

## Skeletal extension of staghorn coral *Acropora formosa* in relation to environment at Kavaratti atoll (Lakshadweep)

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Growth study for 2 years, in respect of skeletal extension, was conducted *in situ* at Kavaratti atoll. Average annual rate of extension of branches was  $7.9 \pm 2$  cm for first year and  $8.2 \pm 1.8$  cm for second year. Growth of individual branches exhibited intracolony variations. Monthly rate of growth was found to be slower during monsoon (June-September) when compared to premonsoon (February-May) and postmonsoon (October-January) seasons. Environmental conditions at the study area, with the exception of the amount of sediments in water, seemed conducive to the growth of *Acropora formosa*.

The existence of Lakshadweep atolls and the maintenance of their resources depend on the continuous growth and survival of corals. Environmental factors play a significant role in the growth of corals and their survival. No study has so far been conducted on the growth and factors affecting the rate of growth of corals at Lakshadweep. In this communication results of growth studies in respect of skeletal extension (growth in length) on a staghorn coral *Acropora formosa* (Dana) in the Kavaratti atoll at Lakshadweep in relation to water temperature, pH, salinity, phosphate, nitrite, nitrate, calcium, current velocity, total suspended matter, sedimentation, rainfall and zooplankton abundance are reported.

### Materials and Methods

Kavaratti atoll (lat.  $10^{\circ}33.5'N$  and long.  $72^{\circ}38'E$ ) has on the western side of the island a shallow lagoon of about 4500 m long and 1200 m wide, with a maximum depth of 3.5 m at high water. The study on skeletal extension was carried out on the lagoon flat, during January 1988 - December 1989. A total of 60 branches of a colony of *A. formosa*, situated at 2 m depth at high water and about 30 m away from the shore were utilised for measurement<sup>1</sup>. Each branch was measured 10 times from the wire tag to the tip, at an interval of 28-32 d, during low tides. Average of these measurements was normalised to a rate per 28 day ( $\text{mm} \cdot 28 \text{ d}^{-1}$ ). After a period of growth some tips developed radial branches, but only the axial branches were measured. The wire tags were cleaned periodically.

Fortnightly data on water temperature, pH, salinity, phosphate, nitrite, nitrate and calcium were collected from surface water of the study area using

standard methods. Weekly measurements on current velocity were made by marking the water using fluorescein dye. Total suspended matter was estimated by filtration. Sediment resuspension or gross sedimentation as expressed by Corts and Risk<sup>2</sup>, was measured using glass sediment traps<sup>3,4</sup>, having mouth diameter of 16 cm and height to diameter ratio of approximately 3:1. Four such traps were mounted in the corners of a  $40 \times 40$  cm frame, with openings set at 50 cm off the bottom, near the colony. The total rainfall data was obtained from the daily weather report published by India Meteorological Department, Trivandrum. Data on daytime zooplankton abundance were collected at fortnightly interval. The seasonal averages were calculated by pooling the data into three seasons—premonsoon (February-May) monsoon (June-September) and postmonsoon (October-January).

### Results

*Skeletal extension*—Among all branches tagged, only 40% (24 branches) were left undamaged at the end of the study. Data from these branches were used for calculating the results. Considerable variations in growth of individual branches were noticed throughout the period of study (Fig. 1). The growth rate exhibited seasonal variation with steady and faster growth during premonsoon and slower during monsoon. The average seasonal rate of growth ( $\text{mm} \cdot 28 \text{ d}^{-1}$ ) calculated during premonsoon was  $7.7 \pm 0.7$ ,  $5.4 \pm 0.5$  during monsoon and  $6.9 \pm 1$  during postmonsoon. The average annual rate of growth of branches in the study area was found to be approximately  $7.9 \pm 2$  and  $8.2 \pm 1.8$  cm respectively for the first and second year.

*Environmental variables*—Temperature varied between  $27.5^{\circ}C$  and  $31.6^{\circ}C$  (Fig. 2A). No significant

variations were noted in pH, salinity and phosphate (Fig. 2B-D). Nitrite varied between 0.02 and 1.62  $\mu\text{g-at.l}^{-1}$ , with exceptionally high values during February-May and October-December (Fig. 2E). The variations in nitrate and calcium were not found to be significant with the exception of high value of nitrate during August 1988 (Fig. 2F, G).

Monthly values of current velocity, suspended matter, sedimentation, rainfall and zooplankton exhibited sharp seasonal fluctuations. Current velocity ranged from 3.5 to 14.9  $\text{cm.sec}^{-1}$  (Fig. 3A), with highest seasonal average value during monsoon ( $11.9 \pm 2.2 \text{ cm.sec}^{-1}$ ). The premonsoon and post-monsoon values were  $4.5 \pm 0.9$  and  $5.6 \pm 1.6 \text{ cm.sec}^{-1}$  respectively. However, the actual velocities could be still high as the measurements were made during low water and the velocity depended on prevailing wind and tide. The amount of suspended matter in water (Fig. 3B) varied between 1.9 and 17.8  $\text{mg.l}^{-1}$ . The monthly rate of sedimentation ranged from 2.3 to 124.5  $\text{mg.cm}^{-2}.\text{d}^{-1}$  (Fig. 3C), with the highest seasonal average value of  $85.7 \pm 24.7 \text{ mg.cm}^{-2}.\text{d}^{-1}$  during monsoon. The premonsoon and post-monsoon averages were  $4.4 \pm 1.8$  and  $10.7 \pm 6.7 \text{ mg.cm}^{-2}.\text{d}^{-1}$  respectively. The data on monthly rainfall is depicted in Fig. 3D. Monthly zooplankton

count ( $\text{no.m}^{-3}$ ) ranged between 64 and 1041 (Fig. 3E).

The correlation between growth and environmental variables showed significant direct relation with nitrite ( $r = 0.456, P \leq 0.05$ ) and zooplankton ( $r = 0.612, P \leq 0.01$ ) and significant inverse relation ( $P \leq 0.01$ ) with current velocity ( $r = -0.682$ ), sedimentation ( $r = -0.791$ ) and rainfall ( $r = -0.715$ ). All other correlations were found to be insignificant.

## Discussion

Skeletal extension exhibited intracolony variations. Variations in rate of growth between branches

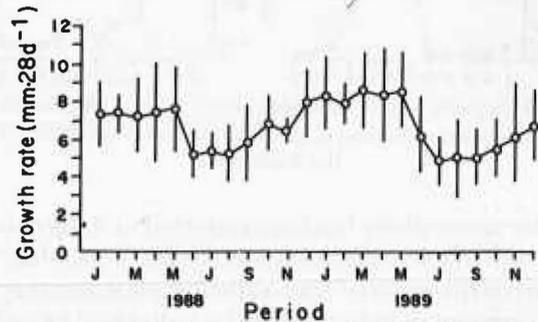


Fig. 1—Monthly rates of extension of branches of *A. formosa* (Means and standard deviations are calculated for  $n = 24$ )

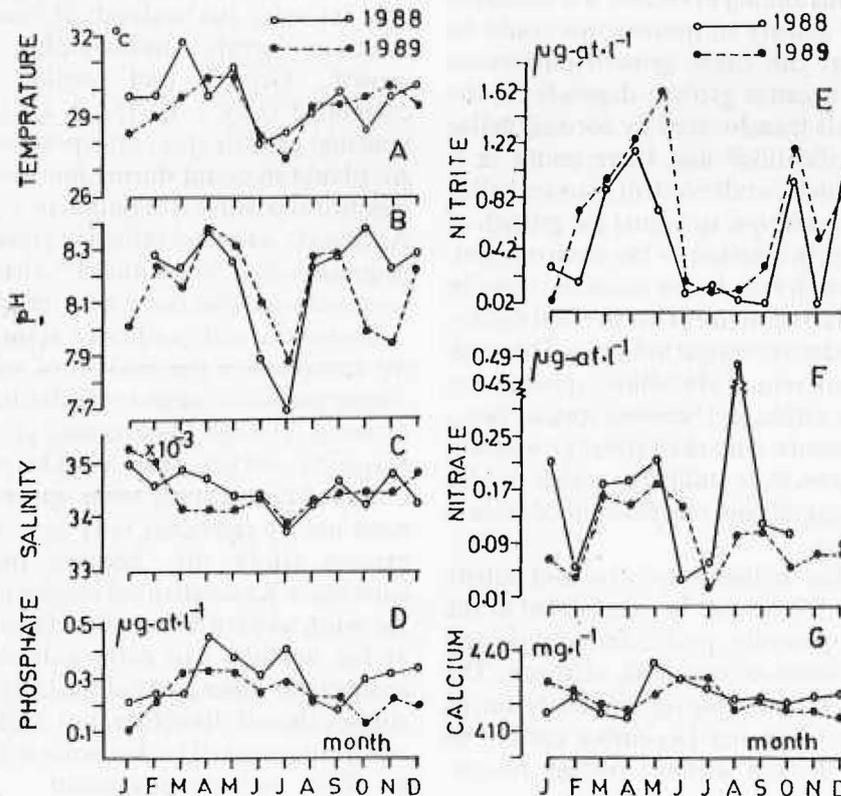


Fig. 2—Monthly mean values of temperature (A), pH (B), salinity (C), phosphate (D), nitrite (E), nitrite (F) and calcium (G), in the study area

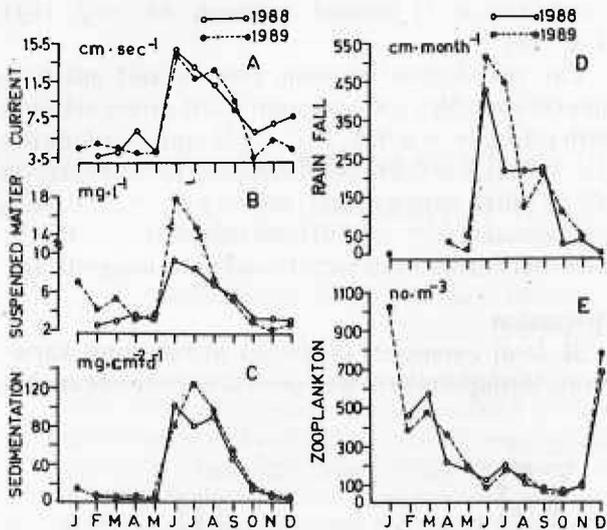


Fig. 3—Monthly mean values of current velocity (A), suspended matter (B), sedimentation (C), rainfall (D) and zooplankton (E) in the study area

of the same colony has been reported in *A. formosa*<sup>5</sup>. Growth in scleractinian corals is light dependent<sup>6,7</sup>, which is the result of zooxanthellar photosynthesis<sup>8</sup>. The amount of light received by individual branches can vary depending on the position of the branches, which cause variation in photosynthesis, resulting in the growth variations among branches. Variations in zooxanthellae cell density in branch tips could be another factor that can cause growth differences among branches, because growth depends on the amount of materials translocated by zooxanthellae to the site of calcification<sup>9</sup> and there could be a mechanism with which corals control zooxanthellae cell density<sup>10</sup> in branch tips, to adjust the growth of individual branches in relation to the environment.

The lowering growth rate during monsoon, may be a reflection of the variation in environmental factors in the study area under monsoonal influence. The range of variations in temperature, pH, salinity, phosphate, nitrate and calcium within and between seasons being of minimum magnitude, a marked effect on account of these on the growth is unlikely, which is also evident from the insignificant correlations of growth with these variables.

Direct correlation between growth and nitrite ( $r = 0.456, P \leq 0.05$ ) cannot be interpreted at the moment as corals generally prefer ammonium and nitrate<sup>11</sup> to other forms of inorganic nitrogen. The exceptionally high values of nitrite, especially during February-May and October-December cannot be attributed to any reason without further investigation.

Current velocity was highest during monsoon, when rate of growth was lowest and growth exhibited

significant inverse correlation with current velocity ( $r = -0.682, P \leq 0.01$ ), indicating an adverse effect on growth. Wave energy was shown to affect skeletal extension in *A. aspera*<sup>12</sup>. Currents hinder feeding activity of coral polyps and adversely affect growth<sup>13</sup>. Strong currents can send particles in suspension and cause sedimentation. Normal suspended matter and sedimentation rates for coral reefs<sup>14</sup>, which are not subjected to human activities appear to be of the order of  $10 \text{ mg.l}^{-1}$  and  $10 \text{ mg.cm}^{-2}.\text{d}^{-1}$  or less. Rate of sedimentation in this area reached  $85.7 \pm 24.7 \text{ mg.cm}^{-2}.\text{d}^{-1}$  during monsoon and inversely correlated with growth ( $r = -0.791, P \leq 0.01$ ), whereas the maximum value of suspended matter was  $17.8 \text{ mg.l}^{-1}$  during monsoon, which showed no significant correlation with growth. In terms of possible effect on corals, low suspended matter values with high sedimentation rates result in large amount of sediment depositing on corals<sup>2</sup>. Acroporid corals have limited ability to reject sediments and the mechanism with which corals shed themselves of sediment requires expense of energy, which otherwise would have been available for growth<sup>15,16</sup>. Sediments in water can reduce incident light<sup>17</sup> and can interfere with the normal feeding of corals<sup>18</sup>. Whatever the means of action, the result of sedimentation is decrease in coral growth rates<sup>19</sup>. Low light intensity due to cloudy sky and rainfall during monsoon create unfavourable conditions for growth. Growth and rainfall were inversely correlated ( $r = -0.715, P \leq 0.01$ ). The lowest seasonal growth also corresponded with the lowest zooplankton count during monsoon and exhibited significant positive correlation ( $r = 0.612, P \leq 0.01$ ). As corals are specialised carnivores depending primarily upon zooplankton<sup>20</sup>, their abundance and seasonal variation can reflect on the rate of growth.

Environmental conditions at the study area, with the exception of the amount of sediments in water during monsoon, seem conducive to the growth of *A. formosa*. Though the quantity of sedimentation at Kavaratti atoll in the past is not known, the high levels observed in this study seem quite unnatural and it need not be restricted only to a small area at the present study site, because the unidirectional currents in Kavaratti atoll accelerating enroute from the south western corner of the lagoon to the entrance at the north<sup>21</sup>, can carry substantial amount of sediment to other parts of the lagoon. Forthcoming studies should, therefore, not neglect the source of sedimentation and its dynamics in the atoll as well as its effects on the environment.

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