Weeding out the Weeds: Mitigating the ecological impact of weedy invasive plant species collected in New York City by encouraging harvest and exploring potential medicinal uses

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ABSTRACT

Invasive plant species are non-native (or alien) plants that cause disruptions in native ecosystems, however their uses in medicine are largely understudied. In this study, we collected plant species in New York City as part of a foraging tour by Steve Brill who specializes in discovering culinary uses for invasive plants, as well as plant species within the students' neighborhoods (Sunset Park, Brooklyn & East Village, Manhattan). We used DNA barcoding to confirm the taxonomic identity of these plants and determined if they are indeed invasive species. We also conducted antibacterial and antioxidant assays to explore potential medicinal uses. Our goal was to encourage the harvest and use of these invasive plants for medicine and food to consequently help mitigate their harmful ecological impact. We were able to successfully barcode a total of 12 samples, 7 considered noxious weed species by USDA, but with antibacterial and/or antioxidant activity including *Aegopodium podagraria* (goutweed, Apiaceae), *Alliaria petiolata* (garlic mustard, Brassicaceae), *Allium vineale* (field garlic, Amaryllidaceae), *Ficaria verna* (lesser celandine, Ranunculaceae), *Galinsoga parv*iflora (quickweed, Asteraceae), *Glechoma hederacea* (ground ivy, Lamiaceae), and *Lamium amplexicaule* (henbit, Lamiaceae). We recommend foraging/harvest of these invasive weed species to reduce their harmful ecological impact, though caution must be exercised with garlic mustard and lesser celandine because of potentially toxic effects.

INTRODUCTION

- There are approximately 50,000 non-native plant species in the US, with around 4,300 considered as invasive. Specifically in New York State, there are over 74 species of prohibited and regulated invasive plants.
- Seeds of invasive plants can be carried and distributed by birds, winds, or humans, and typically have advantages to "invade" such as producing large quantities of seed, aggressive root systems, and inhibiting the growth of other plants around them. This often leads to them competing with native plants in the area for resources such as sunlight, nutrients, and space.
- Because of decreased plant diversity, poor agriculture, increased soil erosion, and degraded wildlife habitats, damages caused by invasive plants to the US economy are estimated to be more than $120 billion dollars annually.
- In the US, invasive species have contributed to the decline of 42% of endangered and threatened species, with invasive species being the main cause of decline for 18% of endangered species.
- Herbal medicine is medicine derived from plants and is used as the primary means of healing in developing parts of the world. If invasive plant species could serve as a hidden resource for promoting human health, their harvest for medicinal purposes could be a way of mitigating the harmful ecological impacts of invasive plants.
- As part of UBRP, we DNA barcoded a total of 22 plant samples, determined if they were invasive or not, then tested for antibacterial an antioxidant activities. Our goal was to encourage the harvest and use of these invasive plants for medicine and food to consequently help mitigate their harmful ecological impact.

MATERIALS & METHODS

- Twelve plant samples were collected from Central Park as a part of Wildman Steve Brill's foraging tour https://www.wildmanstevebrill.com/, in addition to 10 plant samples collected by the UBRP students in their respective neighborhoods (Sunset Park, Brooklyn & East Village, Manhattan).
- Using Qiagen DNeasy Plant Mini Kit for samples collected at Central Park and the Chelex DNA isolation protocol for plant samples collected by the students, plant DNA was extracted from the samples. Primers for the nuclear internal transcribed spacer-2 (ITS2) were then used for PCR amplification following the same methodology in Molina et al. (2018). The PCR products were purified using ExoSAP-it and submitted to Genewiz Inc. (South Plainfield, NJ) for Sanger-based DNA sequencing.
- Sequences were analyzed using the "blue line" workflow in DNAsubway (https://dnasubway.cyverse.org/), where we trimmed undesirable parts of the sequence and compared the resulting sequences to a list of possible hits sorted by pairwise identity. The higher the pairwise identity, the more likely the sample was the same as the species in the Genbank database. DNA sequences were also edited and analyzed using Geneious 11.1.5 (Biomatters Inc), following the methods in Molina et al. (2018) for verification.
- We also made herbal tinctures of each plant sample by pulverizing dehydrated plant samples and adding 40% ethanol in order to test for antibacterial and antioxidant activity within the extracts. In the antibacterial assay, saliva was added to the nutrient agar as a source of bacteria with the plant extract, to test if bacterial growth would be inhibited. Scoring of antibacterial activity is shown in (Fig. 1). The antioxidant assay, on the other hand, was colorimetric, such that those with antioxidant effects dramatically changed the color from dark green to any clear or non-green color. Scoring of antioxidant activity is shown in (Fig. 2).

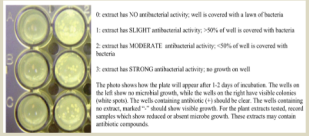

Fig. 1. Scoring of antibacterial activity of plant extracts (Graf et al. 2016). Wells with minimal/no bacterial growth have strong antibacterial activity.

Fig. 2. Scoring of antioxidant activity of plant extracts (Graf et al. 2016). Wells with strong antioxidant activity show a color change from dark green to clear/non-green color.

Common name	Species ID	Pairwise identity with Genbank top hit	Family	Native distribution	Assay results (see Fig. 1 and 2 for interpretation)
Goutweed	*Aegopodium podagraria**	99.78%	Apiaceae	Europe	Antibacterial score: 2 Antioxidant score: 0
Snakeroot	*Ageratina altissima*	100%	Asteraceae	North America	Antibacterial score: 1 Antioxidant score: 2
Field Garlic/Wild Garlic	*Allium vineale**	99.57%	Amaryllidaceae	Europe, NW Africa Middle East	Antibacterial score: 2 Antioxidant score: 0
Honewart	*Cryptotaenia canadensis*	100%	Apiaceae	North America	Antibacterial score: 2 Antioxidant score: 0
Quickweed	*Galinsoga parviflora**	96.79%	Asteraceae	South America	Antibacterial score: 2 Antioxidant score: 0
Ground Ivy	*Glechoma hederacea**	100%	Lamiaceae	Eurasia	Antibacterial score: 2 Antioxidant score: 3
Bergamot	*Monarda fistulosa*	97.55%	Lamiaceae	North America	Antibacterial score: 2 Antioxidant score: 3
Sheep Sorrel	*Rumex acetosella*	98.93%	Polygonaceae	Eurasia	Antibacterial score: 1 Antioxidant score: 2
Ginkgo	No barcode obtained	N/A	Ginkgoaceae	Asia	Antibacterial score: 2 Antioxidant score: 3
Wood Sorrel	No barcode obtained	N/A	Oxalidaceae	North America	Antibacterial score: 1 Antioxidant score: 2
Epazote	No barcode obtained	N/A	Amaranthaceae	Central & South America	Antibacterial score: 2 Antioxidant score: 0
Lamb Quarter	No barcode obtained	N/A	Amaranthaceae	North America	Antibacterial score: 1 Antioxidant score: 0

Table 1. Samples collected as part of Steve Brill's foraging tour in Central Park (Manhattan, NY). Some were not barcoded successfully with their taxonomic identity as presented in the table, based on Brill's identification in the field. Those marked * are considered noxious weed species by USDA (https://plants.usda.gov/home), have been successfully barcoded and found to have medicinal potential and discussed further (images below).

Aegopodium podagraria

Allium vineale

Galinsoga parviflora

Glechoma hederacea

Sample Name	Top species hits	Pairwise identity with Genbank top hit	Family	Native distribution	Assay results (see Data Interpretation Plan)
M5 (garlic mustard)	*Alliaria petiolata**	96.11%	Brassicaceae	Eurasia	Antibacterial score: 1 Antioxidant score: 3
D1 (lesser celandine)	*Ficaria verna**	99.29%	Ranunculaceae	Eurasia	Antibacterial score: 1 Antioxidant score: 3
M3 (Korean Iris)	*Iris koreana*	98.59%	Iridaceae	Asia	Antibacterial score: 1 Antioxidant score: 3
D2 (henbit)	*Lamium amplexicaule**	97.24%	Lamiaceae	Europe	Antibacterial score: 1 Antioxidant score: 3

Table 2. Samples collected by UBRP student participants within their neighborhood. Those marked * are considered noxious weed species by USDA (https://plants.usda.gov/home), have been successfully barcoded and found to have medicinal potential and discussed further (images to the right).

RESULTS & DISCUSSION

- There were 12 samples collected as part of Steve Brill's foraging tour, 8 of which were successfully barcoded, and four were classified as noxious weeds by USDA (Table 1). Noxious weeds decrease biodiversity, reduce yield and quality of crop collection, and can poison livestock in agricultural spaces. However, these species were determined to have antibacterial properties based on our assay. *Allium vineale* was found to be antibacterial by Durmaz et al. (2006) and high levels of allyl polysulfides may be responsible (Satyal et al. 2017). *Aegopodium podagraria,* on the other hand, is known contain polyacetylenes (falcarinol and falcarindiol) as well as essential oils and coumarins and polyphenol compounds that may have anti-inflammatory and antimicrobial properties (Jakubczyk et al 2020). The third noxious weed, *Galinsoga parviflora*, was found to possess antibacterial and antifungal properties possibly from any of its isolated phytochemical components (Mostafa et al. 2013). Kumarasamy et al. (2002) confirmed the antibacterial and antioxidant activity of the noxious weed *Glechoma hederacea*, possibly due to flavonoids, phenyl propanoids, saponins and terpenoids present. Based on our assay and literature analysis, we found that *Allium vineale* (field garlic), *Aegopodium podagraria* (goutweed), *Galinsoga parviflora* (quickweed), and *Glechoma hederacea* (ground ivy) have medicinal potential and can be foraged as herbal medicines for their antibacterial activity with no known poisonous effects when consumed appropriately (Brill pers. comm.).
- As UBRP students, we also collected 10 samples around our respective neighborhoods, but only 4 we were able to successfully barcode. Three are considered noxious weeds (Table 2). None of the 4 samples showed antibacterial properties but all showed strong antioxidant effects based on our assay. *Ficaria verna* was studied to be strongly antioxidant possessing quercetin flavonoids (Hădărugă 2012). However, it can be toxic when consumed raw and can be fatal to grazing animals (Post et al. 2009). Species of *Lamium* including *L. amplexicaule* have been found to have medicinal properties including strong antioxidant activity perhaps due to its flavanol glycosides (Salehi et al. 2019). The young leaves and shoots can be eaten raw or cooked (Elias et al. 2009) *Alliaria petiolata* was found to possess flavone 6-C-glycosides with strong antioxidant potential (Kumarasamy et al. 2004). Garlic mustard has long been used as a spice in Europe and was introduced into the New World as a garlic-type flavoring. The chopped leaves can be used as flavoring in salads and sauces. However, it contains traces of cyanide that may be toxic when eaten raw or in large amounts, but blanching could get rid of the cyanide (Taft 2017).

Alliaria petiolata

Ficaria verna

Lamium amplexicaule

- In this study we were able to taxonomically verify the species identity of invasive noxious weed species through DNA barcoding. We were also able to determine their medicinal potential using antibacterial and antioxidant assays. We encourage the foraging of these species for use as herbal medicine and/or food, as well as further pharmaceutical studies, to potentially mitigate their harmful ecological impacts in New York City.

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