The following supplements accompany the article

Food intake by the parrotfish *Scarus ferrugineus* varies seasonally and is determined by temperature, size and territoriality

Y. Afeworki[1,2,*], Z. A. Zekeria[2], J. J. Videler[1], J. H. Bruggemann[3]

[1]Department of Ocean Ecosystems, University of Groningen, PO Box 14, 9750 AA Haren, The Netherlands
[2]Department of Applied Marine Science, College of Marine Science and Technology, PO Box 170, Massawa, Eritrea
[3]Laboratoire d'Ecologie Marine (ECOMAR) – FRE CNRS 3560, Université de la Réunion, CS 92003, 97744 Saint Denis, La Réunion, France

*Email: y.afeworki@rug.nl

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Supplements 1, 2 & 3. Details of the sampling periods, relationship between turf biomass and ash free dry mass content, and further details of the relationship between bite rate, life phase and fish size

Supplement 1. Sampling periods

Alternating cool and hot seasons in the southern Red Sea are driven by the Indian Ocean monsoon system. The cool season extends from December through March, while the hot season lasts from May to October (Ateweberhan et al. 2005, 2006). Transition periods between these seasons are characterized by variable wind patterns and intermediate temperatures. Mean monthly seawater temperatures at 2 m depth at the study site range from 27.0 to 33.4°C (Ateweberhan et al. 2006, Fig. S1). The bite rate sampling periods were selected to encompass the entire annual temperature range (Fig. S1). Samples for quantifying the yield per bite were collected during 2 periods with contrasting temperatures (Fig. S1). Yield per bite and dawn-to-dusk defecation rates were also determined during these 2 periods.

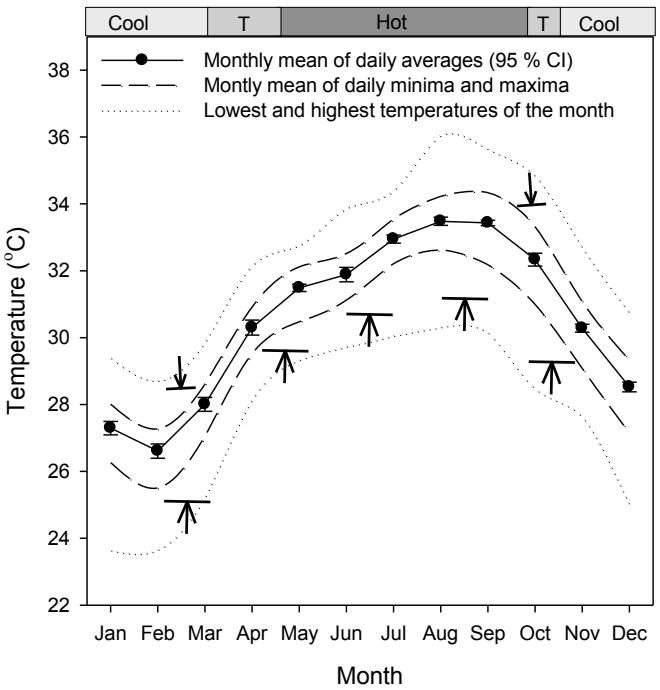

Fig. S1. Monthly variation in seawater temperature at the study site (2003 to 2006). The cool season, associated with the southwest monsoon, and the hot season during the northeast monsoon are shown. T = transition periods with variable wind directions. Upward-pointing arrows indicate sampling periods where bite rates were recorded. Downward-pointing arrows represent periods during which yield per bite and dawn-to-dusk defecation rate were recorded

Supplement 2. Turf biomass and ash-free dry mass (AFDM)

Turf algae biomass was assessed from natural carbonate substrates between 2007 and 2008 at the reef crest, on the shallow fore-reef and on the deep fore-reef during February, April, September and December. At least 4 dead coral substrates covered by turf algae (100% cover) were selected haphazardly. From each of these substrates, a piece was chiseled off and kept in a separate plastic bag during transport to the lab. Turfs were carefully removed using a scalpel, taking care not to include substrate-bound endolithic algae. A piece of aluminum foil of known areal density was modeled over the substrate and carefully trimmed to match the irregular edges of the coral piece. The surface area was then estimated by dividing the weight of the piece by the density per unit area of the aluminum foil. To determine the AFDM, samples were dried at 60°C and ashed at 550°C in a muffle furnace for 8.5 h.

Biomass of turfs at the reef crest and on the shallow fore-reef (the 2 main foraging zones of *Scarus ferrugineus*) is highest during the cool season. The percentage AFDM is negatively correlated with turf biomass (Fig. S2). The cover and biomass of turf algae at our study site show opposing seasonal trends: turf biomass is highest and its cover is lowest during the cool season (Ateweberhan et al. 2006, Afeworki et al. 2011). The fact that low-biomass turfs cover much of the dead coral surface in spring and summer suggests that the availability of food of better nutritional quality is higher during these periods. Indeed, detailed analyses of the nutritional value of the EAM on the Great Barrier Reef show that the nutritional value of EAM is inversely proportional to its biomass (Purcell 2000, Purcell & Bellwood 2001, Bonaldo & Bellwood 2011), as high-biomass turfs tend to contain more sediment and hence are of poor nutritional quality. In addition, there is a positive correlation between the percentage AFDM and the percentage protein content in marine algae (Bolser & Hay 1996). Given this, the percentage AFDM provides an indication of the nutritional quality of turfs (Bolser & Hay 1996, Wilson 2002).

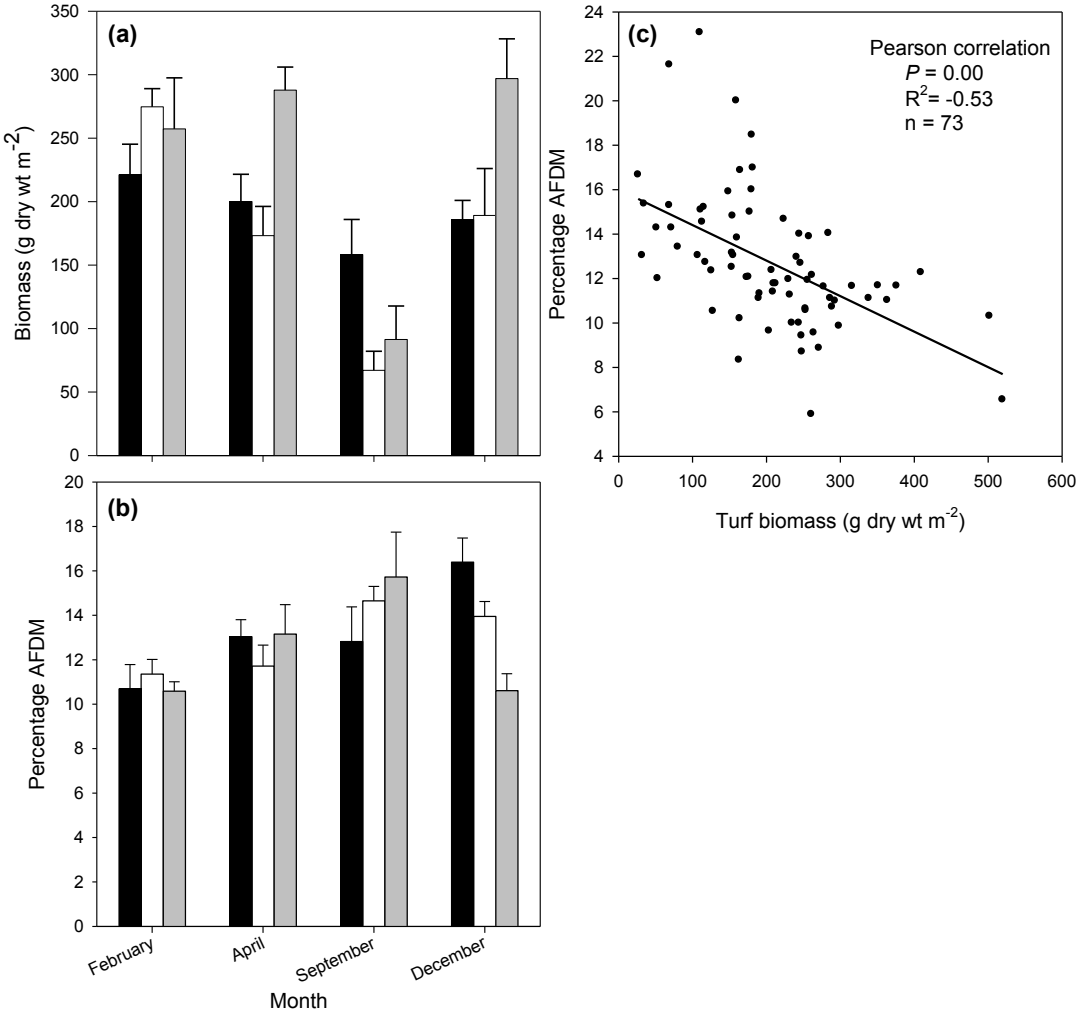

Fig. S2. Seasonal trends in mean (± SE) biomass (a) and percentage ash-free dry mass (AFDM) (b) of epilithic algal matrix (EAM) from 3 reef zones of the fringing reef at Sheikh Said Island. Reef crest: black bars; shallow fore-reef: white bars; deep fore-reef: gray bars. (c) Relationship between percentage AFDM and biomass of EAM

Supplement 3. Fish size, life phase and bite rate

Effect of life phase on bite rate: The objective was to quantify bite rate and intake rate for the 3 main size/social categories of *Scarus ferrugineus*: 20 to 25 cm initial phase (IP), 30 to 35 cm terminal phase (TP) and 30 to 35 cm territorial terminal phase (TTP). However, bite rate differences between 20 to 25 cm IP and 30 to 35 cm TP could be related both to size (Bruggemann et al. 1996, Lokrantz et al. 2008) and to social status (Bruggemann et al. 1994, van Rooij et al. 1996, Bonaldo et al. 2006). To differentiate between these 2 factors, an additional data set of bite rates was collected for TP whose size overlaps with that of the IP. While testing the effect of size and/or life phase on bite rate, data of territorial TP were excluded. Thus, the results reflect the effect of size and/or life phase on bite rate and not of territoriality. ANCOVA was conducted for each period with bite rate as a dependent variable, life phase as a factor and size as a covariate. Prior to conducting ANCOVA tests, data were tested for normality and homogeneity of variance using the Explore procedure in SPSS. In the size class where IP and TP overlap, bite rate did not differ between the two (Table S1).

Table S1. *Scarus ferrugineus*. Summary of ANCOVA results comparing bite rate (bites min^{-1}) between IP and TP fish of 20 to 25 cm fork length. Significant effects are shown in bold

Period	Source	SS	df	MS	*F*	p
February–March	Life phase	98.881	1	98.881	1.388	0.248
	Size	12.899	1	12.899	0.181	0.674
	Life phase × Size	91.201	1	91.201	1.280	0.267
	Error	2137.717	30	71.257		
June–July	Life phase	10.761	1	10.761	0.191	0.668
	Size	164.719	1	164.719	2.925	0.108
	Life phase × Size	10.130	1	10.130	0.180	0.677
	Error	844.703	15	56.314		
August–September	Life phase	7.176	1	7.176	0.112	0.739
	Size	93.097	1	93.097	1.456	0.232
	Life phase × Size	0.099	1	0.099	0.002	0.969
	Error	4412.881	69	63.955		
October–November	Life phase	0.703	1	0.703	0.018	0.893
	Size	160.345	1	160.345	4.212	**0.047**
	Life phase × Size	3.485	1	3.485	0.092	0.764
	Error	1560.663	41	38.065		

Effect of size on bite rate: To fully investigate the relationship between size and bite rate, additional data were collected for sizes outside of the target group (namely <20 and 25 to 30 cm fork length). Since small individuals (5 to 10 cm) are abundant during the summer months, bite rate data for this category were collected mainly during the June to July and August to September sampling periods. As a result, bite rate data for the widest size range of *Scarus ferrugineus* were available during these 2 periods only. Bite rate data of IP and TP were pooled since there is no significant effect of life phase (see above). Data from TTP, however, were excluded. ANCOVA tests showed that the mean bite rate did not differ between June to July and August to September (ANCOVA; period: $p = 0.311$, $F = 1.033$; size: $p < 0.001$, $F = 50.030$, $n = 197$). Consequently, data from these 2 periods were pooled to generate a best-fitting model relating bite rate and fish size using the curve-fitting procedures in SPSS. A quadratic function was selected as the best-fitting model based on the R^2 values. All data analysis was done in SPSS for Windows 16 (2007).

LITERATURE CITED

Afeworki Y, Bruggemann JH, Videler JJ (2011) Limited flexibility in resource use in a coral reef grazer foraging on seasonally changing algal communities. Coral Reefs 30:109–122

Ateweberhan M, Bruggemann JH, Breeman AM (2005) Seasonal dynamics of *Sargassum ilicifolium* (Phaeophyta) on a shallow reef flat in the southern Red Sea (Eritrea). Mar Ecol Prog Ser 292: 159171

Ateweberhan M, Bruggemann JH, Breeman AM (2006) Effects of extreme seasonality on community structure and functional group dynamics of coral reef algae in the southern Red Sea (Eritrea). Coral Reefs 25:391–406

Bolser R, Hay M (1996) Are tropical plants better defended? Palatability and defenses of temperate vs. tropical seaweeds. Ecology 77:2269–2286

Bonaldo R, Bellwood D (2011) Spatial variation in the effects of grazing on epilithic algal turfs on the Great Barrier Reef, Australia. Coral Reefs 30:381–390

Bonaldo RM, Krajewski JP, Sazima C, Sazima I (2006) Foraging activity and resource use by three parrotfish species at Fernando de Noronha Archipelago, tropical West Atlantic. Mar Biol 149: 423–433

Bruggemann JH, Begeman J, Bosma EM, Verburg P, Breeman AM (1994) Foraging by the stoplight parrotfish *Sparisoma viride*. II. Intake and assimilation of food, protein and energy. Mar Ecol Prog Ser 106:57–71

Bruggemann JH, van Kessel AM, van Rooij JM, Breeman AM (1996) Bioerosion and sediment ingestion by the Caribbean parrotfish *Scarus vetula* and *Sparisoma viride*: implications of fish size, feeding mode and habitat use. Mar Ecol Prog Ser 134:59–71

Lokrantz J, Nystrom M, Thyresson M, Johansson C (2008) The non-linear relationship between body size and function in parrotfishes. Coral Reefs 27:967–974

Purcell SW (2000) Association of epilithic algae with sediment distribution on a windward reef in the northern Great Barrier Reef, Australia. Bull Mar Sci 66:199–214

Purcell SW, Bellwood DR (2001) Spatial patterns of epilithic algal and detrital resources on a windward coral reef. Coral Reefs 20:117–125

van Rooij JM, de Jong E, Vaandrager F, Videler JJ (1996) Resource and habitat sharing by the stoplight parrotfish, *Sparisoma viride*, a Caribbean reef herbivore. Environ Biol Fishes 47:81–91

Wilson S (2002) Nutritional value of detritus and algae in blenny territories on the Great Barrier Reef. J Exp Mar Biol Ecol 271:155–169