The ties that bind: social environment effects in marine benthic populations

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Introduction

- Fine-scale genetic structure on ecologically relevant scales appears to characterize many marine populations, e.g.
  - Fishes (Selkoe et al. 2006; Bernardi et al. 2013)
  - Urchins (Ledoux et al. 2012)
  - Seagrasses (Kamel et al. 2012)
  - Limpets (Hoffman et al. 2012)

The social environment

- The density and genetic composition of groups of interacting conspecifics – the social environment – can influence performance, e.g.
  - Barnacles: settlement success (Gamfeldt et al. 2005)
  - Bryozoans: colonization success (Aguirre et al. 2012)
  - Seagrass: resistance to disturbance (Hughes & Stachowicz 2004)

The social environment

- Sessile or sedentary benthic communities
  - Intense competition for food and space
  - Potential impacts on the mating system, e.g.
    - Inbreeding depression

Hamilton’s Rule

Cooperative behaviors can evolve when:

\[ rB > C \]

\( r \) = coefficient of relatedness
\( B \) = benefit of cooperation
\( C \) = cost of cooperation

The social environment

- Hummocking in the acorn barnacle, *Semibalanus balanoides* (Bertness et al. 1998)
  - Costs:
    - High mortality
  - Benefits:
    - Buffer from thermal stress
    - Increased reproductive output
    - Increased feeding efficiency
**Hamilton’s Rule**

Cooperative behaviors can evolve when:

\[ rB > C \]

- \( r = \) proportion of genes in two individuals that are shared due to common ancestry
- \( r = 0 \) unrelated
- \( r = 0.25 \) share \( \frac{1}{4} \) of their gene, e.g., half-sibs
- \( r = 0.5 \) share \( \frac{1}{2} \) of their genes, e.g., parent-offspring, full-sibs
- \( r = 1 \) if two individuals share all their genes

**Genetic structure in the sea**

Paradigm: marine populations are open
Larval dispersal connects local populations over large distances

- Fine-scale genetic structure in species with limited dispersal
  - Allozymes
  - Microsatellites, SNPs
  - Biophysical models

Self-recruitment and kin structure in species with extensive dispersal potential

**Research Questions**

- **Families**: the genetic battleground
  - The evolution of parental care
  - Explaining offspring size variation

- **Neighbors**: relatedness and ecology
  - Relatedness as a predictor of population productivity

**Relatedness is a dominant facet of the social environment**

**Social environment**

- Life history
- Behaviour
- Reproductive isolation
- Community assembly
- Persistence

**Gene flow and dispersal**

**Environmental change**
The family unit

Sources of conflict

Cooperation... and conflict

♀ PARENT
SEXUAL CONFLICT OVER PARENTAL INVESTMENT

♂ PARENT
PARENT-OFFSPRING CONFLICT OVER PARENTAL INVESTMENT

PARENT-OFFSPRING CONFLICT OVER PARENTAL INVESTMENT

OFFSPRING 1

SIBLING CONFLICT OVER PARENTAL INVESTMENT

OFFSPRING 2

Magnitude of conflict

The magnitude of conflict depends upon:
(1) The opportunities for family members to interact
(2) The mating system
    — Specifically the degree of multiple mating (polyandry)

Arenas of conflict

Mating system

Multiple mating decreases relatedness among interacting individuals
Appears to be prevalent in marine organisms across a range of taxa

Paternity and parental care

Exclusive male parental care is rare
*In these cases, males care for their own genetic offspring
*≥ 70% paternity
Males of most mollusc species provide no post-zygotic investment in offspring.

**Solenosteira macrospira** exhibits exclusive male parental care.

Genetically characterize the mating system:
- Distribution of paternity among caring males
- Quantify the costs of care
  - Experimental manipulations of egg capsule load

On average, males sired only 24% of the offspring they were carrying.

Females mated with an average of 13 males within a season.
Paternity and parental care

- Males in this species have no choice but to care
  - The price to pay
  - Best of a bad situation
- *S. macrospira* presents an extreme example of the co-existence of high levels of female promiscuity, low paternity, and costly male care
  - Challenges classical theoretical predictions of the expected relationships between mating system, parental care, and relatedness

Sibling conflict

- Females package $\approx 200$ eggs/capsule
- Hatchlings emerge after one month
  - Severe brood reduction
  - Up to 98% of embryos can be consumed by siblings

Sibling conflict

- The number of fathers within a capsule increases over the reproductive season
- Cannibalism and offspring size appear to vary as a function of polyandry

Offspring size variation

- Mating system variation alone can induce significant variation in offspring traits
- Offspring size has important life-history consequences
  - Affects survival, performance, and dispersal

Conclusions

Fine-scale genetic and kin structure
- Appears to characterize many marine species

Ecological effects of genetic diversity
- Can exert strong effects on performance

The social environment
How and how often are social environment effects expressed in the sea and how are anthropogenic influences affecting them?

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