

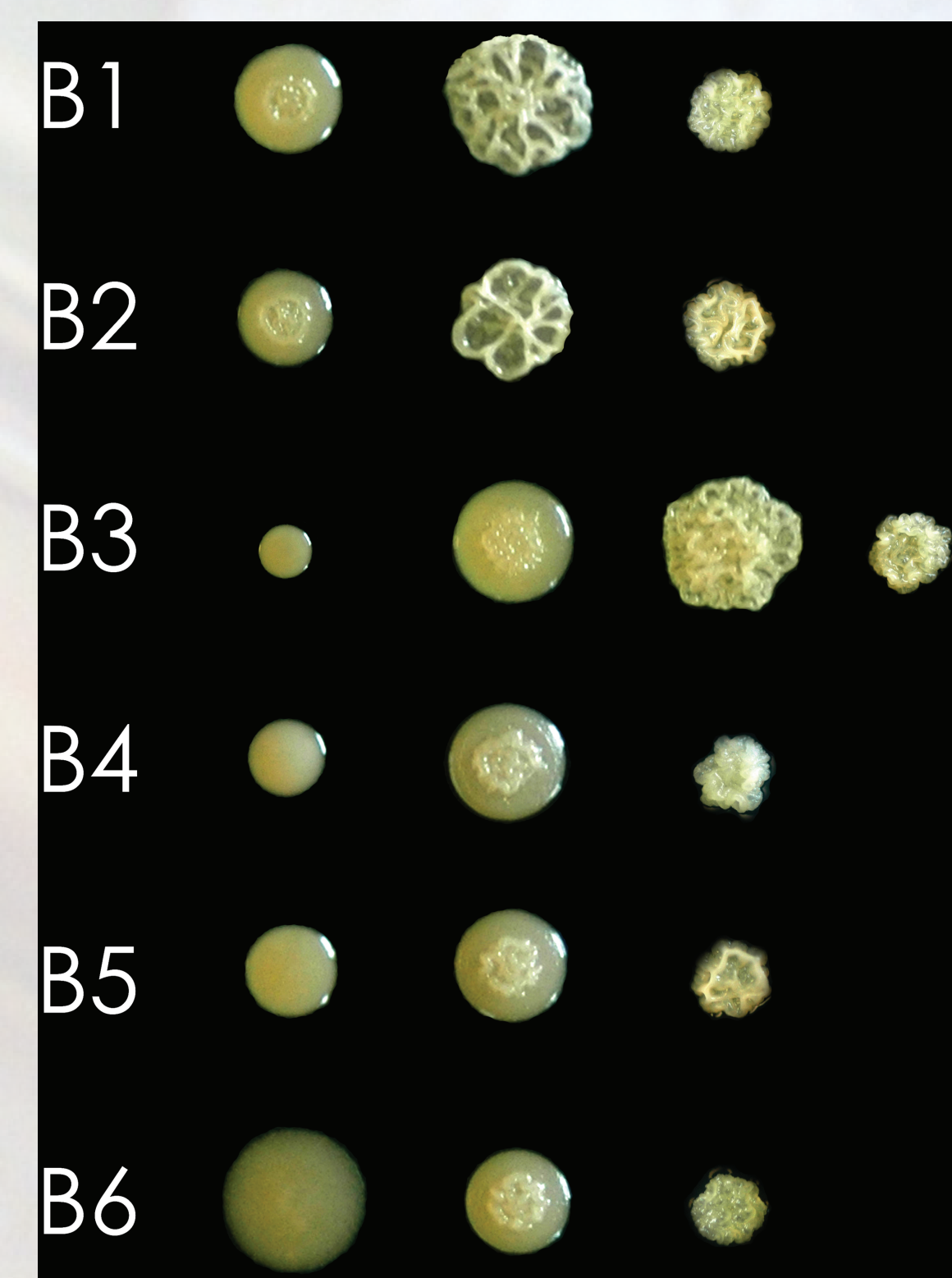
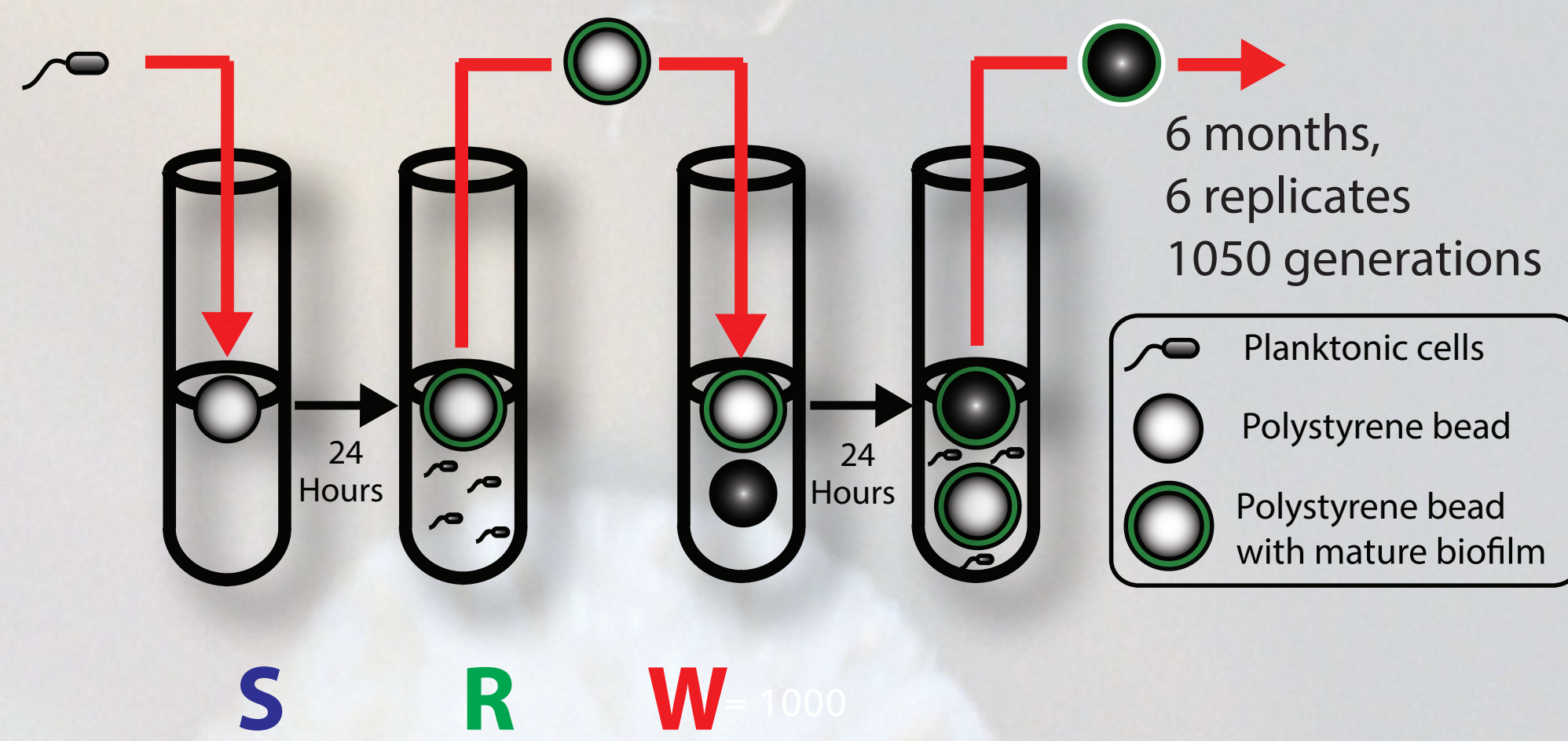
Exploitation of a socially coordinated dispersal signal drives biofilm diversity and ecological succession

Chuck Traverse and Vaughn Cooper
University of New Hampshire, Durham, NH

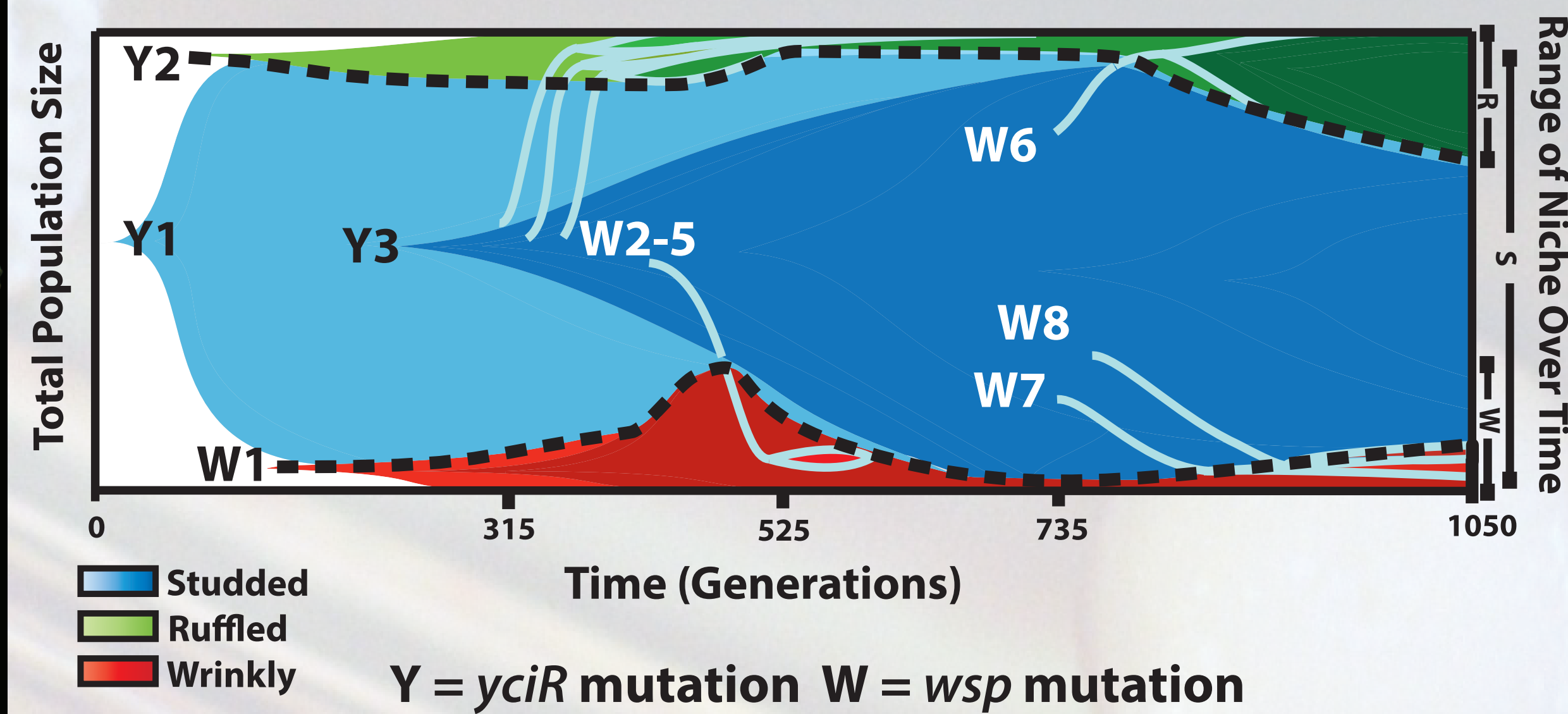
Abstract

Biofilms are associated with hundreds of thousands of infections each year and greatly increase treatment costs and mortality. These adverse effects are caused not only by increased resistance of bacteria living in the biofilm matrix but likely also by adaptive evolution of mutants into different, recalcitrant forms. To study this evolutionary process in biofilms we devised a method enabling long-term selection of populations of the opportunistic pathogen *Burkholderia cenocepacia* that undergo a cycle of attachment, biofilm assembly, and dispersal. Selection repeatedly favored mutations in one gene, *yciR*, which coordinates sensing of a signal (BDSF) that is secreted and detected by a range of species with internal regulation of a switch governing biofilm production (cyclic-di-GMP). Mutations in different protein domains led to different ecological strategies and together different mutants produced a more robust biofilm. The most successful haplotype involved a deletion of both *yciR* and the BDSF synthase (*rpfF*), producing a signaling cheat that neither responds to or produces BDSF. Consistent with the predicted role of similar signals produced by other species, BDSF acts to promote dispersal by activating a phosphodiesterase that degrades c-di-GMP. Thus, likely by failing to contribute or respond to the socially coordinated dispersal cue, deletion mutants invade and reach high frequency, relying upon mass action and shear forces to persist and succeed in this system.

Approach

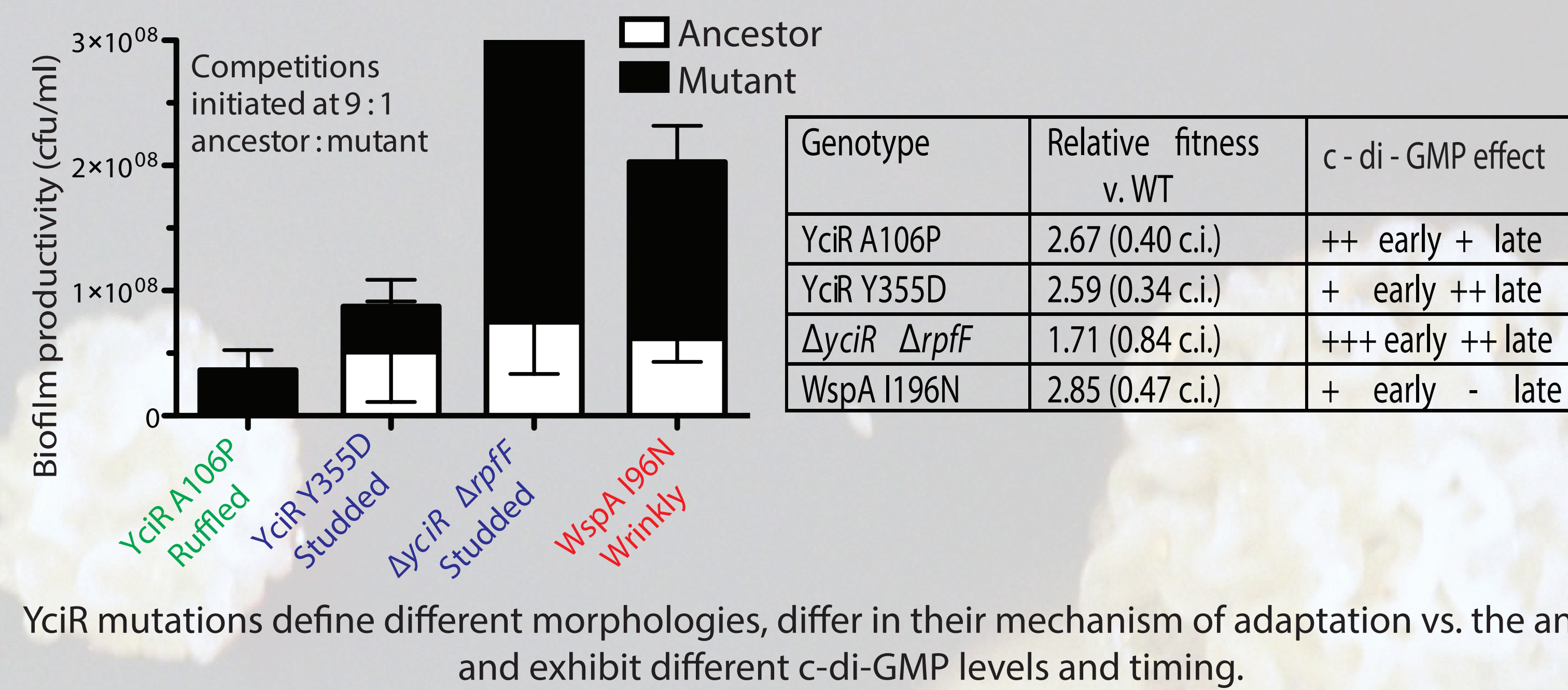
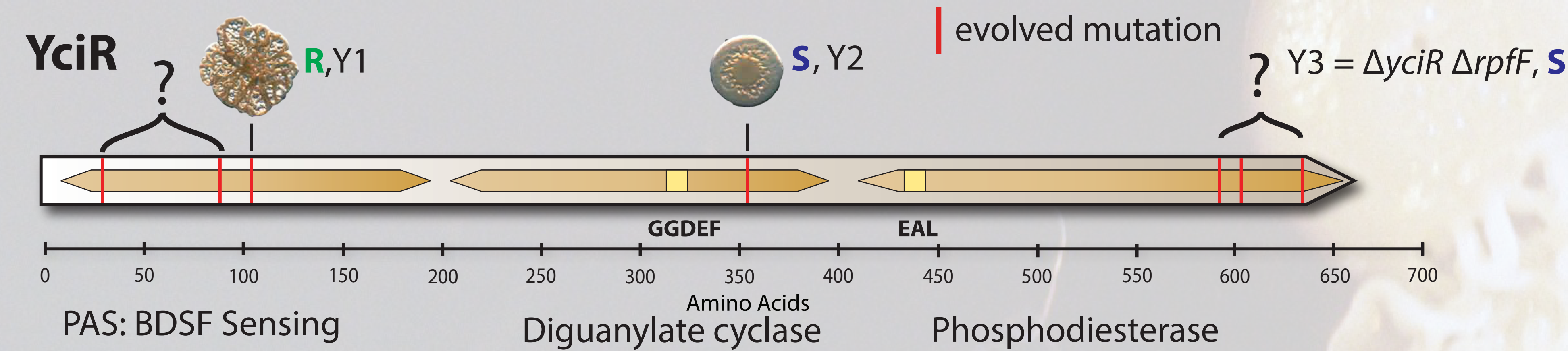


Evolved ecotypes

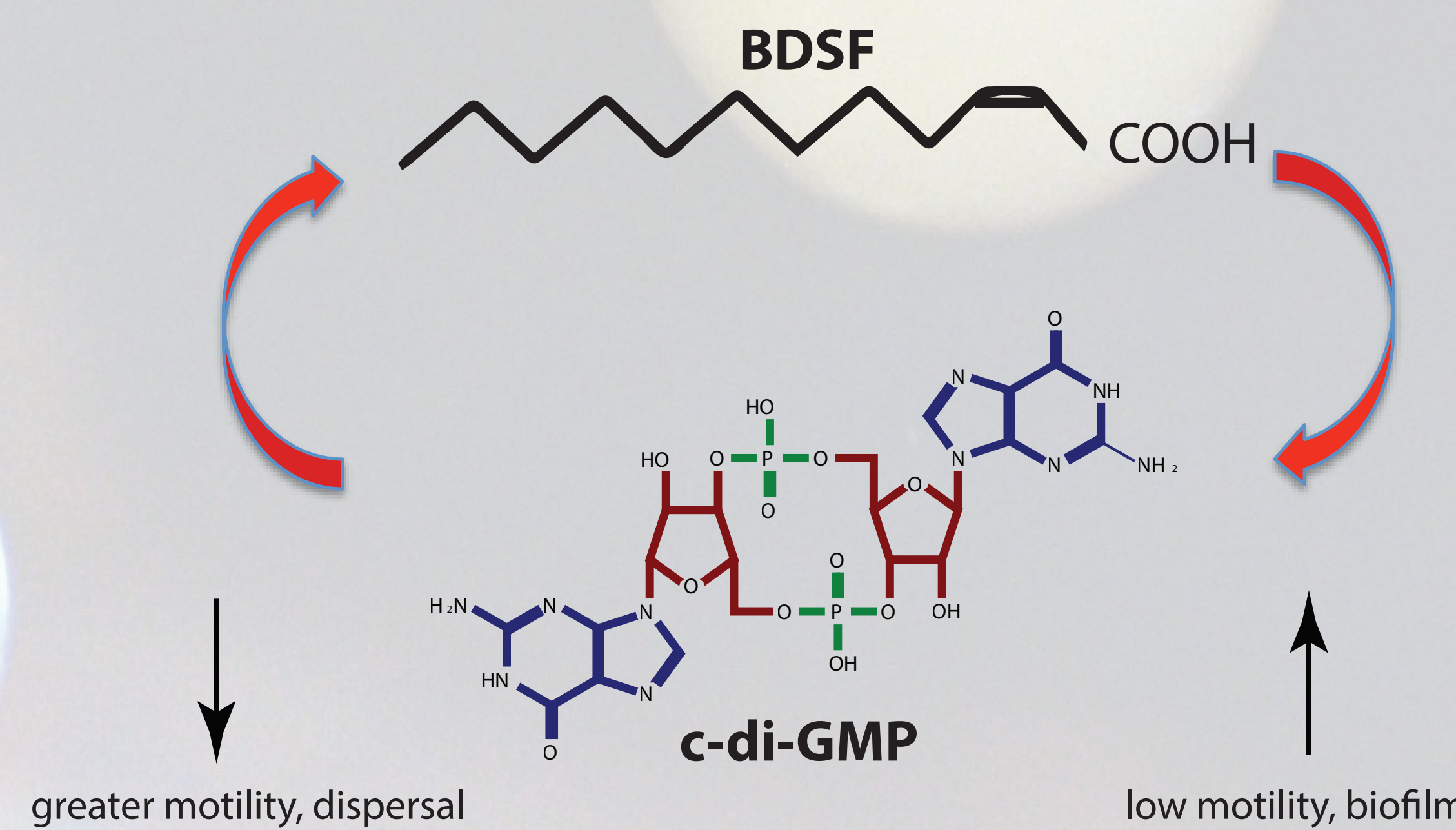


Causative mutations in B1

Parallel adaptive mutations in an extraordinary protein define ecological strategies

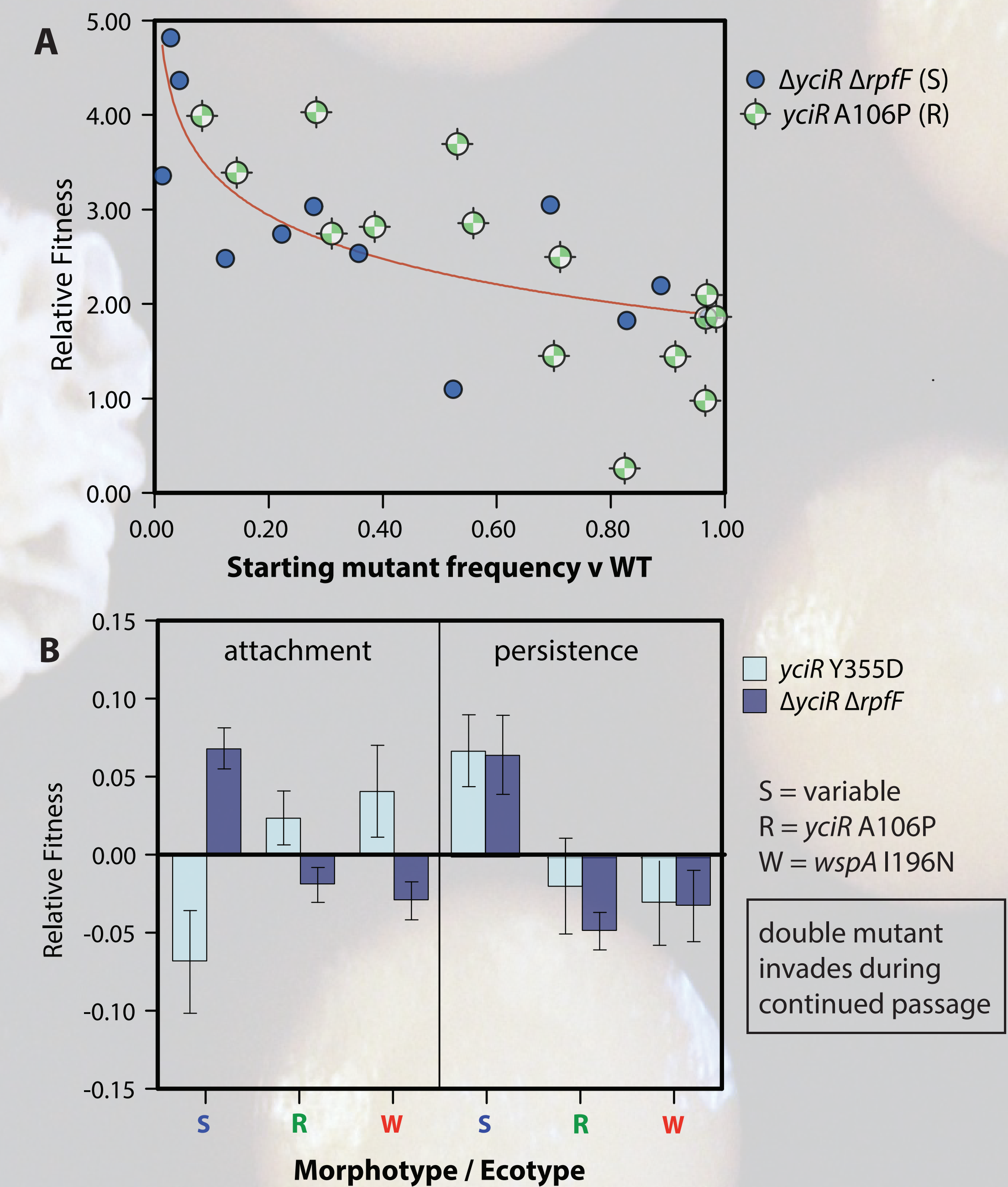


Model: YciR binds the quorum-sensing molecule BDSF, activating the PDE domain that degrades the second messenger c-di-GMP and promotes dispersal



Prediction: dispersal may be a social trait that can be exploited. PAS sensor mutants or deletions should exhibit negative frequency-dependent selection.

Competitions of *yciR* mutants vs ancestor and evolved community members in multiple conditions



Implications

A quorum signal regulates the stick-or-swim switch. Varied signal responses produce distinct biofilm strategies.

Related DSFs can act as cross-species signals

- Xanthomonas campestris*
- Pseudomonas aeruginosa*
- Candida albicans*

Key references

- Poltak, S.R. and V.S. Cooper. 2011. Ecological succession in long-term experimentally evolved biofilms produces synergistic communities. *ISME J.* (3):369-78.
- Traverse, C.C., L.M. Mayo Smith, S.R. Poltak, and V.S. Cooper. 2013. Tangled bank of experimentally evolved *Burkholderia* biofilms reflects selection during chronic infections. *PNAS*, 110(3):E250-E9. doi: 10.1073/pnas.1207025110.
- Deng Y, Schmid N, Wang C, Wang J, Pessi G, Wu D, et al. 2012. Cis-2-dodecenoic acid receptor RpfR links quorum-sensing signal perception with regulation of virulence through cyclic dimeric guanosine monophosphate turnover. *PNAS* 109(38):15479-84. doi: 10.1073/pnas.1205037109.

Acknowledgments

We are grateful to Leslie Mayo-Smith and Chris Waters for contributing foundational experiments. We also thank Crystal Ellis, Kenny Flynn and Rachel Staples for helpful conversation. This work was supported by NIH 1R15AI082528-01 and NSF DEB-0845851.

*Contact Information: chucktraverse@gmail.com, vaughn.cooper@unh.edu