Microborings from different habitats on both sides of the Panama Isthmus

Do they mirror contrasting hydrographic conditions?

Gudrun Radtke, Priska Schäfer, Heidi Blaschek & Stjepko Golubic

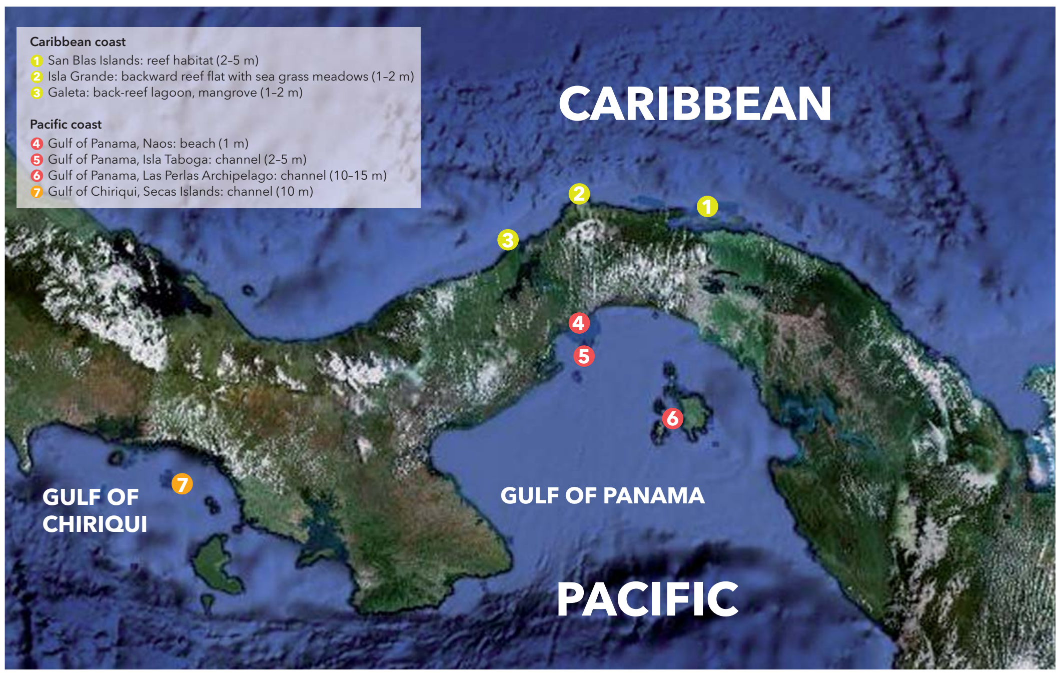


Fig. 1 Satellite image of Isthmus of Panama (http://maps.google.de/) with sample sites.

Introduction

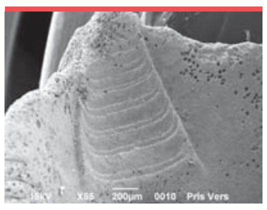
Panama shorelines face distinctly different hydrographies and environments (Fig. 1). The Caribbean coast is year-round under constant oligotrophic conditions with high temperature and salinity. In contrast, the Gulf of Panama on the Pacific side is prone to strong seasonal upwelling created by the north-easterly trade winds with low water temperatures but high nutrient fluxes generating increased primary productivity. The Gulf of Chiriqui on the Pacific side holds an intermediate hydrographic position (Tab. 1). These coasts are characterized by different faunal and floral elements. It was expected that such distinctions are also reflected by microboring assemblages in carbonate substrates. Shallow marine habitats were examined with respect to abundance and distribution of microborings in shell fragments.

Tab. 1 Hydrographic parameters, compiled from D´Croz & Robertson 1997 and D´Croz & O´Dea 2007.

Hydrographic parameters		Caribbean	Pacific	
	season	Sans Blas	Gulf of Panama	Gulf of Chiriqui
Sea surface **temperature** [°C]	dry	27	19	28
	wet	30	28	28
Sea surface **salinity** [PSU]	dry	36	39	32
	wet	32	32	30
Chlorophyll-a [Chl-a/m³]	dry	0.36	0.7 - >10	0.1 - 0.4
	wet	0.41	0.2 - 0.7	0.1 - 0.7
Depth of photic zone [m]	dry	80	15	53
	wet	40	40	53

Fig. 2 Bivalve shells in shallow marine habitats are bored by phototrophic and organotrophic euendolithic microorganisms.


Microboring organisms activity leave a variety of **boring traces**, as observed in translucent shells (bivalve shell ca. 1 cm wide).


Scanning Electron Microscope (SEM) image of bored shell.

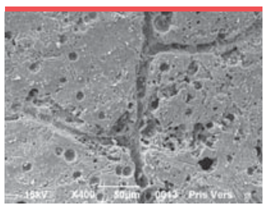
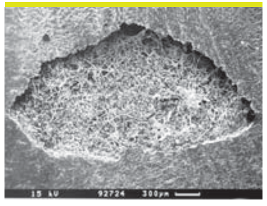
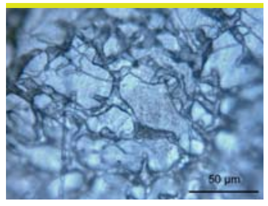

Detail showing different boreholes.

Fig. 3 Distribution and 3-D display of boring tunnels is studied on resin-replicas of microborings as visualized by SEM.

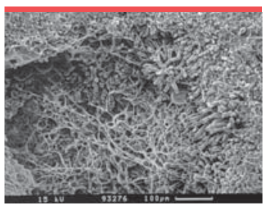

Complex assemblages of traces occupy microecological niches in mm-size shell fragments (Caribbean coast at Isla Grande).

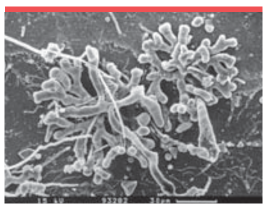

The occurrence of the trace ***Rhopalia catenata***, formed by the green alga *Phaeophila engleri*, is restricted to the Caribbean coast (Galeta).

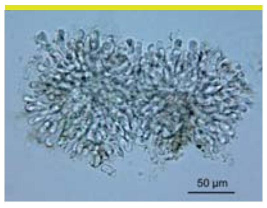

Microboring green algae in a transparent shell (light microscopy): *Phaeophila engleri* (large, branched) and *Ostreobium quekettii* (fine tunnels). The boreholes are mostly empty (Caribbean coast at Isla Grande).


Fascichnus dactylus (left), cyanobacterial trace of *Hyella caespitosa*, forms radiating bundles next to the prostrate borings of ***Rhopalia catenata*** (Caribbean coast at Galeta).

Fig. 4 ***Fascichnus*** traces are most frequent in the entire area of study. They occur on both, Caribbean and Pacific coasts.


Mixed assemblage of ***Fascichnus*** colonies with filamentous borings of ***Scolecia filosa*** (centre left) (Pacific coast at Las Perlas).


Two colonies of ***Fascichnus dactylus*** (Pacific coast at Las Perlas).


Two colonies of *Hyella* sp., the producer of the ***Fascichnus*** trace, extracted from a shell (Caribbean coast at Galeta).

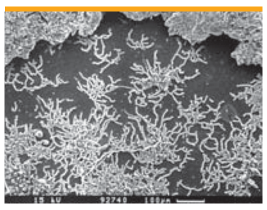
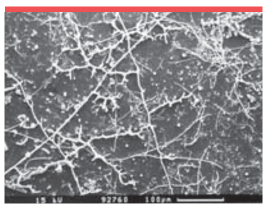
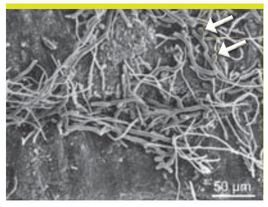

Monospecific colonisation by ***Fascichnus dactylus*** in a shell fragment from the Pacific coast in Gulf of Chiriqui (Islas Secas).

Fig. 5 Characteristic traces of phototrophic microendoliths:


Typical trace of ***Ichnoreticulina elegans*** (made by the green alga *Ostreobium quekettii*) with long straight tunnels and elaborate lateral branches (Pacific coast at Taboga).


Eurygonum nodosum, a characteristic trace in shallow water environments, is formed by the heterocystous cyanobacterium *Mastigocoleus testarum*. Arrows point to the positions of heterocysts on lateral branches (Caribbean coast at Isla Grande).

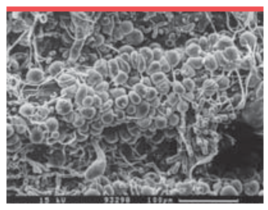
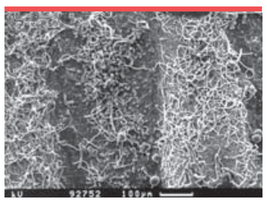
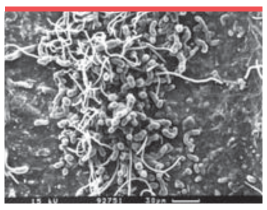
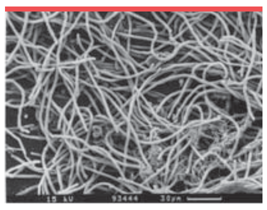

Crowed specimens of the bag shaped ***Planobola*** isp., produced by the cyanobacteria *Cyanosaccus* spp. Note the *Fascichnus dactylus* colony (lower right) (Pacific coast at Las Perlas).

Fig. 6 Differentiation of endolithic micro-niches in ribbed shells.


Alternation of assemblages with ***Fascichnus*** colonies on exposed ribs and ***Scolecia filosa*** in the depressions. ***Planobola*** colonies on the slopes (Pacific coast at Naos).


Detail of the exposed ribs: ***Fascichnus dactylus.***


Scolecia filosa trace of the filamentous cyanobacterium *Plectonema* terebrans on the Pacific coast, Gulf of Chiriqui (Islas Secas).

Tab. 2 Distribution of microborings on Panama coasts.

Microborings	Caribbean			Pacific			
				Gulf of Panama			Chiriqui
locality	1	2	3	4	5	6	7
sites	San Blas	Isla Grande	Galeta	Naos	Isla Taboga	Las Perlas	Islas Secas
waterdepth [m]	2	1	1	0.5	2.5	21	17
Eurygonum nodosum	x	x				xx	
Fascichnus dactylus	xx	x	xx	x	xx	xx	xx
Fascichnus frutex			x		x		
Fascichnus isp.	x						
Fascichnus grandis		x					
Scolecia filosa	xx	x	xx	x	xx	xx	xx
Planobola isp.		x	xx	x		xx	x
Rhopalia catenata	x	x	xx	x	x	x	x
Ichnoreticulina elegans	x	x				x	
Cavernula peduculata		x					
Scolecia botulifera	x						
Orthogonum fusiferum				x	x	x	
Saccomorpha clava	x	x			x	x	
Scolecia serrata						xx	

■ cyanobacteria ■ green algae ■ fungi

Conclusions

- The observed boring patterns in shallow marine habitats are diverse on both, Caribbean and Pacific coasts of Panama in spite of significant differences in water temperature and nutrient supply (compare Tab. 1 and 2).
- On the Caribbean coast the diversity of phototrophs appears slightly higher, whereas the Pacific coast shows higher diversity of heterotrophs (fungi).
- Less than 10 % of borings contain resident microborers at the time of collection.
- Microborings in carbonate substrates represent the cumulative effect of several generations of microborers.
- The density and diversity of microborings in comparable environments largely depends on the time of exposure.
- The qualitative assessment of microbial borings in natural substrate characterizes bathymetric zones.
- The determination of bioerosion rates by microborers requires timed experimental exposure.

References

D´Croz, L.D. & Robertson, D.R. (1997): Coastal oceanographic conditions affecting coal reefs on both sides of the Isthmus of Panama. – Proc. 8th Int. Coral Reef Symp., 2: 2053–2058.

D´Croz, L.D. & O´Dea, A. (2007): Variability in upwelling along the Pacific shelf of Panama and implications for the distribution of nutrients and chlorophyll. – Estuarine, Coastal, and Shelf Science, 73: 325–340.

Gudrun Radtke
Hessisches Landesamt für Umwelt und Geologie
gudrun.radtke@hlug.hessen.de

Priska Schäfer und Heidi Blaschek
Institut für Geowissenschaften
Universität Kiel
ps@gpi.uni-kiel.de

BOSTON UNIVERSITY

Stjepko Golubic
Biological Science Center
Boston University
golubic@bu.edu