Egg production and egg viability of the copepods *Acartia* and *Eurytemora* differ when grown on food of varying nitrogen:phosphorus ratios

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Nitrogen: Phosphorus ratios have increased

- Ammonium
- Phosphate
- N:P ratio (wt:wt)

Graphs showing trends from 1970 to 2010.
Research Question

• Do changes in nutrient availability and proportion alter food quality for consumers?

• How are the nutrient content of copepods and eggs, egg production rates, and egg viability, affected by varying food quality?
Copepods

• *Eurytemora carolleeae* - brood spawners
  – lay their eggs in sacs that develop attached to females

• *Acartia tonsa* - broadcast spawners
  – release large numbers of eggs to environment
Hypotheses

• While phytoplankton nutrient content can be quite variable, due to their ability to take up and store nutrient in excess of their growth requirement, copepod nutrient content should not vary substantially with prey nutrient content.

• Copepods should maintain relatively invariant nutrient content because their excretion, and egg nutrient content should change as diet changes.

• As diet changes, and as egg nutrient content changes, egg production rates and egg viability should change.
Methods

1. Diatom growth, variable N:P

2. 1:20 dilution culture: ASW

Experimental exposures with zooplankton

8 laboratory experiments conducted:
Diatom grown at 4 N:P ratios
Exposed to 2 zooplankton: *Eurytemora* and *Acartia* at same total food amount (in terms of C)
1. Phytoplankton growth, variable N:P

2. 1:20 dilution culture:ASW experimental exposures with zooplankton

3. Time dependent chemical measurements
phytoplankton growth, variable N:P

1:20 dilution culture: ASW

experimental exposures with zooplankton

1

2

3
time dependent chemical measurements

4
egg chemical composition

1

2

3

4
phytoplankton growth, variable N:P

1:20 dilution culture:ASW

1

experimental exposures with zooplankton

2

egg viability

5

time dependent chemical measurements

3

egg chemical composition

4
phytoplankton growth, variable N:P experimental exposures with zooplankton time dependent chemical measurements

Repeat after copepods exposed for 7 days to food of experimentally determined food quality

egg production, chemical composition

egg viability

1:20 dilution culture:ASW

1

2

3

4

5
Egg viability

Acartia tonsa

Eurytemora carrolleeae

Ingestion

Thalassiosira pseudonana

Media

Nutrient supply

Nutrient released

C:N:P

C:N:P

C:N:P

Excretion

Eurytemc carrolleeæ

C:N:P

Egg production

C:N:P

Egg viability
**Acartia tonsa**

**Eurytemora carolleae**

Copepod nutrient content

**Carbon**

**Nitrogen**

**Phosphorus**

**prey cellular N:P (molar:molar)**

HIGH P  HIGH N  HIGH P  HIGH N
Egg viability

Acartia tonsa
Eurytemora carrolleeae

Ingestion

Thalassiosira pseudonana

Nutrient supply

Media

initial C:N:P
C:N:P

Nutrient released

C:N:P
C:N:P
C:N:P

Excretion

Egg production

Nutrient released

C:N:P
C:N:P
C:N:P

Egg viability
**Acartia tonsa**

- **Carbon**
- **Nitrogen**
- **Phosphorus**

**Eurytemora carrolleae**

- **Carbon**
- **Nitrogen**
- **Phosphorus**

Prey cellular N:P (molar:molar)

- HIGH P
- HIGH N

**Egg nutrient content**
Egg nutrient content as a function of copepod nutrient content.
Egg viability

Acartia tonsa

Eurytemora carrolleae

Ingestion

Thalassiosira pseudonana

Initial C:N:P

Media

Nutrient supply

C:N:P

Nutrient released

C:N:P

C:N:P

C:N:P

Excretion

Egg production

C:N:P

Egg viability
Acartia tonsa

Egg production (eggs female-1 day-1)

Day 1

Day 7

Eurytemora carrolleeae

Egg production (eggs female-1 day-1)

Day 1

Day 7

prey cellular N:P (molar:molar)

HIGH P

HIGH N

HIGH P

HIGH N
Egg viability

Acartia tonsa

Eurytemora carrolleeae

Thalassiosira pseudonana

Ingestion

Nutrient supply

Media

initial C:N:P

Nutrient released

C:N:P

C:N:P

C:N:P

Excretion

Egg production

Egg viability

C:N:P

C:N:P

C:N:P

C:N:P
Low P

Excretion

N:P

Egg production

Egg viability

Low P

Excretion

N:P

Egg production

Egg viability

Acartia tonsa

Eurytemora carrolleeae

N:P

N:P

N:P
High P

Excretion

Acartia tonsa

Egg production

Egg viability

N:P

Eurytemora carrolleeae

Egg production

Egg viability

N:P
Conclusions

- *Acartia* and *Eurytemora* differed in their tissue nutrient content and in their response to variable nutrient quality in their food.

- Variable nutrient quality in the diatom prey affected egg production and egg viability even when food quantity (C) was constant and provided in excess.
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Prey cellular N:P

Cellular N:P (molar)

N:P media (molar)