

Microbiome of shrimp : Composition and Significance

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Introduction

Due to the rising worldwide population and market demand, aquaculture must evolve to meet the growing requirement and desire for aquatic-based protein. Because of its economic importance, the shrimp industry has been regarded as one of the aquaculture systems with the quickest growth rate in recent decades. There has been an increasing effort to enhance aquaculture practices to boost the production of raised shrimp. However, numerous infections and a variety of environmental stressors have placed shrimp in threat in high-density shrimp farming, leading to significant differences in shrimp survival rates. Hence, comprehending the primary environmental and managerial elements that impact shrimp health could aid worldwide endeavors to advance sustainable shrimp aquaculture (Xiong et al. 2017). The ability of the host to live, grow, and develop is closely related to the creation of a unique intestinal microecosystem by the host's microbiota. Under normal conditions, shrimp intestinal microbiota maintains a state of dynamic balance to maintain the gut's regular physiological functioning. A category of microbial species specific to a given ecosystem is called a "microbiome" (Li et al., 2018). Shrimp has high diversity and dynamic composition of gut microbiota including Proteobacteria, Bacteroidetes, and Actinobacteria. There is a high correlation between the development of shrimp intestinal microbiota and environmental changes and, subsequently, the health status of shrimp. This correlation seems to be highly plasticity, even over short-term timescales (Huang et al., 2016). The changes in aquaculture ecosystem across age, environment, diet, and diseases or the exposure to new habitat has a significant impact on composition of shrimp microbiota. This article summarizes the methods of shrimp aquaculture and the effects of ecological factors (e.g. dietary manipulation, age, physiological development, and other environmental factors) on gut microbiota composition and the intervention approaches to modulate the intestinal microbial composition.

Shrimp Microbiome

Most research on the microbiome of aquatic species, like shrimp, has found that their microbial communities vary

significantly from those of terrestrial animals. Xiong et al. (2017) stated that instead of Firmicutes and Bacteroides, Proteobacteria dominates aquatic animals. Although Firmicutes, Bacteroides, and Actinobacteria are all secondary contributors to the shrimp microbiome, they are highly affected by both diet and environment (Li et al. 2018) as well as cultivation regions (Cheng et al., 2021). The microbiome is altered by many things, such as changes in the environment, the stages of development, and overall health. All previous changes could happen by selection, drifting, diversification, dispersion, or mutation. The process by which species in the surrounding environment are ingested by the shrimp's digestive tract is called selection (Li et al., 2018). The gut microbiota of wild shrimp can be compared to the microbiota of a shrimp elevated in a pond to determine the diversity of microbiota in the population. Cornejo-Granados et al. (2017) stated that pond-raised shrimp microbiomes have a lower diversity because pond sediment and water do not have the diversity found in natural environments. Bacteria migrate to new areas and occupy niches, evolving or mutating to improve their place in the ecosystem. Due to the constant contact of the environment, feed, and shrimp gut, dispersion is typically limited in the guts of aquatic species. Because both the host and symbiont benefit from a relationship of mutualism, the microbiome evolves to form such an association. Li et al. (2018) noticed that the three primary probiotic bacterial genera in the gut microbiome of shrimp are 1% for *Lactobacillus*, 0.93% for *Streptococcus*, and 0.37% for *Bacillus* spp. helped boost immunity in the species of shrimp known as *P. japonicas*, whereas the same bacterium in the species of shrimp known as *L. vannamei* boosted growth by making nutrients more digestible. Despite their constant presence in the microbiome, opportunistic pathogens are usually only found at low levels, and they remain harmless unless culturing conditions change. The most pathogenic shrimp bacteria belong to the family Enterobacteriaceae, such as *Flavobacterium*, *Escherichia*, *Pseudomonas*, *Shewanella*, *Rickettsia*, *Vibrio*, *Aeromonas*, and *Desulfovibrio*.

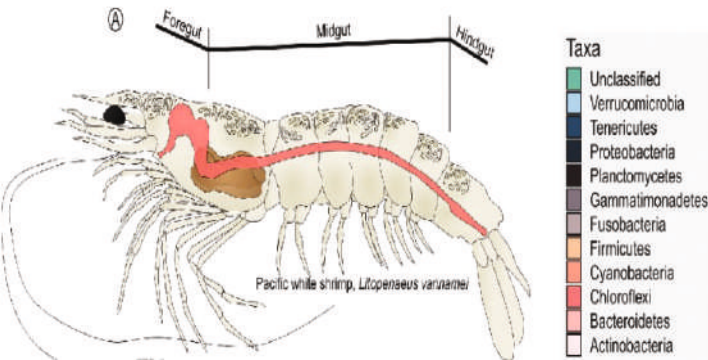
Microbiome of different organs of shrimps

1. Intestine microbiota

There were notable differences in the intestinal bacterial abundance between shrimps impacted by WFS and those that were not. In healthy shrimps, *Candidatus Bacilloplasma*, *Photobacterium*, *Pirellula*, *Rhodobacter*, and *Lactococcus* are prevalent at the genus level. The intestinal microbiota is closely linked to the state of health of the host. An increasing number of research have overlooked abiotic factors in favor of evaluating the effects of biotic factors on the host intestinal microbiota. In the majority of the samples, *Proteobacteria* and *Cyanobacteria* were the most prevalent phyla. Over half of all readings belonging to *Vibrionaceae* and *Enterobacteriaceae*, these were the most prevalent. The communities were abundant in *Vibrio*, *Photobacterium*, and *Paracoccus* at the genus level. More than 70% of the sequences isolated from the guts of wild-caught and domesticated *P. monodon* have been reported to belong to this class, primarily consisting of *Vibrio* and *Photobacterium* spp. The remaining classified sequences have been assigned to other high-level taxa, including *Firmicutes*, *Bacteroidetes*, *Fusobacteria*, and *Actinobacteria* (Rungrassamee et al., 2014). Numerous *Vibrio* species generate chitinolytic enzymes which could account for their prevalence in an environment high in chitin, such as the intestine of crustaceans, by offering a specialized substrate for their use.

2. Hepatopancreas microbiota

According to diversity indices, the bacterial diversity in healthy intestines was higher than in hepatopancreas. When compared to healthy farmed shrimp, the hepatopancreas from shrimp exhibited a considerably higher diversity of bacteria. The *Enterobacteriaceae* family accounted for 44% and 70% of the total cultured derived sequences, respectively, while the *Proteobacteria* phylum was the most prevalent. In samples, the *Vibrionaceae*, *Moraxellaceae*, and *Pseudomonadaceae* families accounted for 27, 12, and 1% of all reads, respectively; in cultivated samples, these families accounted for 7, 0.5, and 19% of all reads. In samples, the most abundant genus was *Photobacterium* (16%), followed by *Acinetobacter* 12% and *Vibrio* 8% (García-López et al., 2020).



Factors influencing microbiota structure

The composition of the gut microbiota of shrimp can be modulated with several factors such as diet composition, diet protein and fat sources, water salinity, light intensity, stock density, water temperature, microbial diversity of culture water, and indoor- vs pond-based culture. Moreover, shrimp gut microbiota has a remarkable plasticity to be altered with the environmental changes. The gut microbiome's impact on age and physiological factors days after hatching, the live feed supplied is the main factor in creating the shrimp's gut microbiota Li et al. (2018). *Actinobacteria*, *Proteobacteria*, and *Bacteroidetes* comprise the majority of the gut bacterial community at this point. The microbiome's makeup changes during developmental stages from being diverse to homogeneous, as suggested by Xiong et al. (2018) that although the microbiome may vary depending on diet, the host's developmental physiology is crucial to the microbiome's development and that changes in the normal microbiome may signal the advancement of disease.

Effects of nutrition on the gut microbiota Healthy digestion depends on gut microbiomes that can break down macro and micronutrients (Huang et al. 2016). Malnutrition and failure to thrive can happen if the gut microbiome is not formed, according to Xiong et al. (2018). Shrimp are pretty susceptible to illness once they are malnourished. Understanding shrimp nutrition requires an understanding of the microbiota and how it interacts with the food that shrimp are fed. The amount of fat, protein, and copper in the diet all have a significant impact on gut flora. This has occurred in the previous few decades as a result of humans switching from expensive and scarce animal-sourced nutrients to widely accessible and inexpensive plant-sourced nutrients (Huang et al., 2016; Li et al., 2018). Plant protein sources typically have higher carb counts than animal protein sources. Due to a small amount of *Bacteroidetes* in the microbiome that metabolize carbs, prawns are genetically predisposed to have difficulty digesting carbohydrates (Li et al., 2018). The microbiota of cultured prawns fed these kinds of diets quickly adapted to the rise in carbohydrate content (Huang et al. 2016). Furthermore, improving the C:N ratio of aqua feed is crucial for the growth and development of prawn gut microbiota, as well as for their overall health and growth.

Variations in the content and organisation of the bacterial community in shrimp culture suggest that various environmental conditions may have a substantial effect on the structure of the intestinal microflora of *L. vannamei*. Aquatic systems can introduce bacteria into the prawn gut by mixing them with sediments and water. More microorganisms are present in the marine environment where shrimps live than in the land. In pond sediment, prawn guts, and culture water, more than 90 different bacterial genera are frequently detected; the most similarity is seen between the stomach and sediment profiles (Li et al., 2018). The most numerous taxa in both the

guts of prawns and sediment are *Streptococcus*, *Lactobacillus*, and *Bacillus*. Global shrimp farmers have lately included the aforementioned genera as probiotics as a result of these findings. Changes in the environment are directly linked to the formation of gut microbiota in shrimp. Additionally, it seems to be quite adaptable to short-term alterations. It's possible that changes in the surrounding environment have also affected the gut microbiota. The shrimp-fish polyculture system, stocking density, water salinity hypoxia, exposure to other environmental stressors, and the rearing system water recirculation rate can all have an impact on the microbiota in both the shrimp gut and the culture water (Kuthoose et al., 2021).

Shrimp health and illness due to changes in the gut microbiota 89% of shrimp health issues are related to nutrition, and the higher carbohydrate and fibre content of commercial diets, which are absent from shrimp regimens, makes these issues worse. Due to their ability to use dietary fiber as a carbon source to synthesize short-chain fatty acids and hence improve gut health, Firmicutes have increased as a result of this dietary shift. Firmicutes, however, metabolize a lot of fiber sources poorly. It was discovered that effective commercial diets must strike a balance between physiological and nutritional requirements to preserve shrimp health. It has been shown that the *Pseudomonadaceae* and *Vibrionaceae* families had greater relative abundances of shrimp infected with the white spot syndrome virus than other families (Pilotto et al., 2018).

Conclusions

Due to the optimal use of land and water, intensifying prawn culture has increased profit margins and economic outcomes. Additionally, super-intensive systems, which are capable of producing more crops annually, have been shown to potentially yield higher financial returns. The shape and form of the shrimp intestinal microbiota are strongly influenced by the various types of shrimp farming systems. Shrimp's health and performance are significantly influenced by their gut microbiota, which also affects the host's resistance to disease and ability to survive environmental stressors. But, there is still a lot to learn about the gut microbiota of prawns, especially about its taxonomy and modulatory effects on intestinal microbiota. The connection between gut bacteria and the host immune system is well-characterized. Therefore, by inhibiting pathogen colonization and adherence to intestinal epithelium and by triggering immunological responses, the restoration of the gut microbiome helps to lessen the severity of disease. It is essential to investigate the factors that influence the gut microbiota in order to improve the health and performance of shrimp. Furthermore, in order to ascertain the effects of this relationship on shrimp health, more structural and functional study is necessary to comprehend the underlying processes of the significant link between gut microbiota and aquatic environmental parameters. Specific intervention strategies, like adding probiotics, prebiotics, and other food additives to the diet, have been shown

to significantly improve the gut microbiome's modification and shaping by increasing the relative abundances of beneficial bacteria and decreasing the number of pathogenic bacteria.

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