Interacting effects of spiders and soil microbes on plant growth

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Background

- Biotic factors contribute greatly to the success of nutrient cycling by recycling and translocating the vital nutrients necessary for microbe productivity (Vanni 2002).
- High densities of predators affect the amount of nutrients deposited into soil and the flow of nutrients within an ecosystem.
  - ❑ bears distribute nitrogen derived from salmon to surrounding terrestrial habitats via urea and partially eaten salmon carcasses (Hilderbrand et al. 1999).
  - ❑ seabird guano enhances the concentration of nutrients in soil on the Gulf of California islands (Anderson and Polis 1999).
- A recent study showed that spiders consume 400 to 800 million tons of food per year (Nyffeler and Birkhofer 2017).

Study Goal

- To test if the presence of a single spider and the presence of soil microbes affects plant growth.

Methods

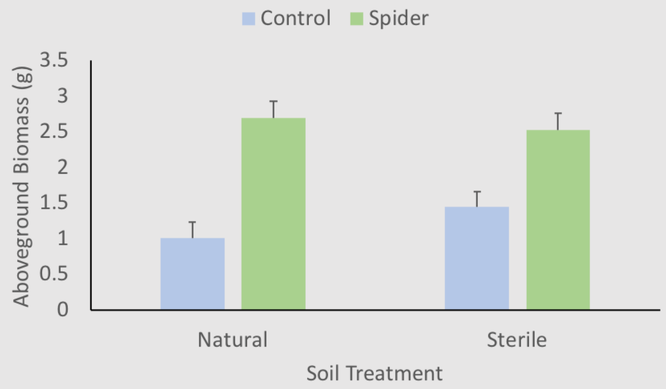
- We collected both soil and female Carolina wolf spiders (*Hogna Carolinensis*) from a field south of lake Carl Blackwell.
- Half of the soil was sterilized in an autoclave, the other half was left natural. Within the 2 groups of sterile and natural soil, some containers held spiders while others were left empty to act as controls.
- Spiders were fed for 2 months, then removed from their 1.1 L enclosures so the soil could be tested for respiration and plant growth.
- Soil respiration was tested by using a CO_2 analyzer.

FIG 1: Carolina Wolf spider rearing up on its hind legs in a defensive position

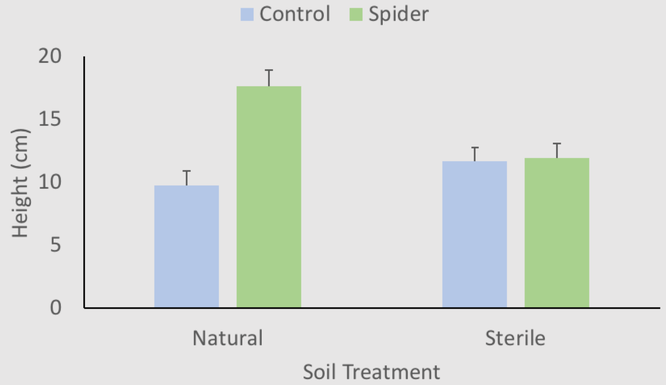
- Plant growth was tested by planting 2 seeds of Wisconsin fast plants in the rosette dwarf genotype (*Brassica Rapa*) in each soil container and allowing the plants to grow for 4 weeks.
- After 4 weeks the plants were removed and both plant height and number of flowers were measured.
- Data were log transformed and analyzed in 2 factor ANOVA.

Results

- Interaction between spiders and soil microbes affected plant mass, plant height, and the number of flowers produced.



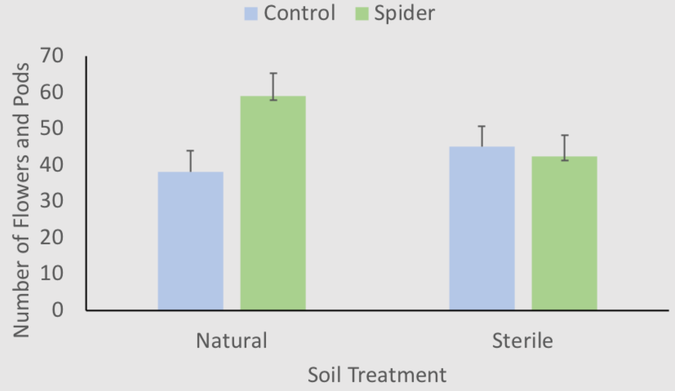
- **FIG 2:** Spiders and soil both affected plant mass. Spiders had a bigger effect on plants in natural soil.
(**Soil** $F_{2,10}$=2.72 **p**= 0.13, **Spider** $F_{2,69}$ = 44.96 **p**= 0.0001, **Interaction** $F_{2,65}$= 7.69 **p**= 0.01)



- **FIG 3:**The spider by soil interaction affected plant height. Spiders had a bigger effect on plants in natural soil.
(**Soil** $F_{3,14}$= 0.67 **p** = 0.42, **Spider** $F_{3,62}$=12.64. **p**=0.0007, **Interaction** $F_{3,61}$= 8.97 p= 0.004)

FIG 4:
(A) Natural soil spider inside of its enclosure.

(B) Rosette dwarf plants (*Brassica Rapa*) growing inside of their soil containers



- **FIG 5:** There was a trend for the spider by soil interaction to affect the number of flowers and seed pods on plants. Spiders had a bigger effect on plants in natural soil.
(**Soil** $F_{5,19}$ = 0.22 **p**=0.65, **Spider** $F_{5,54}$ =6.36 **p**= 0.01, **Interaction** $F_{5,52}$= 3.33 **p**= 0.07)

Conclusion

- Spider presence increased plant growth. This increase was great (i.e., the benefit was bigger) when natural soil microbes were also present.
- This research demonstrates that there are complex relationships between spiders and soil microbes that can have important effects for plant growth. However, many questions remain.

Ongoing Research

- How do spiders and soil interact to affect plant growth? What is the mechanism responsible?
  - ❑ One explanation is that spider excreta affects microbe communities.
    -how do microbe communities change in the presence of a spider?
  - ❑ Another explanation is that spiders add nutrients to the soil.
    -what nutrients are added?

Literature cited

Anderson, W. B., and G. A. Polis. 1999. Nutrient fluxes from water to land: Seabirds affect plant nutrient status on Gulf of California islands. Oecologia 118:324–332.

Hilderbrand, G.V., et al. 1999. Role of brown bears (Ursus arctos) in the flow of marine nitrogen into a terrestrial ecosystem.-Oecologia: 546-550

Nyffeler, M., and K. Birkhofer. 2017. An estimated 400-800 million tons of prey are annually killed by the global spider community. Science of Nature 104.

Vanni, M. J. 2002. Nutrient cycling by animals in freshwater ecosystems. Annual Review of Ecology and Systematics 33:341–370.

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