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Effects of hydrographic conditions of ponds on juvenile fish assemblages in the Kakum mangrove system, Ghana

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HIGHLIGHTS

- Role of hydrographic conditions in the use of mangrove ponds as fish nursery assessed.
- Pond selectivity by juvenile fishes largely influenced by salinity and pond size.
- Smaller juveniles preferred lower salinity conditions and shallower ponds.
- Diversity and abundance of fish higher in ponds closer to the estuary.
- Three fish species out of 18 better adapted to changing hydrographic conditions.

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ABSTRACT

The importance of mangrove ecosystems as nursery grounds for fishes is well established and documented. This paper reports on the possible role of hydrographic dynamics in the selection and utilization of tropical mangrove ponds as nursery habitats for juvenile fishes of ecological and commercial importance. The study was conducted in the Kakum River Estuary mangrove ecosystem near Elmina in the Central Region of Ghana during the peak of the monsoon season. Fish assemblages were sampled using a cast net and a pole seine. Aspects of hydrographic conditions of the ponds were studied. A total of 265 fish specimens, belonging to 18 species and 12 families were sampled. The commonest fish was the blackchinned tilapia *Sarotherodon melanotheron*, a typical brackish water fish in West Africa, which accounted for 66.4% of the total fish sampled. Ten of the 18 species belonging to 7 families, namely *Elops lacerta*, *Eucinostomus melanopterus*, *Porogobius schlegelii*, *Gobionellus occidentalis*, *Mugil bananensis*, *Liza falcipinnis*, *Epinephelus* sp., *Serranus accraensis*, *Penaeus notialis* and *Callinectes amnicola* were of marine origin. Spatial and temporal variations in the prevailing hydrographic conditions appeared to influence the fish species composition, density and size classes to varying degrees. Changes in salinity, dissolved oxygen, pH, conductivity and pond size correlated significantly with abundance of juvenile fish. Major fluctuations in fish species composition occurred on a weekly basis with changing pond depth and volume, indicating the dynamic nature of mangroves ponds that may serve the ecological needs of different species over time. Smaller juvenile fishes seemed better adapted to high variations in hydrographic conditions compared to larger juveniles. Higher fish densities and lower species diversity were encountered when the ponds were shallow compared to deep ponds. The utilization of mangrove tidal ponds as nurseries by juvenile fish may therefore be influenced primarily by the salinity and pond size.

1. Introduction

Human growth and development has caused the degradation and/or disappearance of many mangrove ecosystems worldwide. In the last half century, more than a third of the world's mangroves have been lost (Alongi, 2002) at a considerably high rate of 1%–2% per annum (Di Nitto et al., 2014). With the continued threat of sea level rise from climate change, increased deforestation and pollution due to burgeoning human populations in the tropics, the health of mangrove ecosystems face an uncertain future (McLeod and Salm, 2006).

Mangrove ecosystems provide essential ecological services such as nursery habitat for a host of ecologically and commercially

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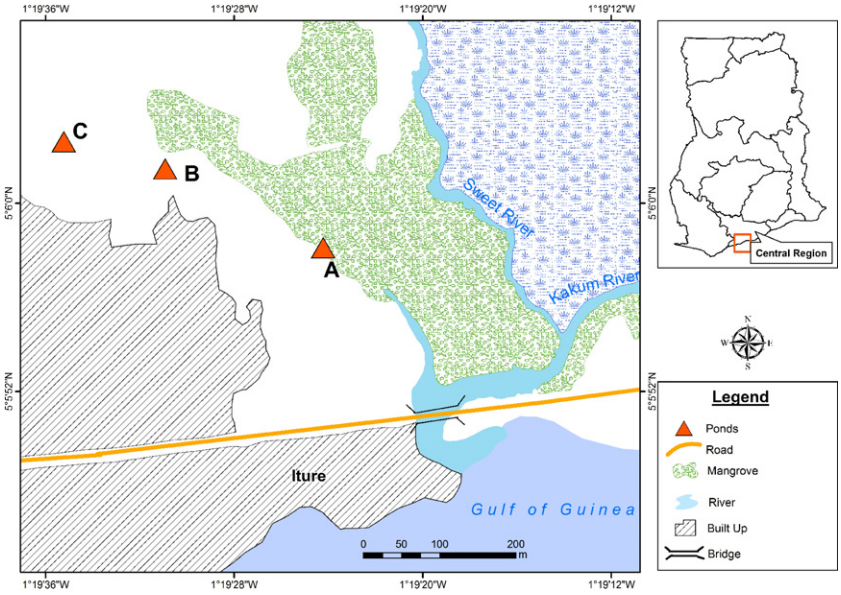

Fig. 1. Map of the study area showing selected ponds within the Kakum mangrove system.

important marine, brackish, and fresh water fish assemblages (Robertson and Duke, 1987; Laegdsgaard and Johnson, 2001) and contribute significantly to recruitment of adult marine fishes (Camp et al., 2011). Many studies have shown that juveniles account for 70%–90% of the fish fauna occurring in mangrove ecosystems, serving as evidence of their importance as nursery grounds (Nagelkerken et al., 2008; Mwandya et al., 2009). In addition, 20%–90% of commercial fishery catches have been directly linked to the health of nearby mangrove ecosystems (Nagelkerken et al., 2008). Recent analyses have quantified the economic value of mangroves to be 200,000–900,000 US$ per hectare, and up to 3,000,000 US$ per kilometer of coastline (Alongi, 2002; Wells et al., 2006). This high value is primarily due to the ability of mangroves to protect the shore against erosion, reduce local pollution, and contribute to fisheries.

Three hypotheses have been postulated as to why mangrove ecosystems are such effective nursery grounds for fish stocks: (1) juveniles face less predation in the mangroves, (2) mangroves provide more food for juvenile fish than other ecosystems and (3) the structural heterogeneity of mangroves attracts juveniles (Laegdsgaard and Johnson, 2001; MacDonald et al., 2009; Nanjo et al., 2014).

In western Africa, mangrove ecosystems remain understudied (Aheto et al., 2014). Ghana, which has a 550 km of coastline, has over 100 estuaries and lagoons (Yankson and Obodai, 1999; Ryan and Ntiamoa-Baidu, 2000). The Kakum River Estuary and its associated salt marshes and mangrove ecosystems have previously been surveyed for their fish and macroinvertebrate fauna (Blay, 1997; Okyere et al., 2012; Aheto et al., 2014). The fringing mangrove ecosystem of this estuary is home to six of the eight true species of mangrove trees found in West Africa (UNEP, 2007) which is considered to be the highest diversity in Ghana (Sackey et al., 1993), making it a botanically important ecosystem. This mangrove ecosystem also has several established heterogeneous microhabitats due to its exposure to anthropogenic influence therefore presenting an ideal ecosystem to investigate ecological dynamics.

Several factors including water depth, temperature, pH, salinity, turbidity and dissolved oxygen have been shown to influence the composition of fish assemblages in brackish water ecosystems (Lin and Shao, 1999; Singkran and Sudara, 2005; Green et al., 2009; Nip and Wong, 2010). Sediment characteristics of brackish water ecosystems have also been established to be of importance to juvenile fish (Camp et al., 2011) and pollution has become an increasingly important characteristic in determining mangrove faunal species composition including fish (Singkran and Sudara, 2005; McLeod and Salm, 2006; Sharma et al., 2013). However, little is known about the underlying factors that determine selectivity of ponds in mangrove ecosystems as nursery grounds by fish species. This study therefore seeks to investigate how changes in the hydrographic characteristics in tidal mangrove ponds of the Kakum River Estuary influence their selection and utilization as nursery grounds by fish species.

2. Methods

2.1. Study site

The Kakum River Estuary mangrove ecosystem is located near Elmina in the Central Region of Ghana (5° 5′ 40″N and 5° 6′ 12″N; 1° 19′10″ W and 1° 19′ 40″W) (Fig. 1).

Several ponds in the Kakum mangrove ecosystem provide habitats and refuge for a variety of fish and macroinvertebrate fauna. These ponds are largely temporary occurring during the wet season and disappearing during the dry season. This is because, many of the ponds are inundated when the adjacent Sweet River overflows its banks or from surface runoffs during the raining season (from May to June and to a lesser degree in October) whilst remaining virtually dry during the rest of the year. Several existing ponds are also interconnected by narrow channels and experience varying degrees of influence from periodic tidal exchanges. Three ponds (A, B and C) of varying sizes, morphology and hydrodynamics were selected for this study (Fig. 1). Pond A was the closest to the estuary, and experienced regular tidal influence. Pond B was the smallest of the three ponds with some tidal influence and connected to a few other smaller ponds. Pond C was the largest and farthest from the estuary with minimal tidal influence. Ponds B and C also experienced intermittent fresh water influx from the adjacent Sweet River.

2.2. Data collection

Weekly samples of fish, water and sediment were taken in June 2014 to coincide with the peak of the monsoon season. In