Sediment Quality Affects Shrimp Physiology in New Caledonia Research

Aerial view of a semi-intensive shrimp farm in New Caledonia.

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The soil quality of production pond bottoms has long been recognized as a factor that influences pond water quality and aquatic animal production. Pond bottom conditions are particularly critical for shrimp, which spend most of their time on the bottom, burrow into the soil, and even ingest soil particles during feeding.

In general, uneaten feed, feces, plankton, and debris settle in patterns throughout pond bottoms. This settling pattern can be affected by pond depth and water circulation. These factors introduce a high degree of spatial variability into soil parameters that is seldom considered in soil quality studies.

Osmotic Pressure

Haemolymph osmotic pressure has been proposed as a parameter for the evaluation of the physiological state of penaeid shrimp, as it is influenced by a large variety of environmental parameters. It can be a convenient tool to detect areas of rearing ponds where sediments are degraded and potentially harmful to shrimp.

Field Experiment

The authors' recent study, conducted in an experimental semi-intensive shrimp pond in New Caledonia, evaluated the stress caused by sediment on shrimp held in bottom cages at different points of a pond and correlated the levels of stress with various sediment parameters.

Thirty shrimp with an average weight of about 13.2 g were placed in 100- x 50- x 15-cm cages in 12 stations on the bottom of a 1-ha pond. After 24 hours, samples of haemolymph from animals in intermolt stage were collected for osmotic pressure measurement.

The experiment was repeated four times. Each time, two groups of free-ranging shrimp of the same pond were sampled and used as controls. Simultaneously, sediment samples were collected and analyzed to evaluate some physicochemical parameters that could be related to the stress observed in the shrimp maintained in the cages.

The redox potential and pH of pore water of the first centimeter of pond bottom sediment were assessed in situ. Sediment samples of the top 1 cm were collected at each station and analyzed for water content, loss of weight, and total ammonia nitrogen (TAN) in the pore water.

Laboratory Experiment

A laboratory test was carried out twice in six closed 70-l tanks. Eight shrimp were placed in each tank for 24 hours. Five pH levels of 6.0-8.0 were tested. After a 24-hour exposure to different pH levels, shrimp haemolymph samples were collected for osmotic pressure measurements.

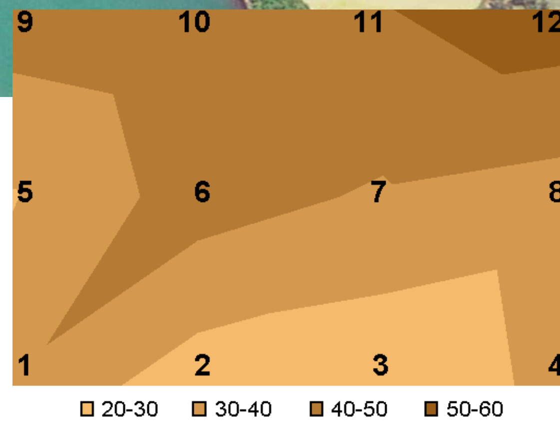

Figure 1. *Effect of level of cages on haemolymph osmotic pressure in pond. Values correspond to the difference between pressure in the cage and that of free shrimp.*

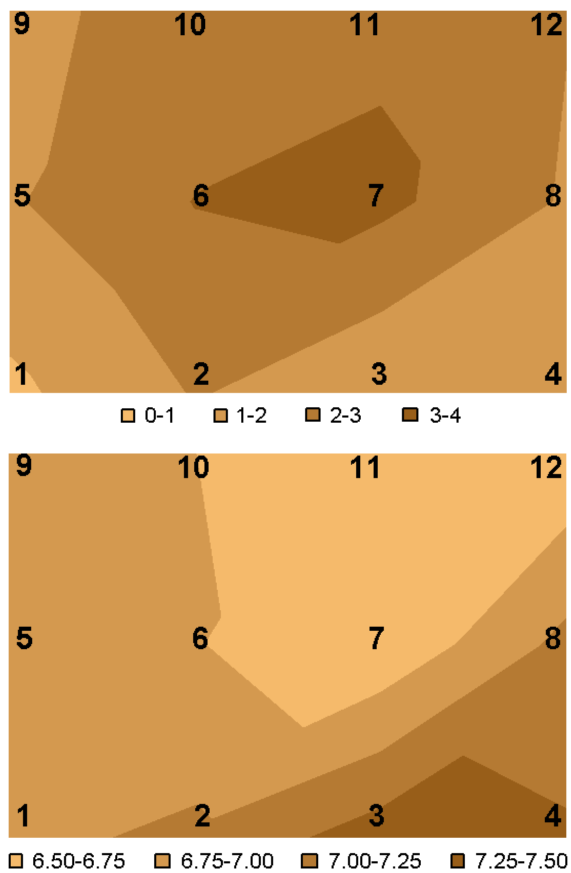

Figure 2. *Schematic representation of physicochemical variables of pond sediment. Top: Total ammonia nitrogen. Bottom: PH.*

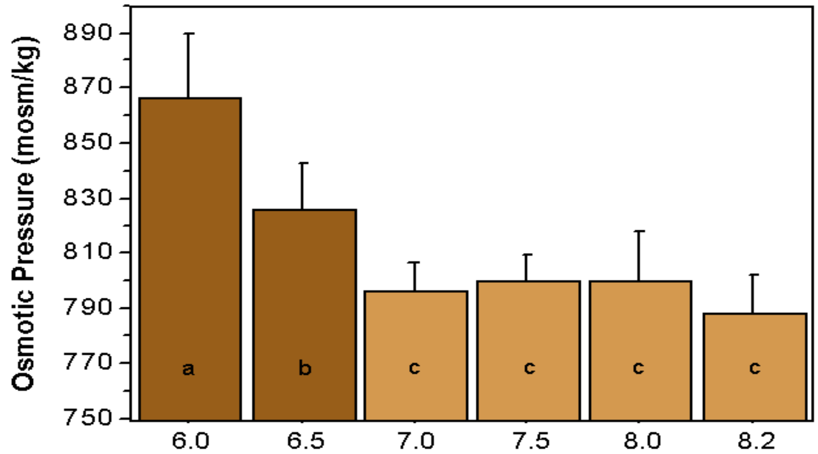

Figure 3. *Effect of pH on shrimp osmotic pressure in tank experiments. Means indicated by the same letter do not differ at p = 0.01. Bars represent standard deviation.*

In seawater, an increase of osmotic pressure indicates a dysfunction in osmoregulation associated with various stressors.

Results

In seawater, an increase of osmotic pressure indicates a dysfunction in osmoregulation associated with various stressors. Figure 1 is a schematic presentation of mean osmotic pressure in each cage in relation to the station. In some areas of the test pond, captive shrimp showed an increase of osmotic pressure.

Figure 2 is a schematic presentation of pond sediment parameters. The sediment loss of weight by combustion was most important in stations 1, 2, and 4, which were characterized by sediment with higher water content. TAN concentration was maximum in the center of the pond.

The lowest redox and highest pH values were found in stations 3 and 4, located in the deepest areas of the pond. The most significant correlation was between sediment pH and osmotic pressure of the captive shrimp.

Postexperiment laboratory analyses (Figure 3) showed that low pH led to an increase of osmotic pressure. This increase seemed to be correlated to a pH range of 6.0-7.0, supporting the field test observations. Osmotic pressure of captive shrimp is directly related to the acidity of sediment.

Conclusion

Studies of shrimp held in cages on a pond bottom showed a spatial variability in the animals' physiology related to the locations of the cages. The most significant correlation was between sediment pH and osmotic pressure of captive animals. Extreme values of pH are known stress factors for crustaceans, and postexperiment laboratory checks showed that low pH led to an osmotic pressure increase.