Global distribution and climatic preferences of $C_4$ eudicots and how they differ from those of $C_4$ grasses

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Abstract

$C_4$ is one of three known photosynthetic processes of carbon fixation in flowering plants. It evolved independently more than 61 times in multiple angiosperm lineages and consists of a series of anatomical and biochemical modifications to the ancestral $C_3$ pathway increasing plant productivity under warm and light-rich conditions. The $C_4$ lineages of eudicots belong to seven orders and 15 families, are phylogenetically less clustered than those of monocots, and entail an enormous structural and ecological diversity. Eudicot $C_4$ lineages likely evolved the $C_4$ syndrome along different evolutionary paths. Therefore, a better understanding of this diversity is key to understanding the evolution of this complex trait as a whole. Compiling 1,207 recognized $C_4$ eudicots species described in the literature and presenting trait data among these species, we identify global centres of species richness and of high phylogenetic diversity. Furthermore, we discuss climatic preferences in the context of plant functional traits. We identify two hotspots of $C_4$ eudicot diversity: arid regions of Mexico/Southern United States and Australia, where several $C_4$ eudicot lineages diversified independently. Further eudicot $C_4$ hotspots with many different families and genera represented are in South Africa, West Africa, Patagonia, Central Asia and the Mediterranean. In general, $C_4$ eudicots were abundant in deserts and xeric shrublands, tropical and subtropical grasslands, savannas and shrublands. We found $C_4$ eudicots to occur in areas with less annual precipitation than $C_4$ grasses which can be explained by frequently associated adaptations to drought stress such as among others succulence and salt tolerance. We conclude that in most eudicot lineages $C_4$ evolved in ancestrally drought adapted clades and enabled these to further spread in these habitats and colonise even drier areas.

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