
ENERGY INVESTMENT IN GROWTH RATE AND REPRODUCTION

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1 **Keywords**

2 allometry; life history; metabolism; productivity; reproduction

3 **Introduction**

4 Recent results from Barneche et al. (2018) have shown that larger fish produce disproportionately
5 more offspring than smaller fish, that is to say reproductive output is hyper-allometric. In other words,
6 a single 2kg fish produces more offspring than two 1kg fish. Currently, many models make the as-
7 sumption that reproduction is isometric with mass, for example Charnov et al. (2001) and West et al.
8 (2001). Additionally, it has been shown that organism resource interactions can also show an allo-
9 metric relationship based on the dimensionality of interactions, where 3D interactions, such as those
10 in many fish, also showed hyper-allometric scaling (Pawar et al., 2012).

11 This project aims to answer the following questions:

12 Can allometry in reproduction be incorporated into existing growth rate models which assume an iso-
13 metric relationship between reproduction and mass? Also, does incorporating this improve accuracy
14 of the model's predictions?

15 Does resource interaction dimensionality indicate allometry in reproductive output?

16 Can a difference in energy investment towards reproduction be seen between organisms with different
17 reproductive strategies, for example r and k selected species?

18 **Methods**

19 The project will use a lifetime reproductive output model to infer how energy allocation to reproduction
20 and growth changes throughout development. Some models will be implemented with some modi-
21 fication so as to take allometric reproduction into account (Charnov et al., 2001, West et al., 2001).
22 Others which already incorporate allometric reproductive output, such as Burger et al. (2019), will
23 be compared to these modified models for comparison. First, parameters will be optimised so as
24 to maximise reproductive output, then the model will be fitted to data in order to compare how "real
25 world" growth compares to the purely theoretical case and what inferences can be made based on
26 the results.

27 The results will then be used to compare the allometry of reproduction with the dimensionality of
28 resource interaction to examine the possibility of a relationship between the two.

29 **Anticipated Outcomes**

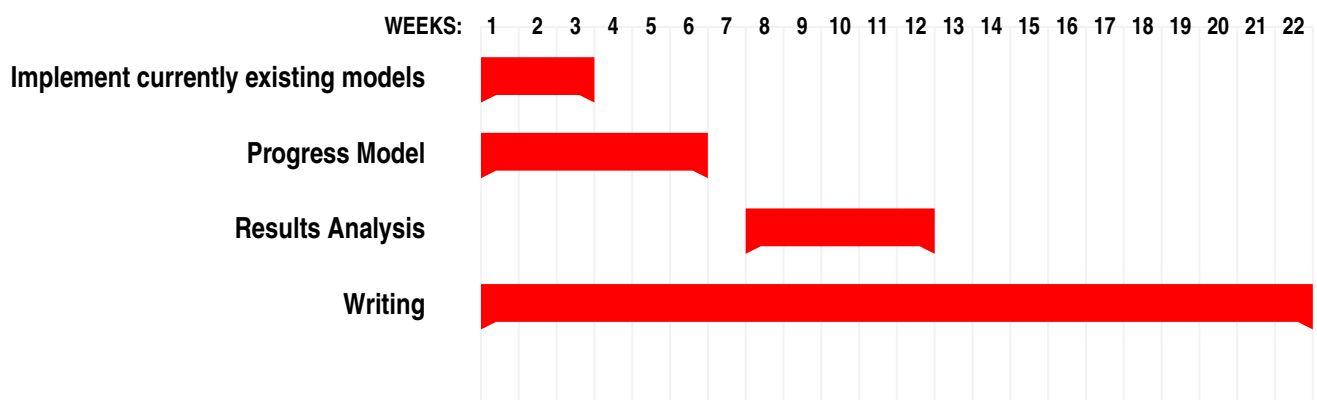
- 30 • Design of a model that can describe the growth of organisms, regardless of whether reproduc-
31 tion is allometric or isometric.
- 32 • To quantify the energy allocation of an organism throughout ontogeny, specifically with regard
33 to growth and reproduction.

- 34 • Determine whether dimensionality of resource interaction may be an indicator of the hypo- or
35 hyper-allometry in reproduction.

36 Timeline

April 15th	Implement currently existing models
May 15th	Finish progressing the model / model ready to apply to data
May 15th	Introduction rough draft
May 22nd	Methods rough draft
June 26th	Finish results analysis
July 10th	Results rough draft
August 14th	Hand in full draft to Supervisor
August 27th	Submit thesis

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39 Budget

Category	Item	Cost	Justification
Data Backup and storage			Backup and storage of project data to ensure no lose of time or progress due to data loss
	1TB external Hard drive	£62	
Travel			Travel to the UK once travel restrictions are lifted
	Flight	£100	

40

41 **References**

- 42 Barneche, D. R., Robertson, D. R., White, C. R. and Marshall, D. J. (2018), 'Fish reproductive-energy
43 output increases disproportionately with body size', *Science* **360**(6389), 642–645.
44 **URL:** <https://www.sciencemag.org/lookup/doi/10.1126/science.aao6868>
- 45 Burger, J. R., Hou, C. and Brown, J. H. (2019), 'Toward a metabolic theory of life history', *Proceedings*
46 *of the National Academy of Sciences of the United States of America* **116**(52), 26653–26661.
- 47 Charnov, E. L., Turner, T. F. and Winemiller, K. O. (2001), 'Reproductive constraints and the evolution
48 of life histories with indeterminate growth', *Proceedings of the National Academy of Sciences of*
49 *the United States of America* **98**(16), 9460–9464.
- 50 Pawar, S., Dell, A. I. and Savage, V. M. (2012), 'Dimensionality of consumer search space drives
51 trophic interaction strengths', *Nature* **486**(7404), 485–489.
- 52 West, G. B., Brown, J. H. and Enquist, B. J. (2001), 'A general model for ontogenetic growth', *Nature*
53 **413**(6856), 628–631.