

Long-term stability of tidal and diel-related patterns in mangrove creek fish assemblages in North Brazil



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ABSTRACT

Intertidal fish assemblages are thought to respond to tidal and diel rhythms although the assumption that these patterns are stable over long time scales (>1 year) is largely untested. Testing the validity of this assumption is necessary to assess whether short-term temporal patterns, once established, can be extrapolated over time and give a better understanding of the temporal dynamics of fish assemblages in coastal habitats. Here, we compare the fish assemblage structure from two intertidal mangrove creeks in North Brazil (Bragança Peninsula, Caeté estuary) sampled with the same sampling methodology (block nets), effort (two lunar cycles) and design (accounting for the combination of tidal and diel cycle) in the rainy seasons of 1999 and 2012 to evaluate the persistence, stability and recurrence of short-term patterns in the fish community organization. The interaction of tidal and diel cycles (inundations at spring tide-night, spring tide-day, neap tide-night, neap tide-day), found to be stable after 13 years, resulted in recurrent and stable intertidal mangrove fish assemblage compositions. The intertidal mangrove creek fish assemblage consisted of a persistent number of dominant species (seven). However, there were notable changes in fish catch mass, abundance and species dominance between 1999 and 2012. The most severe drought in North Brazil in 30 years, linked to lower precipitation and river runoff in the rainy season of 2012, may have resulted in (1) lower abundance of small juveniles of several dominant species in this assemblage (especially Ariidae – *Cathorops agassizii* and *Sciades herzbergii*) and (2) increased dominance of large-sized specimens of the tetraodontid *Colomesus psittacus*. Our findings highlight: (1) the overriding importance and stability of the interactive pulse of the tidal and diel cycles in determining short-term temporal patterns in intertidal mangrove fish assemblages in neotropical macrotidal estuaries despite the occurrence of extreme events (i.e. major decrease in rainfall) and (2) the large-scale influence that these extreme events can exert on recruitment processes in tropical estuarine fish assemblages.

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1. Introduction

Mangroves are nursery sites for nekton (e.g. Robertson and Duke, 1987; Laegdsgaard and Johnson, 1995) as shown by equivocal evidence depending on the geographical area, and they constitute an important habitat for a specific portion of coastal fish assemblages in the tropics and subtropics. Mangrove fish assemblages worldwide show a certain degree of taxonomic and

functional equivalence, indicating some spatial uniformity on large geographical scales (within and between marine provinces) (Sheaves, 2012; Castellanos-Galindo and Krumme, 2013a). However, the extent to which faunal (compositional) characteristics persist over time in specific estuarine mangrove fish assemblages is less clear, at least over time scales >2 years (reviewed in Faunce and Serafy, 2006; but see Lorenz, 1999; Blaber et al., 2010; Ecoutin et al., 2010).

Persistence and stability are two common descriptors of assemblage variability in time, which form central questions in community ecology (Connell and Sousa, 1983). Persistence is considered as the continuous presence of species within assemblages over time, and stability is defined as the degree of constancy in the numbers and/or relative abundances of species within

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assemblages (Meffe and Minckley, 1987). These two concepts have been addressed directly or indirectly in a variety of faunal groups including freshwater and marine coastal fishes (e.g. Oberdorff et al., 2001; Garcia et al., 2012). However, few studies have examined these two ecological properties in intertidal mangrove fish assemblages. Intertidal habitats are unique with respect to the short temporal dynamics that characterize them (e.g. only accessible for fish at high tides during daytime or at night), and therefore constitute a relatively complex system challenging the testing of the persistence and stability of community structure.

An often overlooked source of variability in mangrove fish dynamics in meso- and macro-tidal coasts is the tidal pulse (Gibson, 2003). In combination with the diel cycle, tides can control the community organization of tropical intertidal fishes (reviewed in Krumme, 2009). This has been shown in fish assemblages migrating with the macrotides to intertidal mangroves in the Bragança Peninsula in North Brazil (Krumme et al., 2004). The number of fish species, abundance and biomass were generally greater at spring tides than at neap tides. A major implication of these results is the need to carefully account for the scales of variation when designing the sampling/data collection and interpreting results from mangrove fish assemblages of meso- or macrotidal coasts (Krumme and Saint-Paul, 2010).

The mangroves of North Brazil are a rare example of a tropical coastal area where fish assemblages have been relatively well documented (studies dating back to the late 1990s; see Giarrizzo and Krumme, 2008; Krumme and Saint-Paul, 2010). This area, known as the Amazon macrotidal mangrove coast, is recognized as the largest continuous mangrove area of the world (7424 km², 57% of Brazil's mangrove cover; Nascimento Jr et al., 2013). The study of fish assemblages in this region has included both the subtidal main channels of the estuarine system (i.e. Caeté estuary; Barletta et al., 2005) and the intertidal mangrove creeks (Barletta et al., 2003; Krumme et al., 2004; Giarrizzo and Krumme, 2007), generating baseline information for these relatively “pristine” ecosystems (Blaber, 2013). Whereas in channels of a single estuarine system, assemblages comprise approx. 80–90 species (Barletta et al., 2003), in intertidal mangrove creeks this number is reduced to 34–75 species in different localities depending primarily on the size of creeks and sampling intensity (Giarrizzo and Krumme, 2008; Krumme and Saint-Paul, 2010). Intertidal mangrove creeks are visited by at least 115 fish species along the Amazon macrotidal coast, and constitute an important habitat for estuarine fishes in the area. Creek systems in the Amazon macrotidal coasts are dominated by the same families (i.e. Tetraodontidae, Engraulidae, Sciaenidae, Mugilidae, Haemulidae and Ariidae), but with varying proportions (catch mass) as a function of the proximity to the Amazon mouth (Giarrizzo and Krumme, 2008).

While these studies have advanced our understanding of the spatial variability of these assemblages, their long-term persistence and stability in time remains to be tested. Barletta et al. (2003) and Giarrizzo and Krumme (2007) investigated the monthly and seasonal dynamics of mangrove creek fish assemblages in two relatively close estuarine areas (Caeté and Curuça estuary) for a one-year period. Both studies found no significant differences in overall fish density between seasons (dry and rainy seasons), but significant seasonal changes in density and biomass for selected dominant species. However, the variability between the sampled creeks was always greater than the temporal variability. Only in Barletta et al. (2003) in the Caeté region did the species-specific seasonal changes in biomass result in significantly higher overall fish biomass during the rainy season.

The present study examined long-term changes (after 13 years) in the fish assemblage structure of intertidal mangrove creeks in a locality of the Amazon macrotidal mangrove coast (Bragança

Peninsula) to specifically assess whether (1) tidal and diel-related patterns were persistent between sampling intervals, and (2) the assemblage showed persistency and stability over time. To avoid spatial and temporal confounding effects common in other studies, we sampled the same intertidal mangrove creeks during the rainy season for two complete lunar cycles in 1999 and 2012. This provides a better understanding of the long-term dynamics in mangrove fish assemblages of this region, highlighting that tidal dynamics are a fundamental and stable pulse shaping the distribution of species in macrotidal mangrove creek areas.

2. Materials and methods

2.1. Study area

This study took place in the mangroves of the Bragança Peninsula, North Brazil (0° 52' S, 46° 38' W; Fig. 1). This peninsula (about 8 km wide, 25 km long, covering approx. 180 km²), lies between two of the many estuaries characterizing the Amazon macrotidal mangrove coast (Caeté and Taperaçu estuaries; Souza Filho et al., 2009). Up to 90% of the peninsula is covered with mangrove forest dominated by *Rhizophora mangle*, *Avicennia germinans* and *Rhizophora racemosa* while *Rhizophora harrisonii* and *Avicennia schaueriana* are less abundant (Menezes et al., 2008). Semi-diurnal tides have a tidal range of 3–5 m at spring tides and 2–3 m at neap tides. Mean annual precipitation is 2500 mm; approx. 75% falls during the rainy season (January–June); the dry season is

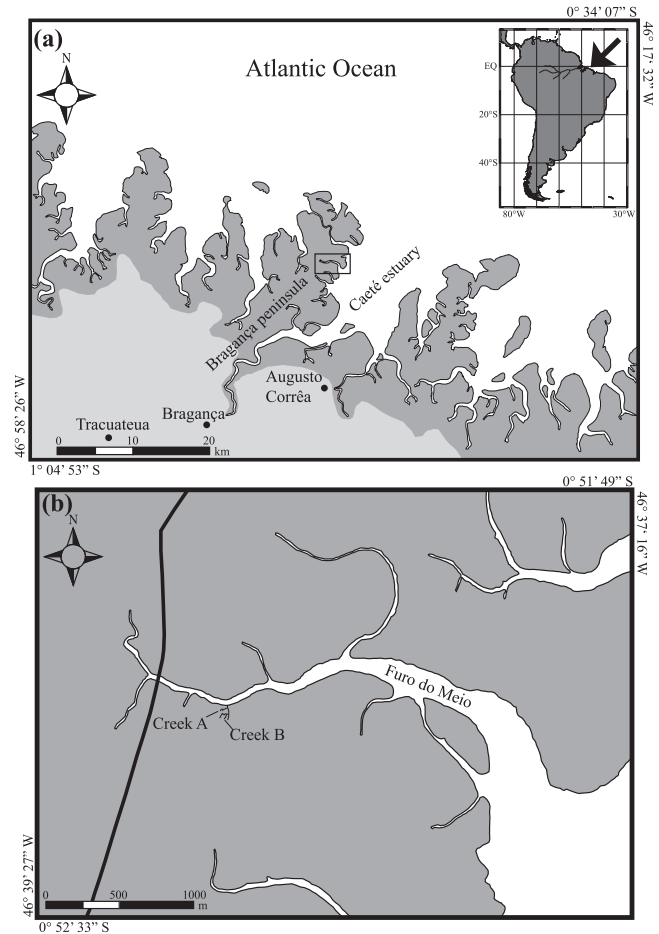


Fig. 1. (a) Bragança Peninsula and the Caeté estuary south of the mouth of the Amazon River, (b) The Furo do Meio and location of creeks A and B, sampled in 1999 and 2012; black line: street to the beach.

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