

1 **Electronic Supplementary Material**

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4 **A heuristic model on the role of plasticity in adaptive**

5 **evolution: plasticity increases adaptation, population**

6 **viability and genetic variation**

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22 **Model details**

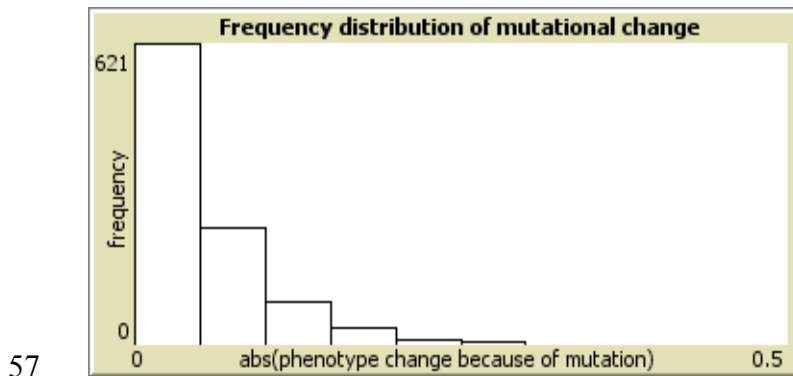
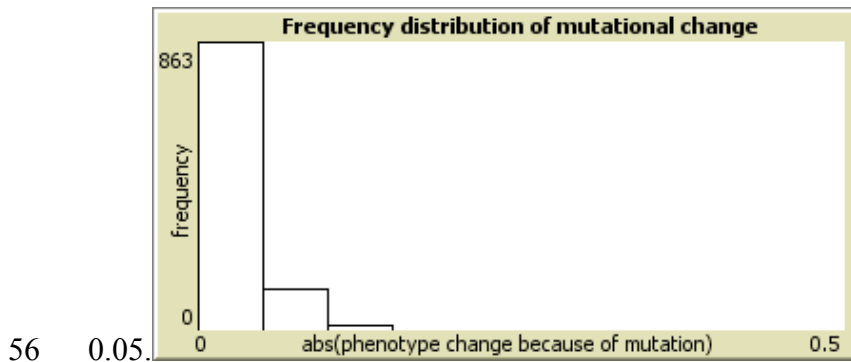
23 — *mean-mutational-change*

24 Mutation rate is often used to describe the probability of change per base-pair per generation,
25 and mutations affecting quantitative trait loci are typically low, ranging from 10^{-9} - 10^{-6} [1, 2].
26 Mutation rate, however, varies widely not only among different organisms [3], but among
27 populations [3], sexes within populations [4] and among genomic regions [5, 6]. Moreover,
28 single nucleotide changes in protein-coding sequences are but one of many possible genetic
29 changes of evolutionary importance, because a large fraction of heritable phenotypic changes
30 can be due to changes in regulatory sequences, epimutations, or even changes in the state of
31 gene networks [7-10]. In fact, whereas phenotypic variants can sometimes be traced back to
32 unique changes in the sequence of protein-coding genes [11, 12], they are often instead
33 mediated by changes in regulatory sequences [13] or epigenetic modifications [8, 14, 15].
34 However, deciding the relative importance of these sources of heritable phenotypic variation
35 to the evolutionary process is well beyond the scope of this study and is not critical for testing
36 our hypotheses.

37 Instead, we have jointly modelled the probability of a genetic change, and its effect
38 size on the phenotype, and we have called it *mean-mutational-change*. In this way, *mean-*
39 *mutational-change* is a parameter used to simulate the magnitude of mutational change on the
40 *genotype* (for *plastics* and *non-plastics*) and on the *plasticity-range* (for *plastics* only). This
41 approach is more inclusive of genetic sources of variation and only assumes that regardless of
42 the nature of the genetic change occurred (single base-pair substitution, recombination,
43 addition/deletion of transcription factors, epimutation, etc), genetic changes causing small
44 phenotypic effects are more likely than genetic changes causing large phenotypic effects. This
45 is in accordance with the literature on quantitative trait loci (QTLs), where a few QTL of large
46 effect and an increasing number of additional modifier QTLs of smaller effects are commonly

47 reported [16, 17]. It is also in accordance with Fisher's geometric model of mutational effect
 48 sizes [18].

49 Consequently, we used a negative exponential function with mean *mean-mutational-*
 50 *change* to describe the probability of occurrence of genetic changes of a certain size. This
 51 distribution captures the idea that larger effects of genetic mutation upon the resulting
 52 phenotype are very rare. This is calculated as $(- \text{mean-mutational-change}) * \ln(x)$, where x is
 53 a floating point pseudorandom number between 0 and 1.
 54 Upper figure shows the resulting histogram for *mean-mutational-change* = 0.025, and lower
 55 figure shows the same for *mean-mutational-change* =



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63 — *plasticity-costs*

64 The evolution of plasticity is thought to be dependent upon costs of plasticity, which could be
 65 of very different nature. The most general notion of costs of plasticity is that of *maintenance*
 66 *costs*, i.e. energetic costs associated to the maintenance of sensorial mechanisms and
 67 regulatory mechanisms enabling the potential for changing the phenotype according to the
 68 perceived environment [19, 20]. In addition to maintenance costs, plastic genotypes are also
 69 expected to incur in *production costs* or costs incurred during the process of phenotypic
 70 change that exceed those experienced by genotypes of fixed phenotypes. In our view these
 71 two are the two most general costs of plasticity that can be expected, and would apply to all
 72 kinds of phenotypic plasticity, regardless of the trait involved, the type(s) of cue(s) triggering
 73 the phenotypic change or the ontogenetic stage of the organism. Discussion of the existence
 74 and relative importance of more particular cases of costs and limits of plasticity can be found
 75 in [19-21]. In our model, we introduced *maintenance* and *production* costs of plasticity. Once
 76 the *phenotype* is developed, individuals have a mortality probability according to their
 77 realized *match* to the environment (see 'die-by-mismatch?' in main text). Costs intervene
 78 because *plastics* have two additional potential mortality causes: costs of maintaining a given
 79 *plasticity-range* and the costs of the *plasticity-used* (see 'die-by-plasticity-costs?' in main text).

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