Notes for meeting 11/7/23

Chapter 1 data on routine metabolic rates of *M. menidia* embryos and newly hatched larvae in different oxygen and CO2 levels

* 7.5 kPa = 2.7 mg/L
* 9.0 kPa = 3.0 mg/L
* 12.0 kPa = 4.0 mg/L
* 23.0 kPa = 7.8 mg/L

From Table 1.2: mean metabolic rates at each oxygen and CO2 level

|  |  |  |  |
| --- | --- | --- | --- |
| ***P*O2**  **(kPa)** | ***P*CO2 (μatm)** | **Mean Embryonic RMR (±s.e.m.)**  **(μmol O2 h-1)** | **Mean Larval RMR (±s.e.m.) (μmol O2 mg-1 h-1)** |
| 23.0 | 400 | **0.022(±0.002)** | **0.165(±0.013)** |
| 2200 | 0.028(±0.003) | 0.148(±0.018) |
| 4200 | 0.034(±0.003) | 0.174(±0.017) |
| 12.0 | 400 | **0.018(±0.002)** | **0.182(±0.019)** |
| 2200 | 0.026(±0.002) | 0.179(±0.013) |
| 4200 | 0.025(±0.002) | 0.173(±0.019) |
| 9.0 | 400 | **0.025(±0.004)** | **0.126(±0.030)** |
| 2200 | 0.022(±0.003) | 0.142(±0.020) |
| 4200 | 0.027(±0.004) | 0.130(±0.024) |
| 7.5 | 400 | **0.025(±0.003)** | - |
| 2200 | 0.018(±0.003) | - |
| 4200 | 0.017(±0.002) | - |

Dashes (-) indicate treatments for which too few embryos survived to hatching for larval respirometry to be done.

Figure 1.3: Metabolic rates plotted with respect to oxygen for embryos (A) and larvae (B). Larval metabolic rates are mass-specific but embryonic ones are not.



**Chapter 2** data on routine metabolic rates at different CO2 levels (similar to Ch. 1 levels) and Pcrit, the oxygen level at which metabolic rates become oxygen-dependent (fish are oxygen-limited). As in Ch. 1, larval metabolic rates are mass-specific but embryonic ones are not.

* **For our purposes, focus on the Ambient (low) pCO2 data in this chapter**

Table 2.2: Mean routine metabolic rates and Pcrit in each experiment and at each CO2 level.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | | Ambient pCO2 | Moderate pCO2 | High pCO2 |
| **Routine Metabolism** | **Embryos** | Exp. 1 | 0.0044(±0.00066) | 0.0036(±0.00075) | 0.0030(±0.00043) |
| Exp. 2 | 0.0018(±0.00034) | 0.0027(±0.00023) | 0.0053(±0.00061) |
| **2dph Larvae** | Exp. 1 | 0.29(±0.041) | 0.28(±0.033) | 0.25(±0.047) |
| Exp. 2 | 0.22(±0.020) | 0.18(±0.0082) | 0.25(±0.028) |
| **5dph Larvae** | Exp. 1 | 0.23(±0.016) | 0.17(±0.014) | 0.23(±0.022) |
| Exp. 2 | 0.21(±0.026) | 0.23(±0.012) | 0.14(±0.011) |
| **Pcrit** | **Embryos** | Exp. 1 | 2.44(±0.54) | 3.01(±0.44) | 2.80(±0.32) |
| Exp. 2 | 1.90(±0.21) | 1.90(±0.32) | 2.51(±0.23) |
| **2dph Larvae** | Exp. 1 | 2.04(±0.25) | 1.56(±0.21) | 1.21(±0.26) |
| Exp. 2 | 1.23(±0.29) | 1.42(±0.23) | 1.34(±0.31) |
| **5dph Larvae** | Exp. 1 | 1.23(±0.18) | 0.94(±0.11) | 0.72(±0.17) |
| Exp. 2 | 1.99(±0.29) | 1.65(±0.16) | 1.17(±0.16) |

Figure 2.2: Routine metabolic rates with respect to CO2 at embryo (A), 2-dph larval (B), and 5-dph larval (C) stages.

A diagram of a graph

Description automatically generated with medium confidence

Figure 2.4: Pcrit with respect to CO2 at embryo (A), 2-dph larval (B), and 5-dph larval (C) stages.

A diagram of a graph

Description automatically generated with medium confidence

Main question: Do we remove maintenance from the model options (it doesn’t improve fit anyway so results stay same) or do we come up with a different function?

* This new formulation isn’t that different than what I included in my dissertation, in that the shape of the curve is visually similar. It’s just that now we have mechanistic explanations proposed for the other parameters but not so much for this one.
* What other shape or relationship would make sense?
* If oxygen consumption is not affected at these oxygen levels, what else would be an indicator of changing maintenance?
  + Cross et al.’s observation that the larvae swim to the surface, possibly for aquatic surface respiration. This would still increase oxygen consumption but they can’t do this in respirometers.
* Would one solution simply be to cite sources saying that the onset of anaerobiosis doesn’t necessarily coincide with the onset of reduced oxygen consumption?
* There was no significant differences but high variability (cite Schwemmer et al 2020), so itsnot unreasonable to include maintenance. Ought to be included for completeness.
  + Can still use single substrate SU because we have no positive evidence that oxygen limitation
* Mortality: there are ROS from virtually all metabolism, if hypoxia inhibits ability o repair or mitigate damage you get 1/c.

-What if assimilation slowing down reduces oxygen consumption, but increased maintenance cancels that out?

* Of course it probably wouldn’t cancel out *perfectly*, but the high level of individual variability in oxygen consumption rates would conceal small differences.
* Actually in embryos mean oxygen consumption technically increased but not significant.

-When above Pcrit: What if increased oxygen consumption is sporadic due to activity responses, and therefore not captured in the time frame of respirometry, but still affects the energy budget on the scale of an entire day or several days?

-Is the increased maintenance of damage repair being paid for with energy from the anaerobic metabolism that is, in theory, causing the damage? Or a portion of it?

* I think one thing that is confusing is the difference between acute and chronic hypoxia. If they are constantly in low-ish oxygen but consuming oxygen at a similar rate to their counterparts in high oxygen, what does that mean?
  + Sensing low oxygen and increasing aquatic surface respiration or escape behavior?
  + Having some percentage of maintenance needs met with anaerobic respiration, less efficiently? Their needs went up but oxygen consumption stayed the same?
  + Maybe more likely that they reduced their needs (and are assimilating less) but having elevated oxygen consumption relative to their needs (body size) because of damage repair and/or activity? As mentioned above.
  + The difference between acute and chronic is also important in terms of the hypothesis for reduced maintenance. Acute severe hypoxia you would see reduced food consumption and oxygen consumption (including from less SDA), but at a more mild chronic hypoxia you might see food consumption continue because they need it and oxygen consumption stay the same.

Because the data don’t support maintenance being the explanatory parameter anyway, we don’t need to justify maintenance being the responsible process – just need to justify testing it.

We borrowed maintenance from *M. beryllina*, using the same approach as in Stevenson et al.

* Based on starvation rate – assuming that all weight lost during starvation is going to maintenance.

Other questions

* Dividing the sections between normoxic/full life cycle fitting (2.3) and the hypoxia correction factor section (2.5)
  + Line 273 – Just say that the control data from these experiments were used to estimate parameters under normoxia (Section 2.3).
  + Rename section 2.3 “parameter est under normoxia”
* Results: JaAm description – is it just not phrased well?
  + Sentence that starts with “Combining” – change to simultaneously

Discussion

* Theory papers tend to have shorter discussions than empirical
* A few things to add
  + Paragraph on limitations of trying to ID physiol modes of actions using purely statistical tests like fitting a deb model
    - Muller work on mussel and oyster larvae with mercury
    - Same data across species but different PMOAs.
    - Need info on underlying physiol
    - That’s where sharper understanding will come from
    - Quote Louise’s paper
    - Wider take home message about DEB

Nina Marn would be good reviewer – Roger hasn’t collaborated

Remove Elke Zimmer

May be okay for this special issue to suggest someone Roger has collaborated with – as long as state in cover letter the conflict of interest/collab