Physiological Study of Common and Glossy Buckthorn's Ability to Outcompete Native Species

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Introduction

Non-native, invasive species are organisms that are not historically from a certain ecosystem but have been moved there, intentionally or not, and are able to outcompete native species. They are able to do this as a result of physiological advantages and a lack of natural predators and diseases. In the Midwest, two such species are Common Buckthorn (*Rhaminus cathartica*) and Glossy Buckthorn (*Rhaminus frangula*). Both species originated in Eurasia and were brought to the United States in the 1800s as ornamental plants. Soon after arriving, buckthorn rapidly spread and overtook native species.

Common Buckthorn – *Rhaminus cathartica*

Glossy Buckthorn – *Rhaminus frangula*

Today, Common and Glossy Buckthorn are prevalent on Calvin College's campus. Their range stretches from the Atlantic Coast to the Rocky Mountains, growing as far north as Michigan and as far south as Tennessee. Through observation, Common Buckthorn has been categorized as a sun-loving plant which thrives in open fields and forest edges, while Glossy Buckthorn seems to prefer shaded, moist areas such as forest understories.

Objectives

1. Verify the observed ideal habitats for Common and Glossy Buckthorn using physiological evidence.
2. Identify physiological traits that provide support for each buckthorn's habitat preference.
3. Gain insight into how Common and Glossy Buckthorn compete with native species in habitats where they coexist.

Methods

4 Sites

- Paired sun and shade locations

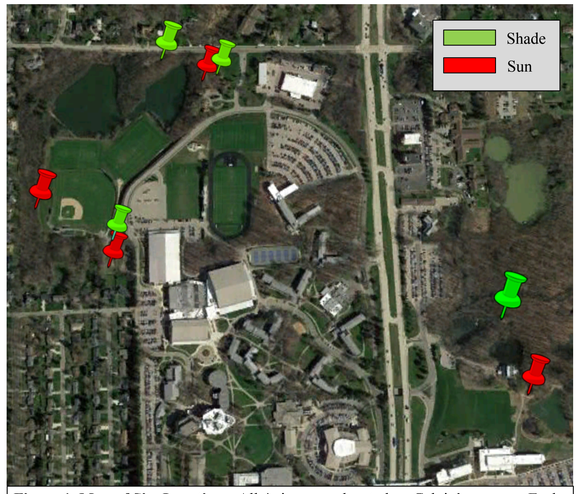

Figure 1. Map of Site Locations. All 4 sites were located on Calvin's campus. Each site had both a sunny and shaded area.

4 Species

1. Common Buckthorn
2. Glossy Buckthorn
3. Gray Dogwood
4. Hawthorn

4 Measurements

1. Light Use Efficiency

Net photosynthesis rates were measured for each species using a LI-COR LI-6400XT Portable Photosynthesis System. The system measured the rate at which each plant performed photosynthesis as the light levels increased from 0 to 2000 μmol m^2 s.

2. Chlorophyll Concentration

Leaf chlorophyll concentration was measured using a Minolta Chlorophyll Meter SPAD 502LD. Three measurements were taken to determine the average chlorophyll content of a representative leaf from each test plant.

3. Stomatal Density and Aperture

Stomatal density and aperture were measured by examining leaf impressions under microscopes. The impressions were made by coating portions of the leaf with clear nail polish, allowing it to dry, and then peeling it off.

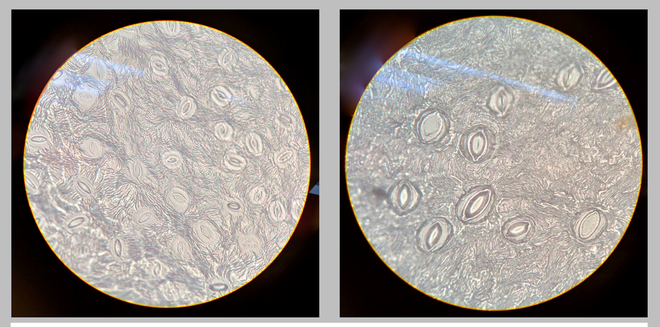

Figure 2: Leaf Impressions Under Microscope View. The picture on the left is of the stomata from a Common Buckthorn leaf. The picture on the right is from a Hawthorn leaf. Notice the size difference between the stomata of the two species.

Results

Species	Exposure	Maximum Photosynthesis Rate (umol/m^2/s)	Average Transpiration	Average Water Use Efficiency (mols/m^2/s)	Average Chlorophyll Content	Average Stomatal Density (stomates per mm^2)	Average Stomatal Aperture (µm^2)
Common Buckthorn	Sun Plant	11.31	0.00351	1512.28	38.713	367.05	74.26
Common Buckthorn	Shade Plant	9.84	0.00269	2388.40	43.059	224.14	76.85
Glossy Buckthorn	Sun Plant	13.08	0.00305	1989.01	38.828	595.39	42.40
Glossy Buckthorn	Shade Plant	6.93	0.00162	2539.20	37.022	333.33	45.57
Standard Error		0.51	0.0001	53.20	0.200		
P - Value		0.0001	0.0001	0.0001	0.0001		
N		60	320	320	320		

Table 1. Comparing Glossy and Common Buckthorn Results From Shaded and Sunny Areas.

Sunny Locations:

- Glossy Buckthorn performed photosynthesis at a higher rate than Common Buckthorn.
- Possible explanations:
  1. Glossy Buckthorn used water most efficiently, allowing it to cope with heat and sunlight best.
  2. Glossy Buckthorn had more stomates per mm^2 on its leaves. This may maximize the plant's control over gas exchange.

Shaded locations:

- Common Buckthorn performed photosynthesis at the rate.
- Possible explanations:
  1. Common Buckthorn had the highest chlorophyll content, allowing it to maximize the absorbance of light in shaded areas.
  2. Common Buckthorn had the greatest stomatal aperture (opening). This allows its stomata to maximize its uptake of CO2, which is necessary to perform photosynthesis.

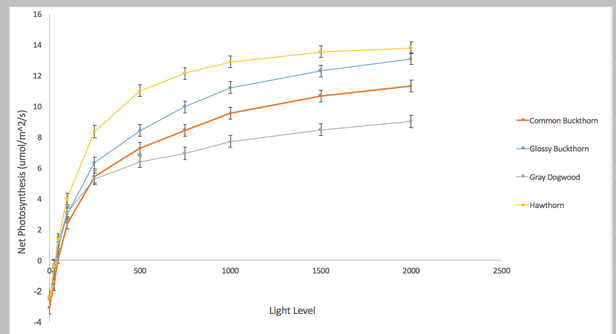

Figure 3. Light Use Efficiency (LUE) Curve for Sun Locations. This curve compares the average photosynthesis rates for each plant at increasing light levels in areas with high sun exposure.

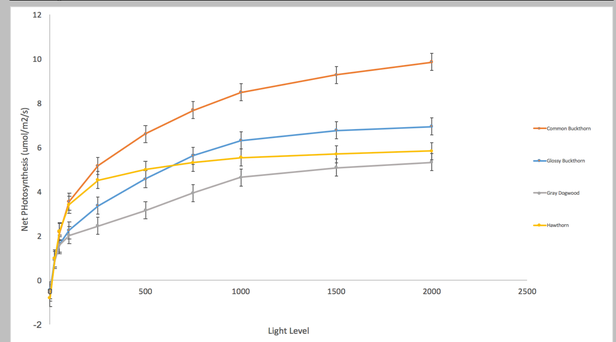

Figure 4. Light Use Efficiency (LUE) Curve for Shaded Locations. This curve compares the average photosynthesis rates for each plant at increasing light levels in areas with low sun exposure.

- In sunny locations, Hawthorn was able to match the photosynthesis rates of Common and Glossy Buckthorn. It was unable to in shaded areas.
- Gray Dogwood's photosynthesis rate was well below that of the other species in both sunny and shaded locations.
- Lower photosynthesis rates mean that the native species are unable to compete with the energy production of Buckthorn and will grow at a slower rate as a result.

Conclusions

- Contradictory to the current understanding of Common and Glossy Buckthorn's preferential habitats, the data suggests that Common Buckthorn tolerates being in shaded areas well and Glossy Buckthorn performs best in sunny areas. The fact that Glossy Buckthorn uses water most efficiently allows it to grow in sun-exposed areas that have less water available. Common Buckthorn's high chlorophyll concentration is critical for its growth in shaded areas because it allows the plant to maximize the capture of any light energy that reaches its leaves.
- Hawthorn was able to compete with the Buckthorns in sunny locations but struggled in shaded areas. Gray Dogwood was unable to compete with the photosynthesis rates of Buckthorn in either sunny and shaded locations.