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An Ecological Survey of a Toxic Dinoflagellate, *Gambierdiscus toxicus*, and Two Other Related Unicellular Algae in the Fiji Islands

Akio INOUE* and Uday RAJ**

Abstract

The distribution of *Gambierdiscus toxicus*, a toxic dinoflagellate, and two other related unicellular algae, *P. lima* and *O. lenticularis*, was extensively studied in the Fiji Islands. This ciguatera causative organism was commonly found in all the surveyed localities suggesting the possibility of blooms of this organism leading to the intoxication anytime when circumstances become favorable for its growth. It is necessary to closely monitor the environment to prevent or minimize the intoxication.

Introduction

An epibenthic dinoflagellate, *Gambierdiscus toxicus*, is attributed to the causative organism for ciguatera[1)]. This disk-shaped unicellular alga was found in the biodetritus on dead corals in Mangareva Island, French Polynesia[2)]. The toxin production of the organism was recognized in native and cultured individuals of the organism[3)]. The dinoflagellate was found to inhabit the surface of bottom substrates such as benthic macro-algae, dead corals and rocks, and rarely swam in the water in ordinary circumstances. Among macro-algae, *Jania* sp., a tufted calcareous red alga, and *Turbinaria ornata*, a tree-like brown alga, were generally preferable substrates for its growth. The peculiar way of life of *G. toxicus* suggested a simple and practical method to study its population density in the nature as described in an earlier paper[4)]. Adopting this method the population was surveyed in Tahiti and other islands in French Polynesia[5)]. In these ecological surveys several aspects on the distribution of the organism were discovered. Periodic observations showed that the population could fluctuate significantly during a period of a few days. There was a distinct regional variation even within a small locality. More abundant populations were noted on reefs than in lagoons, and in the channels of fringing reefs than in stagnant areas. In this report the authors intend to summarize the results obtained in the Fiji Islands and compare those in other areas.

* Kagoshima University Research Center for the South Pacific, Kagoshima 890, Japan
** Institute of Marine Resources, University of the South Pacific, Suva, Fiji

Methods

The method for ecological survey of *G. toxicus* reported previously[5] was adopted here without any further modifications. A suitable amount (100 – 200g ; wet basis) of benthic macro-algae was put into a plastic bag with about 300 ml of sea water. The bag was shaken vigorously by hands and the suspension was passed successively through sieves having mesh sizes of 250 and 37 μm in this order. The residue retained on the smaller pore-sized sieve was transferred to a vial and diluted to 25 ml or 50 ml depending on the amount of sediment. A 0.5 ml portion of the suspension was then placed on a glass microscopic slide fitted with a frame capable of holding 1 ml of the suspension. The suspension was next diluted to 1 ml with filtered sea water and the *G. toxicus* cells were counted under a microscope. The microscopic observation was repeated at least three times in the same way with other 0.5 ml samples of the suspension. When no *G. toxicus* was found at all by repeated ten times observations, it was concluded that no *G. toxicus* cell were present in the sample. Other two dinoflagellates were treated in the same manner as in *G. toxicus*. The population density of the dinoflagellates was expressed in terms of the number of cells contained in 100 g of the algal sample. Prolonged storage periods resulted in a decrease of the number of dinoflagellates mainly by the degradation of the cells and therefore all the procedures for this survey except microscopic observations were carried out at the sample collection sites if possible.

A brown alga, *T. ornata,* a common species in the shallow waters of the tropical regions, was found to be one of the most favorable substrates for *G. toxicus*. Therefore this alga was selected as a test substrate throughout the survey if available. When this alga was not available a red alga, *Jania* sp., was used instead. If both of these were unavailable, other algae were used. In some sampling localities several kinds of algal species were picked up for comparison of the preferency for the attachment of *G. toxicus*.

Results and Discussion

Collection of samples

Macro-algal samples for the examination of unicellular algae were collected from the 20th to the 26th of January, 1984 in the Fiji Islands. The sampling stations are shown in Fig. 1-Fig. 6. Those stations were selected principally in or around the passages of the coral reefs where *G. toxicus* and other dinoflagellate species were usually found higher number in previous surveys in Tahiti and other islands in French Polynesia. The sampling was carried out at low tide level and submerged macro-algal samples were picked up.

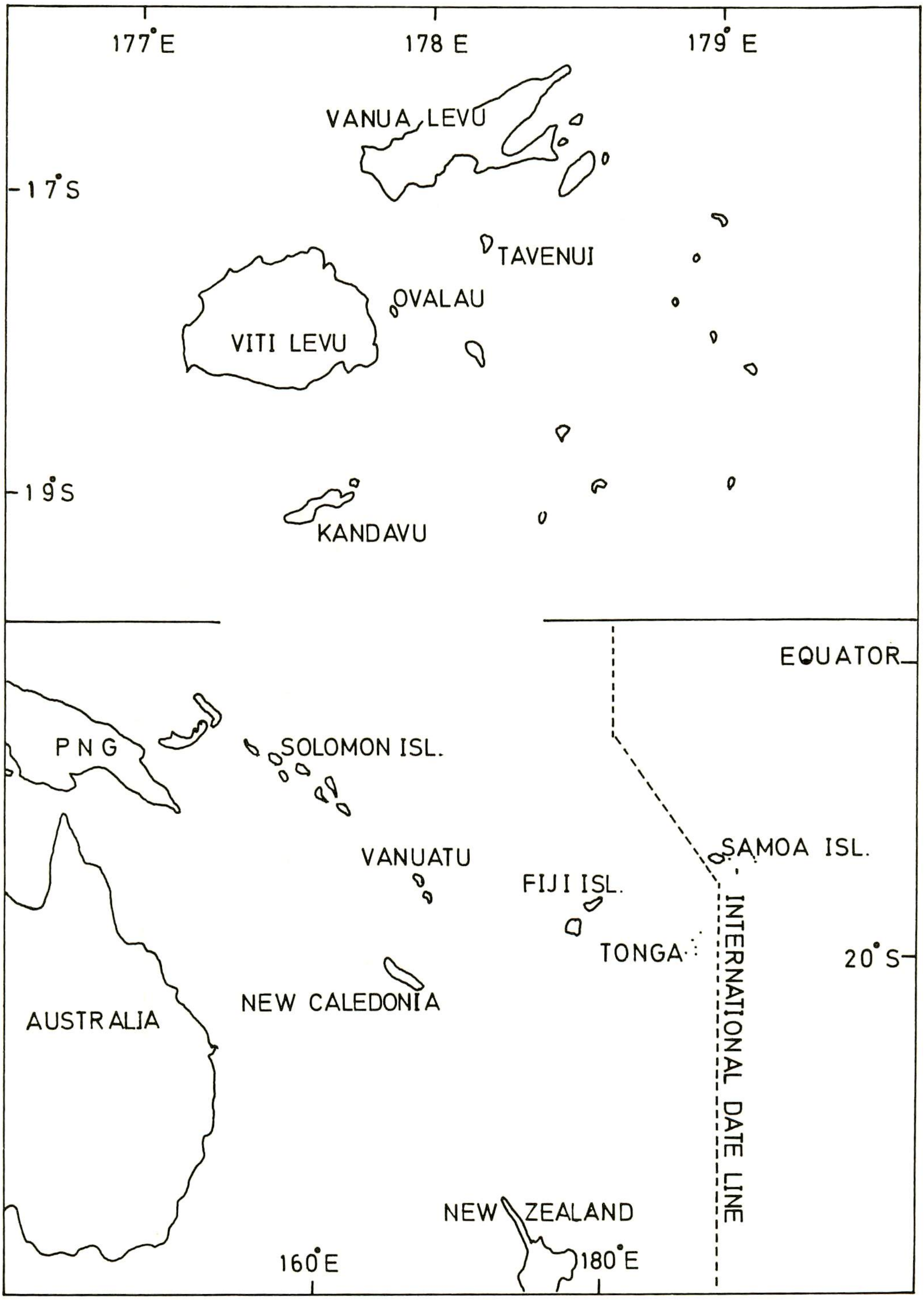

Fig. 1 Fiji Islands

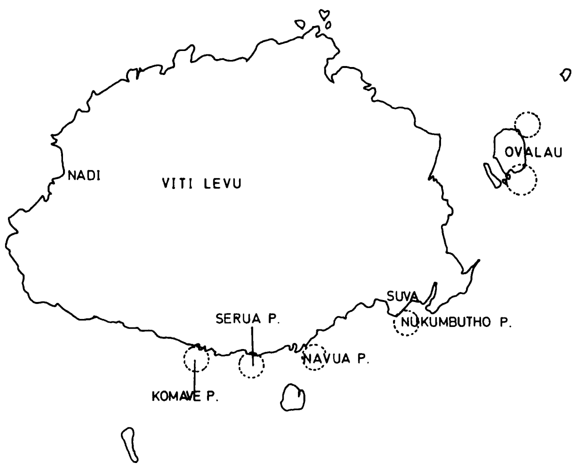

Fig. 2 Sampling stations (○)

Sampling stations

I) Nukumbutho Passage: These stations are located within several kilometers from the Institue of Marine Resources, University of the South Pacific, Suva. Twenty stations were selected on or near the coral reefs. Fourteen stations among those were centered in the Nukumbutho Passage. The flora in that area are comparatively poor and most benthic algae were covered with thin layers of fine granule sediments from the Rewa River. Few attached unicellular algae were found. Fig. 3 shows the stations.

II) Navua Passage: Only one sample, *T. ornata,* was taken for the inspection in the passage.

III) Serua Passge: Thirteen samples were collected here. Algal growth was farely strong and a variety of benthic algae was observed everywhere around the passage. A sandy beach had developed toward the shore where many phanerogams were growing abundantly. The sampling stations are displayed in Fig. 4.

IV) Komave Passage: Benthic algal populations were poor. Domestic drainage from nearby villages flows into the sampling localities untreated. Therefore localized water pollution was observed in some stagnant areas. The sampling stations in this passage are shown in Fig. 5.

V) Ovalau Island: On the coral reefs surrounding the island nine sampling stations were fixed. St. 1-St. 5 were on one extremity of the reef facing the open sea. These stations, St. 6 to St. 8, were chosen in the passage which is the main entrance to Levuka port. St. 9 is on the sand beach near a reef where very poor growth of bethic algae was recognized.

Results

The toxic organism, *Gambierdiscus toxicus,* was found in all the localities examined. The number or the population density of the organism was comparatively low even when it was found. The other two unicellular algae, *Prorocentrum lima* and

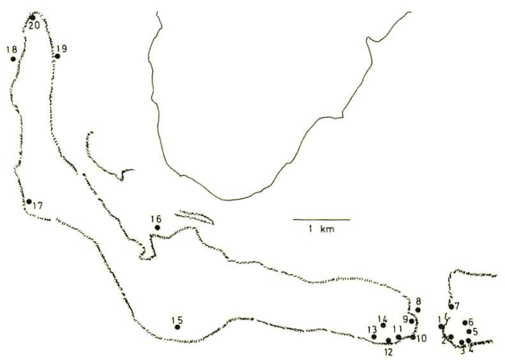

Fig. 3 Sampling stations (Nukumbutho Passage)

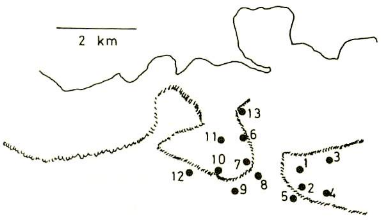

Fig. 4 Sampling stations (Serua Passage)

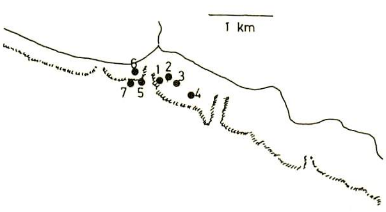

Fig. 5 Sampling stations (Komave Passage)

Ostreopsis lenticularis, were also commonly found in the samples. However their numbers as well as other unicellular species did not exceed those of French Polynesia. It depends partly on the sediments covering the surface of the benthic Macro-algae which disturb the attachments of micro-algal individuals on them. Most samples prepared for microscopic examination contained much silty sediments.

I) Nukumbutho Passage : Only thirteen samples were found to have *G. toxicus* among 49 examined. The highest number of the organism was observed in the sample from St. 10 which is located at the passage at a depth of about 1 m. There were no *G. toxicus* observed in the samples of ten stations. Because of the low population density of the organism, its preferential substrates among the different macro-algal species were not determined conclusively. The results obtained are shown in Table 1. In St. 7, where no *G. toxicus* were found using the method described in this survey, a more intensive search was carried out using about 500 g of *T. ornata*. The result showed the existence of the organism. Thus it is thought that this area has also the potential to be the site of ciguatera.

II) Navua Passage : No *G. toxicus* cell was found in the sample treated by the method

Table 2. Distribution of *G. toxicus* and other two unicellular algae in Nukubutho Passage, Viti Levu.

Sampling Station	Algal Species	Number of Cells		
		G. toxicus	P. lima	O. lent
1	T. ornata	4	0	0
2	T. ornata	1	1	3
	Mixed algae	2	0	0
	Jania sp.	2	3	0
3	T. ornata	0	0	0
	Jania sp.	0	0	0
4	T. ornata	0	0	0
	Mixed algae	0	0	0
	Jania sp.	0	0	0
5	T. ornata	0	0	9
	Jania sp.	0	0	0
6	T. ornata	1	0	1
	Jania sp.	1	0	0
7	T. ornata	0	0	0
8	T. ornata	0	0	0
	Jania sp.	0	0	0
9	T. ornata	0	0	0
	Jania sp.	2	2	2
10	T. ornata	11	0	0
	Jania sp.	2	2	4
11	Mixed algae	0	0	0
12	Mixed algae	0	0	0
	Dictyosphaeria sp.	0	0	0
13	Mixed algae	0	0	0
	Jania sp.	0	0	0
14	T. ornata	1	1	1
	Jania sp.	0	0	0
15	T. ornata	0	0	0
	Jania sp.	0	0	0
	Colpomenia sp.	0	0	1
	Galaxaura sp.	0	0	0
	Padina sp.	1	1	1
16	T. ornata	0	0	0
	Jania sp.	0	0	0
	Padina sp.	0	0	0
	Halimeda sp.	1	0	0
17	T. ornata	1	5	7
	Jania sp.	0	0	0
	Galaxaura sp.	0	0	0
	Padina sp.	0	0	0
18	T. ornata	0	0	0
	Jania sp.	0	0	0
	Padina sp.	0	0	0
19	T. ornata	0	0	0
	Jania sp.	0	0	0
	Galaxaura sp.	0	0	0
20	T. ornata	0	0	0
	Jania sp.	0	0	0
	Padina sp.	0	4	1

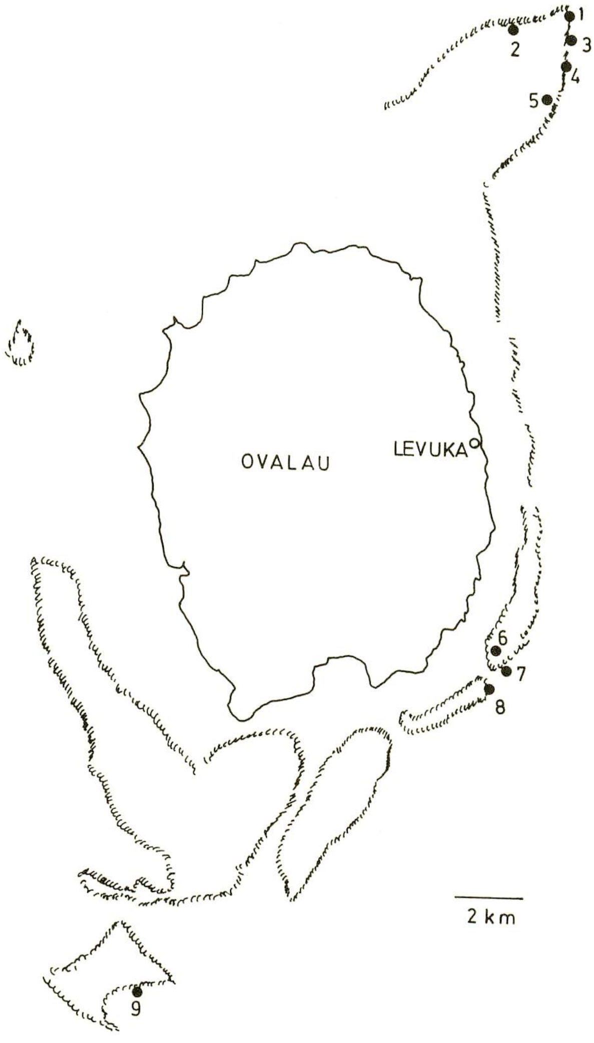

Fig. 6 Sampling stations (Ovalau Isl.)

described previously, nor were *P. lima* and *O. lenticularis* detected.

III) Serua Passage: Twenty three benthic algal samples were collected from 13 stations. *T. ornata* was one of the most common macro-algae around the passage. In a sample taken at St. 6, the largest number of *G. toxicus*, 21 cells per 100 g of substrate alga, was recorded. Except those samples listed in Table 2, small red algae were taken on the dead corals on which some surgeon fishes were observed to feed. This sample contained 129 cells of *G. toxicus* per 100 g.

Table 2. Distribution of *G. toxicus* and other two unicellular algae in Serua Passage, Viti Levu

Sampling Station	Algal Species	Number of Cells		
		G. toxicus	P. lima	O. lent.
1	T. ornata	3	5	2
2	T. ornata	8	0	0
	Jania sp.	11	1	1
	Laurencia sp.	0	0	0
3	T. ornata	0	0	0
	Jania sp.	0	7	9
4	T. ornata	2	1	2
	Jania sp.	2	2	2
5	Gigartina sp.	0	1	0
6	T. ornata	21	0	93
	Jania sp.	5	4	81
	Sargassum sp.	0	0	0
7	T. ornata	0	0	0
	Jania sp.	3	0	0
8	T. ornata	0	0	0
	Jania sp.	0	0	0
9	T. ornata	0	0	0
	Jania sp.	11	0	0
10	T. ornata	0	0	0
	Jania sp.	3	0	5
11	T. ornata	0	0	0
12	T. ornata	8	0	9
13	Galaxaura sp.	5	0	0

IV) Komave passage ; The largest number for the entire survey was recorded in a sample taken at St. 5. The results are shown in Table 3. The population density in other samples was of ordinary level.

V) Ovalau Island : *T. ornanata* was not observed growing around a light house erected on the reefs of St. 1-St. 5. Among those samples collected here only one sample contained *G. toxicus*. The passage where the samples from St. 1-St. 5 were gathered was reputed to be toxic by the inhabitants of the island. Four out of five samples investigated here contained toxic organism. St. 9 was on the protruded coral reefs from Leluvia Island, one cell was noted in a mixed algal prparation.

Discussion

The distribution of *G. toxicus* was investigated in the Fiji islands. At the same time the population density of two other unicellular species, *P. lima* and *O. lenticularis,*

Table 3. Distribution of *G. toxicus* and other two unicellular algae in Komave Passage, Viti Levu

Sampling Station	Algal Species	Number of Cells		
		G. toxicus	P. lima	O. lent
1	T. ornata	1	1	9
	Jania sp.	3	14	92
2	T. ornata	2	0	0
	Jania sp.	4	0	0
3	T. ornata	0	0	0
	Jania sp.	0	8	0
4	Padina sp.	0	8	4
	Galaxaura	0	0	0
5	T. ornata	102	4	2
	Sargassum sp.	9	12	9
6	T. ornata	0	0	0
	Laurencia sp.	0	0	0
7	T. ornata	6	0	8

Table 4. Distribution of *G. toxicus* and other two unicellular algae in Ovalau Island.

Sampling Station	Algal Species	Number of Cells		
		G. toxicus	P. lima	O. lent.
1	Jania sp.	0	0	0
	Dictyota sp.	0	0	0
	Halimeda sp.	0	0	0
2	Jania sp.	0	0	0
	Halimeda sp.	0	0	0
3	Jania sp.	3	0	0
4	Halimeda sp.	0	0	0
5	Jania sp.	0	0	0
6	Jania sp.	33	2	6
7	T. ornata	2	2	2
	Jania sp.	2	2	2
8	T. ornata	0	0	0
	Jania sp.	7	3	9
9	T. ornata	0	0	0
	Jania sp.	0	0	0
	Mixed algae	1	0	0

was surveyed. The former species was confirmed to contain a different kind of toxin from that of *G. toxicus*[6]. The latter, on the other hand, was one of the most common dinoflagellates on the surface of benthic macro-algae in tropical regions and is very similar to *G. toxicus* in shape and size which leads to the confusion of these two species. As for the ecological survey of ciguatera causative organism, *G. toxicus* might be only one target for the study. But when we think of the potentiality of the intoxication occurrences, we must know other information at the same time. Thus the distribution of the other two unialgal species migth give us more useful knowledge.

Throughout the survey a low population density of epibenthic micro-algae was observed. One main reason for the poor growth might be the organic and inorganic detritus covering the benthic algal surfaces. Most samples collected were observed to contain a high quantity of sediments on their surfaces. Such sediments prevent of the attachment of unicellular organisms. Additionally the attached individuals might be suffocated by such coverings. A few samples had less or unrecognizable amounts of sediments.

The maximum growth of *G. toxicus* was noted in a sample taken at St. 5 at Komave passage, Viti Levu Island, at 102 cells per 100 g of substrate algae. This is ordinary level when compared with Tahiti and far less than that found in the Mangareva Island in French Polynesia. Thus it is thought that the situation during the survey was not critical as far as inducing the ciguatera. But it was also suggested the possibility that all the districts investigated were potentially toxic. Continuous efforts for the prevention of ciguatera intoxication can not be neglected.

Environmental factors, such as inorganic nutrients, salinity, temperature, water soluble vitamin and others were not considered in this survey. The understanding of these factors is necessary to better predict and minimize the effect of a *G. toxicus* bloom.

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