Pteropods in Southern Ocean ecosystems: a review

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Earth and Ocean Sciences
What are Pteropods?

Class: Gastropoda

Order Thecosomata  
(shelled pteropods)

Order Gymnosomata  
(naked pteropods)
Order Thecosomata
(shelled pteropods)
4 Southern Ocean species

*Limacina helicina*

*Limacina retroversa*

*Clio pyramidata*

*Clio piatkowskii*

Photo: R. Giesecke

Photo: R. Giesecke
Order Gymnosomata  
(naked pteropods)  
2 Southern Ocean species  

*Clione limacina*  
*Spongiobranchaeaea australis*  

Photo: R. Giesecke  

From van der Spek and Baltovskaya (1981)
Why the interest in pteropods?

- ubiquitous but ignored component of SO zooplankton
  - few studies of their biology

- ocean acidification – SO surface waters to begin to become under-saturated with respect to aragonite by 2050 (Orr et al. 2005)
ocean acidification

reduction in abundance and ultimately a northward shift in the distribution of thecosome pteropods
How will this impact on Southern Ocean ecosystems?

Aim: to investigate the role of pteropods in the SO

- density contribution to zooplankton communities
- feeding biology and grazing impact
- life cycle
- contribution to carbon flux
Densities of pteropod species

- 45 voyages – 2848 samples
- CPR survey – 16456 samples
Densities of pteropod species

- South Georgia
- Prince Edward Islands
- CPR survey
- Antarctic Peninsula
- Lazarev Sea
- East Antarctic
Relative proportions of pteropod species

- **Limacina helicina**: 70%
- **Limacina retroversa**: 29%
- Remaining species: <1%
  - *Clio pyramidata*
  - *Spongiobranchaea australis*
  - *Clione antarctica*
Limacina helicina
ave 165 ind.m⁻³
max 2681 ind.m⁻³

Limacina retroversa
ave 60 ind.m⁻³
max 802 ind.m⁻³

Limacina spp.
average 3.7 ind.m⁻³
maximum 479 ind.m⁻³

All sample ave (Nov-Apr)
Limacina helicina ➢ 24.89 ind.m⁻³
Limacina retroversa ➢ 15.75 ind.m⁻³

Limacina helicina ➢ > 1000 ind.m⁻³
Proportion of total zooplankton
**Prince Edward Islands meso**
1996-2005 ave = 11%
2000 ave = 27%

**CPR survey meso**
1997-2005 ave = 2.5 ± 8.6

**Lazarev Sea**
meso ave = 1.1%
macro ave = 1.1%

**East Antarctic macro**
1985-1990 ave = 11.6%
1985, 1987 ave > 20%
South Georgia meso
11 – 53 % (density)
Atkinson et al 1996
Pakhomov et al 1997

Ross Sea
63 % (density)
23 % (biomass)
Hopkins 1987

Weddell Sea
17 % (biomass)
Boysen-Ennen et al 1991
Pteropods, particularly *Limacina* species, are an abundant group, with regionally very high densities.

Pteropods can make a substantial contribution to both meso- and macrozooplankton communities.
Trophic Ecology
Trophic Ecology: Gymnosophy

Clione limacina

Spongiobranchaea australis

monophagous

Limacina spp.

Clio pyramidalta
Trophic Ecology: Thecosomes

“Flux feeding” Jackson (1993)

Ciliary feeders

trapping of motile organisms Gilmer & Harbison (1986)

mucous web
Diet: Gut content analysis

Only 4 studies in the Southern Ocean:

- No data for *Limacina retroversa*
- *Limacina helicina* (2-3mm) - diatoms and dinoflagellates *(Hopkins 1987)*
- *Clio pyramidata* - dinoflagellates (>40%)
  - microzooplankton (~30%)
  - zooplankton (~25%) *(Hopkins & Torres 1989)*

Northern hemisphere - Arctic and sub-Arctic

- *Limacina retroversa* - diatoms and dinoflagellates
- *Limacina helicina* - diatoms and dinoflagellates
- *Limacina helicina* (5-13mm) – zooplankton ~ 46% of prey volume *Gilmer & Harbison (1986)*
Thecosome diet summary

• phytoplankton dominated diet indicated by stable isotopes and lipid analysis

• possible shift to increased carnivory at larger size
Grazing Impact

- only 6 published studies

Sub-Antarctic Zone

*Limacina retroversa*

- Ave IR = 1430 ng(pig)ind⁻¹.d⁻¹
- 6 years (April/May)

- ave 25 % of community grazing impact (max = 60%)
Grazing Impact

Seasonal Ice Zone

*Limacina helicina*

- Ave IR = 3179 ng(pig)ind\(^{-1}\).d\(^{-1}\)
- 2 years (Dec/Jan)

*Clio pyramidata*

- Ave IR = 22192 ng(pig)ind\(^{-1}\).d\(^{-1}\)
- 1 year (Dec/Jan)

- up to 40% of community grazing impact
Grazing Impact

- Ingestion rates of thecosomes were amongst the highest of any grazers, and in the case of *Clio pyramidata* were equivalent to *Salpa thompsoni*.

- Thecosomes can therefore be major contributors to community grazing impact.
Carbon Flux

Faecal pellets
- assimilation efficiency unknown
- FP production rates unknown
- Clio spp. sink up to 650m.d⁻¹

Mucous flocs
- discarded nets; reproduction
- scavenge suspended particles
- sink at 300m.d⁻¹ up to 1000m.d⁻¹

Consumption by predators
Zooplankton, benthos, pelagic fish (up to 40%)
demersal fish (up to 90%)

Aragonite shells
- ballast for organic carbon transfer
  e.g. Ross Sea - 56-96% of organic carbon flux in April-June
  >50% of carbonate flux south of PF
Conclusions

- Pteropods are an abundant group & make a substantial contribution to both meso- and macrozooplankton communities

- Thecosomes have amongst the highest ingestion rates, and their grazing impact can be substantial

- Thecosomes are potentially important contributors to Southern Ocean carbon flux
Knowledge Gaps

Life cycle
A single study of *L. retroversa* in sub-Antarctic (Dadon & de Cidre 1992)
- population structure
- Intraspecific regional variation in population and size structure

Feeding studies
- the role of carnivory in thecosomes *significance for trophic models*
- mucous web production rates

Carbon Flux
- faecal pellet production and its relationship to food quality
- faecal pellet morphology – sediment trap studies