Mussel growth data, DEB simulations

Pu, Tongyao

March 15, 2023

Table of Contents

lab experiment

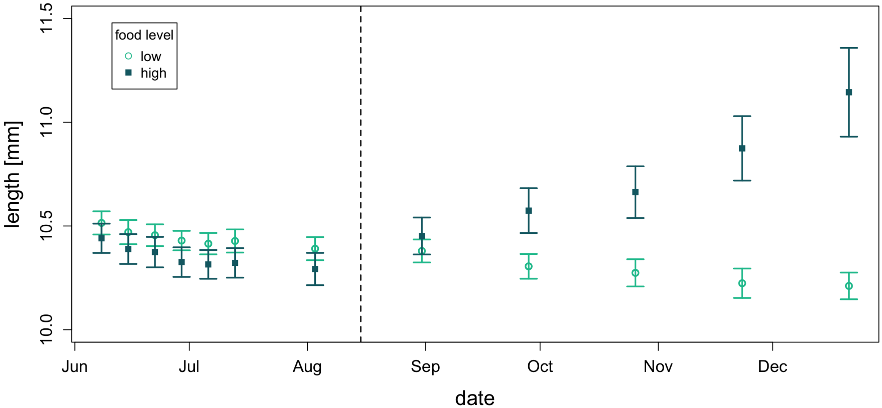
Treatments:

- ~~calcein, low food,~~
- ~~calcein, high food,~~
- no calcein, low food,
- no calcein, high food

- each treatment has 9 replicate tanks, each tank has three mussels.
- I averaged mussels within each tank and then averaged tanks within each treatment. calculated their std and standard error

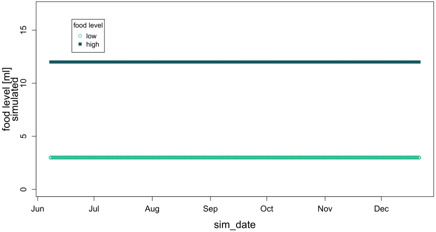
lab experiment

- Food : 0.1% RotiGrow brand Nanno solution every MWF
- low food level : 3 ml solution every MWF
- high food level: 12 ml solution every MWF
- left side of dash line: 5 °C, right side: 12.5 °C

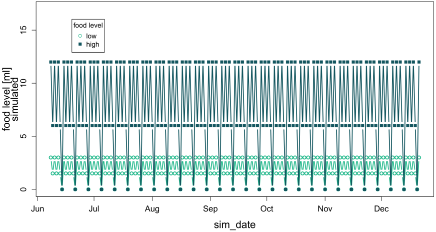


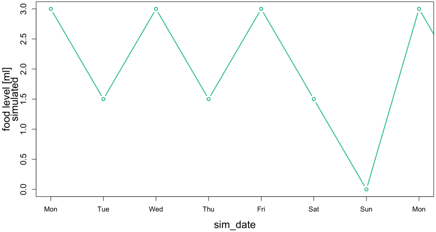
interpreted conditions

constant food level?



time-varing food level? (assume added food are consumed in 2 days)





food being consumed at 1.5 or 6 ml/day?

interpreted conditions

product website:

`https://reedmariculture.com/products/rotigrow-nanno`

dry biomass: 180 g/L

COMPOSITION OF DRY ALGAL BIOMASS	
PROTEIN	< 59.6%
LIPID	< 14.8%
EPA (% OF LIPIDS)	27.3%
ARA (% OF LIPIDS)	3.5%
CARBOHYDRATE	< 18.0%
ASH	< 5.5%

translate food to gC

combustion experiment by Ashley states 108 gC/l for the product

translate food to joule (1)

TABLE 1. Biomass Fractions

fraction	molar mass (g·mol-1)	net calorific value (MJ·kg^{-1})
protein $C_{4.43}H_7O_{1.44}N_{1.16}$	100.1	15.5
carbohydrate $C_6H_{12}O_6$	180	13
lipid $C_{40}H_{74}O_5$	634	38.3

COMPOSITION OF DRY ALGAL BIOMASS	
PROTEIN	< 59.6%
LIPID	< 14.8%
EPA (% OF LIPIDS)	27.3%
ARA (% OF LIPIDS)	3.5%
CARBOHYDRATE	< 18.0%
ASH	< 5.5%

$$
\begin{aligned}
energy = biomass * (f_{protein} * e_{protein} + \\
f_{lipid} * e_{lipid} + \\
f_{carbohydrate} * e_{carbohydrate}) \\
= 3104.35\ [J/ml] \quad (1)
\end{aligned}
$$

Cooperative Institute for Great Lakes Research
CIGLR
Great Lakes Science for Society

The amount of carbon calculated by this method is different from combustion method.

$$
\begin{aligned}
Carbon = biomass * (f_{protein} * c_{protein} + \\
f_{lipid} * c_{lipid} + \\
f_{carbohydrate} * c_{carbohydrate}) \\
= 90\ [gC/L] \quad (2)
\end{aligned}
$$

Cooperative Institute for Great Lakes Research CIGLR Great Lakes Science for Society

translate food to joule (2)

Chen, W.-H., Lin, B.-J., Huang, M.-Y., Chang, J.-S., 2015. Thermochemical conversion of microalgal biomass into biofuels: A review. Bioresource Technology 184, 314–327. https://doi.org/10.1016/j.biortech.2014.11.050

Table 1
A list of elemental and composition analyses as well as higher heating values of microalgae.

Materials	Elemental analysis (wt%)					Composition (dry-ash-free, wt%)				HHV (MJ kg^{-1})	References
	C	H	N	O	S	Protein	Lipid	Carbohydrate	Others[c]		
Chlorella	50.20	7.25	9.30	33.2						21.20	Babich et al. (2011)
Chlorella vulgaris[a]	45.80	5.60	4.60	38.70		29.00	49.50	19.70	1.8	18.40	Xu et al. (2011)
Chlorella vulgaris[b]	53.8	7.72	1.1	37.0		6.00	43.00	51.00	0	24.00	Xu et al. (2011)
Chlorella vulgaris	42.51	6.77	6.64	27.95		41.51	15.67	20.99	21.83	16.80	Wang et al. (2013)
Chlorella vulgaris	43.90	6.20	6.70	43.30		54.90	15.50		29.6	18.00	Kebelmann et al. (2013)
Chlorella vulgaris residue	45.04	6.88	9.79	29.42		61.24	5.71	20.34	12.71	19.44	Wang et al. (2013)
Chlorella sorokiniana CY1 residue						18.81	9.9	35.67	35.62	20.24	Chen et al. (2014b)
Chlamydomonas sp. JSC4 residue						12.18	6.85	35.7	45.27	17.41	Chen et al. (2014b)
Chlamydomonas reinhardtii (wild)	52.00	7.40	10.70	29.80		47.40	18.10		34.5	23.00	Kebelmann et al. (2013)
Chlamydomonas reinhardtii CW15+	50.20	7.30	11.10	31.40		45.70	22.40		31.9	22.00	Kebelmann et al. (2013)
Dunaliella tertiolecta	39.00	5.37	1.99	53.2	0.62	61.32	2.87	21.69	14.12	14.24	Zou et al. (2010)
Hapalosiphon sp.	47.94	7.44	6.45	37.58	0.58					14.75[d]	Liu et al. (2012)
Nannocloropsis oculata	39.90	5.50	6.20			39.00	20.00	17.00	24	16.80	Du et al. (2012)
Nannochloropsis oceanica	50.06	7.46	7.54	34.47	0.47	19.1	24.8	22.7	33.4	21.46	Cheng et al. (2014)
Nannochloropsis oceanica residue	45.24	6.55	11.07	36.58	0.56					18.17	Cheng et al. (2014)
Spirulinaplatensis	46.16	7.14	10.56	35.44	0.74	48.36	13.30	30.21	8.13	20.52	Jena and Das (2011)
Spirulinaplatensis	45.70	7.71	11.26	25.69	0.75					20.46	Wu et al. (2012)
Scenedesmus obliquus CNW-N	37.37	5.80	6.82	50.02		30.38	4.66	13.41	51.55	16.10	Chen et al. (2014a)

[a] The standard nutrients condition.
[b] The nutrients starvation condition.
[c] By difference, others (%) = 100 – protein – lipid – carbohydrate.
[d] Lower heating value.

and many other literatures, around 0.72 - 51 MJ/kg fuel

From component estimation, the product has energy density $3104.35k[J/ml]$

From these biofuel estimations, the product used in the experiment has energy density:

$$energy = 180\ [g/L] * 0.72\ [mJ/kg] = 130\ [J/ml] \tag{3}$$

$$energy = 180\ [g/L] * 50\ [mJ/kg] = 9000\ [J/ml] \tag{4}$$

considering energy density 3k J/ml for the product,

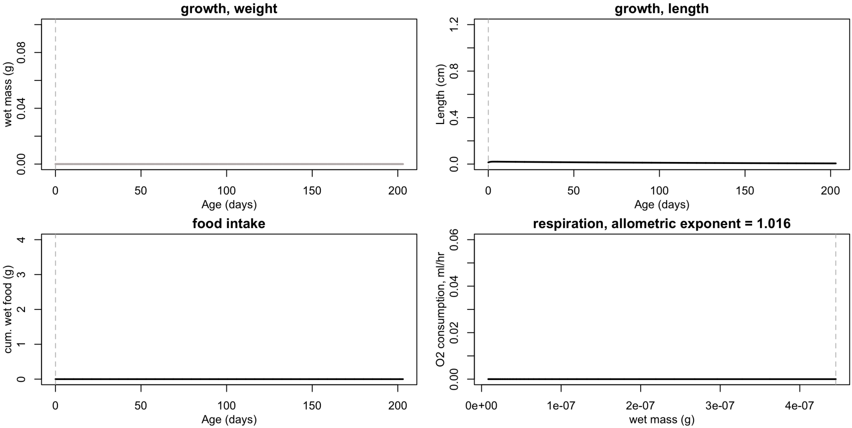
$$
\begin{aligned}
LowFood &= 0.1\% * 3\ ml * 3104\ J/ml & = 9.3\ J/feeding \quad (5)\\
&= 9.3/(\pi * 5^2) & = 0.11 J/cm2 \quad (6)
\end{aligned}
$$

$$
\begin{aligned}
HighFood &= 0.1\% * 12\ ml * 3104\ J/ml & = 37.2\ J/feeding \quad (7)\\
&= 37.2/(\pi * 5^2) & = 0.47 J/cm2 \quad (8)
\end{aligned}
$$

Cooperative Institute for Great Lakes Research
CIGLR
Great Lakes Science for Society

simulation (1), constant low food

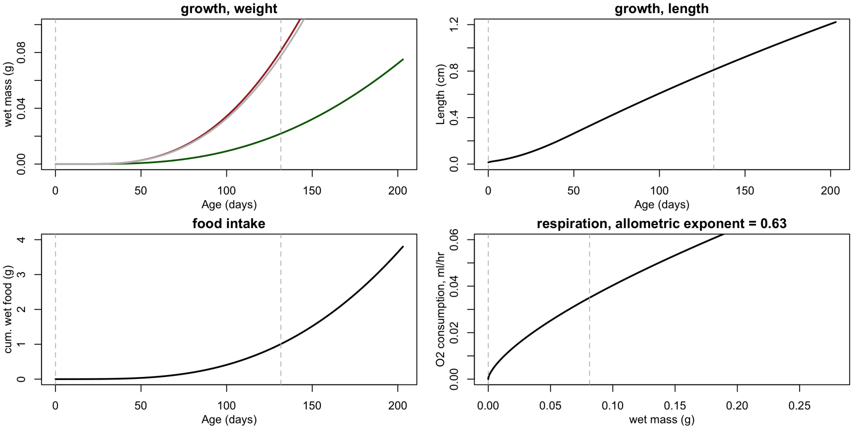
constant food 0.11 J/cm2, constant temp @ 12 °C, initial length 0 mm



Great Lakes Science for Society

simulation (2), constant high food

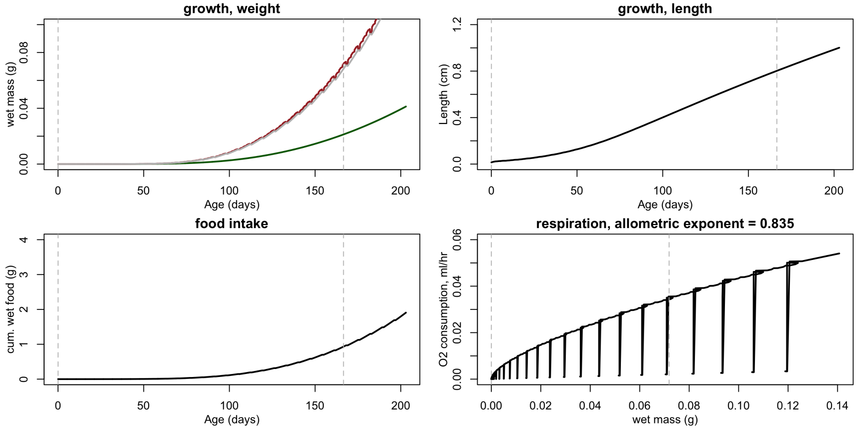
constant food 0.47 J/cm2, constant temp @ 12 °C, initial length 0 mm



CIGLR Great Lakes Science for Society

simulation (3), var high food

varying food level, max 0.47 J/cm2, constant temp @ 12 °C, initial length 0 mm

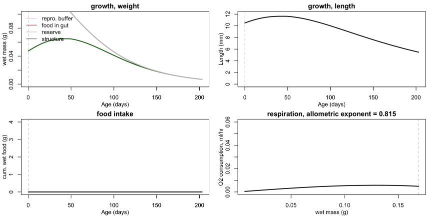


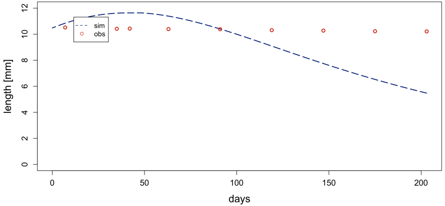
Great Lakes Science for Society

using lower level DEB() function, allow specifying initial length

Different food levels, varing temperature, initial length 10.475 mm. It seems there is no food intake.

I tried: multiply food by 1000, turn off breeding, limit stages to 3, all generated similar results.





- food follows $X/(X+K)$ dynamic, but X is a constant
- maybe the size is too large to be supported by the energy intake?

some food related parameters:

param	val	unit	comments
χ	0.1		digestive efficiency
P	0.5		food to faeces
p.Xm	849.7815	J/cm2/h	surface area-specific feeding rate
p.Am	84	J/cm2/h	surface-area-specific maximum assimilation

Error in eval(substitute(expr), data, enclos = parent.frame()) : object 'dS' not found

Cooperative Institute for Great Lakes Research
CIGLR
Great Lakes Science for Society

next steps

1. look into how the model simulates food intake
2. look into a way to specify food intake directly (according to interpreted exp filtration rate). Suggested by Mark last week.
3. figure out how spawnday, breeding works in the DEB() function
4. figure out how the important parameters are generated for zebra mussels

Cooperative Institute for Great Lakes Research
CIGLR
Great Lakes Science for Society