Evolutionary advantage of small populations on complex fitness landscapes

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Recent experimental and theoretical studies have shown that small asexual populations evolving on complex fitness landscapes may achieve a higher fitness than large ones due to the increased heterogeneity of adaptive trajectories. Here we introduce a class of haploid three-locus fitness landscapes that allows to investigate this scenario in a precise and quantitative way. Our main result derived analytically shows how the probability of choosing the path of largest initial fitness increase grows with the population size. This makes large populations more likely to get trapped at local fitness peaks and implies an advantage of small populations at intermediate time scales. The range of population sizes where this effect is operative coincides with the onset of clonal interference. Additional studies using ensembles of random fitness landscapes show that the results achieved for a particular choice of three-locus landscape parameters are robust and also persist as the number of loci increases. Our study indicates that an advantage for small populations is likely whenever the fitness landscape contains local maxima. The advantage appears at intermediate time scales, which are long enough for trapping at local fitness maxima to have occurred but too short for peak escape by the creation of multiple mutants.