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NOTE

Microbes, meiofauna, and bacterial productivity on tubes constructed by the polychaete *Capitella capitata*

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ABSTRACT: Microbial and meiofaunal abundances and bacterial production on sediment tubes produced by the polychaete *Capitella capitata* (Type I) were examined in laboratory microcosms. Protozoa densities and bacterial production were significantly higher on tubes than in equivalent volumes of sediment taken adjacent to the tubes. Bacterial densities on tubes and in control sediments were not significantly different. Total meiofauna densities were significantly higher in controls due to the absence of nematodes on the tubes. The epibenthic copepod *Tisbe holothuriae* was the only meiofauna species found on the tubes, but their densities were not significantly greater than control populations. This work suggests that sediment tubes constructed by *C. capitata* are sites of enhanced bacterial activity caused, in part, by protozoans grazing on bacteria.

Most research on tube-dwellings of macrobenthos has focused on structures constructed by deep-dwelling equilibrium species, rather than on tubes produced by pioneer, surface deposit-feeders (Aller & Yingst 1978, Reise 1981). Biogenic structures of equilibrium species have received much more attention than structures produced by pioneering species due, in part, to the greater ability of bioturbating organisms to influence sediment biogeochemistry, and to alter the distribution and abundances of microbes and meiofauna.

However, few investigators have considered the effects of pioneering benthos and their tubes on the dynamics of microbial and meiofaunal populations (Rhoads et al. 1978, Reise 1981). In flume studies (Rhoads et al. 1978), dense tube aggregations of the capitellid polychaete *Heteromastus filiformis* led to increased stability of sediments. Stimulation of bacterial growth, Rhoads et al. (1978) proposed, may have been one explanation for this result. This report describes microbial and meiofaunal abundances and bacterial production, on tubes constructed by the capitellid polychaete *Capitella capitata* (Type I) in laboratory microcosms.

Sediment tubes of *Capitella capitata* were examined in 0.25 m^2, 14 cm deep, plastic tanks that received 200 ml min^{-1} of flow-through, 1 µm filtered, temperature-regulated (20 °C ± 1 C°) seawater (24 ± 2 ‰). Mixed cereal was used as detritus source and was added at a rate of 100 mgN $m^{-2} d^{-1}$ (= 4 g dry weight $m^{-2} d^{-1}$). The seawater was continually aerated. Each tank was layered to a depth of 5 cm with autoclaved, fine-grain (< 0.3 mm) sand and was stocked with *C. capitata* (10^4 ind m^{-2}), the nematode *Diplolaimella chitwoodi* (10^6 ind m^{-2}) and the copepod *Tisbe holothuriae* (10^5 ind m^{-2}). The nematodes *Theristus ostentator* and *Paracyatholaimus pesavis* (generally 10^4 m^{-2}), protozoans (mostly hypotrich ciliates), and bacteria colonized each tank with the initial inflow of seawater. Further details are provided in Alongi (1984).

After 25 wk of cultivation to ensure the development of microbial populations typical of organic-rich habitats, samples were taken with capillary tubes (1.7 mm i. d.) in the following manner: for extracting tubes (mean height = 2.8 mm; mean diameter = 1.4 mm), a capillary tube was gently fitted over an occupied tube and pushed into the sediment to a depth of 5 mm. Only tubes with equivalent volumes (18 mm^3) were used. Sediments were oxidized to a depth of 1 cm (Alongi 1984). Immediately after a tube was extracted, the resident worm was pulled out with a Hamilton microsyringe needle usually within 1 min or less. Samples were then processed as described below. Sediment samples (8 mm depth) taken adjacent to the tubes (usually 5 to 10 mm from the nearest tube) were used as controls.

Bacterial numbers were estimated by epifluoresence microscopy (Hobbie et al. 1977). Samples were

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immediately preserved in 5 % buffered formaldehyde. Bacteria were dislodged from particles by ultrasonic treatment (2.5 min) in a sonifying ice water bath. Samples were then further prepared for counting as described by Hobbie et al. (1977). Ten randomly chosen fields or at least 200 bacteria per slide were counted.

Bacterial production was measured from the rate of (^{3}H-methyl) thymidine incorporation into DNA (Fuhrman & Azam 1980). Briefly, each sample was immediately placed into 1 ml of 0.1 µm filtered, autoclaved seawater containing 0.5 ml of 5 µCi of ^{3}H-thymidine (78.2 Ci mmol^{-1}; New England Nuclear). After 15 min, incubations were terminated with trichloroacetic acid (TCA); TCA-insoluble materials were further processed as described by Fuhrman & Azam (1980). Meiofauna and protozoans were counted live on Petri dishes. A few drops of 50 % (v/v) $MgCl_2$ solution were added to facilitate counting under a dissecting microscope.

Bacterial production and protozoan densities were significantly (Student's t-test; $p < 0.05$) higher on the tubes produced by *Capitella capitata* than in equivalent volumes of sediment adjacent to the tubes (Table 1). Consequently, the doubling times for bacteria on tubes were faster than in control sediments. Both sediment tubes and controls had equivalent densities of bacteria. Of the meiofauna present, only the epibenthic copepod *Tisbe holothuriae* was found on tubes; copepod densities on tubes and in control sediments were not significantly (t-test; $p > 0.05$) different. Total meiofauna densities were significantly higher in control samples due to the absence of nematodes on tubes.

Table 1. Microbial and meiofaunal abundances, and bacterial activity, on and adjacent to tubes of *Capitella capitata*. Values are given as mean ± 1 SE of 5 replicates. Protozoa and meiofauna densities are expressed as number of individuals 18 mm^{-3} sediment

	Tubes	Control
Bacteria*	2.1 ± 0.9	2.3 ± 1.6
Bacterial production**	3.9 ± 0.2	2.9 ± 0.3
Doubling times*** (h)	5.4	7.9
Protozoa	325 ± 124	136 ± 40
Total meiofauna	1.6 ± 1.5	6.1 ± 1.1
Tisbe holothuriae	1.6 ± 1.5	2.8 ± 0.8
Diplolaimella chitwoodi	–	0.6 ± 0.9
Theristus ostentator	–	1.2 ± 0.8
Paracyatholaimus pesavis	–	1.8 ± 1.8

* Number of cells × 10^5 (18 mm)$^{-3}$ sediment
** Number of cells produced × 10^4 h^{-1} (18 mm)$^{-3}$ sediment
*** Cell abundances/bacterial production estimates

These data suggest that sediment tubes, at least those produced by *Capitella capitata*, are sites of enhanced microbial activity. The higher production and more rapid turnover of bacteria on tubes is probably due to (1) stimulatory effects of grazing by protozoans; (2) greater availability of O_2 above the sediment surface. The former caveat is reasonable considering that protozoans were the dominant, and nearly only, bacterial grazers associated with the tubes. The observation that bacterial activity was significantly less in control sediments despite containing greater (~ 4 ×) total meiofauna densities infers that meiofauna may play a lesser role in regulating bacterial activities than suggested by Gerlach (1978) and Tietjen (1980). Further investigations are needed to determine whether the greater bacterial activity on, and attraction of protozoans to, tubes are due to activities by the polychaete *per se*, or to indirect or physiochemical factors such as mucus secretions or greater oxygen availability.

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