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The effect of high inorganic seston loads on prey selection by the suspension-feeding bivalve, *Atrina zelandica*

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Abstract

Suspension-feeders are discriminate feeders, selecting prey by size, shape and food quality, this discriminate feeding behaviour has important consequences for the modelling of growth rates, population dynamics and ecosystem change. When given natural seston, the large pinnid bivalve *Atrina zelandica* (Gray), fed on picophytoplankton (<2 μm), larger phytoplankton (2–270 μm) and microzooplankton, but preferentially selected algal species within the 2–20 μm size fraction. Selection for ingestion was based on food quality, with morphotype, carbon content and potential toxicity also being important. Microzooplankton were readily ingested and represented 48% of the available diet in terms of carbon indicating they play an important role in the diet of *Atrina*. Mussels were subsequently fed a selected cultured algal diet consisting of three different types of 2–20 μm sized phytoplankton to assess differences in prey selection and grazing efficiency. When high inorganic suspended sediment concentrations of 500 mg/l were added in addition to the cultured algal diet this caused *Atrina* to increase filtration and rejection rates and reduced the efficiency of *Atrina* to select food in all cases. More importantly, there were changes in the species preferentially selected for ingestion. Our results suggest that as well as reducing feeding efficiency increased suspended sediment concentrations may affect prey selection and therefore have consequences for benthic–pelagic coupling beyond that of reduced removal and deposition rates.

Keywords: Bivalve; Grazing efficiency; Microzooplankton; Particle size; Prey selection

1. Introduction

Suspension-feeders are recognised as important components of shallow ecosystems, affecting water clarity, productivity and benthic–pelagic coupling (Newell et al., 1989; Kemp et al., 1990). Biodeposition in beds of suspension-feeding bivalves results from active filter feeding by the bivalve, which leads to non-digested material being excreted to the sediment surface as faeces and pseudofaeces (Norkko et al., 2001). These processes can increase deposition rates (Dame, 1993), enrich sediments and stimulate microbial growth (Stoeck and Albers, 2000), and may thus provide an important resource for surrounding benthos (Marsh and Tenore, 1990; Norkko et al., 2001). Many bivalves are known to preferentially select phytoplankton for ingestion (Cucci et al., 1985; Shumway et al., 1985a; Dupuy et al., 1999) such that size, morphology, particle shape, motility, density, toxicity and nutritional content of the algae are frequently more important than overall biomass (Defossez and Hawkins, 1997; Engström et al., 2001; Viherluoto and Viitasalo, 2001). Such selectivity has important consequences for modelling growth rates

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and population dynamics of species. It is also likely to have important consequences for ecosystem functioning, with the potential to contribute to feedback loops (Ostroumov, 2002).

Previous investigations have clearly shown that the quality and quantity of total seston influence the feeding rates of suspension-feeding bivalves (Newell et al., 1989; Iglesias et al., 1992; Riisgard, 2001). A major component of the natural seston is suspended sediment which is often largely inorganic and of no nutritional value. This aspect of seston is likely to be of increasing importance in many coastal marine areas as deforestation, urbanisation and changes to the frequency of extreme events occur as a result of global warming (Hicks and Griffiths, 1992). In a New Zealand estuary, Fahey and Coker (1992) reported that an increase in suspended sediment levels occurred in surface waters from 10–20 mg l^{-1} to 1000 mg l^{-1} during a storm. The presence of inorganic particles in seston is known to interfere with bivalve feeding processes and decrease condition (Riisgard, 2001; Ellis et al., 2002). However, the interaction between prey selectivity and changes to feeding rates is largely unstudied, despite the potential implications for predicting and modelling effects of increased suspended sediments on ecosystem processes.

The mechanisms used to sort particles for rejection as pseudofaeces or ingestion have been shown to vary between different bivalve species with morphological differences in feeding apparatus such as the labial palps and ctenidia being important (Ward et al., 1998). Size is also a significant criterion by which particles can be preferentially rejected as pseudofaeces before ingestion (Defossez and Hawkins, 1997). Measurements on the retention efficiencies of many bivalve feeders indicate that small (<5 μm) and very large phytoplankton (>200 μm) are often not efficiently filtered (Widdows et al., 1979; Shumway et al., 1985a; Ward et al., 1998; Dupuy et al., 1999) and are therefore less readily usable as a food source by many bivalves. However, some bivalve species consume very small particles such as bacteria (Kreeger and Newell, 2001), larger phytoplankton sized microzooplankton (Dupuy et al., 1999) and even very large zooplankton (Wong et al., 2003a,b). Size selection varies between species due to differences in their feeding morphologies and behaviour (Hawkins et al., 1996; Gardner, 2002).

This study focuses on the horse mussel, *Atrina zelandica* (Gray), a large, suspension feeding pinnid bivalve common around the coast of north-eastern New Zealand. *Atrina* are found in muddy to sandy soft sediment habitats, from shallow subtidal areas, out to waters of ~50 m in depth (Powell, 1979). Individual *Atrina* can be up to ~30 cm long (Powell, 1979) and protrude above the sediment surface, sometimes forming dense patches. Despite having only a pinched mantle, rather than siphons, *Atrina* has the ability to select organics over inorganics for ingestion and has a high organic absorption efficiency (Hewitt and Pilditch, 2004). Previous studies on *Atrina* have demonstrated that increased suspended sediment concentrations negatively affect *Atrina* biomass and clearance rates under laboratory and field conditions (Ellis et al., 2002; Hewitt and Pilditch, 2004). Longer-term negative effects on *Atrina* biomass have also been demonstrated along a suspended sediment gradient (Ellis et al., 2002). The aim of the current study was to investigate whether *Atrina* preferentially select different organic food items, and if so, to determine whether food preferences were altered when the inorganic fraction of the seston increased.

2. Methods and materials

2.1. *Atrina* collection

Two days before the first experiment, *Atrina* were collected by divers and returned to the lab where they were cleaned of epibionts and placed upright in cages in aerated seawater at 17 °C the ambient temperature at the collection site. In order to clear their digestive systems *Atrina* were not feed 12 h before beginning a grazing experiment (Hewitt and Pilditch, 2004). On the day of an experiment, all experimental chambers were filled with filtered seawater and header tanks were filled with the different diets before *Atrina* were placed in selected chambers. Chambers were allowed to run for ~1 h before the experiment was started. Observations of *Atrina* feeding behaviour were conducted over the 2 h duration of the experiments.

2.2. Experimental chambers

Experiments were performed in sealed flow-through chambers that were designed to hold an *Atrina* in an upright position, thereby preserving their natural orientation. The chambers were constructed from PVC pipe (dia. = 20 cm, vol. = 10 l). At the base of the chamber were in-line valves and a mesh insert (180 μm). Biodeposits were collected at the end of each experiment. The chambers were fitted with an acrylic lid that allowed a limited amount of light to reach the *Atrina* positioned 10 cm below. Diets were supplied from header tanks, via a hose inserted in the lid of the feeding chamber, and were drawn through the chambers by controlling the outlet flow rate. Flow rates through the