Transboundary Aquatic Animal Diseases: History and Impacts in ASEAN Aquaculture

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Abstract

Aquaculture is one of the important sectors in the economy of most Asia-Pacific countries. However, majority of aquaculture farms are small-scale and most often lack the necessary facilities to comply with or are not well informed of the product standards imposed by concerned authorities, especially for international trade. Most countries in the region have a high reliance on aquatic animals as the major source of protein for their populations. In the past 20 years, farming of shrimp and fish for export has become a major employer and revenue earner for many countries in the region. Aquaculture is a major employer, contributes significantly to national economies, assists in poverty reduction, and is an important element in food security and other national development priorities. Aquaculture has developed rapidly in the region and is now a significant component in the national economies of many countries. However, recent disease events in fish and shrimp farming have indicated that preparedness and response measures are lacking, contributing to spread of disease across large areas of the countries involved.

The growth of aquaculture in recent decades has been dependent on the international movement of aquatic animals and, in particular, the introduction of non-native species. The movement of live aquatic animals and their products has the potential to spread pathogens from one country or region to another, which may result to disease outbreaks. In shrimps as example, most major disease outbreaks were associated with the movement of live animals (broodstock, nauplii and postlarvae) when the patterns of disease spread were analyzed. Many aquatic animal diseases, once established, are often difficult to treat or to eliminate. Over the past 30 years, the Asia-Pacific region has been swept by a number of devastating diseases of aquatic animals which have caused massive economic and social losses. These include spread and outbreaks of infection with *Aphanomyces invadans* (EUS) in freshwater fish, viral nervous necrosis (VNN) in marine fish, viral hemorrhagic septicaemia (VHS) in marine and freshwater fish, and several viral diseases in shrimps such as white spot disease (WSD), white tail disease (WTD), yellow head disease (YHD) and infectious myonecrosis (IMN) among others. This demonstrates the vulnerability of the aquaculture industry as well as the wild populations to disease emergence in the region. The impacts of these diseases have been aggravated by the lack of effective preparedness and response whenever diseases emerge. Although some national, regional and international actions towards disease emergencies have paved way to disease spread prevention in recent years (e.g. Acute hepatopancreatic necrosis diseases; AHPND), there are still several emerging diseases that need to be considered by aquaculture-producing countries, especially in the ASEAN, through a harmonized and effective emergency preparedness and disease response.

Introduction

ASEAN member countries are among the top aquaculture producers in the world. In 2016 Indonesia, Viet Nam, Myanmar and Thailand were among the top 10 producers contributing 6.2, 4.5, 1.3 and 1.2%, respectively, of the total world aquaculture production. Table 1 summarizes the total aquaculture production of the rest of the ASEAN member states (FAO, 2018a). Aquaculture in the Asia-Pacific region in general is a significant food production sector that provides many livelihood opportunities, especially for small-scale farming communities which are common in the region. It also contributes to food security, nutrition and health of the general public, and poverty alleviation especially through the production of exportable aquaculture products. As the biggest producer of aquaculture products in the world, Asia is also the biggest consumer. It is estimated that 95% of the fish supply in the ASEAN region was used for human consumption (Chan et al., 2017). Needham and Funge-Smith (2014) reported that among the ASEAN countries, Cambodia is the highest consumer with an average of 63.5 kg per capita per year, while the lowest is Indonesia with 12.8 kg per capita per year.

TABLE 1. Aquaculture production of ASEAN member countries in 2016 (FAO, 2018a)

Rank	Country	Production (x 1,000 T)	Percentage (World Production)
1	Indonesia	4,950	6.2
2	Viet Nam	3,625	4.5
3	Myanmar	1,017	1.3
4	Thailand	963	1.2
5	Philippines	796	1.0
6	Malaysia	408	0.5
7	Cambodia	172	0.2
8	Lao PDR	110	0.1
9	Singapore	6	-
10	Brunei Darrusalam	1	-

With the rapid development of aquaculture in the region, disease outbreaks remain to be the biggest challenge in the sustainability of aquaculture production. Previous and recent disease events in shrimp and fish farming have indicated that preparedness and response measures are still lacking, which contribute significantly to the spread of diseases/pathogens across large areas of the countries involved. Several transboundary aquatic animal diseases have swept the region over the past 30 years which have caused massive economic and social losses. These include spread and outbreaks of infection with *Aphanomyces invadans* (EUS) in freshwater fish, viral nervous necrosis (VNN) in marine fish, viral hemorrhagic septicaemia (VHS) in marine and freshwater fish, and several viral diseases in shrimps (white spot disease [WSD], white tail disease [WTD], yellow head disease [YHD]) (Rogers et al., 2011). More recently, infectious myonecrosis (IMN) and acute hepatopancreatic necrosis disease (AHPND) are seriously affecting shrimp aquaculture in Indonesia (IMN; Senapin et al., 2007) and Malaysia, Philippines, Thailand and Viet Nam (AHPND; Flegel, 2012; Leaño and Mohan, 2012a; Dabu et al., 2015). For finfish, it is the Tilapia lake virus (TiLV) which was first reported in Thailand (Dong et al., 2017a; Surachetpong et al., 2017), then in Taiwan (Yang et al., 2017), Malaysia (Amal et al., 2018), the Philippines and India (NACA, OIE and FAO, 2017). The spread of these transboundary aquatic animal diseases clearly demonstrates the vulnerability of the aquaculture industry, as well as the wild fish populations, to disease emergence where impacts have been aggravated by the lack of effective preparedness and response whenever disease emergencies emerge.

Emergence and spread of serious transboundary aquatic animal diseases

The emergence and spread of transboundary aquatic animal diseases are mainly a result of two important practices in aquaculture: intensification of culture systems; and, international trade (movement) of live aquatic animals and aquatic animal products. The economic impact of these diseases is huge, around US$6 billion annually on direct production losses. Over the years, several transboundary aquatic animal diseases have affected the aquaculture industry in the region. Some of these are summarized in detail below:

Koi Herpesvirus Disease (KHV)

This viral disease can cause mass mortalities in cultured Koi and common carp (*Cyprinus carpio*). Affected culture systems will show many dead and

moribund fish floating at the water surface. Affected fish also exhibit disorientation, erratic swimming behavior (sometimes hyperactivity), and gasping for air. Clinical examination of infected fish will reveal severe gill lesions (mottling with red and white patches), overproduction or underproduction of mucus on skin and gills, enlarged and haemorrhagic kidney and liver, and some fish will have bleeding gills, sunken eyes and pale patches or blisters on the skin.

KHV in the region was first reported in Hong Kong in 2001, then in Indonesia in 2002 (Lio-Po, 2010). From 2002 to 2005, it has spread in Taiwan, Japan, and Singapore. Since koi carps are highly traded ornamental fish, mass mortalities due to KHV has significantly affected production in major producing countries that were hit by the disease. Moreover, trading of healthy koi carps is also greatly affected, especially from countries reported to be positive from the disease, as the aquarium fish trade most likely played a significant role in the transboundary spread of the virus. The disease can be transmitted to common carps, an important cultured food fish in the region, and significant production losses were also reported in some countries (e.g. Indonesia). Some of the reported economic losses due to KHV include Japan with a reported loss of $2.5 million during the first year of outbreak. In Indonesia, $0.5 million loss was reported within three months since the outbreak was reported in 2002 (Sunarto et al., 2005), and as of December 2003, total losses amounted to US$15 million.

Infection with White Spot Syndrome Virus (WSD/WSSV)

WSD/WSSV is, by far, the most devastating disease of farmed shrimps. The virus can infect most of the cultured shrimps and other crustaceans, including the wild populations. It has caused heavy losses among cultured shrimps in Asia, and almost crippled the industry in countries where outbreaks were reported. The typical sign of this disease is the presence of distinct white cuticular spots mainly on the carapace (hence the name white spot disease). Some moribund shrimps also show red discoloration and loose cuticle, surface swimming and gathering at pond dikes with broken antennae. The spread of the disease happened during the peak of *Penaeus monodon* culture in Asia, mainly through trading of live postlarvae and broodstock from China, Taiwan, Indonesia and Thailand. The disease was initially reported in China, Japan and Taiwan in 1993, and from 1994 to 1999, it has rapidly spread in many shrimp-producing countries in the region including Thailand, Malaysia, Indonesia, India, Sri Lanka, Viet Nam, Brunei, Cambodia and Myanmar. The disease was also reported in the Philippines in 2000, and in Iran in 2002 (Lio-Po and Leaño, 2016). WSD is one of the reasons of the collapse of *P. monodon* culture in some major shrimp producing countries in the region (e.g. Taiwan, Indonesia, Thailand) and still considered at present as the most important disease problem in the culture of penaeids.

For economic impacts of WSD, it was reported that after the first outbreak in China in 1992, shrimp production was reduced by 70% resulting in losses of over US$2 billion (Bir et al., 2017). In the same year, Indonesia started to lose shrimp production and in the span of 10 years, production losses were roughly around US$1 billion. In Thailand, the shrimp industry incurred losses of US$1.6 billion in 1994, and by 1997, losses due to WSD was recorded at US$600 million (Flegel, 1998). Overall, total losses of shrimp production due to WSD were estimated to be at US$13 billion (Lio-Po and Leaño, 2016).

Infection with Infectious Myonecrosis Virus (IMNV)

This disease is considered as the current threat in the culture of *P. vannamei* in the region. Originally reported in Brazil, the first outbreak in Asia was reported in Indonesia (East Java) in 2006 (Senapin et al., 2007), and was contained in this area for some time until it started to spread rapidly to other shrimp producing provinces of the country. By April 2007, it reached northeast Sumatra, and by the third quarter of 2009, arrived in ponds in West Kalimantan and Sulawesi (Thong, 2013). In 2016-2017, the disease was reported in India in the shrimp-producing provinces of West Bengal and Tamil Nadu (Sahul Hameed, et al., 2017; NACA, OIE and FAO, 2017).

Shrimps affected by the disease exhibit white necrotic areas in striated muscles, especially at the distal abdominal segment, which become reddened in some affected shrimps. The disease can cause high production losses as mortalities can be instantaneously high (40-70%) and continue for several days after the onset of infection. Reported production loss due to IMNV from 2002 to 2011

(Brazil and Indonesia) was more than US$1 billion. Brazil, Indonesia and India (countries affected by the disease) produce 27% of global shrimp production (Tang, 2016).

Acute Hepatopancreatic Necrosis Disease (AHPND)

Acute Hepatopnacreatic Necrosis Disease is a recent disease problem of cultured shrimps that cause unusually heavy mortality approximately within the first 35-40 days of culture. It was first reported in China in 2009, then in Viet Nam in 2010, Malaysia in 2011, Thailand in 2012 (Flegel, 2012; Leaño and Mohan, 2012a; Joshi et al., 2014), Mexico in 2013 (Nunan et al., 2014; Gomez-Gil et al., 2014) and the Philippines in 2014 (NACA-FAO 2015; Dabu et al., 2015; dela Peña et al., 2015). The disease is caused by a highly pathogenic strain of *Vibrio parahaemolyticus* (Tran et al., 2013) that have acquired a "selfish plasmid" encoding the deadly binary toxins PirAvp/PirBvp (Li et al., 2017), and has caused significant economic losses among cultured *P. monodon* and *P. vannamei* in the affected countries.

The spread of the disease was attributed to trading of live postlarvae and non-SPF broodstock, and trading/movement of live polychaetes as natural food for shrimp broodstock (live polychaetes was found to harbor AHPND *V. parahaemolyticus*) (NACA, 2015). The further spread of the disease to other shrimp-producing countries in the region, however, was significantly prevented through early warning and efficient dissemination of information (Leaño and Mohan, 2012b). Economic losses for Thailand due to AHPND from 2011 up to the present is roughly US$7.38 billion, while in Viet Nam's Mekong Delta, AHPND in 2015 caused losses of US$8.9 million in whiteleg shrimp and US$1.8 million in tiger shrimp (Towers, 2016).

Response to major disease outbreaks in the region: A retrospect

If we look back on how the region responded to some of the major aquatic animal disease outbreaks, it can be seen that they are generally chaotic due to the lack or emergency preparedness strategies when such disease emergencies emerged. Summarized below are some of the disease events that happened in the past, and how the region responded:

Infection with *Aphanomyces invadans* (EUS)

The disease was first reported in Singapore in 1977 and rapidly spread to other countries in the region from 1981 to 1990. Most of the ASEAN member countries were not prepared enough for such emergency epizootic, especially with the rapid spread of the disease. This was coupled with the time required to single-out the main pathogen involved which was responsible for the wide and rapid spread of the disease. Overall, response of the region in dealing with this disease was a total mess.

Koi Herpes Virus Disease (KHV)

After the region's previous experiences with EUS and WSD, the first reported outbreaks in the region immediately alerted the major koi- and common carp-producing countries. Despite some concerted efforts to prevent the disease, several countries were not spared. Significant achievements, however, were made by some countries in prevention of further spread and/or eradication of the disease (e.g. Thailand). Improved preventive measures including biosecurity and quarantine also prevented the wider spread of the disease in some countries. Although some countries are prepared for such emergencies, the disease still created panic before any necessary preventive measures were implemented.

Acute Hepatopancreatic Necrosis Disease (AHPND)

Considering the experiences and improving response of the region in dealing with disease emergencies, and despite the availability of modern diagnostic tools for identification of shrimp diseases, the region was again caught off-guard by the occurrence of this disease. Efforts made to identify the main causative agent were not well-coordinated, especially in hardly-hit countries (e.g. Viet Nam), causing a lot of confusions on what preventive and control measures to be applied in affected farms. However, emergency actions of international

and regional organizations (FAO, OIE, NACA), including wider dissemination of information and advisories prompted several shrimp-producing countries to apply strict biosecurity measures (e.g. Indonesia) to prevent the entry of the disease. Although a significant improvement in emergency preparedness and response by several countries in the region, AHPND still created chaos before appropriate preventive measures and strategies were put into place.

New and emerging diseases: Emergency preparedness and response

Recent outbreaks of new/emerging diseases has again tested how prepared the countries in the region are in responding to such emergencies. The emergence of Tilapia lake virus (TiLV) as an example, clearly showed the capacity of the region to respond, which can be largely due to the previous experiences in dealing with disease epizootics (as mentioned above). TiLV was first reported in the region by Thailand (early 2017) and Chinese Taipei (mid-2017); followed by Malaysia, India and the Philippines in the 3rd quarter 2017 (Dong et al., 2017a; Surachetpong et al., 2017; Yang et al, 2017; Amal et al., 2018; NACA, OIE and FAO, 2017). A local publication also confirmed the presence of TiLV in Indonesia (Koesharyani et al., 2018). The responsible pathogen, however, was already identified from the previous outbreaks in Africa and South America (Eyngor et al., 2014; Ferguson et al., 2014; Bacharach et al., 2016; Tsofack et al., 2016; Del-Pozo et al., 2017; Fathi et al., 2017) when the disease was confirmed to be present in the region, and molecular diagnostic methods were available or immediately developed/improved (Dong et al., 2017b). In response to this, many countries in the region undertook active surveillance for the presence or absence of the virus/disease. Some countries also took precautionary measures of banning importation of tilapia from TiLV-confirmed countries.

TiLV was immediately listed in the NACA-FAO-OIE Quarterly Aquatic Animal Disease (QAAD) reporting system to monitor the prevalence of the disease in the region. Moreover, an emergency regional consultation was undertaken a few months after the first report of the disease in the region (NACA, NFTEC, China-ASEAN CJRPMAT and SYU, 2018). This was organized by NACA and the Ministry of Agriculture (MOA), PR China and attended by experts from around the world and participants from major tilapia-producing countries in the region. An intensive training of TiLV diagnostics was undertaken more than a year after the first report of the disease, organized by FAO and MOA (FAO, 2018b). Overall, a much better disease preparedness and response can be seen in the region in dealing with this recent disease emergency. And while there have been no scientific studies on the socio-economic impact of TiLV, it may pose a significant threat particularly to small-scale fish farmers' livelihoods and wild tilapine populations if left uncontrolled (Jansen et al., 2018).

The question still remains, is the region really prepared enough on how to respond to new and emerging aquatic animal disease problems? In the QAAD list for 2017 to 2019 reporting, the following diseases are considered to be the new threats in crustacean aquaculture:

- Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopeneai* (EHP)
- Viral Covert Mortality Disease of shrimps
- *Spiroplasma eriocheiris* infection in crayfish and freshwatrer prawn
- Infection with Shrimp haematocyte iridescent virus (SHIV)

These emerging diseases might spread in the region anytime, as we continue to trade live aquatic animals, as we continue to intensify culture systems, and as we continue to introduce new species for culture. It should be noted that once a disease is introduced into a country or area, it is often very hard to eradicate. However, it can be managed to prevent or at least minimize the impacts of the disease to the cultured stocks and to the industry. As we have shared water bodies and epidemiological link through trade (especially movement of live aquatic animals), a collaborative approach is necessary in dealing with such disease emergencies for effective aquatic animal health management, for improved disease monitoring, surveillance and reporting, and for effective disease preparedness and response system.

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