Phenotypic plasticity of the polychaete *Ophryotrocha labronica* (Polychaeta, Dorvilleidae): linking life history and thermal tolerance

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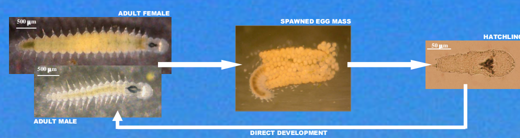
To predict evolutionary changes in response to differences in environmental thermal conditions, we needs details about the trade-offs that constrain the evolution of phenotypic traits.

In this study, we examine variation in a number of life-history traits and thermal-tolerance performances occurring along a thermal gradient in a laboratory strain of *Ophryotrocha labronica*, for assessing the occurrence of potential correlations among life-history traits and thermal tolerance.



The individuals used for the experiment belonged to a strain originally collected in the harbour of Grado (Italy) and kept for at least 20 generations at 20°C.

48 couples composed by sexually matured males and females were assigned haphazardly to one of seven temperature treatments (10°C, 15°C, 20°C, 25°C, 30°C, 35°C, 40°C)...

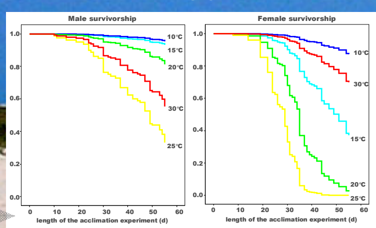
...and followed for 2 months, during which a number of life-history traits were measure (survivorship, reproductive and growth performances);...

...at the end of the acclimation period, tolerance to heat and cold was characterised for the survivors to each experimental treatment, using thermal-limits analysis.

THERMAL LIMITS ANALYSIS

Different end-points were defined for *O. labronica* in preliminary experiments. For lower thermal limits (LTL), the following end-points were observed: digging attempt (DA); offset of spasms (OS-LTL); response to prodding (RP-LTL), when the individual's body contracted only after it was pocked gently; chill coma (CC), when no reaction to pocking was observed but the individual was still able to recover after warming. For upper thermal limits (UTL), the following endpoints were detected: loss of control of the last metamera (LCM), which were risen while walking backwards; non-permanent "U" shape (U), with the individual arching its body but still able to decontract it from this position; offset of spasms (OS-UTL); response to prodding (RP-UTL); and lethal point (LP).

LIFE HISTORY

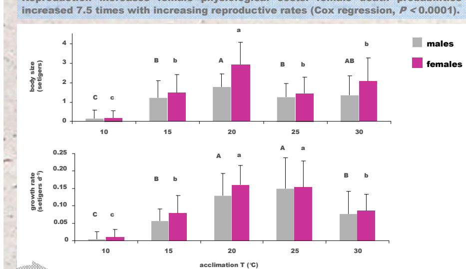


O. labronica could successfully survive between 10°C and 30°C, with the temperatures of 35°C and 40°C being shortly lethal (1 week and 1 day, respectively).

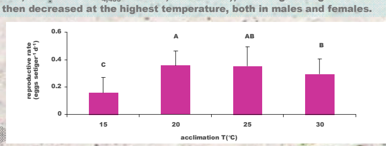
In general, survivorship decreased with increasing temperature (Cox regression, T: P < 0.0001), but the pattern was not monotonic, particularly for females: females exposed to 30°C showed a death hazard comparable to that measured at 10°C.

Females showed to be more vulnerable to temperature variations respect to males (Cox regression, T*Sex: $P < 0.0001$).

Reproduction increases female physiological costs: female death probabilities increased 7.5 times with increasing reproductive rates (Cox regression, $P < 0.0001$).



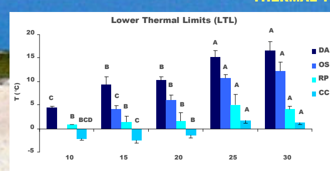
In general, body size and growth rates increased with increasing temperatures (ANOVA, T: maximum $F_{4,435}$ = 57.13, $P < 0.0001$), reaching the highest values at 20°C, and then decreased at the highest temperature, both in males and females.

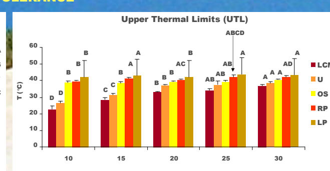


Individuals acclimated to 20°C and 25°C showed to have higher reproductive rates compared to those observed at 15 and 30°C (ANOVA, T: $F_{3,177}$ = 49.88, $P < 0.0001$). No reproduction occurred at 10°C.

- Life-history responses to increasing temperatures did not show a monotonic trend.
- Individuals exposed to 20°C exhibited a general higher fitness. This is consistent with a thermal history effect: the phenotypic plasticity of the species was affected by the environmental temperature (20°C) to which the strain used was exposed for over 20 generations before the acclimation experiment.

THERMAL TOLERANCE

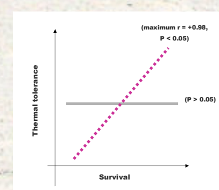




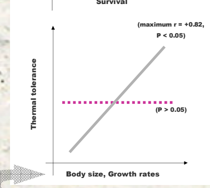
Tolerance to cold decreased with the increase of the acclimation temperature (ANOVA, T: maximum $F_{3,33}$ = 153.95, $P < 0.001$).

Tolerance to heat increased with increasing temperatures (ANOVA, T: maximum $F_{4,57}$ = 372.15, $P < 0.001$), with a pattern that could be clearly identified only for the earlier end-points (LCM and U), as progressively responses become more uniform.

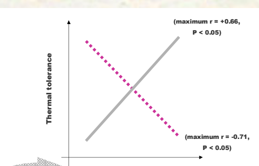
RELATIONSHIP BETWEEN LIFE HISTORY AND THERMAL TOLERANCE



A positive correlation was found between survivorship and cold tolerance, but not with tolerance to heat : individuals acclimated to the lower temperatures displayed higher cold tolerance as well as higher survival capacities, but at the expense of other costly functions, such as reproduction and growth.



Tolerance to heat was positively correlated with size, which had a beneficial effect in enhancing tolerance to increasing temperatures.



Opposite reproductive performances were related to cold and heat thermal tolerance.

CONCLUSIONS

- Tolerance to cold exerts a stronger influence respect to heat on *O. labronica* physiology.
- Since heat tolerance is less plastic, the margins for acclimating to increasing temperatures are not as large as those for coping to decreasing temperatures.
- Thermal tolerance seems to be not affected by the thermal history of the experimental individuals, as acclimation to 20°C treatment did not enhance tolerance to heat or cold.
- We show for the first time in a marine organism that a number of life-history traits co-varies and trades-off with measures of physiological performance, whilst others do not correlate with thermal limits.
- Life-history and thermal tolerance responses seems to be partly driven differently by changes in the thermal habitat of the organism, as supported by the different temperature-dependent patterns resulted form the acclimation experiment: non-monotonic for life-history traits and monotonic for thermal tolerances.