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Abstract

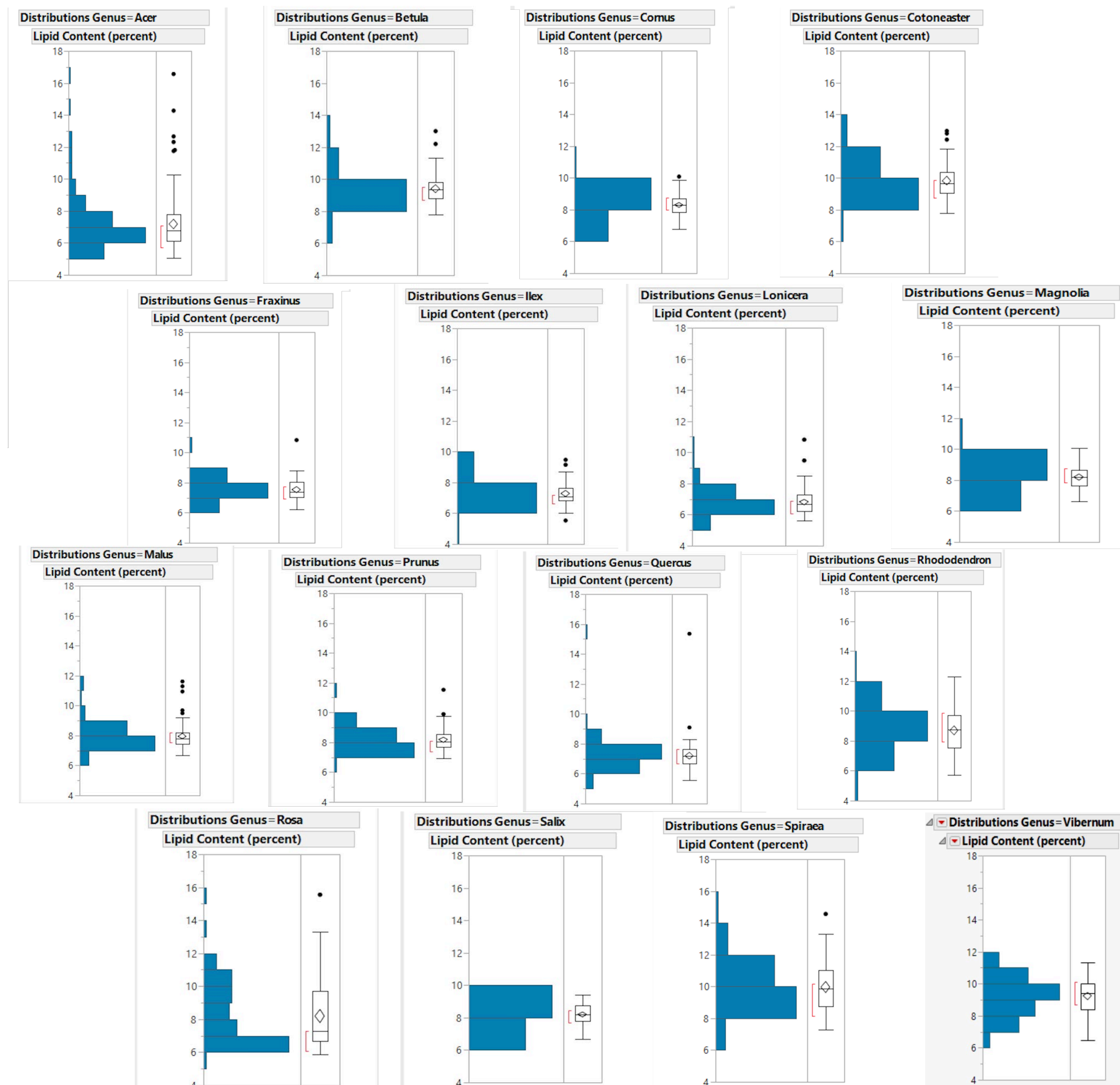
In my research I examined the trade-off between leaf defenses in woody plants. I focused on cuticular waxes, oils, and resins in 16 different plant genera and over 600 species. The function of these waxes and resins in plants is to decrease surface wetting and moisture loss from the plant, as well as provide a barrier to herbivores and pathogens or make tissues toxic to these natural enemies. I used a gravimetric method by which lipid-soluble leaf components like waxes, resins, and oils are extracted and removed from the leaf sample to calculate the lipid content of the leaf. My results vary in each genus showing that there is wide variation among species. To address why each species has evolved a higher or lower concentration of waxes, oils, and resins, we assess the evolution of this trait with environment within each genus. Results provide insight into how selection has shaped chemical defenses evolution in woody temperate plants, and whether evolution behaves predictably and repeatedly as different groups of species diversify across the same environmental gradients.

Introduction

The Optimal Defense Theory (ODT) predicts that plant quantitative allocation of defense is not random, but driven by the potential relative contribution of particular plant tissues to overall fitness. That is the theory I focus on in my defense research, with specific focus on woody plants. I looked at the quantitative amount of waxes, oils, and resins, or more generically, lipids. I measured the amount of lipids in 16 different plant genera and over 600 species to look at the phylogenetic comparison between these species and how the environment affects the evolution of lipid production.

Methods

I weighed an empty 2 ml tube and recorded its mass, used between 0.07 grams and 0.1 grams of dried ground leaf sample, and recorded the combined mass of the tube and the dried ground leaf sample. After weighing, I added 1 ml of petroleum ether to each sample, vortexed it, and placed it on a shaker table. Once that was completed, I put it in the fridge to settle, then put it in a centrifuge to separate the contents in the tube. The next step is removing the lipid extract at the top, by pipetting the petroleum ether since the petroleum ether will have dissolved the lipids at this point, leaving the remainder of the leaf material. Finally, samples are put in a drying oven at 60 °C to dry off the remaining ether and samples are then reweighed for the final mass. I subtracted the final mass from the original mass to find out how much of the waxes, oils, and resins were removed, normalized to the original plant dry mass used. Phylogenetic comparative analysis (PGLS regression) was used to assess evolutionary correlations between species lipid content and native habitat climate and soil variables derived from iDigBio and GBIF herbarium record occurrence data cross-referenced with climate and soil data from the global WorldClim and SoilGrids models.



	Cornus	Cotoneaster	Lonicera	Magnolia	Prunus	Quercus	Rosa	Salix
Latitude				(+) 0.2838				(-) 0.3791
Longitude	(+) 0.2659			(+) 0.2838				
Aridity				(-) 0.2527			(+) 0.1040	
Annual Mean Temperature		(-) 0.3256						(+) 0.4066
Mean Diurnal Range	(-) 0.3417							
Temperature Seasonality			(-) 0.2184					
Annual Temperature Range			(-) 0.1821				(+) 0.1072	
Annual Precipitation				(-) 0.3432				
AWCtS s14				(-) 0.2451				
AWCtS s15	(+) 0.2332			(-) 0.360				
AWCtS s16	(+) 0.2480			(-) 0.4089				
AWCtS s17	(+) 0.2311			(-) 0.3849				
CECSOL s11								
CECSOL s12							(+) 0.1975	
CECSOL s13		(-) 0.2593					(+) 0.2428	
CECSOL s14		(-) 0.2242					(+) 0.2270	
CECSOL s15					(-) 0.1469	(-) 0.1006	(+) 0.1774	
CECSOL s16					(-) 0.1470	(-) 0.1111	(+) 0.1697	
CECSOL s17					(-) 0.1475	(-) 0.114	(+) 0.2034	

Discussion

Lipid content varies in different plant species based upon environmental factors found in species' native habitats. Over evolutionary time these different environmental factors have likely driven the evolution of lipid production in each genus. For *Cornus* species, there is a positive evolutionary correlation between leaf lipid concentration and available water holding capacity of the soil, indicating that soils with higher moisture holding capacity favor the evolution of higher levels of waxes, oils, and resins. This pattern is opposite, however, in *Magnolia*. In both *Quercus* and *Prunus*, the evolution of high lipid concentration was positively correlated with the cation exchange capacity of the soil, which means that high lipids evolve in fertile soils that have a high capacity for holding nutrients. As we see in the *Magnolia* genus, there is a negative evolutionary correlation between lipid content and both precipitation and aridity index, perhaps suggesting higher waxiness in drier environments to prevent water loss. For aridity index however, we observe instead a positive evolutionary correlation in the *Rosa* genus, suggesting that a high lipid content may be selected for in wetter environments. Overall, the lack of strong agreement among genera indicates that lipid content evolves differently with environment in different groups of plants, and that there is not one single generalizable pattern of leaf lipid evolution across temperate woody plants.

Future Directions

Further analyses will be done on other classes of compounds used for chemical defense such as silicates and calcium oxalates, tannins, and phenolics to see how these different chemical defenses compare with one another. Additionally, we will employ multiple regression to see how environmental variables may interact in driving trait evolution.

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