Climate change, body size, and phenotype dependent dispersal

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Gardner and colleagues [1] recently reviewed the evidence for shifts in body size as a third major response to climate change, in addition to widely recognized shifts in the ranges and phenology of species [2]. The authors conclude that, although a pattern of declining body size is commonly observed (i.e. [3]), increases in body size might also occur and more detailed studies are needed [1]. Although their review focuses on the evidence for declining body size as a third general response to climate change, we would like to add that the effect of climate on individual body size has the potential to impact one of the other major responses to climate change dramatically: species' range shifts (Figure 1).

Although rarely made explicit, much of the literature makes the implicit assumption that dispersal will facilitate species' range shifts into areas with newly suitable climatic conditions [2,4,5]. However, there is accumulating evidence indicating that dispersal behavior is often phenotype dependent and that body size is a major factor shaping the propensity and ability of individuals to disperse [4,6,7]. Body size is also likely to play an important role in establishment once those individuals that move beyond the prior range borders arrive in new habitats. Incorporating the interactive effects of body size and dispersal will allow a more thorough understanding of the effects of climate change on range shifts, and will improve the ability to predict the effects of climate change on biota.

Although under some conditions the influence of climate change on body size might facilitate species' range shifts, the emerging consensus that warmer climates will result in generally smaller body sizes [1,3] suggests that this effect will often be inhibitory for many species. In either case, effects of climate on body size and dispersal should be incorporated into analyses assessing range shifts and into planning associated with maintaining the capacity of populations to make such range shifts. To date, there are relatively few examples of direct connections between climate change and dispersal behavior, and observed patterns have been mixed (i.e. [8,9] and references therein). Further studies incorporating explicit linkages between climate, body size and dispersal might provide insight into examples in which species either have not shifted their ranges in response to climate change or have shown unexpected shifts (e.g. examples in [10]).

Long-distance dispersers (the 'tail' of the dispersal kernel) are critical in driving range shifts that are rapid

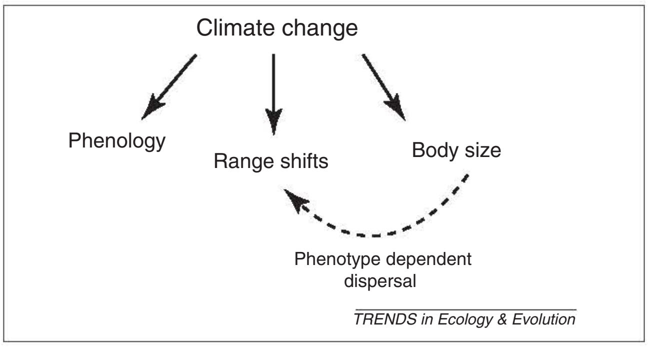

Figure 1. Schematic representation of the direct effects of climate change (solid arrows) and a potential indirect effect of body size on species' range shifts, mediated through phenotype-dependent dispersal (broken arrow).

enough to keep pace with anthropogenically induced climate change. These long-distance dispersers, whose movement behavior differs from most individuals in the population, are likely to be a phenotypically distinct subset of individuals with body sizes that are also outside the central distribution of the population, most commonly larger than the population average [6,7]. These population outliers might be especially sensitive to seemingly small changes in climatic conditions that further reduce their frequency in the population, and the loss of long-distance dispersers could lead to abrupt changes in dispersal dynamics. Under these circumstances, many species ranges might either shift slowly or begin to contract because there are few successful long-distance dispersal events to move the population into newly habitable regions. Technical issues make the study of long-distance dispersal events inherently difficult, but new approaches to following dispersal movements at large spatial scales can facilitate this work [5] and are essential to assessing how phenotype-dependent dispersal can create interactive effects between changes in body size and species' range shifts.

To predict range shifts in response to climate change effectively, there is the need to incorporate emerging knowledge of phenotype-dependent dispersal with a thorough understanding of how temperature affects phenotypic traits relevant to dispersal. We suggest that, in addition to the current focus on the direct effects of climate change on phenology, range shifts and body size, the incorporation of indirect linkages between these outcomes is warranted.

References

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