

## ***Interactive comment on “A trait-based modelling approach to planktonic foraminifera ecology” by Maria Grigoratou et al.***

**Ayata (Referee)**

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Received and published: 10 January 2019

Referee comment on the manuscript "A trait-based modelling approach to planktonic foraminifera ecology", by Maria Grigoratou and colleagues.

Referee: Sakina-Dorothee Ayata (Sorbonne Université, Laboratoire d'Océanographie de Villefranche sur mer, France).

### **1) General comments**

This article presents a new trait-based model for planktonic non-spinose foraminifera in order to test several trade-offs among foraminifera feeding, growth and survival, and more specifically among size, trophic regime, feeding behaviour, predation avoidance,

C1

and shell calcification.

The introduction is easy to follow and presents clearly all the needed information on planktonic foraminifera. However, the sentences on trait-based approaches could be rewritten to avoid some fuzziness in the presentation of the concept of trait. For instance, traits are defined at the individual level (see the recent review by Kiorboe, Visser Andersen, 2018, A trait-based approach to ocean ecology. ICES Journal of Marine Science (2018), doi:10.1093/icesjms/fsy090). The context of the study is clearly stated (model for foraminifera growth) and the study is well justified (need of a trait-based generic model, using body size, calcification, and feeding behaviour).

In the method section, the authors present the trait-based model of planktonic non-spinose foraminifera growth (including two life stages: prolocular and adult) they have developed in order to investigate the cost and benefits (trade-offs) of calcification and feeding behaviours under different environmental conditions (temperature and nutrient concentration).

The model set up adopted in the study is original and provides very interesting results.

The discussion is clear and relatively short, but the authors suggest several hypotheses to explain their results (observed trade-offs among calcification and growth) and the adequate literature is cited. Out of curiosity, I am wondering what type of trade-offs could exist in spinose foraminifera species.

The conclusion is clear and concise.

Therefore I recommend minor revisions before publication. Indeed, the presentation of the manuscript should be improved in order to present the model more clearly (see comments below).

### **Review items**

C2

1. Does the paper address relevant scientific questions within the scope of BG?  
Yes.
2. Does the paper present novel concepts, ideas, tools, or data?  
Yes (novel model).
3. Are substantial conclusions reached?  
Yes.
4. Are the scientific methods and assumptions valid and clearly outlined?  
The methods used should be outlined more clearly. See bellow.
5. Are the results sufficient to support the interpretations and conclusions?  
Yes.
6. Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?  
The code of the model is freely available.
7. Do the authors give proper credit to related work and clearly indicate their own new/original contribution?  
Yes.  
Minor comments: A recent review by Kiorboe et al 2018 on trait-based marine ecology could be added and the legend of Figure 1 should cite Litchman et al. 2013.
8. Does the title clearly reflect the contents of the paper?  
Yes.

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9. Does the abstract provide a concise and complete summary?  
Yes.
10. Is the overall presentation well structured and clear?  
Yes, it is well structured, but the clarity could be improved (again, see bellow).
11. Is the language fluent and precise?  
Yes, although proof editing could prove useful.
12. Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?  
Not clear enough in the present version.
13. Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?  
Yes, clarifications are needed in the methods sections, in Table 3, and in the captions of the Figures. See bellow.
14. Are the number and quality of references appropriate?  
Yes.
15. Is the amount and quality of supplementary material appropriate?  
Yes.

## 2) Specific comments

### 2.1) Remarks on the Model:

C4

I have several comments on the way the equations are indicated. Indeed, this section was difficult to follow, as many precious information was available in the annex and not in the main text of the manuscript.

I recommend to follow, when possible, writing standards for model equations (e.g., keep capital letters for variables and lower case letters for parameters, use mu for growth rates, etc. See comments below). The authors should make the equations much more clear, even for modellers, as this sections is difficult to follow.

Note that I appreciate that the code is freely available. I thank the authors for this effort of sharing their work to the scientific community.

### Miscellaneous comments on the model:

I 116: what is a species model?

I 145: 2.1. Model environment => is "environment" the good term?

I 150: why is the duplication rate called kappa? Usually, it is called d or D in chemostat models.

I 146-147: Looking at your equations, it rather seems that nutrient availability is named N on your equations. Accordingly, replace the notation NO3- by N.

I153: each term of Equation 1 needs to be defined: what are  $j_{prey}$ ,  $J$ ,  $B_{N,j}$ ,  $P_{growth,j}$ ? Why  $j_{prey}$  and not  $j_{phyto}$  (indeed, zooplankton can be a prey, but would not do photosynthesis and impact the nutrient concentration)? Why do you use [ and ] in your equation? It seems not useful and hence confusing. Besides, it is usually written "parameter.Variable" in such differential equations: please reverse the writing and indicate:  $p_{growth,j} \cdot B_{N,j}$ . More generally, please distinguish more clearly among parameters (lower case), functions (with brackets indicating their variables), and variables (capital letters).

C5

Clearly indicate in the text that P and G are in fact functions and refer to the annex section.

I 156 to 159: move these sentences after having presented the equations with mortality terms and sloppy feeding terms.

I 163: shouldn't it be  $B_{N,j}$  of  $B_j$  rather than  $B$  in the left side of equation 2? Note that the subscripts N are not useful here, unless you will later use an other currency than N for the biomass? Please rather indicate 3 equations: one for the autotrophic plankton, one for the heterotrophic plankton, and one for the mixotrophic plankton. What is  $b$  in  $\lambda_{ib,j}$ ?

Impact of linear growth (instead of a Michaelis-Menten functional response) on your results? Considering only linear growth is a string assumption and the reasons to do so (and potential consequences) should be clearly indicated.

I 181: from a biological and ecological point of view, what would be a "specialist predator on planktonic foraminifera", as included in your simple food chain model? What would be its characteristics?

I 222: is it realistic to consider that the "protocolar biomass is similar to the adult biomass"? I would have expected to have much more protocolar biomass than adult biomass, especially given their slow growth (but I am not a specialist of foraminifera...)

I 260: Table 3 is difficult to follow as the horizontal and vertical lines are not indicated. Please make it easier to read. For instance, why is there 3 identical rows for Nutrient region? I would assume that you used the 3 different regimes (O, M, E) for each of the Temperature conditions (10, 20, 30), but it is not what I read in Table 3. Similarly, in the part entitled "Study traits", the rows of "Prolocular (20  $\mu$ m)" and "Adult (160  $\mu$ m)" are identical. If this is correct, then please merge them.

### 2.2) Remarks on the Results:

C6

- I find it strange to start this section with Figures that are all in Annex and not in the main text (Figures B1 and B2).

### 2.3) Remarks on the Figures:

Fig. 1: useful, but indicated in the legend that this figure is inspired from the topology of zooplankton traits proposed by Litchman et al 2013 in JPR.

Legend of Figure 3: indicate the name of the parameter  $\sigma$ .

Figures 4 to 7: the symbols for 'plausible' and 'low biomass' are very difficult to distinguish, especially because the stars and triangles are light green on a light grey background. Please modify (and provide figures with a better resolution).

Figure 4 to 7: why not use the same setting as in Figures 8 to 9, with an horizontal arrow indicating the increase in Temperature (please correct the typo: Tempertature), and a vertical arrow indicated the increase in Nutrient concentration (O-M-E) ?

### 3) Technical corrections:

Please find bellow additional minor comments:

- Check and remove double spaces throughout the ms
- Please revise the manuscript to remove all typos, for instance (in the beginning of the manuscript, I have not indicated all of them here):

I 23: extra space (on trait theory)

I 56: change in police size

I 61: no space (canadress)

I 90-91 : change in police size

I 103: " It has been speculated that the higher abundance...": higher than what?

C7

I 125: the subject ("they"?) is missing in "is that are based"

I 139: no comma in "interactions of planktonic foraminifera, with..."

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Interactive comment on Biogeosciences Discuss., <https://doi.org/10.5194/bg-2018-483>, 2018.