Microbial degradation of the crustose red alga *Peyssonnelia* spp. on reefs of the Caribbean and Great Barrier Reef

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ABSTRACT

A previously undescribed microbial degradation of the calcified crustose red alga *Peyssonnelia* spp. has been observed on coral reefs of the Colombian Caribbean and the Great Barrier Reef (GBR), Australia. Named *Peyssonnelia* Yellow Band Syndrome due to its banding appearance and yellow colour, it has been observed to degrade 3 species of *Peyssonnelia* over a wide depth range (6 – 24 m). The syndrome generally manifests itself as a more or less distinct yellow band of 0.5 to 4 cm wide, composed of densely interwoven gliding filaments of a procaryotic microorganism. The yellow band moves across the surface of the crustose algae, followed by a white mat of the gliding bacterium *Beggiatoa* sp., leaving behind dead algal tissue. Both the invasion process and the microorganisms involved in the disease are similar in behavior and morphology among samples obtained from the Caribbean and GBR, and seem to represent the same infection.

Keywords Coral reef degradation, *Beggiatoa*, Crustose algae, Coral reefs

Introduction

Diseases of coral reef organisms are a matter of concern for reef scientists and environmental managers due to the negative effects on reef populations. Corals, gorgonians, echinoderms and crustose coralline algae are often affected by different types of pathogens (Littler and Littler 1995, Santavy and Peters 1997, Goreau et al. 1998, Harvell et al. 1999). Although coral reef diseases are likely to be critical in reef degradation, there is very little information available concerning pathogens affecting crustose calcareous reef algae. Calcareous algae are ecologically important because they contribute to reef construction and cementation and also facilitate coral settlement (Steneck and Testa 1997, Heyward and Negri 1999). The crustose alga *Peyssonnelia* can be dominant in reef slopes, overhangs or deep rubble-sand plain habitats in both the GBR and the Caribbean, and can play a significant role in reef consolidation (James et al. 1988). Littler and Littler (1995, 1998) described two diseases attacking crustose calcareous red algae (Corallinales) from reefs of the Pacific Ocean. However, none of these diseases seem to infect the crustose calcareous algal genus *Peyssonnelia* (Cryptonemiales).

In this note I report preliminary observations of microbial degradation of coral reef crustose coralline algae of the genus *Peyssonnelia*. The syndrome was observed on coral reefs of the Colombian Caribbean and the central section of the Great Barrier Reef (GBR), Australia. The degradation was associated with mats of an unidentified filamentous procaryotic micro-organism. The syndrome has been named *Peyssonnelia* Yellow Band Syndrome Disease (PYBS) due to its banding appearance and yellow colour. Coral reef band diseases are common in corals and gorgonians (Rutzler et al. 1983), but apparently have not been previously recorded killing crustose calcareous algae *Peyssonnelia* (Correa 1997, Harvell et al. 1999).

Methods

Observational surveys were conducted *in situ* on reefs of Columbia and Australia using SCUBA. Samples of the microbial mats and *Peyssonnelia* spp. were brought to the lab and kept in 5-10 L aquaria with natural seawater, which was changed several times a day, and observed during several days. Samples were fixed in formalin and stained with a solution of aniline blue for examination under a Zeiss light microscope. The microorganisms were also examined using a JOEL 5410LV scanning electron microscope with samples coated with platinum.

Results and Discussion

PYBS was observed on reef slopes and fore-reef terraces at El Morro Islet, located off the city of Santa Marta in the Colombian Caribbean (11°15'N; 74°13'W) and 1 km from a sewage discharge from that city. The reefs in this area are not well developed possibly due to the seasonal upwelling occurring during January-April and July-August and to the influence of continental runoff. However, coral cover reaches 30-40 % of the benthos in some areas (Zea 1993). Monthly water temperatures are 25°C (but as low as 21 °C) during upwelling and 29 °C (but as high as 31 °C) during the warmer months of September-November and May-June (Zea 1993). In the GBR Australia, I observed PYBS on reef slopes of lagoonal patches of Trunk reef. Trunk reef is located in the mid shelf of the GBR (18°23'S; 146°50'E), about 50 km from the coast and receives relatively little anthropogenic influence. Seasonal changes in water temperature occurs throughout the year, with lower values during July-September (21-22° C) and highest during February – March (30° C).

PYBS attacks the alga *Peyssonnelia* over a wide depth range, from 6 – 9 m in Trunk Reef, GBR, to 10 - 24 m in

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El Morro, Colombian Caribbean. 30 observations of the disease were recorded: 20 in Colombia in an area of approximately 1500 m^2 during September 1997, and 10 in Trunk Reef in the GBR in an area of about 300 m^2 in March 1999. A similar condition is believed to have been observed in Sumilon Island in the Philippines and the Greater Antilles in the Caribbean (A. Maypa and A. Bruckner, pers. comm.). Three unidentified species of *Peyssonnelia*, one from the Caribbean and two species from the GBR, may be susceptible to the disease.

PYBS manifests itself generally as a more or less defined yellow band of 0.5 to 4 cm wide (Fig. 1), and consists of densely interwoven gliding filaments of a procaryotic microorganism. The filaments had one trichome only per sheath with a diameter of 7-10 μm and cells 4-6 μm long, were highly motile, and exhibited some necridic cells which help in filament fragmentation (Anagnostidis and Komárek 1988; Figs. 2-6). Based on these morphological features the organism resembles the cyanobacterium *Oscillatoria* sp. (Oscillatoriales; Prof. R.W. Castenholz pers. comm.). However, the definite identification that this procaryotic pathogen is a cyanobacterium will require the demonstration of the presence of chlorophyll *a* and phycobilins.

The yellow band apparently moves across the surface of the crustose algae, followed by a white mat of the sulfide oxidizing and gliding bacterium *Beggiatoa* spp. (Figs. 7-8), leaving behind dead tissue. In every case observed, including repeated visits to the same reef site in Colombia, bare *Peyssonnelia* skeleton almost always occurred behind the yellow band, and never in front (i.e. close to the live crustose alga *Peyssonnelia*). This pattern is consistent with the disease interpretation. Further, on several occasions I removed the microbial consortium from the surface of the crustose algae and there was a clear gradient of increasing algal tissue damage from the front of the band towards the posterior part, suggesting a migration of the microbial consortium over the healthy algal tissue. Time series data and experimental manipulations would provide quantification of the disease process and more definite evidence that the tissue mortality depends on the presence of the yellow filamentous microorganism. Laboratory observations of fresh material from the Caribbean under a stereomicroscope indicated that the filaments of the yellow mat move at a speed of as much as 5 mm per hour (1.4 μm per sec). The white bacterial mat may also be also found intermixed and/or underneath the yellow mat, such that it appears almost completely yellow. The organisms involved in the mat were similar in morphology and behavior within samples obtained from the Caribbean and GBR, and seem to represent the same microbial consortium.

Other crustose algal diseases observed in the Caribbean (Goreau et al. 1998) and the Pacific (Littler and Littler 1995, 1998) have different symptomatology. The coralline lethal orange disease (CLOD) described from reefs of the Pacific, attacks exclusively non-geniculate algae (Corallinales), and not *Peyssonnelia* (Littler and Littler 1995). PYBS also differs from CLOD in that the latter is comprised of a monospecific bacterial pathogen, while PYBS is a consortium of microorganisms. PYBS is similar to the band diseases of corals in that each is associated with gliding pathogens that occur as a band or front that progresses across the host destroying the tissue (Antonius 1981). Although the yellow band disease described from the Arabian Gulf (Korrûbel and Riegl 1998) is similar to the PYBS in that both have a yellow banding pattern of infection, the Arabian Gulf disease attacks only hard corals. Goreau et al. (1998) described another yellow band disease that affects Caribbean corals, causing a yellowish tissue lightening. No information about the pathogen(s) involved in the Arabian or the Caribbean yellow band diseases has been reported.

PYBS seemed to occur mainly during the warmer months in both the Caribbean and the GBR. In Santa Marta, Colombia, it was found in September, when water temperature reaches 28-29^{o}C. In the GBR has been observed only during the summer months (February-March). These observations are in accordance with a general trend observed in band coral diseases caused by cyanobacteria that are more common and invasive during the warmer months in the Caribbean (Feingold 1988, Kuta and Richardson 1996, Bruckner et al. 1997) and the GBR (Baird 2000). However, more studies are needed to understand the possible seasonal impact of PYBS.

The crustose alga *Peyssonnelia* can be abundant in many reef habitats of the GBR and the Caribbean, and can play a significant role in reef consolidation (James et al. 1988). Although PYBS is apparently currently neither common nor locally abundant (observed only in 2 sites out of 280 sites visited), outbreaks of the syndrome could potentially have significant and widespread impacts on reef communities, especially if, when fully characterized, the syndrome is determined to be an infectious disease. The fact that PYBD affects algae growing in contrasting water quality reef areas (closeness to sewage waters and clear blue-waters) makes it difficult to draw any conclusions about its relation to anthropogenic impacts.

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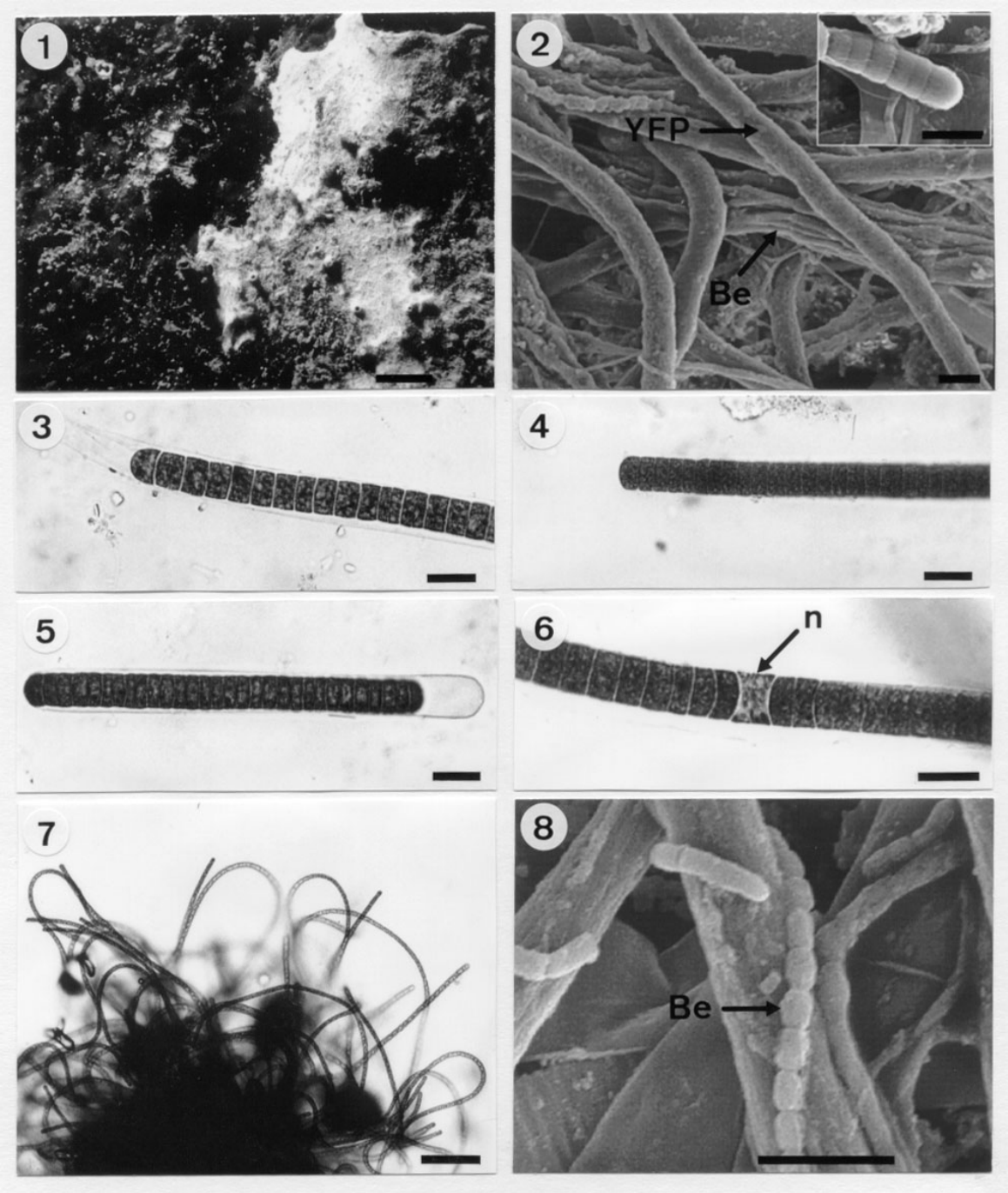

Figs. 1-7 *Peyssonnelia* yellow band syndrome (PYBS) and associated microorganisms. **Fig. 1** PYBS from Santa Marta, Colombian Caribbean, 18 m depth. The alga *Peyssonnelia* spp. is to the left and the yellow filamentous procaryotic and bacterial mats in the centre and right. **Fig. 2** Scanning electron micrograph of the consortium of microorganisms of the PYBS (YFP: yellow filamentous procaryotic, Be: *Beggiatoa* spp.). Inner frame is a filament tip of the yellow filamentous procaryotic, GBR. **Fig. 3** Filament of the yellow procaryotic microorganism from the Caribbean. Note the presence of the sheath. **Fig. 4** Filament of the yellow procaryotic microorganism without a distinctive sheath, Caribbean. **Fig. 5** Juvenile filament of the yellow procaryotic microorganism with sheath, Caribbean. **Fig. 6** Filament of the yellow procaryotic microorganism with necridic cells (n) that contribute to filament breakage, Caribbean. **Fig. 7** Bacterial mat of *Beggiatoa* spp. The intracellular inclusions are granules of elemental sulfur, Caribbean. **Fig. 8** Scanning electron micrograph of the bacterium *Beggiatoa* spp. (Be), GBR. Scale bars: Fig. 1: 1cm, Figs. 2-6, 8: 10 μm; Fig. 7: 20 μm.

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