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Environmental factors affect immune response and resistance in crustaceans

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By Gilles Le Moullac

During the adaptation period, the susceptibility of shrimp to disease is often acute

There is increasing awareness that diseases in aquatic populations are often linked to environmental changes or pollution, which depress the immune system. Although these effects are well documented in cultured fish and mollusks, there have been few quantitative studies on the impact of environmental stressors on the immune system of shrimp.



Abrupt environmental changes often trigger disease episodes in shrimp.

Temperature

Water temperature is probably the most important environmental variable in shrimp culture, because it directly affects metabolism, oxygen consumption, growth, molting and survival. In general, a sudden change of temperature affects the shrimp immune system, which can be critical if the timing coincides with the presence of a pathogen.

Lower temperature can induce a decrease in the number of circulating hemocytes and their phagocytic capability, as measured by their oxidative metabolism. A temperature increase can increase circulating hemocytes and plasmatic protein, but decrease total hemocytic prophenoloxidase.

An example of the effect of temperature comes from New Caledonia, where two well-defined seasons exist. The decrease of temperature in ponds from 27 to 18 degrees-C results in high mortalities. Mortalities are also recorded when temperature increases (Fig. 1).

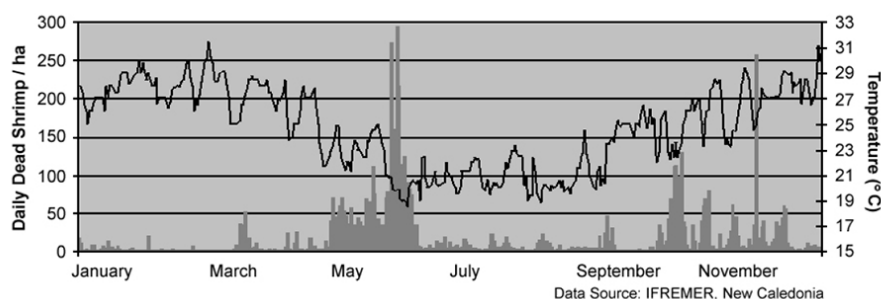


Fig. 1: In New Caledonia, mortality of shrimp (grey bars) is correlated with abrupt temperature changes in May-June and October-November.

There are two types of temperature changes in New Caledonia: long-term variations, which correspond to seasonal changes, and short-term variations, which correspond to circadian and meteorological changes. Longterm studies have shown there is no difference in circulating hemocyte concentration in shrimp between the two seasons in New Caledonia, but it appears from experimental data that the oxidative metabolism of hemocytes is affected at low temperatures.

Salinity

Salinity has relatively little effect on the metabolic rate of euryhaline shrimp, indicating the energy required for osmotic regulation may be relatively low. However, when the health of shrimp is impaired, such as during viral infection, the stress induced by high salinity enhances growth retardation produced by the infection. Lasting and significant differences in hemocyte number are recorded in shrimp subjected to low salinity.

Oxygen

Low oxygen tension hampers metabolic performance in shrimp, and can reduce growth and molting, and cause mortality. In a study with penaeid shrimp, hypoxia induced a significant decrease in immunocompetence. The phagocytic activity of hemocytes was less efficient (about 50 percent) in shrimp under depleted oxygen conditions. Thus, low oxygen levels in pond water lead to an increased susceptibility to infectious disease.

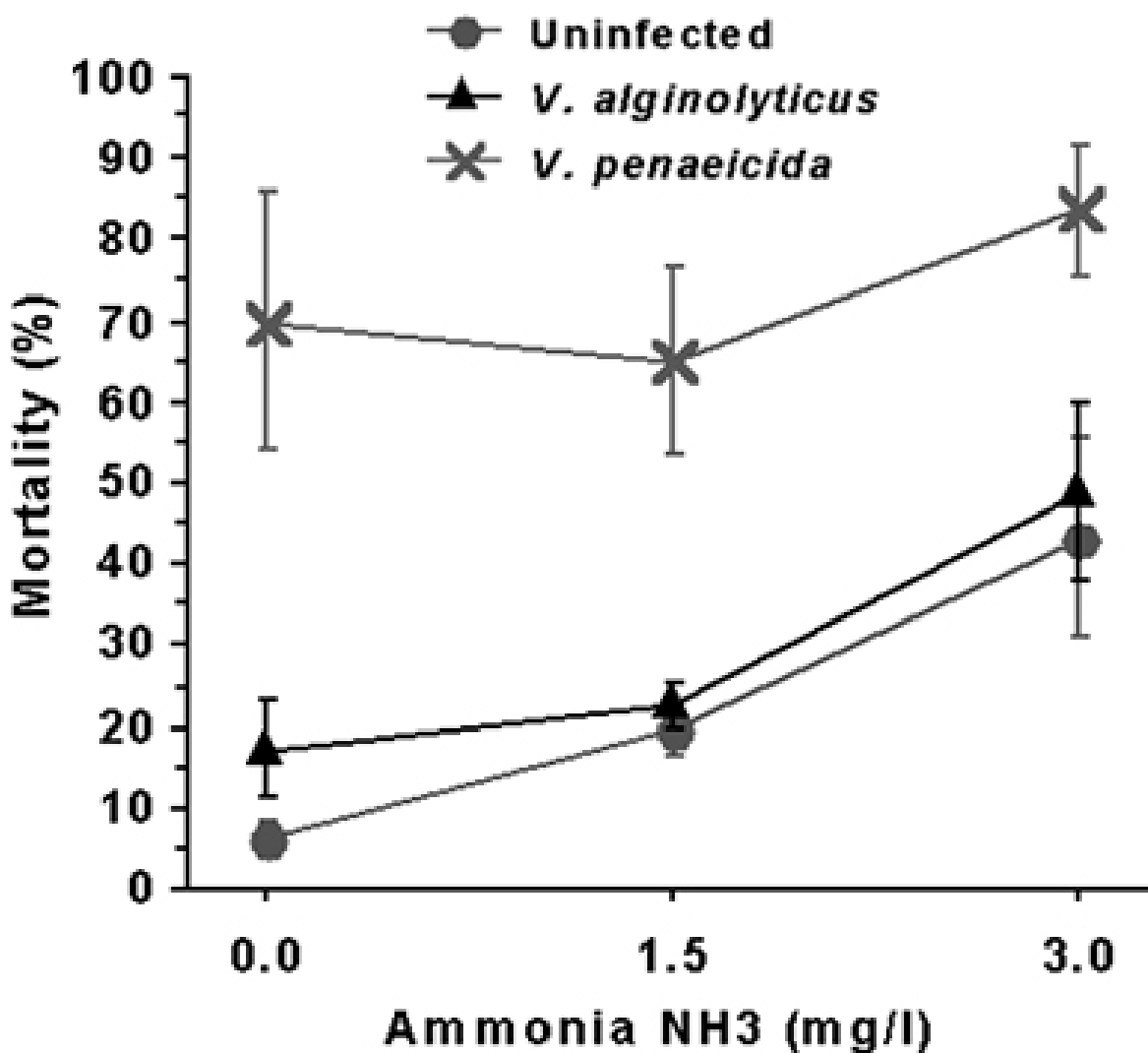


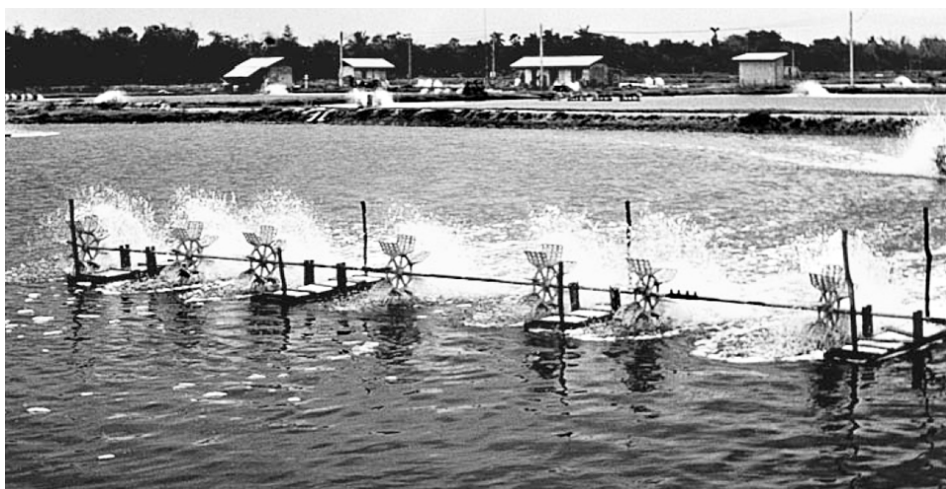
Figure 2. Additive effect of ammonia toxicity and infection on health. Shrimp infected with *V. alginolyticus* are lightly but significantly more sensitive to ammonia than uninfected shrimp.

Ammonia

In intensive culture systems, toxic levels of ammonia can accumulate due to excretion by cultured animals and deamination of protein in unconsumed feed. Lethal and sub-lethal effects of ammonia on shrimp have been well studied. However, until recently, relatively little was known about the effect of ammonia on the crustacean immune system. Recent studies in penaeid shrimp have shown that ammonia significantly affects immune response.

The sensitivity of the shrimp immune system to ammonia is dose-dependent. High ammonia levels diminish hematopoietic tissue activity, oxidative metabolism of hemocytes, and expression of genes implicated in the shrimp defense system. Shrimp suffer acute mortality with highly virulent bacteria such as *Vibrio tenacida*. Lower levels of mortality caused by *V. alginolyticus* are slightly but significantly increased by ammonia toxicity (Fig. 2).

Pollutants



Aeration is critical in intensive ponds to avoid stress due to hypoxia.

Pollutants are an important factor in the reduction of immunocompetence in crustaceans. Shrimp are sensitive to many pollutants, including dredge spoil containing polychlorinated biphenyls (PCBs), polynuclear aromatic hydrocarbons (PAHs), heavy metals and pesticides. In Ecuador, a banana fungicide is widely used in agricultural areas close to the shrimp farm areas. *In vitro* and *in vivo* trials have shown the long-term, dose-dependent immuno-depressant character of this fungicide on the oxidative metabolism in hemocytes in *L. vannamei* shrimp.

Conclusion

Environmental stresses affect the immune system of shrimp in a dosedependent way, increasing susceptibility to disease. The animals require time to adapt to the new environmental conditions. During the adaptation period, the susceptibility of shrimp to disease is often acute.

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Author



GILLES LE MOULLAC

IFREMER
Centre Océanologique du Pacifique
Laboratoire d'Aquaculture Tropicale
Taravao, Tahiti, Polynésie Française

gilles.le.moullac@ifremer.fr (mailto:gilles.le.moullac@ifremer.fr)

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