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The significance of changes in *Mytella falcata* (Orbigny, 1842) gill filaments chronically exposed to polluted environments

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ABSTRACT

The impact of pollutants in an organism can be observed by changes in functional complexity at different levels. Bivalve gills are suitable for histopathological analysis because of their structure and function. This study aimed at examining the morphology of *Mytella falcata* gill filaments from three sites in the Santos estuary (São Paulo, Brazil) with different levels of environmental degradation to identify possible changes in gill structure and discuss the significance of these alterations. For this purpose, histological, histochemical and ultrastructural techniques were used. The filaments of animals from site A (less impacted site) were intact, while in sites B and C, pathological changes were observed, such as: detachment of the epithelium in the intermediate zone, morphological changes of this epithelium, inflammatory process, increase in the number of mucous cells and cell turnover processes. These results suggest that the related changes are an attempt to prevent the entrance of pollutants through gill filaments into the entire organism and that cell turnover is the final way to compensate cell injury.

1. Introduction

Bivalve gills are among the main target organs for metal accumulation and show the highest pollutant levels. This is due to their role in ingestion and respiration and to their close contact with the incoming water. On the other hand, the gill and mantle epithelia are the main barriers against environmental pollutant injury and pathological agents (Bigas et al., 2001).

The structure of bivalve gills is suitable for histopathological analysis, since they consist of a simple epithelium with various cell types, in which the effects of water-soluble pollutants are easily observed (Sunila, 1988). According to Dumouhtsidou and Dimitriadis (2004), *Mytilus galloprovincialis* gill filament consists mainly of a single layer of various types of epithelial cells (ciliated and nonciliated columnar cells and mucous cells) and endothelial cells surrounding a central lumen and resting on a basement membrane. David et al. (2008) described *Mytella falcata* gill filaments and stated that the filaments are divided into abfrontal, intermediate and frontal zones each one with specific cell types including mucous cells in the frontal and abfrontal zones; and stated that these mucous cells were the only cell type without microvilli.

The species *M. falcata* (Orbigny, 1842) is found forming large colonies in the sediments of the Santos estuary. This species is sessile and filter feeding and thus, is constantly exposed to environmental conditions. Also, because they are semi-burrowed in the highly contaminated sediments in the region, this species may be considered an excellent test organism for environmental monitoring studies.

The region known as Baixada Santista in São Paulo State (Brazil) is a densely populated and industrialized strip of the coast, where the Santos estuary is located; in this estuary are based the petrochemical complex of Cubatão with steel mills, refineries and fertilizer plants, and the Port of Santos, considered the most important harbor in Latin America. In addition, the region is considered a tourist center with a population of approximately 1.5 million inhabitants that doubles during the summer. All these characteristics make this location constantly under the influence of a complex mixture of pollutants produced by the activities conducted in the area. In the 1970s, this region was considered an example of environmental degradation. However, after a series of measures taken by the competent agencies, the conditions have greatly improved, although the sediments in the area are still reservoirs of various pollutants such as metals and polycyclic aromatic hydrocarbons (PAH) (Kummrow et al., 2006).

Due to the conditions of the Santos estuary is very interesting to study how *M. falcata* can survive under the influence of those pollutants. Thus, this study examined the gills of *M. falcata* collected in three sites of the Santos estuary to detect possible changes in the gill epithelium and discuss the significance of these changes to the resident mussels.

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2. Materials and methods

2.1. Materials

M. falcata (width about 4.0 cm) were collected in May 2004, October 2004, October 2005, February 2006 and August 2006 in three different areas of Santos estuary (Fig. 1): sites A–C. The total number of individuals along all collects was: site A ($n = 25$), B ($n = 25$) and C ($n = 20$); site C was included in October 2004. After collection, individuals of each site were taken to the laboratory and kept in aquaria filled with 5 L of water from their collection sites for 24 h with constant aeration. This procedure was adopted to avoid collecting and transportation stress.

2.2. Collection sites

The collection sites (Fig. 1) examined in this study were chosen due to the abundance of *M. falcata* which formed big colonies with animals interconnected by their byssi. The three sites are estuarine channels with brackish water and under tide influence. In sites A and B, the mussels were partially buried in the sediment; however, in site C, they were attached to concrete pillars, approximately 3 m from the sediment. In all sites, bivalves were located in the intertidal zone, and thus exposed to air during low tides. When submerged (during the high tide), in all sites, bivalves were at the same distance from the water surface.

Site A (23°55.052′S, 46°26.975′W) is located at a low impacted region of the estuary. Sites B and C are under influence of port activities like navigation and dredging. Site B (23°54.659′S, 46°20.464W) is under the influence of Santos harbor and, according to Kummrow et al. (2006), domestic sewage is the only direct identified pollution source. Site C (23°52.597′S, 46°22.583′W) is located in front of a still mill and is the most contaminated area; receives discharges from the steel mill plant and sewage and, according to Kummrow et al. (2006) PAH concentration can reach 347.55 μg/g of sediment (dry weight).

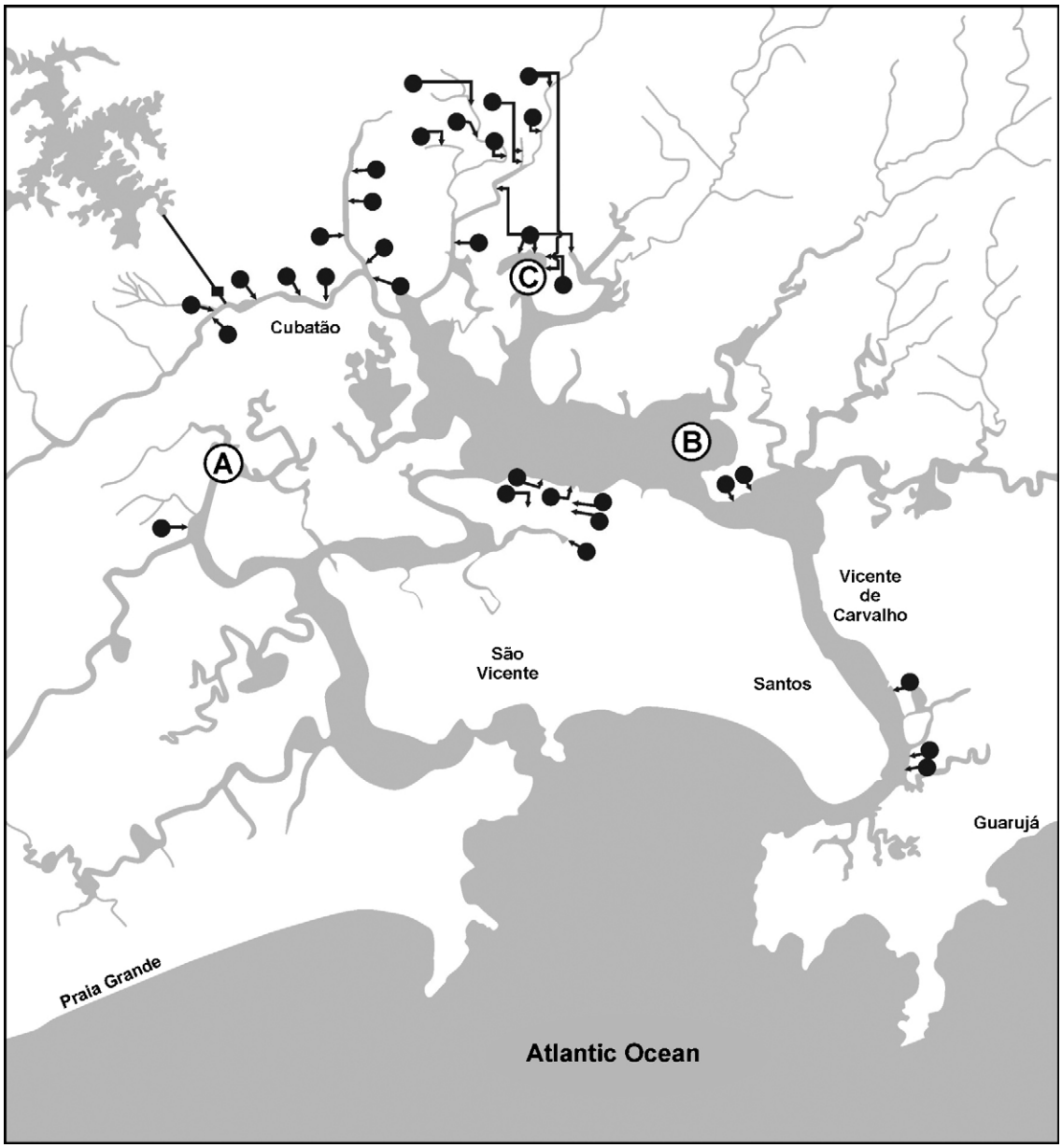

Fig. 1. Map of Santos estuary with collection sites and pollution sources. (○) Collection sites; (●) pollution sources.