Penn FERBS
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Examining Host Susceptibility to Parasitism as a Feature of Legume-Rhizobia Mutualisms

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Abstract

In mutualisms, there exists genetic variation for partner quality. This is an evolutionary paradox, however, since it is expected for species to interact with the most beneficial genotype of their symbiotic counterparts. One mechanism that could support such variation is the relationship between partner cooperation and other fitness-related traits. In this experiment, we tested whether the presence of parasitic nematodes in legume-rhizobia mutualisms can impact cooperation, and thus, prompt variation in partner quality. A reciprocal design was used with five genotypes of the rhizobia *Ensifer meliloti* and two genotypes of the legume *Medicago truncatula*. Two treatments were applied to two separate experimental groups: nematode-absent and nematode-present. Resulting data showed that parasites do cause changes to the legume-rhizobia mutualism. We observed that plants with nematodes formed fewer rhizobia nodules (mutualistic structures) and less aboveground plant biomass than the plants without nematodes. Thus, the benefit (relationship between nodule weight and aboveground plant biomass) provided from the rhizobia to the plants depended on plant genotype as well as infection status. This suggests that nematode infection can cause changes to the legume-rhizobia mutualism and potentially force partners to adjust their cooperation with one another. If host susceptibility to parasitism is a deciding feature of mutualism, it could further the maintenance of genetic variation in partner quality and direct evolutionary changes in positive species interactions.

Introduction

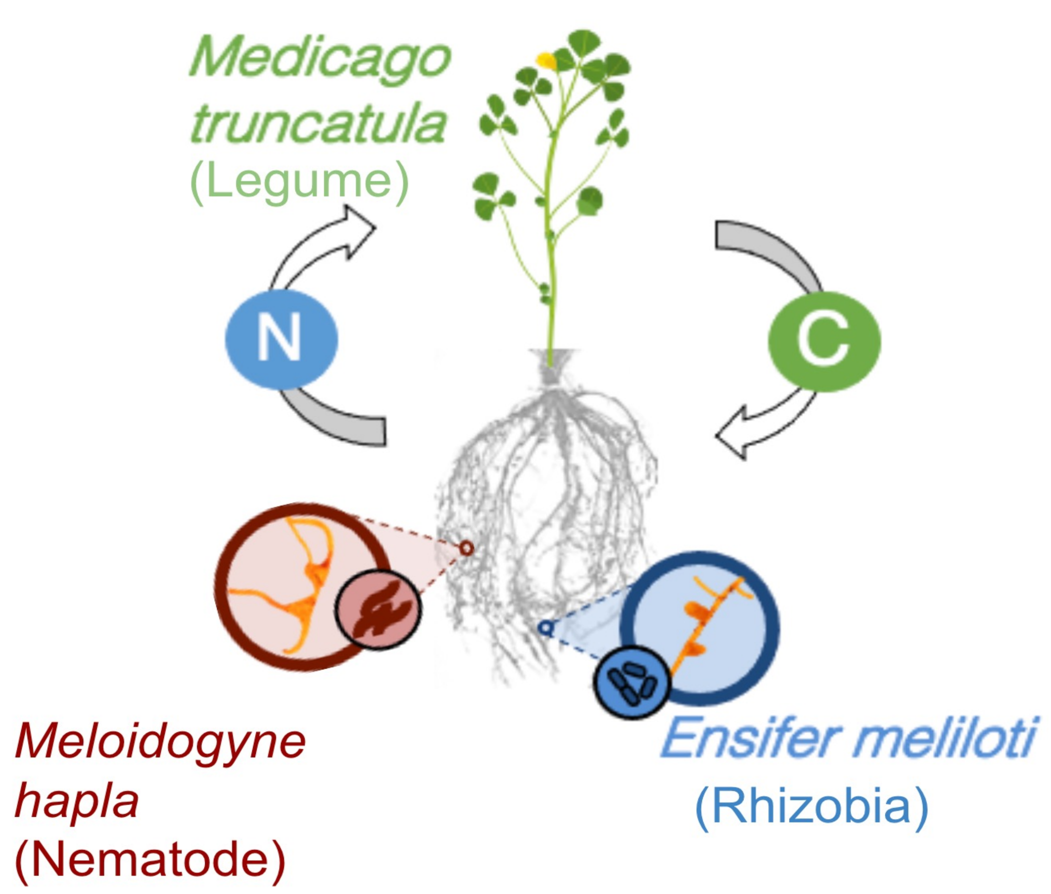


Figure 1. Mutualistic structures called nodules are formed on the roots of legume *M. truncatula* (bottom right) as well as galls containing female nematodes (bottom left). N (top left) represents the nitrogen exchanged from the rhizobia to the plant, while the C (top right) represents the carbon exchanged from the plant to the rhizobia in this mutualistic relationship. Images inspired by Corlett Wood's paper (Wood et al. 2018).

Significance

This research addresses an ongoing evolutionary question: why is there variation in partner quality across several mutualisms, even though low quality partners are selected against in natural selection? Tradeoffs between derived benefits from mutualistic partners and susceptibility to parasitic infection could help to address this inquiry. Additionally, this study introduces a new way of analyzing unique symbiotic relationships. Instead of observing mutualism and parasitism as two separate symbioses, this experiment views them holistically.

Methods

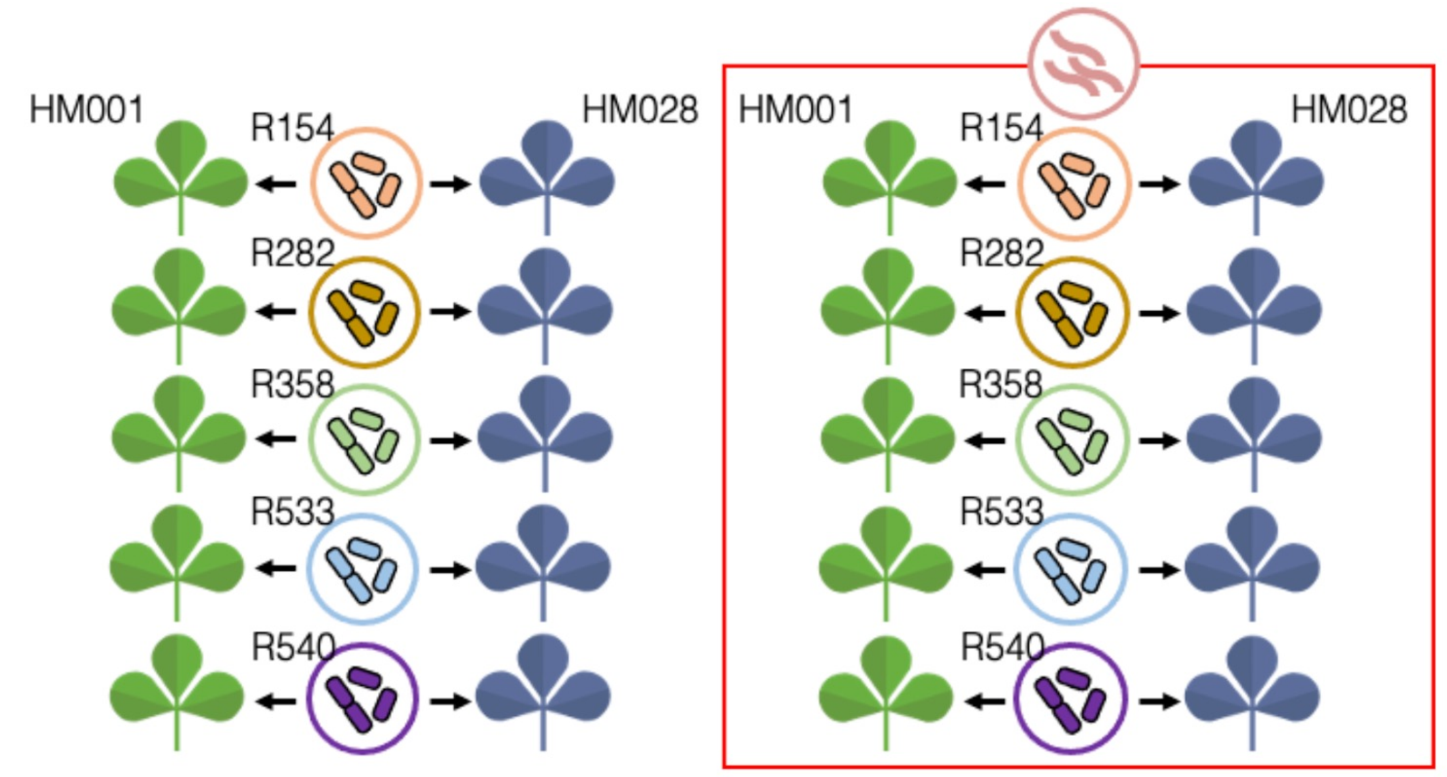
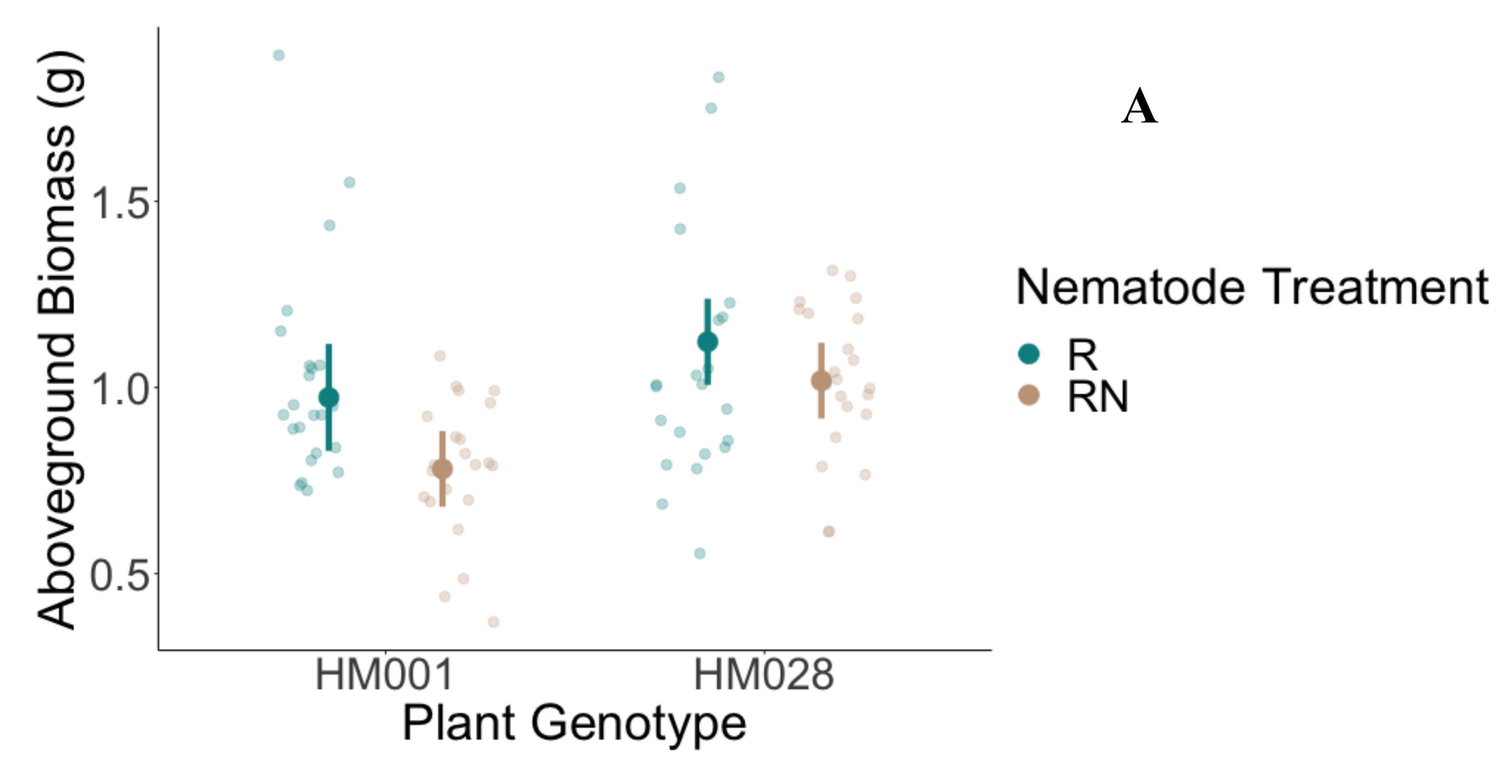


Figure 2. Two *M. truncatula* genotypes HM001 and HM028 were used in this experiment. All plants from these two genotypes were inoculated with 5 different rhizobia genotypes (R154, R282, R358, R533, & R540). Only half of the plants were inoculated with parasitic nematodes, therefore creating two experimental treatments: nematode-present (left) and nematode-absent (red square box). Images adopted from Mac Calvert.

- Grow plants for 11 weeks
- Separate roots from shoots
- Dry and weigh shoots for aboveground biomass
- Perform elemental analyses for C & N concentrations
- Freeze roots to prepare for nodule & gall counting

Results



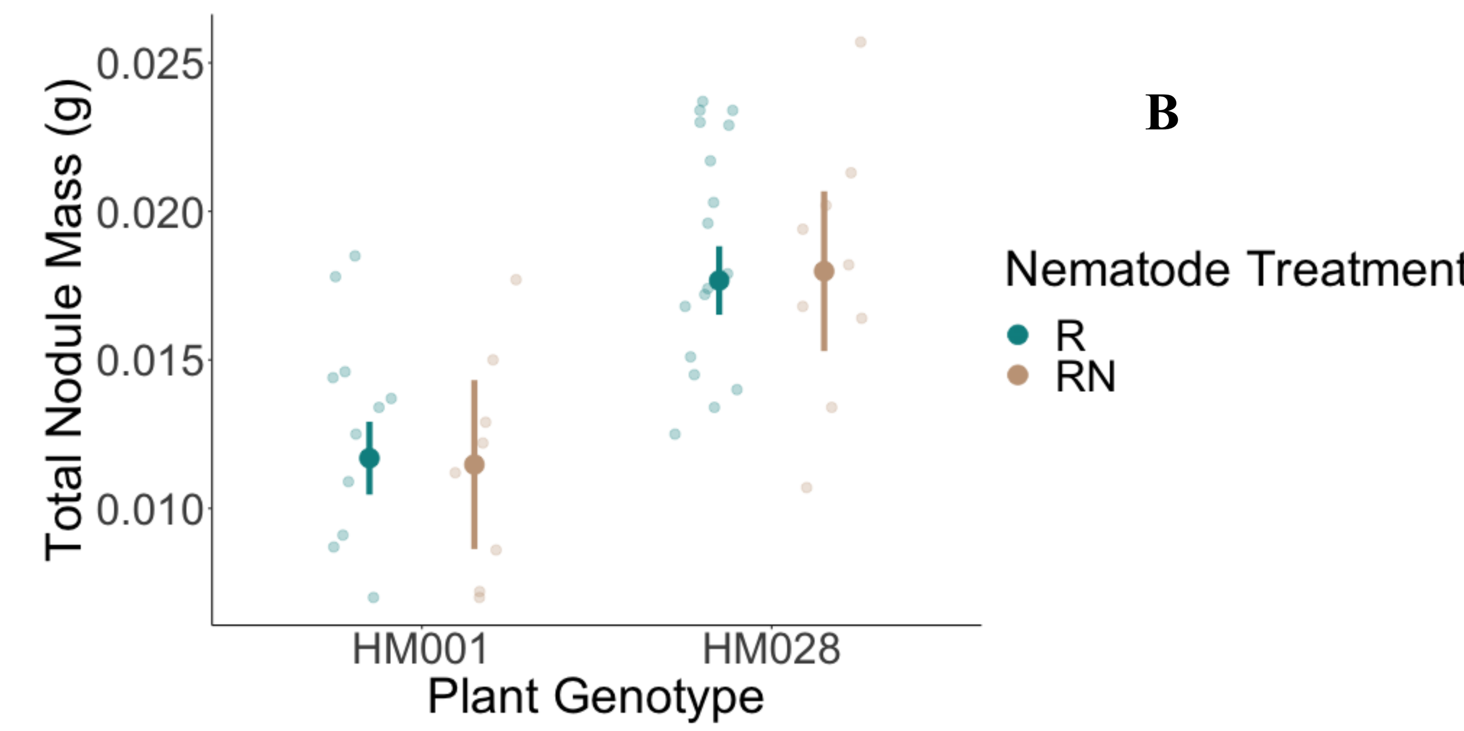


Figure 3. **(A)** Nematodes do not appear to affect total nodule mass ($\chi^2 = 0.06$, $p = 0.8$) Blue represents the nematode absent-treatment and gold represents the nematode present treatment. **(B)** Similarly, there is no significant effect of nematode treatment on aboveground biomass ($\chi^2 = 0.22$, $p = 0.64$). However, there is a significant three-way interaction between nematode treatment, plant genotype, and rhizobia genotype ($\chi^2 = 9.84$, $p = 0.043$). This suggests that the impact of nematode-infection on aboveground biomass is dependent on both plant and rhizobia genotype. We used linear mixed effects models in R to evaluate statistical significance.

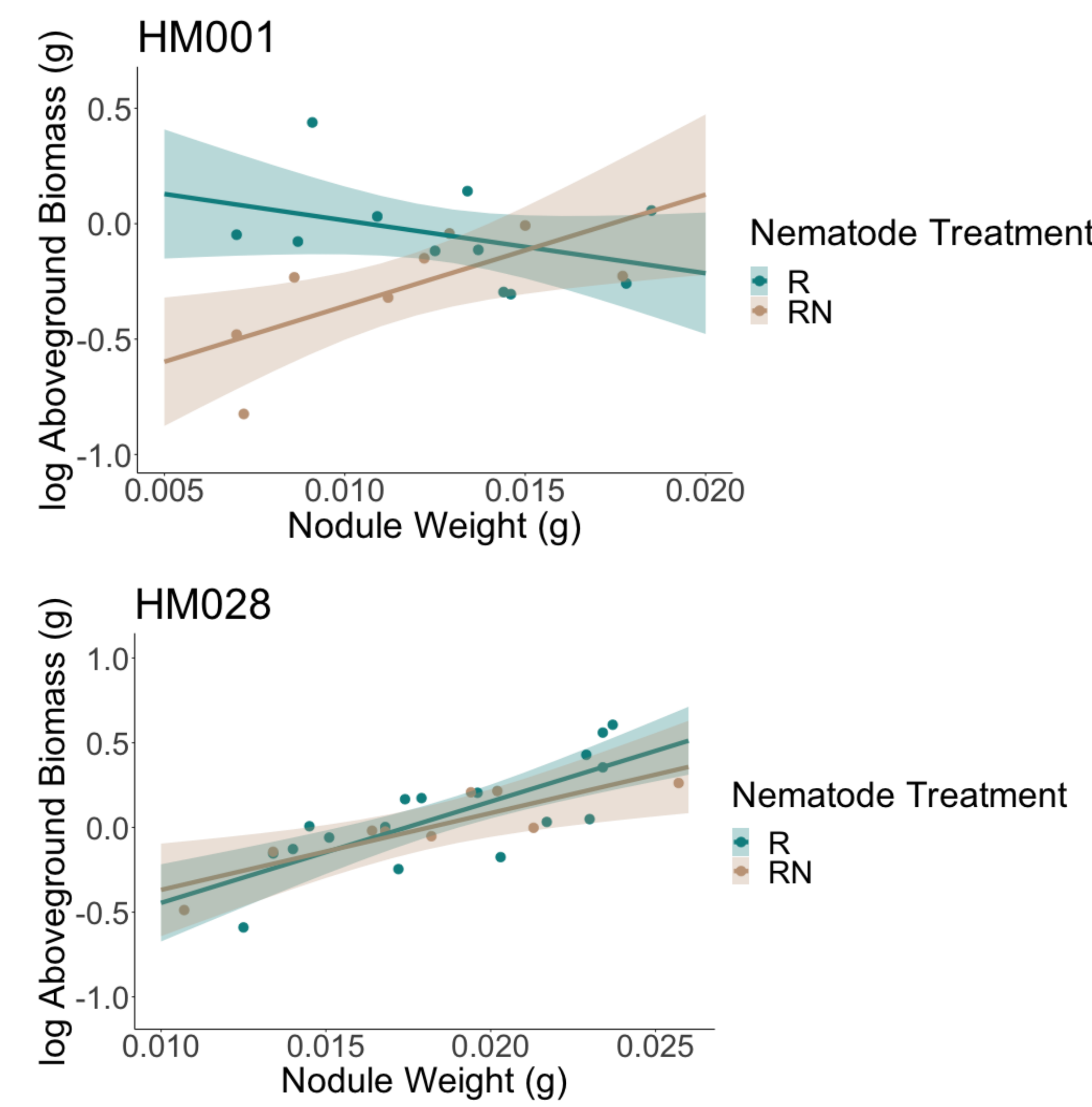


Figure 4. Cooperation (aboveground biomass vs. nodule weight) depends on nematode treatment and plant genotype (($\chi^2 = 7.2$, $p = 0.0077$). Interestingly, rhizobia genotype R154 (shown in these graphs) demonstrates an increase in cooperation during nematode infection. These results suggest that nematode infection can change the degree of mutualistic cooperation within the legume-rhizobia mutualism.

Conclusions/Next Steps

1. Parasites affect mutualism/cooperation in legume-rhizobia symbiosis.
2. Legume susceptibility to parasitic infection is a general feature of legume-rhizobia mutualisms
3. **Next Steps:** More elemental analyses to see if parasites are directly stealing carbon from hosts

References/Funding

Wood et al. 2018
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