Modeling Food Web Interactions Based on Predator Movements and Habitat Use

Kaila Uyeda[1], Rebecca Everett[1], Amanda Laubmeier[2]

1. Haverford College, 2. Texas Tech University

Introduction

Pardosa spp (wolf spider) is a large ground-dwelling predator whose prey includes aphids, and other wolf spiders, and *Orius majusculus* (minute pirate bugs). Past research by Wootton et al. has modeled the relationships between predator species, their microhabitats, and prey using a trait-based Allometric Trophic Network (ATN) Model in order to study the influence of predator behavior on dynamic food webs. Four ATN models were generated and then evaluated for accuracy by conducting an experiment following the parameters of the model and comparing the predicted and observed abundances of predators at different locations within their cages [1]. Results demonstrated that predator interactions are determined by location and should be considered in the ATN model. Therefore, species-specific behavior should be considered, and *Pardosa* can serve as a model organism for behavior of large body mass, ground-dwelling predators. **We seek to better understand the movement patterns over time and between locations in cages of the predator *Pardosa* spp in order to inform behavioral interaction parameters in an ATN model.**

Data Collection

Experiments conducted by Wootton to test the ATN model consisted of placing one of four predators (large & small ground-dwelling and large & small foliage-dwelling) in a cage with barley, beans, or both. Cages were also created with two different ground-dwelling predator species (*Pardosa* and a beetle). Predators were randomly distributed within the cages.

Cages were observed for 8 days, and number of species present at each location was recorded each day. Data was organized by time of day (8-10am, 10am-12pm, 12-2pm, 2-5pm). Observations were not consistently recorded at the same time every day, and not every cage was observed during this time, resulting in discrepancies in number of predators counted at different time points.

Our research focused on *Pardosa* behavior because there were heightened abundances of *Pardosa* at two separate locations as opposed to a heightened abundance at one location for the rest of the predators.

Observed distribution of *Pardosa* over time

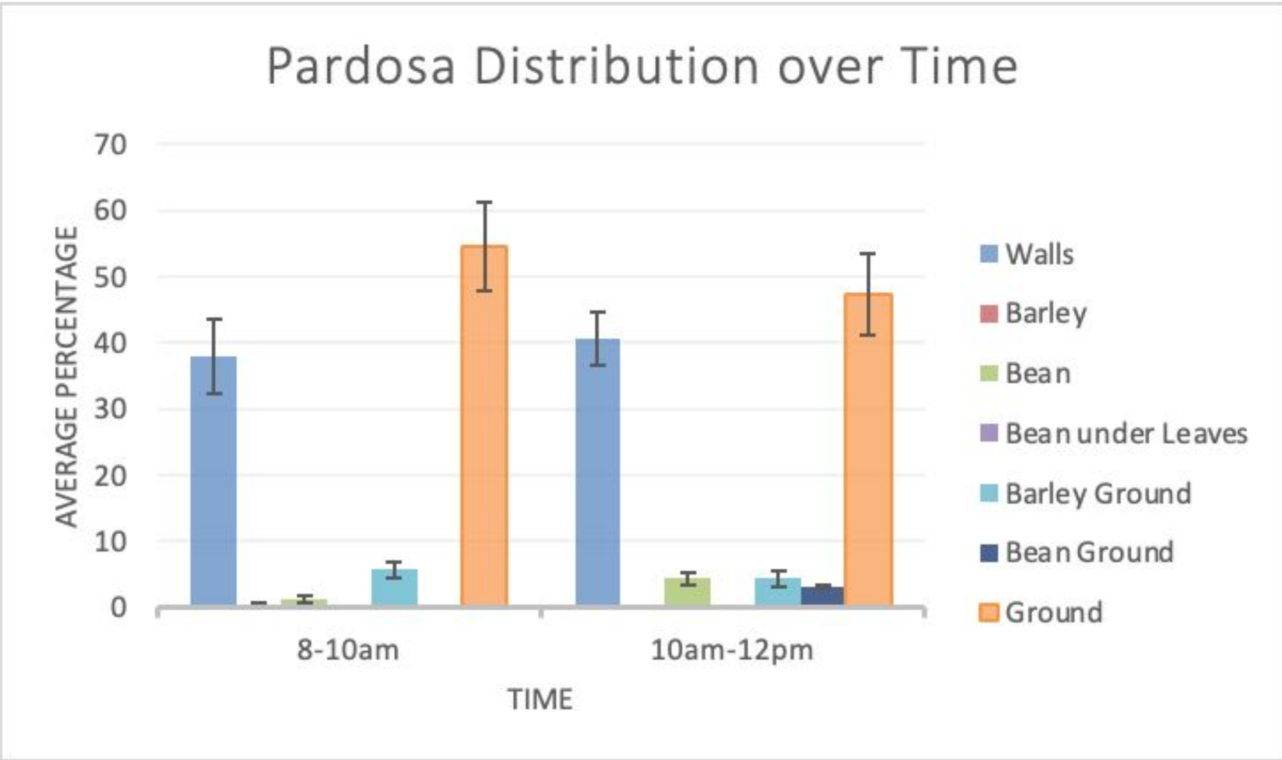

Figure 1. *Pardosa* location does not change much over time. For both time points, the percentage of *Pardosa* at each location was calculated for each of the four cages. Then we found and plotted the average of the four cage percentages in the 8:00-10:00am time point and the 10:00am-12:00pm time point. The error bars represent the standard error of the mean for each location at the two different time points.

- Over the 4 hour period of observation, the location of *Pardosa* did not significantly change, suggesting that *Pardosa* location is not influenced by time of day.
- Lack of change over time was also observed for the other three predator distributions.
- This data can be used to create a compartmental model using a system of ordinary differential equations with movement rates between habitats based on known average percentage equilibrium of *Pardosa* at varying locations in their cages.

Developing a model to predict predator movements

Schematic of Predicted Predator Movement between Locations

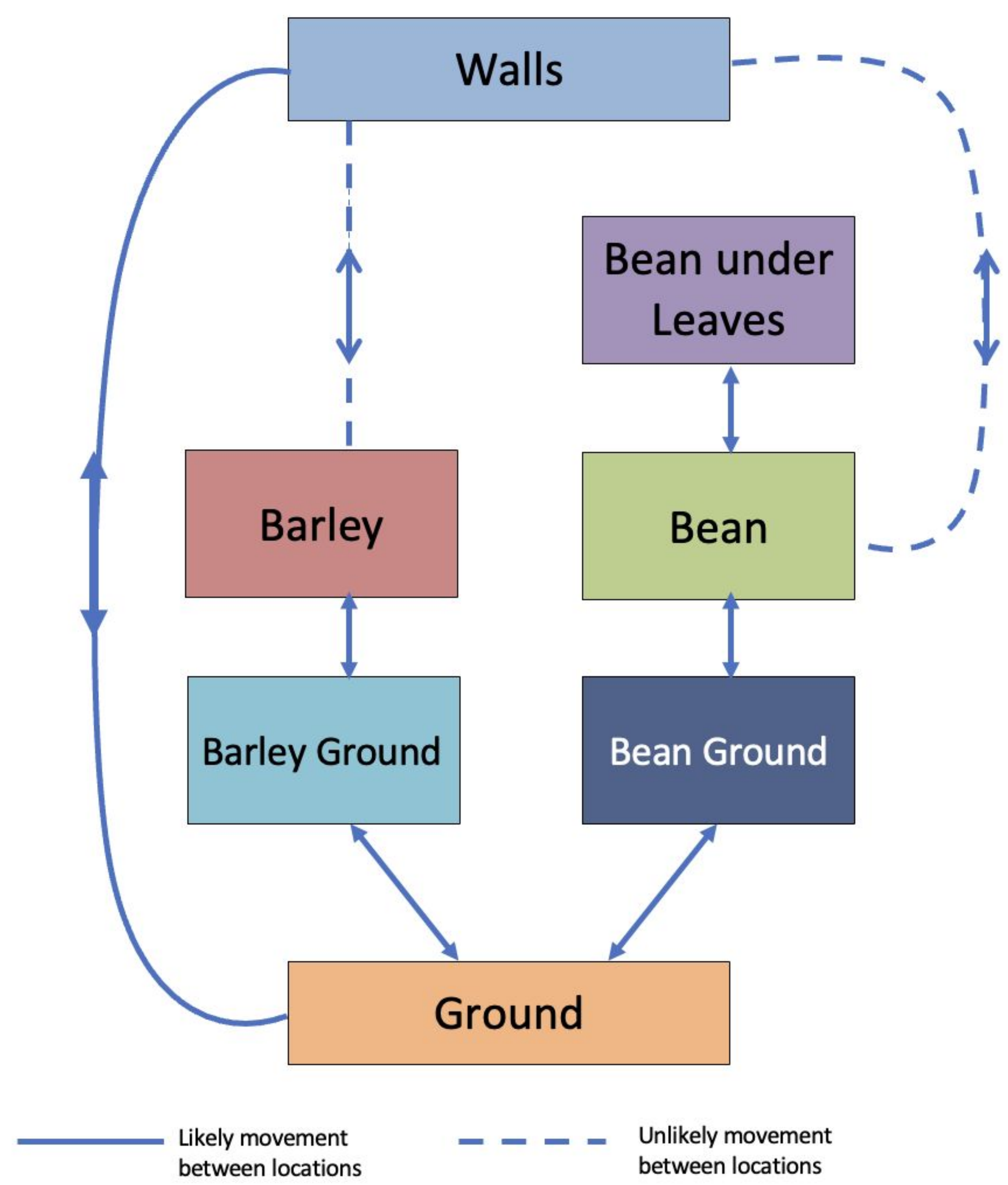

Figure 2. Predicted movement of predators to create model. The network demonstrates the expected movement of predators between locations in the cage that are physically connected. These relationships were developed based on the cage environment of experiments conducted by Wootton.

- Compartmental model representing *Pardosa* movement between locations shown in Figure 2. Arrows are associated with rate with model parameters at which *Pardosa* enters and exits locations, which forms a system of differential equations.

Pardosa distribution at equilibrium based on model

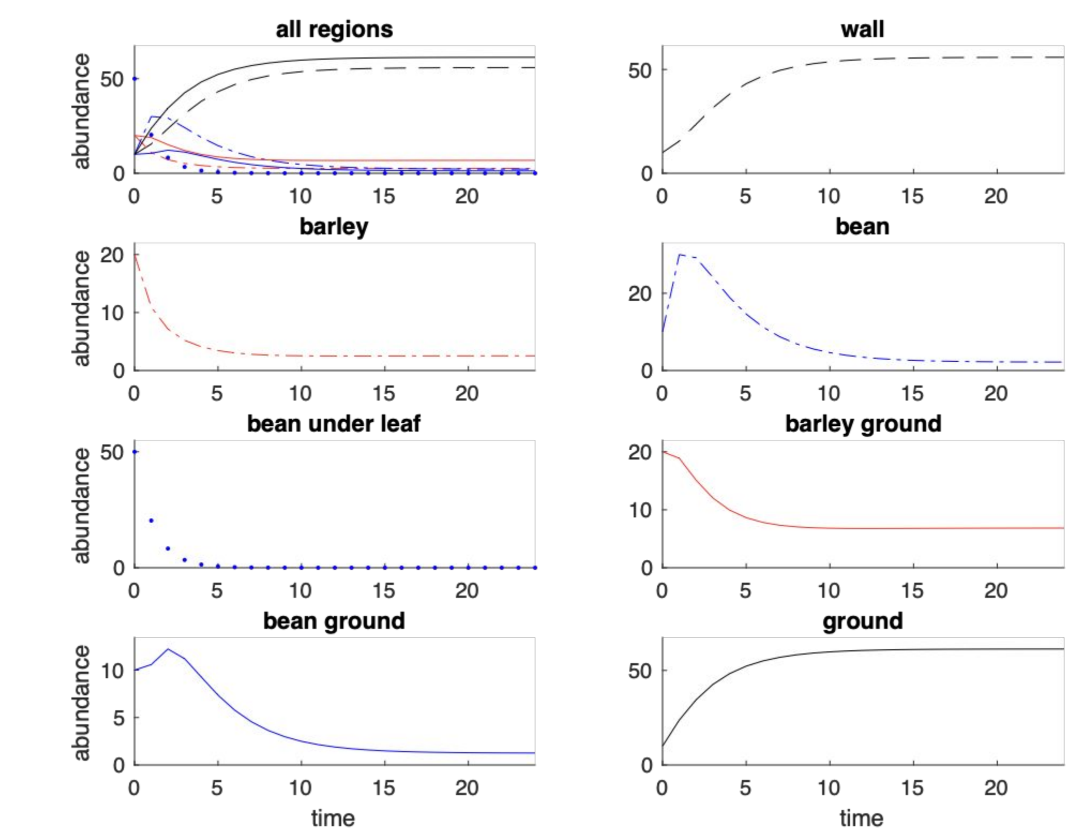

Figure 3. *Pardosa* has highest abundance at wall and ground at equilibrium. The rates of *Pardosa* movement between locations have a trajectory toward equilibrium of average percentage of *Pardosa* at each location. As time increases from t=0 to t=24 hours, the average percentage of *Pardosa* at each location stays constant from t=5 on. The wall and ground locations have the highest average percentage of *Pardosas* at equilibrium at ~55.90 and ~61.31, respectively.

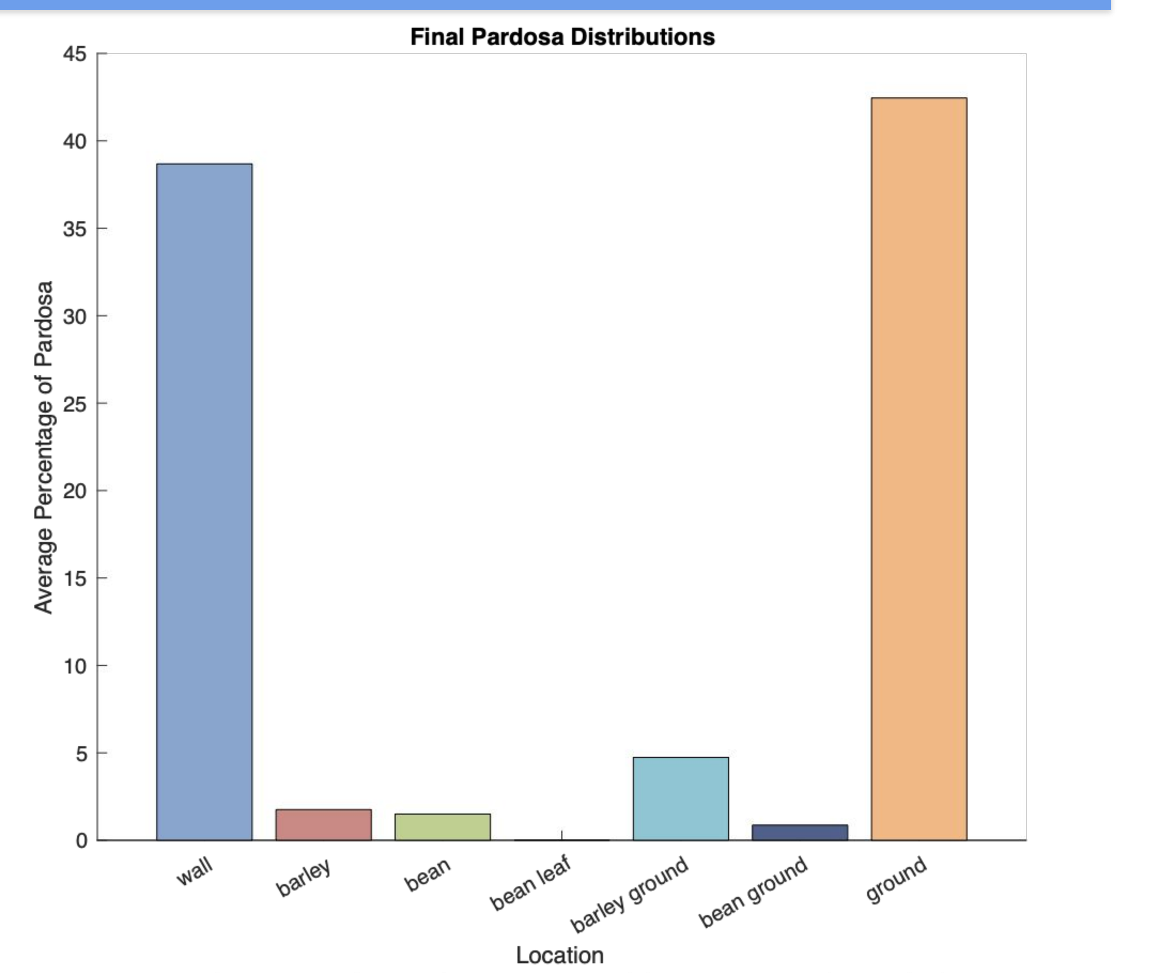

Figure 4. Distribution of *Pardosa* at equilibrium. Display of the equilibrium distribution of *Pardosa* determined by rate at which *Pardosa* enters and exits connected locations in its cage. The distribution of *Pardosa* is measured in average percentage of *Pardosa* at a specific location. This distribution matches the observed data.

- *Pardosa* movements modeled to result in equilibrium similar to that of the observed *Pardosa* distribution in Figure 1.
- Wall & ground are the locations with the greatest percentage of *Pardosa* present. This behavior is reflected in the increased rates at which *Pardosa* moved to walls and ground from other locations.
- There is also a strong interaction between walls and ground due to high rates of movement between the two locations. The final distribution is a result of movement to wall from ground at a rate of 0.65, and movement to ground from wall at a rate of 0.70.

Conclusions

Distribution of predator species across multiple locations in a cage does not change throughout the day. Since aphids are located on plants, it is likely that *Pardosa* travels to the plants to capture its prey and then returns to the walls or ground.

Change in location due to time of day is not a parameter that should be prioritized when creating an ATN model.

We now have a model for how *Pardosa* uses its cage, which demonstrates a specific behavioral interaction that can influence the parameters of the ATN model.

Potential to assist in accuracy of models in the long term based on better understanding of species specific behaviors.

Future Work

Future directions for this work include using this same method to identify the rate of movement of the other three predators used in the experiment: *C. septempunctata* (lady beetle), *O. majusculus* (minute pirate bug), and *Bembidion* spp (ground beetle).

Knowledge of this movement can result in incorporation of rate of movement into the behavioral interaction parameters established by Wootton et al. for their full ATN model.

Increased observations could allow for comparison of predator movement rates based on the different prey present.

Acknowledgements

We would like to thank Dr. Wootton for conducting the experiments and providing the observational data and background information that was used in this research.

References

1. Wootton, K. L., Curtsdotter, A., Jonsson, T., Banks, H. T., Bommarco, R., & Laubmeier, A. N. (n.d.). From theory to experiment and back again — Challenges in 2 quantifying a trait-based theory of predator-prey dynamics. *bioRxiv*. https://doi.org/10.1101/2021.05.06.442910
2. Schmitz, O. J. (2007). Predator diversity and trophic interactions. Ecology, 88(10), 2415-2436.