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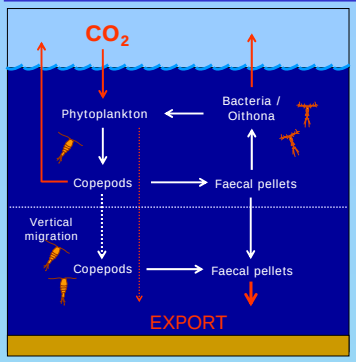
Fate of copepod faecal pellets during an iron induced phytoplankton bloom (EIFEX) in the Southern Ocean

Sandra Jansen[1,2], Joachim Henjes[2], Lars Friedrichs[2], Sören Krägefsky[2] and Ulrich Bathmann[2]

[1]Leibniz-Institut für Meereswissenschaften GEOMAR, Kiel, Germany
[2]Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany



Theory...

Importance of copepods in the carbon cycle

- reduction of phytoplankton biomass
- structuring effects on phytoplankton blooms
- production of fast sinking feacal pellets
- vertical distribution and migration

With potential high sinking rates of faecal pellets from larger copepods, it was formerly expected that the contribution of these faecal pellets to the vertical flux is always high. Vertical flux studies of the recent two decades, however, showed that the contribution of faecal pellets to the vertical carbon flux is not always high but highly variable.

Introduction

In recent years, large scale iron fertilization experiments draw increasing attention. The induction of large phytoplankton blooms and their subsequent, possible export to the deep sea attracted interest as a possibility to reduce CO_2 concentration in the atmosphere and thereby slow down global warming. As one of the main consumers of phytoplankton, copepods were in the focus of this study. The aim of our study was to quantify their impact on carbon export via faecal pellets to the deep sea. A combined examination of faecal pellet production in experiments and the analysis of the faecal pellet standing stock within the water column were carried out in the course of the European Iron Fertilization Experiment (EIFEX) in the Southern Ocean (~ 49°S, 02°E). In response to the iron fertilization a diatom bloom developed with chlorophyll *a* concentrations up to 3.1 µg Chl *a* l^{-1} inside the fertilized patch (Fig. 1).

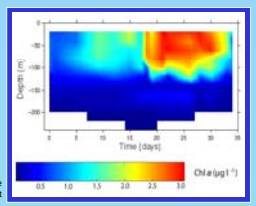


Fig. 1: Development of Chlorophyll *a* in the course of the iron fertilization experiment EIFEX

Faecal pellet production experiments

- Experiments were conducted with a specific number of one copepod species
- 24 hours grazing on the natural phytoplankton community
- Faecal pellet volume (FPV) could be calculated assuming a regular geometrical shape and afterwards converted into feacal pellet carbon (FPC)

FPV → (69.4 µgC/ mm³) → FPC

Faecal pellet production experiments with the abundant copepods *Calanus simillimus*, *Pleuromamma robusta*, *Rhincalanus gigas* and *C. propinquus* showed, that faecal pellet volume as well as faecal pellet production rate increased with increasing chlorophyll *a* values.

Most experiments were conducted with the most abundant copepod *C. simillimus* and results are shown in Fig. 2.

Faecal pellet production rate (FPR) increased from 5 FP ind^{-1} day^{-1} at the beginning of the experiment to a maximum value of 60 FP ind^{-1} day^{-1} measured 33 days after fertilizaton.

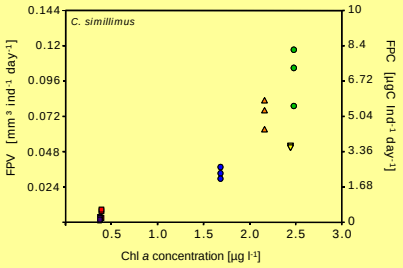


Fig. 2: Faecal pellet production rate of *Calanus simillimus* determined for different chlorophyll *a* start concentrations.

Two regressions were applied to describe the dependency of the faecal pellet production to chlorophyll *a* concentration:

C. simillimus: $FPV_{C.\ simillimus}$ [µgC $Ind^{-1}day^{-1}$] = 2.0838 * Chl *a* conc [µg l^{-1}]

Other species: $FPV_{other\ copepods}$ [µgC $Ind^{-1}day^{-1}$] = 1.7112 * Chl *a* conc [µg l^{-1}]

Faecal pellets in the field

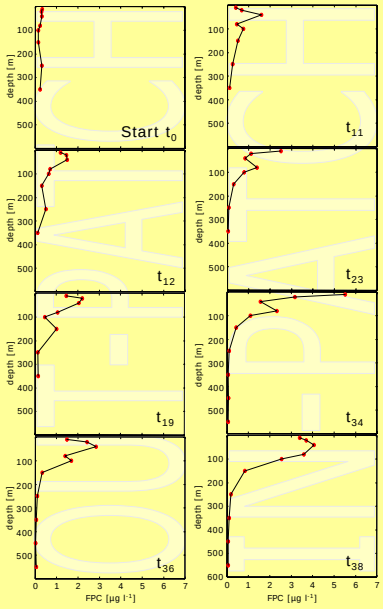


Fig. 3: Depth profiles of feacal pellet carbon (FPC) at selected stations inside and outside the fertilized patch.

Faecal pellet abundances in the field were determined from concentrated water samples, by concentrating 12 or 24 l of water from a discrete depth over a mesh. Faecal pellets were measured under an inverted microscope and values were converted into faecal pellet carbon.

At the end of EIFEX, maximum FPC values inside the fertilized patch were 13 times higher than in the beginning of the fertilization experiment, while the FPC increase at the out patch stations was only half of this (Fig. 3).

In depth beneath 150 m, only 1 – 7 % of the maximum FPC could be detected.

Abundance of calanoid copepodites & adults

Initial: ~ 1.5 * 10^5 individuals m^{-2}

Final: ~ 3.5 * 10^5 individuals m^{-2}

Maximum abundance values were nearly reached at the mid of the experiment. With the copepod abundances in the field and the on board faecal pellet production experiments, it was possible to estimate the expected *in situ* faecal pellet production of the copepod community, making the rough assumption:

FPR for CIV- adults = 100% (experimental values)

FPR for CI- CIII = 40%

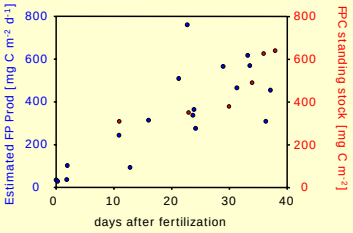


Fig. 4: Blue dots: estimated faecal pellet production (0-150m), calculated from copepod abundances and results from faecal pellet production experiments. Red dots: corrected faecal pellets carbon (FPC) standing stock integrated from concentrated water sample counts (0-150m). Only in-patch stations are shown

Fig. 4 shows that the FPC standing stock within the upper 150 m is as high as the expected daily faecal pellet production of the copepod community in the field, which leads to the conclusions:

→ **Faecal pellet turnover time:**
within the mixed layer (0-150m)
~ 24 hours

→ **Strong evidences for recycling of faecal pellets, rather then export**

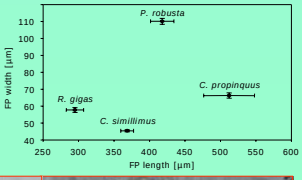
During EIFEX, there seemed to be a high recycling rate of the produced faecal pellets within the mixed layer, with different possible mechanisms. The actual main mechanism triggering the recycling of the faecal pellets during EIFEX can only be speculated and may be a combination of different processes.

Possible faecal pellet recycling mechanisms:

- coprophagy, coprochaly, coprorhexy (*Oithona* spp. ?)
- fragmentation of FPs by other copepod species
- microbial degradation

Faecal pellet size measurements:

Neither length, nor width of the faecal pellet sizes overlapped with regard to the 95 % confidence intervals.



Faecal pellets produced by *Pleuromamma robusta*

Faecal pellets produced by *Calanus simillimus*

Faecal pellets produced by *Rhincalanus gigas*