

Short Term Growth Rate of *Acropora downingi* in the Coral Reef of Hengam Island, the Persian Gulf

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Received: February 2012

Accepted: May 2012

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Abstract

In the Persian Gulf, *Acropora*-dominated coral reefs have been damaged by global and local disturbances. Inversion of coral colonies mostly occur due to anchoring and fishing in many coral reefs, particularly those established nearby human societies, like the coral reef of Hengam Island, in the Persian Gulf. The short term growth rates (weight increment) of inversely and normally transplanted colony fragments of *Acropora downingi*, the dominant species of the coral reef of Hengam Island, were compared in autumn 2011. Transplants showed self-attachment to substrates after a few weeks. Our results showed sub-normal growth rate of inversely transplanted fragments and provided some basic knowledge about the growth rate of *A. downingi* in a coral reef with a high benthic coverage during a medium thermal season.

Keywords: *Anchor damage, Cable tie, Colonial inversion, Transplantation, Weighting*

1. Introduction

Scleractinian corals of the Persian Gulf exist in the most extreme environment with regard to high summer and low winter temperatures (about 36-16°C, respectively) and high salinities of greater than 38 psu (Kleypas et al., 1999; Sheppard et al., 2010). Mass bleaching events followed by extensive mortalities have been reported from some coral reefs of the Persian Gulf, particularly in hot summers (Riegl, 2003; Riegl et al., 2011). These suggest that thermal tolerant coral reefs of the Persian Gulf may be damaged by global warming in the future. In the

Persian Gulf, coral reefs are also disturbed locally by oil pollution, breakwater construction, sedimentation caused by coastal developments, dredging, ornamental fishing, extensive anchor damage and discharge of nutrients and sewages (Maghsoudlou et al., 2008). As a consequence of global and local stressors many coral reefs have been disturbed or degraded in the Persian Gulf. Therefore, in many coral reefs, there is an urgent need for restoration and rehabilitation projects. Rehabilitation is the process of changing the structural or functional characteristics of a degraded or destroyed ecosystem to help its recovery (Edwards and Gomez, 2007). Indeed, knowledge about physiological and especially growth

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characteristics, the relevant time (season) and methods for transplantation of target coral species will improve future rehabilitation or restoration projects (Edwards, 2010). Nevertheless, there are not many published reports about the mentioned subjects for coral reefs of the Persian Gulf.

From the morphological prospective, branching corals including Acroporids, are known as the most susceptible corals to the thermal bleaching (Loya et al., 2001; McClanahan et al., 2004). *Acropora* dominated coral reefs of the Persian Gulf have also been damaged severely by thermal bleaching events and break water construction in last decades (Riegl, 2003). Therefore, many former *Acropora* dominated coral reefs urgently need rehabilitation projects. In coral reefs which are established nearby human societies, anchoring and fishing cause the colonial inversion (i.e. detachment and inverse positioning of coral colonies). In the inverted colony, lower parts (usually tips of some branches) contact the sedimentary basin and usually experience rapid mortality, while other parts may survive (authors, pers. obs.). Nevertheless, in surviving parts, the main photosynthetic surface (i.e. upper surface of normal colonies) situates downward. This probably perturbs the energetic status of the colony via disturbing the photosynthesis until the photosynthetic tissue migrate to the upper side and continue the normal photosynthesis. Therefore, it is the most probable that corals face reduced physiological performances during the first weeks after the colonial inversions.

Yet, there is no quantitative assessment of the reduced physiological performances of inversely positioned colonies. So, in this research, the 42 days growth rates (weight increment) of inversely and normally transplanted fragments of *Acropora downingi* (Wallace 1999) were evaluated to answer following questions: 1) How much was the medium growth rate of transplanted fragments of *A. downingi* during a medium thermal season (i.e. autumn)? 2) Did colonial inversion of *A. downingi* lead to the sub-normal growth of the colony at the initial stage

of inversion (during some weeks after inversion)? and 3) Did cable tie stabilize *Acropora* fragments on concrete substrate?

2. Material and Methods

2.1. Site and Study Organism

This study was carried out from 23 October to 4 December 2011 in the coral reef of Hengam Island, Persian Gulf (study site: 26° 39' 30.1" N, 55° 55' 02.2" E). This *Acropora*- dominated coral reef, at the eastern side of Hengam Island, has about 65 % live coral coverage (Rezai et al., 2010a). The branching coral *Acropora downingi* which is a hermaphroditic broadcast spawner with a single gametogenic cycle around April (Bauman et al., 2011), was selected for this study. This species is one of the common Acroporid corals of the Persian Gulf and is reported from many coral reef communities in the region (e.g. Wallace, 1999; Vajed Samiei et al., in press).

2.2. *In Situ* Growth Rate and Temperature Measurements

Growth rate of transplants were evaluated by the weighting technique in which the weight increments in a period of time were used as growth rates (see: Bates et al., 2010; Langdon et al., 2010; Herler and Drinwober, 2011). Since the present study also aimed to evaluate, 18 fragments were cut from the tip of a single colony of *A. downingi* at about 4 m depths using a small hammer and hatchet. Then, transplants were submerged in seawater in plastic containers and transported to a nearby coast where they were weighted using a digital field scale (Pars, accuracy of ± 0.5 gram). Later, transplants were transported back to the site (near the mother colony) and transplanted inversely and normally on concrete blocks using cable ties (e.g. Fig. 1). Stabilization of colony fragments with cable tie is an effective method for transplantation of branching corals (Williams and Miller, 2008; Edwards, 2010).

Initially, underwater photographs of transplants were taken. Thereafter 42 days, transplants were weighted and photographed with the same technique as the initial stage. The weight increment of transplants was assessed by subtracting the initial weight from the second weight. The response or dependent variable, the weight-specific weight-increment (WSWI) of transplants (g g^{-1}), was achieved by dividing the weight increment by the initial weight (IW).

Two thermo-loggers (HOBO Pendant Temperature Data Logger) were lodged in the coral reef of Hengam Island, one at about 4 and another at 6 m depths. Out of two thermo-loggers, one was lost. So, data from the thermo-logger at 6 meter depths are reported. Temperature was logged regularly at 30 minute intervals for 45 days. The graph was prepared using Statistica 8.



Fig. 1: An example of inversely (left) and normally (right) transplanted colony fragments of *Acropora downingi* on concrete blocks. (a) Initial transplants; (b) Same transplants after 42 days

2.3. Statistical Procedure

The categorical predictor or factor was the form of transplantation with two levels (i.e. inverse vs. normal). IW was negatively correlated with WSWI ($N=9$, $r >0.4$); this meant that mostly bigger transplants had a lower WSWI and vice versa. Therefore, unavoidable size differences between transplants of both samples (i.e. inverse and normal) could confound our results by increasing the residual (unexplained) variation. Since, the correlation coefficient was more than 0.4, it was most appropriate to use IW as the covariate in the analysis of covariance (Sheskin 2004).

Analysis of covariance (ANCOVA) is a statistical test in which the effects of a continuous predictor or covariate will be accounted and then, a large reduction in the error SS may be achieved (Field 2005). So, the analysis of covariance (ANCOVA) was used to assess the difference between growth rates of inverse and normal transplants. All statistical procedures were done using Statistica version 8.

3. Results

42 days after the initial transplantation of *Acropora downingi* fragments, all transplants showed complete self-attachments to the concrete blocks. None of transplants were dead or bleached. Table 1 summarizes the basic statistics for 42 days growth of inversely and normally transplanted fragments of *A. downingi* using concrete blocks and cable ties.

ANCOVA showed that growth rate of inversely transplanted corals were significantly lower than the growth rate of normally transplanted colonies (ANCOVA, $F_{1, 15} = 5.137$, $p <0.05$). Table 2 and Fig. 2 summarize the results of ANCOVA and show the observed differences between two forms of coral transplantation.

Table 1. Basic statistics for growth rates of inversely and normally transplanted fragments of *Acropora downingi* after 42 days in autumn 2011.

| Factors | Sample size (N) | Mean of IW (g) | Mean of SW (g) | Mean (±SD) of WI (g) | Mean (±SD) of WSWI (g) |
|-------------------------|-----------------|----------------|----------------|----------------------|------------------------|
| Normal transplantation | 9 | 63.000 | 83.888 | 20.888 (±6.954) | 0.336 (±0.058) |
| Inverse transplantation | 9 | 58.222 | 73.111 | 14.888 (±5.904) | 0.274 (±0.086) |

IW = initial weight; SW = second weight; WI = weight increment; WSWI = weight-specific weight-increment; SD = standard deviation.

Table- 2 Analysis of covariance on form of transplantation (factor) and initial weight(covariate) affecting the growth rate of *Acropora downingi*

| Source of variation | Df | MS | F |
|--------------------------------|----|----------|------------|
| Initial weight | 1 | 0.022216 | 5.17176*** |
| Form of transplantation method | 1 | 0.022070 | 5.13787*** |
| Error | 15 | 0.004296 | |

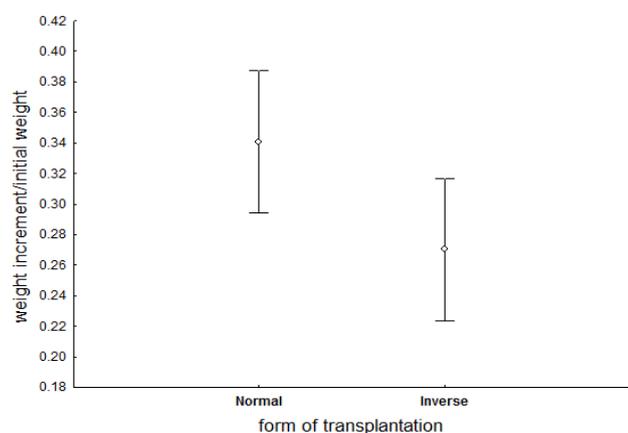


Fig. 2: Weight-specific weight-increment (weight increment/initial weight) of inversely and normally transplanted corals after using the initial weight as covariate and computing for covariate at their means (F = 5.13, p < 0.05). Vertical bars denote 0.95 confidence intervals.

Sea water temperature varied from 30.5 °C in 24 October 2010 to 25.5 °C in 4 ecember 2011 at 6 meter depths of the coral reef of Hengam Island (Fig. 3).

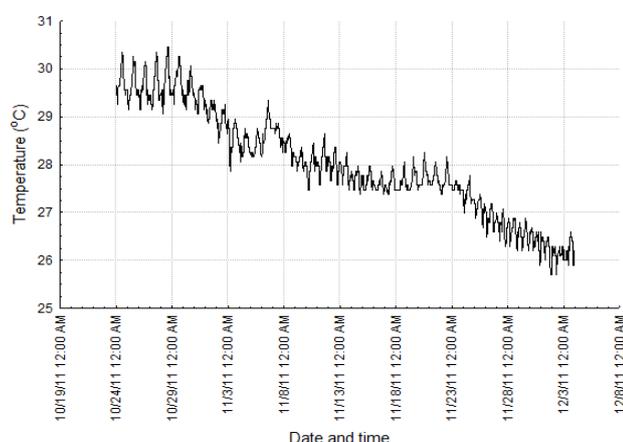


Fig. 3: Sea water temperature profile at 6 meter depth of the coral reef of Hengam Island, Persian Gulf

4. Discussion

Branching corals including Acroporids are known as the most susceptible corals to the thermal bleaching (Loya et al., 2001; McClanahan et al., 2004). Thermal bleaching and breakwater construction have been degrading many *Acropora* dominated coral reefs of the Persian Gulf in last decades (Riegl, 2003; Rezai et al., 2010b; Riegl et al., 2011). Therefore, many *Acropora* dominated coral reefs need to rejuvenate through rehabilitation. Indeed, knowledge about physiological and especially growth characteristics, the relevant time (season) and methods for transplantation of target coral species will improve future rehabilitation or restoration projects (Edwards, 2010). Currently, there is no published data about the growth rate of *A. downingi*, one of the main reef building corals of the Persian Gulf.

Our study provided some basic knowledge about the growth rate of *A. downingi* in a coral reef with a high benthic coverage at a season with a medium thermal regime in the Persian Gulf. Since the growth rate is one of the parameters to indicate the physiological performance of organisms (Willmer et al., 2005) including corals (Longdon et al., 2010; Herler and Drinwober, 2011), the result of the current study could be used as a source or control data for the physiological status assessment of newly transplanted

A. downingi fragments in the future rehabilitation projects (for examples see: Edwards, 2010).

One of the most important steps in the transplantation of corals is the stabilization of colonies on the hard substrates. Two of the most widely used methods are using the epoxy glue and cable ties (Edwards, 2010). While both methods have been effective for transplantation of corals on hard substrates, the latter is known to be faster and easier (Williams and Miller, 2008; Edwards, 2010). We used cable ties for the stabilization of colony fragments of *A. downingi* on the concrete blocks. Transplants grew and were self-attached at the end of the study period. It was further verified that the cable tie was useful for stabilization of coral colony fragments on relevant substrates (Williams and Miller 2008; Edwards, 2010).

This study was the first to address the negative effect of the colonial inversion (i.e. detachment and inverse positioning of coral colonies) on the physiological performance of a scleractinian coral. After 42 days, the upward surfaces of inversely transplanted colonies of *A. downingi* were similar in color and shape to the normal ones (Fig. 1). The medium specific growth rate of inversely transplanted colonies was significantly lower than the normally transplanted ones.

Under natural condition and usually after inversion, lower parts of the inverted colony (usually tips of some branches) contact the sedimentary basin and may face rapid mortality while other parts of colony may survive (pers. obs.). Nevertheless, this probably perturbs the energetic status of the colony via disturbing the photosynthesis until the photosynthetic tissue translocates to the upper side and continue the normal photosynthesis. This could probably be the main reason for the observed lower growth rate of inversely transplanted fragments after 42 days. Our study was done in a coral reef with a high benthic coverage at a season with a medium thermal regime. Thus, the result could be different at other seasons and sites. As such, the spatial and temporal variability of the effects of colonial inversion on the energetic

related processes (like metabolism, photosynthesis) and physiological performance of scleractinian corals need to be studied further.

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