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Public health aspects: Molluscs as food

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Public Health Aspects

Bivalves such as the green mussel *Perna* are mostly cultured in coastal and estuarine areas and may thus be exposed to industrial waste and sewerage discharges. Studies on European mussels have shown their high tolerance to a wide range of environmental contaminants and their ability to accumulate pollutants from the environment. To not only ensure the wholesomeness of the product but also assist in the choice of sites for farming the mussels, there is a clear need to monitor heavy metals and other possible pollutants in prospective or existing culture areas. Depuration techniques are extensively studied in connection with European mussel industries but so far have received little attention in tropical regions.

Bacterial contamination

The presence of bacterial and viral pathogens is usually the consequence of sewage pollution. The level of pollution is often closely related to the discharge of freshwater from land. This makes it in some cases mandatory to develop guidelines to restrict harvesting of mussels following periods of heavy rainfall. Contamination with bacterial and viral pathogens presents a major risk to the consumer, especially when the mussels are eaten raw or only lightly cooked. Viral infection from eating oysters leading to infective hepatitis has been well documented. Lack of awareness of the possible linkage between human fatalities and the consumption of mussels might be the primary reason that so far no reports exist on bacterial disease transmitted through consumption of any of the *Perna* species.

Depuration of mussels is recommended when they are to be eaten raw or semi-cooked. Studies in Singapore showed promising results when highly polluted mussels, stocked at a density of 100 kg/m^3 water in a recirculating seawater system, were depurated to acceptable limits (<20 MPN *Escherichia coli*/g flesh) within 48 h. The water was sterilized by means of ultraviolet radiation. Waterflow was maintained at 3 m^3/h, with complete replacement of water after 24 h. Other researchers evaluated the organoleptic properties of *P. viridis* depurated in stagnant water and sucrose solution (200 ppm) and found color, texture, flavor, and general acceptability not affected by the depuration. They noted, however, a significant change in fat and protein content after 24 h depuration.

Paralytic shellfish poisoning

Many countries with good prospects of culturing *Perna* have become increasingly aware of the grave public health and economic problems associated with the sporadic outbreak of paralytic shellfish poisoning (PSP). Bivalves, including *Perna,* can carry substances poisonous to humans as a result of bio-accumulated toxins produced by a small number of species of dinoflagellates, notably those belonging to the genus *Gonyaulax* (or *Protogonyaulax*), *Gymnodinium,* and *Pyrod-*

To eat or not to eat ...

inium. Throughout the Indo-Pacific region, *Pyrodinium bahamense* var. *compressum* is considered the major causative organism of PSP. However, it has been suggested that *Protogonyaulax tamarensis* triggered a few cases of PSP in Thailand in 1983. The toxins isolated from infected molluscs were in general derivates of saxitoxin, neosaxitoxin, or gonyautoxin. They belong to the class of neurotoxins which cause symptoms such as weakness of the limbs, fatigue, and numbness and tingling in the fingers, toes, lips, and tongue of humans. The toxins are heat-stable, but detoxification down to acceptable levels within 6 to 7 days can be achieved by treatment with ozone or PVP-iodide-iodine complex.

Researchers suggest that standardized toxicity testing be applied such as the standard mouse bioassay technique advocated by the AOAC (Association of Official Analytical Chemists). The toxicity threshold set by the United States Food and Drug Administration for closure of mollusc beds is fixed at 80 µg toxin/100 g mussel flesh. Depending on the method applied, this represents approximately 400 mouse units (MU) per 100 g mussel flesh.

The blooms of dinoflagellates that can pose an increased risk of PSP are usually called "red tide". This phenomenon seems to be, therefore, of primary importance in any monitoring program. Some researchers suggest aerial surveys, flown at an altitude of 300 m, to be most useful in detecting and monitoring red tides. However, PSP can occur, as in Malaysia, without any visible planktonic bloom. This might happen either because the concentration of dinoflagellates can reach toxic levels before their presence is manifest in red tides or because of the long retention period of the toxins in the molluscs, which can last for several months. The possible absence of clearly distinguishable indicators make standard monitoring programs indispensable. Plankton and sediment samples should be collected regularly together with oceanographic data. Their evaluation should enable the timely closing of mussel farming areas and the launching of public awareness programs.

Trace metals

A substantial number of investigations has been carried out to determine concentrations of trace metals in *Perna*. This was born out of concern over the far reaching implications for human health of the mass-culture and marketing of marine organisms that could contain potentially dangerous levels of heavy metals.

So far no generally accepted standards exist for upper limits of heavy metal concentra-

(next page please)

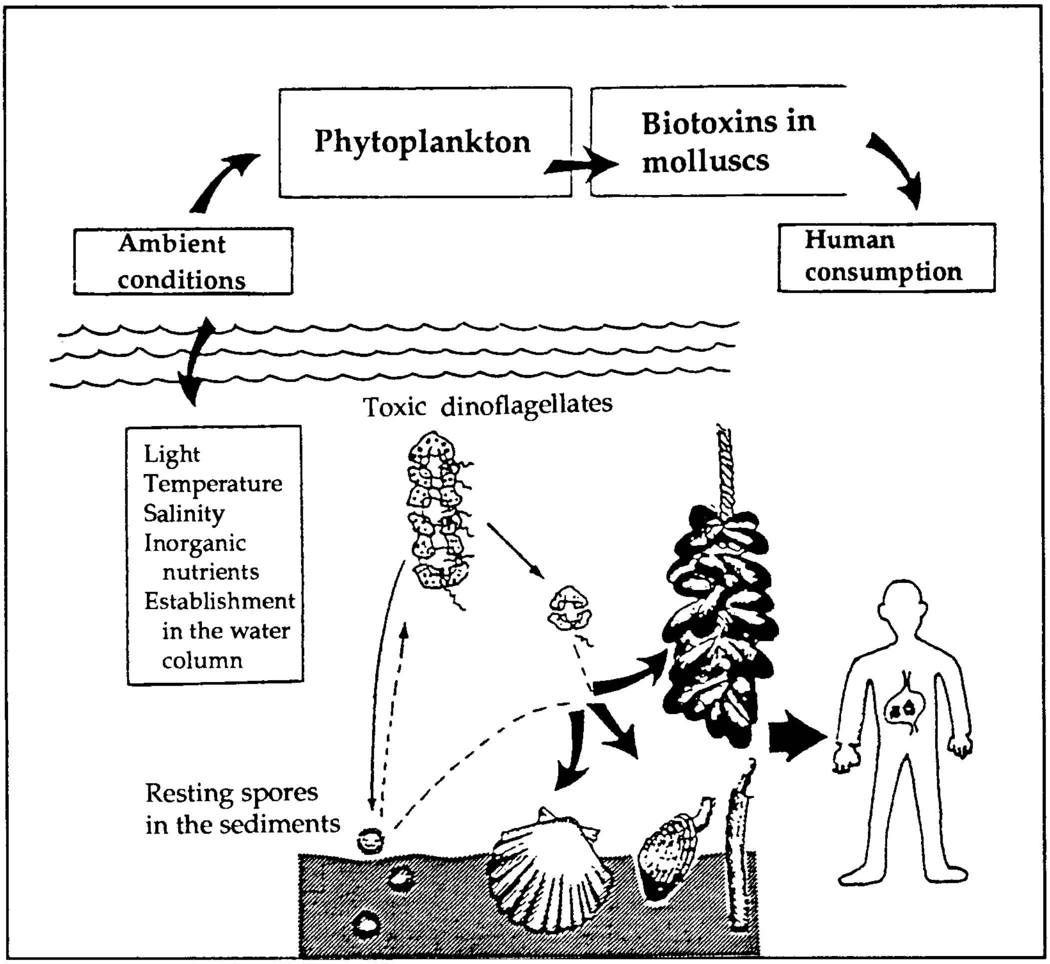
Giant clams ... from p. 11

clams are thinned out to prevent overcrowding. Transfer to the ocean nursery is done as much as possible without detaching the juveniles from the original substrate so that the transition is accomplished smoothly.

In conclusion, culture of giant clams requires a system that can deliver clean flowing seawater to suitable tanks for rearing clam eggs through larval stages to juveniles. The technology itself is relatively easy to learn, although the hatchery aspect may require more equipment and know-how than is available to coastal inhabitants and may have to be provided by better funded government or private institutions. The need for serotonin, which is expensive, to induce spawning can be dispensed with by using gonad slurry from one or two sacrificed clams.

Future work should focus on improving survival during the larval stages possibly by providing better sources of nutrition, and on inducing early settling and metamorphosis of pediveligers so that the clams grow bigger at an earlier date and can thus be harvested sooner.

Source: MJ Trinidad-Roa and EO Alialy. *Mariculture of Giant clams (Family Tridacnidae) in Bolinao, Pangasinan*. p. 28-35. In: **Proc. Symp-Workshop on the Culture of Giant Clams (Bivalvia: Tridacnidae)**; Silliman Univ, Dumaguete City; March 15-17, 1988. Los Baños, Laguna: Philippine Council for Aquatic and Marine Research and Development and the Australian-Centre for International Agricultural Research; 1989. 131 pp.



Pathway of biotoxins: from water to shellfish to man *(Modified from JA Ferragut. 1989. Mollusc sanitation and marketing in Spain.* In: **Report of the Workshop and Study Tour on Mollusc Sanitation and Marketing**; 15-28 Oct 1989; France. Bangkok, Thailand: Regional Seafarming and Development and Demonstration Project, Network of Aquaculture Centres in Asia; 98-110.)

tion in bivalves. The reason for this has to be seen in the fact that only the final concentration of contaminants in humans is of real concern. Recommendations on maximum tolerable levels of contaminants in humans are published by the World Health Organization. Relating this to recommended upper concentration limits of heavy metals and other contaminants in bivalves on a global scale is impractical. National differences in consumer preferences have to be considered when determining the respective thresholds of tolerable contamination. Regulations, therefore, vary from country to country.

In Thailand, trace metal concentrations in *P. viridis* and other economically important mollusc species have been investigated. Results suggest that contamination of *P. viridis* with trace metals is at acceptable levels. Researchers who investigated environmental pollution at various coastal stations along the Island of Penang, Malaysia in 1978 determined trace metal contents in cultured *P. viridis*. Except for nickel (Ni) at 46 ppm, total trace metal content was still within acceptable limits.

It was also found that there is a marked increase in the levels of chromium (Cr) and copper (Cu) in mussels during the rainy season and this is related to the reduced salinity of the water. A similar pattern of seasonal variation in the levels of trace metals in *P. viridis* was observed in India. Low pH values during the rainy season is a possible reason for increased dissolution of precipitated forms of trace metals. This coupled with industrial effluents carried by freshwater discharge and increased rate of filtration in mussels would necessarily result in higher concentrations of trace metals in *P. viridis*. Investigations in the contents of trace metals in *P. viridis* in Manila Bay, Philippines, also noted an increased heavy metal level in the mussels during the rainy season. Lower concentrations (in relation to dry flesh weight) during summer were probably a mere "dilution effect", caused by the mussels being in better condition.

Pollution monitoring

Bivalve molluscs are commonly used as sentinel organisms to monitor aquatic pollution by conservative contaminants which they accumulate above ambient levels. Whether any of the *Perna* species can act as bio-indicators largely depends on their capacity to reflect efficiently and accurately ambient concentrations of the pollutants. A researcher investigating cadmium content in *Mytilus* worldwide also included some information on *P. viridis*. He found a highly significant relationship between cadmium concentrations in mussel soft tissue (Cd_{mussel}, in µg/g dry weight) and seawater (Cd_{water}, in µg/l) of the form:

$$Cd_{mussel} = 0.39 + 0.074\,(Cd_{water})$$

This relationship suggests that in mussel breeding areas, a standard of 150 ng/l should be proposed as the upper limit for cadmium content of the seawater.

It was shown that the uptake of lead in *P. viridis* is almost linear over a period of seven days. In addition, *P. viridis* was considered very suitable for the monitoring of copper, organochlorine pesticides, and PCBs. Other researchers who studied the reaction of *P. viridis* to different water soluble fractions of diesel fuel noted that byssal thread production and, hence, attachment, was significantly depressed in all but very low concentrations of the toxicant. A similar effect on byssus production was observed under ammonia stress.

P. viridis showed continuous uptake of mercury when it is exposed to a concentration of 100 ppb over a period of 45 days. Depuration was a very slow process. Even after 151 days of continuous self-cleansing, 15.3% of the total mercury body burden remained unpurged. Because of this, *P. viridis* could be used as a bio-indicator for cadmium, cobalt, chromium, copper, nickel, and lead, but was unsuitable for iron, manganese, and zinc.

Researchers also investigated the load of fecal coliforms in the waters around Hong Kong. Though tremendous differences in bacterial contamination between sites existed, they found a close relationship between the number of fecal coliforms in the water and in bivalves, one of which was *P. viridis*.

Investigations on the influence of sex, size, and substrate on the bio-accumulation of heavy metals in *P. perna* along the coast of Rio de Janeiro, Brazil showed substrate-specific differences in the uptake of Fe and Ni. Concentrations of Ni are positively and Fe and Cu are negatively correlated with size of *P. perna*. However, no sex-related differences in heavy metal uptake can be established. Investigations into the bio-accumulation of radionuclides along the Rio de Janeiro coast (Brazil) in *P. perna* revealed significant levels of ^{210}Polonium. This endorsed an earlier assumption that *P. perna* might be a valuable bio-indicator for radioactive pollution of the marine environment.

Source: JM Vakily. 1989. ***The Biology and Culture of Mussels of the Genus Perna.*** International Center for Living Aquatic Resources Management, Manila, Philippines and Deutsche Gesellschaft Fur Technische Zusammenarbeit, GmbH, Eschborn, Fed. Rep. Germany. 63 pp.