How Functional Leaf Traits of Tropical Dry Forest Legumes Contribute to Water Conservation Mechanisms

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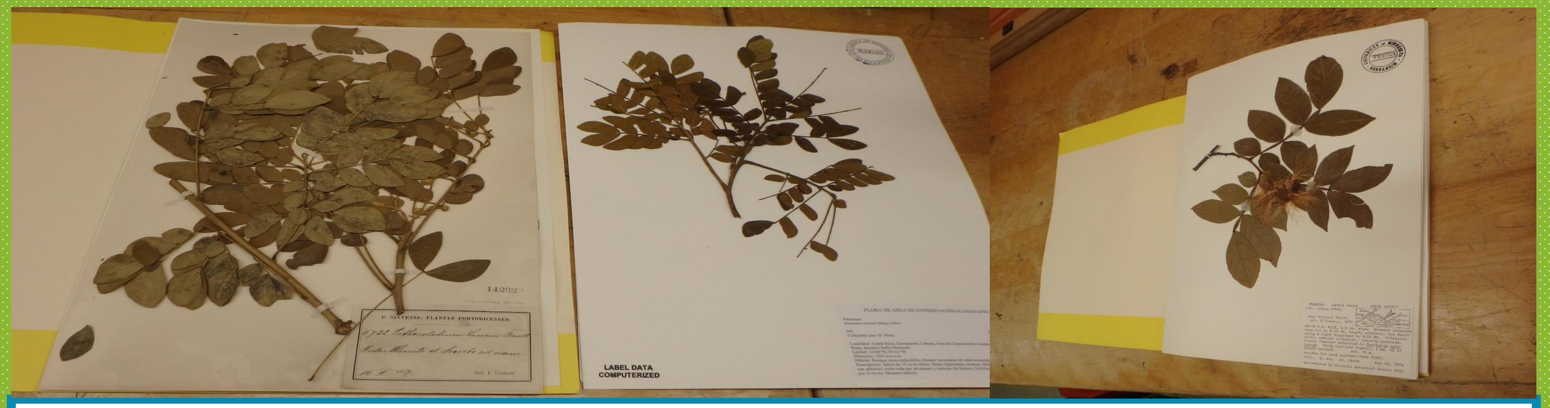
Background

Trees of Fabaceae (the Legume family) are prevalent in tropical dry forests (Pennington et al., 2004). These ecosystems go through periods of water scarcity that make water conservation important for survival (Borchert, 1994). There is anecdotal evidence that suggests legumes in dry forests have water conservation strategies such as small leaves and pulvini that move leaves, regulating the amount of light exposure (van Zanten et al., 2010). However, there has been no empirical evidence to confirm or determine a mechanism.

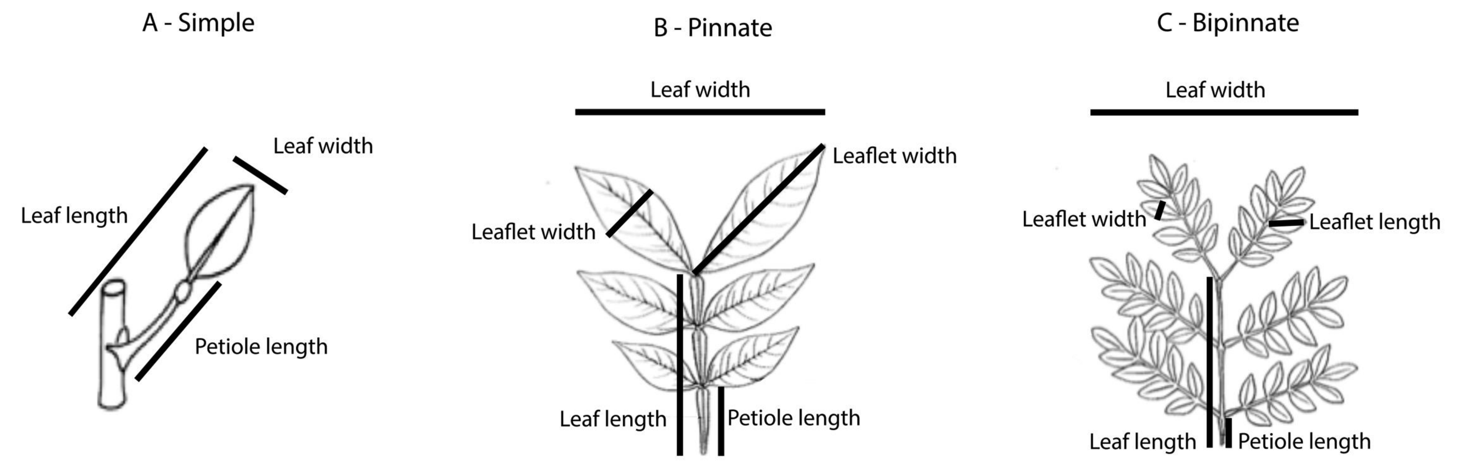
Question:

How do functional traits of legume species vary over a precipitation gradient in tropical forests?



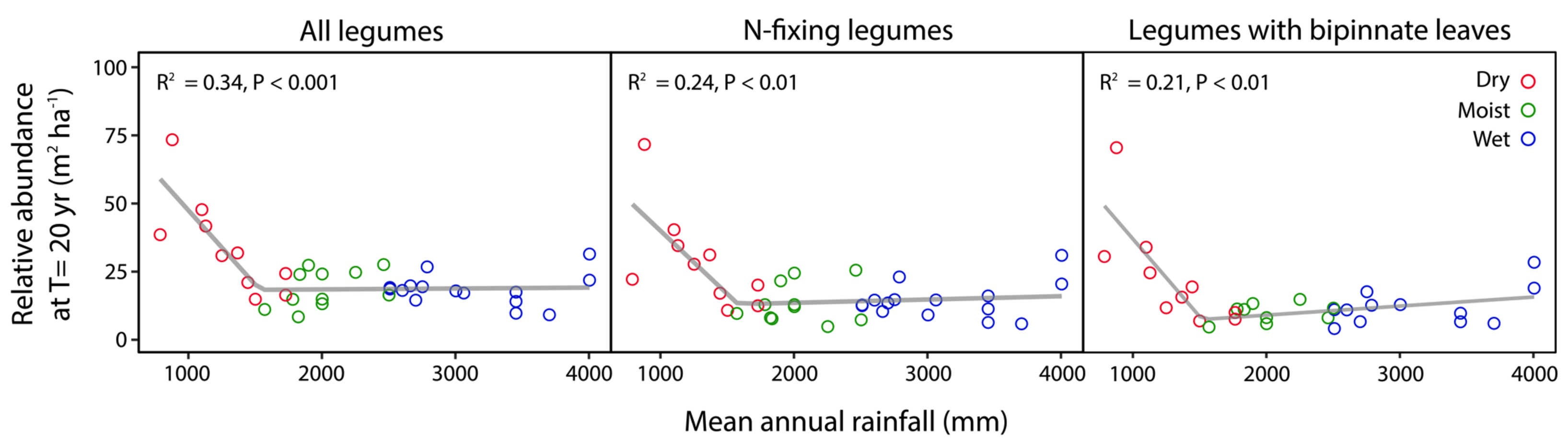
Methods

- Functional Traits Measured: Leaf width, leaf length, leaflet width, leaflet length, and petiole length



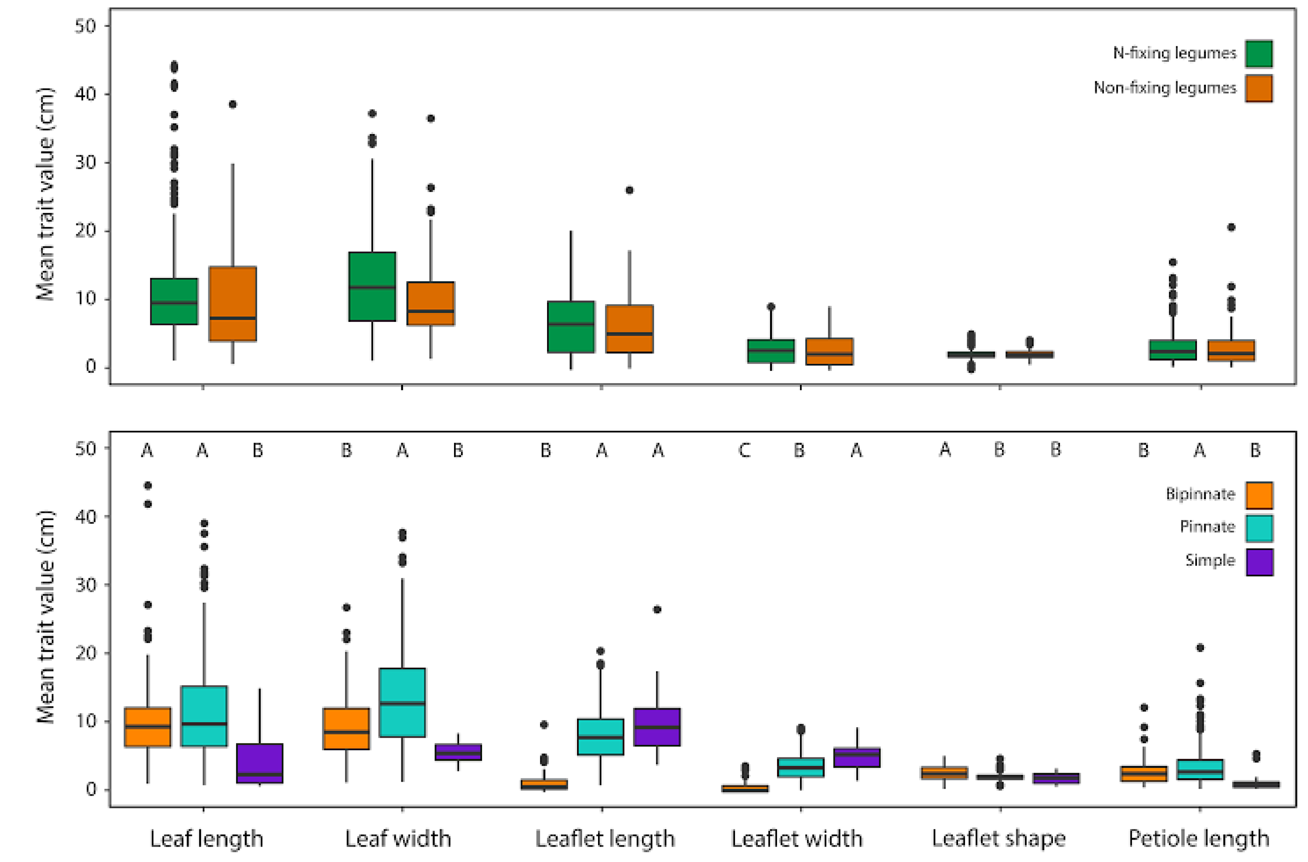
- Leaf traits were measured on specimens from the University of Minnesota Herbarium or online Herbaria using ImageJ
- For each species, 3 leaves of 3 specimens were measured and averaged
- Basal area of legume species was measured on chonosequences across dry and wet neotropical forests using data from the 2ndFOR network (Poorter et. al., 2016)

How do legume abundances vary between dry and wet forests?



Legumes are more abundant in dry forests, especially those species that fix nitrogen and have bipinnate leaves. There is little difference in abundances over 1500 mm of rainfall.

What traits drive the trends?



The differences cannot be explained only by N fixation because leaf traits are not significant different between fixers and non-fixers.

Letters indicate significant differences in between leaf types in each trait (ANOVA and Tukey tests)

Bipinnate have smaller leaflet size and higher leaflet shape, indicating a more slender leaf.

The abundance of N fixing legumes and bipinnate leaves drive functional trait trends in dry forests. Both traits are integral to the success of legumes in dry forests.

Acknowledgements

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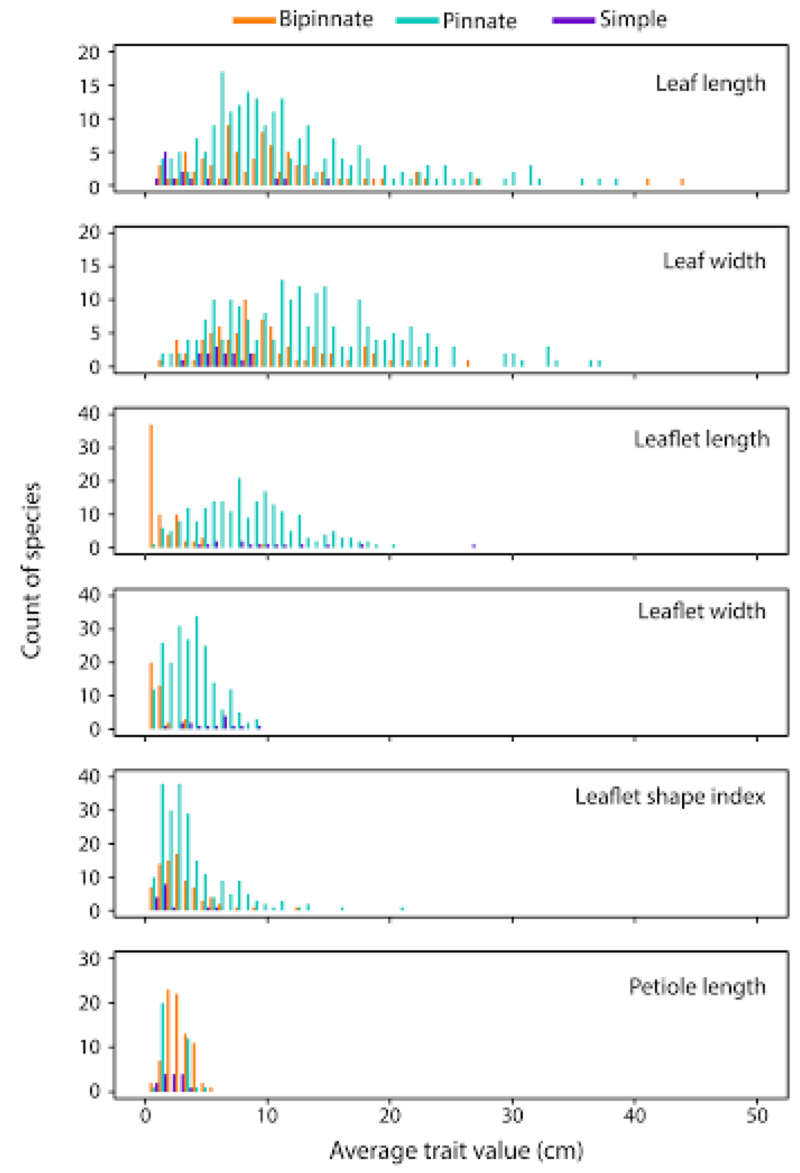
What makes bipinnate leaves different?

While leaf length and width have similar distributions across leaf types, differences are seen in leaflet length and width. Species with bipinnate leaves have constrained abundances of small leaflet lengths and widths while traits in species with pinnate and simple leaves have more widespread distributions. Overall, bipinnate leaflets tend to be smaller than pinnate or simple leaflets.

The benefit of having bipinnate leaves lies in the small leaflet size



Discussion

Small leaflets are beneficial to a plant in part because of their ability to reduce water loss through transpiration. A smaller surface area reduces the rate of transpiration and a smaller size allows for more air movement around the leaflets decreasing the boundary layer, the stationary air held around a leaf, which increases the temperature of the leaf itself (Givnish & Vermeij, 1976). Because small leaves have reduced boundary layers, leaf temperature is lower and less transpiration occurs (Givnish, 1984). Additionally, the rachis of a leaf is able to photosynthesis but transpires less than the rest of the leaf (Givnish, 1984). The combination of a smaller leaflet surface area and boundary layer as well as photosynthetic ability of the rachis allow bipinnate leaves to maximize their photosynthesis to transpiration (water loss) ratio. These leaf traits and the ability to fix nitrogen provide a mechanistic explanation for the success of legumes in tropical dry forests.

References

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