

THE COPPER AND REDUCED SALINITY EFFECTS ON METABOLISM OF HERMATYPIC CORAL *Fungia* sp

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ABSTRACT

The research determined the physiological responses in *Fungia* sp that's exposed to combination of copper presence and reduced salinity for 12 h. The changes of primary production rate per chlorophyll-a and respiration per surface area were used to determine the stress occur. The results showed that no significant on the respiration rate in any of treatments between treatments or compared with control. Corals exposed to 10 $\mu\text{g.l}^{-1}$ copper to reduced salinity were unaffected and did not affect the production rate. Coppers exposed to 30 $\mu\text{g.l}^{-1}$ copper, reduced salinity, and combination of two stressors significantly decreased the production rate of *Fungia* sp.

Keywords : Copper, salinity, *Fungia* sp

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INTRODUCTION

Coral reef has been subjected to various study parameters which related to the increasing stress on tropical marine environment from any sources such as perturbation (Hughes and Connell, 1999), destructive fishing and pollution (Nystrom *et al*, 2000), or even human utilization (fishing and tourism) (Paine *et al*, 1998). Every single stress may has severe damage on coral; various stressors may greater negative effect by generating synergic effects, such as coral recovery after an extreme low tide event was severely hampered by chronic oil pollution affecting on both reproduction and settlement (Loya, 1990). Since it has been proved that reef building depend on the symbiotic dinoflagellates (zooxanthellae), which generate effects of coral on a community level (Brown, 1997; Hughes and Connell, 1999).

Copper is an essential heavy metal element which is also known as a common marine pollutant with a significant negative effect for marine biota (Dubinsky and Stambler, 1996; Jones, 1997a). Copper could affect coral by inhibiting the electron transfer in photosystem II (Samson *et al*, 1988) and also incorporated in the skeleton making the coral fragile and thus become more sensitive to physical actions (Howard and Brown, 1984). In the other hand, the effect of copper could be reduced by the presence of symbiotic marine algae zooxanthellae, which have a high tolerance for heavy metals (Muller-Parker and D'Elia, 1997) and event prepare more binding site for heavy metal ion uptake mechanism (Howard and Brown, 1984). Nystrom *et al* (1997) showed that the metabolism of corals *Pocillipora damicornis* and *Porites lutea* were significantly affected when exposed with 10 $\mu\text{g.l}^{-1}$ of copper.

Fungia sp was the most common scleractinian coral genera and frequently

present in area with high loads of terrigenous or ballistic sediments, such as Lampung Bay (Tomascik *et al.*, 1997). The *Fungia* sp found in habitat with characteristic of protected turbid coastal waters, where reduced light levels are the primary limiting factor. Because of them, *Fungia* sp may use to be a bioindicator for environmental specific purpose.

The inner Lampung Gulf has been exposed with pollutant material for at least two decades. Large amounts of freshwater load to the gulf via nine major rivers and might cause occasional drops in salinity. The initial heavy metal measurement levels showed that copper ranging between 0.42 and 10.51 $\mu\text{g.l}^{-1}$. The effects of combined disturbances might not too simply. The research aim was to determine the physiological effects of copper and salinity simultaneously on hermatypic coral *Fungia* sp. The physiological response was determined by measure the changing in net production and respiration, which is a sub-lethal approach where stress responses could be detected within hours.

MATERIALS AND METHODS

Coral Sampling

This research was conducted during June and July 2006, at Mari-culture Station Hanura, South Lampung. Coral community was collected from Marine Protected Area (MPA) on Sebesi Island, South Lampung. Corals *Fungia* sp were collected at 5 m depth by scuba diving and transported to an outdoor facility. The corals were kept in a large flow-through tank (300 l) in 2 (two) days with continuous aeration before exposure.

Treatments

Specimens were placed in exposure tank (60 l) for 12 h over night before the start of physiological measurements. The treatments were **I**: 30 psu (ambient), **II**: 20 psu, **III**: 10 $\mu\text{g.l}^{-1}$ copper in 30 psu, **IV**: 10 $\mu\text{g.l}^{-1}$ copper in 20 psu, and **V**: 30 $\mu\text{g.l}^{-1}$ copper in 30 psu, and **VI**: 30 $\mu\text{g.l}^{-1}$ copper in 20 psu. Copper ions were derived from a main stock solution of CuSO_4 . The number of replicates for each exposure was 8 for the production and chlorophyll measurements.

The specimens were put in individual transparent airtight experimental containers (± 5 l), equipped with submersible pumps ($\varnothing 40$ mm, capacity 200 min^{-1}) which containing water from exposure tank. The pumps were running during measurements and for 5 s every 15 min to build water movement in order to prevent oxygen gradients from building up in the container.

A one way ANOVA was carried out to ensure that the data did not differ between days. Analysis of variance was performed in order to evaluate the observed differences in net production, respiration, and chlorophyll level between treatments. The net production per chlorophyll a data was transformed with the square root. A posteriori test were made with Tukey HSD for equal sample size.

Physiological measurements

Net production was measured between 11:00 am and 13:00 pm. The experimental containers were placed in a cooling tank to avoid temperature abuse during production measurements. Observation showed an average increase of ± 1.5 $^{\circ}\text{C}$ during the measurements. The light intensity was approximately equal to the habitat at 5 m depth. The experimental

containers were placed in non-transparent tanks for respiration observations.

Chlorophyll-a analysis

The living polyp surface area of each replicate was determined using the aluminium foil method (Marsh, 1970). A small fragment (5 cm²) was removed from each coral replicate and mortared. Chlorophyll-a was extracted in 7 ml of 90% acetone for 24 h. The samples were centrifuged at 3500 rpm for 15 min and acclimatized to room temperature for 30 min to avoid condensation in spectrophotometer. Absorption was measured at 75, 664, and 630 nm with a 90% acetone solution serving as blank (Parsons *et al*, 1984). In order to ensure that all of chlorophyll a had been extracted, a second extraction was performed on samples. The result showed that less than 4‰ of the

chlorophyll a was un-extracted, thus one extraction was sufficiently accurate.

RESULTS AND DISCUSSION

Effects of copper and salinity on respiration rate

The result showed that no significant changes in respiration rate per surface area were detected in any treatments (compared with controls) and even between treatments (Figure 1). The physiological measurements showed that salinity had no significant effect on the respiration rate. Moberg *et al* (1997) found that no effect on respiration per biomass when salinity was reduced from 30 to 20 psu.

Table 1. Statistical comparison of net production per chlorophyll-a

Treatment (µg Cu ²⁺ : psu)	Chl-a (µg chl-a.cm ⁻²)	Net Chl-a (µgO ₂ .µgChl-a ⁻¹ .h ⁻¹)	N	Statistical result						
					I	II	III	IV	V	VI
0 : 30	28.2	1.32	10	I	-	*	NS	NS	**	**
0 : 20	31.5	0.67	12	II	*	-	NS	*	NS	NS
10 :30	30.7	1.08	12	III	NS	NS	-	NS	**	**
10 : 20	25.7	1.23	15	IV	NS	*	NS	-	**	**
30 : 30	31.5	0.47	14	V	**	NS	**	**	-	NS
30 : 30	30.6	0.48	12	VI	**	NS	**	**	NS	-

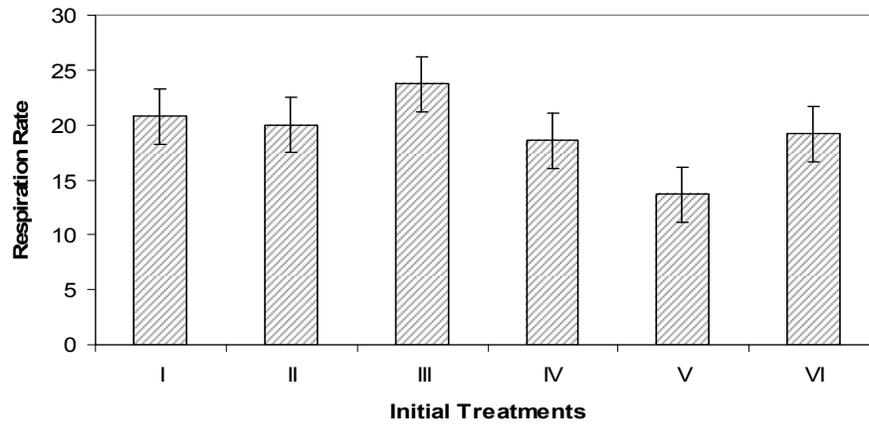


Fig 1. Respiration rate (unit describes in, $\mu\text{g O}_2.\text{cm}^{-2}.\text{h}^{-1}$)

Long term exposure may cause respiration decreasing. Ferrier-Pages *et al* (1999) demonstrated reduced respiration rate after minor changes in salinity on *Stylophora pistillata*. The current research result showed too that neither of the two copper concentrations had any significant effect on the respiration rate as well as copper primarily effects the photosynthesis activity on *Fungia* sp.

Effects of copper and reduced salinity on chlorophyll a concentration

Zooxanthellae have a greater ability to accumulate heavy metal than their host. Their expulsion was a response system to heavy metal absence in coral and suggested as a kind of mechanism to control heavy metal concentration in symbiotic animal (Peter *et al.*, 1997). Discoloration was occur during the experiments, especially in those exposed to a combination of $30 \mu\text{g.l}^{-1}$ copper and reduced salinity and ambient salinity. It looks that the higher dose of copper may cause discoloration. Figure 2 showed that treatment I has a significantly higher production rate than II, V, and VI treatments.

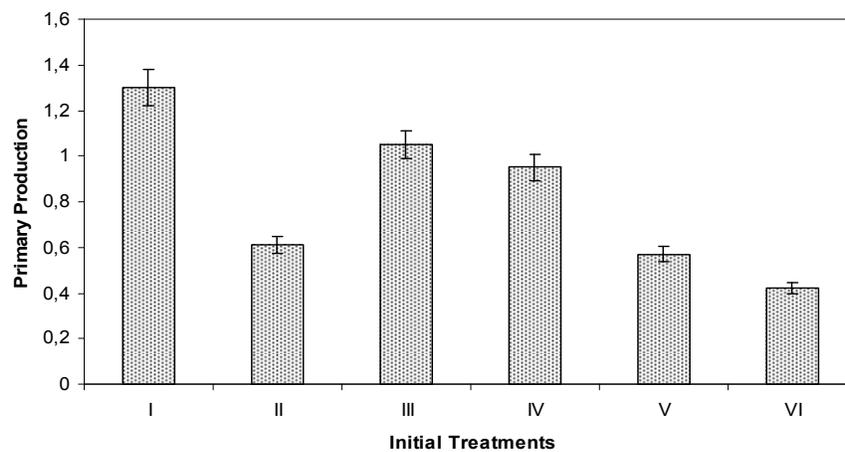


Fig 2. The rate of net primary production per chlorophyll-a (unit describes in, $\mu\text{gO}_2.\mu\text{gChl-a}^{-1}.\text{h}^{-1}$)

Treatment III was significant higher than V and VI treatments. Those results showed that no significant loss of chlorophyll-a despite the observed color loss in biota tested exposed with copper. It suggested that the discoloration of coral exposed to copper could be due to a contraction of coral polyps exposing the white naked skeleton (Brown *et al.*, 1984). The alternative mechanism was remaining symbionts might increase their production of Zooxanthellae chlorophyll-a (Jones, 1997b).

Effects of copper and salinity on net production per chlorophyll a

The post hoc tests showed that net production rate was significantly reduced in coral exposed to 20 psu, 30 $\mu\text{g.l}^{-1}$ copper in 30 psu, and 30 $\mu\text{g.l}^{-1}$ copper in 20 psu which compared with control. Coral exposed to 30 $\mu\text{g.l}^{-1}$ copper in 30 psu had significantly lower production rate compared with those exposed to 10 $\mu\text{g.l}^{-1}$ copper in 30 psu. Coral exposed to 10 $\mu\text{g.l}^{-1}$ copper in 20 psu had higher production rate than those exposed to 30 $\mu\text{g.l}^{-1}$ copper in 20 psu. Those indicated that net production was significantly difference between treatments (Figure 2 and Table 1).

The osmoregulatory mechanism of hermatypic coral may be able to cope with reduced salinity by behavioral responses to minimize exposure with media. This implies hampered photosynthesis due to less light available for the symbiotic algae. The result showed no discoloration in coral exposed to 20 psu there was a significant reduction in production rate.

Copper directly affected photosynthesis by electron transport inhibition on the oxidizing side of photosystem II (Samson *et al.*, 1988). The result showed that exposure to the higher copper concentration significantly reduced net production per chlorophyll a, whereas corals exposed to the lower copper concentration remained unaffected. In the other hand, salinity decreasing indirectly reduced production. The treatment of 10 $\mu\text{g.l}^{-1}$ copper in ambient

salinity did not generate any change in net production while reduced salinity and 30 $\mu\text{g.l}^{-1}$ copper in ambient salinity lead to significantly decreased production rate. The unexpected combination result showed that 10 $\mu\text{g.l}^{-1}$ and 20 psu did not affect the production rate indicating an antagonistic effect. The combination of increased salinity and temperature was less stressful to corals than exposure to elevated temperature alone (Porter *et al.*, 1999).

CONCLUSION

The physiological measurements showed that salinity had no significant effect on the respiration rate. The two copper concentrations tested had no significant effect on the respiration rate as well as copper primarily effects the photosynthesis activity on *Fungia*. There was no significant loss of chlorophyll-a despite the observed color loss in biota tested exposed with copper. The result showed that exposure to the higher copper concentration significantly reduced net production per chlorophyll a, whereas corals exposed to the lower copper concentration remained unaffected. In the other hand, salinity decreasing indirectly reduced production.

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