The role of microzooplankton grazing in the microbial food web of a tropical mangrove estuary

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ABSTRACT

In the Matang Mangrove Forest Reserve (MMFR), the role of microzooplankton (20–200 μm) grazing on phytoplankton as a channel for carbon transfer to higher trophic levels was investigated. Our results showed that primary production was higher during the southwest monsoon (SWM) (1905 ± 1478 μgCl^{-1}d^{-1}) than in the northeast monsoon (NEM) (708 ± 474 μgCl^{-1}d^{-1}). Microzooplankton grazing was tightly coupled to primary production in both SWM and NEM, accounting for 97% and 68% of primary production, respectively. Both primary production (activation energy: 1.29 ± 0.54 eV) and microzooplankton grazing (2.05 ± 0.63 eV) showed temperature dependency, and revealed a shift towards heterotrophy with seawater warming, specifically at temperatures above 32 °C. As a conclusion, the microbial food web in MMFR is characterised by high primary production that was efficiently grazed by microzooplankton.

1. Introduction

Microorganisms, with a total number of cells more than 10^{29}, outnumber macroorganisms (Azam and Malfatti, 2007), play an important role fulfilling key ecosystem functions. Among microorganisms, microzooplankton (20–200 μm in size) are important trophic intermediaries in the marine food web (Calbet and Landry, 2004). Microzooplankton are heterotrophic and mixotrophic microorganisms, and include planktonic ciliates, dinoflagellates, foraminiferans and small metazoans such as copepod nauplii and copepodites and meroplanktonic larvae. (Calbet, 2008; Yong et al., 2016).

Microzooplankton grazes about half of primary production (Calbet and Landry, 2004; Tsuda et al., 2010), and is in turn mainly consumed by copepods in the larger mesozooplankton fraction (Kleppel, 1993; Calbet and Saiz, 2005). The energy transfer from primary producers to fish via microzooplankton and copepods formed the 'classical' food chain (Steele, 1974; Thingstad, 2000). However this was an inadequate representation of the marine food web as bacteria play an important role repackaging dissolved organic matter into bacterial biomass. The carbon and energy is then transferred back to higher trophic levels via protozoa and microzooplankton in what is now known as the microbial loop (Pomeroy, 1974; Azam et al., 1983).

Other than primary producers, microzooplankton is also shown to regulate both bacteria and nanoplankton (<20 μm) population (Verity, 1986; McManus and Fuhrman, 1988; Sherr and Sherr, 1988; Rejas et al., 2005; Gonsalves et al., 2017) while regenerating nutrients and dissolved organic carbon to the ecosystem (Harrison, 1980). Moreover, by having a wide range of prey and growing at rates on a par with their prey, microzooplankton efficiently transfers biomass in the microbial food web (Steinberg and Landry, 2017).

Ever since Landry and Hassett (1982) developed the dilution technique, assertions of the pivotal role of microzooplankton as the primary grazers of marine food web has gained traction in recent years (Calbet and Landry, 2004; Huang et al., 2011; Schmoker et al., 2013; Zhou et al., 2015; Aberle and Piontkovski, 2019). The dilution technique estimates the grazing impact of microzooplankton on natural communities of marine phytoplankton together with an estimation of primary production. Although nutrient limitation, grazing saturation and non-linear response (Ayukai, 1996; Paterson et al., 2008; Schmoker et al., 2016) may affect the dilution technique, results from this method have generally been comparable to the more common light-dark dissolved oxygen and ^{14}C uptake methods (Landry et al., 2011; Lim et al., 2015; Selph et al., 2016).

Despite the usefulness of the dilution technique in elucidating the

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