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INVITED ESSAY

Stuck in the mud

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One had to be quick. Walk like a stork. Easier said than done, carrying a backpack full of equipment, buckets full of samples and a shovel over the shoulder, sinking knee-deep into the mud under the scorching tropical sun and watching out for crocodiles. I looked like a pig already. What was I doing here?

Growing up near the coast of the North Sea, harbouring the Wadden Sea being one of the most extensive tidal flat ecosystems on Earth, I was addicted to wide intertidal areas and already gained in-depth knowledge of its biota. Generations of scientists were studying this system, but data from tropical tidal flats were scarce. This raised my curiosity. Every other coastal habitat in the tropics had received more attention, although sand- and mudflats abound along many tropical shores (Fig. 1).

At that time, it was doubted by the scientific community that species interactions

Fig. 1. Tidal flat area near the Australian Institute of Marine Science in North Queensland, Australia.

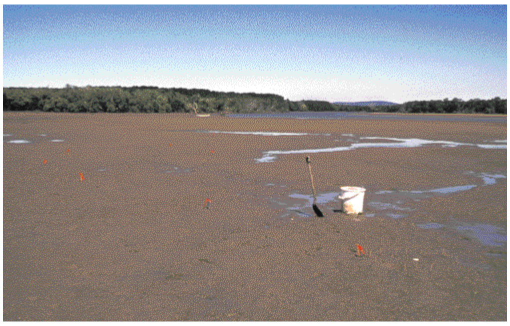

Fig. 2. Parts of my experiments in tidal mudflats of North Queensland, Australia.

Fig. 3. Soldier crabs (*Mictyris longicarpus*) gathering at a water puddle during their foraging activities.

would play a role in benthic communities of tropical tidal flats, as extreme environmental conditions appeared to be the prevailing factor. Yet, no one had investigated any interactions there. This was a topic for me. Luckily I was given the chance to test this in the field during a post-doc funded by the German Research Council (DFG), carried out at the Australian Institute of Marine Science (AIMS) in North Queensland, Australia. Only later did I find out that José A. Vargas had a similar objective and was already putting up predator exclusion cages in the mudflats of Punta Morales, Costa Rica (Vargas 1988).

I was heading out into uncharted territory in many ways. Not just finding access to tidal flats through the bush or from the sea, but getting to know all the creatures in the sediment (the benthos) and the tracks they leave on the sediment surface at low tide turned into a major pastime of mine. Soon I learned what it means to work in the tropics. Every other specimen in my samples belonged to a yet unseen new species. This was further aggravated by my use of several mesh sizes to separate the animals from the sediment, as finer sieves yielded more and more organisms, especially polychaete species of small individual size. This component of the tropical benthos had been overlooked before (Dittmann 1995). Altogether I recorded nearly 500 species of benthic animals in the tidal flats of North Queensland and quite a few of them are awaiting proper names. Yet, when I plotted a species-area curve it was disillusioning to see that I had not even fully assessed the species stock. There is a lot of scope for further surveys and taxonomic efforts to investigate the biodiversity of tropical tidal flats.

Bringing corer, shovel and sieve into the field is essential to study tidal flat fauna, as most of the organisms are leading a secret live hidden in the sediment (Fig. 2). Yet, while scurrying across the mud in tropical tidal flats, I typically found decapod crustaceans active on the sediment surface. These crabs are adapted to spend the low tide period out of the water, although some occasionally retreat into their burrows to replenish their gills with water. Fiddler crab colonies give colourful sparks on the greyish mud and herds of soldier crabs roam the flats on their foraging trails, littering the sediment with pellets from their feeding activity (Fig. 3). I could show with my studies and exclusion experiments that soldier crabs (*Mictyris longicarpus*, Mictyridae) take up meiofauna for food and affect infaunal community composition, one example for the existence of biotic interactions in tropical tidal flats (Dittmann 1993). During more recent visits to sandflats in East Africa and Malaysia, I had a real déjà-vu, seeing herds of little crabs wandering around there. They were crabs of the genus *Dotilla* (Ocypodidae), forming an analogue to the Australian Mictyridae.

Benthic fauna in tidal flats is like a textbook on invertebrates coming alive. With the exception of insects, all major taxa are represented in these marine sediments. Finding my first *Lingula* made me jump of joy, as these

Fig. 4. Tidal flats and mangroves function as nursery sites for fish and prawns. Here, fishermen are collecting bait fish in a tidal creek in Northeast Australia.

brachiopods are considered to be living fossils. A related species (*Glottidia*) occurs on the Pacific shores of Costa Rica (Emig & Vargas 1990). Not just invertebrates, some fish have also adapted to live in these intertidal areas. I always enjoyed watching mudskippers sliding over the mud. Quite often I saw juvenile fish and prawns gathering in tide pools during low tide (Fig. 4). At certain times of year, the tidal flats abound with birds, using these areas as stop-overs or over-wintering sites on their migration (Barrantes and Pereira 1992, Piersma *et al.* 1993, Wolff *et al.* 1993).

All these species interact in some way and I wanted to find out whether their interactions affect benthic communities in tropical tidal flats. The predator-prey relationship I studied between soldier crabs and meiofauna was a case of repressive interaction. However, interactions can also be promotive, as had been shown in temperate tidal flats, where certain worms provide microhabitats for associated organisms in their burrows (Reise 1985). I could show that this process is of equal importance in tropical tidal flats by investigating the burrows of several macrobenthic species and finding associated meiofauna in all cases. Excluding the burrows experimentally removed their home and resulted in reduced infaunal numbers and a modified benthic assemblage (Dittmann 1996). Yet, while my studies on soldier crabs and on burrow infauna supported the relevance of species interactions in benthic communities of tropical tidal flats, José A. Vargas detected only a negligible effect with his experimental exclusion of macropredators. Further experiments are surely needed to comprehend ecological processes in tropical tidal flats. However, this takes scientists tolerant to frustration, as I can tell from experience how easily experiments are destroyed by cyclones or other disturbances.

Knowing temperate tidal flats from childhood days and having had the opportunity to visit tropical tidal flats in every continent, comparative aspects gained my interest. What is similar or different in tropical tidal flats compared to their counterparts in other parts of the world? I could corroborate the hypothesis that species richness is higher in the tropics, while abundances are lower (Reise 1991, Dittmann 2002). However, high variations emerged in a comparison of tidal flats just within tropical latitudes (Vargas 1996, Dittmann and Vargas 2001), and we have not yet fully understood the reasons behind it. One of my plans for the future includes comparative studies using the same methodology. Worldwide, the large-scale zonation of benthic communities appears to follow comparable environmental conditions along an intertidal gradient (Dittmann 2000). Even the spatial distribution of certain life-forms is similar worldwide, yet represented by either analogue or related species. Finding both similarities and dissimilarities between tidal flats of various latitudes, the search must go on to detect their underlying causes as well their effects on ecosystem functioning.

Working in the tropics as a marine ecologist usually pegs you straight away as being either a coral reef or mangrove person. Try explaining that you prefer mudflats! The chance to be considered a lunatic is pretty high. Being stuck in the mud once again and trying to dig out my shoe, it occurs to me that this might not be so wrong. Yet looking up and seeing a pelican glide over the creek and feeling the tranquil mood in an ecosystem time forgot, I wouldn't want to swap with any other place on Earth.

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