. *Journal of Fish Diseases*, **37**, 805-814.

GRIJALVA-CHON, J.M., CASTRO-LONGORIA, R., ENRIQUEZ-ESPINOZA, T.L., MAEDA-MARTINEZ, A.N. & MENDOZA-CANO, F. (2015). Molecular evidence of the protozoan parasite *Marteilia refringens* in *Crassostrea gigas* and *Crassostrea corteniensis* from the Gulf of California. *Latin American Journal of Aquatic Research*, **43(4)**, 776-780.

GRIZEL, H., COMPS, M., RAGUENES, D., LEBORGNE, Y., TIGÉ G. & MARTIN, A.G. (1983). Bilan des essais d'acclimatation *d'Ostrea chilensis* sur les côtes de Bretagne. *Revue des travaux de l'Institut des pêches maritimes*, **46**, 209-225.

ITOH, N., MOMOYAMA, K. & OGAWA, K. (2005). First report of three protozoan parasites (a haplosporidian, *Marteilia sp*. and *Marteilioides sp*.) from the Manila clam, *Venerupis (DRuditapes) philippinarum* in Japan. *Journal of Invertebrate Pathology,* **88**, 201–206.

LE ROUX, F., LORENZO, G., PEYRET, P., AUDEMARD, C., FIGUERAS, A., VIVARES, C., GOUY, M., & BERTHE, F.C.J. (2001). Molecular evidence for the existence of two species of Marteilia in Europe. *Journal of Eukaryotic microbiology,* **48(4)**, 449–454.

LÓPEZ, C. & DARRIBA, S. (2006). Presence of *Marteilia sp*. (Paramyxea) in the razor clam *Solen marginatus* (Pennántt, 1777) in Galicia (NW Spain). *Journal of Invertebrate Pathology*, **92**, 109-111.

LÓPEZ-FLORES, I., ROBLES, F., VALENCIA, J.M., GRAU, A., VILLALBA, A., DE LA HERRÁN, R., GARRIDO-RAMOS, M.A., RUIZ-REJÓN, C., RUIZ-REJÓN, M. & NAVAS, J.I. (2008a). Identification of *Marteilia refringens* infecting the razor clam *Solen marginatus* by PCR and in situ hybridization. *Molecular Cell Probes*, **22**, 151–155.

LÓPEZ-FLORES, I., DE LA HERRAN, R., GARRIDO-RAMOS, M.A., NAVAS, J.I., RUIZ-REJON, C., RUIZ-REJON, M.(2004). The molecular diagnosis of *Marteilia refringens* and differentiation between Marteilia strains infecting oysters and mussels based on the rDNA IGS sequence. *Parasitology*, **129**, 411-419.

LÓPEZ-FLORES, I., ROBLES, F., VALENCIA, J.M., GRAU, A., VILLALBA, A., DE LA HERRAN R., GARRIDO-RAMOS, M.A., RUIZ-REJON, C., RUIZ-REJON, M. & NAVAS, J.I.(2008b). Detection of *Marteilia refringens* using nested PCR and in situ hybridisation in *Chamelea gallina* from the Balearic Islands (Spain). *Diseases of Aquatic Organisms,* **82**, 79–87.

LÓPEZ-SANMARTIN, M., BATISTA, F. M., DEL CARMEN MARIN, M., GARRIDO, I., QUINTERO, D., GRADE, A., RUANO, F., DE LA HERRAN, & R., NAVAS, J. I. (2015). Detection of *Marteilia refringens* infecting the European flat oyster *Ostrea edulis* and the dwarf oyster *Ostrea stentina* in southern Portugal and Spain. *Journal of Invertebrate Pathology*, **130**, 52-55

MARTIN, A.G. (1993). Relance de l'huître plate – Rapport d'avancement des travaux année 1991. *Rapport Ifremer. RIDRV-93.026 RA/Trinité*, 40 pp.

MICHALEK, K., VENTURA, A. & SANDERS, T. (2016). Mytilus hybridisation and impact on aquaculture: A minireview. *Marine Genomics*, **27**, 3-7.

MIAHLE, E., BACHERE, E., LE BEC, C. & GRIZEL, H. (1985). Isolement et purification de Marteilia (Protozoa: Ascetospora) parasites de bivalves marins. *Comptes Rendus de l'Académie des Sciences de Paris*, **301**, Serie III, 4, 137–142.

MOYER, M.A., BLAKE, N.J. & ARNOLD, W.S. (1993). An ascetosporan disease causing mass mortality in the Atlantic calico scallop, *Agropecten gibbus* (Linnaeus, 1758). *Journal of Shellfish Research*, **12(2)**, 305–310.

NORTON, J.H., PERKINS, F.P & LEDUA, E. (1993). Marteilia-like infection in a giant clam, *Tridacna maxima*, in Fiji. *Journal of Invertebrate Pathology*, **61**, 328–330.

NOVOA, B., POSADA, D. & FIGUERAS, A. (2005). Polymorphisms in the sequences of Marteilia internal transcribed spacer region of the ribosomal RNA genes (ITS-1) in Spain: genetic types are not related with bivalve hosts. *Journal of Fish Diseases*, *28(6)*, 331-338.

PASCUAL, S., VILLALBA, A., ABOLLO, E., GARCI, M., GONZALES, A.F., NOMBELA, M., POSADA, D. & GUERRA, A. (2010). The mussel *Xenostrobus securis*: a well established alien invader in the Ria de Vigo (Spain, NE Atlantic). *Biological Invasions*, **12**, 2091–2103.

PASCUAL, M., MARTIN, A.G., ZAMPATTI, E., COATANEA, D., DEFOSSEZ, J. & ROBERT, R. (1991). Testing of the Argentina oyster, *Ostrea puelchana* in several French oyster farming sites. ICES Council Meeting Papers. *ICES CM 1991/K:30 (ICESCM1991K30)*, Copenhagen, Denmark. 17 pp.

PODER, M., AUFFRET, M., & BALOUET, G. (1983). Etudes pathologiques et épidemiologiques des lésions parasitaires chez *Ostrea edulis* L.—premiers résultats d'une recherche prospective comparative chez les principales espèces de mollusques des zones ostréicoles de Bretagne nord. *CNRS-CNEXO*, Montpellier, p 125–138.

RENAULT, T., COCHENNEC, N. & CHOLLET, B. (1995). Marteiliosis in American oysters *Crassostrea virginica* reared in France. *Diseases of Aquatic Organisms*, **23**, 161-164.

SALVI, D., BERTSCH, H., CÀCERES-MARTÍNEZ, J., CRUZ-FLORES, R., DEL RIO-PORTILLA, M., EERNISSE, D.J., HEALY, J.M., LAFARGA-DE LA CRUZ, F., LONDOÑO-CRUZ, E., MCDOUGALL, C., OLIVER, G.P., OLIVERIO, M., PANIAGUA, C., WILLAN, R.C. ZACHERL, D.C. MARIOTTINI, P. (2022). Taxonomic discussion on scientific names for Pacific oysters requires evidence-based arguments and pluralism. *Aquaculture*, **546**, 737298.

SALVI, D. & MARIOTTINI, P. (2020). Revision shock in Pacific oyster taxonomy: the genus *Magallana* (formerly *Crassostrea* in part) is well founded and necessary. *Zoological Journal of the Linnean Society*, **192**, 1-16.

SALVI, D. & P. MARIOTTINI. (2017). Molecular taxonomy in 2D: a novel ITS 2 rRNA sequence structure approach guides the description of the oysters subfamily Saccostreinae and the genus *Magallana* (Bivalvia: *Ostreidae*). *Zoological Journal of the Linnean Society*, **179**, 263–276.

SIGWART, J.D., WONG, N.L.W.S. & ESA, Y. (2021). Global controversy in oyster systematic and a newly described species from SE Asia (Bivalvia: *Ostreidae*: *Crassostreinae*). *Marine Biodiversity*, **51**, 83.

Other references reviewed by the ad hoc Group but not referred to in the report above:

ALDERMAN, D.J. (1979). Epizootiology of *Marteilia refringens* in Europe. *Marine Fisheries Revie*w, **41**, 67-69.

BALSEIRO, P., MONTES, A., CESCHIA, G., GESTAL, C., NOVOA, B., & FIGUERAS, A. (2007). Molecular epizootiology of the European *Marteilia spp*., infecting mussels (*Mytilus galloprovincialis* and *M. edulis*) and oysters (*Ostrea edulis*): an update. *Bulletin of the European Association of Fish Pathology*, **27(4)**, 148-156.

BERTHE, F.C.J., LE ROUX, F., ADLARD, R.D. & FIGUERAS, A. (2004). Marteiliosis in molluscs: A review. *Aquatic Living Resources*, **17**, 433–448.

CAMACHO, A.P., VILLALBA, A., BEIRAS R. & LABARTA, U. (1997). Absorption efficiency and condition of cultured mussels (*Mytilus edulis galloprovincialis* Linnaeus) of Galicia (NW Spain) infected by parasites *Marteilia refringens* Grizel *et al.* and *Mytilicola intestinalis* Steuer. *Journal of Shellfish Research,* **16(11)**, 77-82.

CARRASCO, N., GREEN, T. & ITOH, N. (2015). Marteilia spp. parasites in bivalves: A revision of recent studies. *Journal of Invertebrate Pathology*, **131**, 43-57.

CARRASCO, N., ARZUL, I., BERTHE, F.C.J., AND FURONES, M.D. (2008a). In situ hybridization detection of *Marteilia refringens* (Paramyxea) initial infective stages in its host *Mytilus galloprovincialis*. *Journal of Fish Diseases*, **31**, 153-157.

CARRASCO, N., ARZUL, I., FURONES, D., CHOLLET, B., ROBERT, M., JOLY, J.P. AND BERTHE, F. 2005. Comparative experimental infection of *Marteilia spp*. from mussels and oysters in the copepod *Paracartia grani*. *Poster 12th International Conference on Fish and Shellfish Pathology, Copenhagen, Denmark,* 11-16 September 2005.

CAVALIER-SMITH, T & CHAO, E.E. (2003). Phylogeny and classification of phylum Cercozoa (Protozoa). *Protist*. **154(3-4)**, 341–358.

FEIST, S.W., HINE, P.M., BATEMAN, K.S., GRANT, D.S. & LONGSHAW, M. (2009). *Paramarteilia canceri* sp. n. (Cercozoa) in the European edible crab (Cancer pagarus) with a proposal for the revision of the order Paramyxida Chatton, 1911. Folia Parasitologica. 56 (2), 73–85.

GAITÁN-ESPITIA, J.D., QUINTERO-GALVIS, J.F., MESAS, A. & D'ELIA, G. (2016). Mitogenomics of southern hemisphere blue mussels (Bivalvia: pteriomorphia): Insights into the evolutionary characteristics of the *Mytilus edulis* complex. *Scientific Reports*, **6**, 26853.

GRIZEL, H. (1985). Etude des récentes épizooties de l'huître plate (Ostrea edulis Linné) et leur impact sur l'ostréiculture bretonne. *Thèse Doctorat es Sciences, Université des Sciences et Techniques du Languedoc, Montpellier, France*. 145 pp.

GRIZEL, H., COMPS, M., BONAMI, J.R., COUSSERANS, F., DUTHOIT, J.L., & LE PENNEC, M.A. (1974). Recherche sur l'agent de la maladie de la glande digestive de *Ostrea edulis* Linne. *Science et Pêche Bulletin de l'Institut des pêches maritimes*, **240**, 7-29.

KLEEMAN, S.N., LE ROUX, F., BERTHE, F. & ADLARD, R.D. (2002). Specificity of PCR and in situ hybridisation assays designed for detection of *Marteilia sydneyi* and *M. refringens*. *Parasitology*, **125**, 131–141.

LE ROUX, F., AUDEMARD, C., BERNAUD, A. & BERTHE, F.C.J. (1999). DNA probes as potential tools for the detection of *Marteilia refringens*. *Marine Biotechnology*, **1(6)**, 588–597.

LIMPANONT, Y., KANG, H. S., HONG, H. K., JEUNG, H. D., KIM, B. K., LE, T. C., KIM, Y. O. & CHOI, K. S. (2013). Molecular and histological identification of Marteilioides infection in Suminoe Oyster *Crassostrea ariakensis*, Manila Clam *Ruditapes philippinarum* and Pacific Oyster *Crassostrea gigas* on the south coast of Korea. *Journal of Invertebrate Pathology*, **114(3)**, 277-84.

LONGSHAW, M., FEIST, S.W., MATTHEWS, A. & FIGUERAS, A. (2001). Ultrastructural characterisation of Marteilia species (Paramyxea) from *Ostrea edulis*, *Mytilus edulis* and *Mytilus galloprovincialis*. *Diseases of Aquatic Organisms,* **44**, 137–142

MONTES, J., LONGA, M.A., LAMA, A. AND GUERRA, A. (1998). Marteiliosis of Japanese oyster (*Crassostrea gigas*) reared in Galicia NW Spain. *Bulletin of the European Association of Fish Pathologists*, **18**, 124-126.

PERKINS, F.O. & WOLF, P.H. (1976). Fine structure of Marteilia sydneyi sp. n. – Haplosporidian pathogen of Australian oysters. *Journal of Parasitology*, **62**, 528–538.

RIERA, V., SANTMARTI, M. & DURFORT, M. (1993). Presence of *Marteilia refringens*, in the cultures of bivalve molluscs in the Catalan littoral. In: *Actas del IV Congreso Nacional de Acuicultura, Centro de Investigaciones Marinas, Ponte-vedra,* 539-544.

ROBERT, R., BOREL, M., PICHOT Y., & TRUT, G. (1991). Growth and mortality of the European oyster *Ostrea edulis* in the Bay of Arcachon (France). *Aquatic Living Resource*, **4**, 265–274.

ROBLEDO, J.A.F., MIAHLE, E. & FIGUERAS, A. (1995a). Purification of several phases of the parasite Marteilia (Protozoa: Ascetospora) from mussels (*Mytilus galloprovincialis*). In: *Techniques in Fish Immunology – 4. Immunology and pathology of aquatic invertebrates, Stolen J.C., Fletcher T.C., Smith S.A., Zelikoff J.T., Kaattari S.L., Anderson R.S., Soderhall K. & Weeks-Perkins B.A., eds. SOS Publications, Fair Haven, New Jersey, USA*, 117–121.

ROBLEDO, J.A.F., SANTAREM, M.M., GONZALEZ, P. & FIGUERAS, A. (1995b). Seasonal variations in the biochemical composition of the serum of *Mytilus galloprovincialis* Lmk. and its relationship to the reproductive cycle and parasitic loads. *Aquaculture*, **133**, 311–322.

RUIZ, M., DARRIBA, S., RODRIGUEZ, R. & LÓPEZ, C. (2015). *Marteilia sp*. and other parasites and pathological conditions in *Solen marginatus* populations along the Galician coast (NW Spain). *Diseases of Aquatic Organisms*, **112**, 177-184.

SPENCER, H.G., WILLAN, R.C., MARIOTTINI, P. & SALVI, D. (2022). Taxonomic consistency and nomenclatural rules within oysters: Comment on Li et al., (2021). *Molecular Phylogenetics and Evolution*, **170**, 107437.

THÉBAULT, A., BAUD, J.P., LE SAUX, J.C., LE ROUX, F., CHOLLET, B., LE COGUICC, M.J., FLEURY, P.G., BERTHE, F. & GERARD, A. (1999). Compte rendu sur les mortalité de juillet 1999 des moules (*Mytilus edulis*) en poches dans l'Aber Benoît. *Rapport IFREMER*, 12 pp.

THÉBAULT, A.,BERGMANN, S., POUILLOT, S., LE ROUX, F. & BERTHE, F.C.J. (2005). Validation of in situ hybridization and histology assays for the detection of the oyster parasite *Marteilia refringens*. *Diseases of Aquatic Organisms*, **65(1)**, 9–16.

VENCES, M., GUAYASAMIN, J.M., MIRALLES, A., & DE LA RIVA, I. (2013). To name or not name: Criteria to promote economy of change in Linnaean classification schemes. *Zootaxa*, **3636(2)**, 201-244.

VILLALBA, A., MOURELLE, S.G., CARBALLAL, M.J. & LOPEZ, M.C. (1993b). Effects of infection by the protistan parasite *Marteilia refringens* on the reproduction of cultured mussels *Mytilus galloprovincialis* in Galicia (NW Spain). *Diseases of Aquatic Organisms*, **17**, 205-213.

VILLALBA, A., MOURELLE, S.G., LOPEZ, M.C., CARBALLAL, M.J. & AZEVEDO, C. (1993a). Marteiliasis affecting cultured mussels *Mytilus galloprovincialis* of Galicia (NW. Spain). I. Etiology, phases of the infection, and temporal and spatial variability in prevalence. *Diseases of Aquatic Organisms,* **16**, 61-72.

ZRNCIC, S., LE ROUX, F., ORAIC, D. & BERTHE, F. (2001). First record of Marteilia sp. in mussels, *Mytilus galloprovincialis* in Croatia. *Diseases of Aquatic Organisms*, **44**, 143-148.

———————

…/Annexes

Annex I. List of Participants

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

November–December 2021 and May–June 2022

_____

MEMBERS OF THE *AD HOC* GROUP

Dr Isabelle Arzul
(Chair)
IFREMER
Laboratoire de Génétique et Pathologie de Mollusques Marins
FRANCE

Dr Robert Adlard
Marine Biodiversity at Queensland Museum Network
AUSTRALIA

Dr Chang-Ming Bai
Yellow Sea Fisheries Research Institute, CAFS
Division of Maricultural Organism Disease control and Molecular Pathology
CHINA (PEOPLE'S REPUBLIC OF)

Dr Lori Gustafson
Surveillance Design and Analysis
USDA/APHIS/VS/CEAH
UNITED STATES OF AMERICA

Dr Karin B. Lohrmann
Departamento de Biología Marina
Facultad de Ciencias del Mar, Universidad Católica del Norte,
CHILE

MEMBERS OF THE COMMISSION

Dr Kevin William Christison
Department of Forestry, Fisheries and the Environment
Directorate: Aquaculture Research and Development
SOUTH AFRICA

WOAH HEADQUARTERS

Dr Bernita Giffin
Scientific Coordinator for Aquatic Animal Health
Standards Department

Dr Benedetto Zangrilli
Scientific Coordinator for Aquatic Animal Health
Standards Department

WOAH *AD HOC* GROUP ON SUSCEPTIBILITY OF MOLLUSC SPECIES TO INFECTION WITH OIE LISTED DISEASES

November–December 2021 and May–June 2022

_____

Background

Chapter 1.5. Criteria for listing species as susceptible to infection with a specific pathogenic agent, 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 Members 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 WOAH *ad hoc* Group on Susceptibility of mollusc species to infection with OIE listed diseases will undertake assessments for infection with *Marteilia refringens* in molluscs.

Terms of Reference

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

2) Review relevant literature documenting susceptibility of species for infection with *Marteilia refringens*.

3) Propose susceptible species for infection with *Marteilia refringens* based on Article 1.5.7.

4) Propose a list of susceptible species of molluscs for infection with *Marteilia refringens* based on Article 1.5.8.

Expected outputs of the *ad hoc* Group

1) Develop a list of susceptible species for inclusion in Article 11.4.2. 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 its February 2022 meeting.