Rapid Adaptation of a Marine Copepod to a Greenhouse World

Hans G Dam[1], James deMayo, Gihong Park[1], Xuejia He[2], Lydia Norton[1], Michael Finiguerra[1], Hannes Baumann[1], and Melissa Pespeni[3]

[1]University of Connecticut, USA [2]Jinan University, China [3]University of Vermont, USA

Introduction

Problem: Consequences of a greenhouse world, **GW,** (**Fig.1**) on copepod fitness?

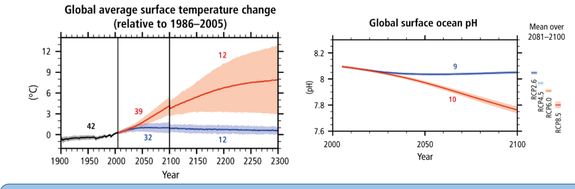

Figure 1. Temperature and pH projections (ICCP 2014)

Hypothesis: (Fig. 2)

- Additive or synergistic effects of lower pH and higher temperature.
- Adaptation Improves performance with tine and changes reaction norm.

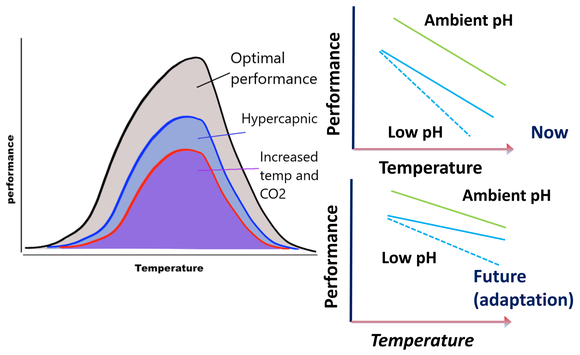

Figure 2. Hypothesized thermal performance curve (left) shows additive or synergistic effects of CO_2. Slopes of reaction norms (right) indicate additive (solid blue line) or synergistic (dashed blue line) effects. Changes in reaction norms between generations provide a test of the adaptation hypothesis.

Methods

FACTORIAL DESIGN: CO_2 X TEMPERATURE

	~400 ppm pCO_2 pH 8.2	2000 ppm pCO_2 pH 7.5
Ambient Temp 18˚C	A (AA) Control	B (AH) Effect of CO_2
High Temp 22˚C	C (HA) Effect of Temp	D (HH) Effect of Temp & CO_2

Cosmopolitan copepod, *Acartia tonsa*

1. Survivorship (N1 to C6)
2. Egg production rate, EPR
3. Hatching frequency, HF

} This poster

- **15 generations, woo hoo !**
- **4** copepod cultures/treatment
- **3** (survival) to 10 (EPR, HF) replicates/culture
- > **5000** copepods/culture
- **Non-limited food conditions; controlled for food quality effects**

Results

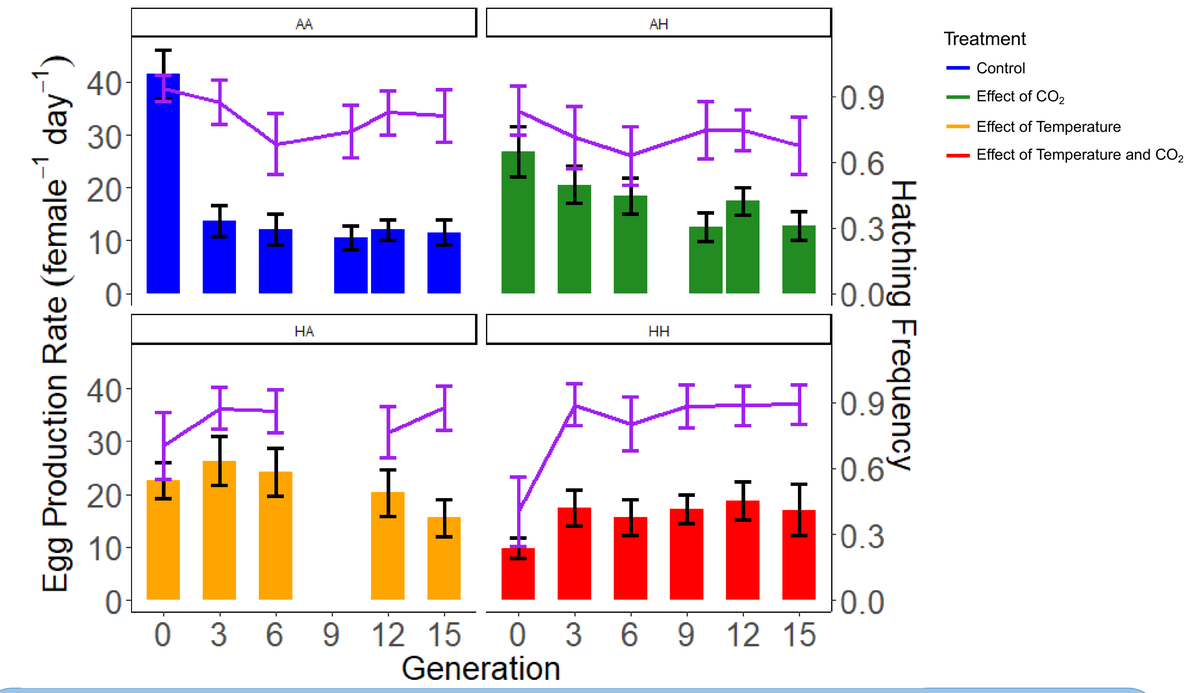

Figure 3 – Mean EPR (histograms) and HF (lines) versus generations. The ecological effects of a **greenhouse world, GW** (high temperature and high CO_2) are evident in dramatic drop in EPR and HF in the F0 generation relative to the control. Yet, copepods in the GW rapidly increase egg production by ~ 50% relative to the start of the experiment ($p < 0.03$). HF increases by 30% in the high-temperature treatment ($p < 0.03$), and doubles to resemble control levels in the GW ($p < 0.001$).

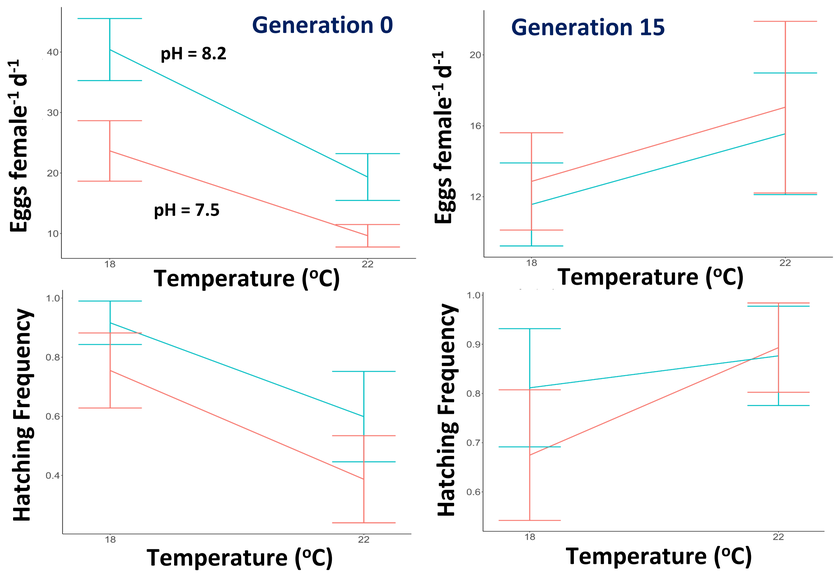

Figure 5. Reaction norms at generation 0 (left) and 15 (right) for egg production (top) and egg hatching frequency (bottom). In all cases, there is a significant ($p < 0.05$) effect of t**emperature**, and **pH**, but **no interaction effect**. The latter indicates only additive effects of temperature and pH. However, notice the change in the reaction norm slopes between generations, indicating adaptation to both elevated temperature and CO_2.

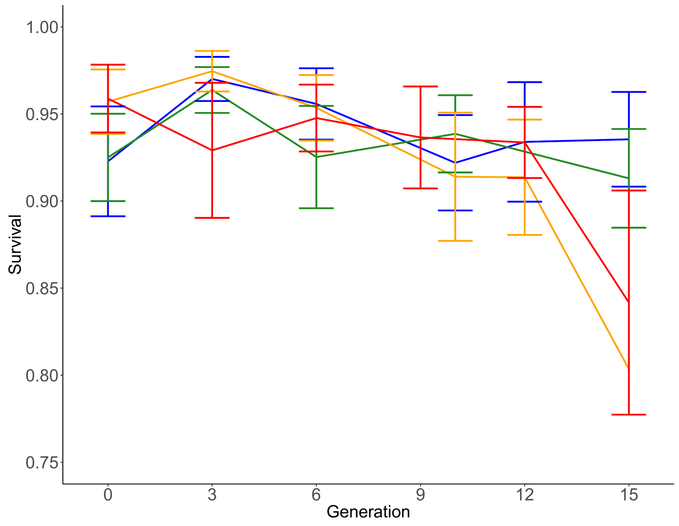

Figure 4 – While survival (N1-C6 stage) in the **high temperature** and the **GW** treatments appeared lower by generation 15, there was **no significant** effect of generation or treatment on survival, which was high for all treatments.

Conclusions

- **Negative ecological effects (F0):** Reduced EPR or HF under high T, CO_2, and GW.
- **Additive, not synergistic,** effects of temperature and CO_2.
- **Rapid Adaptation:**

1. Improved EPR (GW) and HF (high temperature and GW).
2. Change in slopes of the reaction norms between generations.

- **Selection mechanisms:** Egg hatching success and egg production rate, but not survival of post egg stages.

Acknowledgements

NSF

Sea Grant Connecticut