Allelopathy and Biotoxicity of Cape Ivy *Delairea odorata*

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Abstract

Cape ivy (*Delairea odorata*), a plant from South Africa, has become a serious problem along the central California coast, dominating coastal scrub and riparian communities. It grows thickly over other plants and trees, creating vast areas of monocultures. To the best of our knowledge, this work is the first attempt to identify bioactive metabolites in Cape ivy that give it a selective advantage over native vegetation. Our aim is to investigate the biotoxicity and allelopathic effects of Cape ivy and the Cape ivy rhizosphere. Water or rhizosphere soil gathered from a nearby native ecosystem were used as controls. The effects of aqueous plant extracts and rhizosphere soil extracts on angiosperm seed germination, plant growth, and aquatic arthropod growth were evaluated using US Environmental Protection Agency bioassays. Rhizosphere soil from Cape ivy monocultures and Cape ivy leaf extract inhibit lettuce seed germination. After 5 days, 55% fewer seeds germinated . Germinating seeds had 84% shorter roots in 0.1-0.4 g/mL plant extract compared to the water control. Lettuce seeds grown in Cape ivy rhizophere soil also had 12.5% less germination compared to native soil. Leaf extract (10%) decreased *Lemna minor* growth by 72%±0.2. *Lemna* showed strong adverse effects (chlorosis and necrosis) to 1-10% extracts. We are currently determining toxicity of Cape ivy to aquatic arthropods and characterizing the toxic and allelopathic chemicals. Identifying bioactive compounds in the Cape ivy rhizosphere is of fundamental importance to understanding Cape ivy's dominance and may lead to effective control methods.

Aim

To determine the effects of Cape-ivy extract on aquatic organisms and terrestrial plants.

Background

- Cape ivy, *Delairea odorata*, originally from the Cape region of South Africa, was brought to California in the 19th century as a houseplant. It is now the most unwanted invasive plant in California, while also invading areas of Oregon, Hawaii, and Australia. (1)
- Cape ivy quickly becomes a monoculture by growing over and depriving native ecosystems of light. (1)
- Many plant species are known to use allelopathy to suppress competitors or predators. Native California sagebush (*Artemisia californica*) prevents other plants from establishing (5). *Eucalyptus globulus,* another invasive plant in California, uses allelopathy to suppress soil microorganisms and other plants (7).
- It has been reported that Cape ivy shows antifungal and antibacterial properties (6).
- The purpose of this work is to determine whether Cape ivy's invasiveness is due to biochemicals that it produces.

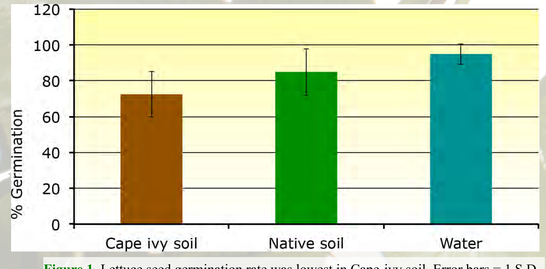

Figure 1. Lettuce seed germination rate was lowest in Cape-ivy soil. Error bars = 1 S.D.

Methods

Site Selection

D. odorata plant and under-plant subsoil samples were collected from an infestation in the Golden Gate National Recreation Area (GGNRA) adjacent to Skyline College. Native coastal sage scrub subsoil was collected from the GGNRA.

Extract preparation

1. Leaves were rinsed with distilled water and patted dry, then ground into a paste with a mortar and pestle.
2. Leaf extracts were diluted to desired concentrations with distilled water.
3. Large debris and organisms were removed from soil samples.

Standard methods accepted by the U. S. Environmental Protection Agency were used to test biotoxicity.

Seed Germination (4)

1. 7 cm-diameter Lab Nerd filter paper in sterile Petri plates were saturated with the diluted extracts, distilled water, or soils wetted with distilled water.
2. Simpson Elite lettuce seeds (Burpee) were soaked in 10% bleach for 15 min and rinsed in sterile water 5 times.
3. 10 seeds were placed on each saturated filter paper. Plates were incubated at room temperature in the dark for 5 days. Germination times and root lengths were measured.

***Lemna minor* Growth** (2)

1. *L. minor* was collected from a hillside spring at Skyline College. The *Lemna* was cultivated in stream mud and distilled water.
2. 5 *Lemna* thalli were placed in varying concentration of Cape-ivy extract in cell-well plates. Plates were incubated at 25°C for 7 days on a 16-hr light schedule.
3. Thalli were counted and observed for general health.

***Paramecium caudatum* Reproduction** (8)

1. Each trial was run in 10 6 × 50 mm culture tubes with 0.2 ml of culture water.
2. Groups of 2-12 *Paramecium caudatum* (Carolina Biological) were added to each tube.
3. 0-1.00% filtered Cape-ivy extract was added to each trial. The extract was filtered though a coffee filter to get a more liquid extract.
4. *Paramecium* populations were counted after 10 min, 2 hr, and 24 hr.

Aquatic Arthropod Biotoxicity (3)

1. Wild copepods were cultured in local stream mud and water.
2. Groups of 7-10 copepods were added to 30 ml stream water in 100-mm Petri plates. Stream water was used as a control.
3. Cape-ivy extracts were added to the water to final concentrations of 0.1, 0.25, 0.5, and 1.0%.
4. Populations and activity were monitored at 24 and 48 hr.

Results

- 12.5% fewer seeds germinated in Cape-ivy rhizophere soil compared to native soil (**Figure 1**).
- 55% fewer lettuce seeds germinated in Cape-ivy extract than in distilled water control. Of those germinated seedlings in extract, their root systems were 84% shorter than control seedlings (**Figure 2**).
- *Lemna* experienced chlorosis and necrosis in 1-10% Cape-ivy extract. Concentrations as low as 1% caused colony breakup, chlorosis, and thallus death. Growth was observed at concentrations up to 2.5% extract (**Figure 3**).
- All *Paramecium* died after 24 hr in Cape-ivy extracts as low as 0.25% (**Figure 4**).
- Copepod populations in 1% Cape-ivy extract dropped 58% after 48 hours. Populations in 1% extract were 61% below control populations.

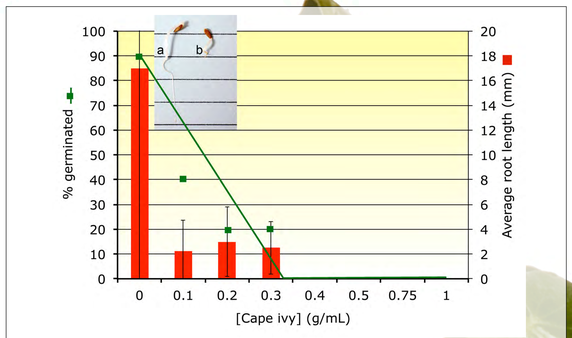

Figure 2. Germination was inversely proportional to [Cape ivy]. Seeds in extracts had shorter root systems. Insert: (a) Control (b) in Cape ivy. Error bars = 1 S.D.

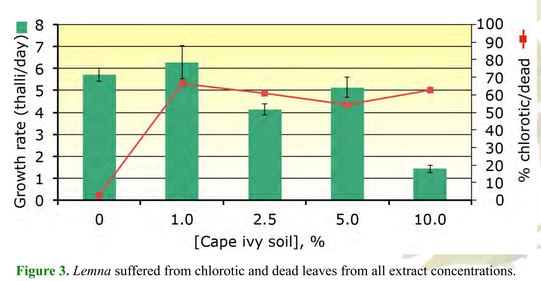

Figure 3. *Lemna* suffered from chlorotic and dead leaves from all extract concentrations. Error bars = 1 S.D.

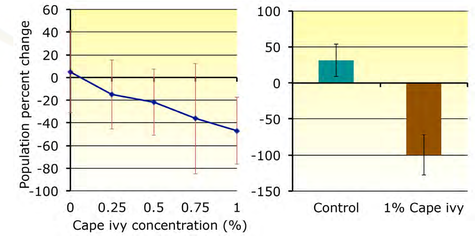

Figure 4. Cape ivy in very small amounts is toxic to *Paramecium.* Error bars = 1 S.D.

Discussion & Conclusion

- Cape-ivy extracts were used to mimic leaf litter and mulch that normally accumulates on the soil around Cape ivy monocultures.
- Alvarez reported pyrrolizidine alkaloids and xanthones in Cape ivy, making it toxic to mammals, spiders, and fish (1). Cape ivy is toxic to *Paramecium* and arthropods. Thus, toxicity to aquatic microorganisms could be due to these alkaloids and xanthones.
- This is the first documentation that Cape-ivy leaves and soil inhibit plant germination and growth. Allelopathic phytochemicals could contribute to the success of Cape ivy.
- Isolation and identification of allelopathic chemicals will be needed to fully understand the Cape ivy's success.

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