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Survival status of experimental transportation and transplantation of acropora corals from Lakshadweep to Gujarat, India

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Abstract

As a pioneering feat, *Acropora* species coral fragments were transported and transplanted from Lakshadweep to Gulf of Kachchh, Gujarat on an experimental basis. Fragments were transported with 81% survival rate, over four days long travel. After acclimatization process, the fragments were transplanted at two sites in and around the Gulf of Kachchh Marine National Park. The survival status was monitored over six month period. Coral fragments survived for four months at Lagu reef and six months at Mithapur reef.

Key words: *Acropora humilis*, Gulf of Kachchh (GoK), Laku, Lakshadweep (LAK), Mithapur, Transplantation, Transportation.

INTRODUCTION

Coral reefs are amongst the most mature and complex marine ecosystems of the earth, providing shelter, feeding and breeding grounds to nearly one quarter of all marine life forms (Garrison and Ward, 2012). The Gulf of Kachchh (GoK) is one of the major coral reef habitats in India that comprises 32 reef islands. However, the coral diversities in GoK is quite low compared to other coral reefs like Gulf of Mannar, Lakshadweep group of Islands and Andaman and Nicobar islands (Pillai and Patel, 1988;Dixit *et al*., 2010). The extreme environmental variations, anthropogenic pressure and the natural hurdles may have lead to coral reef decline around GoK (Desmukhe et al., 2000; Biswas, 2009; Dixit *et al*., 2010). The dead skeletons of *Acropora* sp. (*A.humilis* and *A. squarrosa*) have been found periodically at various locations of GoK (Pillai and Patel, 1988; Rajagopalan). There have been no live forms of this species reported, leading to the conclusion that *Acropora* species may have died out or has a restricted distribution in GoK waters (Pillai and Rajagopalan,1979. As one of restoration measures for GoK coral reef recovery, Wildlife Trust of India and Gujarat Forest Department planned to restore *Acropora* species at GoK in partnership with TATA Chemical Limited and Lakshadweep Forest Department. A small number of *Acropora humilis* fragments were transported from Lakshadweep and transplanted to GoK in March 2012 for the first time in India on an experimental basis. This paper reports the results of the experimental transportation and post transplantion's survival status of Acropora fragments in Gujarat waters.

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STUDY AREA:

Site -1: Lakshadweep group of islands are the closest coral reef ecosystem to the GoK, located within the Arabian sea (Pillai and Patel, 1988). Agatti Island (10°51'N and 72°21' E) was found suitable as the donor site based on literature survey. (Pillai, 1971, 1983 ; Pillai and Jasmine 1989;Suresh,1991; George, 2008). Agatti island is an atoll, with the semi-circular lagoon located on the western side of the island. Most of the *Acropora* sp. colonies are present inside this lagoon whereas on the outside, only a few digitate forms of *Acropora* colonies are present.

Site- 2: Mithapur reef is located outside of the GoK between N 22°.25'.746": E 068°.59'.950" and N 22°.25'.082": E 068°.59'.331", and facing Arabian sea. The fringing form of reef has good tidal pools with two to three meters depth at low tide. Around twenty three species of hard corals have been recorded (Subburaman *et al*., 2014). The dead skeletons of *Acropora* (*A. humilis*) have been observed along of Mithapur coast.

Site- 3: Laku Island is one of the adjacent reefs, located inside the GoK, near Poshitra covering a total area of 1.2 km² and eighteen hard coral species have been reported from the Laku Island (Dixit et al., 2010; Subburaman *et al*., 2014). Some dead *Acropora* skeletons also were observed on the northern side of the island. The northern portion of Laku island has the tidal pool with sandy bottom. Compared to Mithapur, Laku tidal pools generally have poor visibility due to turbid water, even during low tide.

Fig 1 : Study areas

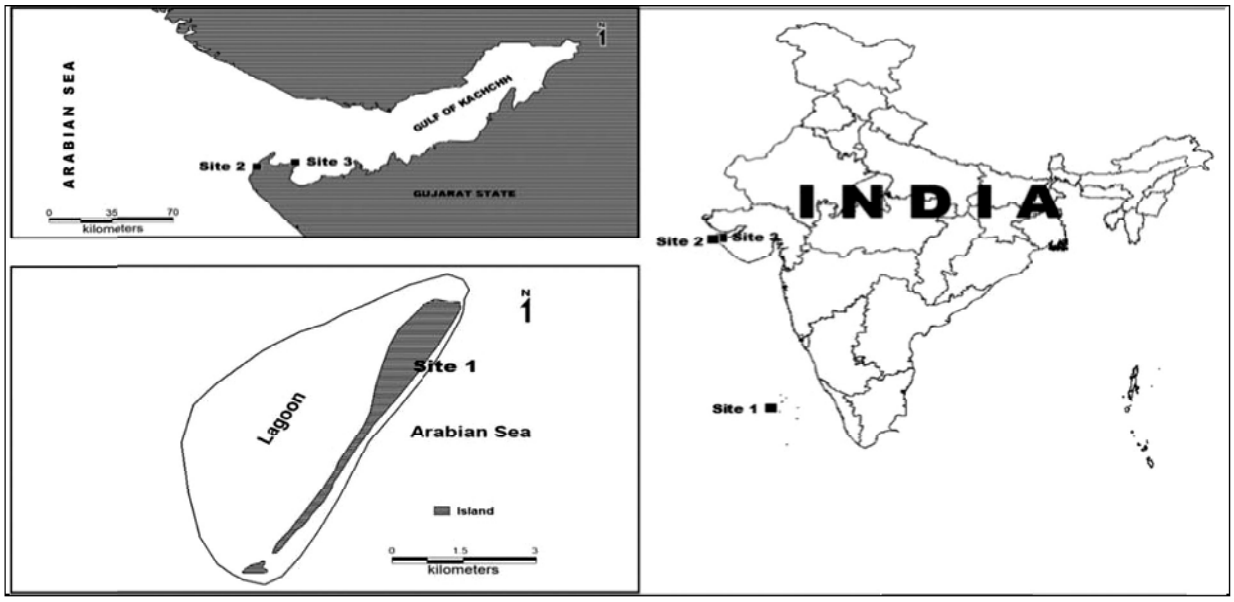

Fig 2: Survival status of *A.humilis* fragments at Gujarat waters.

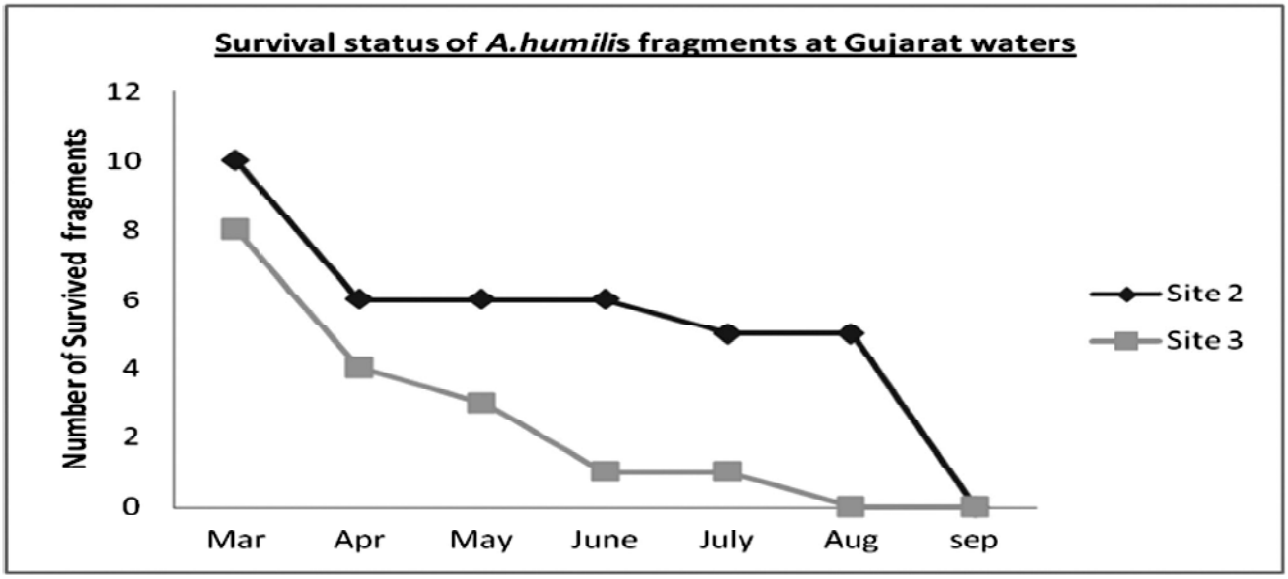

Fig 3 : Mean Daily wise sea surface water temperature between May and August (2012) at Mithapur reef

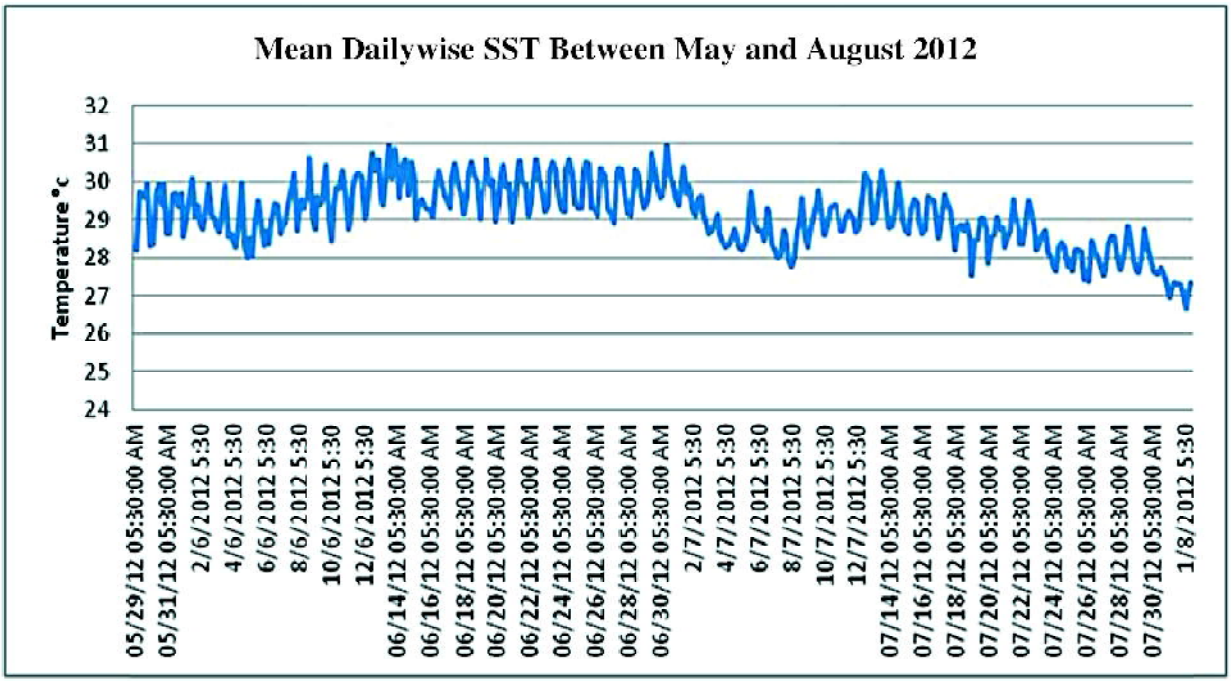

Table 1 : Monthly wise oceanographical parameters around at Mithapur reef (2012)

			Oceanographical Parameters			
Months (2012)	pH	Salinity	Nitrite (ppm)	Phosphate (ppm)	Visibility	Sedimentation rate (mg/day)
January	7.7	40	0.0045	0.0035	< 10 m	5.8
February	7.8	40	0.0052	0.0064	8m	4.4
March	7.5	41	0.0131	0.0063	8m	8.3
April	8.2	42	0.0085	0.0074	6m	18.3
May	7.8	42	0.0223	0.005	3m	54.8
June	7.7	40	0.133	0.022	1m	83.09
July	7.7	40	0.161	0.0645	>0.5 m	< 90
August	7.4	38	0.1	0.092	0	<90
September	7.8	38	0.0112	0.0083	>0.5 m	31.1
October	7.8	37	0.0135	0.0051	1 m	14.7
November	7.6	38	0.005	0.004	3m	5.88
December	7.9	39	0.0126	0.0044	6 m	8.8

MATERIALS AND METHODS:

Six iron culture frames covered with wire mesh were fabricated (size two meter long , one meter wide, and one meter hight) and three were deployed at Site -1, two were deployed at Site 2 and on at Site 3 thereby creating a coral nursery. Survey and monitoring was conducted by snorkling and SCUBA diving at all three sites. Seventy five healthy colonies of *A.humilis* were identified at Site 1 using existing identificion keys (Dana,1846;Veron,2000). Hundred fragments (app. 4 to 7 cm length) were harvested from those colonies and attached to limestone slabs and concrecte blocks with the help of plastic tags. Limestone slabs and cement blocks were used as a base for the establishment of the harvested coral fragments. The limestone slabs were fabricated in the size of 5 cm radius and with 3 cm thickness .Cement blocks were also prepared with 5 cm x 5 cm with a 3 cm thickness. A central hole was made in each slab and block for coral attachment. All harvested fragments were transplanted to the Site -1 lagoon (depth three meter) to recover from post harvesting stress and establishment on the limestone/ concrete base. The monitoring was continued for sixty days at Site -1 using SCUBA. Algae and other bio-fouler were removed from the substrate using 2 mm painting brush.

A combination of transport i.e. sea vessel (ship), train and roadways were used for transportation through "Submerged method". It was ensured that connections between various modes of travel could be obtained without delays and that the fragments could be transported in temperature controlled environment (Osinga, 2009). Plastic containers (25 L capacity) were used as transport containers. These conatiners were specially fabricated with concrete to hold the fragments in place.Each container's base was fabricated using concrete cement and for additional support, iron bolts (10 cm height) were fixed on the container base, which serves the purpose of anchoring the established fragments during transportation. The plastic containers were numbered for purposes of identification like PC1 to PC9. Aeration was provided using an aerator (atmospheric air/ Air pressure – 3.2MPa / Output Air – 3.2 L/min). Both natural sunlight (whenever possible) and artificial (40 watt) light were provided during transportation. Upon reaching the destination site, all corals were shifted from their plastic containers to plastic trays (2 feet long and 1.5 feet wide) for acclimatization. The fragments were placed in trays filled with seawater from the source (Site - 1), which was carried along in containers. Continuous aeration and light were provided throughout the acclimatization process. All corals were introduced to mixed seawater in a 1:1 ratio (Lakshadweep water and Gujarat waters) after which they were introduced gradually to 100% Gujarat water. After acclimatization process, all corals were transplanted at the selected sites of GoK. Post transplantation monitoring was carried out to measure the status and survival rate of the transplanted corals at the nursery sites. Other oceanographic parameters were monitored constantly for both the sites at Gujarat.

RESULTS

This transportation started on 9th March 2012 with 60 day old cultured fragments. The lagoon at Site - 1 and the tidal pools at Sites - 2 and 3 were selected as nursery grounds. During this experiment, a total of 25% (25 numbers) fragments were taken for transportation. One plastic container was damaged at Site -1. Therefore, twenty two fragments were selected for transportation. Remaining, seventy eight fragments were left behind at the Site -1 for next transportation. Eighteen fragments (14 healthy and 4 stressed) survived after a four day journey. Four fragments died due to transportation stress on third and fourth day of the journey. Acclimatization process was continued for three days after transportation. One coral fragment partially bleached during acclimatization process. Ten fragments (six healthy and four stressed) were transplanted at Site -2 on the seventh day and eight fragments (Seven healthy and one stressed) were transplanted at Site-3 on eighth day of the transplantation process. Post-transplantation monitoring was continued for six months. All the five stressed coral fragments died after few days of transplantation at both sites of Gujarat. But all the healthy fragments were in well conditions at Site- 2 till three months from the date of transplantation. In July, it was noticed that one fragment was missing from the table and bleaching was observed in the rest of fragment's axial corallites. The seawater was very turbid, and very poor visibility was observed in August, leading to bleaching in 50% of the transplanted fragments. All fragments perished in September. At the same time, it was observed that the native species of Gujarat reef were also bleached severely and many perished in October. *Acropora* sp coral fragments survived six months at Site -2. (Fig.2). In Site -3, monitoring was carried over five months between March and July during the neap tides. One stressed coral was died within few days after transplantation. Two healthy corals were died due to tissue damaged and one healthy fragment was lost from the culture frame during April, while the remaining fragments were in a healthy condition. In May, one more coral was lost. Finally a single coral remained until it was affected by bleaching in June leading to its mortality in August.

DISCUSSION

Restoration attempts focused to recover the damaged reef back, as nearly as possible, to its original state with regard to biological diversity, structure and functions (Edward *et al*., 2006). The main objective of this experimentation was to assess the survivability of *Acropora* species in Gujarat waters. According to Edwards and Gomez.(2007), transplantation causes stress to corals and those stresses have to be minimizing during transportation. However, Pillai and Rajagopalan (1979) stated that the sedimentation is the major factor to restrict *Acropora* growth and survival at GoK. It is therefore important that healthy corals are transplanted to minimize the mortality during post transplantation. Edwards (2010) recommended that a small pilot study should be undertaken before undertaking the full scale transportation and transplantation based on which this small scale pilot study was conducted to avoid the major loss.

Eighteen fragments survived without any physical damage and four fragments died during transportation. According to Petersen *et al*. (2004), inappropriate handling induces stress on the transported corals. Containers experienced much strain during transit from ship to road vehicle which induced stress in corals of two containers. Finally all coral fragments of PC9 (container) and one coral in PC5 died during the train journey. Two more corals in PC5 and two fragments in PC7 also showed signs of stress post the train journey. It was noted that the train journey caused more stress on the corals than other mode of transportation.

Acclimatization process at Site -2 was initiated by placing the coral fragments in trays with Lakshadweep water for the first 12 hrs. Delbreek (2008) stated that using a slow drip to acclimate is wise to prevent shocking the corals. So, seawater from Mithapur was slowly introduced to the coral fragments in the ratio of 1:1 (Gujarat water: Lakshadweep water) upto 24 h then slowly increasing the concentration of Gujarat water, finally all coral fragments were introduced 100% of Gujarat water. Only a single coral fragment was observed to be under stress during this process. A total of 18 fragments were transplanted over an area of 3 m^2. Macro algae are the major competitors (Liman, 2001) mostly attracted by the substrates and it caused damage to coral tissue. (Ammar *et al*., 2013). However, other competitors like Hydrozoans, Ascidians and Fungi were also found and carefully removed at all the three sites during the post transplantation monitoring.Similarly coral polyp could suffer due to high sedimentation and turbid conditions (Liang *et al*., 2011). Gujarat water showed relatively more turbid conditions than other Indian coral reef habitat. (Pillai and Rajagopalan,1979). Therefore, stressed corals could not survive a few days after transplantation. However, heavy turbid condition also reduces the light transmission and inhibits the photosynthesis by symbiotic algae. Site -3 had relatively less visibility than Site- 2, even in the low tide of March, whereas Site-2 at eight meter level of visibility (Table 1), the healthy corals remained alive for nearly six months at Site -2 and four months at Site- 3. It can be assumed that light availability was sufficient at both transplanted sites at the initial period, later deteriorated with increased turbidity as the monsoon intensified.

Peterson *et al*. (2004) stated that changes in physio-chemical parameters (especially temperature) trigger high-level of stress to corals. During the time of transportation and acclimatization process, the sea water temperature was maintained between 25°C to 28°C. According to Liang *et al*. (2011) corals would suffer stress at sea temperatures above 30°C. The Sea surface temperature (SST) data recorded during the experiment showed that the sea water temperature rose above 30.5°C at GoK in mid of June, 2012 (Fig 3). This temperature rise might have triggered the bleaching effect on axial corallites of all healthy coral fragments at Site- 2. Oceanographic parameters used to increase from June and at its peak in August around GoK. (Saravanakumar *et al*., 2008). However, Mathews and Edward (2005) stated that the attached coral fragments with the small area are vulnerable to strong water movements. Thus this experiment results showed that the strong wave actions and strong current movements could be the reason behind the missing coral fragments off the nursery table at both the sites of Gujarat. In the month of June oceanographic parameters made further hurdle to the survivability of *Acropora* at Site -3. Peak monsoon parameters killed all *Acropora* and several other Gujarat corals got bleached at Site-2 (Table 1). Hence mitigation measures should be undertaken for the better survivability of *Acropora* species during the peak monsoon periods of August and September.

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