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Is polychaete family-level sufficient to assess impact on tropical estuarine gradients?

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ABSTRACT

Regular, robust monitoring programs set up to assess the environmental conditions of aquatic systems often target different biological groups. And, of these, macroinvertebrate communities and particularly the class Polychaeta are frequently used. Identifying these organisms takes time, money and specialized expertise to ensure correct identification to the lowest possible taxonomic level. Identification errors can lead to an erroneous assessment. The concept of taxonomic sufficiency has been proposed both to minimize errors and to save time and money. This study tested the usefulness of this concept in tropical estuaries in northeast Brazil. We selected two transitional systems with different degrees of human impact due to different land uses and different conservation systems: the Mamanguape estuary, which is in an environmental conservation unit for sustainable use, and the highly impacted, urban Paraíba do Norte estuary. The results clearly showed that nutrient concentrations were markedly higher in the Paraíba do Norte estuary in the dry season and that the composition of the polychaete assemblages differed between the two estuaries as well as along the spatial gradient of each estuary. The use of either genus or family level led to equivalent representation in each system in terms of taxon richness and both the Margalef and Shannon-Wiener diversity indices. Both taxonomic levels described similar changes in the polychaete assemblage along the estuarine gradients. Based on our findings, the use of a coarser taxonomic level (i.e., family) is a good option when the aim is to implement a monitoring program in tropical estuaries with the polychaete assemblages as one of the target groups. This time-efficient taxonomic resolution can help improve sampling designs and allow long-term monitoring studies without losing much vital information.

Contents

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1. Introduction

Estuarine ecosystems are highly dynamic environments governed by variations in the hydrological, morphological, physical and chemical conditions of marine and freshwater environments (Day et al., 2013). These transition systems serve as refuge and breeding grounds for resident and migrant species of fish and microinvertebrates. What's more, they play a key role in nutrient cycling as well as processes related to the decomposition of organic matter (Elliott and McLusky, 2002; Potter et al., 2015). Estuaries also provide numerous ecosystem services essential to the well-being of humans. However, such ecosystems suffer environmental impact that can lead to the loss of biodiversity. Biomonitoring has been used to assess the condition of coastal ecosystems (Rosenberg et al., 2004; Salas et al., 2006) and is based on the responses of organisms to different environmental changes, particularly anthropogenic ones such as litter, agricultural run-off, aquiculture effluents, untreated wastewater, etc.

Biomonitoring involves the use of methods to assess the response of ecosystems to different degrees of human pressure. Environmental indicators, such as diversity indicators, indicator species, indicators based on ecological strategies and multi-metric indices, are often used. These indicators employ information on biological communities. Benthic macroinvertebrates are good indicators of environmental conditions (Patrício et al., 2009), since they are mostly sedentary organisms, have relatively long lifecycles (lasting mere weeks to five years), are sensitive to disturbances in the surrounding environment and have different degrees of tolerance plus the ability to adapt to adverse situations.

Polychaetes are the main macroinvertebrates used in environmental assessment studies (Del-Pilar-Ruso et al., 2009). These organisms are abundant, occupy different habitats (Fauchald and Jumars, 1979) and can have relatively long lifecycles (up to five years), which makes it possible to use them to detect variations on a larger time scale (Surugiu, 2005). Because such organisms have distinct abilities to adapt to environmental changes, analyzing the presence or absence of certain families and/or genera allows inferences regarding environmental conditions (Pocklington and Wells, 1992).

To properly use the benthic community in environmental assessment programs, identification of polychaetes is a crucial yet costly step that requires time and expertise in order to identify individuals to the lowest possible taxonomic level (Dauvin et al., 2003; Couto et al., 2010). In an attempt to minimize the problems caused by errors in identifying organisms, Ellis (1985) proposed the concept of taxonomic sufficiency, which involves a higher taxonomic resolution level in assessing the impacts of human pressures without detriment to the information gathered, thus avoiding more specific, time-consuming, costly identification processes (Osgard and Somerfield, 2000). Taxonomic sufficiency studies compare information obtained on successive levels of taxonomic resolution (i.e., species, genus, family, order, class and phylum). A taxonomic sufficiency assessment reduces costs, since less detailed identification data are necessary and less time is needed to process each sample (Marrero et al., 2013). Since the 1980s, studies employing taxonomic sufficiency have been published on different environments, geographical locations and biological groups (see Bacci et al., 2009; Marrero et al., 2013). Several of these studies show that family or genus can accurately reflect the effect of human disturbances (Terlizzi et al., 2003; Muniz and Pires, 2005; Del-Pilar-Ruso et al., 2009; Bacci et al., 2009; Marrero et al., 2013). Marrero et al. (2013) determined the minimum level of taxonomic identification needed for environmental quality monitoring of subtidal benthic communities in a coastal zone affected by human activities (the La Plata River in Uruguay) and concluded that the family level is sufficient for the area studied and strongly recommended for monitoring the coastal area under the effects of multiple stressors. Bacci et al. (2009) tested taxonomic sufficiency in two case studies: one around an offshore gas platform located in the Central Adriatic Sea and the other in a coastal area under human pressure, limited to fishing activities in the North Adriatic Sea. In both cases, the authors concluded that taxonomic sufficiency was sufficient and that family level was the best compromise when accurate identification could not be obtained. Méndez and Ferrando (2015) investigated to what degree reduced taxonomy could be used to detect anthropogenic effects in Estero de Urías, which is a tropical coastal lagoon in Mexico, using polychaete data. These authors recommend the use of family-level data for the monitoring and characterization of the system. Tweedley et al. (2014) tested the usefulness of family-level AMBI (see Borja, 2000 for a detailed description of AMBI-AZTI Marine Biotic Index) using data from four southwest Australian estuaries previously subjected to environmental quality assessments, concluding that family-level AMBI was valid for use in the northeast Atlantic, but not for assessing the health of Australian microtidal estuaries. Not all researchers agree with the use of taxonomic sufficiency-based approaches and, as Bacci et al. (2009) point out, the relationship among taxonomic sufficiency and sampling procedures, data analyses, spatial scale, habitat features and assemblage structure still has to be assessed and is far from general.

The aim of this study was to use the polychaete assemblage to test whether family (broader taxonomic resolution) or genus (narrower taxonomic resolution) is sufficient for assessing the environmental conditions of two tropical estuaries subjected to different levels of human pressure without losing information. The hypothesis was that taxonomic resolution on the family level was sufficient to describe changes in the Polychaeta assemblage along the estuarine gradient in tropical estuaries with different degrees of anthropogenic pressure.

2. Materials and methods

2.1. Study area

This study was conducted in two transitional systems located on the northeast coast of Brazil: the Paraíba and Mamanguape estuaries (Fig. 1). In both estuaries, the rainy season lasts from February to August, with the highest rainfall occurring in June and the lowest in November. However, the Paraíba estuary has a wetter climate (1717 mm/year) than the Mamanguape estuary (1392 mm/year) (data from 1999 to 2014; CPTEC/INPE, 2015). The tides on the coast of the state of Paraíba are semi-diurnal, i.e., two high tides and two low tides every 24 h, with a tidal amplitude of 2.80 m (Nishida et al., 2006).

The Paraíba do Norte estuary (6°54′14″ and 7°07′36″S;