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Reproductive response of the copepod *Rhincalanus gigas* to an iron-induced phytoplankton bloom in the Southern Ocean

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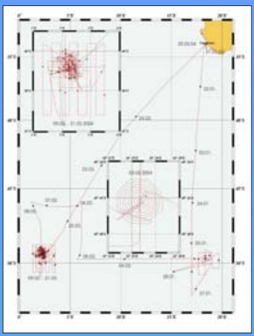


Fig. 1: Polarstern cruise plot (ANT XXI/3: EIFEX)

Introduction

The Southern Ocean is characterised 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 concentration are not clearly demonstrated yet. The European iron fertilization experiment (EIFEX) provided an unique opportunity to follow the reproductive response of the calanoid copepod *Rhincalanus gigas* during the entire development of a diatom dominated phytoplankton bloom.

Can spawning in *Rhincalanus gigas* be induced by enhanced phytoplankton concentrations?

Fig. 2: *Rhincalanus gigas*, carapax length ~9 mm

Material and Methods

Egg production experiments were performed with *R. gigas* 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* L^{-1}. Samples were taken inside and outside the fertilized patch, subsequently referred to as „in-patch" and „out-patch".

R. gigas 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.

Between 40 and 60 *R. gigas* females from selected stations were examined to determine the stage of the ovarian development. Gonad maturation stages were established from whole, unstained animals under a dissecting microscope and five gonad developmental stages (GS) were distinguished (Table 1).

Egg Production and Hatching success

R. gigas did not produce eggs at the beginning of the experiment. Egg production increased in-patch with increasing chlorophyll *a* concentrations until day 30 after fertilization with an average of 50 eggs $female^{-1}$ day^{-1}. The egg production rate out-patch remained close to zero during the entire experiment.

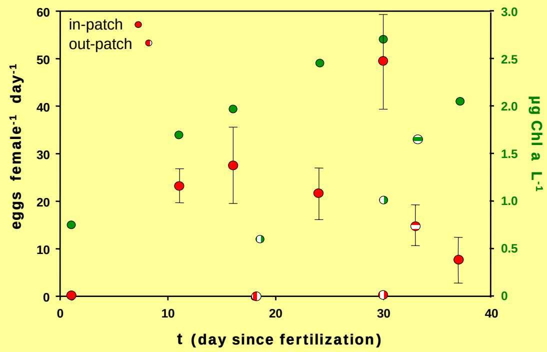


Fig. 3: Egg production rate of *Rhincalanus gigas* in-patch (filled symbols) and out-patch (striped symbols). Corresponding chlorophyll *a* concentrations are given (green symbols).

Number of egg producing females:

In patch 60-90%

Out patch 0-15%

Hatching success

In patch 44±1,5%

The highest individual egg production rate of 153 eggs $female^{-1}$ day^{-1} was observed at day 30 after fertilization. Development from the egg to the first naupliar stage took four to five days and determined hatching success was consistently low with ~45%.

Egg diameter: 221±1 µm (n=110)

Body length N1: 286±2µm

Width: 122±1µm (n=22)

Body length N2: 505±8µm

Width: 162±2µm (n=16)

Fig. 4: (A) Egg and (B) first two naupliar stages (N1, N2) from *Rhincalanus gigas*

Gonad development

The development of the copepod gonads over the time of the experiment underlined the data from the egg production experiments and took place concurrent with increasing chlorophyll a concentrations.

GS 1	Oocytes present in the ovary; oviduct empty or only with single, transparent, small oocytes
GS 2	Transparent oocytes in the oviduct in one or maximal two layers
GS 3	Transparent oocytes in the oviduct in several layers; all oocytes similar in size; no nucleus visible
GS 3.5	Oocytes in the oviduct in several layers, all similar in size; with visible nucleus, but still transparent
GS 4	Several rows of oocytes in the oviduct; oocytes increase in size in ventral direction, ventral row is larger, darker and with visible nucleus

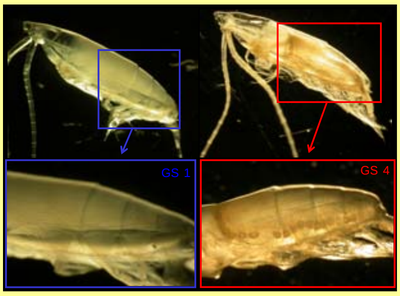
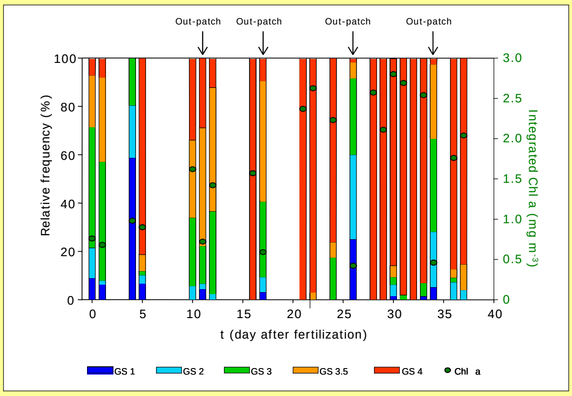


Table 1: Classification of the gonad developmental stage (GS) based on macroscopic criteria, modified for *Rhincalanus gigas*

No significant differences between in- and out-patch were found until day 12 after fertilization. In contrast, the out-patch station at day 17 and all following days show significant differneces in *R. gigas* gonad development compared to the in-patch stations where almost all females were found in GS 4.

Fig. 5: Percent composition of *Rhincalanus gigas* female population gonad development stages (GS) from multinet samples with corresponding average chlorophyll a concentrations over the upper 100 m of the water column (green dots). Arrows mark the out-patch stations.



Life cycles of Antarctic copepods are diverse and especially the strategy of *R. gigas* is still under debate. The observation that...

... *R. gigas* showed a clear reproductive response to increasing chlorophyll *a* concentrations ...

...in autumn suggest 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 indicate that *R. gigas* was food limited during the period of this study in the Antarctic Polar Front region. The advantage of the ability to react on high phytoplankton concentrations during autumn is questionable. Generally, the early copepodit stages are known as the main overwintering stages of *R. gigas*. The advantage of the reproductive response to increasing food concentrations is therefore dependent on the duration of the development of the nauplii to an early copepodite stage- which can only be speculation with the present knowledge.

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