HARMFUL AND TOXIC ALGAL BLOOMS

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Edited by

TAKESHI YASUMOTO
YASUKATSU OSHIMA
Department of Applied Biological Chemistry
Faculty of Agriculture, Tohoku University
Tsutsumi-dori Amamiyamachi, Aoba-ku, Sendai 981, Japan

and

YASUWO FUKUYO
Asian Natural Environmental Science Center
The University of Tokyo
Yayoi, Bunkyo-ku, Tokyo 113, Japan

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NOTE ON THE OCCURRENCE OF PYRODINIUM BAHAMENSE IN EASTERN INDONESIAN WATERS

N. N. WIADNYANA*, T. SIDABUTAR*, K. MATSUOKA**, T. OCHI***, M. KODAMA****
AND Y. FUKUYO*****

*Research and Development Centre for Oceanology (LPII), Poka Ambon 97233 Indonesia; **Faculty of Liberal Arts, Nagasaki University, 1-14 Bunkyo-Machi, Nagasaki 852 Japan; ***Marine Environment Research Station, Faculty of Agriculture, Kagawa University, 4511-12 Takasago, Aji-Cho, Kita-Gun Kagawa-Ken 761-01 Japan; ****School of Fisheries Sciences, Kitasato University, Okirai, Sanriku, Iwate 022-01 Japan; *****Centre for Asian Natural Environmental Sciences, University of Tokyo, 1-1-1 Yayoi, Bunkyo-Ku, Tokyo 113 Japan

ABSTRACT

The search for possible harmful algal bloom organisms in the eastern waters of Indonesia finally has shown results in the form of identification of P. bahamense var. compressum in several locations, such as Ambon Bay, Ceram and north Irian Jaya waters. In Kao Bay this toxic dinoflagellate bloomed in March 1994 changing the water to a brownish-red. In July 1994 in Ambon, three children died and 33 other people showed paralytic shellfish poisoning (PSP) symptoms after consuming shellfish (Hiatula chinensis) collected from Ambon Bay. This incident occurred coinciding with the presence of P. bahamense var. compressum in the bay at numbers varying from 0.4 to 1.6 x 10^3 cells L^{-1}. Therefore, it is suspected that the PSP outbreak was caused by toxin released by Pyrodinium. In Ceram and north Irian Jaya waters Pyrodinium was detected in low concentrations and no PSP incident has been reported. The dinoflagellate was found in areas near mangrove swamps. The result suggests that Pyrodinium distributes in wider areas than expected and monitoring of its occurrence in Indonesian waters is necessary to prevent damaging effects of PSP produced organisms.

INTRODUCTION

The Indo-West Pacific region is susceptible to Pyrodinium red tides [1]. A number of countries in this region were affected by this dinoflagellate, which causes paralytic shellfish poisoning. In Indonesia, several PSP incidents have been reported by Aman [2], but no causative organisms were recorded. Although P. bahamense var. compressum was suspected to be responsible for those incidents, the presence of Pyrodinium was unknown until 1994 when this dinoflagellate was identified to be causative organism for the red tides in Kao Bay, North Moluccas [3]. Since then intensive monitoring activities were conducted at several locations to study in the geographical distribution. This paper is intended to provide current information on the distribution of this toxic dinoflagellate in east Indonesian waters.

MATERIALS AND METHODS

The study was carried out from March 1994 to February 1995, covering water of Kao Bay, Ambon Bay, Piru Bay, Elpaputh Bay, Cenderawasih Bay, Sorong water, and waters adjacent to Biak water (Fig. 1).

During a red tide outbreak in March 1994, a survey was conducted in Kao Bay to collect plankton samples and measure several environmental parameters, i.e. temperature, salinity, dissolved oxygen, phosphate and nitrate. Besides net samples, additional plankton samples were obtained using Van Dorn bottles. The later samples were preserved in Lugol’s iodine solution. Similar field surveys were carried out at other locations, such as Ambon Bay (July 1994), Piru Bay and Elpaputh Bay (July-August 1994), Sorong (August-September 1994 and January-February 1995), Biak (August-September 1994), and Cenderawasih Bay (January-February 1995).

Plankton samples from Kao Bay and Ambon Bay were collected by horizontal haul at the sea surface using a fitoplankton net equipped with a flowmeter. While plankton samples from Piru Bay, Elpaputh Bay, Sorong, Biak and Cenderawasih Bay were obtained by vertical hauls from 100 m to the surface with the same net. All plankton samples were preserved in 4% formalin.

Fig. 1. Study site of Pyrodinium: 1-Kao Bay; 2-Ambon Bay; 3-Piru Bay; 4-Elpaputh Bay; 5-Sorong water; 6-Biak water; and 7-Cenderawasih Bay.
Phosphate and nitrate concentrations were measured by methods described by Strickland and Parsons [4]. Salinities were measured using salinometers and water temperatures were obtained from inverse thermometers fitted in Nansen bottles. Dissolved oxygen was measured using Winkler method. Phytoplankton cells were counted under an inverted microscope.

RESULTS AND DISCUSSION

The occurrence of *P. bahamense* var. *compressum* (Fig. 2) was recognized in several east Indonesian waters (Fig. 3). Except in Kao and Ambon Bays, no PSP case occurred in the other locations.

Fig. 2. Specimen of *P. bahamense* var. *compressum* from Kao Bay.

**Kao Bay**

The first record of a bloom of *P. bahamense* var. *compressum* was in March 1994, coincided with a red-brown colour discolouration. Plankton concentration of this red tide organism obtained from Van Dorn's samples was 0.8 - 2.3 x 10^6 cells l^-1. These values are lower than the in Manila Bay where 7.0 x 10^6 cells l^-1 occurred [5]. These values were much higher than those obtained from net plankton samples reported previously in 1994 [3] with differences of 2 orders of magnitude. This indicates that plankton net sampling would give an under estimation of concentration while phytoplankton population appears in high density.

The bloom appeared off Malifut. On the period of March the wind tends to blow from northerly directions, the bloom might spread the *Pyrodinium* to the inner bay.

Hydrological conditions at the bloom occurrence were characterized by relatively high temperature (30.9 - 31.5 °C), low salinity (29.2 - 30.1), low phosphate content (0.32 - 0.35 µg-at-P l^-1) and moderate nitrate concentration (0.91 - 1.18 µg-at-N l^-1). In fact, the water mass off Malifut is known as a fertile area enriched by mangrove swamps. Wiadnyana [6] obtained relatively high phosphate and nitrate concentrations during the period of January. There, the climate changed frequently, followed by heavy rain fall and strong sunshine. These climatic and hydrological conditions might play an important role to trigger the bloom of this dinoflagellate. A recent study proves the existence of *Pyrodinium* cysts in sediments from these locations (Unpubl. data). This suggest that this bloom of dinoflagellate might come from the germination of cysts sedimented in the bay, brought up in the water column by local upwelling or earth quake effect. In the area it occurred relatively strong earth quake about 6 weeks before the bloom occurrence.

The discovery of *Pyrodinium* red tide organisms in Kao Bay could help to describe clearly the events of water discolouration phenomena, observed frequently by local people since 1930's. Information acquired from them describes that there were initially several victims of poisoning. However, no complete data were available quantitatively. Fortunately, most of the local people understand that red water is dangerous, and they avoid to consume sea food during certain periods of red water appearance, particularly mussels or other bivalves found in the area probably intoxicated by this toxic organism.

**Ambon Bay**

At location, no bloom of *Pyrodinium* has been recorded until 1994. However, a tragedy occurred on 21 - 22 July 1994 at a village of Inner Ambon Bay, where three childrens (5 - 7 years old) were died and 33 persons got sick. They consumed mussels (*Haustula chinensis*) mixed with oysters, collected in an area of Inner Ambon Bay. From observation by the family of victims, we know that the symptom suffered was similar to PSP with initially burning sensation of lips and face and followed by the present of weakness, malaise, dizziness, difficulty of movement (paralysis).

Although there was no further analysis of PSP toxins in the foods consumed and plankton found in adjacent to the village, the occurrence of the toxic dinoflagellate, *P. bahamense* var. *compressum*, might be responsible for the tragedy on July 1994. At locations nearby Latta's Village where the tragedy happened, *Pyrodinium*, occurred during these times with concentrations of 0.4 to 1.6 x 10^3 cells l^-1 (1 to 41 % of total cells). The maximum concentration obtained is classified as dense [6] and might represents an important source for toxin contents both in the plankton and the mussels [5].

There are several villages on the landward side of the semi-enclosed Inner Ambon Bay. It appears that only one village (Latta) was affected by the *Pyrodinium*. In fact, *Pyrodinium* population seems spread in the water adjacent of this village and did not reach a red tide density. During this period (July),
precipitation was generally high due to the east monsoon (24.6 - 26.5 °C) and salinity (30.5 - 32.0). Phosphate and nutrient contents were on average, 0.64 μg-at-P 1⁻¹ and 1.30 μg-at-N 1⁻¹. These environmental conditions seem to be slightly different of Kao Bay, however, this difference is not sufficient to explain, why the blooms of this red tide organism did not occur in the locations. Recent information indicates the existence of *Pyrodinium* cysts in sediments of Inner Ambon Bay (Unpubl. data). Results suggest that these *Pyrodinium* cysts might be source of the bloom in Ambon Bay and the water environments of the bay should be monitored, to avoid and mitigate human health impacts, caused by this toxic dinoflagellate.

*Ceram waters*

There are two locations surveyed during July and August 1994; i.e: Piru Bay and Elpaputh Bay. These bays are open to the Banda Sea and some of the landward sides are occupied by mangrove swamps. The number of *Pyrodinium* cells found ranged from <1 to 17 cells l⁻¹ (1 to 39 %) in Piru Bay and <1 cells l⁻¹ (3 % of total phytoplankton cells) in Elpaputh Bay. Their concentrations at these two locations are relatively low. Since the survey was conducted at only one time, a bloom of *Pyrodinium* was not observed. A water mass of homogeneous depth layering (0 - 100 m) in Piru Bay was characterized by relatively low temperature (21.4 - 25.8 °C), high salinity (34.21 - 34.48), moderate concentration of dissolved oxygen (2.85 - 4.62 ml l⁻¹) and phosphate (0.14 - 1.99 μg-at-P 1⁻¹), and relatively high nitrate concentration (0.53 - 32.82 μg-at-N 1⁻¹). While the condition of water mass of Elpaputh Bay was almost similar to Piru Bay, except for water temperatures that showed higher variation (17.2 - 28.3 °C).

The occurrence of *Pyrodinium* in Piru Bay and Elpaputh Bay was in waters near mangrove forests that spread along the coast of east Piru Bay and around Samahu Village of Elpaputh Bay. These bays seem have similar environmental conditions as in Kao Bay, particularly the occurrence of mangrove swamps. Then, the question posed is, whether the bloom of *Pyrodinium* will occur in Piru and/or in Elpaputh Bay. The answer is depend on the existence of cysts of *Pyrodinium* and also the possibility of *Pyrodinium* motile cells coming from other areas.

**North Irian Jaya water and Adjacent**

Northern Irian Jaya waters are related to the southern Pacific Ocean. In these areas, three locations were surveyed; i.e: Sorong, Biak and Cenderawasih Bay. Except in Biak, landwards of these locations are also occupied by dense mangrove swamps.

During two periods (August - September 1994 and January - February 1995) of the survey in Sorong water, *Pyrodinium* was always found in the samples of several stations. Cell numbers varied from < 1 to 14 cells l⁻¹ (1.2 to 12.1 %) and < 1 to 1.3 cells l⁻¹ (0.1 - 0.3 %) for the period August - September 1994 and January - February 1995, respectively.

Both water temperature and salinity in the homogeneous depth layer during two periods seemed to be relatively high. The values were 20.0 - 28.5 °C and 32.20 - 35.00 for temperature and salinity. Dissolved oxygen contents were moderately (3.02 - 4.54 mg l⁻¹), while the nutrient concentrations were relatively low (0.33 - 2.91 μg-at-P 1⁻¹ for phosphate and 0.06 - 10.10 μg-at-N 1⁻¹ for nitrate).

Cell numbers at two other locations; i.e: Biak water and Cenderawasih Bay, surveyed on the August - September 1994 and January - February 1995, respectively ranged from < 1 to 42 cells l⁻¹ (0.2 to 5.8 %) and < 1 cells l⁻¹ (0.1 % of total cells).

Water temperature was high and seemed to be slightly higher than that of Sorong water (20.7 - 30.0 °C). Other parameters such as salinity, dissolved oxygen, phosphate and nitrate, were moderately and almost similar to Sorong water.

The existence of *Pyrodinium* in Irian Jaya water and Adjacent, might be related to *Pyrodinium* population from other locations such as Papua New Guinea (PNG), Philippines or Brunei Darussalam and Sabah (Malaysia). These locations have been known to be affected by *P. bahamense* var. *compressum* [1]. Maclean described that in PNG waters, harmful blooms of *P. bahamense* var. *compressum* were first found in 1972 and at several times later. The same red tide organisms were discovered first time in Brunei, in 1976 and in the Philippines, in 1983. Several major outbreaks occurred there until 1981 in Brunei-Sabah and 1989 in the Philippines. The widespread distribution of this toxic dinoflagellate towards Irian Jaya waters might be strongly influenced by the water mass movements happened in these areas. Wyrki [7] described the water exchange within the southern Pacific Ocean, including northern Irian Jaya coasts. During the western monsoon period (December - February), currents from North Equatorial flow through the Philippines waters - Sulu Sea - Makassar Strait - Java Sea - Flores Sea - Banda Sea - Arauira Sea. While during eastern monsoon period (July - August), currents from North Equatorial flow through Papua New Guinean waters - along north coast of Irian Jaya (Biak water and Cenderawasih Bay) - Sorong water - Arauira Sea - Banda Sea.

In many cases the blooms of *P. bahamense* var. *compressum* may cause calamity for humans regardless the origin of this population. Therefore, the need of basic research activities would be very necessary to prevent and mitigate economic losses, the poisoning of the victims and environmental impacts. The investigations proposed must include the monitoring of
the geographical distribution in Indonesian waters and bloom dynamics as well as the amounts and types of toxins produced by this red tide organism.

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REFERENCE


Fig. 3. Distribution of *P. bahamense* var. *compressum* in Kao Bay (1), Ambon Bay (2), Piru Bay (3), Elpaputh Bay (4), Sorong water (SA) period of August-September 1994 and SB period of January-February 1995, waters adjacent to Biak (6) and Cenderawasih Bay (7).