The Variation in Biodiversity of Arachnids and Insects throughout the Northern and Southern Shores of Long Island due to Soil pH and Sediment Size

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ABSTRACT

Biodiversity is important to the health of all ecosystems. Since there are 950,000 identified species of insects and 40,000 identified species of arachnids, in the world they too are important to the health of an ecosystem (Danks, 2016; Blaze.com, 2014). As some ecosystem change, species are forced to evolve to survive. These organisms with the genetic factors allowing it to survive in the new environment can, over generations, evolve into their own distinct species. This speciation is a result of environmental differences such as sediment size, and soil pH.

Data from this experiment indicated that speciation has occurred within the insect population between the Northern and Southern Shores of Long Island. However, there was no evidence indicating that variation occurred among the arachnid population.

Research Questions & Hypothesis:

Research Questions:

1) Has speciation occurred in the Arachnid population of the Northern and Southern shores of Long Island?

2) Has Speciation occurred in the Insect populations on the Northern and Southern Shores of Long Island?

Hypothesis: Speciation has occurred between the insects and arachnids on the Northern and Southern Shores of Long Island due to environmental differences such as soil pH, sediment size,

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INTRODUCTION

When an ecosystem has a large variety of species inhabiting it is considered to be a biodiverse and healthy ecosystem. There are an identified 950,000 species of insects and there are 40,000 identified species of arachnids. Insects and arachnids can be found on every continent except Antarctica (Danks, 2016; Blaze.com, 2014). Since insects and arachnids of very geographically widespread the are integral to the health of an ecosystem.

Insects are crucial to the health of an ecosystem because many are detritivores, meaning they eat decaying organic matter. This speeds up the decaying process which fertilizes the soil. They also pollinate the plants which provide the produce supplementing the diets of millions around the world (Purdue, 2014), without them there would be widespread famine.

Arachnids are also crucial to the health of an ecosystem and therefore humans because they are carnivores, which makes them biological controls (Levi, 2001). This means that they limit the spread of diseases that can harm the human population such as West Nile Virus and Eastern Equine Encephalitis by limiting the population of mosquitos carrying said diseases.

Speciation occurs when an organism is reproductively isolated in a different environment. As they continue to reproduce they will eventually become their own distinct species(Understanding Evolution Team, 2015). Evidence indicates that the environments on the Northern and Southern Shores of Long Island differ in soil pH and sediment size. These differences could cause speciation to occur in the insect and arachnid species on the Northern and Southern Shores of Long Island.

The biodiversity of insects and arachnids are crucial to the health of the ecosystems on the Northern and Southern Shores of Long Island. Without insects and arachnids the ecosystems would collapse, and that collapse would impact the surrounding ecosystems, throwing off the dynamic equilibrium for the region.

MATERIALS & METHODOLOGY

20 insect and arachnid samples will be collected from various locations on the Northern and Southern Shores of Long Island. Once retrieved they will be placed in a clean Ziploc bag and placed in the freezer. Their GPS coordinates will be recorded at the time of collection and soil samples will be collected.

The process followed to obtain DNA barcodes is outlined by Cold Springs Harbor Laboratory. The DNA extraction and PCR analysis will be done in school. PCR is done by putting a DNA sample from the insect or arachnid into the PCR vial, as well as placing the CO1 primer, and DNA polymerase, which is an enzyme. The CO1 gene is added to amplify the CO1 gene. This vial was then placed into a thermocycler. Inside the thermocycler the strands of DNA will be heated to 95 degrees Celsius. At this temperature the DNA strands begin to denature and separate. Following this the samples are cooled down to 60 degrees Celsius, and it's at this temperature that the DNA primers can anneal to the individual DNA strands. The next step in PCR is the reheating of the DNA sample to 75 degrees Celsius, this is when the polymerase enzyme adds bases to the primer segments to build a completed, 2 strand, DNA segment.

Once the DNA has been amplified using PCR Gel Electrophoresis is used to determine if the sample of DNA is a good sample. This sample is represented as being a dark band when placed under an ultraviolet light. For Gel Electrophoresis the first step was to pour and create the gel. Once that was done the amplified DNA was pipetted into the wells, as was the primer (control) and a ladder. Then an electrical current is applied to the gel. This current pushes the DNA and the control out of the wells and down the gel. This movement is made possible due to the porous nature of the gel. Smaller DNA strands will move further down the gel than larger ones.

These samples were then sequenced by Genewiz, then it was analyzed using DNA Subway, a DNALC bioinformatics tool, to determine if speciation had occurred among the arachnid and insect populations on the northern and southern shores of Long Island.

This experiment will confirm whether or not speciation has occurred in the insect and arachnid populations between the Northern and Southern Shores of Long Island due to environmental differences such as sediment pH and sediment size.

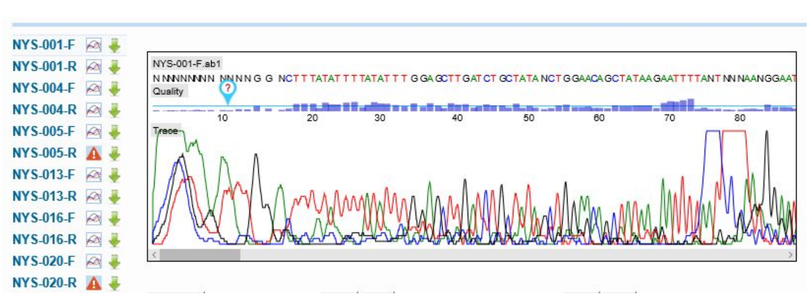
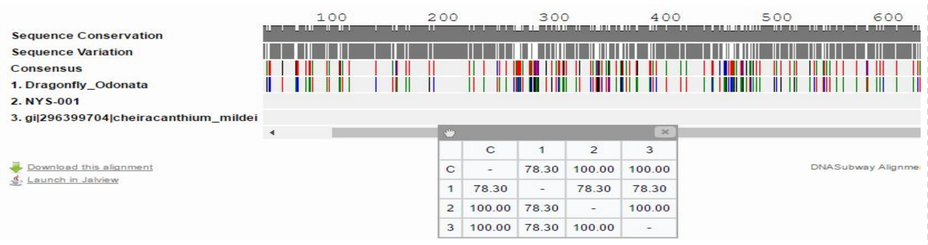


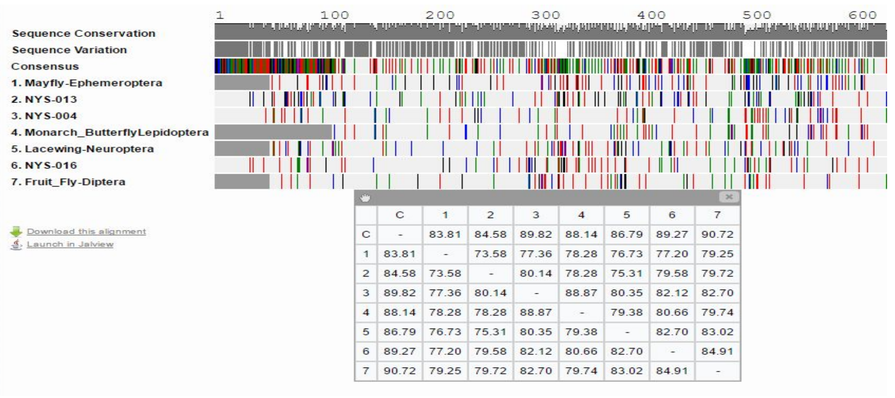
Figure 1: A phred score indicates how sure the computer from DNA subway is that the nucleotide listed in the DNA sequence is the correct one. The blue line indicates a phred score of 20, and is the phred score is above that line then the nitrogenous base is accepted as correct. There were very few insects or arachnids with low phred scores in this experiment.

RESULTS



	C	1	2	3
C	-	78.30	100.00	100.00
1	78.30	-	78.30	78.30
2	100.00	78.30	-	100.00
3	100.00	78.30	100.00	-

Figure 2: This is a barcode comparing an arachnid sample (NYS-001) to a common insect (Dragonfly_Odonata). This barcode indicates that the arachnid's DNA sequence is 78.3% similar to the DNA sequence of the Dragonfly. The colored bars indicate differences in the DNA sequences, and the gray indicates similarities in the DNA sequences.



	C	1	2	3	4	5	6	7
C	-	83.81	84.58	89.82	88.14	86.79	89.27	90.72
1	83.81	-	73.58	77.36	78.28	76.73	77.20	79.25
2	84.58	73.58	-	80.14	78.28	75.31	79.58	79.72
3	89.82	77.36	80.14	-	88.87	80.35	82.12	82.70
4	88.14	78.28	78.28	88.87	-	79.38	80.66	79.74
5	86.79	76.73	75.31	80.35	79.38	-	82.70	83.02
6	89.27	77.20	79.58	82.12	80.66	82.70	-	84.91
7	90.72	79.25	79.72	82.70	79.74	83.02	84.91	-

Figure 3: This barcode demonstrates the similarities and differences, in the DNA sequences, between the insect samples collected and those in the database. The data table reveals the similarity percentage between the samples collected (NYS-004-NYS-016) and those in the database. The higher the percent of similarity the more closely related the organisms are.

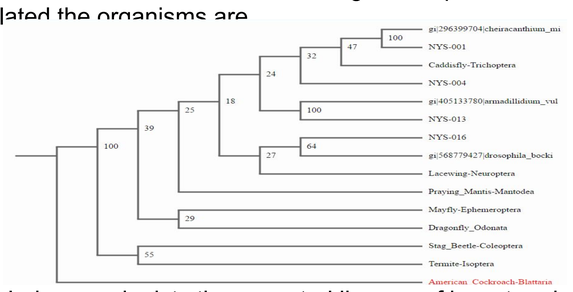


Figure 4: This cladogram depicts the ancestral lineage of insect and arachnid samples collected in comparison to one another. This cladogram indicates that sample NYS-005 (which couldn't be positively identified due to the inability to get a full sequence, but it was an arachnid) and sample NYS-001 (Cheiracanthium mildei) are most closely related and were matched together in this cladogram 100% of the time. Also NYS-016, a sample which was believed to be an earwig, was most closely related to drosophila bocki, which is a fly, and sample NYS-013 was most closely related to armadillidium vulgare.

The soil samples collected along with the insects and arachnids revealed that the Northern Shore of Long Island has sediment of a larger size, mainly sand and pebbles with a few cobbles, while the sediment from the Southern Shore has mainly silt and sand, with a few pebbles.

Since both shores receive the same amount of acid rain their pH's should be similar, but sea spray can also have an effect on the soil's pH by making it more basic (Hansen, Gilbert). Soil collected with the insects and arachnids from the Southern Shores pH ranged from 4.8 to 5.33, and the soil collected with the samples from the Northern Shore was 6.22.

After using Polymerase Chain Reaction (PCR) and Gel electrophoresis, as outlined in the Methodology section, DNA sequences for 6 were obtained. In comparison to insects previously in the databank, the insects and arachnids from the Northern and Southern Shores of Long Island had 70%-80% matches in their DNA sequences. Indicating that they weren't completely similar to one another, but that they are related in some way.

The cladogram expresses that the 6 samples are all related, which was predicted since all the bugs native to Long Island appeared around the same time, as the Laurentide Ice Sheet finally retreated. This also caused the differences in sediment size on the Northern and Southern Shores of Long Island.

Discussion and Conclusion

It was hypothesized that the differences in both sediment size and soil pH caused speciation to occur with the insect and arachnid populations on the Northern and Southern Shores of Long Island. To test this hypothesis a total of 20 insects and arachnid samples were collected (12 insects, 8 arachnids).

Data from this experiment indicates that speciation has occurred in the insect samples collected (Understanding Speciation Team, 2015). A new DNA sequence was found in this experiment. The sequence belongs to *Anisolabis maritima*, which is believed to be a novel species. This indicates that speciation may have occurred due to variation in the environment in which earwigs are found. The nucleotide sequence was put into NCBI genbank and Bold databases with no results appearing.

However, there is no evidence indicating that speciation had occurred in arachnid population on the Northern and Southern Shores of Long Island, despite there being environmental differences. However, the number of samples tested was small, meaning that whether or not speciation has occurred in the arachnid population on the Northern and Southern Shores of Long Island needs further investigation.

FUTURE IMPLICATIONS

To improve the research for the next trial it would be beneficial to gather more samples. On top of gathering more samples it would be beneficial to gather more information on the soil and the environments the samples were gathered in such as, air and soil temperature, relative humidity and other plants in the area. This data would be beneficial because it would allow the researcher to determine that it was the environments that caused the speciation and that it wasn't another factor.

This experiment should be repeated in order to verify that the hypothesis was correct, and to ensure that the answers aren't only achievable once. A second reason why this experiment should be repeated is because the results will get more accurate with every trial, therefore, if you want accurate results the experiment must be repeated.