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ABSTRACTS

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The importance of *Ctenochaetus striatus* (Acanthuridae) for the sediment balance of coral reefs in the Northern Red Sea

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The rate of carbonates and other minerals which sink down on fringing reef surfaces at the desert coast of the South Sinai Peninsula was quantified with a standardised technique. The minimum masses which de facto remain on the reefs without any feeding pressure were measured applying a new method. The common herbivorous fish species Ctenochaetus striatus which is grazing on coral rock was found to defecate exclusively outside the reef.
Behaviour observations and faeces analyses were done to quantify the masses of inorganic matter exported out of the reef. It was found that the examined C. striatus population exports 572.5g m-2 y-1 inorganic particles (276.9g carbonates, 295.6g land born minerals) out of the reef crest. This value represents approximately one third of the here-observed mean accumulation rate of particles from the water column. This function of C. striatus within the sediment budget underlines that some organisms can contribute significantly to the sediment removal from coral reefs. This should be considered when discussing the phenomenon that living reefs are persisting in areas with naturally high sediment inputs. A scheme for sediment balances in coral reefs is presented.
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The Importance of *Ctenochaetus striatus* for the Sediment Budget of a Coral Reef in the Northern Red Sea

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Introduction

Sedimentation is decisive for the existence of coral reefs. Where sedimentation is too high corals die and new ones do not settle. Wind-induced waves, currents und hurricanes have been identified as mechanisms removing seston from reef surfaces (e.g. Hubbard et. al. 1990, Hubbard 1992). It has been known for a long time that some bio-eroding fish translocate enormous quantities of calcareous matters within reefs (Bardach 1961). In particular parrotfish can transport considerable parts of their erosion products away from the reef's surface (Bellwood 1995).
We investigated the role of the surgeonfish *Ctenochaetus striatus*, a very common reef fish in the Indo-Pacific, with regard of the sediment balance of a fringing reef in the northern Red Sea. Using its bristle teeth this fish ingests algae and sediment from reef surfaces (Montgomery et al. 1989) and is also suggested to be a bio-eroder (Krone et al. 2006). Moreover, the fish usually defecate outside the reef, thus exporting sediments from the reef surface (Krone et al. submitted).
The rates of carbonate and other particulate matters which settle on the reef surfaces fringing the desert coast of the South Sinai Peninsula were quantified with a standard technique. The minimum masses which remain on a reef interference of feeding fish were measured applying a modified method. Behavioural observations and faeces analyses were performed to quantify the sediment masses transported by *C. striatus* away from the reef. These investigations allow a differentiated scheme to determine the sediment budget and the components involved.

MATERIAL AND METHODS

All observations took place on a fringing reef in the Bareika Bay in the Ras Mohammed National Park, South Sinai (background picture, Fig. 1) in November 2005.
Fish census: The abundance of *Ctenochaetus striatus* was determined with belt transects on the reef crest adjacent to the reef edge.
Behavioural observations: The reef edge within the home range of 6 *C. striatus* individuals was filmed starting with the first defecation of the day until the last visible action in the evening. The number of faecal pellets dropped above the sand bottom outside the reef (Fig. 2) was counted.
Faeces analysis: 10 faeces pellets per day were sampled over a period of 15 days. These samples were analysed for their calcareous and non-calcareous mineral contents.
Sedimentation: Classical tube traps were placed beside the seaward fringing reef edge for 15 days (emptied every 24 hours).
Petri dishes (h = 2mm, d = 900mm) were weighted down and protected by cages against feeding (Fig. 3). These „petri traps" were placed on the reef crest for 15 days. The dishes served to determine the sediment masses which remain on the surface despite water movements. Tube traps are not suitable to answer this question, they rather collect the total amount of sediment.
Wind: Speed and direction were measured continuously 10m beside the reef (background picture) to gain clues to the origin of terrestrial sediments.
Calculation of sediment export by *C. striatus*: The mineral masses detected in the faeces

were multiplied by the fish number of fish on the fringing reef crest and their minimal defecation rate.

Results and Discussion

When sediment accumulation is at a low ~2.3g m^{-2} d^{-1} (calculated excluding the high peak of sedimentation detected in the present investigation, the rate is similar to results by Eisinger 2004 and Kotb et al. 1991) ***C. striatus*** **has the capacity to export ~75% of the sediment masses not replaced by water movements** (Fig. 7). Calculations show that during phases of such low sedimentation also sediments which have been generated within reefs could partly be exported by *C. striatus*. Doubtlessly both transports can not easily be separated and it should be considered that even *C. striatus* might produce sediments (Krone et al. 2006).
In the light of our investigations the budget of sediment input and removal should be refined by a differentiated consideration of the source of sediments and the agents of sediment removal with special emphasis on biological sediment export. Then the budget reads as follows:

$$Cr + Tr = Cp + Cf + Tf - Ew - Eb$$

(Cr = calcareous sediments remaining on the reef, Tr = terrigene mineral sediments remaining on the reef, Cp = calcareous sediments produced on the reef (bioerosion, Foraminifers etc.) Cf = calcareous fall down, Tf = terrigene fall down, Ew = sediments exported by water movements, Eb = biological sediment export)

In addition to other functions -like algae limitation (Paddack and Cowen 2006) and bioerosion (Bellwood et al. 2004)- the importance of an organism on the reef fitness increases with the bulk of sediments it ingests inside and egests outside the growth zones of reefs. Furthermore, an organism becomes a crucial factor if it exports huge amounts of particles it did only recycle. We suggest *Ctenochaetus striatus* to possibly be only one among many more such important "reef sweepers". In some areas this mechanism might be an important precondition for the persistence of coral reefs. In most reefs it might have a determinable function.

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