Intertidal and subtidal populations of *Crepidula fornicata* experiencing drastically different thermal conditions have similar physiological tolerances

Casey M. Diederich and Jan A. Pechenik
Tufts University Department of Biology

**Abstract**

For sessile marine organisms, the intertidal zone is a physically stressful environment at low tide. However, intense subtidal predation and competition force some species to live intertidally; individuals of those species are rarely found subtidally, and thus few studies compare the physiological tolerances of intertidal and subtidal conspecifics. In New England, dense populations of the gastropod *Crepidula fornicata* live both subtidally and intertidally. We characterized the tissue temperatures that intertidal and subtidal individuals of *C. fornicata* experienced throughout the summer and then determined the upper thermal tolerances of adults, lab-reared juveniles, and field-collected embryos. Intertidal animals experienced temperatures as high as 42°C, about 15°C higher than those experienced by subtidal conspecifics. However, most animals from both environments died following a 3 hour laboratory exposure to only 35°C, suggesting that intertidal individuals experienced drastically different thermal conditions, and showed little variability in lethal temperature; intertidal animals showed a decrease in thermal tolerance over two years of sampling. Thus, *subtidal* *C. fornicata* seem pre-adapted to cope with the thermal stresses associated with life in the intertidal zone. It is unlikely that either population is undergoing directional selection for higher thermal tolerance.

**Population Distribution**

The vertical distribution of *C. fornicata* is broad, but the snails generally do not live above 0.5m MLLW in Wickford, Rhode Island (Error bars = 1 SEM, n=5 per tidal height). All <0.4m animals spend approx. 3 hours per tidal cycle exposed to air, but may spend up to 6 hours exposed during spring tides. Animals at <1.0m are never exposed to air.

**Thermal Environment**

Intertidal (+0.4m) and subtidal (-1.0m) *C. fornicata* experience drastically different thermal environments. In the summer of 2011, biomimetic temperature-logging devices were deployed intertidally and subtidally in Wickford, Rhode Island. Intertidal animals were regularly exposed to temperatures 10-15°C higher than subtidal conspecifics.

**Thermal Tolerance – Field-collected**

Freshly collected *C. fornicata* embryos and adults from intertidal and subtidal habitats have similar thermal tolerances. Animals were exposed to a 3 hour stress at the indicated temperature and then allowed to recover for 48 hours before survival was determined. Note that high mortality was observed at temperatures that animals encounter in the field.

**Thermal Tolerance – Lab-acclimated**

There is little genetic variation in thermal tolerance among offspring of intertidal and subtidal parents of *C. fornicata*. Juveniles hatched from different parents were reared under constant conditions for at least one month in the laboratory before a 3 hour thermal stress at the indicated temperature.

**Conclusions**

- Intertidal and subtidal *C. fornicata* experience drastically different thermal conditions, and temperature is an important factor in controlling the upper distribution of this species.
- Intertidal *C. fornicata* are closer to their thermal maximum than subtidal conspecifics.
- Subtidal *C. fornicata* seem pre-adapted for thermal life in the intertidal zone.
- Different life history stages of *C. fornicata* have similar thermal tolerances; embryos were often most tolerant.
- Little genetic variation for thermal tolerance in this species suggests that intertidal populations may be at risk in the face of global climate change.