

lations, where the populations do not evolve vigilance behavior (Wilcoxon rank-sum $p = 0.79$ between group size 5 and 50). Unlike the other treatments, the heterogeneous/semelparous populations actually experience a *decrease* in fitness with increasing group size (Wilcoxon rank-sum $p = 2.77 \times 10^{-6}$ between group size 5 and 50), which suggests that cooperative behavior is not evolutionarily stable in larger heterogeneous groups. Accordingly, these findings highlight the fact that heterogeneous populations are much more susceptible to non-vigilant, “cheating” prey that sweep the population and reduce the overall population fitness.

Optional grouping

So far we have shown that prey appear to take advantage of collective vigilance to increase their fitness when they are forced to group. We might expect from this (and the many eyes hypothesis predicts) that grouping provides a selective advantage. To test this expectation explicitly, we relax the constraints of the previous experiment by allowing the prey to evolve whether to group or not at every simulation time step. Since there is no direct fitness trade-off for grouping in this model yet (as there was for foraging and vigilance), this allows us to study whether the evolutionary advantages of grouping are favorable enough for vigilance and grouping to co-evolve.

Figure 3 shows that when we allow prey to choose to group, we find nearly the same results as before. This suggests that collective vigilance provides enough of a selective advantage to favor the evolution of grouping. It is not surprising that the homogeneous treatments evolve to group nearly 100% of the time, given that the population is genetically identical and any “altruistic” action indirectly benefits the altruist as well. As in the forced grouping experiment, we observe a decline in fitness in the heterogeneous/semelparous populations as group size increases, to the point that the population is nearly driven extinct. The inability of the heterogeneous/semelparous populations to evolve consistently high levels of vigilance further supports the hypothesis that evolution is favoring short-term competitive advantages over long-term survival. This phenomenon is commonly known as the tragedy