COMPARISON OF ALGAE AT 20 AND 45 FOOT DEPTHS IN THE FORE REEF OF DISCOVERY BAY, JAMAICA

Janis M. Hall

Abstract. In this study of algae distribution at two depths in the forereef at Discovery Bay, approximately 40 species of algae were identified. There was no significant difference in the total number of species or genera found at 20 feet and 45 feet. Algae of three genera were found more at 40 feet, while two genera were found more at 20 feet. The patterns of distribution may be linked to thallus structure and its response to wave stress in several genera, but for others the limiting factors are not clear. Sandy and hard substrate plots at 45 feet were also compared, and four algal species were found more on one type than in the other. (JMH)

INTRODUCTION (JMH)

Patterns of algal distribution in Jamaican reefs have been described by Goreau and Goreau (1973), who compared algae in reef zones such as the lagoon, buttress-zone, and forereef. Variations in the levels of environmental stress, herbivory, and competition determine the species composition in these zones, and the morphology of algae present should reflect the types and degree of stresses to which they are subjected.

The thallus form of an alga affects the plant's ability to withstand stresses such as wave surge and herbivory, but it also can affect the plant's photosynthetic rate. It has been shown that many algae which are persistent, or long-lived, tend to invest more in structural components at the expense of photosynthetic tissues. Hay (1981) found, for example, that algal turfs are poor competitors because they have lower photosynthetic rates than individual plants. However, their growth form reduces damage by dessication and herbivores, and therefore they are more persistent than some more productive algae in stressful habitats. The different branching forms of some coralline algae appear to influence distribution of these species in relation to consumers, competition, and dessication stress (Padilla 1984). Littler, Littler, and Taylor (1983) found that algae which are thick and leathery, jointed-calcareous, or crustose are more resistant to herbivores than sheet- and filamentous-type algae. Littler and Littler (1980) observed greater toughness and resistance to wave-shearing forces in persistent algae.

In surveying populations of algae in Discovery Bay, Jamaica, I expected to find differences in the abundance of genera found at different depths in the fore reef. I assumed that a shallower site near the reef crest would be subjected to more wave force than a deeper area, and hypothesized that tough, leathery, and turf-forming algae would be more common at such a site than at a deeper site. I also expected that, within a genus which inhabited both depths, different species might be found more at one depth than another due to their morphological differences. I also realized the possibility of additional major influences on distribution besides wave stress, particularly herbivory. In the case of higher grazing at one site, I expected leathery and turf-forming, but also calcareous and crustose thallus forms.

METHODS (JMH)

I sampled from transects at 20- and 45-foot depths near Mooring 1 at Discovery Bay Marine Laboratory. At 20 feet, on rock and coral (hard) substrate, I placed twelve 25cm x 25cm quadrats along a transect, with 25cm between quadrats. At 45 feet I found both hard substrate and sand, and I sampled both types of substrate separately using similar sized quadrats.

I catalogued the algae present in each plot by a combination of identification in the field and in the lab. If I could not identify an alga in the field, I collected it for later identification. I also took a bit of rock or plant material from each plot, in order to check in the lab for very small algae which I might otherwise have missed. I collected representatives of all *Halimeda* species present in 8 plots at 45 feet and in all plots at 20 feet. I did not include encrusting algae in the survey because of the difficulty in identifying and collecting them.

RESULTS (JMH)

I was able to identify to genus all but five of the algae I found, and I also identified many to species. Three of the unknown algae were not included in the analyses because they were rare or because I could not reliably recognize them.

I used a G-test to compare the number of plots with a genus to the number of plots without, for two plot types (Appendix A). Looking at only hard-substrate plots, I found that *Anadyomene stellata*, *Caulerpa* spp. and Species A were in a significantly lower proportion of the plots at 20 feet than at 45 feet (G-test, p=0.01, p=0.01, and p=0.005, respectively; Table 1). The species found more often in plots at 20 feet were *Neomeris annulata* (G=6.04, p=0.019) and *Rhipocephalus* spp. (p=0.043).

Algae found more frequently in sand than hard substrate quadrats were *Ceramium nitens* (G=5.55, p=0.02) and *N. annulata* (G=4.53, p=0.036). Found less frequently in sand than hard substrate were *A. stellata* (p=0.01) and *Lobophora varigans* (G=7.76, p=0.008).

There was no significant difference in the total number of genera found in plots at 45 and at 20 feet (U=48.5, p=0.45) or in plots on sand and on hard substrate (U=35.5, p=0.44).

Of the three most common species of *Halimeda*, none was found significantly more often at either depth. Those species were *H. gracilis* (p=0.068), *H. tuna* (G=0.037, p=0.85), and *H. opuntia* (G=2.5, p=0.11).

DISCUSSION (JMH)

The species which were found more often at one depth than the other were quite varied in their morphological characteristics (Table 1). *A. Stellata* is a fairly delicate, thin sheet alga, approximately 3cm in width and height. *Caulerpa* spp. have a rhizoid growth form and the thallus has narrow blades or spikes which are fairly tough. Species A is ~1cm in height, with prolific, soft, almost gelatinous branches. Since *A. stellata* and Species A seem delicate, it may be that wave stress limits their population at 20 feet. The *N. annulata* thallus is a soft, small (~1cm tall), fingerlike form. Due to its low profile, it probably would be little affected by wave action. *Rhipocepha-*

Table 1. Algae found at Mooring 1, algae characteristics, and results of G-tests between quadrat types. Bullets show genera with significant differences in distribution.

Genus, species if known	*	#quadrats genus was found in† A	B	C	G-test between quadrat types A and B G	p	G-test between quadrat types B and C G	p	morph‡	comments
•*Anadyomene stellata*	C	0	6	1		0.01	7.18	0.001	TS	
Amphiroa fragilissima	R	1	5	2		0.13	2.85	0.009	VC	
Avrainvillea	C	0	1	0				0.26		
•A (unknown species)	R	3	5	0				0.005	GL	soft, pink, ~1cm, branched, epiphytic
B (unknown species)	C	1	5	5		0.13	0.15	0.69	FL, TF	
•*Caulerpa spp.*	C	5	6	1			7.18	0.01	LE	
•*Ceramium nitens*	R	6	3	5	5.55	0.02	0.38	0.57	FL	
Chaetomorpha (linum?)	C	1	0	0					FL	
Cladophoropsis macromeres	C	0	0	1					FL, TF	Grouped with B
Coelothrix	R	0	1	3				0.36	TF	
Corallina cubensis	R	3	1	1		0.16			VC	
Dictyota spp.	P	7	10	12						
Ernodesmis verticillata	C	1	1	0					FL	
Galaxaura spp.	R	1	3	3					LE	
Halimeda spp.	C	6	10	12					VC	
Jania (adherens?)	R	1	4	9			2.81	0.096	VC	
Laurencia	R	0	2	7			3.46	0.06	LE	
•*Lobophora varigans*	P	1	8	12	7.76	0.008		0.1	LE	
•*Neomeris annulata*	C	4	1	7	4.53	0.036	6.04	0.019		
Padina sanctae-crucis	P	1	1	1					LE, TS	
Penicillus spp.	C	1	2	1					LE,VC	
Polyphysa polyphysoides	C	1	0	0					VC	
•*Rhipocephalus*	C	0	0	4				0.043	VC	
Sargassum spp.	C	3	3	4				0.8	LR	
Udotea	C	1	1	0					VC	
Valonia and *Ventricaria*	C	2	4	6	0.22	0.64				2 genera combined

*Division classification: Chlorophyta (C), Rhodophyta (R), Phaeophyta (P)

† Quadrat types: A: 45 ft, sand (7 quadrats); B: 45 ft, hard (10 quadrats); C: 20 ft, hard (12 quadrats)

‡Morphological Classifications: GL: gelatinous; TS: thin sheet; FL: filamentous; TF: turf-forming; LE: leathery; MC: moderatedly calcified; VC: very calcified

lus is tough and therefore probably resistant to wave stress as well.

I have focused on the possible relationship of wave action and algae distribution, in which case the species which are better adapted for 20 feet wave stress might be less common at 45 feet, where they would be competing with less tough species which have faster growth rates or better light gathering capabilities in low-light conditions. However, it is not certain that wave action is the critical factor even at 20 feet, and there are other influences on distribution of these species. Herbivory may be greater at 20 feet, reducing numbers of delicate algae such as *A. stellata* and species A and encouraging growth of the inconspicuous *N. annulata*. *Caulerpa* spp. are tough and seem resistant to predation (and may be toxic to herbivores; see reference to this in Balser and Soucy, this volume), so differential herbivory and wave stress don't seem likely to affect them. In this case, thallus morphology may have little influence on distribution. Another possibility is the tolerance of the species to ultraviolet radiation which, if low, could restrict the species to deeper areas.

The distribution of the *Dictyota* species may be indicative of grazing pressure since these seem to be some of the more edible algae. However, my sampling method was not sensitive to differences in abundance of this very common genus. Originally aiming to measure percent cover of species in many replicates, I later decided to record only the presence or absence of species or genera in plots. This change was necessitated by the diversity and complexity of the algal community. I found many species, including epiphytes and very small algae which could not be easily identified in the field, and the scattered distribution of many of these algae defied percent cover estimates. The plot size was more appropriate for sampling larger species and those which were patchy on a larger scale. I could have detected differences in density of the most common algae using a different sampling method. One improvement might be using smaller quadrats. This would have provided more useful data on *Dictyota*, *Halimeda*, and *Lobophora*. I observed, in the case of *Dictyota*, a greater density of plants at 20 feet, but this did not show in the data. If I were to do a similar study in the future, I might use a point-survey method, in which the species present is recorded at various points along a transect or within a quadrat. This would give a less complete species list, but would result in data which better reflect how common the species are.

The comparison of sand and hard substrates showed differences in populations of only two species, which may suggest that the algae on those different substrates are not very different. However, once again the sampling method is not showing the whole picture. In sand plots, most of the species recorded were found only on a fragment of dead coral within a mostly barren plot. If I had not included species found on the coral fragments, my results would have been very different, since I would have found fewer species, mainly *Penicillus*, *Halimeda*, and *Caulerpa*, all species with substantial root systems for anchoring them in the sand. In comparing the algae at 20 and 45 feet, I used hard substrate plots because there was little or no sand at 20 feet.

It is clear that there are patterns of algae distribution related to depth in this study. In order to sort out the various causes of algae distribution, more studies of narrower focus and greater depth are essential. Responses of algae with interesting distribution patterns could be further studied to determine their response to the various conditions which change with depth at Mooring 1. Responses to wave stress, light conditions, and herbivory should be studied, and the presence and degree of these stresses should be measured. The conditions will affect different algal species differently, but we may still expect that species with similarities in thallus morphology will have similar distribution patterns in some cases.

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Appendix A. Example of the contingency table format used for G-tests between quadrat types. (Comparison of *A. stellata* in quadrat types A and B)

	Plot type	
	A (45ft, sand)	B (45ft, hard)
#of plots with *A. stellata*	0	6
#of plots w/o *A. stellata*	7	4