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Emerging diseases in shrimp culture: overview of viral and bacterial diseases in the Americas

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Abstract

The expansion of shrimp culture in the Americas has been historically limited by disease epidemics that caused severe production crashes. As intensive culture systems provide almost ideal conditions for the propagation of infectious diseases, the producers are constantly looking for means to manage diseases to minimize losses in production and quality. The most attractive options are exclusion or eradication, breeding for disease resistance and various sanitary measures. On the other hand, low market prices limits the resources invested in shrimp diagnostics and prevention. In this scenario, identification of new pathogens could be restricted to outbreaks with high mortalities, thus making shrimp producers more susceptible to the effect of shrimp pathogens. In this review, we analyzed the main shrimp diseases in the Americas.

Introduction

Due to the fact that shrimps have only recently been cultivated and only since the last three decades have cultivated populations been isolated from wild populations, most populations of cultivated shrimp have only had a relatively short period to evolve and adapt to intensive cultivated production systems. Diseases that remain at a low level of incidence in natural populations may reach epidemic levels in intensive cultivation systems. Modern intensive shrimp systems (with animals confined in tanks or ponds, with limited water exchange and with the cannibalistic behaviour of shrimp) provide almost ideal conditions for the outbreak of diseases. Also, other crustacean species, such as crabs or copepods, may be alternate hosts of shrimp diseases. All these conditions favour epidemics and the appearance of apparently new diseases in intensive shrimp production systems (Cock et al. 2009).

In any population, disease emergence can occur by different mechanisms such as: i) evolution of pathogens; ii) introduction of existing pathogens or hosts to a new

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location with establishment and spread; and iii) simultaneous infection with two or more pathogens that affect the immune mechanisms of the host and produce an outbreak with a pathogen that otherwise would not have been so pathogenic.

In aquatic ecosystems, which are very complex, a clear distinction between health and disease in shrimp culture is not clear; survival is difficult to calculate during the cycle and low chronic mortalities are often not identified. Even during disease outbreaks, the underlying cause is often difficult to ascertain and in most cases, is usually the end result of a series of events involving environmental factors, health condition of the post-larvae, presence of an infectious agent and/or poor management practices.

Diagnostic information and procedures for shrimp diseases must include epidemiological and risk-analysis studies to identify, not only the pathogen and/or pathogens present, but also the conditions that lead to its prevalence and/or pathogenicity. However, many farmers are still only considering one major cause of disease; i.e. every event of mortality in the regions affected by white spot syndrome virus (WSSV) is attributed to the virus while other diseases are missed or underestimated. Effective management of the health of shrimps requires consideration of the fact that there is a balance between the host, pathogen and environment. Many shrimp pathogens are present in association with shrimp, or are present in their environment. With most pathogens of this type, the shrimp are apparently healthy and show normal growth. Often, conditions such as high stocking density, poor water quality, or under optimal oxygen levels induce stress in the shrimp, which can facilitate the outbreak of disease due to parasites or bacteria normally associated with shrimp.

Shrimp Diseases in America

The shrimp farming industry in the Americas has developed and emerged as one of the major aquaculture industries in the region. It has evolved from the initial stages, where shrimp producers relied almost entirely on the capture of wild post-larvae (PL) in estuaries and coastal areas, to the development of reproductive closed cycle and the establishment of several shrimp breeding programs. This has been done in an attempt to stabilize seed availability and improve disease resistance and growth rates of shrimp stocks.

Most countries in the region are concentrating on the production of specific pathogen resistant (SPR) or specific pathogen tolerant (SPT) shrimp, selecting the best surviving (but not necessarily disease-free) animals from pond grow-out facilities and growing them further in various facilities before transferring them to maturation systems. Due to the culture systems employed, with extensive non-lined ponds and no water treatment, the use of specific pathogen free (SPF) animals is not the preferred seed for pond stocking.

As in most of the producing regions in the Americas, diseases are still one of the major constraints for the growth of the shrimp industry. Diseases such as those caused by Taura syndrome virus (TSV) and WSSV have been significant threats and new viral and bacterial pathogens associated with management practices or environmental factors are emerging as new causes of concern for shrimp producers.

White Spot Syndrome Virus (WSSV)

One decade after its initial identification in the Americas, infection by WSSV is still considered to be the main cause of mortalities in shrimp farming along the Pacific coast of America, from Peru to Mexico and in the south of the Atlantic coast in Brazil. Average shrimp survival in WSSV affected regions is 35-50%. During the past year, several outbreaks of WSSV have been reported in Mexico, (Camara Nacional de Acuacultura: http://www.cna-ec.com/index.php?option=com_content&task=view&id=815&Itemid=31 accessed June 24 2009) Guatemala, Ecuador and the states of Santa Catarina and Bahia in Brazil (Muller et al. 2010). These outbreaks have been related to a decrease in the water temperature in the ponds, or are associated with the presence of other opportunistic pathogens such as *Vibrio* sp. WSSV has never been reported in the Atlantic Coast of Colombia and Venezuela, probably due to the higher water temperature in the Caribbean coast that impairs its replication (Reyes et al. 2007).

Breeding for resistance against WSSV has proven to be an elusive task, although there are reports of increased resistance in selected stocks from endemic areas such as Panama and Ecuador (Perez et al. 2001, Chamarro and Mialhe 2004). However, at present, a shrimp line resistant to WSSV is not yet identified. In addition, the negative correlation between shrimp growth and resistance to WSSV infection (Gitterle et al. 2005) makes the selection of animals even more difficult. For disease control, farmers rely on management practices such as low stocking densities, drying out the ponds during the cold season and in some cases, emergency harvest if mortalities are high.

Taura Syndrome Virus (TSV)

Taura syndrome virus (TSV), although considered to be a manageable disease responsive to breeding selection for resistance, has caused major losses to the shrimp industry in the Americas since its initial description in 1992. As with other RNA viruses, TSV exhibits high genetic variability. Variation in the nucleotide structure of the genes found in ORF2, especially of the genes coding for the nucleocapside protein CP2 or VP1, have been described in TSV isolates from different geographical regions: Mexico (Robles-Sikisaka et al. 2002), Belize (Erickson et al. 2005), Venezuela (Côté et al. 2008) and Colombia (Caraballo et al. 2007). It has also been demonstrated that some strains, such as the Belize strain, show higher degree of pathogenicity (Tang and Lightner 2005). At present, TSV is still prevalent in Belize, Colombia, Nicaragua, Panama and Venezuela.

Other Viruses

Infectious myonecrosis virus (IMNV) was initially identified in the State of Piaui (Brazil) in 2002 and by 2004 it had extended to almost all of the shrimp farms in the northern states (Piaui, north of Ceara and Rio Grande del Norte). At that time, mortality rates ranged from 35 to 55% in 12 g shrimp and the economic loss was estimated to be about US$20 million in 2003 (Nunes et al. 2004). In 2007, a study of IMNV prevalence identified 10% of samples as RT-PCR positive and 9 out of 11 evaluated farms had at least one animal positive for IMNV. However, in spite of the high prevalence of IMNV, shrimp survival has improved and is now at rates present before IMNV first appeared in Brazil. Brazilian farmers attribute the increase in survival to a higher resistance of the shrimps to the virus and to stress control in the shrimps and stability in the environmental conditions. In 2004, another virus that causes muscle necrosis, similar to IMNV, was identified in *Litopenaeus vannamei* in Belize in affected ponds that had a 50% reduction in production. Cloning and sequencing showed similarity with the *Macrobrachium rosenbergii* nodavirus (Tang et al. 2007). It was denominated *PvNv*. At the present, there are no confirmed reports of *PvNv* in other countries in Central or South America.

Bacterial Diseases

Bacterial diseases are one of the emerging disease threats in shrimp ponds in America. Problems ranging from mass mortalities to growth retardation and sporadic mortalities have been identified in almost every country and new species that affect *L. vannamei* have been described. While *Vibrio* spp. continue to be the most important bacterial pathogens of shrimp, with the increasing cases of septic diseases, new bacteria will be identified as potential shrimp pathogens.

Spiroplasma penaei: This intracellular bacterium was identified in 2003 in one farm in the Atlantic Coast of Colombia (Nunan et al. 2004). During the outbreak, mortalities in shrimp ponds ranged from 10-90%. Biosecurity measures applied since the identification of the pathogen prevented its spread to other farms, regions or countries. Management practices such as increasing the dry out time in ponds, managing soil bottom and decreasing stocking densities have been successful and since 2007, *S. penaei* has not been identified in any of the Colombian shrimp farms.

Necrotizing hepatopancreatitis (NHP) is still prevalent in America and has been reported in many countries (Peru, Colombia, Ecuador, Venezuela, Brazil, Panama, Mexico) with variable rates of mortalities in grow-out ponds and in maturation facilities. Outbreaks of pathogenic bacteria have been identified at increased frequency, especially in shrimp intensive ponds. In Venezuela, enteric and systemic bacterial infections are causing high mortalities in shrimp farms located in the Gulf of Maracaibo. In Colombia, *Vibrio harveyi* and other bacteria are responsible for a decrease in production in intensive shrimp ponds. Filamentous bacteria are highly prevalent in ponds stocked at high densities (45-70 animals$\cdot m^{-2}$) and in some cases, high levels of infestation can affect shrimp growth and survival.

Parasitic Diseases

Several endo and exo-parasites also affect shrimps at different stages of development. Protozoan genera, such as *Zoothamnium*, *Epistylis*, *Vorticella*, *Anophrys*, *Acineta*, *Lagenophrys* and *Ephelota*, are present in shrimp ponds throughout the region and are associated with low water quality. Although their pathogenicity is very low, at high levels of infection, these protozoa may induce gill obstruction (brown gill) leading to anorexia, retarded growth, reduced locomotion and increased susceptibility to infection by other viral or bacterial pathogens. Gregarines, endoparasitic protozoans, are found with different levels of severity, but are not usually associated with a decrease in productivity or survival.

Less known parasites, such as a haplosporidian described in Cuba in 1988, were found again a decade later in some ponds in Belize, where they were causing hepatopancreatic infections in cultured *L. vannamei* (Nunan et al. 2007). Other pathogenic organisms, such as microsporidia (*Agmasoma* sp. and *Ameson* sp.), are also endemic around the region but as in the case with endoparasitic protozoans are not usually associated with high mortalities or production losses.

Conclusion

Shrimp aquaculture, especially in extensive non-lined ponds, provides a suitable environment for the emergence, establishment and transmission of new pathogens. Diagnostic laboratories, preventive biosecurity measures and risk analyses are all needed to mitigate the risk of disease emergence, establishment and spread.

Studies of disease prevalence at different stages in shrimp culture are useful to identify the pathogens that are, or could be, a potential cause of disease out-breaks. Shrimp farmers need to be aware of the effect of non-optimal conditions in the shrimp susceptibility to pathogens and need to manage the ponds accordingly to reduce the risk of diseases.

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