

## Rebuttal letter for “Anywhere but here: local conditions alone drive dispersal in *Daphnia*”

We would like to thank the reviewers for their thoughtful feedback and comments. We believe their suggestions have improved the manuscript immeasurably. For clarity, each of our responses is listed beneath a characterisation of the comment, rather than a direct quote from the review. Our responses were based on the reviews themselves however, rather than the characterisations given here.

### Reviewer 1:

- Line by line suggestions.
  - All adopted with no exceptions.
- Table typographical error.
  - Corrected.
- Figures could be formatted more clearly according to the following guidelines.
  - Figure 1 has been altered in accordance with the recommendation insofar as our plotting software allows us to do so (ggplot2 for R). Figure 2 has been left as is, since using the approach that would be necessary with ggplot2 (faceting, as in figure 1) would unfortunately prevent us from labelling which groups are significantly different in a clear manner.
- How were the standard errors in figure 2 derived? And did you count once or multiple times?
  - The standard errors shown on the figure are for each container replicate’s proportion of dispersers. They were calculated according to a formula that is typical for calculating the standard error of a binomial proportion. This formula has now been added to the caption of figure 2. Counts were performed once per day exhaustively by eye, and this how now been specified in the methods.
- Can you present some statistics that make the ANOVA assumption check explicit?
  - We have now amended the methods to state how we checked normality and homogeneity of variances, and reported the test statistics associated with our checks.
- Do patch conditions in linked containers equalise over time?
  - Although we didn’t collect any specific data on how much algae was entering the inter-patch tunnel nor the other patch, it was clear from observation that algae fed into one patch did not visibly reach the other patch. Our algae species is non-motile (now noted in the methods) and always settled between feedings, so we judged that differences in patch condition were maintained between linked patches on different feeding regimes. This is also likely to be the case because there was no flow of liquid between linked patches that could have helped to transfer algae.
- Could an interaction between density and resource shortage have been affecting your results?
  - As reviewer 1 remarks, since we didn’t control for density, it remains possible that there could have also been a separate effect of density, as well as an interaction between density and our resource availability treatments. To more closely examine this, we have now produced a supplementary figure that shows density versus the proportion of dispersers based on whether patch 1 was fed or not. We have expanded our density discussion paragraph to

interpret this figure; it appears that density may have had an effect, although it was small in comparison with resource availability.

- Some elaboration of consequences and implications might help.
  - To expand upon the consequences and implications of our research, we have now added a discussion paragraph that raises some cautionary points concerning the use of our results and those from similar experiments to parameterise dispersal models. Also see “relaxing the assumption” response below.
- Some examples when making literature statements might help.
  - See response to a similar comment by reviewer 2 below.
- Can you discuss the implications of “relaxing the assumption that dispersal is unchanging” in more detail?
  - We have elaborated on the two specific examples we cited in our concluding paragraph to demonstrate how moving from the assumption of fixed to conditionally-dependent dispersal may alter predicted evolutionary/ecological outcomes, as well as introduced its implications for metacommunity stability. We have also drawn attention back to some of the potential outcomes that were mentioned in our introduction.

#### Reviewer 2:

- There are a number of sentences that are too long. “And” is overused.
  - We’ve divided up or shortened the particular sentences pointed out by the reviewer. We’ve also shortened a number of other sentences.
- Is it possible that this is not representative of the entire species?
  - Yes. We now specifically highlight that fact in the discussion.
- How likely is it that the *Daphnia* weren’t aware of the tunnel opening?
  - In our estimation unlikely, since a large proportion of individuals were able to find and use the tunnel in particular treatments. *Daphnia carinata* are highly active swimmers and most individuals repeatedly encounter the opening each day. Still, as the reviewer suggests, it is possible that individuals who would have otherwise dispersed did not because they couldn’t find the opening, which may have depressed overall dispersal rates. A line acknowledging this idea has been added to the discussion paragraph on the experimental set-up/environment.
- How was the tunnel length selected? Is it long or short for *Daphnia*?
  - The equipment set-up that we use was primarily designed for undertaking experimental invasions with *Daphnia* as a model organism. As such, the lengths between patches were set to accord with the above goal, rather than with recourse to specific questions about *Daphnia* dispersal distances in natural settings. Admittedly this may limit the applicability of our findings, which we now highlight in the discussion paragraph on experimental set-ups. We don’t consider the tunnel’s length to be long for *Daphnia*, since an individual could easily traverse such a distance in less than a minute if travelling in a straight line. We now include a reference in support of the above statement for readers that may not be familiar with the speeds at which *Daphnia* can move.
- What of somatic fitness and reproductive fitness?
  - Unfortunately we have been unable to locate the reference (“Byrne et al. 2018”) suggested by the reviewer, nor other references concerned with the distinction between somatic and reproductive fitness in an ecological context.

Since we see our manuscript as being concerned with the extent to which organisms use local and non-local information on resources to inform dispersal decisions, we feel that considering other factors that motivate dispersal is largely outside of our remit. However, it may be that we have missed the reviewer's point here as we haven't seen the reference.

- Can you draw out species and examples in the introduction?
  - In the introduction, we now relate the species that feature in a number of our citations and provide some examples. We also now highlight the variety of taxa that were shown by Fronhofer et al. 2018 to use resource availability and predator presence to inform their dispersal decisions.
- Line by line suggestions.
  - All accepted, with the following exceptions and notable cases:
    - L125. We've opted to remove the specific number of animals that was given here, as the purpose of the line was rather to explain that our populations contained individuals of a variety of age/sizes when dispersal began, and not to provide specific results that are already contained within figure 1.
    - L153. Most of our discussed results are of our counts that were taken 96 hours after dispersal commenced. As such, we have changed "at" to "after" rather than followed the specific suggestion of the reviewer.
    - L163ff. We believe that food availability in patch 2 did not have much of an effect on growth/die-off in patch 2 for a number of reasons that we now include in our discussion. Briefly stated here, they are: (1) individuals reaching patch 2 were overwhelming juveniles (shown in the newly added Figure A2), which were incapable of reproducing whether patch 2 was provisioned or not; (2) individuals reaching patch 2 had to be healthy enough to successfully disperse, and so were less likely to die-off even when patch 2 was not provisioned; (3) dispersers had only been in patch 2 for between 1—4 days, so detectable differences in die-off and population growth in patch 2 may not have had time to manifest yet.
    - L175: With the exception of Martorell and Martínez-López 2014 (the focal species of which is now communicated in our introduction), we have deliberately avoided listing specific species from either Bowler and Benton 2005 or Fronhofer et al. 2018. This is because both papers deal with many species, as the former is a review with 5 species in the food availability section, and the latter a distributed "metaexperiment" that examined 21 species. Thus, rather than exhaustively list all 26 species, we instead opted for the general statement that "Studies on taxa ranging from plants to invertebrates and vertebrates either imply, or experimentally demonstrate, that resource shortage is a powerful piece of information motivating dispersal", which we believe summarises the most salient aspect of the references. As highlighted below, we also now expand upon our discussion of Fronhofer et al. 2018 in the introduction to make sure that readers have a better impression of the reference if they are not familiar with it.
    - L178: As mentioned above, in our introduction we now expand upon the landmark study by Fronhofer et al. (2018) in which it was shown that local resource levels were a powerful motivator of dispersal in all 21 species that the authors examined, which spanned taxa as diverse as

protists, slugs, crustaceans, crickets, newts, and fish (amongst others). We now also refer back to this study more obviously in our discussion to support our assumption that it's likely that similar behaviours would be seen in other species of *Daphnia*.

- L179ff: As discussed in relation to a similar query about the effects of density on our results by reviewer 1, we have now extended our results and discussion to include the role that density may have played in shaping the dispersal we observed. We now communicate this potential role in our abstract. Since we did not specifically control for density in our experimental design however, we believe that our experiment only makes a minor contribution to the question of density and dispersal, and so don't believe that it is necessary to represent it as a major aim of the experiment in our introduction.
- L206ff: As stated in response to reviewer 1, there was no substantial flow between our linked patches. *Daphnia* occupy still water environments, and so this particular aspect of the experiment accords with their natural habitat. However, as detailed in our discussion of the tunnel length above, we now have a paragraph in the discussion that acknowledges the potential limitations of extrapolating our results to natural environments.

### Reviewer 3:

- You should cite (or perhaps cite more) Fronhofer et al. 2018.
  - We now cite the published version of this reference, rather than the preprint. The published version, released just last month, had not come out when we were first drafting the manuscript. We also take additional time to explain the scope and significance of the paper in the introduction.
- Figure 2 seems to present very similar data to figure 1.
  - Since we dealt with the proportion and absolute counts of dispersers separately, we felt that having one figure for each was necessary. Figure 2 also has the additional advantage of displaying the variation seen both across and within (from the standpoint of a binomial proportion) our container pair replicates.
- Figure 1 should not be formatted as a histogram (to be reserved as count data) but rather as a mean +/- CI (or other measure of variation, which is currently missing).
  - We believe that there may be some confusion as regards the difference between a bar chart and a histogram here. Our figure is a stacked bar chart (used for depicting counts/frequencies across categorical variables), rather than a histogram (used for depicting the distribution of numerical data across a continuous variable). We have, however, now added error bars to show variance.
- Table results do not specify that they relate to counts at 96 hours.
  - Corrected.
- Table typographical error.
  - Corrected.
- The caption title of table 1 is uninformative.
  - Since the tables are intended to do no more than present statistical test results, we are not sure how to give them more informative titles than they presently have. The captions have been expanded to highlight the significant results however.

- How did you count specifically?
  - We now state in the methods how we conducted our counts (once per day exhaustively by eye).
- What's your justification for the length of the connection?
  - Repeated from our answer to reviewer 2:  
 "The equipment set-up that we use was primarily designed for undertaking experimental invasions with *Daphnia* as a model organism. As such, the lengths between patches were set to accord with the above goal, rather than with recourse to specific questions about *Daphnia* dispersal distances in natural settings. Admittedly this may limit the applicability of our findings, which we now highlight in the discussion paragraph on experimental set-ups. We don't consider the tunnel's length to be long for *Daphnia*, since an individual could easily traverse such a distance in less than a minute if travelling in a straight line. We now include a reference in support of the above statement for readers that may not be familiar with the speeds at which *Daphnia* can move."
- It seems unlikely that *Daphnia* could sense extra-patch conditions. Saying that they might ignore it is not strong enough, as it implies that it is knowable. You should be clear that the absence/ignorance of extra patch information is speculative. Or else use less definite language.
  - It is a fair point that it is possible (and indeed likely) that *Daphnia* were simply incapable of detecting extra-patch conditions (rather than just ignoring extra-patch information). Emphasising that idea was the intention of our original statements towards the start of the discussion that "it appears that *D. carinata* either did not use, or were incapable of using, extra-patch information" and towards the end of the discussion that "[patch 2 information possibly had no effect] because that information was in some way imperceptible or ignored", however we recognise that the language used elsewhere in the manuscript may have been too definite. We have now amended sections of the abstract and discussion to better reflect that it is likely that *Daphnia* are simply incapable of detecting extra-patch conditions. We believe that the title does not overstate our findings since local conditions were indeed found to be alone in affecting dispersal rates in our experiment, presumably due to the likely imperceptible nature of extra patch conditions (which, as stated, we now give additional emphasis in the rest of the manuscript).
- Some discussion about potential differences in the results if other *Daphnia* clones had been tested would be nice, since it's known that there's clonal variation.
  - We have now added a statement at the end of the second discussion paragraph that our results can only strictly be said to apply to a single clone line of a single species. However, we believe that our now expanded introduction and discussion (in particular as regards Fronhofer et al. 2018) helps to more clearly justify our assumption that the phenomenon is likely to be general across *Daphnia* spp.

Thank you,

Philip Erm, Matthew D. Hall, and Ben L. Phillips