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Changing seawater temperature effects on giant clams bleaching, Mannai Island, Rayong province, Thailand

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ABSTRACT
In this study, we recorded the effect of changing sea water temperatures on two species of giant clams at Mannai Island, Rayong province. Surveys were carried out between November 2009 and September 2010. The study site was located at a distance of 100m from the shore had a total area of 200m^2. We used a data logger to measure the water temperature at 1m and 5m depths (reef flat and reef slope, respectively). During this study, 12 individuals of *T. squamosa* and 117 of *T. crocea* were observed. The clams' shell lengths varied from 20.0 to 35.0cm and from 0.6 to 13.5cm, respectively. The changes in seawater temperature fluctuated between 28.8 – 31.1 ºC during the study. The first bleaching event was recorded in April with 60% of individuals showing faded coloration, 30% partly bleached and 10% bleached completely. In May, bleaching became more severe with 90% completely bleached, 8% partly bleached and just 2% remaining with faded coloring. In June, the temperature began decreasing (below 30ºC on average). Finally, we found that 40 %of the giant clams had died and started becoming re-colored in August. The overview of this study, since exposure to temperatures over 30ºC for longer than two weeks could result in the expulsion of the symbiotic living zooxanthallae. Such a process was considered to have a direct impact on the giant clam's survival. Moreover, the giant clam located in shallow waters has shown the ability to re-color.

***KEYWORDS*: Giant Clams, *Tridacnasquamosa*, *Tridacnacrocea*, bleaching, zooxanthellae**

INTRODUCTION

Giant clams are classified as the bivalves of shallow, coral reefs (Indo-Pacific Tropical and Subtropical Zone) (Braley, 1992). According to the list of species protected under Thai Law, giant clams are one of the most endangered clam species and are protected by conservation measures in Thailand. There are 8 species of giant clams existing throughout the world. These are *Tridacnagigas*, *T.derasa*, *T.maxima*, *T.squamosa*, *T. crocea*, *H. porcellanus*, *H. hippopus* and *T. tevoroa*. (Kittiwattanawong, et al.,2001). Five species have been reported living in Thai waters although presently, only three species of *T.crocea*, *T.squamosa* and *T.maxima* (Nugranad, 1997) have been observed.

Giant clams live in symbiosis with the photosynthetic algae (zooxanthellae) that live in their fleshy, prominent mantle. While zooxanthelle produce mainly complex sugars, they can also produce amino acids and fatty acids, a portion of which are released through the algal cell wall directly into the bloodstream of the clam (Stephen CJ, 1976; Svane, 1996 and Jantzen, C., et al., 2008). As both an autotrophic and heterotrophic organism, giant clams have a nutritional advantage over other mollusks but this symbiotic relationship could also make these clams more vulnerable if the relationship between host and algae is damaged (E. Blidberg et al., 2000).

The presence of zooxanthellae in their mantle is responsible for the clams' vivid colorations. Zooxanthellae densities and genetic makeup can affect giant clam resistance against changing environmental conditions (Rowan and Knowlton, 1995). According to Fitt and Warner's studies in 1995, some corals, after acquiring new algae species, show more resistance when facing higher temperatures and light intensities. Different zooxanthellae also contribute to different growth rates among clams. As reported by Ukkrit in 1997, an 1-3 °C increase in water temperatures is one of the key contributing factors inducing coral bleaching. Moreover, other environmental factors such as sedimentation, lack of nutrients, decreased salinity, changes in tide water level and the presence of pathogens all contribute to the local bleaching of corals (Kleppel et al, 1989; Iglesias et al, 1992).

Coral bleaching in Andaman Sea coastal areas, reported in 1991 and 1995, affected the coral reefs of Phuket Island, the Similan Islands and the Surin Islands. The 1998 bleaching occurrence in the Gulf of Thailand was concluded as being the result of the 1997 El Niño weather pattern. The phenomenon brought about extreme weather conditions right across the earth, which led to coral bleaching occurring in many regions (Vipoosit, 1998). According to reports from 1980 – 1990, coral bleaching in many areas is directly related to rising water temperatures and mainly occurs among reefs existing at greater depths (Williams et al, 1990).

Rising sea temperatures cause higher mortality in giant clams and coral animals, which could consequently lead to collapses of the ecosystem and decreased biodiversity. This study attempted to use the bleaching condition in giant clams to provide an indicator for changes in seawater temperatures.

MATERIALS AND METHODS

Study area

In the gulf of Thailand, two species of giant clams (*Tridacnasquamosa* and *Tridacnacrocea)* have been found. The study area is located on the western port of Mannai Island, Rayong province, Thailand (Fig 1). Surveys were carried out from November 2009 to September 2010. We surveyed the area by SCUBA diving and through use of the belt transect method within a 100 x 2m (200 m^2) measured area along the shore profile. The species and abundance of giant clams were recorded. Physical changes of the clams were noted and recorded photographically.

Data loggers

To record measurements of the seawater temperatures, we used a data logger (model HOBO pendant Temp/light) to measure the water temperature at depths of 1m (reef flat) and 5m (reef slope).

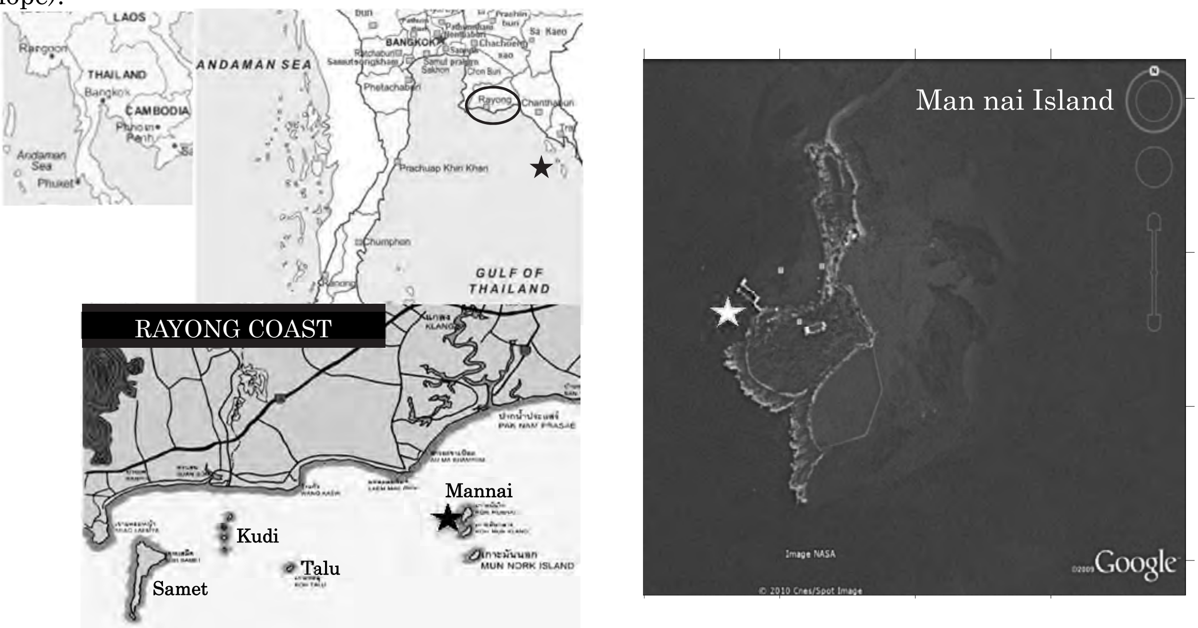

Fig.1 Study area: Mannai Island, Rayong Province, Thailand.

RESULTS

Giant clam distribution and diversity

From the survey carried out along the western coast of Mannai island, within the 200 m^2 study area, two species of giant clams were found. 12 individuals of *Tridacnasquamosa*, each with a shell length variation of 20.0–35.0cm and 117 individuals of *T. crocea,* with shell lengths from 0.6–13.5cms were recorded. The mantle colors of the giant clam were usually green, blue, purple, brown or orange. *T. squamosa* has been observed to have brown, yellow or purple mantle color. Their distribution was recorded from 0.5–5.0m in depth, along the coral reef habited by

Poriteslutea.

The distribution of *T.crocea* was found buried deeply in both living and dead coral, especially on the stony coral of genus *Poriteslutea,* in relatively shallow waters near living reefs. *T.squamosa* was living almost on sand and was either attached or unattached to small pieces of substrate at a water depth exceeding 2m on average. (Fig.2)

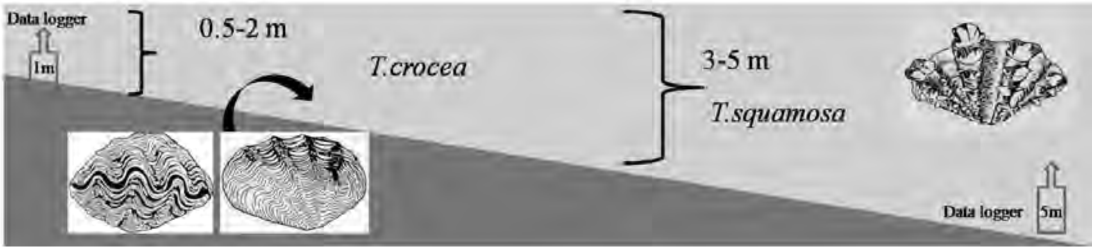

Fig.2 Diagram of the giant clam distribution of water depth at 1 and 5 meters

How changes in water temperature effect giant clam bleaching

Seawater temperatures were recorded using data loggers from November, 2009 to September, 2010. There was little difference evident between the reef flat and reef slope areas, as seen in Fig.3. As a result, the water temperatures increased from an average of 28.7°C in November 2009, to over 30°C in February 2010.

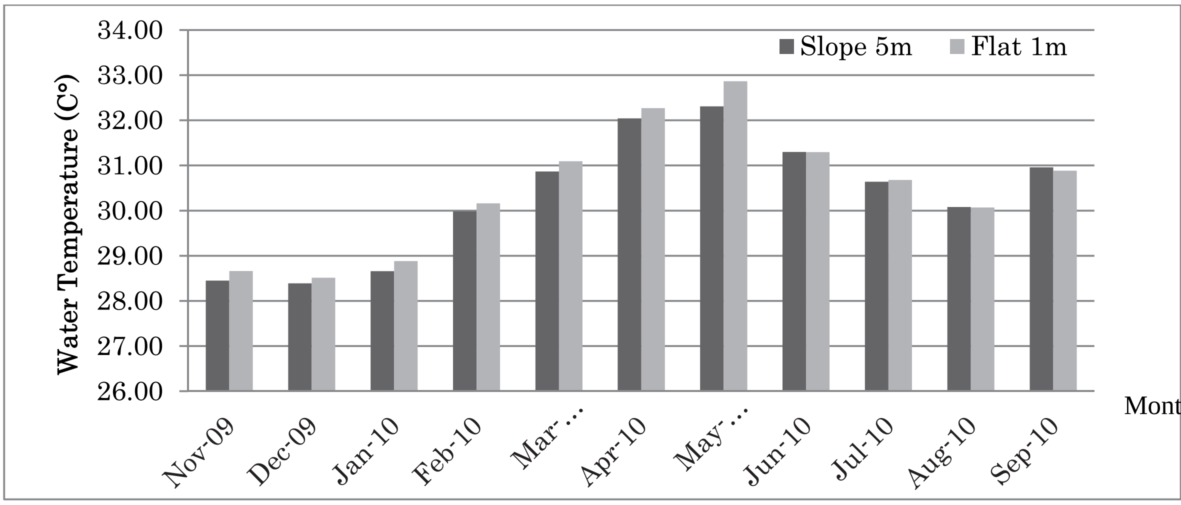

Fig.3 The changing sea water temperatures at depths of 1m (reef flat) and 5m (reef slope) from November, 2009 to September, 2010, Mannai Island, Rayong.

Bleaching of giant clams was first observed occurring in April, 2010. Initially, 60% of the clams were experiencing faded coloration, 30% were partly and 10% were completely bleached. Later in May, bleaching became more severe as 90% of the clams became completely bleached, 8% were partially bleached and only 2% were left with some coloring. In June 2010, the temperature began decreasing (below 30ºC on average). Finally, we found that 40% of dead giant clams started to show re-coloration in August. (Table.1)

Table.1: Data of percentages showing the bleaching of, dead and recovered giant clams.

Species	*Tridacnasquamosa*	*Tridacnacrocea*
Individuals per 200m^2	12	117
Size (cm)	20.0-35.0	0.6-13.5
Bleaching (%)	100	84
Dead (%)	67	60
Recovered (%)	33	40

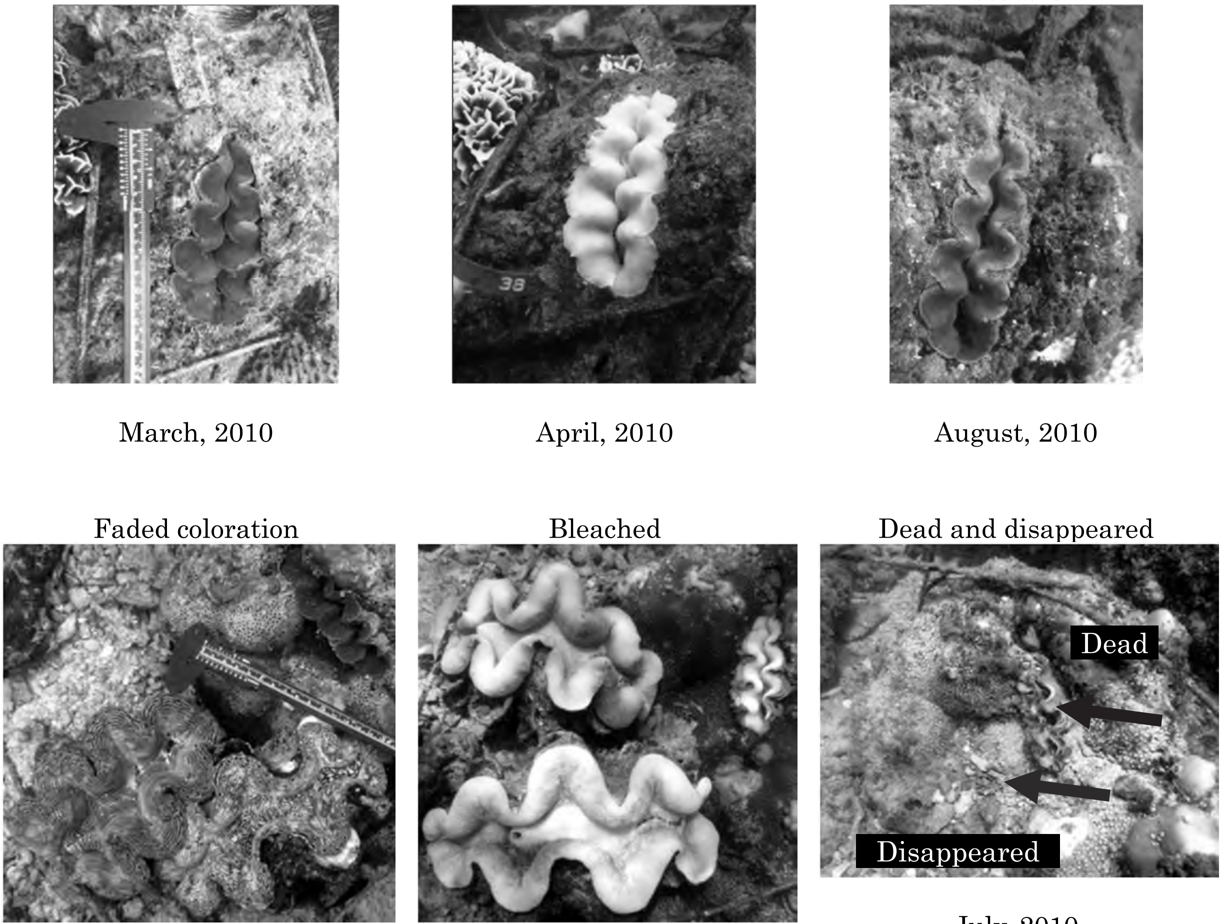

Fig.4 Bleaching in giant clams: *T.crocea* has almost recovered and some examples of *T.squmosa which* have died or disappeared.

DISCUSSION

The results show the existence of an abundance of *T.crocea* with 0.12 inds./m^2. Munanunsap (1997) reported that the density of giant clams at Mannai Island was 0.87 inds.m^2, which indicates a decline in giant clam numbers. Giant clams have often been overfished, but they grow fast and can be successfully farmed. Almost all of the *T.squamosa* found in Mannai Island waters came from restocking programs.

The seawater temperature at Mannai Island increased to over 30°C in February, 2010. Normally, seawater temperatures in southeastern Asia average around 28–30°C (Kastoro et al, 1999). However, the water temperatures from our study were higher, which presumably resulted in the bleaching of giant clams. Since the temperature exceeding 30°C, first observed in April 2010, can cause the enzymes participating in photosynthetic reaction to cease functioning, this can result in a lack of available oxygen and the accumulation of waste products in the mantle. The clam would respond by expulsing the zooxanthellae from its tissue so as to reduce its metabolism. Thus, the bleaching begins (Ukkrit, 1997; Iglesias et al, 1992; Klumpp, D.W, et,al., 1994). In addition to this, the critical temperatures which induce the photosynthetic performance can be altered and physiological disadvantages can affect clams' growth and/or reproduction. (Gomez and Mingoa-Licuanan, 1998)

According to the observations included in this study, bleached giant clams had become slower to respond to external disturbances. This could be seen as an adaptation to preserve energy. When bleaching events occur, the number of algae in the mantle tissue will decrease by 60–90%.As the source of pigment concentration, this leads to the loss of color, either from a reduction in zooxanthellae density and/or from the decreased concentration of photosynthetic pigments in the algal cells (Gates et al. 1992, Brown 1997). This may lead to eventual death for the giant clams, caused by food deficiency (Kleppel et al., 1989; Svane, 1996; Glynn, 1996).

Furthermore, some of the recorded animals did not show any sign of bleaching and the giant clams located in shallow waters have shown the ability to re-color. Presumably, the resilience of the host is dependent on the differences in zooxanthellae species (Rowan and Knowlton, 1995). Recent work on corals has shown that the greater resistance to high temperatures and irradiation of certain zooxanthellae taxa is indicative that resistance to bleaching may be a property of the zooxanthellae and not the animal (Fitt and Warner, 1995).

The majority of giant clams became completely bleached during May, 2010. The average sea temperature at the time was 32.6°C with a maximum of 34.3°C. This was relatively higher when compared with the 32.5°C recorded in Vipoosit's study of Si-Chang Island in the same month of 1998. In any case, with reference to the statistic from 1987-1997, Thailand's sea temperature reached an average of 30.6°C, while the Chonburi coastal water temperature was 32.3°C (Pollution Control Department, 1999).

Regarding the NASA Goddard institute for Space Studies surface temperature analysis conducted until 2009, the average sea temperature of the southern hemisphere over the past century (2000 – 2009) had become higher when compared to records from the previous 30 years. Likewise, there is a potential trend which could see global seawater temperatures increase by 0.2°C every 10 years. Additionally, the El Niño – La Niña cycle is also responsible for the rise in temperature every 2 years (www.giss.nasa.gov.com, 2010).

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