An Evolutionary Case for Plant Rarity

Alivia Nytko[1]*, John Senior[2], Rachel Wooliver[1], Julianne O'Reilly-Wapstra[2], Jennifer Schweitzer[1], Joseph Bailey[1]

1. Ecology and Evolutionary Biology, University of Tennessee 2. Department of Biology, University of Tasmania

Species Rarity is Common

Most species are rare, have high conservation value, and contribute disproportionately to ecosystem function.[1,2] As anthropogenic change increases in prevalence, species rarity is expected to increase across global landscapes.[3] While rare species are often characterized spatially using geographic axes such as range size, habitat specificity, and local population size, factors such as functional traits, many under genetic control, are not accounted for when classifying rare species.[4] Consequently, many rarity studies lack an eco-evolutionary perspective to understanding and predicting the future persistence of rare species.

Although rarity is commonly thought to be a culmination of unfavorable random ecological processes and environmental factors leading to poor survival outcomes, studies suggest that performance traits, such as biomass, are positively related to geographic aspects of rarity.[2,5] Identifying a suite of evolved traits associated with geographic rarity is critical in connecting genes to ecosystems to demonstrate the trait-mediated evolution of range size, habitat specificity, and population size. Furthermore, if an endemic suite of traits is correlated with the evolution of rarity, as rarity increases, there are likely to be significant impacts on biodiversity and ecosystem function critical for climate change mitigation.

There are specific performance traits associated with plant rarity that may determine if and how a species is rare

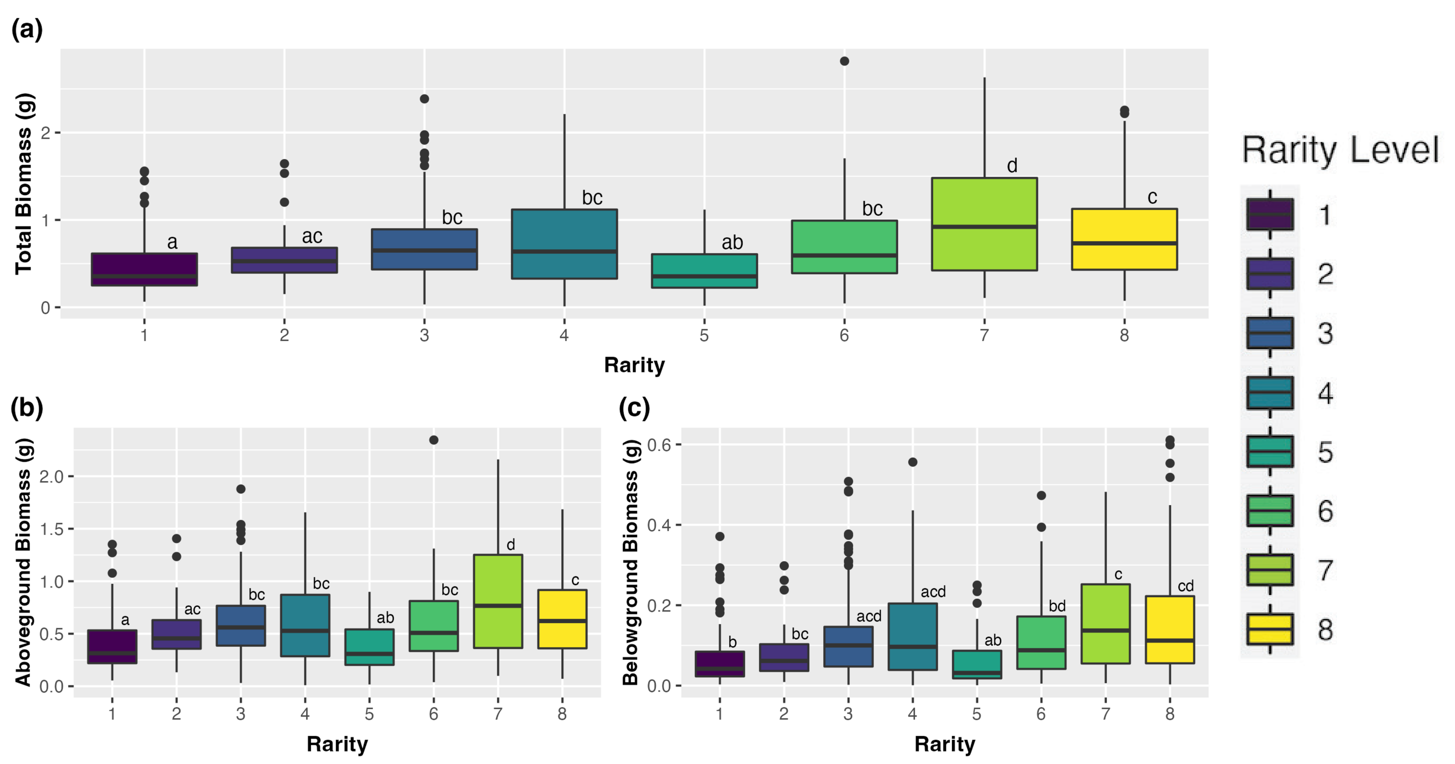

Fig 1. There were significant differences in the aboveground, belowground, and total biomass of rare versus common species. The rarest species maintained 53% lower total biomass, 47% lower aboveground biomass, and 73% lower belowground biomass than common species.

Rarity may be a consequence of evolutionary processes acting on plant performance traits

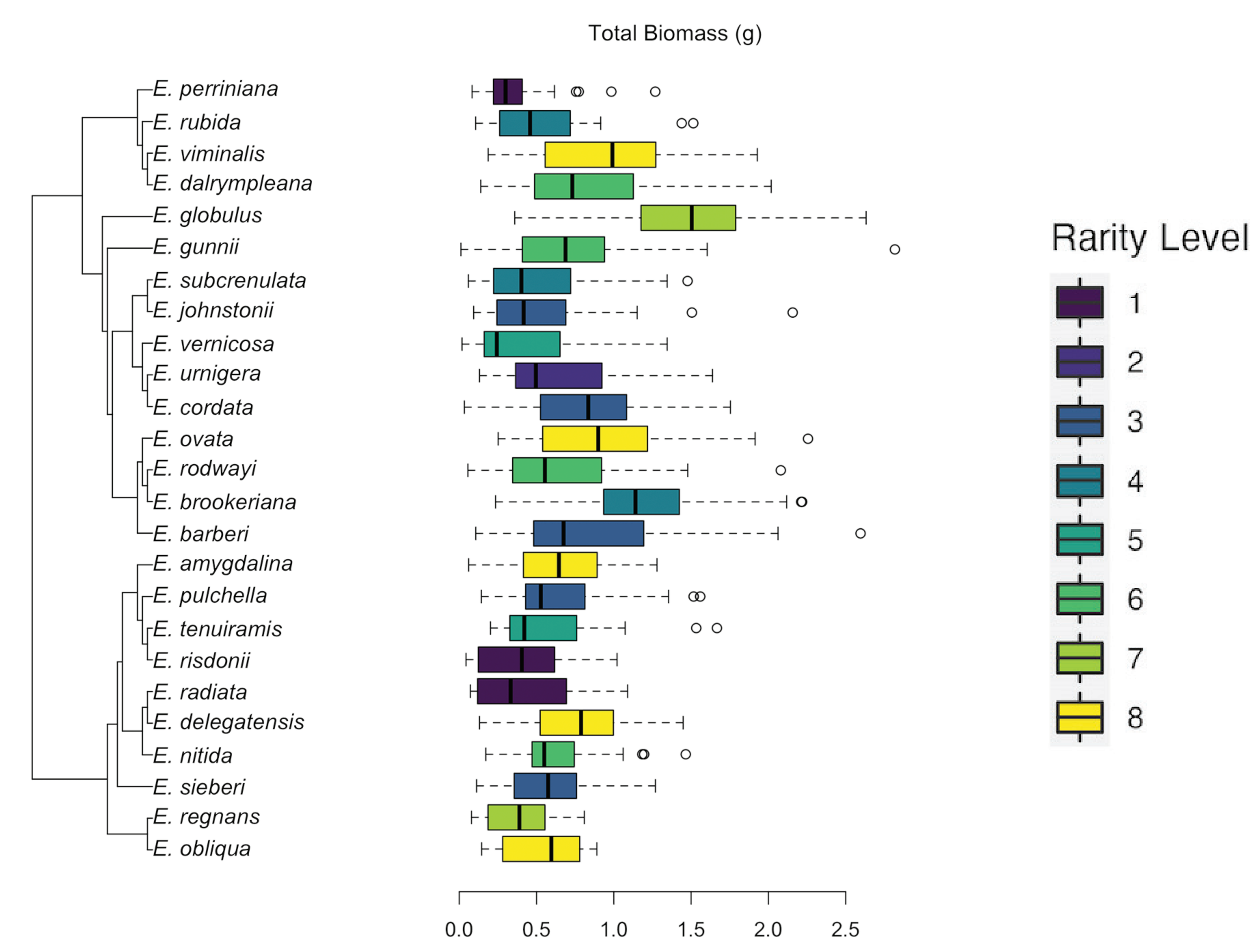

Fig 2. Plant performance traits are under genetic control and have evolved across the phylogeny, demonstrating strong negative phylogenetic autocorrelations for plant biomass in both major clades of Tasmanian eucalypts.

Convergent evolutionary patterns of biomass production can affect fundamental determinants of species rarity

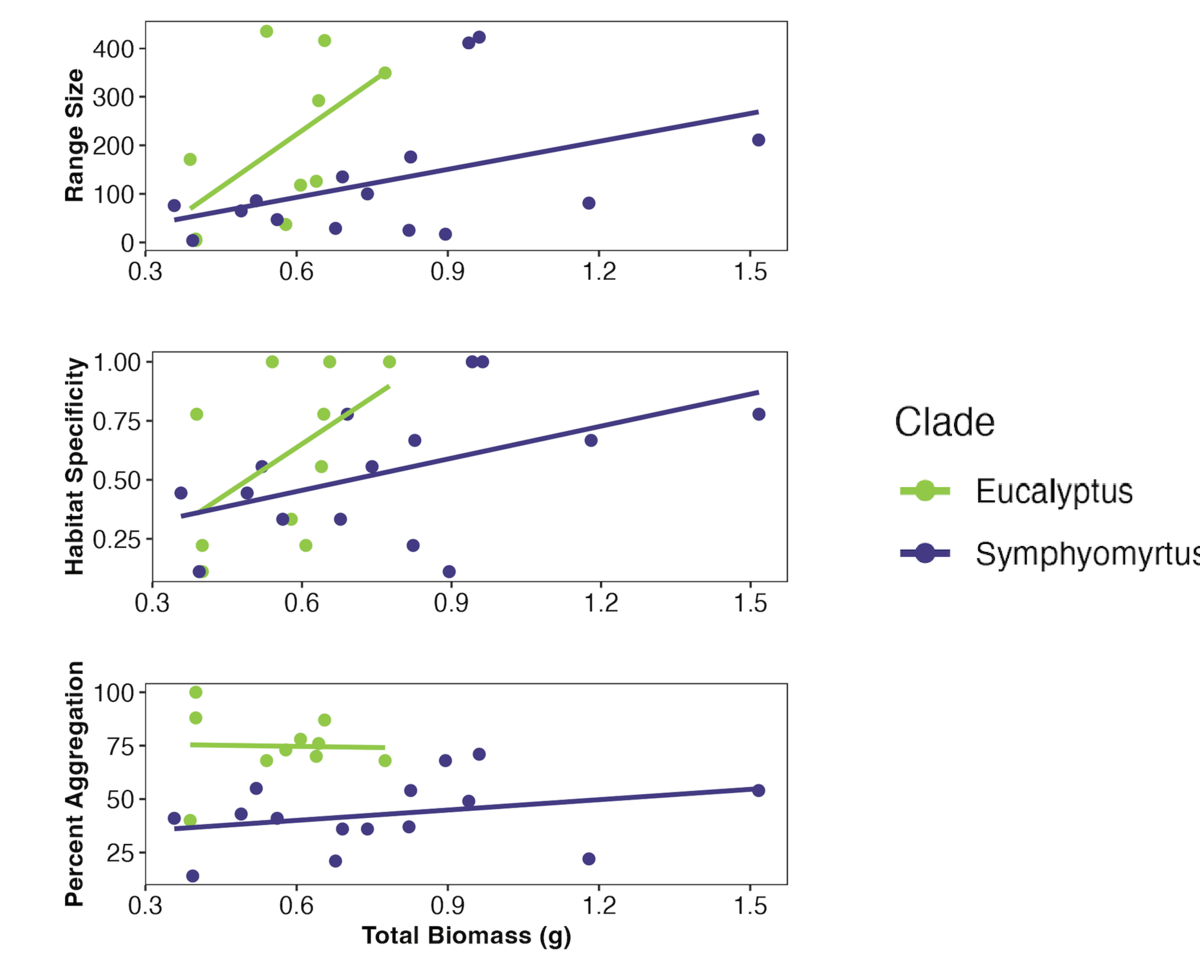

Fig 3. Range size and habitat specificity varied significantly in response to the total biomass of plant species. Both clades of Tasmanian eucalypts exhibited a positive linear relationship between range size/habitat occupancy and seedling biomass.

Evolution of rarity and phylogeny determine biomass in plant-plant interactions

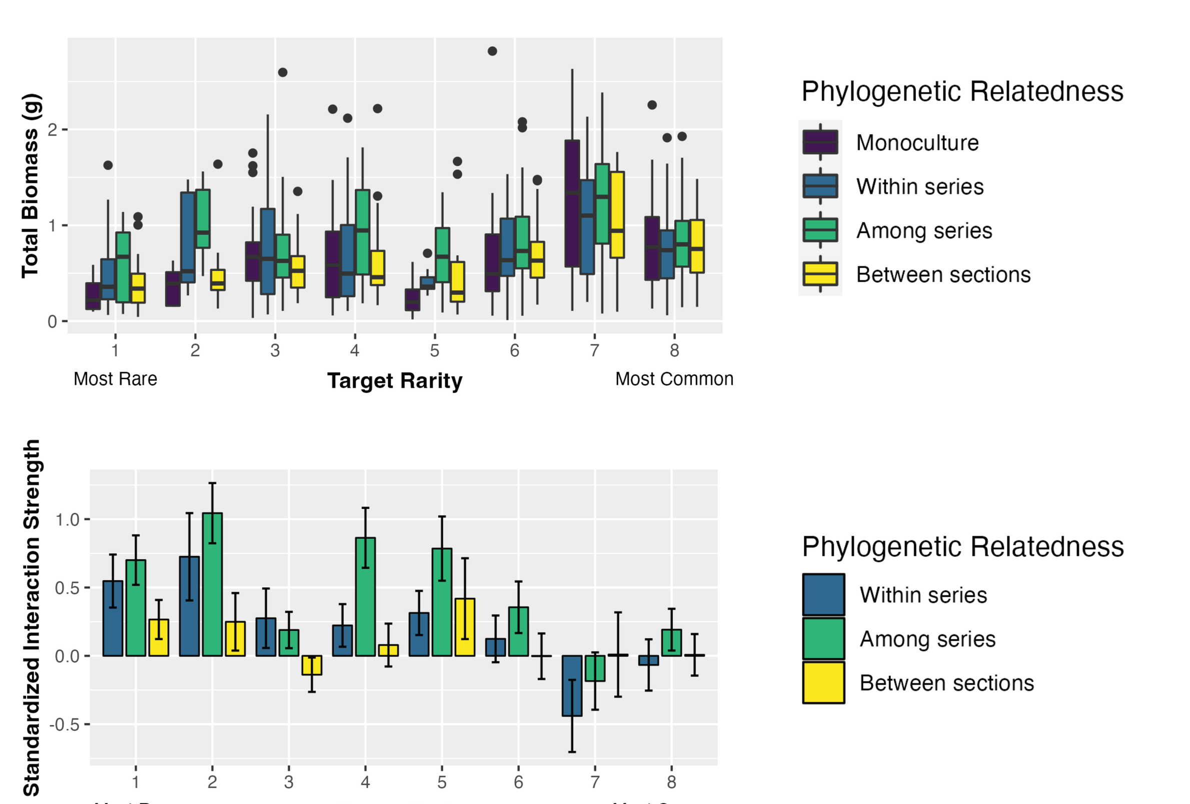

Fig 1. The phylogenetic distance and rarity status of interacting neighbor species were strong determinants of total biomass. Irrespective of the phylogenetic distance of the interacting species, there were non-additive synergistic effects where rare species over-performed in mixture based upon expectations when grown in monoculture.

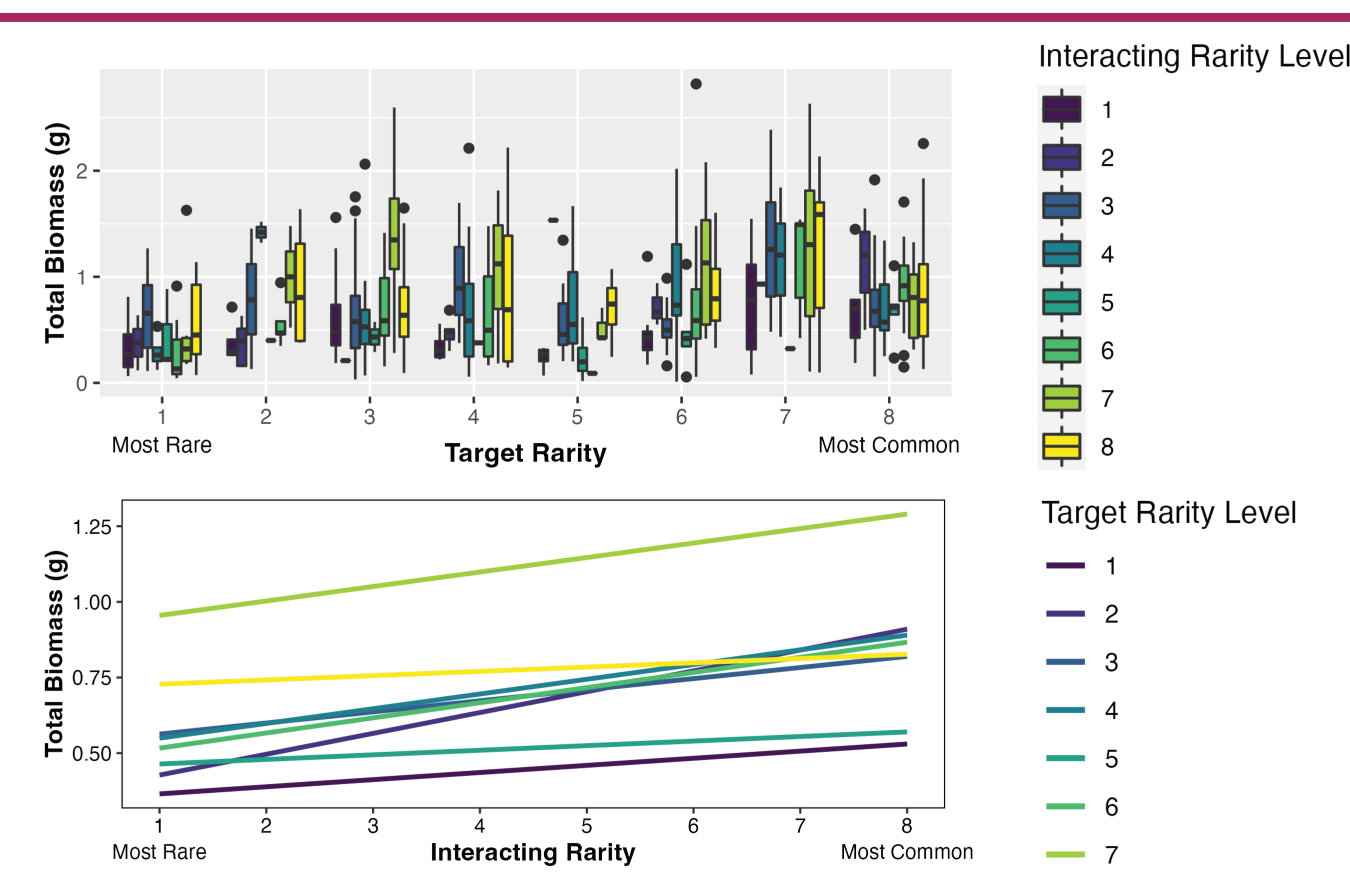

Fig 2. Across all phylogenetic backgrounds, the rarity level of interacting species had a significant effect on the total biomass of all target species.

Methodology

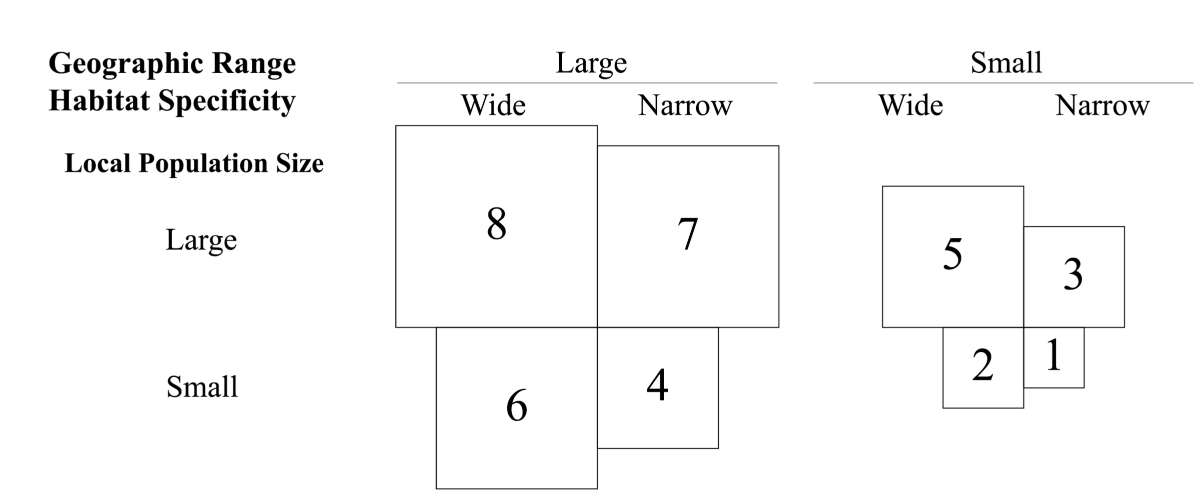

Fig 1
Ordinal rarity classification

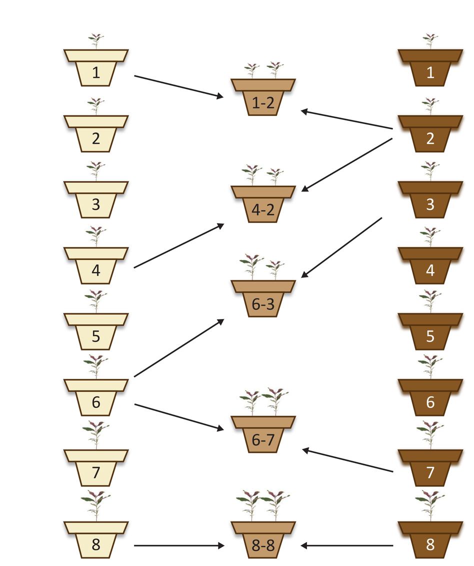

Fig 2
Full factorial common garden experimental design

- Linear mixed models (LMM) were first used to demonstrate a lack of interactive effects between rarity and other variables.
- Phylogenetic generalized least squares (PGLS) models were used to determine statistical differences in the above- and belowground biomass of rare versus common species as well as analyze the effects of biomass and clade on range size, habitat, specificity, and local population aggregation.
- Phylogenetic signals of total, above, and belowground biomass were analyzed using Blomberg's K.

References

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