Micronesica 26(1): 11–18, 1993

Guam Seaweed Poisoning: Common Marine Toxins

JOHN C. STEELE, M.D., F.R.C.P.(C.)

Neurologist, Micronesian Health Study
University of Guam Mangilao, Guam 96923

Abstract—Ciguatera poisoning is the most frequently diagnosed type of marine food intoxication on Guam. It occurs world-wide in tropical areas but is more common in some regions than others. Large predatory reef fish are most likely to accumulate substantial levels of ciguatoxin in their flesh but there is no readily available way to tell which individual fish may be affected. Symptoms include vomiting, diarrhea and characteristic neurologic abnormalities. Treatment is symptomatic: no specific therapy is available although intravenous administration of mannitol has been recommended.

The principal marine foodborne poisonings are caused by eating fish and shellfish (Table 1). Ciguatera poisoning is an acute illness due to a toxin produced by marine microorganisms that are ingested by reef fish. Scombroid poisoning is caused by improper preservation of pelagic fishes such as tuna, mahimahi, mackerel, skipjack and related species that allows endogenous bacteria to convert histadine in the fish muscle to saurine, a histamine-like substance. The reaction is immediate, self-limited and readily reversed by antihistamines. Gymnothorax poisoning is a ciguatera-like acute illness due to neurotoxins produced by dinoflagellates that accumulate in the muscle tissue and viscera of eels. Tetrodon poisoning is due to a particularly potent toxin present in the skin and viscera (particularly the ovary) of the pufferfish or "fugu". The flesh of the fish is a great delicacy and in Japan chefs are trained to safely prepare it by carefully removing the toxic organs.

On Guam, the most common form of toxic marine food illness is ciguatera poisoning. Scombroid poisoning, most frequently associated here with frozen mahimahi, is less common and tetrodon poisoning has never been reported on Guam, apparently because very few local people attempt to eat pufferfish. This morning I will focus on ciguatera intoxication, which is commonly referred to on Guam simply as fish poisoning.

Ciguatoxin is elaborated by a dinoflagellate, *Gambierdiscus toxicus,* identified by Japanese scientists in the 1970's. *G. toxicus* lives in association with algae that grow in channels of coral reefs. Herbivorous fish feed on the algae, accidentally consuming the dinoflagellates, and carnivorous fish, in turn, feed on the herbivorous fish. Thus the toxin tends to accumulate in large (therefore older) predatory fish. Although the toxin causes no apparent illness in fish, when they are eaten by animals or man, there may be severe illness (the young of cats and mongooses are particularly susceptible).

Table 1. Common marine foodborne toxins.

Vertebrate	Etiological Agent	Geography	Species Involved	Incubation	Symptomatology Gradation			Duration of Disease (Prognosis)	Prevention
					Gastro-intes-tinal	Neuro-logic	Cuta-neous		
Ciguatera	Ciguatoxin from dinoflagellates	South Pacific, Caribbean, Hawaii, Florida	Large fish, barracudas, sea bass, parrot fish, red snapper	2 to 30 Hours	+	++	+	Days to months (Good)	Avoid large reef fish, avoid viscera, gonads, roe
Scombroid	Saurine, histamine (from fish skin degradation)	Tropical waters; California, Hawaii	Tuna, albacore, bonito, mackerel, skipjack, mahimahi	Minutes to hours	+	−	++	Hours (Excellent)	Refrigerate fish upon catching
Gymnothorax	Ciguatoxin like neurotoxin from dinoflagellates	Tropical	Moray eel	0.5 to 30 hours	++	++	−	Days (supportive care essential)	Avoid eating moray eel
Tetrodon	Tetrodotoxin	California, Africa, South America, Australia, Japan	Puffer ("fugu") globe, balloon, blowfish, toad fish, newts (Taicha sp.)	Minutes to hours	++	+	−	First 24 hours critical—high case fatality rate	Avoid eating puffer-type fish
Shellfish									
Paralytic	Saxitoxin from Gonyaulax (dinoflagellates)	Atalantic and Pacific, New England, West Coast, Alaska	Mussels, clams, scallops, oysters	Half-hour	+	++	−	Hours to days (supportive care essential)	Avoid eating shellfish during summer (redtide months)
Neurotoxic	Gymnodinium sp.	Florida gulf and Atlantic coasts	Mussels, clams, scallops, oysters	Minutes to hours	−	+	−	Hours to days (Excellent)	Avoid eating shellfish during summer months

I became familiar with this disease while working in the Marshall Islands 19 years ago and I would like to tell you of my experience there. The atolls of this archipelago are located close to the equator at the international date line. Robert Louis Stevenson described Majuro atoll as the pearl of the Pacific. It is the administrative center of the Marshall Islands. The central lagoon of Majuro is bounded by a perimeter of low lying coral islands. A great variety of fish abound in these waters. They are easily caught from the reef and are a staple of the native diet being eaten raw or cooked over open fires. The Marshallese are generally very healthy; they have traditionally led active lives and eat a balanced diet of fish, breadfruit and coconut. The abundant food supplies and easy subsistence available in these islands has resulted in a harmonious society of happy people.

However, all is not perfect in paradise. I have documented the effects of a severe case of ciguatera poisoning in a 14 year-old Marshallese boy. He became seriously ill after eating a relatively small fifteen in. grouper. For the first week he was unconscious, totally paralysed and had trouble breathing. In movies taken two months after his acute poisoning a profound leg weakness which is most marked distally can be noticed. There was wasting and areflexia but only mild sensory impairment and he demonstrated here a marked residual peripheral neuropathy. This boy was also ataxic; this was more than could be accounted for by limb weakness or sensory loss. Most often the neurological symptoms of ciguatera poisoning are distal paresthesia, limb weakness and trouble with swallowing. Symptoms are seldom severe and usually resolve within seven days.

Of the many hundreds of fish poisoning patients I cared for from 1972 to 1977, none died. When death does occur it is usually due to respiratory paralysis. Severe residual neuropathy and ataxia occurred in only 4 patients. Recovery of the young patient previously described was still incomplete after 7 years but that certainly is an exception to the usual course of ciguatera poisoning which typically is a much more benign almost flu-like illness.

Ciguatera may occur wherever fish feed on reef algae. Thus it is most common in the circumglobal coral belt between latitudes 35 degrees north and south. In some regions it is more common than in others. The illness is relatively common in the Marshalls, certainly more so than in other districts of Micronesia and much more common than here on Guam.

In 1974 and again in 1977 we surveyed the population of Majuro atoll to learn the types of fish that had caused poisoning, the number of people who had been ill, and locations where the toxic fish had been caught. Each survey inquired about the preceding three years, so this study covered a period of six years. The majority of the poisonings were caused by carnivorous reef fish; snappers, groupers and jacks. Large fish of a species were more likely to be toxic than small ones, indicating that toxicity was cumulative. The chief toxic herbivorous fish were surgeon fish and sardines (Fig. 1). During the six years covered by the study, 386 fish of 55 species were reported to have caused illness. This, however, is a small number when one considers the many thousands of fish that are consumed each year. The 386 toxic fish were eaten by 1560 people and caused illness in 829. Although toxic fish were caught around the whole perimeter of the atoll, the

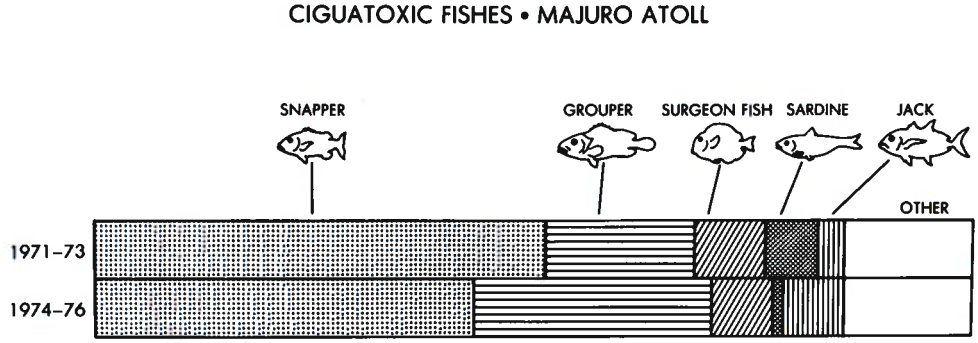

Figure 1. Ciguatoxic fishes, Majuro Atoll.

majority were caught in the deep water channel which provides entry into Majuro lagoon. It is in this same area that most of the fishing is done so that may explain the high prevalence of toxic fish reporeted from that location (Figs. 2, 3). The conclusion of this study was that fish caught in any area of the atoll might cause illness but that certain species, particularly when they were large and caught in certain locations, were most likely to be toxic.

At present there is no way fishermen can accurately tell whether a specific fish is toxic and there is no known way of preparing or cooking fish that will inactivate the toxin. Kittens are particularly sensitive to ciguatoxin and will develop symptoms within 24 hrs of being fed toxic fish.

I would like to review the clinical features of ciguatera fish poisoning (Table 2). Ciguatera causes a distinctive, acute, multisystem disease. Its chief symptoms are referable to the neurological, gastrointestinal and cardiovascular systems. Neurological symptoms are the hallmark of the disease. Typically, 3 to 6 hours after eating a toxic fish affected patients experience a painful tingling numbness about the lips and mouth. This quickly spreads to involve the hands and feet. When severe, this altered sensation may be felt over the entire body. Contact with a cool breeze or water greatly intensifies this discomfort. Occasionally numbness is accompanied by intense itching, which has led the French to call the illness "La gratte" or "The itch" in Polynesia. The arms and legs are heavy and weak. There is seldom paralysis but strength is diminished and the tendon reflexes are reduced. The tongue feels rough and swollen and its movements are clumsy. Speech is slow and slurring. A tightness and constriction of the throat causes difficulty in swallowing. Vision alters and blurs. The eyes burn and light is painful. Hearing is impaired. Some patients experience mild euphoria, others are apprehensive and restless. Headache is common and may be intense. In the majority of cases diarrhea and vomiting cease within 24 hours, though these symptoms often present early and prominently. Neurological symptoms of sensory disturbance persist longer, and the usual interval to resolution is seven days. Very severe cases may lose consciousness and have convulsions. There is then severe flaccid paralysis, respiratory failure and cardiovascular collapse.

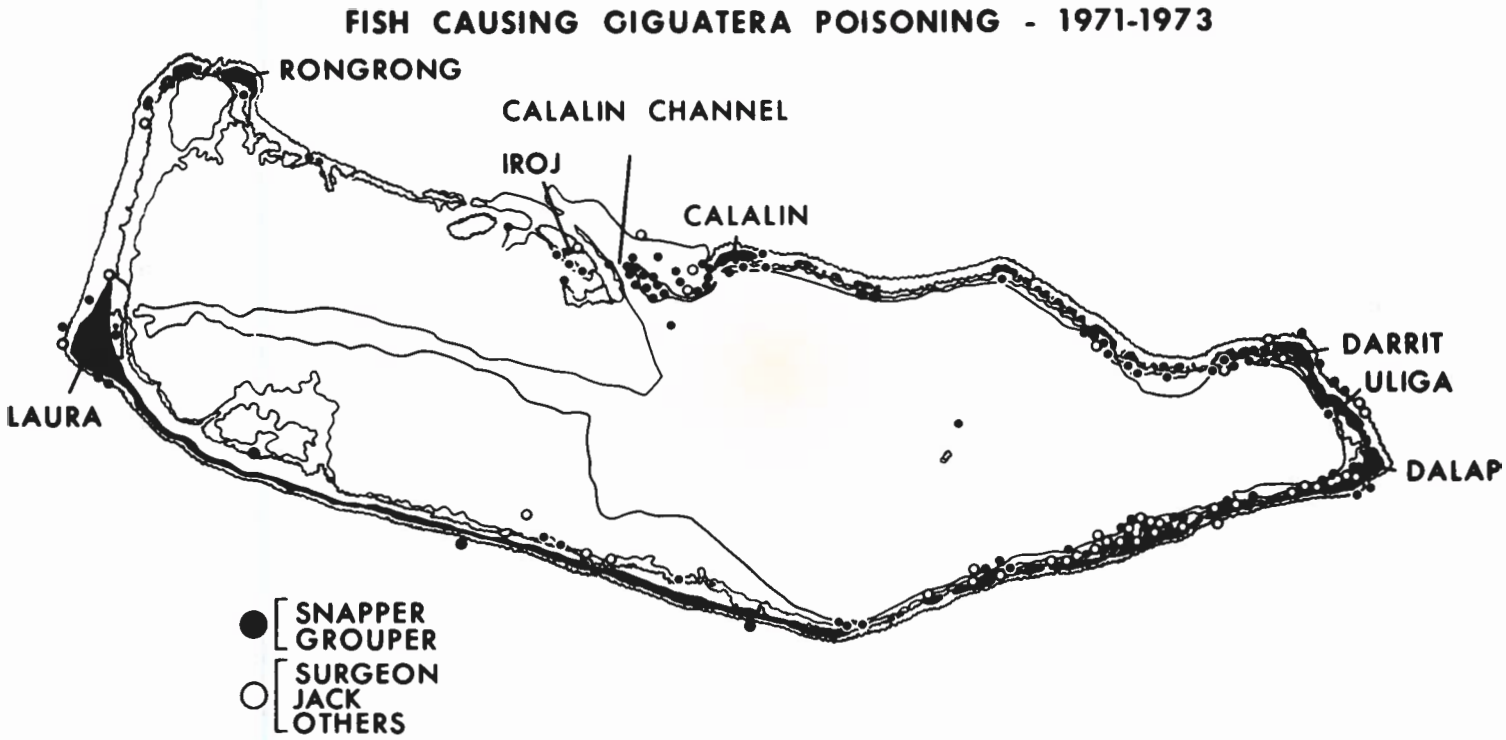

Figure 2. Fish causing ciguatera poisoning, 1971–1973.

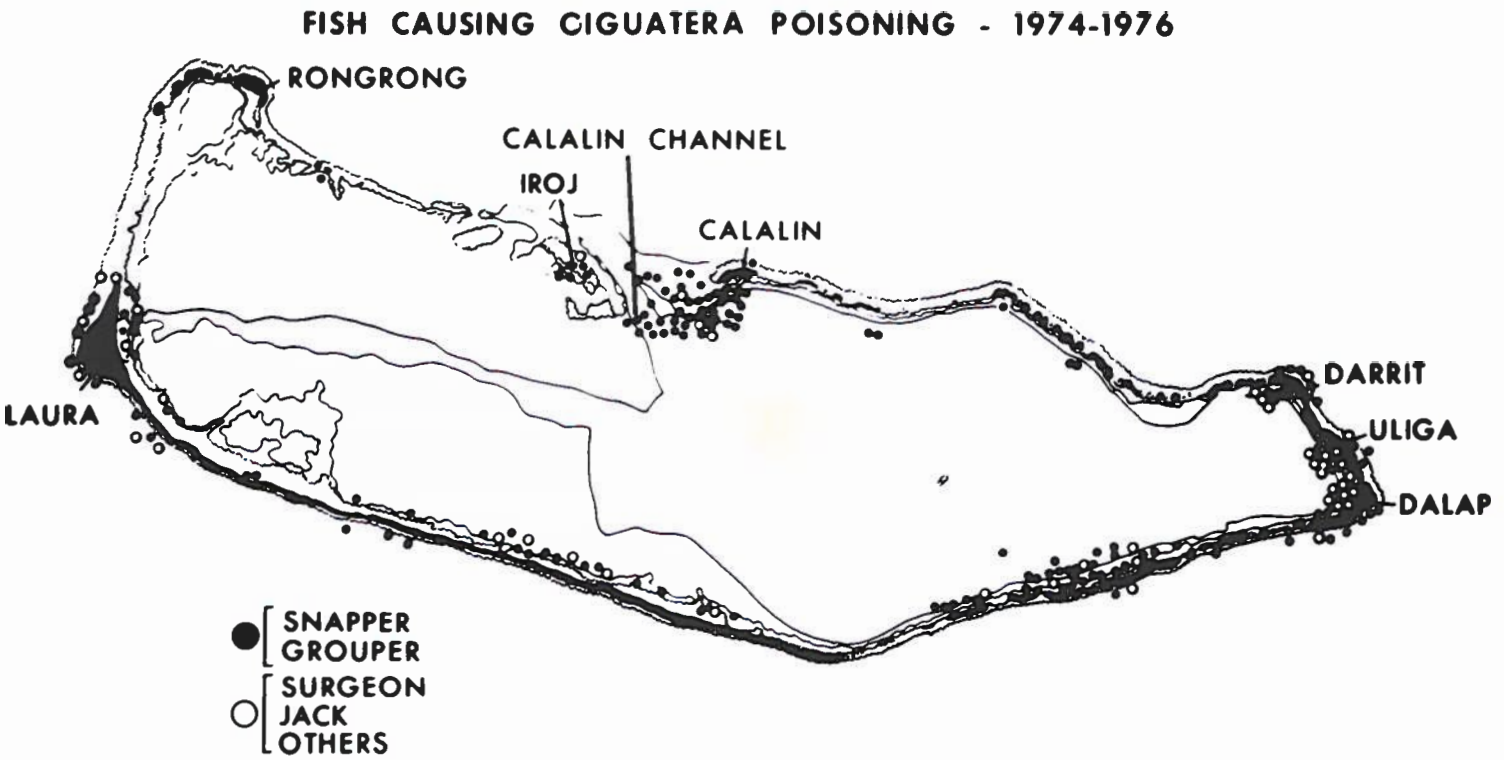

Figure 3. Fish causing ciguatera poisoning, 1974–1976.

Table 2. Symptoms of ciguatera in ten patients

			SYMPTOMS OF CIGUATERA																										
AGE	NUMBER POISONED	INTERVAL ONSET (HOURS)	ABDOMINAL PAIN	NAUSEA	VOMITING	DIARRHEA	TINGLING LIMBS	WEAKNESS LIMBS	TROUBLE SWALLOWING	TROUBLE SPEAKING	ALTERED CONSCIOUS	HEADACHE	ALTERED VISION	ALTERED HEARING	MUSCLE PAINS	JOINT PAINS	FEVER	ITCHING	FAINTNESS	SWEATING	TROUBLE BREATHING	PALPITATION	ALTERED VOIDING	SEVERITY ILLNESS	INTERVAL RECOVERY (HOURS)	PREVIOUS CIGUATERA
27	1/3	6				2	1	1			3						4						Mo	36	0
22	1/2	8	1	2	3		4				5				6								Md	12	0
63	1/4	6	3	2			1	1	1	✓	✓	✓	✓	5				6	4	4	4		Mo	36	x1
57	1/5	4	2	3	4		5	1			✓							1	1	1			Mo	24	0
30	1/4	4		6	7	5	8	4	1	✓	✓	✓	✓	✓		3		2	2				Mo	11	x1
24	1/2	1/2		3	4		1	1				✓	✓	✓				2	2	2			Mo	20	x2
17	1/1	4		4	4	1	3	3				2		1				✓		✓			Md	7	0
18	2/2	9	1	2	3	3											✓	4		5	5	5	Md	30	0
21	2/3	4	2	5		1	3	4			✓												S	36	0
26	2/3	3	3	1	2		5								4	4							Md	24	x5

Numbers indicate the sequence of symptoms; check marks indicate presence of a symptom—sequence not recorded.

Detailed inquiry of 50 patients admitted to the Amer Ishoda Memorial Hospital, Majuro, during 1974 and 1975 allows for several generalizations about toxic fish. All parts of the fish may be poisonous. The quantity of fish eaten does not always determine the severity of symptoms, thus some become ill after eating only a small amount while others who have eaten much more may not become ill. Patients who have eaten the same fish may experience similar symptoms but not always. There is no relation between the interval before the onset of symptoms and their severity; some mild cases become symptomatic within half an hour while those with severe illness may not develop symptoms for ten or twelve hours. There is no relationship between the sequence of symptoms and the severity of illness. These observations lead us to conclude that there is considerable individual human variation in susceptibility and response to ciguatoxin (Table 2).

Ciguatera poisoning has been associated with more than five toxins including ciguatoxin, a fat soluble ammonium compound, maitotoxin, a water soluble component, lysolecithin, a maitotoxin-associated hemolysin, and ciguatoxin-associated ATPase inhibitor. Scaritoxin is like ciguatoxin but is specific to parrotfishes. All of these toxins appear to be closely related chemically as well as mechanistically. They are all colorless, odorless and heat stable. Their pharmacology and modes of action are still being worked out but the primary effect seems to be on the sodium channels. Thus one mode of action of ciguatoxin is the blocking of the calcium receptor site that modulates sodium pore permeability in neural, muscle and myocardial membranes. This allows increased permeability to sodium

and causes sustained depolarization. Ciguatoxin also appears to have cardiac stimulatory effects, but maitotoxin is a myocardial depressant; these pharmacological differences may explain contrasting clinical presentations.

The treatment of ciguatera is primarily symptomatic and supportive. Pruritus may be relieved by antihistamines and minimized by avoidance of moist heat, exercise and alcohol. Severe myalgia may respond to analgesics and Indomethocin. Nausea and vomiting, if severe, can be controlled by phenothiazines or other antiemetics. Symptomatic bradycardia and hypotension respond to atropine intramuscularly. Diarrhea is almost always self-limited. In-vitro studies have shown that calcium ions may antagonize the action of ciguatoxin on membranes and this has led some to use calcium gluconate in treatment but its effect is variable and not proven. Most recently treatment with mannitol has been advocated but there has been no controlled trial of its efficacy. Some have reported improvement with Elavil, 25 milligrams, twice a day.

You will be interested in the origin of the term ciguatera. "Cigua" is the Cuban name for a bivalve mollusk. People who became ill after eating this shellfish were said to be "ciguatos" and to suffer "ciguatera". A Portuguese biologist working in Cuba in the 1700's astutely observed from personal experience that the symptoms he had after eating a toxic fish were similar to those suffered by the "ciguatos". It was he who first termed fish poisoning "ciguatera" and that designation stuck. His observations relating shellfish poisoning to fish poisoning were, however, overlooked for several centuries by the scientific community and it is only recently that dinoflagellate organisms have been identified as the common cause of both paralytic shellfish poisoning and ciguatera fish poisoning.