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SHELLFISH POISONING IN THE SOUTH PACIFIC

by

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INTRODUCTION

Shellfish Poisoning is a sporadic, but world-wide phenomenon. Caused by "blooms" of dinoflagellates, the usual manifestation is the "Red Tide", although all red tide does not consist of toxic dinoflagellates. In addition, harmful, and even lethal concentrations of toxic dinoflagellates can be built up in the digestive gland and gut of filter feeding lamellibranchs, without the presence of sufficient numbers to make the red tide apparent nor to produce a fish kill.

The symptoms of comparatively mild dinoflagellate poisoning are very similar to those produced by ciguatera fish poisoning. More severe poisoning results in respiratory paralysis and death. In many countries, monitoring of filter feeding shellfish is done by bio-assay (mouse tests) during the season when the dinoflagellate bloom can occur.

In the South Pacific area, the resources rarely exist to conduct these regular sampling procedures, nor are helicopters available to survey coastal areas for red tide outbreaks. In some areas, pilots of comparatively low flying local airlines can be asked to look out for and report upon areas of red sea.

With the current research into the problem of fish poisoning, and the accumulation of epidemiological information, it is important that fisheries workers and health departments co-operate to the maximum to determine and seperate the true causes of fish poisoning cases. It is hoped that this paper will assist in determining the causative sources.

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Red tides are caused by sudden population explosions or blooms of various marine organisms, resulting in localised reddish discolourations of the sea. One of the best known red tide organisms is the filamentous algae, Trichodesmium, which blooms in and gives the name to, the Red Sea. But this is a relatively harmless algae. It is widespread and in the Australasian region Trichodesmium blooms covering large areas of sea are frequent in the Coral Sea and in Papua New Guinea waters. In 1973 they have been seen in Torres Strait, Port Moresby, Milne Bay and Manus Island.

These waters are occasionally tinted a similar colour by aggregations of salps, transparent football-shaped organisms about one centimeter long, whose reproductive organs are pigmented so that from the air they form a red tide when swarming together.

Far more important are red tides caused by dinoflagellates, microscopic single-celled algae in the plankton which have been responsible for massive fish kills as well as mortality to shellfish and even humans.

In Japan, blooms of various dinoflagellate continue to wipe out shellfish farms. Pearl farms are the worst hit. The oyster in which pearls are cultured, Pinctada martensi, is highly vulnerable to the poison released by these dinoflagellates.

On the western Florida coast of the U.S.A., the dinoflagellate Gymnodinium breve regularly forms red tides which kill fish by the ton. The latter cause great nuisance as they are washed up onto beaches.

Humans are killed indirectly by dinoflagellates, in the form of paralytic shellfish poisoning.

Paralytic shellfish poisoning is a world-wide problem. Worst affected areas are the west coast of America from Alaska to Mexico, and many parts of Europe. Poisonings were thought to be extremely rare in Papua New Guinea until attention was focused on the matter dramatically with an "epidemic" situation which occurred near Port Moresby at the end of April, 1972. At Walai, a coastal village 80 kilometres south east of Port Moresby, several persons were taken ill after a meal of seafoods and rushed to Port Moresby hospital. Two patients, both young children, died. The following day there was another outbreak in the village at a "wake" for the earlier victims. This time another child died. Twenty other patients admitted to hospital survived. Their symptoms - tingling sensations around the mouth and extremities changing later to numbness, then weakness, nausea, and muscular paralysis which may leave the patient helpless, then in extreme cases death by respiratory paralysis - were confusing to doctors, since the epidemic was the first of its kind here. By retrospective diagnosis, doctors at the hospital recognised a further seven cases admitted over the previous three months from villages near Port Moresby.

These symptoms are similar to some of those exhibited following ciguatera fish poisoning. This form of poisoning occurs sporadically throughout the tropical Pacific islands and in the West Indies. Ciguatera usually begins with severe stomach pains accompanied by nausea and diarrhoea and muscle aches, 3-5 hours after eating a poisonous fish. The tingling and numbness associated with paralytic shellfish poisoning also appear, and in extreme cases death is also by respiratory paralysis.

The Port Moresby epidemic was eventually recognised as paralytic shellfish poisoning, and samples of oysters and clams from the reef adjacent to Walai village confirmed the doctors' diagnosis. This confirmation was made by Department of Agriculture, Stock and Fisheries' chemists, who performed a standard bioassay test to detect the poison. In this test, toxin is extracted from the shellfish tissue by chemical processes, and injected into mice. The samples from Walai killed the mice in 2-5 minutes, indicating a lethal concentration of toxin in the shellfish.

The samples contained both uni-valve (gastropod) and bivalve (pelecypod) shellfish. Only the bivalves were poisonous. The reason for this lies in their respective feeding habits. Uni-valves are browsers, scraping algae and detritus from rocks or extracting them from mud. Bivalves, on the other hand, are filter feeders. They extract nutrients from planktonic organisms, such as dinoflagellates, from the sea water which they filter through their sieve-like gills, trapping the plankton with a sticky mucus. If bivalves are exposed to heavy concentrations of toxic dinoflagellates, they accumulate enough poison to produce ill effects in persons eating them. There is no escape by cooking the shellfish, since the toxin is very stable and hardly affected by prolonged boiling.

Paralytic shellfish poisoning is caused specifically by dinoflagellates, so the next step in investigating the Walai epidemic was to look for dinoflagellate concentrations - red tides. A helicopter survey of the coastline revealed many orange-red patches in the sea along the coast from Moresby harbour to near Walai. Samples were collected by hovering over the patches and lowering a Nansen bottle, an apparatus that traps a sample of water on command from a messenger weight, and records temperature simultaneously.

The organism causing the red tide was indeed a dinoflagellate, Pyrodinium bahamense, previously unknown in coastal waters of Papua New Guinea or in fact the western Pacific. Its previous distribution was the northern hemisphere tropical and sub-tropical waters on both sides of the American continent, and in the Red Sea and Persian Gulf. It is a bioluminescent species, producing well-known phosphorescent displays in bays in the Bahamas, Jamaica and Puerto Rico. Nowhere has it been found poisonous, until now. Cell extracts killed mice in 1.5 minutes, confirming Pyrodinium as the origin of the shellfish poison. The helicopter samples contained up to 5 million Pyrodinium per litre of sea water.

Bivalve shellfish are an important source of food to coastal villagers, especially in the south-east trade wind season, when conditions are often too rough for fishing. It was therefore necessary to order a ban on the sale of these shellfish in the district after the fatalities, until such time as they became safe to eat. This necessitated monitoring the level of shellfish toxicity by mouse bioassay, the movements of the red tide by regular observation flights, and the concentration of Pyrodinium in sea water by plankton analyses.

The results of these investigations were significant. Red tides disappeared at the end of May, and Pyrodinium became an insignificant constituent of the plankton within a fortnight. Some shellfish, such as the arc shell Anadara, which was the main species involved in the Walai tragedy, lost their toxicity within six weeks. However, Spondylus, the thorny oyster, was still highly toxic at this time, and the rock oysters (Crossostrea) retained a high level of toxicity for over four months, but were safe to eat by December.

This year red tide again appeared along the 100 kilometre stretch of coastline that had been kept under aerial surveillance since the 1972 blooms. However, this time we were able to give the Health Department one month's advance warning of its coming. The proportion of Pyrodinium in the plankton population had been ascertained every fortnight since the disappearance of red tides in May, 1972. In early January, 1973, the Pyrodinium population began to increase rapidly. The first red tide sighting took place in mid-February, and red tides were observed intermittently until the end of June. The ban on shellfish sales this season extended from February to the end of September.

By checking all available records and sighting reports, supplemented by plankton analysis and aerial observation in other areas of Papua New Guinea, we have found that red tides are far more common and widespread than at first thought. Dinoflagellate red tides have occurred along almost the whole of the southern Papuan coast, east (but not west) of Port Moresby, Milne Bay, parts of the New Guinea coastline and in various outer islands - Admiralty, Trobriands and west New Britain. Many poisonings have also occurred in these areas. Records are scanty. Those we have discovered, a total of 10 deaths and over 150 treated non-fatal cases since 1956, appear to be merely a fraction of the actual number of paralytic shellfish poisonings in this period.

Our enquiries into this problem have revealed some interesting aspects. For example, on the Morobe coast, east of Lae, the red tide is said to be virtually an annual event in November. It is looked forward to by local villagers, who are not shellfish eaters, because the red tide kills large numbers of fish in many bays, and these are cooked and eaten. Occasionally even dolphins and turtles have been killed by the score and washed up, to the delight of the villagers. At Kiriwina, Trobriand Islands, dinoflagellate blooms occur in the shallow western lagoon, but the water there is too turbid to allow sightings of the blooms. Bivalve shellfish are a major food of villagers here and many deaths from paralytic shellfish poisoning are said to have occurred. Sufferers rarely report to the hospital at Losuia. However, villagers there have developed a warning system. When the characteristic phosphorescence appears at night in the water, they abstain from eating the shellfish until it has disappeared. The waters around Amazon Bay on the southern coast of Papua are much clearer and red tides are not uncommon there. Villagers are aware of the significance of the blooms as a result of fatalities in the past from shellfish poisoning and they now abstain from certain species while red tides are in the vicinity.

Not all villages recognise the dangers of poisonous shellfish during red tide seasons. The people of Walai, scene of the most recent fatalities, were so adamant that shellfish were not responsible for their children's deaths, that early investigations there were severely hampered. Doctors were threatened by hostile villagers who believed their water had been poisoned by anti-malaria spraying. Later when the true nature of the sickness had been explained to them they recalled similar illnesses and resulting deaths in the past, but had never associated them with shellfish.

Dinoflagellate toxin is not stored evenly throughout the tissues of shellfish, but varies in concentration in different organs and different species of shellfish.

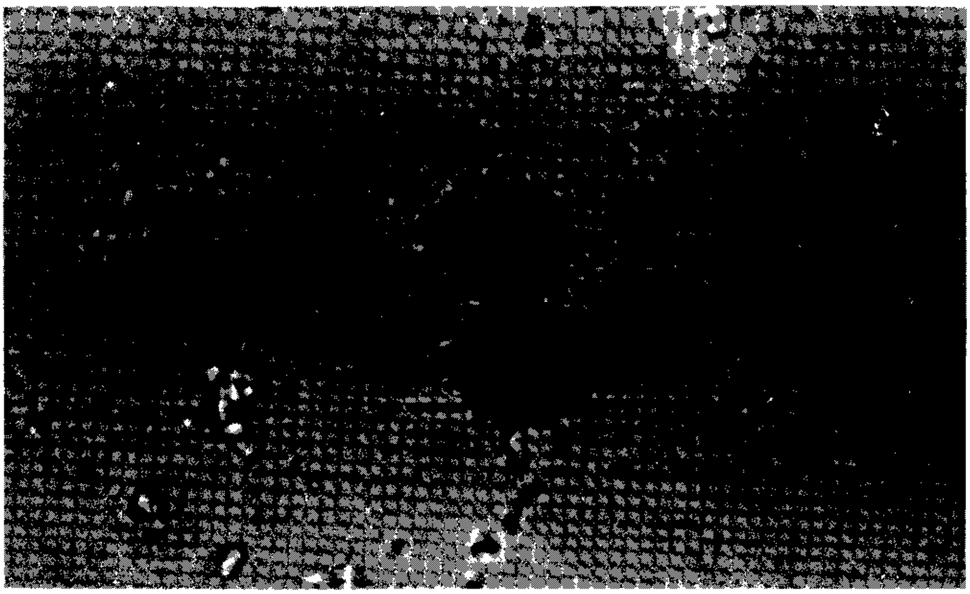
We were curious to learn why Pyrodinium toxin did not affect workers in the pearl farm at Port Moresby, who eat toxic pearl oyster (a bivalve shellfish) meat in large quantities during pearl harvesting in the red tide season. By dissecting the pearl oyster flesh into its various parts it was discovered that the toxin accumulated mainly in the digestive gland and gonad tissue, while the foot, mantle and gills were only mildly toxic. However, the muscle was free of toxin, and in fact, only this part of the oyster meat is eaten by the pearl farm workers, thus explaining their apparent immunity.

Rock oysters were also found to contain highly toxic digestive gland and gonad tissue, and mildly toxic mantles and gills, but the muscle is also mildly toxic. Since all parts of oysters are generally eaten, they are unsafe to eat during and for some time after Pyrodinium red tide seasons. This general rule applies to all other shellfish which are eaten whole.

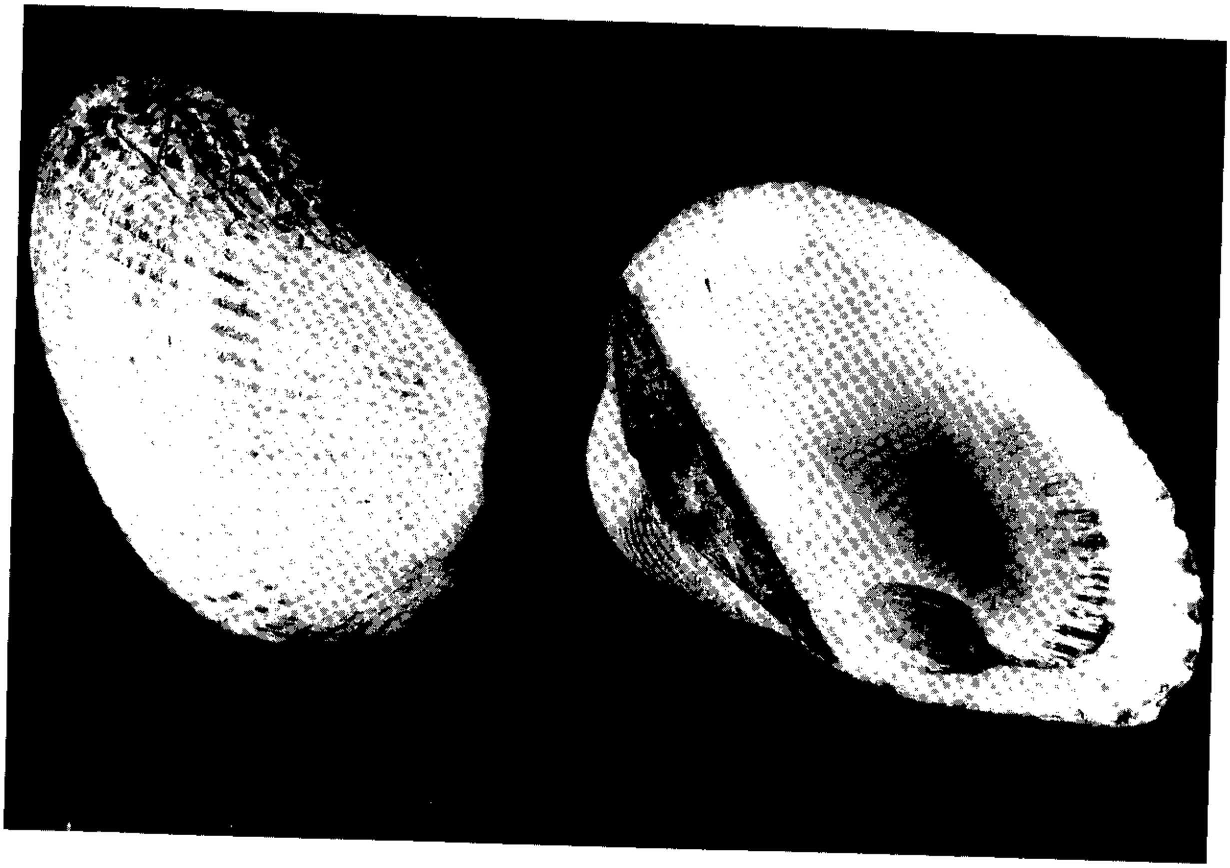
It must be pointed out that in relation to the vast quantities of bivalve shellfish eaten, the number of fatalities is negligible. Villagers continue to collect and consume bivalves during the red tide season despite

Health Department warnings. This year no cases of paralytic shellfish poisoning were reported to Port Moresby hospital even though the harbour and nearby coastal foreshores were dotted with women and children gathering bivalve shellfish at almost every low tide, and red tides were frequently seen nearby offshore.

Some preliminary laboratory experiments at our Fisheries Research Station near Port Moresby seem to indicate that Pyrodinium may become toxic only in certain conditions, but more research into the problem will be necessary to discover the exact relationship between red tide and shellfish poisoning.



The toxic dinoflagellate *Pyrodinium bahamense* undergoing reproduction by cell fission. Under favourable conditions rapid cell division takes place until there may be several million cells per litre of seawater. The central "girdle" across each cell houses a whip-like tail which provides propulsion. Magnification x 400. (Actual cell diameter 0.05 mm.)



Anadara is both popular and common throughout Papua New Guinea waters. Actual size 6-8 cm.

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