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Pale Shrimp Disease: An Emerging Bacterial Threat to Shrimp Aquaculture

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Introduction:

Shrimp farming plays a vital role in ensuring food security, employment and economic development worldwide. Among cultured shrimp species, the Pacific white shrimp dominates global production due to its rapid growth, high stocking density tolerance and adaptability to diverse farming conditions. In India, *L. vannamei* constitutes the backbone of the shrimp aquaculture industry, contributing substantially to seafood exports and the national economy (Salunke et al., 2020). Despite remarkable advances in farming practices, the sustainability and profitability of shrimp production continue to be severely constrained by infectious diseases caused by viruses, bacteria, fungi and parasites, resulting in significant production losses worldwide. In recent years, the emergence of bacterial diseases has become a *major concern for the shrimp farming industry* because of their rapid spread and substantial economic impact. One such emerging bacterial disease is Pale Shrimp Disease (PSD). The disease was first recognized in commercial low-salinity shrimp farming systems in Surat Thani Province, southern Thailand, where outbreaks have been reported since 2022. Local farmers commonly refer to the condition as "Pale Shrimp Disease" or "Pale Body Disease" (Chuchird et al., 2024).

Causative agent:

Initially identified based on its characteristic clinical appearance, the causative agent was subsequently confirmed as *Photobacterium damselae* subsp. *damselae* (PDD), an opportunistic marine bacterial pathogen. It is a Gram-negative, halophilic, facultatively anaerobic bacterium belonging to the family Vibrionaceae. The bacterium was originally isolated from skin lesions of the blacksmith fish (*Chromis punctipinnis*) and was initially designated as *Vibrio damsela*. Following detailed genetic and phenotypic characterization, it was reclassified in 1995 as *Photobacterium damselae* subsp. *damselae*. Since then, PDD has been recognized as an important pathogen of numerous marine animals, including mollusks, sharks, sea turtles, dolphins, whales, and a wide variety of cultured fish species such as gilthead seabream (*Sparus aurata*), turbot (*Scophthalmus maximus*), eel (*Anguilla* spp.), rainbow trout

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(*Oncorhynchus mykiss*), and ovate pompano (*Trachinotus ovatus*). Its broad host range and increasing incidence have established PDD as an emerging bacterial pathogen of marine aquaculture. The pathogenicity of PDD is primarily attributed to the production of potent extracellular virulence factors. Its major toxins include the pore-forming hemolysins damselysin (Dly), phobalysin P (PhlyP), and phobalysin C (PhlyC), which cause extensive hemolysis and cytotoxicity. Damselysin also possesses phospholipase activity that contributes to membrane disruption and tissue damage. The combined action of these toxins results in severe cellular injury, muscle necrosis, and destruction of internal organs (Alolod et al., 2024).

observed in affected Pacific white shrimp. Affected shrimp frequently exhibit a pale hepatopancreas and an empty or poorly filled gut, suggesting reduced feed intake and impaired digestive function. Diseased shrimp may also show lethargy, reduced swimming activity and decreased growth performance, particularly during severe outbreaks.

Figure. PSD infected shrimp (left) and healthy shrimp (right)

Reports of PDD incidence:

Host species	**Country**	**Reference**
Black tiger shrimp (*Penaeus monodon*)	Taiwan	Song et al. (1993)
Indian white shrimp (*Penaeus indicus*)	India	Vaseeharan et al. (2007)
Ridgetail white prawn (*Exopalaemon carinicauda*)	China	Liu et al. (2016)
Pacific white shrimp (*L. vannamei*)	India	Singaravel et al. (2020)
Pacific white shrimp (*L. vannamei*)	China	Wang et al. (2020)
Kuruma shrimp (*Penaeus japonicus*)	Japan	Alolod et al. (2024)
Pacific white shrimp (*L. vannamei*)	China	Chuchird et al. (2024)

Clinical signs:

Pale Shrimp Disease (PSD) is characterized by a distinctive uniformly pale body coloration, which represents the most prominent and consistent gross clinical sign

Histopathological Changes

Histopathological examination of naturally infected and experimentally challenged shrimp has demonstrated that the most consistent lesions occur in the hepatopancreas. The hepatopancreas exhibits degeneration and necrosis of the hepatopancreatic tubules, epithelial cell sloughing, tubular atrophy and varying degrees of inflammatory cell infiltration. These alterations impair digestive and metabolic functions, contributing to the pale appearance and poor nutritional status of affected shrimp. Severe muscle necrosis is another hallmark lesion of Pale Shrimp Disease. Histologically, muscle fibres show degeneration, fragmentation, hyalinization, coagulative necrosis and loss of normal tissue architecture. In advanced infections, extensive destruction of muscle tissue may be accompanied by bacterial colonization and hemocytic infiltration (Singaravel et al., 2020).

Epizootiology

The epizootiology of Pale Shrimp Disease (PSD) is still being elucidated because of its recent emergence. Current evidence suggests that natural transmission occurs primarily through the oral route, with shrimp becoming infected by ingesting PDD contaminated feed, water, detritus, or infected carcasses. Horizontal transmission within culture ponds is therefore considered the principal mechanism for disease spread. Environmental factors, particularly salinity, appear to influence the occurrence of disease outbreaks. The predominance of PSD in low-salinity culture systems suggests that reduced salinity may favour pathogen persistence, increase host susceptibility, or alter host–pathogen interactions. However, the precise role of salinity in disease development and transmission has not yet been fully established.

Impact:

During disease outbreaks, the initial cumulative mortality typically ranges from 20–30%, but under severe conditions mortality may increase rapidly, reaching up to 100% if appropriate control measures are not implemented (Alolod et al, 2024). Such extensive losses can severely affect production efficiency and farm profitability. In addition to mortality, surviving shrimp frequently exhibit a persistent pale body coloration, which markedly reduces their commercial appeal and consumer acceptance.

Conclusion:

Pale Shrimp Disease (PSD) has recently emerged as a significant bacterial disease threatening the sustainability of shrimp aquaculture. The emergence highlights the dynamic nature of bacterial diseases in intensive shrimp aquaculture and emphasizes the continuous need for effective health management practices. As a recently recognized disease, significant knowledge gaps remain regarding its epidemiology, environmental drivers, host susceptibility, and long-term impacts on shrimp production. Strengthening disease surveillance, adopting robust biosecurity measures, and implementing routine pathogen monitoring will be essential for early detection and containment of outbreaks. uture research should focus on elucidating the molecular mechanisms of pathogenicity, identifying risk factors associated with disease emergence, and developing rapid diagnostic tools and effective preventive strategies.

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