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Interspecific competition for algal resources alters disease dynamics in *Daphnia*

Species other than the host and parasite (predators, competitors, resources) can alter disease spread. Using a tractable disease (the fungus Metschnikowia bicuspidata and its host Daphnia dentifera) we explore the direct and indirect effects on the host population. We integrate the role of Daphnia as grazers of algae, competitors with other zooplankton, and as prey to investigate the effects these roles play on the contraction of the disease. For instance, the rate at which hosts consume food (and fungal spores) and move it through their gut depends on body size, genotype and food levels. Gut passage time influence disease susceptibility, because Daphnia become infected when fungal spores puncture the gut wall. Resources, which are determined in part by competitors, influence the production of infective forms of the parasite. Other planktonic competitors consume but do not produce infective forms of the parasite, hence may reduce disease via a dilution effect. As prey the Daphnia can be eaten by fish such as Bluegill which consume the daphnia whole and remove the spore from the population. They also hunt the infected at a higher rate due to the color difference in daphnia. Another predator *Chaoborus* are sloppy eaters and while eating the daphnia release the spores back into the population. We do not include this sloppy eating into our model. We integrate a mathematical model for the nonlinear interactions of five populations (susceptible hosts, infected hosts, parasite spores, algae, diluters) with laboratory experiments and field data from epidemics occurring in Midwestern lakes. The model consists of a system of five coupled ordinary differential equations.

We find signatures of a dilution effect influencing prevalence of Metschnikowia bicuspidata in Daphnia dentifera in Midwestern lakes. Years with smaller epidemics often had increased abundances of other Daphnia species relative to D. dentifera. In addition, within a season, increasing densities of D. pulicaria were often correlated with declining prevalence of Metschnikowia. The field data suggest that disease dynamics are likely influenced both by D. pulicaria consuming spores but not becoming infected (i.e., acting as a diluter) and D. pulicaria altering resources (i.e., acting as competitor). Laboratory measurements of gut passage time for both species have revealed striking differences between the two species, and among genotypes within each species. Gut passage time ranges from a few minutes to almost a half an hour, depending on the species, genotype, body size, and food level. This difference in gut passage time may help to explain the observed differences in susceptibility among species, genotypes and environmental conditions that we have observed. We have also analyzed the seven biologically meaningful equilibria and performed a stability analysis. Several bifurcations depending on the parameter values have been found.