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Diseases in marine invertebrates associated with mariculture and commercial fisheries

Michael J. Sweet [a,*], Kelly S. Bateman [b]

[a] Molecular Health and Disease Laboratory, University of Derby, DE22 1GB, UK
[b] European Union Reference Laboratory for Crustacean Diseases, CEFAS, Barrack Road, The Nothe, Weymouth, Dorset DT4 8UB, UK

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ABSTRACT

Diseases in marine invertebrates are increasing in both frequency and intensity around the globe. Diseases in individuals which offer some commercial value are often well documented and subsequently well studied in comparison to those wild groups offering little commercial gain. This is particularly the case with those associated with mariculture or the commercial fisheries. Specifically, these include many Holothuroidea, and numerous crustacea and mollusca species. Pathogens/parasites consisting of both prokaryotes and eukaryotes from all groups have been associated with diseases from such organisms, including bacteria, viruses, fungi and protozoa. Viral pathogens in particular, appear to be an increasingly important group and research into this group will likely highlight a larger number of diseases and pathogens being described in the near future. Interestingly, although there are countless examples of the spread of disease usually associated with transportation of specific infected hosts for development of aquaculture practices, this process appears to be continuing with no real sign of effective management and mitigation strategies being implicated. Notably, even in well developed countries such as the UK and the US, even though live animal trade may be well managed, the transport of frozen food appears to be less well so and as evidence suggests, even these to have the potential to transmit pathogens when used as a food source for example.

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* Corresponding author.
E-mail address: m.sweet@derby.ac.uk (M.J. Sweet).

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1. Introduction

Globally, documented cases of disease outbreaks are increasing in both frequency and intensity in many marine taxa (Burge et al., 2014; Harvell et al., 2004). These recent increases in disease outbreaks (Ward and Lafferty, 2004) may be caused by either the introduction of new pathogens or changes within the environment (Burge et al., 2014; Harvell et al., 2004). Although there are many recorded disease outbreaks in invertebrates, here, we are only focusing on those diseases associated with mariculture and other commercially important marine species. We will also focus on the potential of spread of certain well documented pathogens, through specific pathways such as the transportation of commercially important species from country to country, a result which inadvertently often includes the transfer of specific pathogens capable of infecting native populations of similar species. The three most commonly cultured phyla or subphyla include that of Echinodermata, Crustacea and Mollusca. The World Organisation for Animal Health (Office International des Epizooties (OIE)) currently lists notifiable diseases for only the two latter groups, crustaceans and molluscs, as these are arguably the most important invertebrates on a commercial basis. However, Holothuroidea (i.e. sea cucumbers) are increasing in popularity throughout many areas of the globe and likely warrant being added to OIEs' list of notifiable diseases in the not too distant future.

The ability to assess the effects that disease may have on wild fisheries in terms of production losses is far more challenging than in farmed stocks. Therefore, as a result, there is limited information available on the pathogens and disease of echinoderms, crustaceans and molluscs, and this has led to a deficit in knowledge on causes of mortalities within the wild populations. Furthermore, recent work has also highlighted a difference in pathogens present in juvenile and adult populations of wild organisms (Bateman et al., 2011). Such data is important in understanding the potential for disease to cause 'silent mortalities' (i.e. unobserved) in commercially exploited stocks. This data, also highlights that the ability to accurately assess the effect disease may have in terms of production losses in the wild is far more challenging than in a farmed environment (Stentiford et al., 2012). In this respect an emerging disease within wild fisheries may be more difficult to identify and classify when compared to the farmed stocks. In this review, we are not listing all known diseases for the three main commercially important phyla/sub-phyla and/or class (echinoderms, crustaceans and molluscs), but instead focus on those which likely pose a major threat and/or are infecting large populations of both wild and farmed organisms around the world. We have therefore opted to split the review into sections outlined by major pathogenic and/or parasite causal agents.

1.1. Phylum: Echinodermata — Class Holothuroidea

The impacts of disease on numerous echinoderm species have been relatively well documented over previous years and have in some cases provided compelling examples of major shifts in ecosystem state and cascading community effects following disease-induced die-offs in wild systems (Uthicke et al., 2009). In addition to the fact that such outbreaks in the wild can illicit dramatic changes to whole ecosystems, the increase in mariculture for certain species particular those from the class Holothuroidea (sea cucumbers) has further exacerbated the need to understand diseases in this phylum. Recent improvements in artificial breeding techniques of sea cucumbers around the world have occurred rapidly. In areas of Asia, in particular the northern coast of China, rearing currently results in over 1–2 billion seeds being produced with ~90,000 tonnes of sea cucumber (live weight) being harvested every year. Such rapid expansion and intensification of sea cucumber farming have subsequently led to the occurrence of various diseases, causing serious economic losses and becoming one of the limiting factors in the sustainable development of this industry. Although, little research has been conducted on these diseases so far, it is clear that in the next few years the causes and consequences of outbreaks in this group of organisms need to be understood for commercial practices to continue unabated.

1.1.1. Viral diseases in Holothuroidea

1.1.1.1. Acute peristome edema disease (APED). Agent: To date, although there have been no definitive results, the most likely candidates for pathogenesis appear to be viruses.

Hosts affected: Cultured sea cucumbers in particular *Apostichopus japonicus* (Wang et al., 2007).

Clinical signs and pathology: Diseased individuals first show edema in their peristomes, the tentacles cannot retract completely and adhesion capacities are weakened. This latter ailment results in diseased individuals dropping to the bottom of the ponds. Grazing rate and activity decrease and upwards of 80% eviscerate (i.e. eject their internal organs). About 2–3 days later, small white lesions usually appear on the surface of the skin and gradually expand, and increased mucus secretion is often noticed over large areas of the body wall. About 5–6 days after occurrence of the first symptoms the sea cucumbers die, with mortality often in excess of 90% (Wang et al., 2005a). Virus-like particles (VLPs) have been found associated within the epithelium of the intestine of diseased individuals (Wang et al., 2007). Transmission electron microscopic examinations showed that the virions are spherical, 80–100 nm in diameter, and composed of a helical nucleocapsid within an envelope with surface projections. Detailed studies on the morphogenesis of these viruses found many characteristics previously described for other coronaviruses (Wang et al., 2007). Virus particles were found to be congregated, and always formed a virus vesicle with an encircling membrane (Wang et al., 2007). The most obvious cellular pathologic feature appears to be large granular areas of cytoplasm, relatively devoid of organelles. Tubular structures within virus-containing vesicles, nucleocapsid inclusions, and double-membrane vesicles are also routinely found in the cytopathic cells. Furthermore, in support of a viral pathogen being the causal agent for this disease, no rickettsia, chlamydia, bacteria, or other parasitic organisms have been seen to be associated with any of the diseased tissues sampled (Wang et al., 2007). Furthermore, these VLPs are only present in diseased individuals and absent in healthy animals. However, no infection trials have been conducted to date. Therefore, further evidence is required to prove that these VLPs are the aetiological agent. Interestingly, the same VLPs have also been observed in diseased larvae (30 days old). This latter finding suggests that the disease may be transmitted vertically from parents, which may have severe implications for transportation of brood stock from pond to pond.

Epidemiology: First reported in cultured sea cucumbers along the Shangdong and Liaoning province coasts in China in 2004, it has now caused a significant number of deaths in cultured sea cucumbers throughout China.

Diagnosis and/or treatment: Based on disease signs only at the current time.

1.1.1.2. Stomach atrophy syndrome (SAS). Agent: An unknown virus approximately 75–200 nm in diameter (Deng et al. 2008).

Hosts affected: *A. japonicus.*

Clinical signs and pathology: The stomach of diseased larvae can be observed to shrink gradually exhibiting thick, rough and distorted walls. Virus like particles have been observed only in diseased individuals, these are predominantly spherical or hexagonal with a well-defined envelope, and exhibit dense core structures (Yin-Geng et al., 2005). Sizes range from 75 to 200 nm in diameter. The VLPs have also been found in the gonad, body wall, alimentary canals and the