

13 February 2020

Dear Dr. Alyssa Findlay:

We are here submitting a revised version of our manuscript “Disconnects between underlying ecological theory and data in phenological mismatch research”for consideration as a Review Article in *Nature Climate Change*. We thank the two reviewers for their insightful and constructive comments that have helped make this a much stronger paper. A detailed account of our responses can be found below.

Both reviewers concluded that our manuscript provides a valuable contribution to the field. However, they both had some suggestions to further clarify the text and improve the presentation of our framework. We have now addressed these comments by revising the text, figure 1 and the figure in box 2 for greater clarity.

We hope you and the reviewers will find it suitable for publication. We look forward to hearing your assessment.

Sincerely,



Heather Kharouba (First author)

Reviewer Comments:   
  
**Reviewer #1 (Remarks to the Author):**  
  
I have re-read the manuscript by Kharouba and Wolkowich. I am still supportive of this manuscript as a valuable contribution to the field. I think the ms has been much improved in this round of reviewing. I found some minor issues only, but think the authors should go through the whole text carefully and check for any possible mistakes and remove any potential sources for misunderstandings.

***\* Our response:*** *We thank the reviewer for their support and positive response to the latest version of the manuscript. We address the reviewer’s specific concerns below and have also closely reviewed the full manuscript again for clarity and consistent terms, logic etc.*  
  
L39-40 Sentence seems to need editing. ‘Cushing match-mismatch’ -> ‘Cushing match-mismatch hypothesis/principle’. This would be in line with what you write later, and I would not regard this (relatively simple) hypothesis as a theory. Rather, theory could be based on the Cushing match-mismatch (henceforth CMM) hypothesis.

***\* Our response:*** *We have now added ‘hypothesis’ and removed theory from this sentence (lines 39-40) and other places (line 85; line 116).*

L83-84. This phrase ‘most common’’ is a repeat from the intro (+ abstract), plus you introduce unnecessary vagueness here by again alternating between calling CMM theory and hypothesis.

***\* Our response:*** *We thank the reviewer for catching this repetition in our language. We have edited this sentence and removed ‘theory’ on lines 85-86.*  
  
L103-104. If neither of these assumptions is met, then fitness consequences due to changes in the relative timing of the interaction will be either weak or non-existent.

***\* Our response:*** We are not completely clear on the reviewer’s concerns regarding this sentence, but we do see how it could be clearer and exact, thus we have changed it to: “If these assumptions are not met, then the Cushing hypothesis does not apply, and thus makes no predictions about fitness and relative timing.” (lines 104-105).

L441 ‘Research outside of the Cushing hypothesis’ is not a logical title (99.99% of all research is ‘outside’); the research you discuss here is quite related to match/mismatch, so try to find a more fitting title.

***\* Our response:*** *We thank the reviewer for this suggestion and have now changed it to “Testing alternative hypotheses” on line 441.*

L474-476 I suggest you change from ‘a model’/’the model’ to ‘modeling’ or so more in general. Trying to include all relevant processes of all possible systems involving phenological mismatch into a single modeling framework is likely to become very ‘clunky’ and not so useful as you always have a trade-off between predictive power and number of parameters you include. But development of common frameworks would be positive as it helps synthesize across systems.

***\* Our response:*** *We thank the reviewer for this comment. We have changed ‘a model’/’the model’ to ‘modeling’ on line 474 and ‘models’ on line 476.*  
  
Figure 1  
  
The meaning of the curves are unclear. The solid line presumably does not mean abundance but ‘energetic demand’ or something like that: I presume the abundance of adult birds (which you illustrate) remains fairly constant over the time period. Abundance may be more appropriate if you would instead illustrate zooplankton eating phytoplankton. In that case, however, it becomes unclear what ‘total fitness’ means in Figure 1d. It cannot be individual fitness because some individuals even in Fig. 1b are clearly active before as well as after peak resource abundance.

***\* Our response:*** *We thank the reviewer for highlighting this confusion. We have changed the y-axis in figure 1a-c to indicate ‘consumer energetic demand’ and ‘resource availability’.*  
  
L863 ‘the gray areas represent the temporal overlap’. This cannot be true. If you would increase the resource abundance, without shifting the peaks, the gray areas would be enlarged, without this involving any phenological shifts. Temporal overlap is thus misleading. These ‘areas of overlap’ graphs look good and are common in phenology concept theory but are rarely well defined. Please don’t add to that, in my mind, very confusing habit. If you redefine the solid line as ‘energetic demand’ there might be an interpretation of the shaded area though: ‘the demand which is met by the supply’, but you probably have to find a better word for it. Or simply don’t shade the areas gray and avoid this problem altogether.

***\* Our response:*** *We thank the reviewer for raising this issue that we had overlooked. We have removed the shaded areas.*  
  
Figure 3. ‘size mediated priority effect’ should have a capital S.

***\* Our response:*** *We assume the reviewer is referring to Figure 2 and have capitalized ‘size’.*

I am not native English speaker, but the following sentences seem to need language improvement:

L89 ‘We follow others, ‘ sounds strange.

***\* Our response:*** *We have changed this sentence to “We assume that Cushing’s19 use of the term ‘mismatch’ is focused on the ‘match’ having the highest fitness (i.e., consumer fitness is maximized at phenological synchrony, an assumption in line with previous literature, see 13,22,25); therefore…” (line 90-92).*

L100, L108. Controller on or controller of?

***\* Our response:*** *We have changed ‘controller on’ to ‘controller of’ on line 101 and line 868.*

L112-114 Only one sentence in the paragraph. Merge.

***\* Our response:*** *We have merged the sentence with the previous paragraph (lines 112-114).*

L197 Unclear what ‘such data’ is. Seems like this links to the previous sentence, although it is a new paragraph and a new section in between.

***\* Our response:*** *We have made this phrase more specific, so that it refers to the data required to provide strong tests of the Cushing hypothesis (line 200).*

L209 Part of these discrepancies may->these discrepancies may partly?

***\* Our response:*** *As suggested by the reviewer, we have changed ‘part of these discrepancies’ to ‘these discrepancies may partly’ on line 212.*

L214 ‘when populations turn over too quickly to track individuals,’ sounds like the organisms are too fast and that organisms track individuals. But surely it is the researchers who attempt to track them. I suggest rephrase.

***\* Our response:*** *Good catch. We have updated this phrase to be ‘When populations turn over too quickly, it can be difficult to track individuals, so consequently, …’ (lines 217-218).*  
  
L812-813. ‘for a single system’ is vague here, some context seems warranted.

***\* Our response:*** *To add some context, we have specified that we mean a pair-wise interaction here (line 815-816).*

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Reviewer #2 (Remarks to the Author):  
  
This is my second time reviewing the manuscript from Kharouba & Wolkovich. I thought it was a strong manuscript in the previous round of reviews, and continue to find that it is a timely and thoughtful contribution to the literature. My previous major comment concerned the broadness of the introduction. The authors have tightened up their language in the introduction, and are now much more specific, which I appreciate. I have only one further clarification. In the section ‘Disconnect between theory and empirical studies’ (starting line 116), the authors make several references to testing the Cushing hypothesis from the perspective of life history theory and food web theory (lines 138-147, 174-180). Although they define those theories broadly in Box 1, it remains unclear exactly what types of studies fall into these two categories. How are they distinguished? I think this could be addressed with an example from each.

***\* Our response:*** *We thank the reviewer for their positive feedback.**We have added more detail about how we defined these types of studies in our literature search to Box 1 and the main text on lines 138-139 and lines 147-149. Specifically that, in our literature search, we define life history studies as those that collected data at the individual level, and food web studies as those that collected data at the population or community (i.e., across species) level. We have also added an example of a study for each type.*

Overall, I believe this is an important manuscript that provides novel insight into an ongoing theoretical and empirical challenge for climate change science (predicting phenological mismatch). Further, the authors use this insight from a systematic review to give concrete suggestions for how to more rigorously assess phenological mismatch going forward.  
  
Other minor comments:   
  
I find the manuscript overall to be very well written. However, I still find the first paragraph of the introduction difficult to follow. The use of multiple parentheses and em dashes decreases readability, but this shouldn’t be difficult to fix.

***\* Our response:*** *To improve readability, we have eliminated a few parentheses and em dashes (lines 51-56).*  
  
The figure in Box 2 may not be color-blind friendly, if only using red and green to distinguish points. I would suggest changing the colors or using different shapes.

***\* Our response:*** *Thanks for the suggestion to improve the figure in Box 2. We have added shapes to further distinguish the two groups.*