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Underestimated Eroder among Reef Fishes – Experimental Comparison between *Ctenochaetus striatus* and *Acanthurus nigrofuscus* (Acanthuridae)

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Abstract. The acanthurid fish species *Ctenochaetus striatus* and *Acanthurus nigrofuscus* are common detritivore browsers. Less is known about their erosion potential. We offered coral limestone for grazing in aquarium experiments and recorded the feeding behaviour by video. *C. striatus* produced 15 times more calcareous sediments compared to *A. nigrofuscus* despite of a 5 times higher biting rate of *A. nigrofuscus*. Whereas *A. nigrofuscus* performed careful picking bites only, *C. striatus* showed soft sweeping of the surface alternating with chafing the substrate with grasping bites. Hereby a special palate structure (bow of hard knobs in the upper jaw) is engaged which allows to rasp the reef substrate. The measured eroded masses per bite and the number of bites per individual were related to the population densities of the two species on three reef crests in the Northern Red Sea. Based on these extrapolations, *A. nigrofuscus* attains maximum erosion rates of 2.6 g m^{-2} yr^{-1} and may therefore not be regarded as a relevant bioeroder, but *C. striatus* achieves erosion rates of up to 70.0 g m^{-2} yr^{-1} which is in the same order as that of the co-occuring sea urchin *Diadema setosum.*

Key words: Detritivore acanthurids, jaw morphology, bioerosion, Red Sea

Introduction

Coral limestone plates which were set up for colonization experiments at Aqaba (Jordan, Northern Red Sea) were found to be eroded after two years by up to 6.12 mm (v.Treeck et al. 1996). The experimental set-up excluded bioeroding sea urchins, but not grazing fish. Surgeonfishes and parrotfishes are the principal grazing groups with many fishes in the latter family capable of scraping and excavating coral limestone (Glynn 1997). In situ video recordings and observations showed that the plates were most frequently grazed by the acanthurid fish *Ctenochaetus striatus* (Quoy and Gaimard 1825) and *Acanthurus nigrofuscus* (Forsskal 1775). Scaridae, however, were rare. Hence, the feeding behaviour of the two species which are known as detritus feeders (Randall and Clements 2001) was investigated in aquarium experiments with supplementary observations in three reefs in the Northern Red Sea.

Trials to run experiments close to the reef in the laboratories of the Ras Mohamed National Park (southern tip of Sinai-Peninsula) could not be sufficiently standardized, since we were not allowed to catch the wanted specimens, but depended on the supply of healthy fishes by Bedouin fishermen. In addition we arranged an experimental set-up in the university aquarium plant in Essen. These data, albeit obtained from a necessarily limited sample size, are presented here and discussed in conjunction with the specific jaw morphology of the two fish species.

Material and Methods

Aquarium trials were run at the University of Duisburg-Essen in spring 2005 with fish obtained from the aquarium trade.Two subadult individuals (8-9 cm TL) of each species were at our disposal. *Favia* plates from the same stock as had been used in the above mentioned experiments at Aqaba were immersed in seawater taken from an aquarium accommodating “living rocks” and invertebrates from the Red Sea, until being covered with a veneer of diatoms, green and bluegreen algae; then they were offered to the individual fish. These had been kept without food for one day to empty the intestinal tract. The browsing activities were recorded by video. After 7-8 hours the plates were removed. The fish, however, remained in the tank for another 12 hours without food. Then all loose particles (i.e. predominantly faeces, not ingested but removed limestone particles, and material generated by handling) were sucked off and collected in 50 µm gauze. These sediments were analyzed for their dry weight carbonate content.

As control, a coral slab of the same size was similarily handled in an aquarium – without fish. To prevent coprophagy during the time when the fish’s gastrointestinal tract was emptied a net was installed a few cm above the bottom.

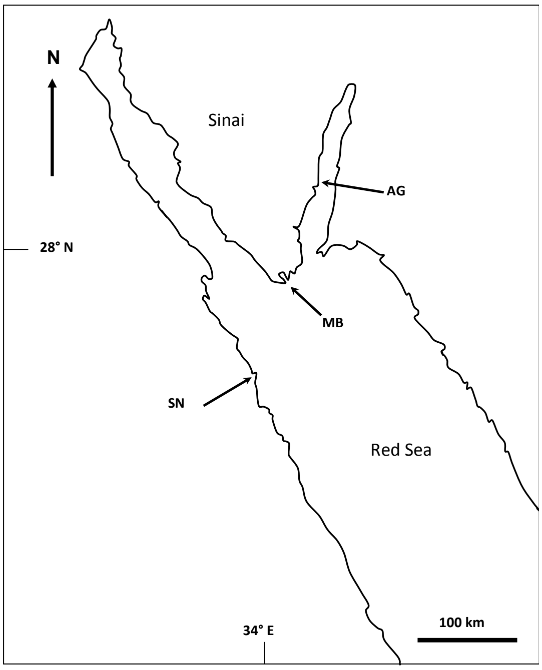

Figure 1: Map of study sites, see text for details.

Field observations were performed by extensive snorkelling on three reefs at different seasons: 1. Abu Galum (AG), 2. Marsa Bareika (MB), and 3. Sharm el Naga (SN, see Fig. 1). Individual fish were observed for several hours at different times of the day counting those bites which clearly occured on hard substrate. Bites on sponges, fleshy algae, and sand covered substrate were ignored. Therefore, the recorded bites per day represent minimum values. The abundance of the acanthurid fish was recorded at the three sites by counting all individuals within 50x5 m transects (3 replicates), placed on the reef crests with a distance of 2.5 m to the edge (English et al. 1997).

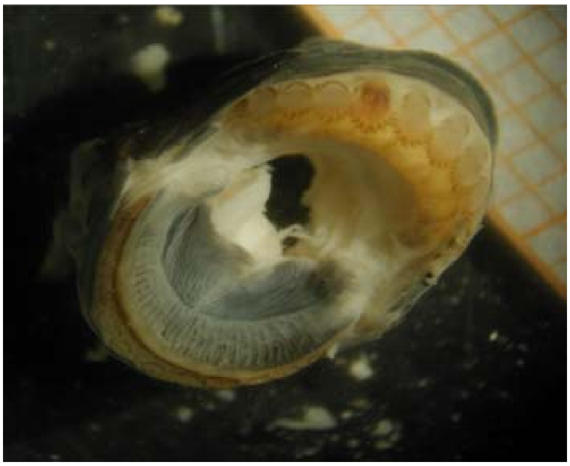

Figure 2: Opened mouth of *A.nigrofuscus*; upper jaw with millimetre grid in background.

Results

Corresponding to the aquarium experiments of Purcell and Bellwood (1993) we found two different feeding techniques.

Figure 3: Upper jaw (top) and lower jaw (bottom) of *C. striatus*; arrow points to the knobby structure behind the bristle-like teeth.

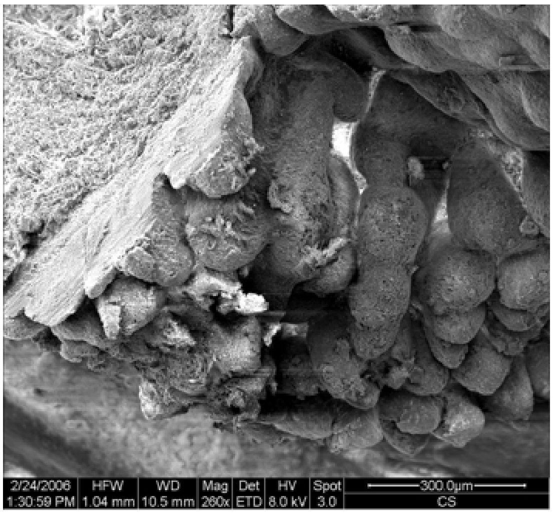

Figure 4: SEM picture of a section of the hard palate structure pointed to in Fig.3.

A.. nigrofuscus grazes with a minimal contact to the substrate. It feeds using quick punctual bites. *C. striatus* feeds opening its mouth up to an angle of 180° sweeping the substrate with its jaw bristles; in addition, forceful grasping bites at which the whole body is shaking and exerting thrust were observed.

Table 1 provides data on number of bites and removed carbonate masses. Although *A. nigrofuscus* showed a five times higher bite rate, fifteen times more loose calcareous matter was found to be produced by *C.striatus* inside the aquarium. Hence, an erosion rate of 0.09 mg per bite results for *C. striatus* compared to 0.001 mg/bite for *A. nigrofuscus*.

On all three reef sites both acanthurid species were very common and much more abundant than scarids (details of the surveys are omitted here).

The pooled data of bites per day of a single individual are 13679 (SD ± 2177) for *C. striatus* and 22220 (SD ± 5092) for *A. nigrofuscus*. Combining the experimentally obtained data of removed carbonate material per bite and observed number of bites on the reef per day results in the following hypothetical approximations of erosional efficiency: 449 g/ind.yr for *C. striatus* versus 6 g/ind.yr for *A. nigrofuscus.*

Table 1 Number of bites and amount of produced sediment [mg] per experimental run

A. nigrofuscus						
Individual A				Individual B		
Bites	mg	mg/bite		Bites	mg	mg/bite
27751	37.81	0.0014		13070	5.08	0.0004
22367	32.12	0.0014		6368	7.93	0.0013
C. striatus						
Individual A				Individual B		
Bites	mg	mg/bite		Bites	mg	mg/bite
5063	543.10	0.1073		1524	125.24	0.0822
3788	362.59	0.0957		3181	230.26	0.072

Discussion

The experiments resulted in a clear answer to the initial question which of the two acanthurids was responsible for the erosion of the *Favia* plates. A look at the mouthparts of the two species is helpful to understand the significant difference in the capability to remove carbonate substrate. The spatulate teeth of *A. nigrofuscus* are arranged in bundles (Fig 2) – well adapted to collect fine detrital material and algae. *C. striatus* is equipped with bristle-like teeth – well suited to sweep the bottom and to take in loose material (Fig. 3). In addition, there is a bow of hard knobs in the upper jaw (arrow in Fig. 3, SEM photo, Fig 4). This special palate structure is engaged to abrade hard bottom (Krone et al. 2006). This until recently overlooked morphological detail qualifies *C. striatus* as bioeroder – in addition to its affiliation to the guild of detritus feeders. The annual erosion impact of *C. striatus* is comparable to that of the sea urchin *Diadema setosum* in the Gulf of Aqaba which are eroding carbonate masses varying between 1023g/ind. (Kroll 1995) and 113g/ind. (Mokady et al. 1996).

On the basis of our estimates of abundance on some reefs *C. striatus* can achieve erosion rates of up to 70.0 g m^{-2} yr^{-1} which again reaches the same order of magnitude as that of the co-occuring sea urchin *Diadema setosum*. *A. nigrofuscus*, however, attains maximum erosion rates of 2.6 g m^{-2} yr^{-1} and may therefore not be regarded as a significant bioeroder.

The presented data and extrapolations are definitely conservative, since they were obtained from subadult fishes feeding on an especially hard substrate not yet weakened by endolithic borers (dried *Favia* plates were used to have standardized conditions with regard to the experiments mentioned in the introduction). Supplementary experiments run in the wet lab of the Ras Mohamed Park with natural reef substrate yielded five times higher excavation rates (unpub. data).

On the basis of the presented pilot study it might be fruitful to investigate the ecological functions of *C. striatus* within the sediment regimes of Indo-West-Pacific reefs in more detail.

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