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Secondary production of the fiddler crab *Uca rapax* from mangrove areas under anthropogenic eutrophication in the Western Atlantic, Brazil

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ABSTRACT

Fiddler crabs *Uca rapax* were analyzed in three mangrove areas located in both a lagoon and estuarine system in order to study the influence of eutrophication on their population dynamics and production. Populations at the three sites showed a biased sex ratio. Densities were similar at the three sites, but biomass was higher at the lagoon system. Despite biomass being higher at the most eutrophic site, this site exhibited the lowest production. Regarding age structure, the population inhabiting the less eutrophic site mainly comprised younger crabs. The lower production and smaller P/B ratio found in the more eutrophic site were most likely consequences of a high mortality rate and an aged population. Our study evidences the high plasticity of the fiddler crab *U. rapax*, and confirms secondary production and P/B ratio estimates as useful tools to assess the effects of environmental change.

1. Introduction

Mangroves are highly productive ecosystems situated at the transition between land and sea in subtropical and tropical regions (Donato et al., 2011). These ecosystems harbor valuable ecological and economic resources—acting as important nursery grounds and breeding sites for birds, reptiles and mammals; supporting coastal food webs, including fish, crustaceans and mollusks of commercial value; offering protection against coastal erosion; and through their role as an accumulation site for sediments, contaminants, carbon and nutrients (Alongi, 2002; Cannicci et al., 2008). It is estimated that at least 35% of the global total mangrove area has been lost in the past two decades (Valiela et al., 2001), and perhaps the services offered by this ecosystem will disappear within the next 100 years (Duke et al., 2007). The loss of mangrove forests is directly linked to increasing human populations in coastal zones; the main threats include coastal urbanization, deforestation for aquaculture, agriculture, production of timber and coal, and overfishing (Alongi, 2002; Valiela et al., 2001).

In the mangroves, crabs represent the main source of heterotrophic biomass and energy (Wolff et al., 2000). Crabs are involved in soil carbon sequestration through their burrowing activity, potentially representing a component for climate change mitigation strategies and policies (Andreetta et al., 2014). Deposit-feeding crabs of the genus *Uca* (known as fiddler crabs) process large amounts of sediment and associated organic matter as a food resource (Dye and Lasiak, 1987). That feeding mode modifies the amount of different sources of organic carbon, which can have a profound impact on the overall organic carbon dynamics in mangrove systems (Kristensen et al., 2008). The foraging behavior of fiddler crabs also modifies sediment surface properties, reducing microalgae standing stocks (Kristensen and Alongi, 2006) and having indirect effects on microbial and meiofaunal communities (Dye and Lasiak, 1986). The bioturbation induced by the burrowing activity of these crabs also changes the biogeochemical sediment properties of mangroves, supporting the growth of mangrove plants (Kristensen et al., 2008). Fiddler crabs are viewed as ecosystem engineers in these ecosystems due to their importance in habitat structure and its significance for mangrove fauna and flora (Kristensen, 2008; Cannicci et al., 2008).

The nutrient enrichment typical of mangroves stimulates the growth of bacteria, macroalgae and benthic diatoms that are sources of food for macrofauna, enhancing secondary productivity (Meziane and Tsuchiya, 2002). Of these microorganisms inhabiting mangrove sediments, the main food source for fiddler crabs is bacteria (Meziane and Tsuchiya, 2002), perhaps due to their high assimilation efficiency (~98%) (Dye and Lasiak, 1987). Hypertrophic conditions in mangroves greatly affect the biology and behavior of fiddler crabs (Bartolini et al., 2009; Penha-Lopes et al., 2009a).

Secondary productivity can be a useful measure of population fitness, being influenced by several factors, both biotic and abiotic, that determine individual body mass, reproductive rate, population density, growth rate, mortality, and life-span (Dolbeth et al., 2012). In addition, data on secondary production reveal the effects of pollution and other threats to natural populations since they are a functional variable rather than being an

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instantaneous structural measure, such as density or biomass (Benke, 2009). Various studies have dealt with assessment of eutrophication impacts on ecosystems using secondary production estimates (e.g. Dolbeth et al., 2003, 2005; Pranovi et al., 2008; Cross et al., 2006). Another important measurement in this context is the production and biomass ratio (P/B), commonly referred to as "productivity", relating to the turnover of biomass or energy (Dolbeth et al., 2012). Cusson and Bourget (2005) reviewed marine benthic macroinvertebrate production and concluded that the life histories of populations are more significant than abiotic variables in explaining secondary production and P/B ratios, both being negatively affected by life-span and body mass. Populations dominated by young individuals have a high P/B ratio because of the fast turnover compared to populations dominated by older individuals since younger individuals expend more energy on growth while older individuals invest more energy in reproduction.

Our study aims to assess the effects of eutrophication on the secondary production and productivity of the fiddler-crab *Uca rapax* (Smith, 1870) by comparing populations inhabiting mangrove areas with differing levels of eutrophication.

2. Material & methods

2.1. Study areas

Fiddler crabs were collected from three sampling stations located at two sites along the coast of Rio de Janeiro State in Southeast Brazil: Itaipú–Piratininga Lagoon System (IPLS) and Guanabara Bay (Fig. 1).

IPLS belongs to a set of coastal lagoons located along the eastern coast of Rio de Janeiro State. These lagoons exhibit a microtidal regime and are classified as choked due to having single, narrow and shallow connections with the sea and the long residency time and low renewal

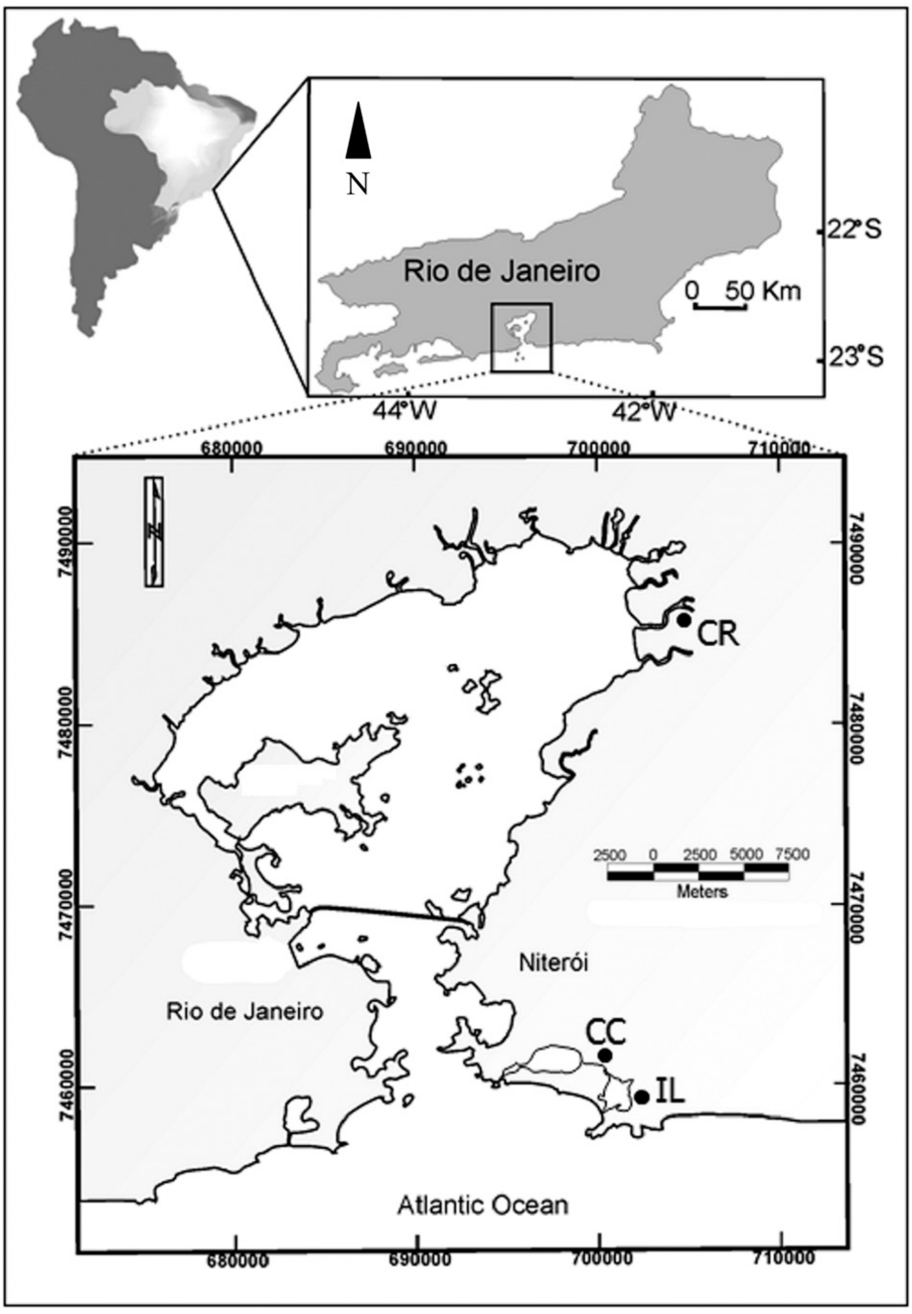

Fig. 1. Location of the study sites. (CR): Caceribu River; (CC): Camboatá Channel; (IL): Itaipu Lagoon.