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The Assessment of Herbivorous Coral Reef Fish Clearance of Macroalgae

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Abstract

Numerous studies have examined the comparative functional effects of herbivorous fish species on ecological functions in Indian coral reefs. This study investigated the potential grazing effect of individual species within an inshore herbivorous reef fish ecosystem in the central Great Barrier Reef (GBR) by determining whether fish species were capable of eradicating specific macroalgal species. Using transplanted multiple-choice algal tests in conjunction with stationary remote digital submerged video cameras, the effects of six varieties of macroalgae on local herbivorous reef fish species were examined. Fishes have been reported to eliminate macroalgae rapidly. Three hours of exposure to herbivorous reef fishes resulted in the observation of extensive grazing. After 12 hours of exposure, the mass of four of the six macroalgal species reduced by less than 15%. Even after 24 hrs of exposure, Chlorodesmisfastigiata (Chlorophyta) & Galaxaura sp. (Rhodophyta) were significantly more resistant to herbivorous reef fish grazing than any other macroalgae. 6 herbivorous or ostensibly herbivorous reef fish species were found as the most important macroalgae grazers: Acanthuruslineatus, Acanthurusnigrofuscus, Zebrasoma scopas, Scaridae (Parrot fishes), Pomacentridae (Damsel fishes) & Siganidae (Rabbit fishes). Scaridae (Parrot fishes) fed voraciously on Hypnea sp., whereas Siganidae (Rabbit fishes) fed heavily on Sargassum sp. Variability in macroalgal susceptibility was uncorrelated with morphological and/or chemical herbivore repellents previously reported. In spite of this, the results highlight the potential importance of particular herbivorous reef fish species in the reduction of macroalgae on coral reefs.

Keywords: Herbivorous, reef, fishes, macroalgal, species

INTRODUCTION

The global health of coral reefs is deteriorating, primarily as a result of overexploitation [1, 2], pollution [3], climate change [4] and disease. Most typically observed is a transition from coral to fleshy algal dominance [5], with macrofauna loss and fish stock decline serving as early warning indicators [6]. By affecting the organisation of benthic communities [7], herbivorous fishes contribute to the maintenance of healthy coral reefs.

Macroalgae can outcompete corals by colonising space & inhibiting coral development and recruitment if reef fish grazing is limited due to overfishing. In addition to direct effects on coral health, macroalgae indirectly impact coral health by encouraging pathogenic bacteria associated with corals, which increases coral mortality [8]. Herbivorous fishes are a keystone guild in Indo-Pacific reef ecosystems [9] because to the crucial role they play in preventing the buildup of macroalgae. Grazing fishes, which are herbivores, prefer turf-forming, encrusting, & endolithic algae to huge, upright macroalgae, which often have chemical defences [10].

Coral reefs provide ecological services in the form of fisheries productivity, coastal protection and tourism money. Changes in salinity, sedimentation, and temperature of coastal waters, as well as frequent submersion during low tides, have a negative effect on the state of corals. However, coral reef fisheries are a significant influence in the deterioration of coral reefs. Herbivorous coral reef

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fish eat benthic primary producers & keep fleshy algae and reef-building corals in check by limiting their competition. Yet, nothing is known regarding the status of these herbivorous coral reef fishes as fishery targets.

Acanthuruslineatus

Acanthurusnigrofuscus

Zebrasoma scopas

Scaridae (Parrot fishes)

Pomacentridae (Damsel fishes)

Siganidae (Rabbit fishes)

Fig. 1: Herbivorous coral reef fish

LITERATURE REVIEW

Fox et al. (2007) [11] investigated the relative roles of various species in reef-scale ecological processes. Orpheus Island on the Great Barrier Reef is the focus of this investigation into the effects of grazing by free-swimming herbivorous fish. From dawn to dark observations of feeding rates, examination of bite sizes, and relative abundance allowed researchers to determine that Scarusrivulatus, Chlorurusmicrorhinatus & Siganusdoliatus dominated the Orpheus Island system. All three species' estimated impacts varied substantially over the reef's depth gradient, with the highest rates of disturbance occurring at the reef's crest & the lowest rates occurring at the reef's base. According to the species-specific disturbance levels evaluated, S. rivulatus grazes 104% of a

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square metre of the reef crest in a single month, while C. microrhinos grazes 40%. In the same region, S. doliatus eliminates a total of 26 cm^3 of algal detritus.In comparison to the reef crest, grazing activity on the reef flat decreased by a factor of 240. The distribution of macroalgae was inversely connected to the grazing pattern of statistically dominant siganid & scarid fishes in the same reef gradient. The results of this study provide further evidence that herbivory levels affect the structure of algal communities.

Paddack et al. (2006) [12] evaluated the rates of production & consumption of benthic phytoplankton on nearshore & offshore reefs in the higher Florida Keys. Using confined and uncaged experimental plates, algal production rates were measured in situ. They were low (mean 1.05 g C m2 day-1) and comparable across reef varieties. Estimating algal consumption rates required a complex model that included fish bite rates, algal yield-per-bite for a particular species extrapolated to guild-wide values & a general regression connecting fish biomass to algal consumption. The majority of algal growth was consumed by offshore reefs (55 to 100 percent), proceeded by inshore patch reefs (31 to 50 percent). Variations in algal uptake at various localities were caused by alterations in the species composition, density & size structure of herbivorous fish across reef types. Seasonal declines in biting activity and the rare appearance of large, nimble schooling species both contributed to annual fluctuations in algal consumption rates.

Vermeij et al. (2013) [13] examined the ability of four common herbivorous fish species in the Caribbean to disseminate live algal fragments by consuming macroalgae and then defecating them. 98% of fish species' faeces contained fragments of the three principal algal taxa (Phaeophyta, Rhodophyta, & Chlorophyta); however, the capability to survive gut passage & attach to a substrate varied among algal taxa. Rhodophyta (mainly Gelidiaceae species) fragments were 76.4% more likely to survive intestinal passage and develop & reattach to the substrate by forming new rhizomes than Phaeophyta or Chlorophyta fragments. Based on our findings, aquatic herbivores appear to be beneficial to certain kinds of Gelidid algae.

Materials and methods

Study site and macroalgae

The research was performed between January & February 2015 in the Gulf of Mannar, India, between 8°47'N and 9°15'N latitude and 78°12'E and 79°12'E longitude. The average distance between the islands and the mainland is eight kilometres.

The reef flats in the Gulf of Mannar's inner & middle intertidal zones were sampled for six different kinds of macroalgae. Macroalgal species were selected from all three phyla (Chlorophyta, Rhodophyta & Phaeophyta) for this investigation (Table 1). Before being employed in feeding trials, macroalgae were maintained in outdoor tanks with recirculating saltwater (within 24 h of collection). When possible, macroalgae were recognised to the species level, but in most cases, only the genus level was reached.

Table 1: Locations and descriptions of the six macroalgal species employed in this study

Species	Division	Morphology	Location
Chlorodesmisfastigiata	Chlorophyta	Soft, filamentous	Reef crest
Halimeda opuntia	Chlorophyta	Calcareous, segmented	Mid reef flat
Padina sp.	Phaeophyta	Sheet-like, frondose	Mid reef flat

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Sargassum sp.	Phaeophyta	Tough, leathery, branching	Inner reef flat
Amphiroa sp.	Rhodophyta	Calcareous, brittle, branching clumps	Mid reef flat
Galaxaura sp.	Rhodophyta	Strong, branching clumps	Outer reef flat and crest

Initial macroalgal-removal trials

The clearance rates of various macroalgal species after 3, 12, and 24 hours of exposure to herbivorous reef fishes were determined using multiple-choice algal assays. Each of the six macroalgal species was represented by a single 'representative' specimen in these tests. Each specimen was affixed to a one-meter-long piece of fishing line every eight centimetres in a random arrangement. To show algae in their natural state, proportional-sized specimens were selected (i.e., with little alteration to their appearance). Algae that were harmed or discoloured were not utilised in tests.

Algal samples were brought to the reef in plastic self-sealing bags and placed at random positions inside the reef crest of each site (the habitat with the greatest herbivorous fish feeding rates) [14]. Each end of the algal assay lines was attached to a coral or rock fragment. The removal of macroalgae trials began daily at 0800 & 1300 hrs for 7 days, totaling 28 repetitions (14 at each site & seven each in the morning & afternoon). The 12-hour and 24-hour macroalgae removal investigations commenced at 06:00 & concluded at 18:00 or 06:00 the very next day. On each site's crest, three replicates were performed for both the 12 h (n = 6) & 24 h (n = 3) studies (n = 6, n = 3). Prior to and following every experiment, macroalgae were blotted to eradicate excess water and weighed to the nearest 0.01 g. Throughout the duration of the investigation, macroalgal removal rates were determined as mass loss for each species, with the residual mass represented by a percentage of the initial algal mass.

Video analysis

Using a stationary digital video (DV) camera situated 1–2 m away from the multiple-choice algal assays, we observed the feeding behaviour of herbivorous reef fishes for the first three hours. The use of stationary underwater DV cameras to capture algal elimination in the field without the existence of an observer is helpful [15]. Some reef species' behaviour, however, may be mildly affected by the mere existence of a video camera.

Seven days of feeding trials were filmed at 0800 & 1300 hours to document the grazing behaviour of herbivorous reef fishes in the morning and afternoon. Three uninterrupted hours of feeding activity were recorded with the exception of two brief 5-minute tape changes at 09:30 and 14:30 hrs. There were a total of 28 video recordings of feeding attempts (84 hours) made, 14 at each site's peak.

For the entire 180 minutes of each feeding session, the cumulative number of nibbles per fish species on each macroalgae species was recorded, and the 84 hours of video were watched to determine the relative clearance rates of macroalgae by different herbivorous reef fish species. Within 3 hrs of each trial to eradicate macroalgae, all common herbivorous fish species passed a multiple-choice test identifying the algae present. The species with the greatest functional importance (as measured by bite rates) all appeared during the first thirty mints. Only if the fish was observed applying its jaws to the algae and closing its mouth was a "bite" recorded. Rapid,

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impossible-to-separate chews were counted as a single mouthful. If dislodged food was expelled, the number of bites was not recorded.

RESULT

There were no statistically significant differences in macroalgal loss after 3 hours of exposure between sites or between times of day for any of the 6 macroalgal species utilised in the macroalgae-removal trials, nor was there a statistically significant interaction between these two parameters. As a result, all subsequent evaluations were conducted on the basis of combined site & morning/afternoon trials.

Macroalgal removal rates

The rates of clearance of macroalgae were significantly different between the six different species of macroalgae. Research is being done on the six herbivorous reef fish.

Table 2: Macroalgal species remaining after 3h

Herbivorous reef fishes	**Macroalgal species**					
	Chlorodesmisfastigiata	Halimeda opuntia	Padina sp.	Sargassum sp.	Amphiroa sp.	Galaxaura sp.
Acanthuruslineatus	84 ± 0.80	65±3.01	72.84±0.79	59±4.02	75±5.05	47.84±3.08
Acanthurusnigrofuscus	54±0.24	64.74±2.63	47±4.53	62±3.52	37±1.63	41±2.67
Zebrasoma scopas	43±6.70	56±5.63	74±6.21	49±2.74	58±2.84	46±1.83
Scaridae (Parrot fishes)	67±3.73	57±2.93	36±2.65	48±6.20	73±1.63	**95±0.31**
Pomacentridae (Damsel fishes)	53±4.52	64±3.72	39±4.21	67±4.37	59±3.61	48±3.73
Siganidae (Rabbit fishes)	59±3.53	66±2.76	45±5.35	**87±3.72**	69±3.73	74±2.46

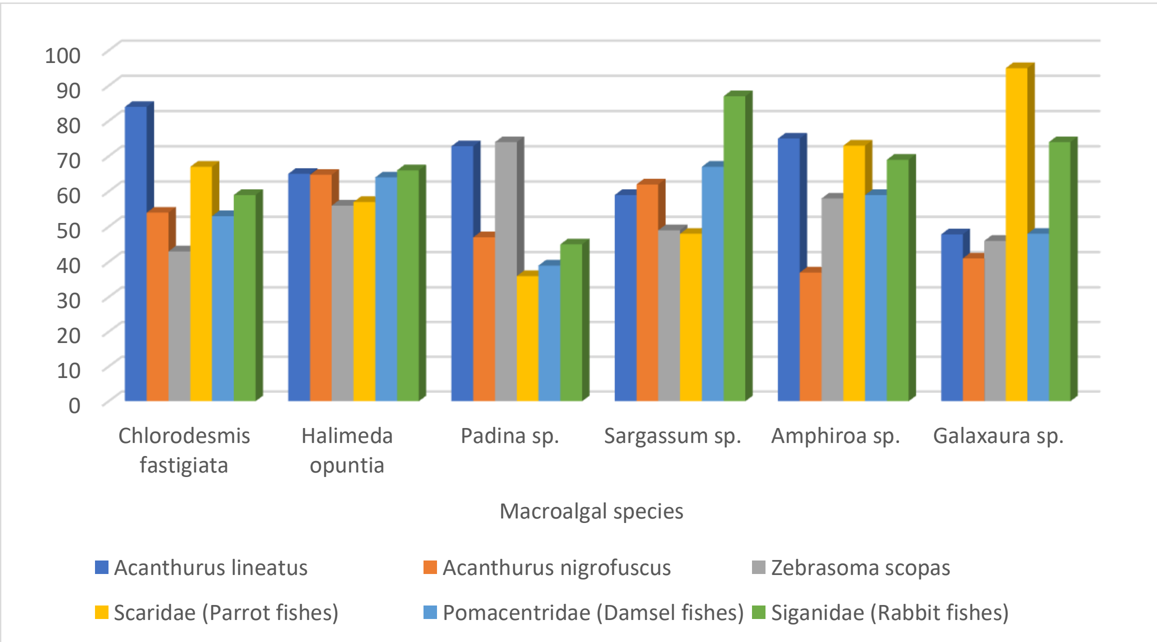

Fig. 2:Macroalgal species remaining after 3h

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Variation in removal efficiency was large among the six macroalgal species (P<0.001; Fig. 2, Tab. 2). The green alga C. fastigiata (84 0.80% SE) & the red alga Galaxaura sp. (950.31% SE) differed significantly from all other macroalgae in terms of the proportion of algal mass remaining after 3 hours of exposure to herbivorous reef fishes. Halimeda species, Padina sp., Sargassum sp., & Amphiroa sp. showed marginally less mass loss than most brown & red algae, with the exception of Galaxaura sp.

Table 3: Macroalgal species remaining after 12h

Herbivorous reef fishes	**Macroalgal species**					
	Chlorodesmisfastigiata	Halimeda opuntia	Padina sp.	Sargassum sp.	Amphiroa sp.	Galaxaura sp.
Acanthuruslineatus	85±2.53	65±3.75	49±2.95	52±4.82	67±2.94	59±2.15
Acanthurusnigrofuscus	63±2.08	48±3.95	52±1.47	64±3.26	57±2.05	49±3.91
Zebrasoma scopas	49±1.97	52±3.74	62±3.64	46±3.21	67±4.32	59±5.42
Scaridae (Parrot fishes)	53±3.75	43±2.05	63±4.03	52±2.38	47±2.84	92±0.74
Pomacentridae (Damsel fishes)	62±1.94	48±5.32	67±3.07	56±1.09	37±4.82	43±2.63
Siganidae (Rabbit fishes)	54±2.07	47±3.93	61±3.82	86±2.83	49±2.91	66±3.95

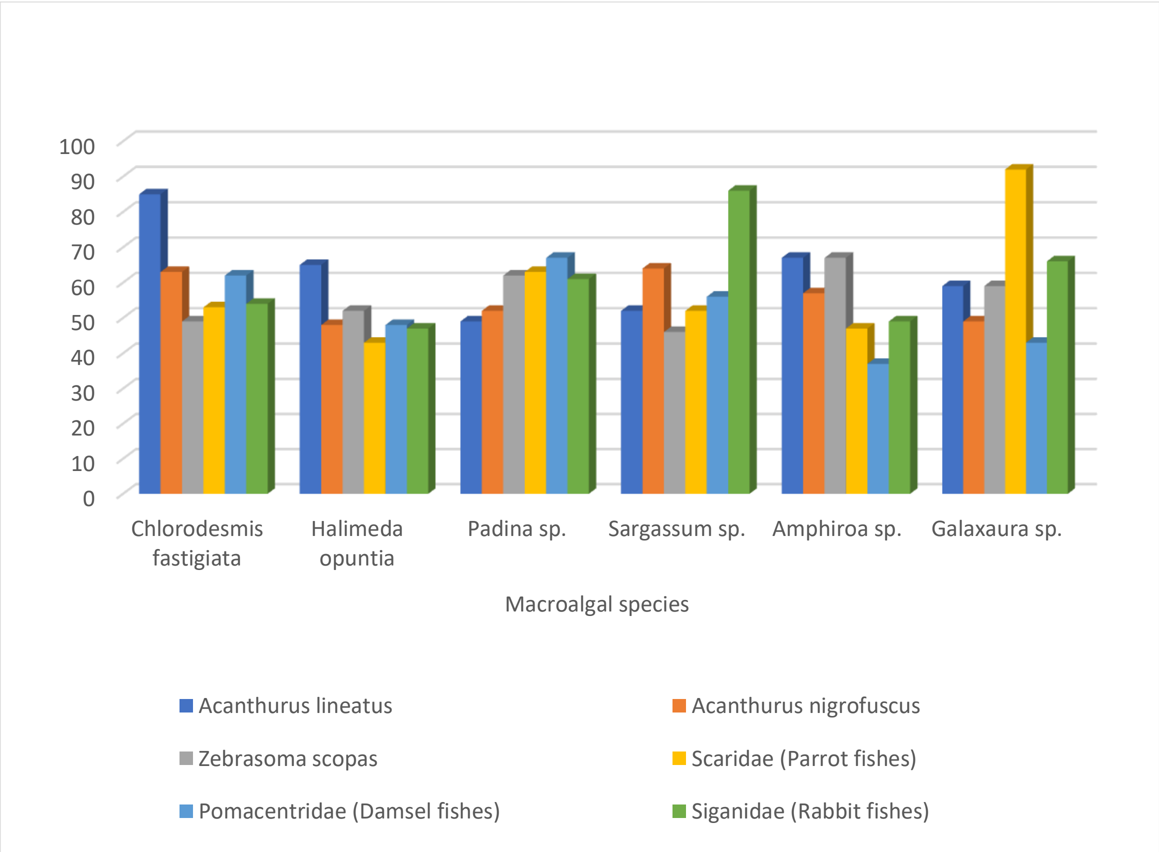

Fig.3:Macroalgal species remaining after 12h

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After 12 hours of being exposed to herbivorous reef fishes, Fig. 3 and Table 3 demonstrate that C. fastigiata (85±2.53% SE remaining) &Galaxaura sp. (92±0.74% SE remaining) were still in a relatively good condition. In contrast, only fragments of the other four species of macroalgae remained after the extinction.

Table 4: Macroalgal species remaining after 24h

Herbivorous reef fishes	**Macroalgal species**					
	Chlorodesmisfastigiata	Halimeda opuntia	Padina sp.	Sargassum sp.	Amphiroa sp.	Galaxaura sp.
Acanthuruslineatus	56±1.73	24±2.94	31±3.61	16±2.85	17±3.92	52±6.42
Acanthurusnigrofuscus	48±2.75	15±3.95	21±3.53	12±5.62	16±3.26	46±2.01
Zebrasoma scopas	49±5.61	22±3.75	18±1.64	9±4.38	13±5.13	43±3.51
Scaridae (Parrot fishes)	52±1.25	13±4.61	7±2.93	17±3.82	14±3.74	59±4.21
Pomacentridae (Damsel fishes)	47±2.64	18±3.63	13±6.73	18±3.72	12±1.84	44±3.83
Siganidae (Rabbit fishes)	55±2.03	14±2.83	17±1.94	8±5.82	11±3.94	50±1.94

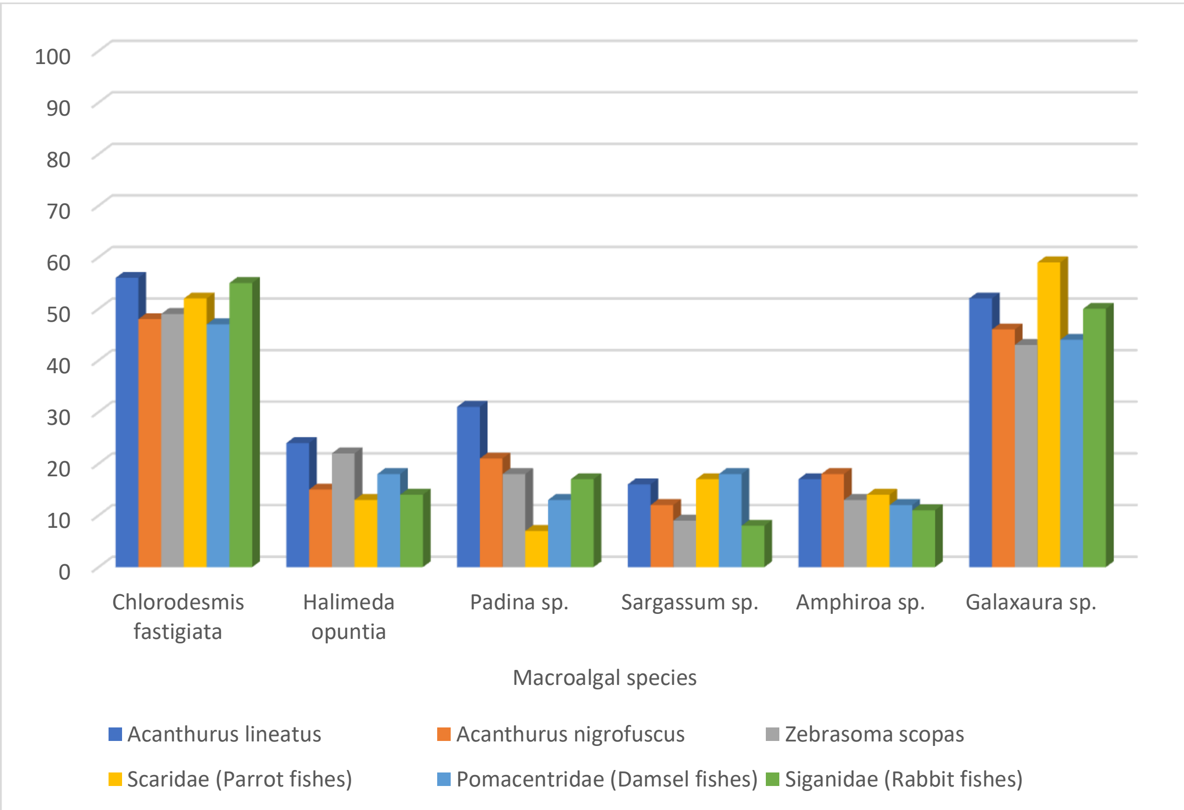

Fig. 4: Macroalgal species remaining after 24h

After being exposed of 24 hours, Fig. 4 and Table 4 show that the mass of C. fastigiata and Galaxaura sp. reduced to 56±1.73 and 59±4.21% SE of their initial biomass, respectively, whereas the mass of all the other exposed macroalgae was either completely reduced or only remained as small fragments.

CONCLUSION

The conclusion of this study is that herbivorous reef fishes may play a significant role in the clearance of macroalgae from Indo-Pacific coral reefs. The distribution of macroalgae within the study area explains the alteration in their sensitivity to herbivorous reef fishes that was observed. Alteration in growth rates, distributions within the studied area & structural & chemical defences likely account for the broad range of macroalgal susceptibility to browsing. On the reef crest in the Gulf of Mannar, six herbivorous reef fish species were discovered to be feeding on macroalgae. Nonetheless, there appears to be significant differences in their dietary habits. It will be critical to assess the degree of feeding selectivity of each fish species in order to comprehend the significance of each species' contribution to macroalgae removal in this reef system.

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