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Productivity of the coral reef alga *Halimeda gracilis* Harv. ex J. Ag. at Minicoy island, Lakshadweep

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ABSTRACT

The present investigation deals with the morphology and productivity of *Halimeda gracilis* from 3 locations of Minicoy Island. The estimated percentage cover of *H. gracilis* were 32.6% on the reef, 10.9% on the shore reef and 17.3% on the seagrass beds. *Halimeda* in seagrass beds had the highest biomass of 1339.2 g/m^2 followed by the shore reef with 1256.0 g/m^2 and the lowest biomass at the reef (420.8 g/m^2). The length of *Halimeda gracilis* varied between 4.6 cm at the reef and 8.5 cm in seagrass beds but the weight showed only slight variation. Length weight relationship of *Halimeda gracilis* indicated least variable morphology at reef and lagoon. Plants collected from seagrass beds in the lagoon showed highest productivity of 0.64 gC/m^2 / day while the lowest production of 0.08 gC/m^2 / day was recorded from the shore reef. Environmental parameters such as temperature, salinity, dissolved oxygen and nutrients were monitored at the three stations.

Introduction

Plants belonging to the genus *Halimeda* inhabit shallow coasts and coral atolls. Calcareous algae are integral part of the coral reef ecosystem and contribute to the building up of coral rocks, stones and eventually the reef itself (Krishnamurthy and Jayagopal, 1995). They are important members of some of the highly productivecommunities. *Halimeda* segments were found in the core samples of coral reefs in Funafuti, Bikini, Enewetak and other atolls of the Marshall Islands (Hillis - Colinvaux, 1980), thus providing direct evidence of its importance in coral reef development and high productivity.

Qasim *et. al.* (1972) estimated the primary production by a number of algae including *Halimeda* and concluded that the reef community on Kavaratti atoll produces more organic matter in a day than it consumes in 24 hours. The erect calcareous alga of the genus *Halimeda* grows abundantly on the reef flats in various locations of the world (Merten, 1971; Umamaheswara Rao, 1972; Morrissey, 1980; Drew, 1995). *Halimeda gracilis* is the common species reported from Lakshadweep (Kaliaperumal *et. al.*, 1989) inhabiting all the islands. Other species include *H. incrassata*, *H. macroloba* and *H. opuntia*. Kaladharan and Kandan (1997) classified *H. gracilis* as a low producer. In spite of its abundance in coral reefs, there is very little information on the

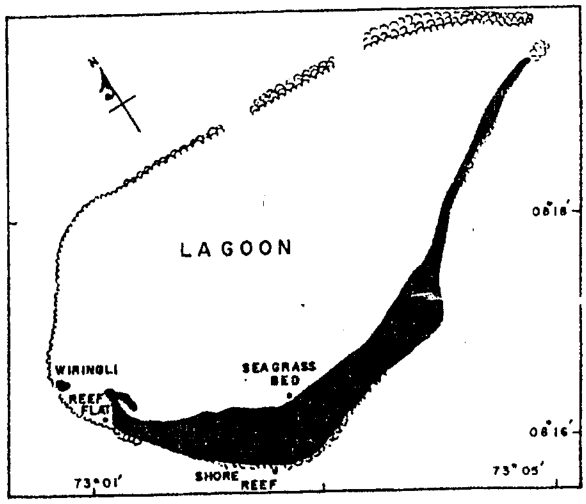

Fig. 1. *Map of Minicoy island showing the sampling stations.*

productivity by *Halimeda*. The present study reports the productivity of *Halimeda gracilis* from 3 regions of Minicoy lagoon.

Materials and Methods

The sites at the reef flat, shore reef and seagrass bed were selected for collecting samples of *H. gracilis* (Fig. 1). The total width of the reef is 110 m at the sampling site and the width of the reef flat proper is 25 m. The reef extends seawards to a length of 35 m and slopes down to 25 m depth contour. The reef is directly exposed to the action of incoming waves and dominant corals are *Pocillopora damicornis* and *Porites* spp (Pillai, 1972). Major algae other than *H. gracilis* are *Turbinaria ornata* and *Gelidiella acerosa*.

Shore reef extends along the entire length of the island on the eastern side with the maximum width of 30 m. Shore elevation is about 2 m with coral rubble and boulders near the shore. Prominent algae apart from *H. gracilis* are *Turbinaria ornata, Gelidiella acerosa* and *Sargassum duplicatum*. Seagrass vegetation is found extending to an area of 2.2 sq. km along the intertidal zone of the lagoon (Kaladharan *et.al.*, 199[illegible]). [illegible] is sandy with thick vegetation of *Thalassia hemprichii* near the shore and *Syringodium isoetifolium* in the deeper waters. Predominant algae during the study period besides *H. gracilis* are *Gracilaria edulis*, *G. crassa* and *Chaetomorpha linoides*.

Twenty temporary random quadrat of 0.25 sq. m was employed at the 3 sites to provide data on the biomass and also to collect *H. gracilis* samples for productivity studies. Percentage cover was estimated visually with the end of a square frame measuring 0.5 m subdivided into a grid consisting of 4 squares of equal size.

In the laboratory, individual plants of *H. gracilis* was sorted, washed and the maximum length of primary axis was measured and weighed. Net productivity was determined using "Light and dark" bottle oxygen technique as described by Qasim *et.al.* (1972). Baseline environmental parameters such as water temperature, salinity, dissolved oxygen and nutrients were also monitored using the method of Strickland and Parsans (1972).

Results

The variations in length, weight, productivity, biomass and percentage coverage of *H. gracilis* studied for three months period are presented in Table 1. Average length was maximum at seagrass bed, while at reef flat and shore reef it was more or less similar. In spite of the wide variation in length, the weight of individual plant averaged 2.5 g. Primary productivity by *H. gracilis* was highest at seagrass bed followed by reef flat and the least at shore reef. Seagrass beds also recorded high biomass while the percentage cover of *H. gracilis* was maximum at reef flat site.

Environmental parameters studied at the 3 sites and their variations are given in Table 2. A 1-way ANOVA with factor 'site' showed significant differences in most of the parameters studied ($P < 0.01$, Table 3). Parameters that did not show significant differences between sites include phosphate, nitrate and weight of *H. gracilis*. Regression equations for length against wet weight of *H. gracilis* indicated high r^2 values at reef flat and seagrass bed sites (Table 4). This indicates that these two sites have the least variable morphology within the sites.

Discussion

The net production by *H. gracilis* at Minicoy ranges from 28.8 gC/m²/yr at the shore reef to 234.7 gC/m²/yr in seagrass bed. Qasim *et. al.* (1972) obtained net productivity values ranging from 365 to 800 gC/m²/yr for four species of macrophytes including *H. incrassata* from Kavaratti atoll. It is difficult to estimate the productivity of *H. incrassata* alone from the work of Qasim *et. al.* (1972) as they reported only the total plant biomass. But an approximate calculation of the net production of *H. incrassata* based on their data indicates that the production would be 114 gC/m²/yr which is similar to our average of 112.2 gC/m²/yr. Hillis-Colinvaux (1974) reported a higher value of 839 gC/m²/yr in dense stands

Table 1. *Length, weight and productivity of* H. gracilis *at 3 stations*

Biological Parameters	Reef flat Mean	Reef flat Range	Shore reef Mean	Shore reef Range	Seagrass bed Mean	Seagrass bed Range
Length (cm)	4.01±2.37	2.3 to 10.1	4.84±2.39	2.6 to 10.4	8.53±2.45	4.4 to 13.0
Weight (g)	2.21±2.54	0.40 to 9.82	2.84±2.95	0.39 to 9.60	2.87±2.07	0.27 to 7.82
Productivity (gC/m²/d)	0.20±0.05	0.15 to 0.26	0.08±0.02	0.06 to 0.10	0.64±0.39	0.31 to 1.08
Biomass (g/m²)	420±323	64 to 948	1256±1224	104 to 2696	1339±1156	272 to 3128
Percentage cover	32.6±11.1	21.5 to 43.6	10.9±8.7	2.9 to 20.2	17.3±10.1	7.8 to 27.9

Table 2. *Environmental parameters at 3 stations*

Parameters	Reef flat		Shore reef		Seagrass bed	
	Mean	Range	Mean	Range	Mean	Range
Temperature (°C)	31.5±0.46	31.1 to 32.6	30.4±0.47	30.1 to 31.2	29.6±0.[illegible]	29.3 to 30.1
Salinity (ppt)	32.4±0.64	31.5 to 33.4	32.3±0.52	31.8 to 33.1	33.9±0.99	32.8 to 35.3
Dissolved oxygen (ml/l)	4.25±0.14	4.07 to 4.41	5.24±0.67	4.01 to 5.82	4.47±0.24	4.24 to 4.81
Phosphate (µg at/l)	0.40±0.18	0.16 to 0.65	0.39±0.22	0.16 to 0.68	0.40±0.21	0.24 to 0.74
Nitrate (µg at/l)	0.37±0.07	0.26 to 0.45	0.35±0.08	0.27 to 0.48	0.41±0.14	0.24 to 0.61
Silicate (µg at/l)	3.62±0.61	2.76 to 4.32	3.27±0.34	2.87 to 3.71	3.77±0.39	3.13 to 4.19

Table 3. *One - way ANOVA between the 3 stations for different variables (n=20)*

Variables	df	MSS	F	P
Temperature	2	16.16	79.7	**
Salinity	2	15.09	38.1	**
Dissolved oxygen	2	5.40	39.7	**
Phosphate	2	0.01	0.2	n.s.
Nitrate	2	0.02	2.2	n.s.
Silicate	2	1.40	7.9	**
Length	2	130.31	25.5	**
Weight	2	7.60	1.1	n.s.
Productivity	2	2.10	52.1	**
Biomass	2	76418.56	9.4	**
Percentage cover	2	2447.49	35.3	**

Table 4. *Linear regression between length and weight of* H. gracilis *at the 3 stations*

Site	Equation	r^2
Reef flat	W=0.881 L-1.857	0.67
Shore reef	W=0.426 L+0.813	0.12
Seagrass bed	W=0.685 L-2.982	0.66

(W = wet weight in gm, L = maximum length of primary axis in cm, n = 128)

of *H. opuntia* at Glory Be Reef, Jamaica. The primary production of reef building algae from Enewetak atoll was investigated by Marsh (1970) and the production of calcareous algae at the surface of the reef was of the same order of magnitude as those of other benthic producers. Net primary production was approximately 240 gC/m²/yr.

Most studies on reef productivity deal with the total contribution by the community rather than the individual components (Odum and Odum, 1955; Nair and Pillai, 1972; Balasubramanian and Wafar, 1974). However, a broad estimate of the contribution by *Halimeda* to the total benthic algal production can be made based on the studies of Qasim *et. al.* (1972) and Nasser (1994). The percentage contribution ranges between 9 and 27 respectively for Kavaratti and Minicoy atoll. These values indicate that *Halimeda* is a major contributor to primary production in the atolls of Lakshadweep. The contribution of carbon to a reef by *Halimeda* may be very high and in association with other algae and seagrasses, the primary production of the reef may be in the order of a magnitude as the most productive *Laminaria* forests (Mann, 1972).

A comparison of productivity of *Halimeda* in different locations of Minicoy with the work of Hillis-Colinvaux (1974) reveals that the production is site specific. Hillis-Colinvaux (1972) found higher production at shore reef for the more hardier species of *H. opuntia,* while in the present study maximum values are recorded from seagrass bed for *H. gracilis.* The regression equation at shore reef indicates that *Halimeda* is more susceptible to variations in morphology. This may partly explain the low productivity values obtained from this area. Vigour and density of *Halimeda* populations will obviously affect the extent of their energy contribution to the reef community (Hillis-Colinvaux, 1974). *Halimeda gracilis* collected from the reef flat and shore reef had higher percentage of dead, white segments when compared to the young, green samples of seagrass beds. Ryther (1969) pointed out that eventhough *Halimeda* plants are thinly spaced in *Thalassia* beds, their contribution to productivity is still better than that of phytoplankton of typical coastal waters.

Environmental parameters do not seem to have a strong influence on the productivity of *H. gracilis.* Variations in phosphate and nitrate between sites is insignificant. Delgado and Lapointe (1994) reported that calcareous algal productivity is not as nutrient limited as the productivity of non-calcareous algae. *Halimeda* populations are abundant on atolls that are typically placed in nutrient-poor regions of the oceans. Atolls are without the nutrients supplied by runoff from land to coastal sites, nor are they supplied with the nutrients of upwellings (Hillis-Colinvaux, 1980).

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