In a Lotka-Volterra model, evolutionary stability does not align with ecological predictions

We evaluated the invasion fitness of a novel phage specialist in a generalist population and vice versa to compare evolutionary stability with the ecological predictions of our Lotka-Volterra model. We found that, regardless of the type of prey interactions, a specialist strategy was not evolutionarily stable and was vulnerable to invasion by a generalist. When prey were mutualistic, invasion by a generalist was possible given a minimum threshold of infective ability (as measured by the product of attachment and burst size) on the novel prey *E. coli* or given an infective advantage on the shared prey *S. enterica*; invasion was made more difficult if expanded diet breadth on *E. coli* was offset by a cost of generalism, in comparison to the resident specialist, on the shared prey *E. coli* (Supplemental Figure 2A). When prey competed, invasion of a generalist required a minimum threshold of infectivity on the novel prey *E. coli*; that threshold decreased as the specialist’s infectivity on the shared prey *S. enterica* increased, likely due to competitive release of the novel prey facilitated by efficient predation of the shared prey (Supplemental Figure 2B).

In comparison, our analyses demonstrated that phage generalism was evolutionarily stable in certain cases and was not always vulnerable to invasion by a specialist using *S. enterica* as the shared prey. In particular, when prey were mutualistic, a specialist on *S. enterica* could never invade; this result stands in contrast to our findings on ecological selection (Supplemental Figure 2C). However, when prey competed, a specialist on *S. enterica* could invade a resident generalist population depending on the interaction outcomes between prey and the infective ability of the generalist (Supplemental Figure 2D). If the shared prey *S. enterica* was the stronger competitor (𝜷e,s > 𝜷s,e or 𝝁s > 𝝁e), then invasion by the specialist was generally possible assuming that the infectivity of the specialist on *S. enterica* was greater than that of the generalist on *S. enterica*. This was consistent with the expectation that, if the alternative prey *E. coli* was eliminated by competitive exclusion, then the invasion ability of the novel specialist must depend only on the relative abilities of the two phage predators to compete for *S. enterica*. These results demonstrated the importance of competitive prey outcomes for the evolutionary stability of predator diet breadth.

All analyses were completed in Mathematica 13.1, with pairwise invasibility plots and related simulations completed in R v. 4.2.1. Notebooks and corresponding pdf outputs are available at <https://github.com/bisesi/Host-Ecology-and-Host-Range>.