Comparison of the Soil Microbiomes of *Delairea odorata* and California Native Plants

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Abstract

Microbes, the unseen majority, compromise a large portion of the soil, yet we know very little about their impact on the ecosystem. Invasive plants alter the ecosystem by competing with native plants and altering habitat and food sources for consumers in the food chain. *Delairea odorata* (Cape Ivy) is a native vine from South Africa that was brought to California in 1950s. As a perennial vine, Cape Ivy is considered a serious threat with severe ecological impacts. Its population exponentially increases and kills native plants by covering their light source, preventing photosynthesis. The goal of this research is to learn more about the soil microbiome of Cape Ivy to explain its high adaptability to a foreign environment and to eventually develop effective eradication measures. Through community level profiling (CLPP), diversity of organisms in the Cap-Ivy soil was compared to soil without Cape Ivy. Both soils contain microorganisms that use 7 carbon sources however, Cape Ivy contains more organisms that use those carbon sources, especially dicarboxylic acids. Cape-Ivy soil contained 12.6% more soil moisture content in comparison with the 7.2% of control soil. Differences in microbial metabolism were observed. This results suggest that Cape Ivy's rich and diverse soil microbiota potentially aid in the invasive plant's survival and ability to out-compete our native plants.

Aim

The aim of this research is to compare the soil microbiota of Cape Ivy to the soil microbiota of native plants.

Background

- Cape Ivy (**Figure 1**) is the most invasive, plant species in California. It needs human intervention and management, otherwise it will reduce the biodiversity of an area (8).
- Cape Ivy expanded 87% between 1987 and 1997 in the Golden Gate National Recreation Area (GGNRA) and is continuing to increase (3).
- Plots invaded by Cape Ivy contained 36% fewer native plant species and 37% fewer nonnative taxa. (1).
- Beneficial rhizospheric microbes can alter plant morphology, enhance plant growth, and increase soil mineral content (5).
- Plants and rhizosphere microbes mutually interact through rhizodeposition, production of regulatory compounds, decomposition, and nutrient cycling (5,7).
- Plant–soil microbe interactions play a large role in determining plant community structure and may in some cases strengthen invasive ability of plants through complex feedback loops (2,7).
- There are very few studies investigating the effects of invasive plants on the soil microbiome and the relationship of the soil microbiome to plant fitness.

Methods

- **Soil samples.** Test soil samples were taken from a Cape Ivy monoculture in the GGNRA in San Bruno. Control samples were aseptically taken 30.5 cm deep. The same depth and aseptic method were used to get the control soil samples from under native coastal scrub vegetation.
- **Soil moisture.** Each soil sample was weighted before and after drying at 120°C for 12 hrs.
- **Community-level physiological profiling (CLPP).** 10 g of Cape-Ivy soil were diluted using phosphate buffered saline (PBS) to 10^{-4}. 100 uL of 10^{-3} dilution were transferred to Biology Ecoplates containing different carbon sources (**Figure 2**). Plates were incubated at 25°C. After four days incubation, absorbance of each well was measured at 590 nm with a microplate reader.
  - The average absorbance in the three blank wells was subtracted from the average absorbance of each substrate well, with the difference being the net change.
- **Denitrification.** 100 g soil was mixed with 0.10 g KNO_3 and 100 mL distilled water in a sealed 250 mL flask. After one week, pH of samples were measured and NO_2^- production was tested using acidic diphenylamine.
- **Nitrification.** 10 g soil was mixed with 50 mL PBS with 1.0 mL of ammonium sulfate solution in a 125 mL flask and incubated at 37°C. Samples were analyzed at 0 sec and 2 hr after incubation by addition of 0.1 mL of sulfanilamide solution and naphthalene reagent followed by comparison of absorbance at 543 nm with a standard curve to detect NH_4^+ conversion to NO_3^-.
- Procedures were repeated with the control, absence of Cape Ivy, soil samples.

Figure 1. Cape Ivy plant forms a blanket that covers native plants in Golden Gate National Recreation Area at San Bruno.

Results

- Cape Ivy contained 12.62% soil moisture content in comparison with the 7.19% of control soil, absence of Cape Ivy.
- Functional diversity for the control soil is 45.2 % with microbes using 14 substrates, while the Cape-Ivy soil has 67.7% with its microbes using 21 substrates.
- Cape-Ivy soil has a more diverse microbiota (**Figure 3**). Both soil samples used seven different carbon types, however the Cape-Ivy soil microbiome uses carboxylic acids (dicarboxylic acids, itaconic acid and D-malic acid) more efficiently.
- NO_3^- was reduced in both samples as shown by the negative results of NO_3^- spot test confirming the presence of denitrifiers working at pH 6.5 on both the test and control soil samples. Results are summarized in **Table 1**.
- Nitrification results were inconclusive.

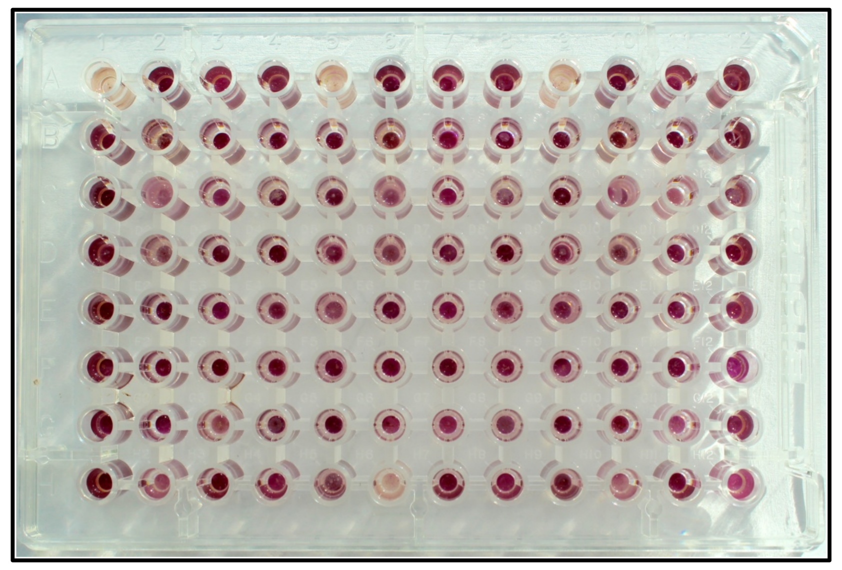

Figure 2. The Ecoplate has three replicates of 31 substrates and water blanks. Each well contains a redox dye as an indicator for substrate utilization. Purple color indicates use of the carbon source.

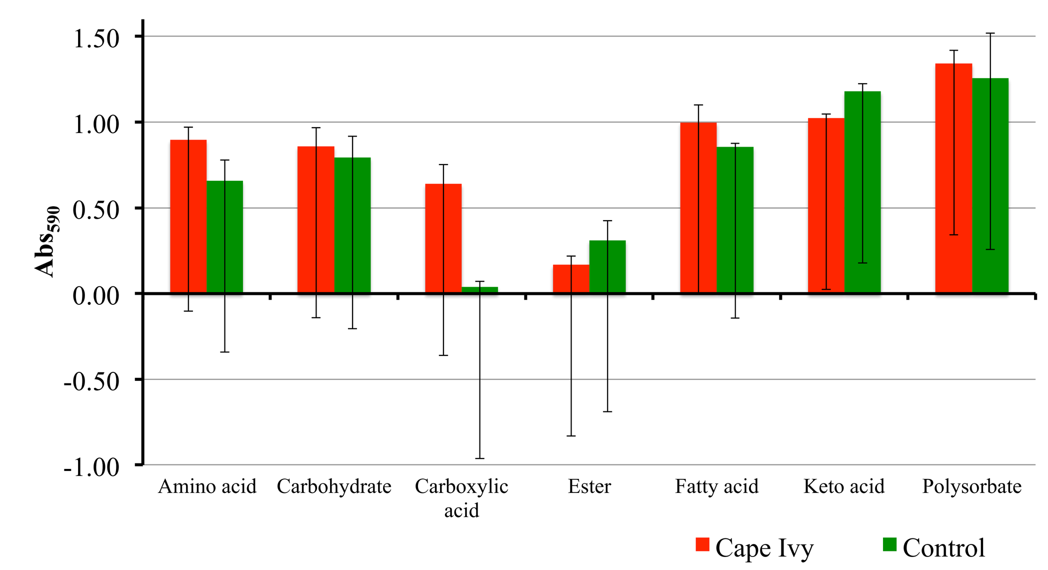

Figure 3. Carbon sources. An increase in absorbance indicates the carbon type was used. Cape Ivy shows higher amounts of microbes that use all carbon sources except esters and keto acid. Error bars ± 1 S.D.

Table 1. Comparison of Cape Ivy and native-plant soil

Soil	Functional diversity, %	NO_2^- reduced	pH	Soil moisture, %
Cape Ivy (Test)	67.7±0.09	+	6.5	12.62
Natives (Control)	45.2±0.66	+	6.5	7.19

Discussion & Conclusion

- Cape-Ivy soil retains more moisture compared with the native-soil control, which may increase plant growth and organic matter in the soil.
- Cape Ivy appears to change microbial communities in areas they invade as indicated by the increased functional diversity of soil microbes. The rapid plant growth supplies organic matter for soil microbes (6).

Future Studies

- Further research is needed to identify not just the metabolic diversity, but the taxa of bacteria present in the soil.
- Specific host plant-microbe interaction as to how these microbes affect the Cape Ivy, whether its positive or negative calls for further research.
- Samples were taken following high precipitation due to rain in comparison with the five years of continuous drought in California. Comparison of Cape Ivy's soil microbiota during drought and non-drought conditions can help identify vital symbiotic relationship the Cape Ivy's roots has with specific microbes.

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