CIGUATERA FISH POISONING
AND
REEF DISTURBANCE

Observations on ciguatoxin level
in reef fishes
at Nei Tebaa Channel,
Dai Nippon Causeway,
South Tarawa, Kiribati.

by

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CONTENTS

ABSTRACT

Ciguatoxin was extracted from a variety of fish species caught off Nei Tebaa Channel (between Betio and Bairiki, Tarawa, Kiribati) using a technique adopted by the Southern Fisheries Research Centre, Brisbane, Australia. Bioassay was done on 20 g mice. Moray eel-*Gymnothorax sp.* (rabono) was found most toxic. Surgeon fish-*Ctenochaetus striatus* (ribaroro) and parrot fish-*Scarus* spp. (ikabata) were toxic. Spotted cod-*Epinephelus sp.* (kuau), blue spotted trout-*Cephalopholis argus* (nimanang), striped surgeon fish-*Acanthurus lineatus* (ribatanin), wrasse-*Coris sp.* (newekabane) and the *Lethrinus sp.* (te kiritauno) were only slightly toxic. The eastern side of the channel was more toxic than the western side. Toxicity level appears to have increased after the construction of the causeway.

Keywords: Ciguatoxin, Nei Tebaa Channel, Bioassay, Fish, Toxic, Causeway.

INTRODUCTION

Ciguatera is a type of poisoning associated with consumption of fishes from sub-tropical and tropical reefs around the world.[1-10] Ciguatera is one of the major food poisonings in Kiribati[11-15] although the full extent of ciguatera poisoning in this tiny state is unknown. Through the marine food chain these edible fishes accumulate in their flesh and viscera toxins which originate from benthic microorganisms[13,16-19] The dinoflagellate *Gambierdiscus toxicus* is the presumed elaborator of ciguatoxin, the principal toxin involved in ciguatera poisoning.[9,18,21-23] This type of poisoning was brought to wider public attention following poisonings of soldiers based on Pacific islands during World War II.[11,14,15] Ciguatera continues to be of great concern to the general populace of Kiribati, whose main staple diet, among other marine sea food, is reef fish. A survey conducted in 1984 showed half of the islands in the Gilbert group are facing this problem.[15] Attempts have been made to understand this phenomenon with particular emphasis on South Tarawa (Fig. 1), the capital of Kiribati, where about half of the population lives.[24] Results of a *Gambierdiscus toxicus* population study showed very low counts[25] as compared to results of similar work before and after.[18,22,23,27]

The presumed causes of this fish poisoning, according to local residents, ranges from shipwreck to hospital effluent.[15,25] Such speculation has some scientific basis as reef disturbance, be it naturally or human induced, is known to have some association with increases in ciguatera in any one location. The increase in the number of causeways and blasted channels in the Gilbert chain has aroused suspicion among the general public as to how they may affect their marine resources and in particular if such developments will increase the risk of ciguatera in local fishes.

The longest causeway (3.4 km) built in Kiribati is the Dai Nippon Causeway (completed 1987) which now links the islet of Betio, the main battle ground during World War II, to the rest of South Tarawa (Fig. 2). This giant structure (13 m width by 6 m high) forms a partition between lagoonal and oceanic waters leaving only a narrow channel Nei Tebaa (blasted out of the reef platform) which now enables the boatmen and fishermen gain access to both sides of the reef.

Prior to construction, locals regarded most fishes from the area of Nei Tebaa channel as non toxic although some including moray eel were toxic. In this study, a quantitative bioassay procedure was employed to quantify the level of ciguatoxin in fishes from this area. A data base on the level of ciguatoxin in reef fish species at Nei Tebaa channel was established. On the basis of these data the extent that reef blasting may have affected ciguatera fish poisoning incidence in this area was determined.

MATERIALS AND METHODS

Sampling sites

Two sampling grounds were selected, east and west of the blasted channel, Nei Tebaa (Fig. 2). Each site is approximately 100 metres from the main entrance on the ocean side of the reef platform.

Fish collection

Moray eels were caught using locally-made traps known as 'Te Uu'. These structures (made of ironwood-*Pemphis acidula*, te ngea and string from coconut husk fibre) require special baits, most sought after include octopus and surgeon fish species. The bait is changed at least once a day but in some cases where a typical and more skilled technique is used bait needs to be changed every 2-3 hours. Other fish species were speared. Sufficient numbers (from each species) were collected to obtain at least 50 g of liver and viscera. The large eels were gutted and both liver and viscera were removed. Smaller individuals were pooled and shipped whole. Medium sized fish of the same species were gutted and visceral content and liver were pooled.

Storage and shipment

The specimens were identified, labelled, placed in plastic bags and stored at -10°C. The storage time was normally 1-3 weeks. The frozen specimens were packed in styroform containers and airshipped to Southern Fisheries Research Centre, Brisbane, for toxin extraction and testing.

Extraction

Liver and viscera were extracted twice with acetone (3:1, v : w) in a blender and the ether fraction obtained as outlined in Figure 3.[28] Ciguatoxin and possibly maitotoxin were contained in the ether extract. To separate the two toxins, ether fractions from selected fishes were further fractionated on silicic acid columns: using a 30 g silicic acid for each 1 g of extract. Chloroform, chloroform-methanol (9:1) and methanol fractions were eluted, dried under vacuum and a stream of nitrogen, weighed, stored at -20°C and activity assayed with mice. If maitoxin was detected the ciguatoxin quantification was based on toxicity of the 9 : 1 chloroform fraction from silica gel.

Bioassay

Fractions suspended in 0.5 ml 5% Tween 60 saline were assayed by i.p. injected into 20 ± 3 g Quackenbush mice of either sex. Doses < 1 g/kg (i.e. < 20 mg of extract per 20 g mouse) only were administered because doses > 1 g/kg can produce a non-specific toxic reaction (Lewis, unpublished observation). The response of the mouse and the time to death were recorded for each fraction and compared to responses to reference toxins (Table 1). Ciguatoxin content was determined using the dose-time and death relationship for mice.

RESULTS

The fishes collected included mainly herbivorous (parrot and surgeon) and carnivorous (moray eels and coral trouts/cods) species (Table 2). Toxicity level (expressed in mouse units) on some fish species collected for this report (after the construction the causeway) is shown in Table 3. Bioassay results on the same species or genus collected around the same area prior to the construction of the causeway are also included. It appears that the eels caught east and west of Nei Tebaa channel were very toxic as well as those caught off Nanikai reef. Parrot fish caught east of the same channel were found slightly toxic while those from the western side were not. The surgeon fish species, *Ctenochaetus striatus*, caught east of the channel were found toxic while those from the west were not. One of the two specimens of the blue spot coral trout-*Cephalopholis argus* (nimanang) from the eastern side was slightly toxic, the other specimen was not. The Scaridae-*Scarus sp.* (ikabata) from the same area was confirmed toxic. Other species, spotted cod (te kuau), stripped surgeon fish (ribatanin), wrasse-*Halichoeres nebulosus* (te newekabane) and a *Lethrinus sp.* (te kiritauno) were found only slightly toxic.

Despite the small size of data base available, graphs plotted (Fig. 4) indicated that toxicity level may vary from species to species and from location to location. In addition, both toxicity and tissue weight are not necessarily positively correlated. Moray eels appeared to be highly variable and can be extremely toxic. Results indicated the eastern side of Nei Tebaa passage was more toxic than the western side (Table 3). It appears that the toxicity level is generally higher in fishes caught after the completion of the causeway than those collected before.

DISCUSSION

The viscera, livers and flesh of moray eels contain high levels of ciguatoxin (>2.5 mouse unit), lethal to human beings. These results support findings on the presence of the *Gambierdiscus toxicus*[25] (Tebano, 1983) and particularly serious incidences of fish poisonings (supposed to be ciguatera) caused by consumption of eels and surgeon fish species caught from Bairiki and Nanikaai villages (Fig. 1) during the same period (pers. comm., Tebano unpublished data).

The presence of detectable levels of toxin in most herbivorous fishes on this reef suggested that the public is potentially at risk as past incidences have shown. Although many of these species are non toxic or only slightly toxic, the toxin they contain may be passed on to larger carnivorous species in the food chain.[21,29] These predators accumulate the toxin without hurting them and are often more toxic than their prey.[4,21,28] That surgeon and parrot fish species often cause ciguatera[7,8,10,15,25,30] was confirmed by bioassay. The surgeon fish species was identified as *Ctenochaetus striatus* (te ribabui), the parrot fish species was only identified as *Scarus sp*. (te ikabata). The two species are known to be toxic in other problematic areas in the Gilbert chain[15,25] and elsewhere in the Pacific.[3,7,8,31,32] The association of reef disturbance with ciguatera fish poisoning has been observed worldwide.[3,4,16] It is believed new faces created by damaged coral reef provide new habitat for algae and seagrass which in turn provide more habitat for *G. toxicus*. Sporadic increase in the organism may not necessarily trigger increases in ciguatoxin level. Gillespie *et al* [27,33] reported the absence of ciguatoxin in fishes from Flinders reef, Queensland, Australia, where annual blooms of *G. toxicus* occur. As ciguatera is not a problem in this area Lewis *et al*[34] concluded that the *G. toxicus* on this reef does not even produce precursors convertible to ciguatoxin by fish. This may not be the case in the Gilberts as there have been reports of sporadic increases in ciguatera in infested areas as a result of reef blasting (pers. comm.). For example, ciguatera fish poisoning was not known by the residents of Maiana Island over a long period. Very recently (1988), there were speculation on the occurrence of toxic fishes caught from the blasted channel at the leeward side of the atoll. These incidences implied that reefs in this chain of islands can produce precursors convertible to ciguatoxin and that foreign impacts such as reef blasting may trigger ciguatoxin production or the conversion mechanism.

Ciguatoxin is a potent and stable toxin insoluble in fat, resistant to heat and acid and cannot be destroyed in cooking.[10,30] It is always a health problem in societies where fish is the most readily available source of protein.[3,11,26,32,35] There is no established cure for ciguatera although mannitol is used in Majuro, Marshall Islands to treat ciguatera possibly flushing out ciguatoxin from the body through urine.[36,37] A preliminary study in Australia has indicated mannitol can provide relief to at least some sufferers but its effectiveness in relieving chronic symptoms of ciguatera remains in question.[38] Ciguatera fish poisoning incidence reported for

Tarawa was estimated to be 4 : 1, a ratio of reported to non reported cases.[39] This ratio is presumed to be significantly higher in the outer islands where transport to health centres is a problem and therefore incidences were not reported. SPC/Fisheries 1988 report showed that between 1973 and 1987 there were periods of cooling off in ciguatera (1976-1979). At the beginning of the 80's there has been a steady increase in the number of reported cases implying that this phenomenon remains a public concern and a potential barrier to small scale commercial fisheries.

The future status of ciguatera in the studied area is expected to worsen as a result of recent reef disturbances. It is, therefore, recommended that follow up work is necessary to keep a watchful eye on likely sporadic increases in toxicity level. The public is at risk by consuming fish species around the area and should take great precautions. Future plans on similar developments must consider the likely effects of foreign impacts such as reef blasting and dredging on the environment, marine resources and public health. The benefits of these large man-made changes may be immediate and advantageous to the community, but must be balanced with potential adverse effects that may be considerable and permanent.

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Table 1. Response of mice to ciguatoxin and maitotoxin[1] (Lewis, *et al*, 1988a and 1988b).

Ciguatoxin	Maitotoxin
reduced activity and body temperature	reduced activity and body temperature
copious diarrhoea	no copious diarrhoea
dyspneoa	dispneoa
lachrymation[2]	slight lachrymation[2]
slight hind-limb paralysis	hind-limb progressing to fore-limb paralysis
hypersalivation[2]	no hypersalivation
death-times from 36 min to 24 hrs[3]	death-time from 65 min to 72 hrs[3]
cause of death is respiratory failure	cause of death is respiratory failure

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[1] Responses obtained after i.p. injection of authentic ciguatoxin and maitotoxin.

[2] These signs not displayed by every mouse.

[3] Death-times are inversely related to dosage.

Table 2. Fish species collected from Nei Tebaa Channel, local, English and species names.

Local name	English cammon name	Species name
Te Rabono	Moray eel	*Gymnothorax sp.*
Te Inai/Ikamawa	Parrot fish	*Scarus pectoralis*
Te Ribaroro	Surgeon fish	*Ctenochaetus striatus*
Te Kataawa	Striped surgeon fish	*Acanthurus lineatus*
Te Nimannang	Bluespot coral trout	*Cephalopholis argus*
Te Kuau	Spotted cod	*Epinephelus merra*
Te Ikabata	Parrot fish	*Scarus sp.*
Te Kiritauno	Emperor fish	*Lethrinus sp.*
Te Newekabane	Wrasse	*Coris sp.*

Table 3. Results of bioassay for ciguatoxin in fish species captured around Nei Tebaa Channel (ocean side), Tarawa, Kiribati.

Fish Name	Species	Toxicity (m.u/100g flesh)		
		[4]	[5]	[6]
Moray eel	*Gymnothorax sp.*	NT	NT	8.2w
Moray eel	*Gymnothorax sp.*	NT	ST	5.1w
Moray eel	*Gymnothorax sp.*	-	-	16.2e
Moray eel	*Gymnothorax sp.*	-	-	6.9e
Moray eel	*Gymnothorax sp.*	-	-	6.9e
Moray eel	*Gymnothorax sp.*	-	-	17.1e
Surgeon fish	*Acanthurus archilles*	-	ST	STe
Surgeon fish	*Acanthurus lineatus*	3.0	-	-
Surgeon fish	*Acanthurus lineatus*	ND	-	-
Surgeon fish	*Acanthurus olivaceus*	5.0	-	-
Surgeon fish	*Ctenochaetus striatus*	3.0	-	9.5e
Surgeon fish	*Ctenochaetus striatus*	-	-	1.2e
Surgeon fish	*Ctenochaetus striatus*	-	-	STw
Parrot fish	*Scarus pectoralis*	-	-	STe
Parrot fish	*Scarus sp.*	ND	NT	STe
Parrot fish	*Scarus sp.*	-	CTX	6.6e
Parrot fish	*Scarus sordidus*	5.0	-	-
Parrot fish	*Scarus niger*	2.5	-	-
Spotted cod	*Epinephelus sp.*	-	ST	STe
Coral trout	*Cephalopholis argus*	-	ST	1.7e
Wrasse	*Coris sp.*	-	NT	STw

m.u = mouse unit, LD50 in a 20g mouse within 24 hours.
ND = no death in test mice
NT = not toxic
ST = slightly toxic
CTX = ciguatoxic
e = east of Nei Tebaa Channel
w = west of Nei Tebaa Channel

2.5m.u/100g has been accepted as the safety level for consumption.

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[4] Bioassay results from Institute of Marine Resources, University of the South Pacific, Suva, Fiji, 1982.[15]

[5] Bioassay results from Chemistry Department, University of Hawaii at Manoa, Honolulu, Hawaiii, 1983.[15]

[6] Bioassay results from Southern Fisheries Research Centre, Deception Bay, Brisbane, Queensland, Australia, 1990.

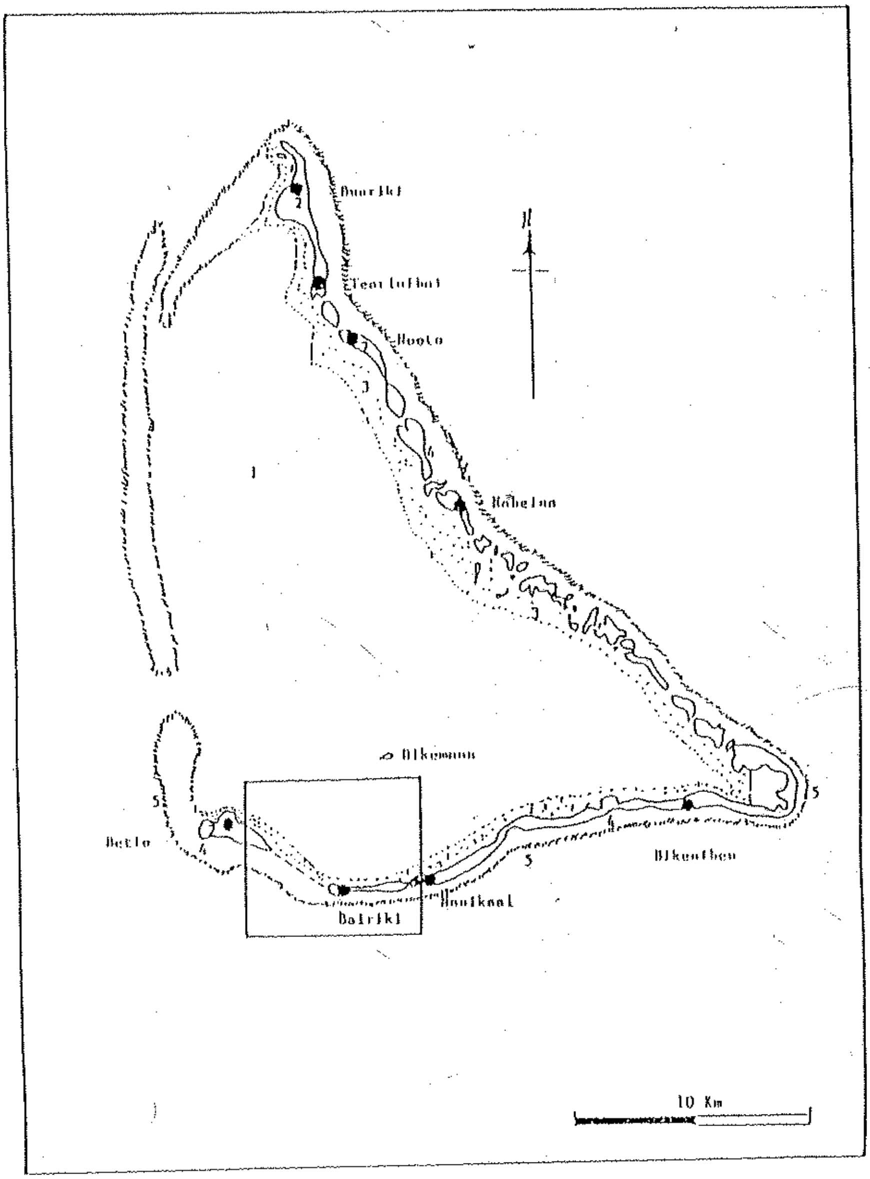

Figure 1. Map of Tarawa Atoll showing the position of a study location. Inset is shown in Figure 2.

Keys:

1. lagoon
2. village
3. mudflat
4. reef platform
5. reef crest

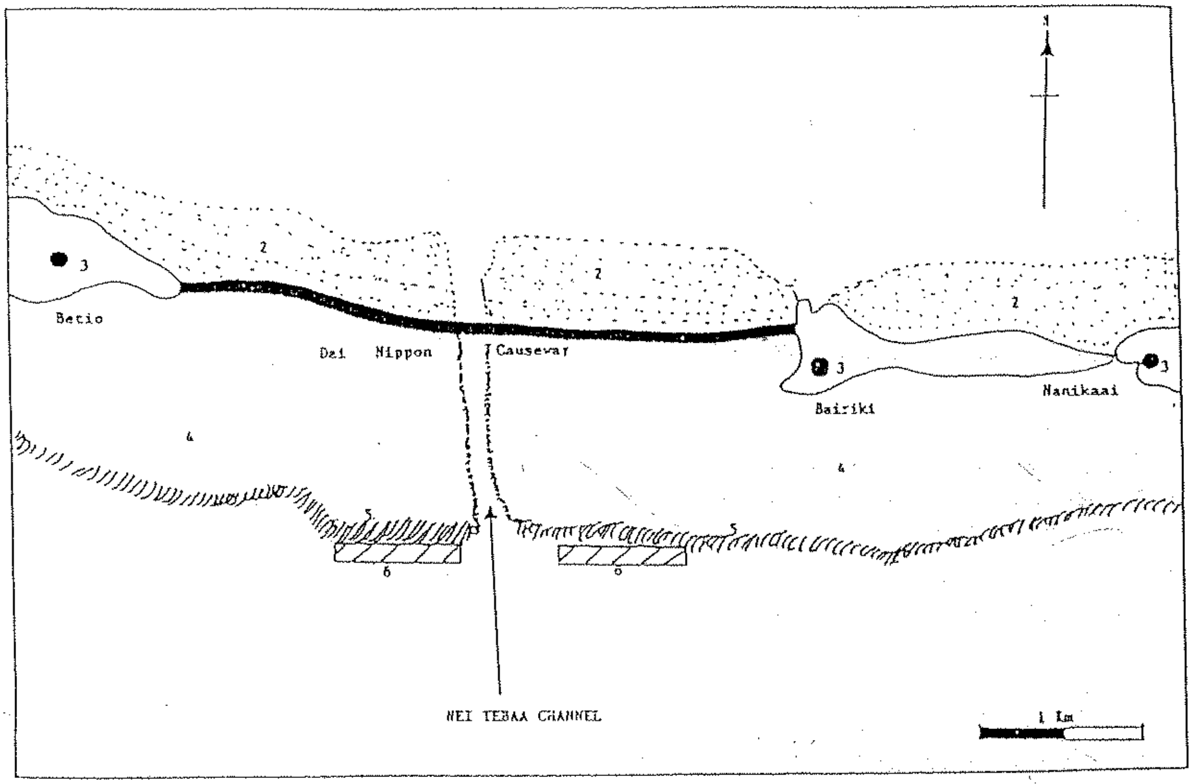

Figure 2. Map of southern end of South Tarawa Atoll showing the position of the Dai Nippon Causeway and Nei Tebaa Channel. The channel was blasted in the reef platform in 1985.

Keys:

1. lagoon
2. mudflat
3. village
4. reef platform
5. reef crest
6. sampling site
7. ocean side

Figure 3. Extraction of ciguatoxin by Southern Fisheries Research Centre, Deception Bay, Brisbane, Australia.

Sample types: liver, viscera, liver/viscera, flesh

Sample extracted with Acetone (2 x 3 : 1 v : w)

Acetone filtered and dried down

Fraction made up to 9 : 1 Methanol : Water then
extracted with Hexane (2 x 1 : 1 v : v)

Methanol : Water dried down

Hexane soluble fraction
stored at -20°C

Fraction made up to 1 : 3 Ethanol : Water then
extracted with Diethyl ether (3 x 1 : 1 v : v)

Diethyl ether dried down
under vacuum and a stream of nitrogen

Water soluble fraction
stored at -20°C

Weighed and stored at -20°C

Toxicity assayed with mice

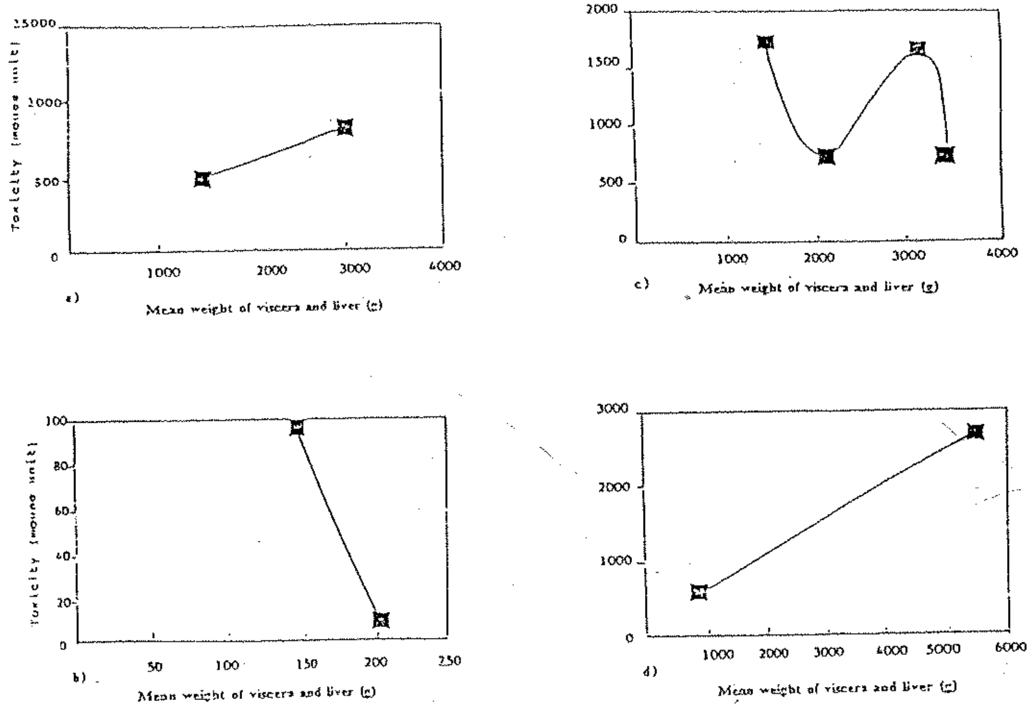

Figure 4. a) Toxicity versus mean viscera/liver weight from eels caught west of Nei Tebaa, Dai Nippon Causeway.

b) Toxicity versus mean viscera/liver weight from eels caught east of Nei Tebaa, Dai Nippon Causeway, Tarawa, Kiribati.

c) Toxicity versus mean viscera/liver weight from *Ctenochaetus striatus* caught east of Nei Tebaa, Dai Nippon Causeway, Tarawa, Kiribati.

d) Toxicity versus viscera/liver weight from eels caught from Nanikaai reef, Tarawa, Kiribati.