Canopy phenology and the coexistence of invasive species in a walnut woodland understory

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Outline

• Environmental Heterogeneity and Coexistence
• Southern California Walnut Woodlands
• Question and Hypotheses:
  – Light and Juglone
• Methods
  – Greenhouse Experiments
• Results
  – Germination, physiology, health, and reproduction
• Conclusions
Environmental Heterogeneity

How does environmental heterogeneity affect the coexistence of species?
Abiotic Filtering

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Species Interactions

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Species Interactions

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Environmental Heterogeneity

Woodlands and Light

Bernardo Hernández, 2011
David R. Tribble, 2012
Juglans californica S. Watson

- Southern California Walnut Woodland
- Deciduous and allelopathic

1970 Elbert Little, USDA
Invasive Understory

• Black Mustard (*Brassica nigra*)

• Italian thistle (*Carduus pycnocephalus*)
Light Heterogeneity

Percent Shade

Plot ID
Soil Juglone Heterogeneity

Effects of Juglone

Grown in Petri dish with water

Grown in Petri dish with 1 mM solution

Some species do not even germinate in a 1 mM solution
Specific Questions

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?

2. How does light availability affect the health and fitness of black mustard and Italian thistle?

3. How do these environmental factors influence the competition between these two species?
Hypotheses

Light

Juglone

Benefits black mustard

Dr. Edward Bobich

Benefits Italian thistle
Hypotheses

Competition

Light

Juglone

Benefits black mustard

Dr. Edward Bobich

Benefits Italian thistle

Abiotic Filtering
Specific Questions

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?

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3. How do these environmental factors influence the competition between these two species?
Greenhouse Germination Experiment

Full Sun (11% Shade)

- Mustard 0 mM 5 pots each
- Mustard 1 mM 5 pots each
- Mustard 2 mM 5 pots each
- Thistle 0 mM 5 pots each
- Thistle 1 mM 5 pots each
- Thistle 2 mM 5 pots each

Medium Shade (63%)

- Mustard 0 mM 5 pots each
- Mustard 1 mM 5 pots each
- Mustard 2 mM 5 pots each
- Thistle 0 mM 5 pots each
- Thistle 1 mM 5 pots each
- Thistle 2 mM 5 pots each

Dark shade (88%)

- Mustard 0 mM 5 pots each
- Mustard 1 mM 5 pots each
- Mustard 2 mM 5 pots each
- Thistle 0 mM 5 pots each
- Thistle 1 mM 5 pots each
- Thistle 2 mM 5 pots each
A GLMM using a binomial distribution was used.

Thistle species effect: $\beta = 1.646$, $P < 0.001$. 

A GLMM using a binomial distribution was used.
A GLMM using a binomial distribution was used

- Full sun effect: $\beta = -0.53280$, $P = 0.0254$
A GLMM using a binomial distribution was used.

Effect of Juglone:
1 mM: $\beta = -1.212$, $P < 0.001$
2 mM: $\beta = -1.757$, $P < 0.001$
Question 1

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?

• Black mustard had significantly less germination rates than Italian thistle.

• Italian thistle germination was reduced by increasing light levels.

• Black mustard and Italian thistle germination was significantly reduced by juglone.
Specific Questions

1. How do juglone and light availability affect the germination of black mustard and Italian thistle?

2. How does light availability affect the health and fitness of black mustard and Italian thistle?

3. How do these environmental factors influence the competition between these two species?
Greenhouse Competition Experiment

Full Sun (11% Shade)
- Mustard
- Thistle
- Both

Medium Shade (63%)
- Mustard
- Thistle
- Both

Dark Shade (88%)
- Mustard
- Thistle
- Both
Photosynthesis

A GLMM using a gamma distribution was used.

- Effect of Thistle $\beta = -0.394$, $P < 0.001$
- Full Shade: $\beta = 1.03497$, $P < 0.001$
- Medium Shade: $\beta = 0.77157$, $P < 0.001$
A GLMM using a gamma distribution was used.
Photosynthesis

Photosynthesis Rate (μmol CO₂ m⁻² s⁻¹)

Species Treatment

Mustard Competition

Thistle Competition

Full sun: β = 0.997, P < 0.001
Medium shade: β = 0.890, P < 0.001
Mustard Competition: Full Sun: β = 0.32112, P = 0.026
Thistle Competition: Medium Shade: β = -0.35484, P = 0.013

A GLMM using a gamma distribution was used.
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A GLMM using a gamma distribution was used.

- No significant effect of Species competition on Biomass
- Thistle Effect: $\beta = -0.37130$, $P = 0.0264$
Reproduction

A GLMM using a gamma distribution was used

- Full Sun $\beta = 1.49842$, $P < 0.001$
- Medium Shade $\beta = 0.67492$, $P < 0.001$
- No effect of competition
A linear model was used:

- Full Sun $\beta = 5.6370$, $P = 0.011$
- Medium Shade $\beta = 6.5296$, $P < 0.001$
- No effect of competition
2. How does light availability affect the health and fitness of black mustard and Italian thistle?

- Lower light levels significantly reduced photosynthesis for both species.
  - Thistle was significantly inhibited when in competition with mustard in full sun treatments.

- Lower light levels significantly reduced the biomass and reproduction of both species, but there was no effect of competition on either species.
Question 3

3. How do these environmental factors influence the competition between these two species?
Summary

Benefits black mustard

Benefits Italian thistle

Competition

• Photosynthetic rate

Abiotic Filtering

• Germination rate
• Biomass
• Reproduction
Summary

Benefits black mustard

Benefits Italian thistle

Competition

• Photosynthetic rate

Abiotic Filtering

• Germination rate
• Biomass
• Reproduction

Environmental Heterogeneity

Dr. Edward Bobich
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