Delairea odorata's Offensive and Defensive Physiology

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Abstract

Delairea odorata (Cape Ivy) is an ornamental vine native to South Africa, which has escaped and is invading natural areas in Australia, Europe, and the United States. It is a serious pest that currently occupies over 500,000 acres of California. This perennial vine with a distinctive odor climbs over native species blocking their light source and impairing their ability to photosynthesize. This rapidly growing invasive plant raises questions and calls for research into the inhibition factors it utilizes to out-complete surrounding plants. The objective of our research was to identify these factors. Transpiration rates were measured using a LiCor-6400 Portable Photosynthesis System. *D. odorata* has a 92% lower rate of water loss through transpiration than the dominant native species. The effects of aqueous *D. odorata* extracts and rhizosphere soil extracts on angiosperm seed germination and toxicity were evaluated using US Environmental Protection Agency bioassays. Only 2.2% of lettuce seeds germinated in *D. odorata* extracts compared to controls. Germinating seeds had 76.9% shorter roots in soil, root, and leaf extracts compared to controls. Test herbivorous animals (*Phodopus campbelli* and *Manduca sexta*) did not readily eat *D. odorata* leaves. Identifying reasons for the success of *D. odorata* is of fundamental importance to understanding its dominance and may lead to effective control methods.

Aim

Determine how *D. odorata* uses its physiological attributes to out-compete native species.

Background

- Originating in South Africa, *Delairea odorata* is well adapted to grow along California's coast. The invasive plant *D. odorata* is increasing its threat to California's vast biodiversity (3).
- Cape Ivy rapidly grows up and over the native vegetation, including small trees, covering and eventually killing them (**Figure 1**). It quickly regrows after mechanical removal or treatment with herbicides (2).
- The U. S. Park Service considers Cape Ivy as a threat to 12 rare native plant species, two federally listed butterfly species, as well as compromising the habitats for freshwater shrimp and Coho salmon and has spent over one million dollars in an effort to eradicate the plant (1).

Figure 1. Cape Ivy forms large monocultures that block light from other plants.

Methods

- 10 g *D. odorata* leaves, roots and rhizosphere soil were ground with a mortar and pestle in 20 mL of distilled water, and centrifuged at 1500 ×g for 20 min. The extract was diluted with distilled water to 0.5 g/mL, 0.05 g/mL, and 0.005g/mL.
- 2 mL of each extract was placed into wells in a cell well plate. Each well contained 5 *Lactuca sativa* (lettuce) seeds. Distilled water was used as a control.
- Two *Phodopus campbelli* were isolated in separate cages. The animals were starved for 24 hr and then fed 2.5 g of *Spinacia oleracea* or *D. odorata* leaves. The animals were observed for 96 hr.
- Obtained and weighed two *Manduca sexta* and isolated them in separate containers, incubated at 25°C. One animal was fed *S. lycopersicum* and the other, *D. odorata.* Observations made at 96, 120, and 144 hours.
- A LiCor-6400 Portable Photosynthesis System was used to measure transpiration. CO_2 was set at 400 µmol and light intensity was set at 800 µmol $m^{-2}s^{-1}$.

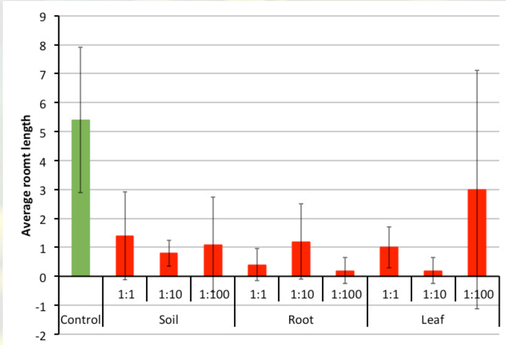

Figure 2. Average lettuce seed germination in various extracts and concentrations. Error bars = 1 S.D.

Results

- USDA Toxicity Test Procedures state that germination consists of the primary root reaching 5 mm (4). All *D. odorata* extracts except the 0.005 g/mL leaf extract completely inhibited germination (**Figure 2**).
- The lowest average length (0.6 mm) occurred in the Cape Ivy root extract: 89% shorter than the distilled water control.
- 64% of all extract seeds showed some primary root growing from the split seed, but did not reach the 5-mm standard. The remaining 36% did not germinate.
- The *P. campbelli* control ate 90% of the spinach leaves compared to the experimental animal, which ate 15% of *D. odorata* leaves. The control animal had more fecal matter in the cage and looked healthier than the experimental animal.
- The *M. sexta* control fed tomato leaves gained weight over time compared to the experimental animal, which lost 33% of its body weight (**Figure 3**). Weight for the experimental animal fluctuated, but never reached the same the weight of the control.
- *D. odorata* has a 92% lower rate of water loss through transpiration than the dominant native species, Coyote Brush (**Figure 4**).

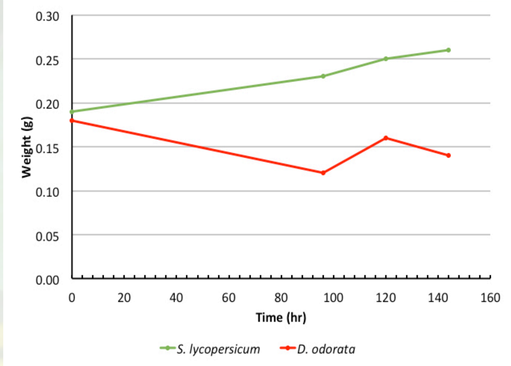

Figure 3. *Manduca sexta* did not eat Cape Ivy leaf willingly.

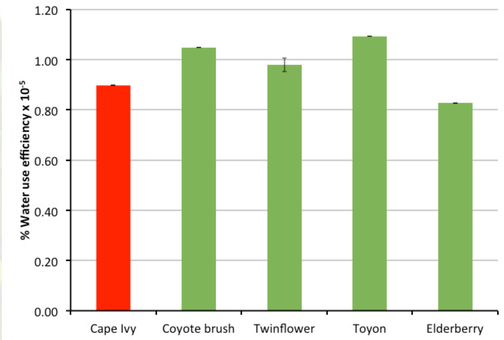

Figure 4. Cape Ivy has a lower rate of water loss than most of the native plants tested. Water use efficiency is the rate of photosynthesis/rate of transpiration. Error bars = 1 S.D.

Discussion & Conclusion

- Refusal by both herbivorous species to eat *D. odorata* suggests a defensive physiology that deters herbivores.
- *D. odorata* loses less water through transpiration than the dominant native species. This could provide an advantage in the warm summer and fall months.

Future Studies

- Testing for alkaloids to determine whether an alkaloid is present in the leaves, roots, or rhizosphere soil as a defense mechanism.
- Comparison of transpiration and CO_2 fixation with leaf area:root weight ratio to understand water use in Cape Ivy.

Literature Cited

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Acknowledgements

We would like acknowledge Dr. Case for all of her insight, guidance, infinite knowledge and high tolerance for all of our many questions. We would also like to thank Dr. Folsom for her instruction in the use of the Licor Li-6400 and Kylin Johnson for providing all of the materials and lab equipment and always being so accommodating.