Assessing Ant Biodiversity in New York State and Detection of Introduced Species

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SCIENCE SANDBOX

Abstract

Ants are one of the most diverse groups of animals with over 13,000 named species around the world, and they perform critical roles in ecosystems, such as mixing and aerating soils, preying on pests, and dispersing seeds. Furthermore, their interactions with abiotic and biotic factors are vital to the sustainability of life. The purpose of our project was to identify the species composition of the ant community in several city parks of Queens, NYC. However, due to a failure in our PCRs, we devoted our efforts to assess the diversity of ants in the state of New York based on DNA sequences published on the GenBank and BOLD (The Barcode of Life Data System). We found 42 published records, with nine species, out of which, seven were native to North America and two were introduced. Despite the challenges in amplifying DNA and because of the dearth of studies on ants in New York City, we feel motivated to try to find more ants and be able to study them using the DNA barcoding method.

Introduction

Ants are insects that belong to the family Formicidae (Hymenoptera), and they are not only abundant in terms of number of species but also in term of their biomass, as they are estimated to contribute 15–20 % of terrestrial animal biomass, greatly exceeding that of vertebrates[2]. In addition, ants play important roles in ecosystems that are vital to the sustainability of life[3].

Surprisingly, there is a dearth of studies about the diversity of ant species in New York City, and even about the presence of invasive ant species. In a metropolis such as New York City, with the heavy traffic of humans and goods from all over the world, the presence of exotic species is very likely. Knowing about the native diversity of ant communities and the potential impact of invasive species is of crucial relevance for local environmental organizations and policy makers.

The initial purpose of our project was to identify the species composition of the ant community in several city parks of Queens, NYC. However, due to a failure in our PCRs, we devoted our efforts to assess the diversity of ants in the state of New York based on DNA sequences published on the GenBank.

Materials & Methods

Our group collected ant specimens in Flushing Meadows Corona Park, Baisley Pond Park, Elmhurst Park, and Roy Wilkins Park on two different days in December 2021 and March 2022. We used bait traps and beat sheeting as methods to capture the ants. Total DNA was extracted from the specimens using the Zymo Research Quick-DNA Tissue/Insect Miniprep Kit. PCR reactions were performed. However, we failed to amplify mitochondrial genes to determine the species identity of the collected samples. This failure could be due to several reasons, such as a low quantity of DNA; yet these challenges are what makes science advance because it allow us to ponder and to reevaluate the focus of future experiments.

Therefore, we approached this project in a different way. We searched the NCBI database and BOLD (The Barcode of Life Data System; www.barcodinglife.org). We selected cytochrome oxidase genes for all the ant records collected in New York State. We aligned the sequences using the online version of Clustal Omega[5], a software that align multiple sequences from a series of pairwise alignments (https://www.ebi.ac.uk/Tools/msa/clustalo/). With the aligned sequence matrix, we estimated a phylogenetic tree of the ant Cytochrome c oxidase I gene (COX1) using the IQ-TREE2[6] software, and we calculated a 1000 non-parametric bootstrap support of the nodes of this tree. These nodal supports were estimated using the ultrafast bootstrap approximation ('-B' option) with the additional control option '-bnni' to reduce the risk of overestimating branch supports due to severe model violations. Finally, we used the MI Map Tools-GeoPlotter to create a map and visualize the locations where the specimens with COX1 data were collected in NY state (https://mobisoftinfotech.com/tools/plot-multiple-points-on-map/).

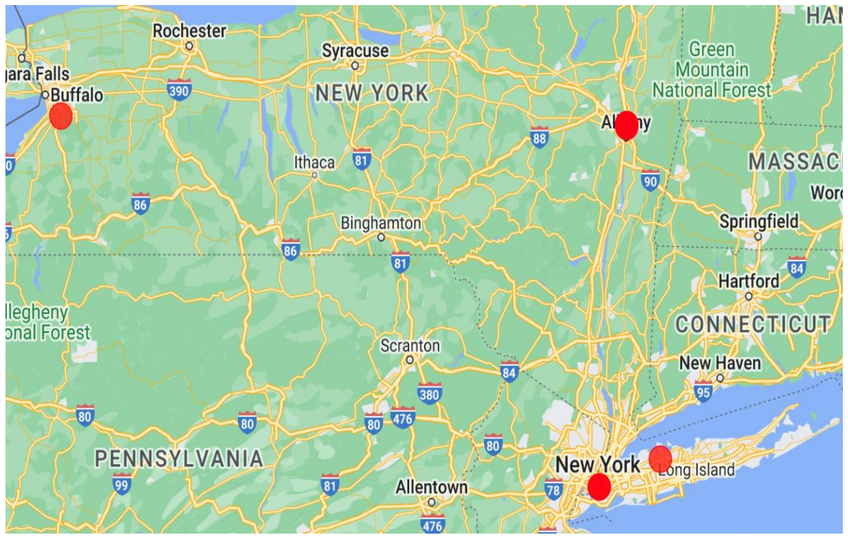

Figure 1: Map of the collection locations in New York State. Red dots indicate areas where samples had coordinates associated with COX1 sequences

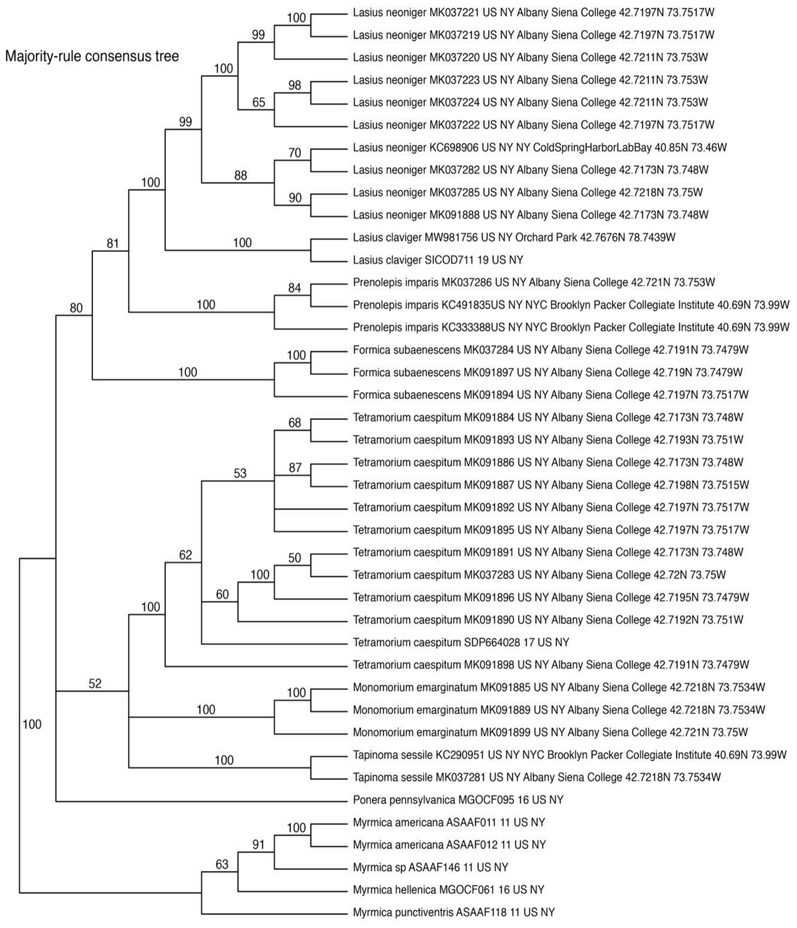

Figure 2: Phylogeny of the ants of New York State present in the GenBank and BOLD databases. Nodal support with a value >75 is considered strong and all values <50 are indicated as collapsed nodes

Results

We found 42 records published in the GenBank and, of these records, 37 had species names that correspond to 9 species. The vouchers are deposited in five institutions, such as Universite du Quebec a Chicoutimi, the Smithsonian Institution and the National Museum of Natural History. The location of the specimen collections can be seen in Figure 1.

The phylogeny of these species is provided Figure 2. The species found were the following: *Tetramorium caespitum* (12 records), *Lasius neoniger* (10), *Monomorium emarginatum* (3), *Formica subaenescens* (3), *Prenolepis imparis* (3), *Tapinoma sessile* (2), *Lasius claviger* (2), *Ponera pennsylvanica* (1), *Myrmica hellenica* (1), and five records of unspecified ants that were mined from the GenBank.

Most of the species found in these records are native to the United States[7-13], with the exception of *Tetramorium caespitum* and *Myrmica hellenica*. The former is a Eurasian species with a wide distribution in its native area. In North America, it seems to be part of a complex and can sometimes be confused with *Tetramorium immigrans.* Therefore, with the little data available, it is difficult to say if the records correspond to the native or the exotic species[14-16]. *Myrmica hellenica* is an introduced species from Eastern Europe[17]. Based on the characteristics of this species, that is, its relative abundance and the number of European countries where it is found, we could say that this species can occupy a wide range of temperate conditions, which could result in a widespread distribution in the state of New York.

Discussion

Ants form matriarchal societies that, in certain ways, resemble human societies, for example by creating infrastructures, traffic laws and even, some of them, have been farming much earlier than humans existed on the planet[18,19]. Ants perform crucial ecological roles and, with the exception of the Artic, Antarctica and the oceans, these creatures can be found everywhere on the planet, even on tiny islands far away from major continents.

Currently, most of the known ant diversity in New York City comes from dubious websites of exterminator companies and a few literature accounts[20]. Our team explored the Flushing Meadows Corona Park, Baisley Pond Park, Elmhurst Park, and Roy Wilkins Park. However, due to our failed PCRs reactions, we were unable to assess which species our samples belonged to. We were not discouraged by this negative result. These challenges are actually common when doing science and when trying to understand the world. Instead, we feel motivated to collect more ants in the future. According to the US 2020 census, there are 8.38 million humans in New York City, and it is very likely that the number of ants greatly surpass that of humans. Therefore, it would be humbling and pertinent to have a more thorough knowledge of our fellow ant New Yorkers.

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