Reproduction of the copepods Rhincalanus gigas, Calanus simillimus and Pleuromamma robusta during an iron induced phytoplankton bloom (EIFEX) in the Southern Ocean

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Introduction

The Southern Ocean is characterized by low temperatures and a short growth season for primary producers, which potentially limit zooplankton growth and reproduction. Different copepod species seem to exhibit a spectrum of adaptations and life cycles are diverse. However, the association of spawning events with phytoplankton concentrations is not clearly demonstrated yet. The European iron fertilization experiment (EIFEX) provided an unique opportunity to follow the reproductive response of the calanoid copepods Rhincalanus gigas, Calanus simillimus and Pleuromamma robusta during the entire development of a diatom dominated phytoplankton bloom.

Conclusions

The observation that R. gigas reacted in autumn on enhanced food concentration with increasing egg production, suggests that this species can react on favourable conditions and that their reproduction during this study was neither dependent on lipid reserves, nor on seasonal aspects. The fast reproductive response indicates that R. gigas was food limited during the period of this study in the Antarctic Polar Front region. Throughout the experiment the phytoplankton assemblage was dominated by chain-forming and large diatoms. Deformed N2 nauplii from R. gigas were observed during the hatchling experiments.

The three different copepod species showed different responses to the induced phytoplankton bloom:

- **Pleuromamma robusta**
  - Number of egg producing females:
    - In patch <10%
    - Out patch <10%
  - Pleuromamma sp. produced almost no eggs during the whole fertilization experiment. Egg production rate (EPR) was low or zero, with no differences with regard to the chlorophyll concentration.

- **Calanus simillimus**
  - Number of egg producing females:
    - In patch 50-85%
    - Out patch 50-60%
  - C. simillimus produced constantly ~18 eggs female\(^{-1}\) day\(^{-1}\) at stations where chlorophyll concentration exceeded 0.6 µg Chl a \(\text{L}^{-1}\).

- **Rhincalanus gigas**
  - Number of egg producing females:
    - In patch 60-90%
    - Out patch 0-15%
  - R. gigas did not produce eggs at the start of the experiment. Egg production increased "in patch" until day 30 after fertilization with an average of 50 eggs female\(^{-1}\) day\(^{-1}\). The egg production rate "out patch", corresponding to low chl a concentrations remind close to zero during the entire experiment.

Field observations

Most studies of spawning have been made on temperate and high latitude species. One area of interest is the possibility that laying of eggs is timed to take advantage of phytoplankton increase or blooms. The association of spawning events with phytoplankton concentrations is not clearly demonstrated. During the iron fertilization experiment EIFEX we observed three different responses to enhanced phytoplankton concentrations from three different abundant copepod species. Results from the experiments were reflected in the egg abundance in the field (Fig. 5).

Material and Methods

Egg production experiments were performed with Rhincalanus gigas, Calanus simillimus and Pleuromamma robusta during the iron fertilization experiment EIFEX in the beginning of 2004. In response to the iron fertilization a diatom bloom developed with chlorophyll a concentrations up to 3.1 µg Chl a \(\text{L}^{-1}\). Samples were taken inside and outside the fertilized patch. Females were caught with Bongo nets and incubated individually for ~24 hours in 100 ml beakers with filtered seawater. All females were included in the calculation of the egg production rates, whether they spawned or not.

Further reading:

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**Addenda**

- **Pleuromamma robusta**
  - Number of egg producing females:
    - In patch 70%
    - Out patch 50% (determined at one in patch station only)

- **Calanus simillimus**
  - Number of egg producing females:
    - In patch 50-85%
    - Out patch 50-60%

- **Rhincalanus gigas**
  - Number of egg producing females:
    - In patch 60-90%
    - Out patch 0-15%

**Can spawning of copepods be induced by enhanced phytoplankton concentrations?**

- **No** Spawning seasonally timed?
  - Independent from phytoplankton concentrations

- **Maybe** Threshold at about 0.6 µg Chl a \(\text{L}^{-1}\)
  - Maximum rate reached at 0.8 µg Chl a \(\text{L}^{-1}\)

- **Yes** Threshold at about 1.5 µg Chl a \(\text{L}^{-1}\)
  - Maximum rate not reached at 2.7 µg Chl a \(\text{L}^{-1}\)

**Laboratory Experiments**

- **Egg production rate (EPR)** [Eggs female-1 day-1] from Pleuromamma robusta dependent on Chl a concentration during EIFEX

- **Egg production rate (EPR)** [Eggs female-1 day-1] from Calanus simillimus dependent on Chl a concentration during EIFEX

- **Egg production rate (EPR)** [Eggs female-1 day-1] from Rhincalanus gigas dependent on Chl a concentration during EIFEX

**Figures**

- Fig. 1: Malvinbank cruise plot [AWI XX/12 R.86]
- Fig. 2: Egg production rate (EPR) from Pleuromamma robusta dependent on Chl a concentration during EIFEX
- Fig. 3: Egg production rate (EPR) from Calanus simillimus dependent on Chl a concentration during EIFEX
- Fig. 4: Egg production rate (EPR) from Rhincalanus gigas dependent on Chl a concentration during EIFEX
- Fig. 5: Egg abundance from Multinet samples during the course of EIFEX
- Fig. 6: Egg abundance from MalaNet samples during the course of EIFEX