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Turbidity effects on feeding and mortality of the copepod *Acartiella natalensis* (Connell and Grindley, 1974) in the St Lucia Estuary, South Africa

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ABSTRACT

The St Lucia estuarine lake is the largest in Africa and has recently experienced a freshwater-deprivation crisis, partly because its connection with the large Mfolozi catchment has been discontinued. This is due to the extremely high silt load carried by the Mfolozi waters. A study was undertaken during 2012 with the aim of determining the effect of high silt loads on the mortality and feeding rates of *Acartiella natalensis*, a key copepod species in the St Lucia Estuary. Two different types of experiments were conducted: one using natural organic silt to determine the effect of turbidity on mortality rate; and the other with inorganic silt to determine feeding rates. For the mortality experiments, the copepods were subjected to six different turbidity levels, ranging from ambient to 2500 NTU, with survival monitored at 0, 4, 24, 48, and 72 hour time intervals. For the feeding experiments, copepods were incubated in the same turbidity levels for a 24 hour period. Results revealed a significant effect of turbidity on both feeding and mortality, with lowest ingestion rates and survival recorded in the high turbidity treatments. These findings indicate that overall, this copepod species is negatively affected by high turbidities, but an unexpectedly high mortality rate was recorded under control conditions (6-38 NTU). The lowest mortality rate occurred at 500 NTU, suggesting that while very high silt loads (>1000 NTU) clearly interfere with the physiological functioning of *A. natalensis*, some sediment may be advantageous, perhaps as a supplementary source of nutrition.

1. Introduction

Estuaries are dynamic ecosystems characterized by extreme variability in physico-chemical factors (Carrasco and Perissinotto, 2011; Cyrus et al., 2011). These fluctuations often result in the resident biota being categorised by strong spatial and seasonal variability (McLusky and Elliott, 2004). The St Lucia Estuary is the largest estuarine lake system in Africa and is of great significance for southern Africa (Wallace, 1975; Wright and Mason, 1993), as it forms part of the iSimangaliso (previously known as the Greater St Lucia) Wetland Park (Carrasco and Perissinotto, 2011), South Africa's first World Heritage Site (Begg, 1978). The St Lucia Estuary is also classified as a Ramsar Wetland of International Importance. The system is regulated by cyclical wet and dry phases, with each period lasting between 4 and 10 years at a time (Begg, 1978). The lake system experienced below average rainfall between 2002 and 2011, with drought conditions intensified by the Mfolozi River canalization and the successive freshwater diversion away from the St Lucia Estuary. Prior to 1920, the Mfolozi River discharged into the St Lucia Estuary and would buffer water loss during periods of drought, but in the 1930s a canal was excavated through the Mfolozi flats for agricultural purposes (Begg, 1978; Whitfield and Taylor, 2009). The natural filtration system of the swamps was, therefore, destroyed and the two systems have since been artificially maintained separate in an attempt to avoid siltation from the Mfolozi into the already naturally turbid St Lucia system.

Copepods belonging to the genus *Acartiella* are common constituents of zooplankton communities in many South African estuaries, where they occur in relatively high densities (Carrasco and Perissinotto, 2011; Jerling et al., 2010; Montoya-Maya and Strydom, 2009; Wooldridge, 1999). In the St Lucia system, *Acartiella natalensis* is one of three key zooplankton species that play a vital role in the ecosystem. With the dramatic salinity changes and prevalent drought spells caused by the canalization, the relevance of the St Lucia Estuary as an established nursery and spawning site has increasingly become compromised (Cyrus and Vivier, 2006). The resident zooplankton taxa are important indicators of change in systems such as St Lucia, that experience erratic changes in environmental conditions, as they have a faster physiological response than most other larger organisms (Hays et al., 2005).

The detrimental effects of the Mfolozi canalization on the estuarine functioning of St Lucia has led to various stakeholders questioning the decision to maintain the two systems separate, with management eventually calling for their re-connection (iSimangaliso Wetland Park Authority, 2012). The plan to build a beach spillway between the mouths of the Mfolozi River and St Lucia Estuary was initiated in the early months of 2012, with the channel becoming fully functional

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from 6 July 2012. To date, it has been successful in serving as a channel for freshwater passage between the mouths of the Mfolozi River and St Lucia Estuary (iSimangaliso Wetland Park Authority, 2012). However, although salinity levels throughout the lake have been reduced and lake water levels have increased, sediment loading remains a threat.

Turbidity can have a variety of adverse and beneficial consequences for zooplankton (Hart, 1988). On the one hand, suspended sediment may impair the ability of zooplanktivorous fish to locate prey (Gardner, 1981; Vinyard and O'Brien, 1976), thereby allowing the coexistence of large zooplankton species with their fish predators (Hart, 1986a, 1986b). Secondly, dissolved organic matter may adsorb to surface charged sediments, and zooplankton capable of ingesting such particles may benefit nutritionally from this potential resource (Arruda et al., 1983). On the other hand, phytoplankton productivity declines with an increase in turbidity, since suspended particulate matter increases the attenuation and back-scattering of light (Kirk, 1985). This depletion in food resources is compounded by the negative effect that high silt loads may have on the feeding of some zooplankton taxa (Arruda et al., 1983; McCabe and O'Brien, 1983). The indirect effects that suspended sediment has on water temperature may also be of importance (Schiebe et al., 1975).

Knowledge of the effect of high turbidity levels on the zooplankton communities of St Lucia will enhance the understanding of zooplankton response to fluctuations in environmental conditions and allow for the implementation of informed management strategies. The present study, therefore, aims to determine the effect of silt loading on the feeding and mortality of the dominant copepod, *A. natalensis*.

2. Materials and methods

2.1. Experimental design

Copepods were subjected to two different kinds of experiments, one investigating the effect of turbidity on feeding and another testing the effect of turbidity on mortality rate. These experiments were both repeated twice and were conducted during the dry winter season of 2012, when ambient turbidity levels were expected to be low due to low rainfall during this season. The sediment used in these experiments was collected from Esengeni in the Narrows (Fig. 1), as this sediment is composed largely of silt (<63 μm). For the feeding experiment, the sediment was rid of its organic matter. It was first dried in an air circulating oven (60 °C) for 2 days and thereafter placed in the muffle oven for 24 hours to burn off any organic matter. The sediment was then crushed with the use of a grinder mill for 3 min and only particles retained from a 63 μm sieve were used. For the mortality experiment, natural silt was used,

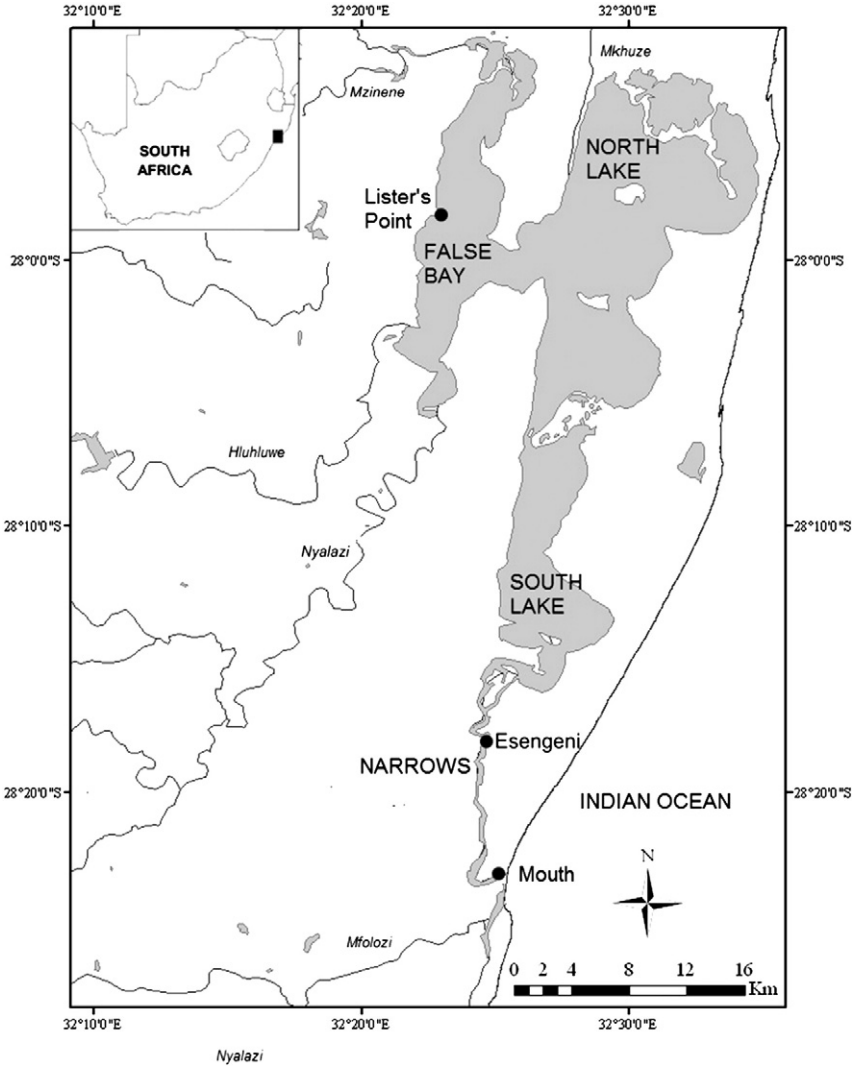

Fig. 1. Map of the St Lucia Estuary showing sampling stations as well as the geographic position within South Africa.