An Examination of the Impacts of Long Island Ant Species on Soil Nutrients

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Abstract

Ants change the nutrient levels in the soil surrounding their nests by competing with other organisms and producing wastes. This begs the question: how do different species of ants affect soil nutrient levels? This project aimed to answer this question by using DNA barcoding to identify the species of ants and examining the difference between ant nest soil nutrient levels and normal nutrient levels. Ants were captured using Petri dishes and their DNA was isolated and amplified for sequencing and comparison with soil nutrient levels. The data showed that certain nutrients were present in lower amounts in the nests of certain species. The data was inconclusive for one of the species. This suggests that certain ant species reduce certain soil nutrient levels.There were numerous opportunities for human error during the procedure due to errors and certain constraints. Nevertheless, it appears that certain ant species lower certain soil nutrients.

Introduction

The quality of soil is very influential to the environment and the things that live in that environment. Soil quality is very important in areas such as agriculture because organisms such as ants inhabiting the soil can influence the health and growth of the plants. A study was done at the Academy of Sciences of the Czech Republic to determine the impact of ants on soil fertility, which is relevant to the growing of food. The objective of this experiment was to determine whether or not there is a connection between the presence of ants and soil nutrient levels. It was found that ants actively alter the nutrient levels in the soil. This is supported by the fact that soil in active ant nests had different nutrient levels from the soil of surrounding areas and abandoned nests, which are similar. Since abandoned nests had nutrient levels similar to the surrounding soil, it was evident that it was the ants affecting the soil and not the other way around. This implies that ant populations are relevant to the agricultural productivity of the land that they inhabit. Therefore, it is possible that measures such as insecticides taken by farmers that harm or kill ant populations could reduce natural soil nutrient levels. (Dostal 1) Another study was conducted at the South Bohemian University to research the effects of ants on soil pH, particle displacement, biological processes, and decomposer communities inside the nest. It was found that ants affect many soil properties and are considered ecosystem engineers because of the changes they cause affecting the growth and yields of plants in farms by changing the soil they are growing in by competing with plants for needed nutrients and changing the grain size of the soil by sorting them by size. (Frouz 1)

Sample	Coordinates
001	40.7604°N, 73.6583°W
002	40.7606°N, 73.6581°W
003	40.7606°N, 73.6581°W
004	40.7608°N, 73.6578°W
005	40.761025°N, 73.657808°W
006	40.699173°N, -73.522457°W
007	40.699173°N, -73.522457°W
008	40.699173°N, -73.522457°W
009	40.699173°N, -73.522457°W
010	40.699173°N, -73.522457°W

Materials and Methods

Ants were collected from nests by placing a bait, such as sugar water at the bottom of a test tube and putting the opening of the tube over the opening of the nest. The ants were collected from ant nests by scooping them up with petri dishes as they exited the nest. Soil samples were collected from the soil of the nest and the area nearby. The ants and soil samples were collected from Herricks Pond Park, Theodore Roosevelt Memorial Park, and Forest City Community Park. The coordinates of each location were recorded along with the samples using Google Maps. It was necessary to find and collect ants from different nests, especially those that were phenotypically different, in order to ensure that the content of the soil was not what led to different types of ants being present there. The soil was analyzed using the Luster Leaf Rapitest Soil Test Kit. The volumes of each soil sample were measured, and dissolved in five parts water. The indicators for phosphorus, nitrogen, and potash were added into the solution in each respective comparator. The solutions were left to develop for 10 minutes and were photographed and analyzed. The ants were frozen to kill them. Next, small pieces of the ants such as legs were removed with tweezers. DNA was isolated from these pieces and the CO1 gene of the mitochondrial DNA was amplified by PCR. The amplified DNA was run on a gel to ensure that amplification was successful, and then the DNA was sent off for sequencing. The results of the DNA was analyzed using tools such as BLAST and used to identify the species of ants collected. The soil samples was organized according to the species of ant found there, and this was used in an effort to establish connections between different species of ants inhabiting soil and the levels of various nutrients in the soil. If there was a significant difference between the nutrient levels of the soil in the nest and the soil that was not a part of the nest, then this would indicate that the ants were affecting the nutrient levels of the soil.

Sample	Species	P(normal)	P(nest)	N(normal)	N(nest)	K(normal)	K(nest)
001	*Monomorium minimum(little black ant)*	Sufficient	Sufficient	Surplus	Sufficient	Sufficient	Surplus
002	*Formica subsericea (Field ant)*	Surplus	Sufficient	Surplus	Surplus	Surplus	Surplus
003	*Formica subsericea (Field ant)*	Sufficient	Sufficient	Sufficient	Surplus	Sufficient	Surplus
004	*Monomorium minimum(little black ant)*	Surplus	Surplus	Surplus	Surplus	Surplus	Surplus
005	*Prenolepis imparis (Small honey ant)*	Surplus	Surplus	Surplus	Sufficient	Surplus	Surplus
006	*Monomorium minimum(little black ant)*	Surplus	Surplus	Surplus	Surplus	Sufficient	Surplus
007	*Monomorium minimum(little black ant)*	Sufficient	Sufficient	Surplus	Surplus	Sufficient	Sufficient
008	*capensis formicin (black sugar ant)*	Surplus	Sufficient	Sufficient	Sufficient	Surplus	Surplus
009	*capensis formicinae (black sugar ant)*	Surplus	Surplus	Surplus	Surplus	Sufficient	Sufficient
010	*Monomorium minimum(little black ant)*	Sufficient	Surplus	Surplus	Surplus	Sufficient	Surplus

Discussion

The data seem to suggest that *Capensis formicinae* may slightly reduce phosphorus levels, *Monomorium minimum* may reduce potassium levels, and *Prenolepis imparis* may reduce nitrogen levels. However, the impact was not great, suggesting that the use of pesticides and insecticides will not change the nutrient content of the soil by much. However, the data on *Formica subsericea* was contradictory. This calls into question the validity of the other results of the experiment. This is especially true considering the fact that SYBR Green loading dye was accidentally added to all extracted DNA. SYBR Green interferes with the DNA sequencing process, and time constraints made it impossible for more DNA to be isolated. Therefore, the ants needed to be taxonomically identified by a group of people inexperienced in that discipline. Furthermore, the limited budget for the experiment led to the use of a soil tester that used a rather subjective method for determining nutrient levels. These create numerous opportunities for human error. Repetitions of this experiment should include more objective means of specimen identification such as DNA barcoding and more quantitative and precise measurements of soil nutrients. This would greatly reduce the dubiousness of the results of this experiment. Unfortunately, time and budgetary constraints made this impossible.

References

Dostal, Petr. "Ant-Induced Soil Modification and Its Effect on Plant below-Ground Biomass."*Pedobiologia*, Urban & Fischer, 3 Feb. 2005, www.sciencedirect.com/science/article/pii/S0031405604001404.

Farji-Brener, A G, and V Werenkraut. "The Effects of Ant Nests on Soil Fertility and Plant Performance: a Meta-Analysis." *The Journal of Animal Ecology.*, U.S. National Library of Medicine, July 2017, www.ncbi.nlm.nih.gov/pubmed/28369906.

Frouz, Jan. "The Effect of Ants on Soil Properties and Processes ." *Researchgate*, Sept. 2008, www.researchgate.net/publication/228499939_The_effect_of_ants_on_soil_properties_and_processes_Hymenoptera_Formicidae.

H., E. L., et al. "The Impact of Ants on Mineral Soil Properties and Processes at Different Spatial Scales." *Journal of Applied Entomology*, Blackwell Publishing Ltd, 9 Apr. 2008, onlinelibrary.wiley.com/doi/10.1111/j.1439-0418.2008.01281.x/abstract

Acknowledgements

We would like to thank Saint Dominic High School, especially Melissa Cipriano and Shana McNamee, for making the class in which this research took place possible in spite of faculty changes. In addition, we would like to thank the Cold Spring Harbor Laboratory, DNA Learning Center, and Dr. Sharon Pepenella for providing us with the education and resources used to barcode DNA and perform our experiment.

To view images of the samples, go to the Barcode Project Sample Database and look at the projects from Saint Dominic High School. The Project code is PWP.