

LETTER TO THE EDITOR

# In a Warming World: *Sarracenia* as a Possible Model for Range Shift Dynamics and Conservation Highlights Need for Additional Population Genomics Research.

Whether they sport rapidly snapping traps, elegant pitchers with plump peristomes, or sticky, tentacular adhesive leaves, the botanical carnivores are often described as charismatic plants in a world where plants are seldom described as such. In fact, carnivorous plants have become the subject of interest to an entire hobby industry of cultivators, enthusiasts, and *ex situ* conservationists (Mellichamp and Gardner 1987; Mellichamp 2008). Indeed, far from simply being botanical quirks, these plants represent important ecological and evolutionary model systems. Perhaps most obviously, botanical carnivory is compelling in its own right, made even more interesting by its multiple independent origins (Pavlovič and Saganová 2015). In this case, each independent evolutionary origin tells its own story, while weaving together a greater, collective tale about convergent evolution. Studying these systems generates high-order taxonomic insights about convergence among families (Thorogood et al. 2018; Wheeler and Carstens 2018), while also discovering within-genus convergence, such as recently described in two species of *Nepenthes* (Chomicki et al. 2024). The genus *Sarracenia*, more specifically, provides a significant challenge in our understanding of inter- and intraspecific relationships. The genus radiated recently and is prone to hybridization coupled with subsequent introgression (for example, Furches et al. 2013), which can obscure phylogenetic signals and challenge our evolutionary models. This makes *Sarracenia* an excellent model not only for refining existing phylogenetic analyses but also for understanding the ongoing role of hybridization and introgression on plant evolution. A proper understanding of the subgeneric taxonomic relationships in *Sarracenia* requires a population genomics approach. Others have begun this important work (for example, Stephens et al. 2015), but no work to date has captured anything close to the infraspecific variation of the genus. Population genomic techniques can be costly and analytically challenging, but understanding these relationships can inform conservation efforts and help us understand adaptation (Siol et al. 2010) as it relates to botanical carnivory and future range shifts. Finally, most of these botanical carnivores, including nearly all members of the genus *Sarracenia*, will serve as convenient models for studying hydrophytic species range shifts (Vilà-Cabrera et al. 2019; Hernández-Lambraño et al. 2021) in the unfortunate face of a changing climate.

Climate change continues to present itself as one of the greatest existential threats to humanity. The Intergovernmental Panel on Climate Change (IPCC) has diligently modeled changes to the planet that accompany a change of +1.5°C when compared to pre-industrial levels. These changes include ecosystem collapse, record-breaking heatwaves, food insecurity, as well as more frequent and intense storms (Hoegh-Guldberg et al. 2018). The Paris Climate Agreement states the goal of keeping global average temperature increase to ‘well-below 2°C’. This requires that greenhouse gas emissions must peak before 2025 and decline significantly before 2030 (United Nations Environment Programme, 2015). While anthropogenic activities have already warmed the climate, models suggest that an additional +0.5°C to +1.0°C warming presents additional risk (Hoegh-Guldberg et al. 2019).

The exact effects of climate change will depend on region and ecosystem. Wetland ecosystems will fare poorly, shifting location, contracting, or being swallowed by a rising ocean (Erwin, 2009). Habitat to many rare and endangered species (Means 2006; Peet 2006), longleaf pine savannas of

the southeastern United States are already reduced from their peak expanse of ~37 million hectares to less than one million hectares (Frost 2006). The threat to ecosystems introduced by rapidly changing environmental conditions is likely to contribute to continued decline. The majority of longleaf pine habitats in the southeastern United States will fare quite poorly in the face of global climate change, as increasing summertime droughts (Ingram et al. 2013) threaten hydrophytic species native to the mesic longleaf savannas (Van Lear et al. 2005; Sharma et al. 2020). A host of *Sarracenia* and *Drosera* species make their home in mesic longleaf savannas of the southeastern United States coastal plain. Will the entirety of the remaining native range of *Dionaea muscipula* become part of the Atlantic ocean?

The time for remediation and research, conservation and conversation is here. The goals of empirical research, practical *in situ* and *ex situ* conservation efforts, and fundamentally understanding global change as an extinction-level event all intersect in the study of these weird botanical carnivores.

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