Supplemental Material (not copyedited or formatted) for: Elizabeth C. Lange, Joseph Travis, Kimberly A. Hughes, Leithen K. M’Gonigle. 2021. "Can You Trust Who You See? The Evolution of Socially Cued Anticipatory Plasticity." The American Naturalist 197(4). DOI: https://doi.org/10.1086/712919.

Online Supplement:

Can you trust who you see?

The evolution of socially cued anticipatory plasticity

The American Naturalist

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Appendix A: Supplementary Figures

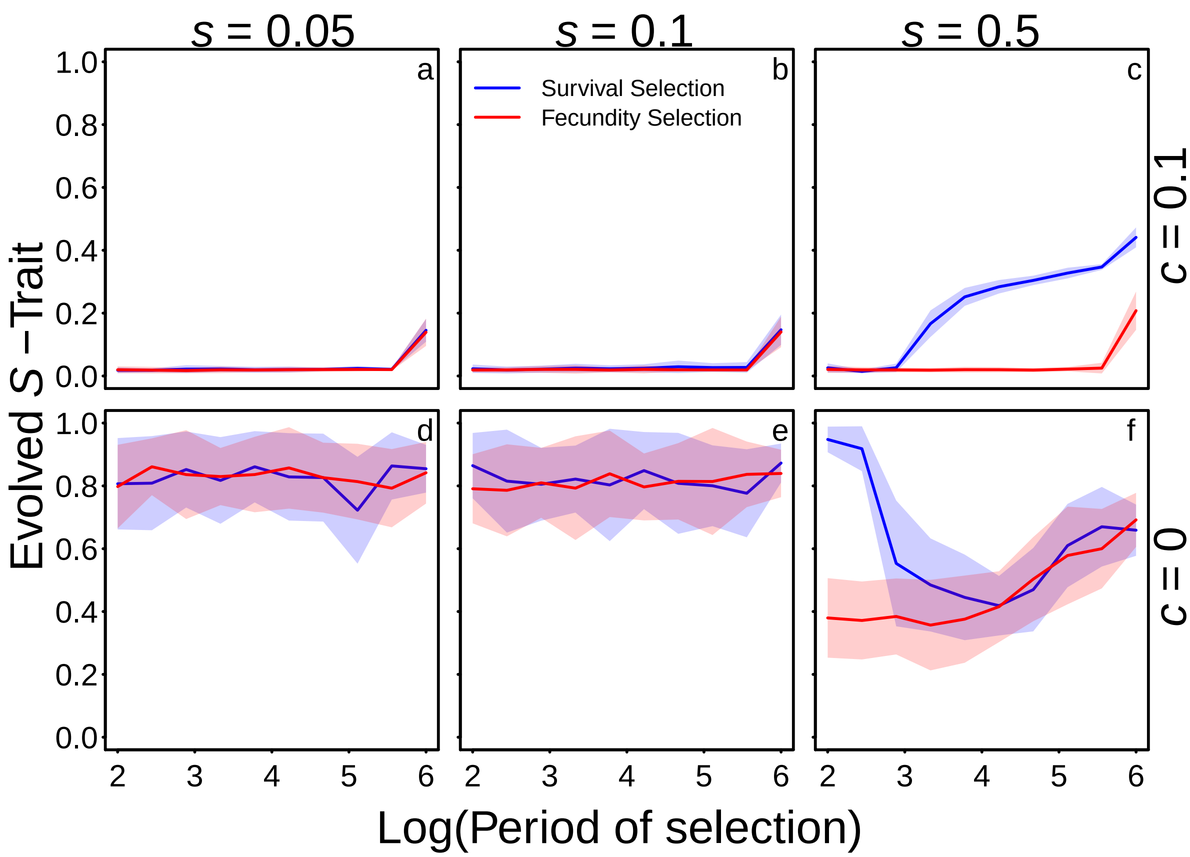

Figure A1: Evolved *S*-trait values after 10^7 days of evolution as a function of the period of environmental change for the survival model (blue) and fecundity model (red) when the initial *S*-trait is equal to 1. See Fig. 2 for description of panels. Other parameter values were as in Figs. 1 and 4.

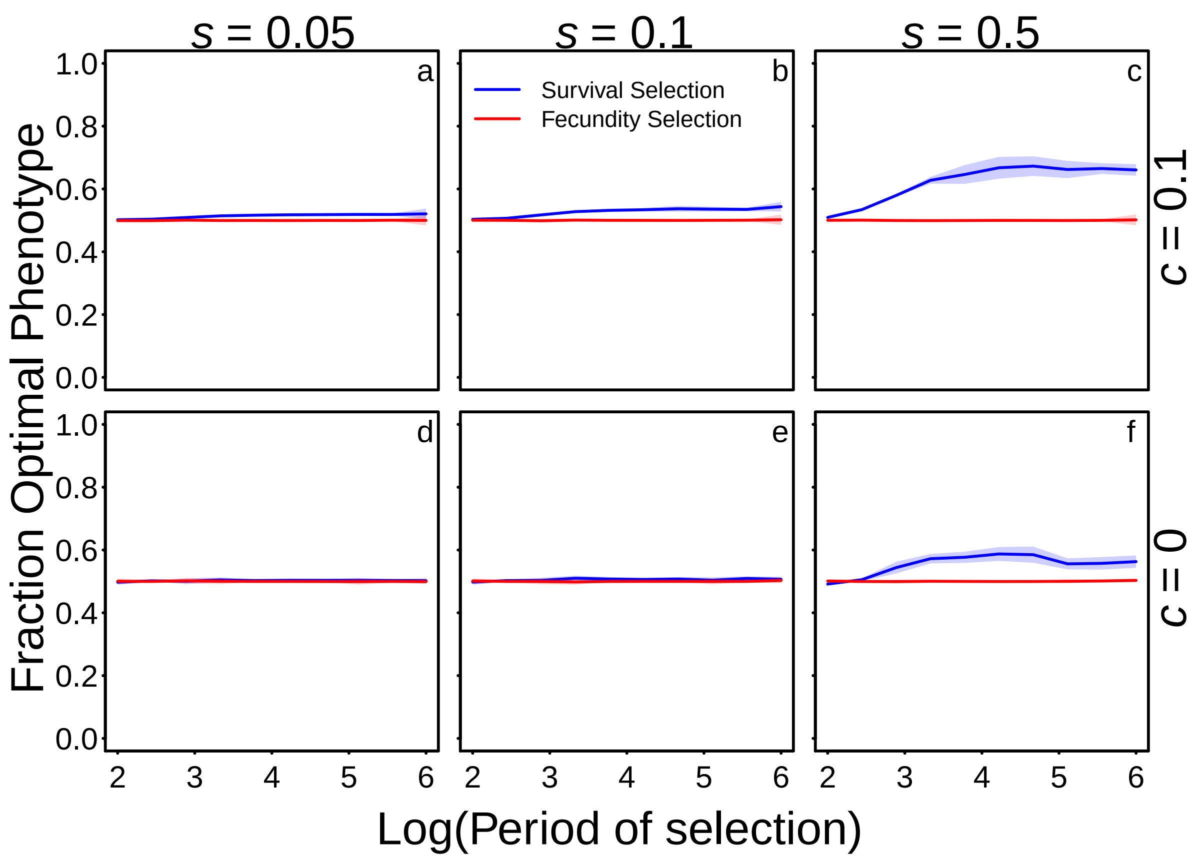

Figure A2: The fraction of the population adopting the favored phenotype as a function of the period of environmental change for the survival model (blue) and fecundity model (red) when the initial *S*-trait is equal to 1. Values for fraction optimal phenotype were calculated as in Fig. 3. See Fig. 2 for description of panels. Other parameter values were as in Figs. 1 and 4.

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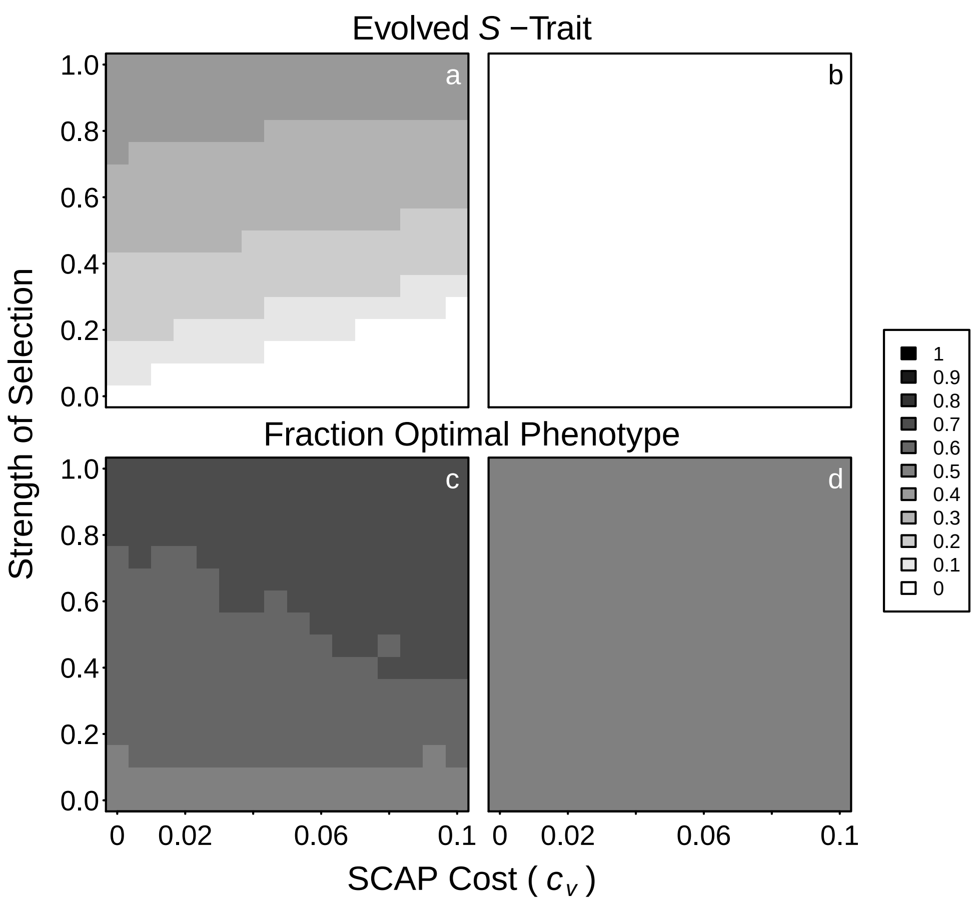

Figure A3: The evolved S-trait value (top row) and fraction of the population adopting the favored phenotype (bottom row) over a range of strengths of selection and costs to plasticity for the survival model (left column) and fecundity model (right column) where the number of individuals that die each day is one ($n_d = 1$). Other parameter values were as in Fig. 5.

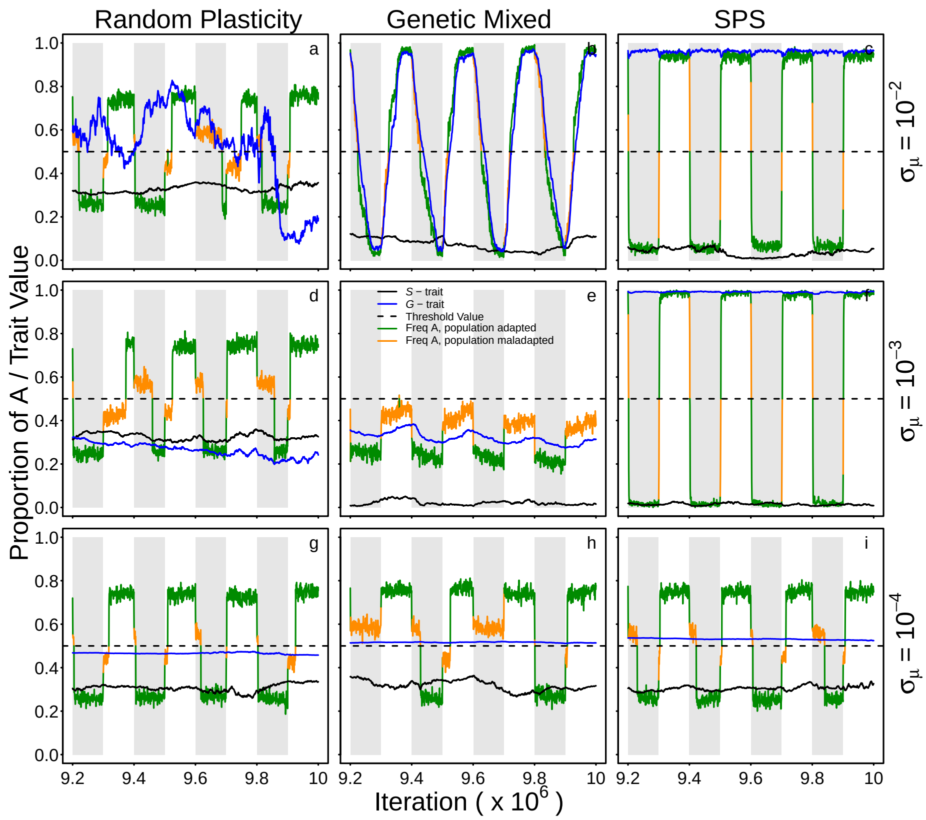

Figure A4: Sample model runs when evolution occurred in a background comprising individuals who initially adopted phenotypes using random plasticity (left column), via the genetic mixed strategy (middle column), or via stochastic phenotype-switching (SPS, right column) for a model where selection acts on survival. Rows correspond to different mutational variances for the G-trait. The colored line shows the fraction of the population expressing the A phenotype (line is colored green when the majority of the population is expressing the favored phenotype and orange when the majority of the population is expressing the non-favored phenotype). The black solid line shows the population average S-trait and the blue line shows the population-average G-trait. White shaded regions indicate when the A phenotype is favored; gray regions indicate when the B phenotype is favored. In each panel, the last $8P$ days are shown for runs that comprise 10^7 days in total. Models were run with $N = 1000$ individuals for $P = 10^5$ days with $c_v = 0.1$ and initial trait values $S_i = 0$ and $G_i = 0.5$. Refer to Table 1 for default parameter values.

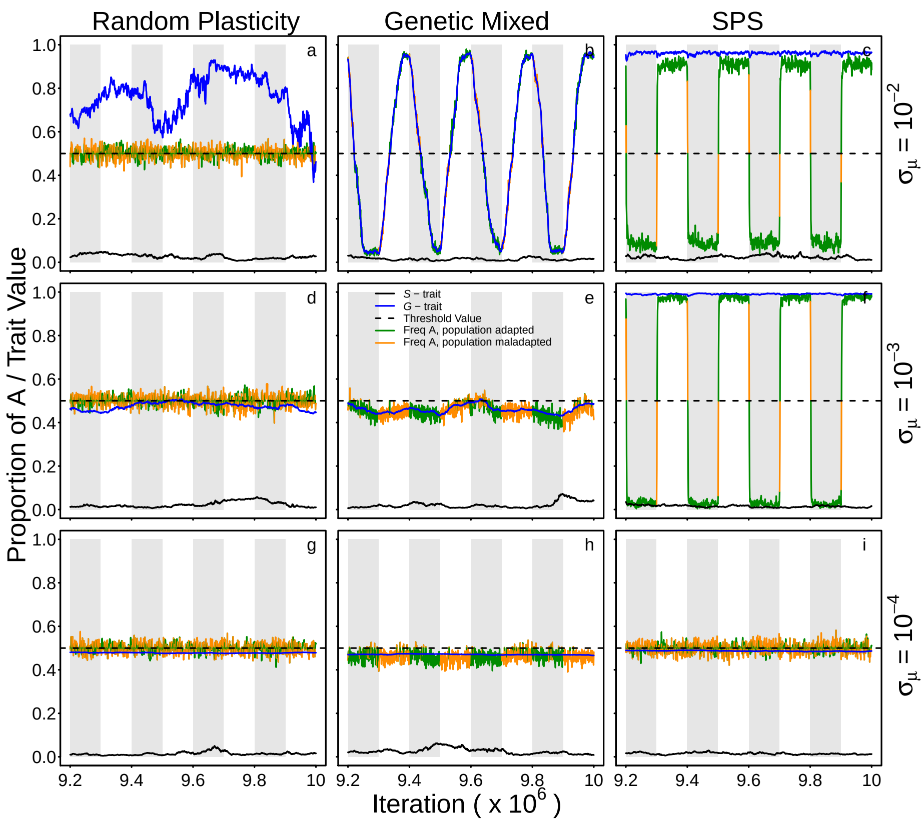

Figure A5: Sample model runs when evolution occurred in a background comprising individuals who initially adopted phenotypes using random plasticity (left column), via the genetic mixed strategy (middle column), or via stochastic phenotype-switching (SPS, right column) for a model where selection acts on fecundity. All parameters are as in Fig. A4, except here there is a fecundity cost associated with plasticity (c_f=0.1), rather than a survival cost. Rows correspond to different mutational variances for the *G*-trait. Other parameter values were as in Fig. A4.

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Appendix B: Asymmetrical Cases

Results

When selection strength is asymmetric (selection favoring *A* over *B* is stronger than selection favoring *B* over *A*), dynamics are qualitatively similar to symmetric selection strength when asymmetry is low (Fig. B1a,d) or intermediate (Fig. B1b,e). Here, phenotypic cycles still occur, which allows socially cued plastic individuals to effectively switch between adapted phenotypes.

When selection on survival is strongly asymmetric, *and the environment changes quickly*, socially cued plasticity evolves to high levels (Fig. B1c), but almost all of the plastic individuals express the same phenotype, regardless of which phenotype is favored. This is because, when the majority of the population use social cues, environmental selection on phenotypes cannot shift the adult composition quickly enough to change the direction of the plastic development responses and, thus, socially cued plasticity is not adaptive (Fig. B1f). In contrast, *when the environment changes slowly*, and strongly asymmetric selection acts on survival, socially cued plasticity evolves (Fig. B1c) and individuals express the optimal phenotype more often than random (Fig. B1f). Because a lower proportion of individuals use social cues to mature, those that do often express the optimal phenotype. However, this requires that *S*-trait values are not too high; once the *S*-trait becomes too high, the population shifts into a state where fluctuations in population composition induced by changes in the environment remain always above or below 0.5 such that the most common phenotype is always *A*, regardless of which phenotype is favored by selection.

While selection is, again, ineffective when it operates on fecundity, we do find a rare exception: When selection on fecundity is strongly asymmetric (Fig. B1c), occasionally evolution can lead to a state where *S*-trait values are appreciable and the frequency of the *A* phenotype is appreciably greater than 0.5 . Once this occurs, weak selection favors individuals with higher *S*-trait values, because these individuals will express the phenotype that is more strongly favored via fecundity selection (in this case A). Consequently, the S-trait evolves to values near 1. This rare behaviour explains the small blip in the red line in Fig. B1c.

When the period of selection is asymmetric (e.g., A is favored over B for longer than B is favored over A), the results are similar to the symmetric case (e.g., socially cued plasticity evolves and is adaptive when strong selection acts on survival, but not fecundity) regardless of strength of asymmetry (Fig. B2).

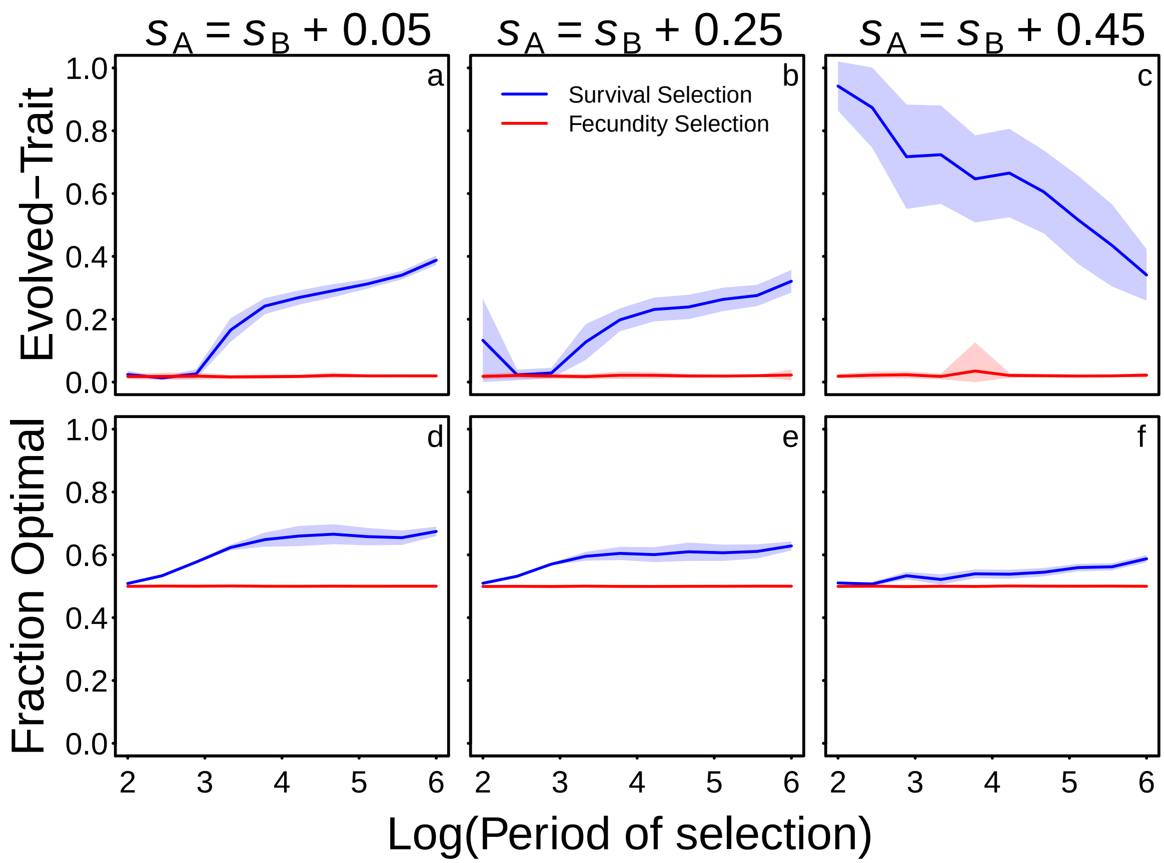

Figure B1: Evolved S-trait values (top row) and fraction of the population adopting the favored phenotype (bottom row) over a range of asymmetrical selection strengths ($s_B = 0.5$) with a cost to plasticity ($c_v = 0.1$ in survival model; $c_f = 0.1$ in fecundity model). Other parameter values were as in Fig. 1.

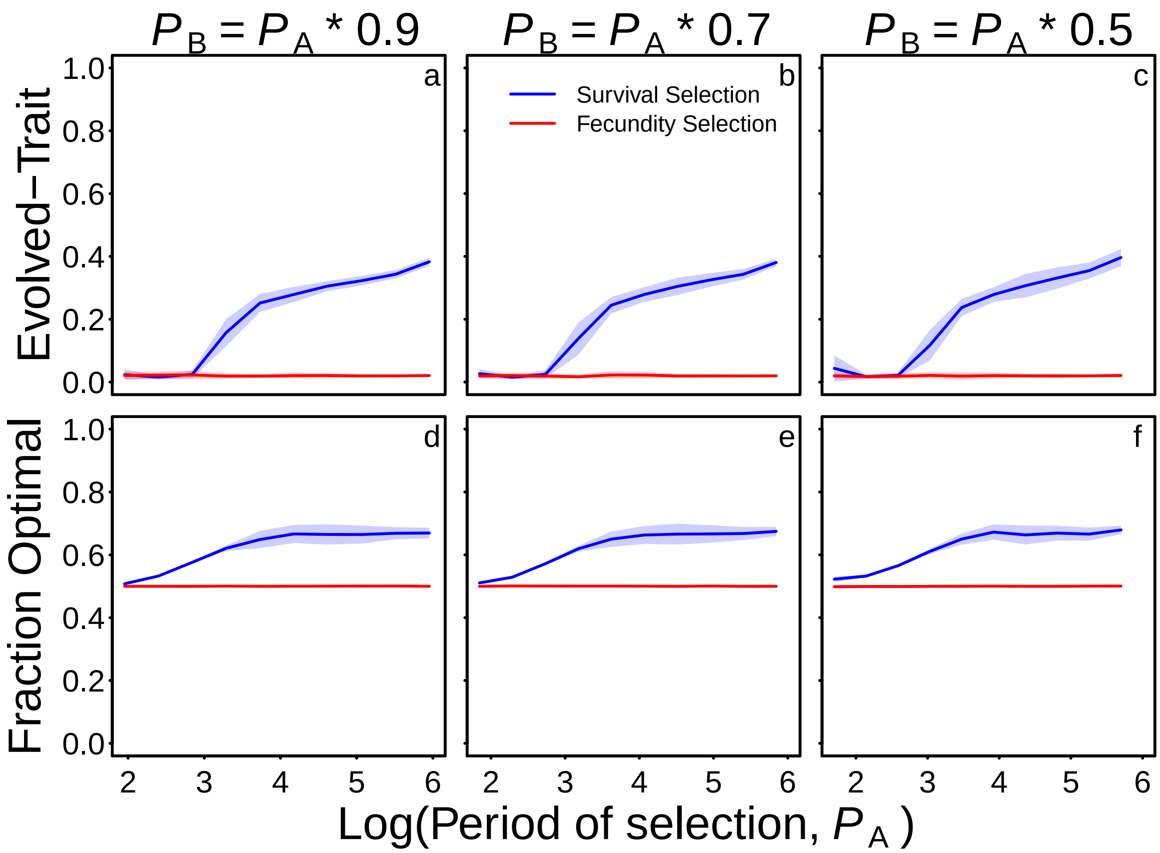

Figure B2: The evolved S-trait value (top row) and fraction of the population adopting the favored phenotype (bottom row) over a range of asymmetrical periods of environmental change for selection strengths of s equal to 0.5 with a cost to plasticity ($c_v = 0.1$ in survival model; $c_f = 0.1$ in fecundity model). Other parameter values were as in Fig. 1.

Appendix C: Age at Maturation

If individuals mature at an older age, a_m, the lag between the time point at which they use a social cue to commit to an adult phenotype and the time point when they actually express that phenotype will be greater. In our model, maturation also affects the turnover of the adult population, and these adults comprise the population from which the juveniles are drawing their social cues. To examine robustness of our model to this parameter, we varied maturation age while either 1) holding the the number of adults in the population constant or 2) allowing the number of adults to change, accordingly. In all cases, model dynamics were similar to those presented in the main text model where $a_m = 100$ days (Fig. C1; cases where the number of adults are constant are shown). Namely, we find that adaptive socially cued plasticity evolves when selection acts on survival, but not fecundity differences between phenotypes (Fig. C1).

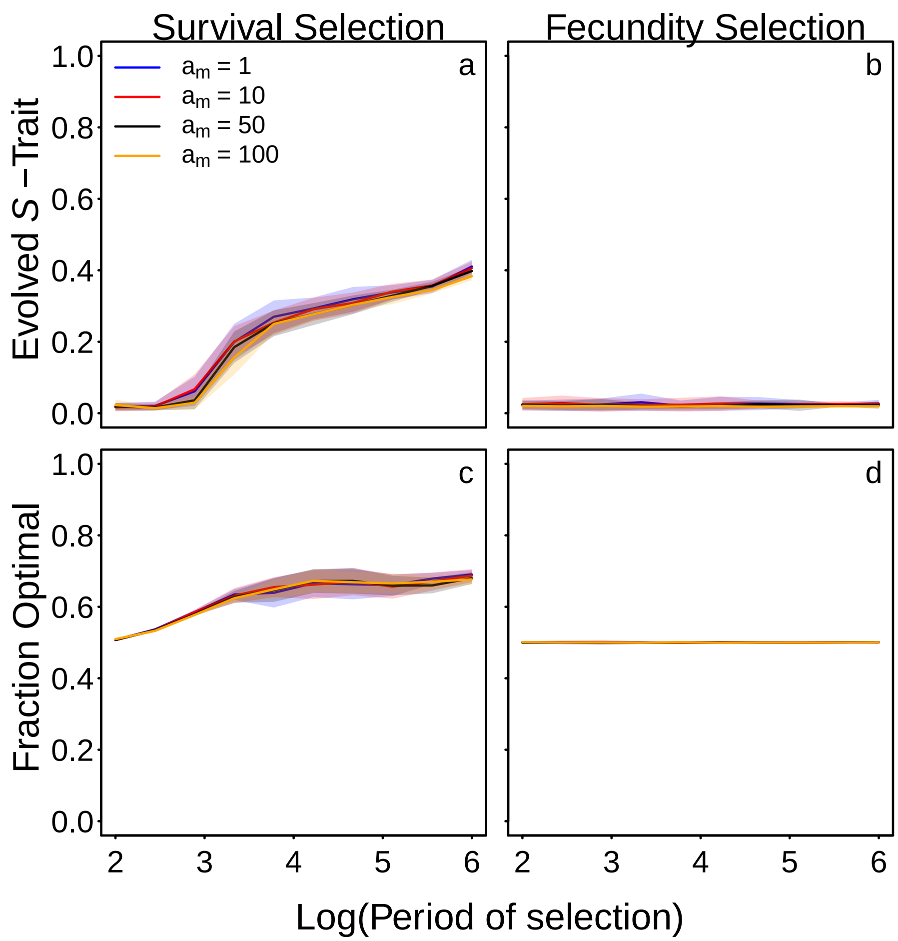

Figure C1: Evolved *S*-trait values (top row) and fraction of the population adopting the favored phenotype (bottom row) across a range of periods of environmental change. Different colors correspond to different maturation ages (a_m). Here, strong selection (s=0.5) acted on survival (a,c) or fecundity (b,d) and plasticity was costly in both cases ($c_v = 0.1$ in survival model; $c_f = 0.1$ in fecundity model). Other parameter values were as in Fig. 1.

Appendix D: Obligate Strategies

Methods

We also considered a related model where expression at the S-trait was binary ($S = 0$ vs $S = 1$). Here, instead of determining the probability that an individual used socially cued plasticity (as in the main text), individuals either never ($S = 0$) or always ($S = 1$) used socially cued plasticity. We only examined conditions here that promoted the evolution of socially cued plasticity in our main text model. Specifically, when the background in which evolution occurred comprised individuals who chose phenotypes at random (random plasticity), selection was strong and symmetrical, and there was a cost to plasticity. We again contrasted the mode of selection (survival or fecundity), and varied both period length and the mutational variance.

Results and Discussion

We find that when the mutation rate is high, conclusions here are qualitatively similar to the main text model. Namely, we find that adaptive socially cued plasticity evolves when strong selection acts on survival (Figs. D1a,d, D2a). When mutation rate is intermediate and the period is long, socially cued plasticity evolves to near fixation (Figs. D1b,e, D2b,e). In this case, immediately after an environmental change (e.g., after the environment switches from favoring A to favoring B), selection favors lower values at the S-trait, because a randomly chosen phenotype is better in the new environment than a misinformed one. However, once the population largely comprises individuals expressing the correct phenotype, socially cued plasticity is again advantageous. When the mutation rate is low, we see a similar pattern when selection acts on survival except that for a range of intermediate period lengths the population never switches between alternative phenotypes, so although socially cued plasticity evolves, it is not adaptive (Figs. D1c,f, D2c). However, socially cued plasticity does not evolve when selection acts on fecundity when mutation rate is low (Figs. D1c,f, D2f).

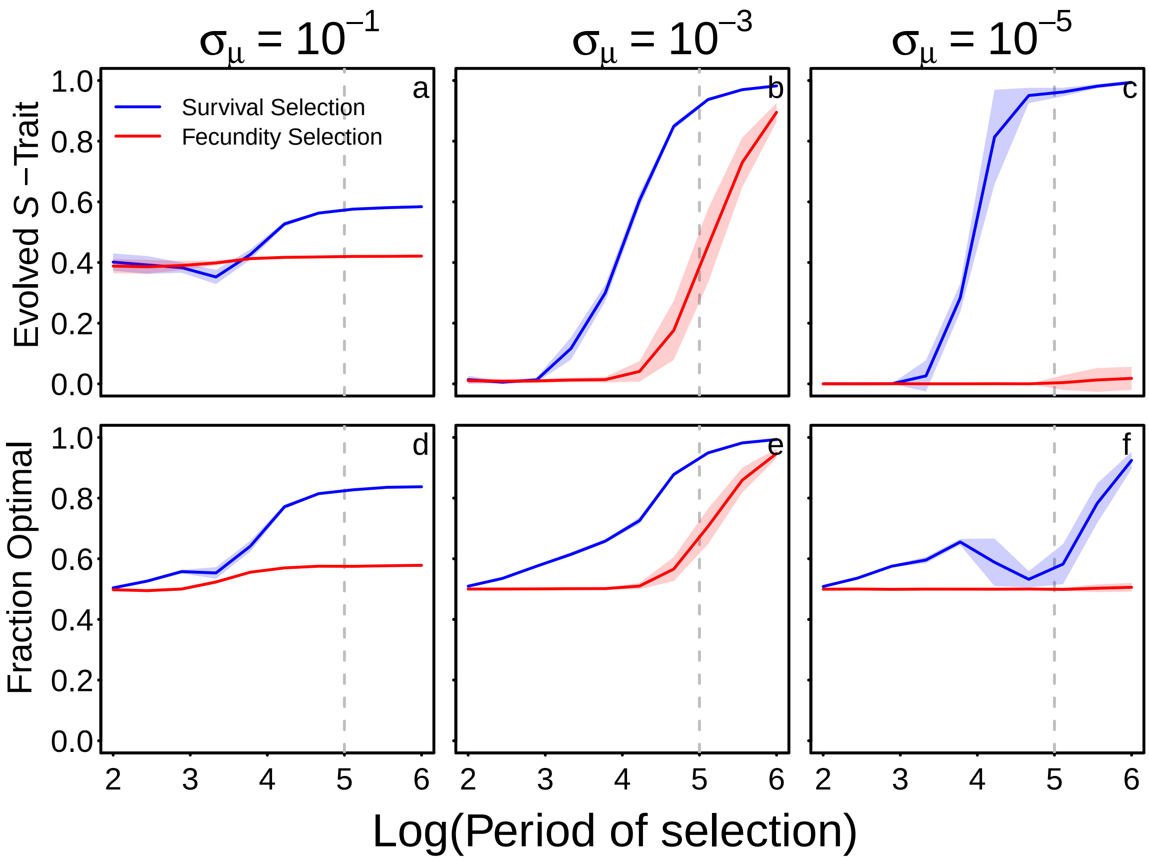

Figure D1: Evolved S-trait values (top row) and fraction of the population adopting the favored phenotype (bottom row) for cases where the the S-trait was binary ($S = 0$ vs $S = 1$) and selection (s=0.5) acted on survival (blue) or fecundity (red) over a range of mutation rates (columns) with a cost to plasticity ($c_v = 0.1$ in survival model; $c_f = 0.1$ in fecundity model). Other parameter values were as in Fig. 1.

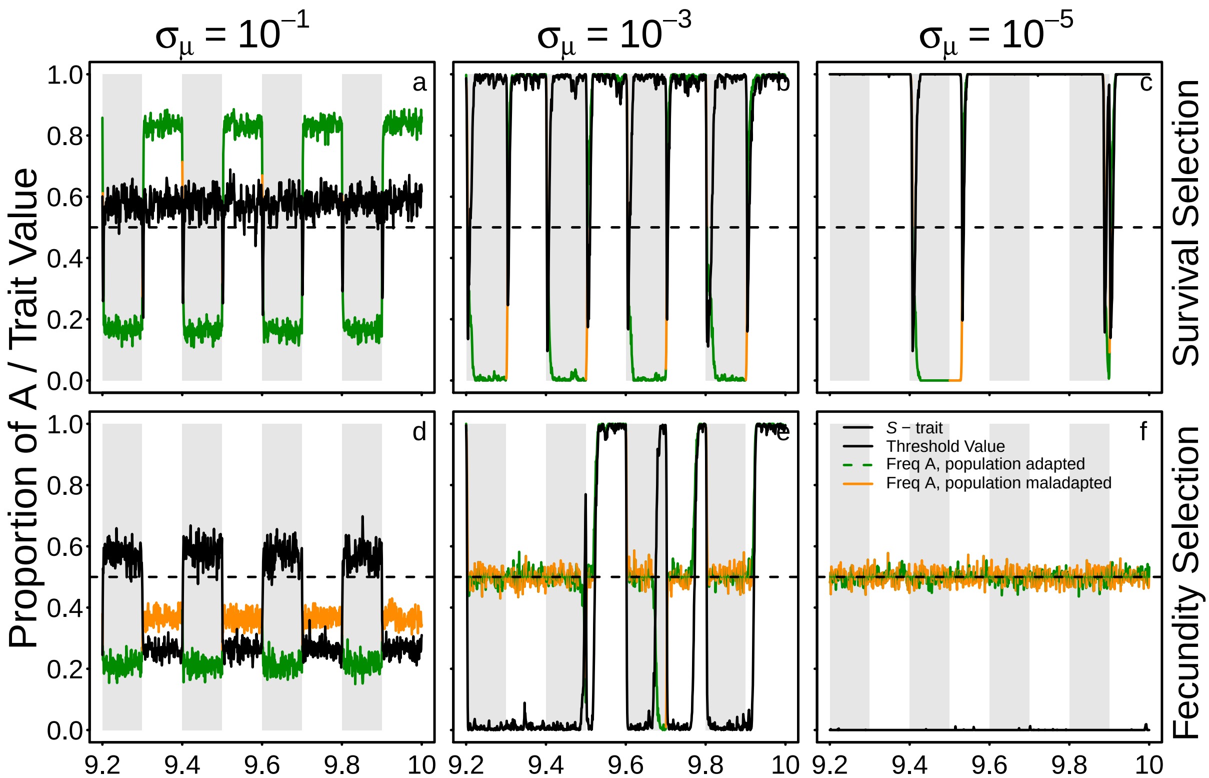

Figure D2: Sample model runs for cases where the the S-trait was binary ($S = 0$ vs $S = 1$) and selection acted on survival (top row) or fecundity (bottom row). Columns correspond to different mutational variances of the S-trait. The colored line shows the fraction of the population expressing the A phenotype (line is colored green when the majority of the population is expressing the favored phenotype and orange when the majority of the population is expressing the non-favored phenotype). The black solid line shows the population average S-trait. White shaded regions indicate when the A phenotype is favored; gray regions indicate when the B phenotype is favored. In each panel, the last $8P$ days are shown for runs that comprise 10^7 days in total. Models were run with $N = 1000$ individuals with initial $S_i = 0$ and $P = 10^5$ days; $c_v = 0.1$ in left panels and $c_f = 0.1$ in the right panels. Refer to Table 1 for default parameter values.