Interaction Between *Chattonella* and Bacteria and Prevention of this Red Tide

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In the Sea of Harima, the situation of proliferation of *Chattonella* is fluctuating with the period of about 5 years. The mechanism of this fluctuating is expressed to this report. Certain bacteria promoted the proliferation of *Chattonella*. And other bacteria inhibitted the proliferation. The situation of proliferation of *Chattonella* was controlled by these bacteria. The bacteria that parasitizes *Chattonella antiqua* and muders it was isolated. This bacteria was able to utilize *C. antiqua* as the nutrients for proliferation.

The situation of proliferation of Chattonella is shown in Fig.1. The maximum values of the Chattonella's concentrations that were observed in each year is plotted as the measure of the proliferation of Chattonella. These values fluctuated with the period of about 5 years. A large scale red tide of Chattonella occurred in the Sea of Harima in 1972.

The relation between this fluctuation and communities and characteristics of bacteria was studied.

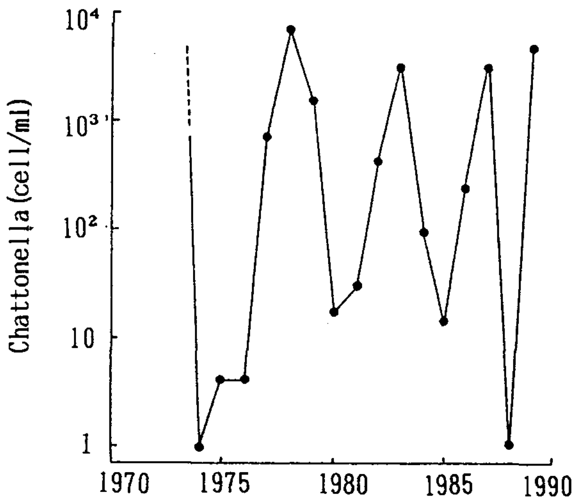

Fig. 1 Fluctuation of the growth of Chattonella in the Sea of Harima.

Methods

We investigated the Sea of Harima with 2 times a week from June through August. C.antiqua was incubated in the sea water that was withdrawn and the situation of the proliferation was observed.

Sea water was filtered with 0.2um filter or 1.2 um filter. Sea water was sterilized by former. By latter plankton was eliminated from the sea water. Raw sea water and the sea water that were processed like this were enriched by addition of inorganic nutrients(these were abridged in SW1, SW2 and SW3 individually). These sea waters were inoculated with C.antiqua and incubated.

Raw sea water and SW3 were incubated and proliferation of aboriginal phytoplankton was observed.

Results and discussion

In 1982 Chattonella proliferated in some degree. The situation of proliferation of Chattonella in this year is shown in Fig.2. The range of values of Chattonella's concentration every a day of survey were protted. Chattonella appeared in middle of June. It increased from the first ten days of July and decreased from after August on.

The situations of proliferation of C.antiqua in SW1, SW2 and SW3 are shown in Fig.3.

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In SW2 and SW3 from the sea water that was withdrawn in July in the Sea of Harima, (at this time, Chattonella was increasing in the sea), C. antiqua that was inoculated in to these sea waters grew well. In SW3, C. antiqua predominated over other aboriginal species of phytoplankton in interspecific competition and proliferated preferentially. In SW2, although

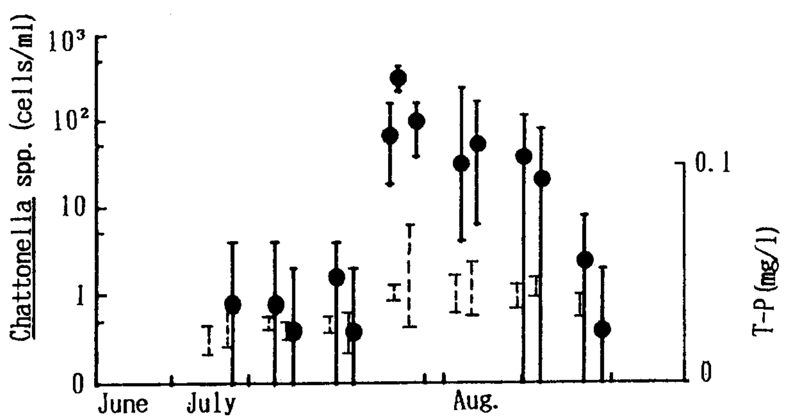

Fig. 2 The situation of proliferation of Chattonella in 1982 in the Sea of Harima.
Chattonella —●— T-P ----

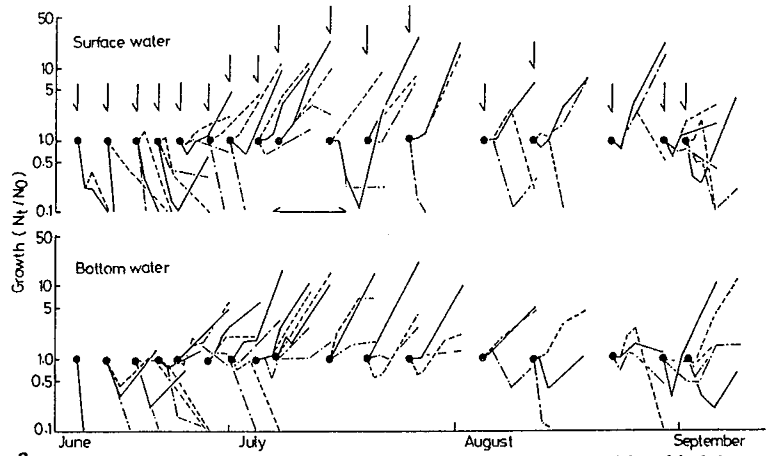

Fig. 3 Growth curves of inoculated *C. antiqua* in the sea water with added inorganic nutrients: (—·—) filtered by a 0.22 μm bore filter for sterilization, (——) filtered by a 1.2 μm bore filter for remove of plankton, (·······) raw sea water. (↓) sea water used was taken and (●) beginning of cultivation. (←→) cultivation time: 10 days.

only inorganic nutrients were added to the sea water, bacteria and C. antiqua grew well. C. antiqua and bacteria supplemented the deficient nutrients (vitamin B_{12} for C. antiqua and some organic matter for bacteria) each other and they grew. Mutualistic interactions have been found to exist between C. antiqua and bacteria. Under these condition, when raw sea water and enriched raw sea water (SW3) were incubated aborignal Skeletonema costatum and Chattonella proliferated at both case (in Fig. 4). In raw sea water, S. costatum and Chattonella proliferated well for 3days. In after the proliferation of phytoplankton suspended, because nutrients were exhausted. Phytoplankton in SW3 did an action similar to those in raw sea water for 3 days. In after the 3rd day other phytoplankton suspended growth but Chattonella proliferated well. Finally only Chattonella existed. Both symbionts in the Chattonella -bacteria association received nutritional benefit from the mutualism. Under these condition, if the concentrations of nitrogen and phosphorus were high Chattonella and the symbiotic partner amplified the benefit from the mutualism and Chattonella grew preferentially.

In the other hand, in SW3 from the sea water that was withdrawn in August (at this time, Chattonella was decreasing in the sea), C. antiqua was not able to proliferate. Chattonella was not able to proliferate in SW2 and SW3 form the sea water that was withdrawn at the sea that Chattonella was disappearing. These difference do not originate in a difference of a nutrition condition or physical condition because we incubated on equal these terms.

In SW1, situation of proliferation of C. antiqua did not show a regular trend.

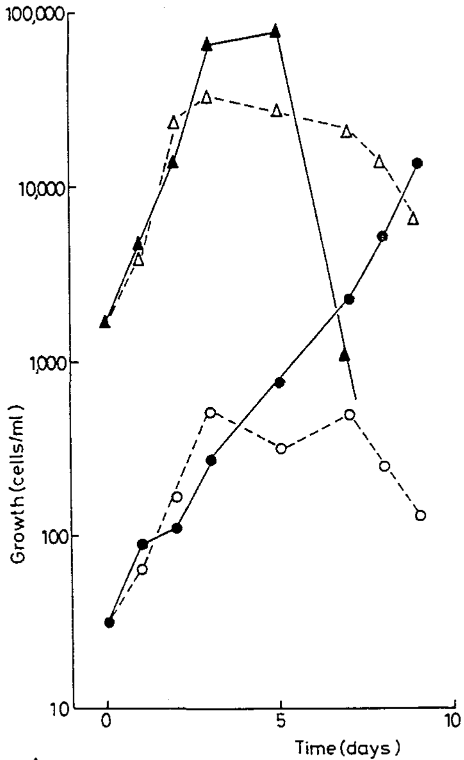

Fig. 4 Growth of aboriginal phytoplankton in the sea water which was taken at sampling station (26 July 1982).
Chattonella spp.: (○) raw, (●) nutrients added.
S. costatum : (△) raw, (▲) nutrients added.

In 1985, Chattonella did not proliferated over 20 cells/ml in the sea of Harima. SW1, SW2 and SW3 from the sea water that was withdrawn on July 9th were inoculated with C. antiqua and S. costatum or C. antiqua were incubated. The results are shown in Fig. 5. The withdrawn sea water seemed to contain vitamins. In SW1, C. antiqua proliferated well on either case. In SW2, C. antiqua proliferated well like in SW1 in early period of incubation. However, C. antiqua sharply perished halfway of incubation. Extent of inhibition of C. antiqua's proliferation was biggest in SW3 and that decrease in order of co-cultivation C. antiqua with S. costatum in SW2 and uni-algal cultivation of C. antiqua in SW2.

On the other hand, S. costatum proliferated well at all cases. The bacteria that murder C. antiqua was isolated from this SW2. This bacteria did not grow on usual medium (rich growth mediums and oligotrophic mediums). We isolated the bacteria with the plate that was prepared with autolyzed C. antiqua as a substrate. A photograph of this bacteria is shown as Fig. 6. This bacteria that adhered to C. antiqua is shown in Fig. 7. This bacteria was able to utilize C. antiqua as a substrate for proliferation.

There wasn't correlation between the situation of proliferation of Chattonella and rise of water temperature or change of salinity. There weren't the correlations between the situation and fluctuation of other items of water quality too. The fluctuation of Chattonella's concentration in the sea was mutually related to only the results of incubation.

These show that influence of aboriginal bacteria on the interspecific competition exerted to the proliferation of Chattonella in the sea. It was estimated that these interactions are causes that the situation of proliferation of Chattonella fluctuates in the sea.

Summary

The situation of proliferation of Chattonella fluctuates with the period of about 5 years in the Sea of Harima is well-known. We examined about the causes of this fluctuation. The following results were obtained.

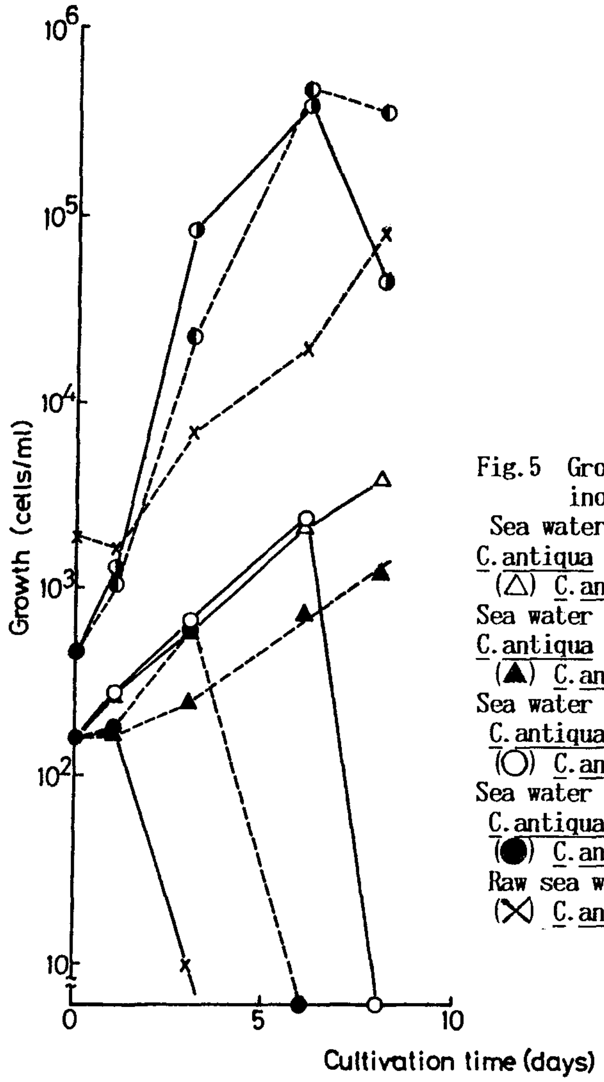

Fig. 5 Growth of C. antiqua in the sea water with added inorganic nutrients.
Sea water was passed through a 0.22um-filter
C. antiqua was inoculated
(△) C. antiqua (cells/ml)
Sea water was passed through a 0.22um-filter.
C. antiqua and S. costatum were inoculated
(▲) C. antiqua (cells/ml) (◐) S. costatum (cells/ml)
Sea water was passed through a 1.2um-filter.
C. antiqua was inoculated
(○) C. antiqua (cells/ml)
Sea water was passed through a 1.2um-filter.
C. antiqua and S. costatum were inoculated
(●) C. antiqua (cells/ml) (◑) S. costatum (cells/ml)
Raw sea water. C. antiqua was inoculated
(✕) C. antiqua (cells/ml) (✕) S. costatum (cells/ml)

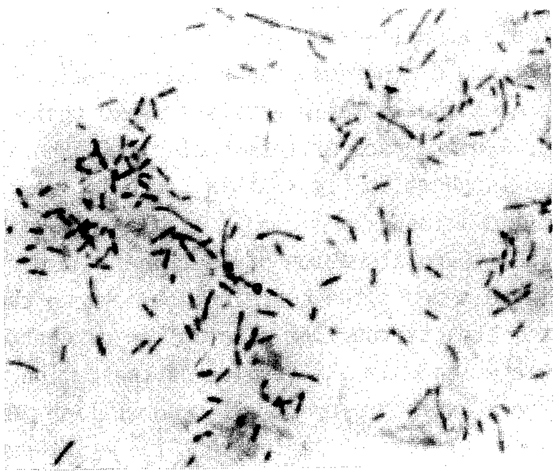

Fig. 6 The parasitic bacteria to Chattonella

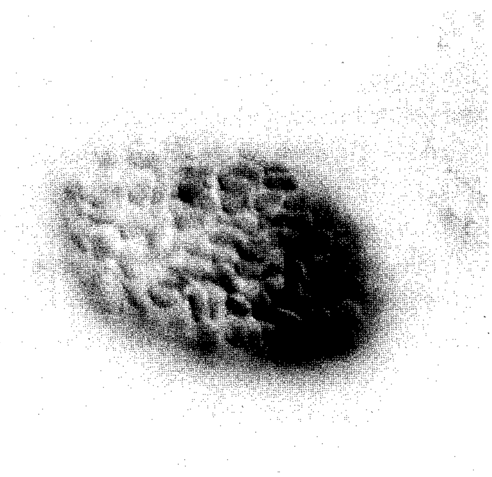

Fig. 7 The bacteria that adhered to C. antiqua

The bacteria that advance the growth of Chattonella and the bacteria that inhibit the growth live in the sea. The former proliferated together with Chattonella. When this bacteria existed Chattonella became a predominant organism in interspecific competition among phytoplankton. Chattonella was parasitized by the latter. When this bacteria lived in the sea Chattonella was not able to proliferate. The bacteria that murder C.antiqua was isolated. This bacteria was able to utilize C.antiqua as the nutrients for proliferation.

There is currently great interest in the utilization of the mechanism that the proliferation of Chattonella was controlled by bacteria for prevention of the red tide.

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