Do cooperative groups of the species *Bradyrhizobium japonicum* have lower fitness when there are higher frequencies of "cheaters" in the group

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Introduction

- Cooperation benefits both species involved
- Cheaters take more than they give

- Negative frequency-dependent selection means cheaters will be rare
- Comparing bacterial strains

- Fitness and population growth
- Population size and range

Study Species:
Nitrogen-fixing bacteria
(*Bradyrhizobium japonicum*)

Pea plant
(*Ottleya strigosa*)

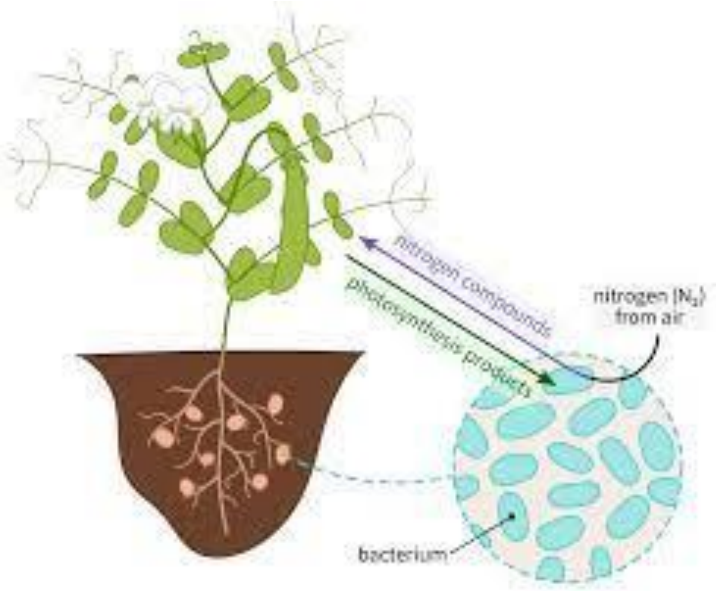

Figure 1: Nitrogen fixation via bacteria living in root nodules

Research Question

Hypothesis 1: Higher frequencies of "cheater" phenotypes in cooperative groups of *Bradyrhizobium japonicum* correlate negatively with population size.

Specific Aim 1: Investigate whether communities of *B. japonicum* with cheater phenotypes result in smaller nodes on the roots of legume plants.

Specific Aim 2: Statistically determine whether the size of the nodes on the roots of the flowering pea plant correlates to the frequency of cheater phenotypes in the communities.

Hypothesis 2: Higher frequencies of "cheater" phenotypes in cooperative groups of *Bradyrhizobium japonicum* correlate with an increased range of a population due to increased dispersal of group members.

Specific Aim 1: Investigate whether communities of *B. japonicum* with cheater phenotypes spread out into a higher number of smaller colonies rather than a few larger colonies.

Specific Aim 2: Investigate whether a dispersion of cheaters increases the fitness of the bacterial colonies.

Proposed Methods

- Cooperative relationship impacted by negative frequency-dependent selection?

- Locations: UVU microbiology laboratory and greenhouse

- Materials: Rhizobia strains and legume seeds, biochemical analysis techniques, Petri dishes, hydroponics system

- Set up: (Jeudy et al., 2010)

- Analysis using visible nodule analysis throughout the study by observing bare roots in hydroponic tank

- Study length: 14 days

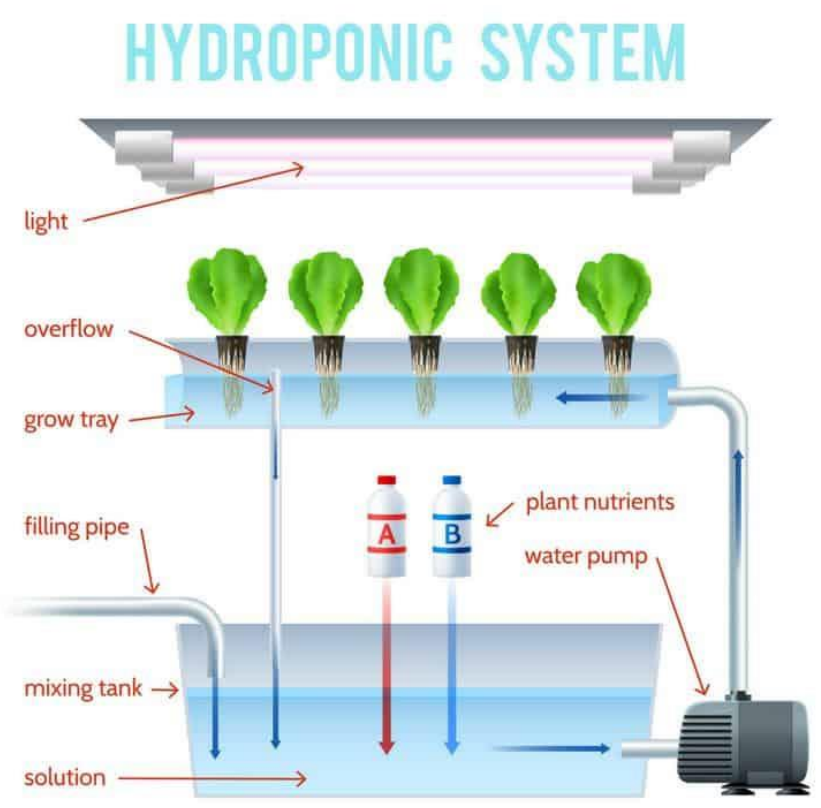

Figure 2: Diagram of equipment set up, Hydroponic system utilized for visualization purposes.

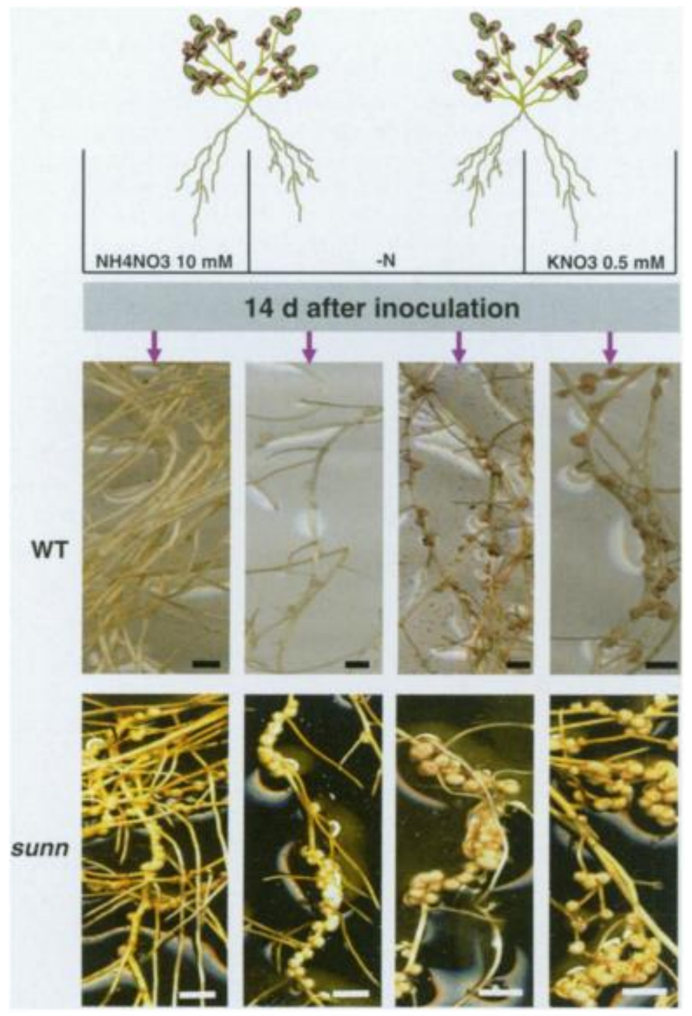

Fig. 8 Local and systemic effect of mineral nitrogen (N) on nodulation in wild-type (WT) and *sunn-2* mutant plants. Hydroponically grown *Medicago truncatula* plants fed with 1 mM NO_3^- (sixth leaf stage) were subjected to two contrasting nitrogen (N) regimes in split-root systems. Treatments consisted of maintaining half of the root system of these plants in nutrient solution containing either a high concentration (10 mM NH_4NO_3, N-sufficient plants) or a low concentration (0.5 mM NO_3^-, N-limited plants) of mineral N, the other roots being exposed in both cases to a mineral N-free nutrient solution. After 4 d, roots of N-sufficient and N-limited plants were then exposed to *Sinorhizobium meliloti* 2011. Root/nodule morphology was observed 14 d after inoculation.

Figure 3: Visible nodules analysis based on size and dispersal

Expected Results

Higher frequencies of cheaters

- Smaller total nodule volumes.
- Higher average distance between nodules

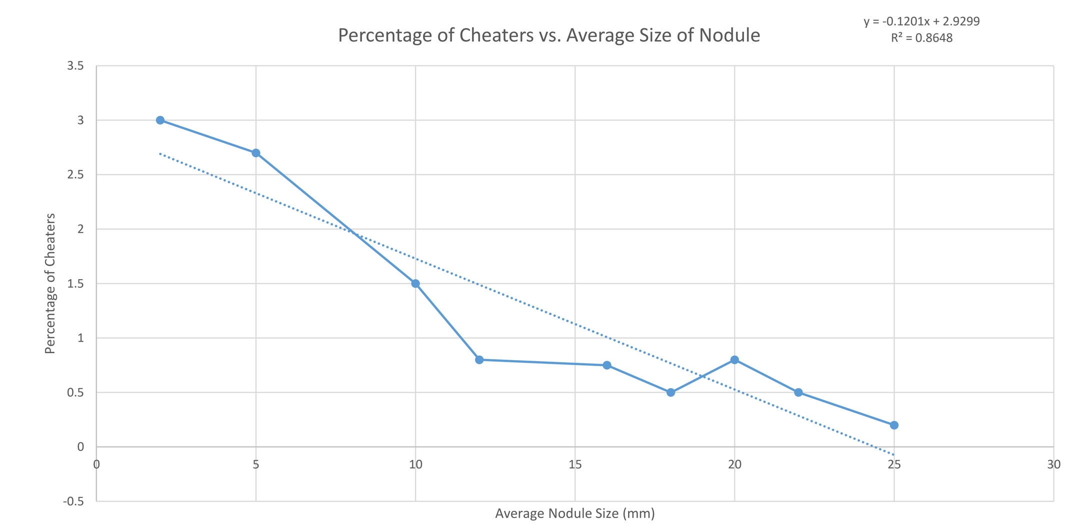

Figure 4: Nodule size decreases as percentage of cheaters increases

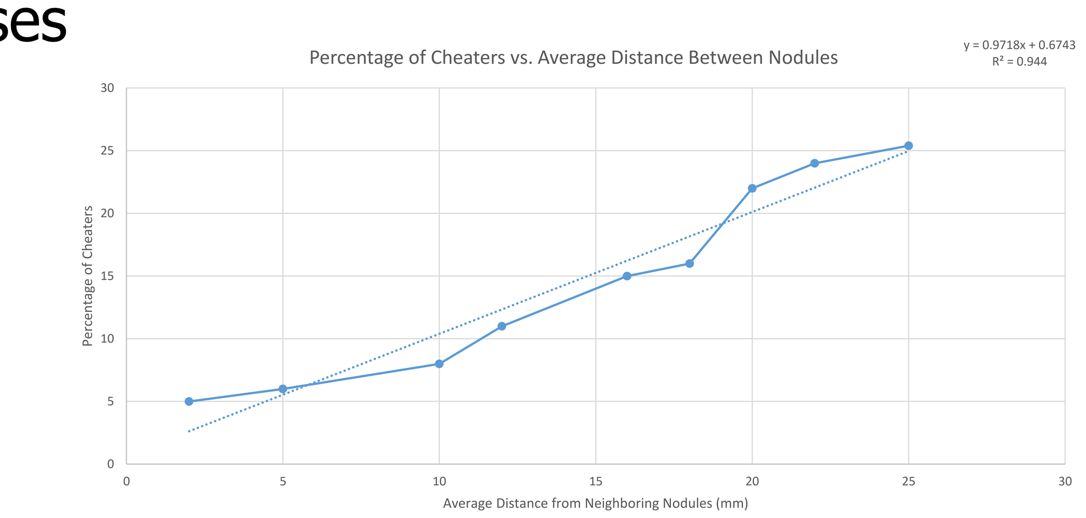

Figure 5: Distance between nodules increases as percentage of cheaters increases

Significance

- Cheaters influence population size and range
- Research around cheater strains is sparse
- Understand how cheaters interact
- Apply to other cooperative systems

Acknowledgements

I am grateful for the researchers who taught me about cooperative systems and for my Evolution professor Dr. Cusick.

References

Britannica, 2020; Denison et al., 2003; Dugatkin et al., 2005; Frederickson & Kokko, 2013; Harvard School of Public Health, 2022; Jeudy et al., 2010; Kiers & van der Heijden, 2006; MasterClass, 2021; Pruitt & Riechert, 2009; Rosenberg, 1983