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Experimental insights into angiosperm origins.

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The angiosperms occupy almost every habitat type on Earth and comprise nearly 90% of extant plant species. Yet this ascendency is a relatively recent (geological) phenomenon. Palaeobotanical evidence indicates a likely first occurrence in the Early Cretaceous followed by a relatively rapid increase in diversity with their rise to dominance marking the onset of modern world. Understanding this diversification event has been a key research question since Darwin commented on this “abominable mystery”, and it remains one of the most significant unanswered questions in plant biology. Sequencing work shows that the diversification and radiation was accompanied by successive whole genome duplication (WGD) events. Furthermore proxy data and predictions from long-term carbon cycle models indicate that the angiosperm diversification was accompanied by a decline in atmospheric CO_2. These observation raise the intriguing possibility that declining atmospheric CO_2 concentration and capacity to undergo polyploidy could have given angiosperms a competitive advantage when compared to other plant groups.

Using comparative ecophysiology we set out to test the effects of declining atmospheric CO_2 by growing a six species (*Ranunculus acris* and *Polypodium vulgare*, chosen to represent Cretaceous understorey angiosperms and pteridophytes respectively. *Liquidambar styraciflua* and *Laurus nobilis* represented canopy angiosperms and *Ginkgo biloba* and *Metasequoia glyptostroboides* canopy gymnosperms) in controlled conditions across a CO_2 gradient (2000, 1200, 800 and 400 ppm) to simulate Cretaceous CO_2decline. To test for WGDs we use the relationship between guard cell size and genome size to reconstruct angiosperm genome size as they radiated.

Analysis of our fossil dataset shows that earliest angiosperms had a small genome size. Our experimental work shows that angiosperms have a greater capacity for acclimation suggesting that declining CO_2 could have acted as a trigger for the angiosperm rise to dominance. When viewed collectively our data indicate that within angiosperms there is a close coupling of genome size to physiological and reproductive processes that is absent in other plant groups. Consequently the ability of angiosperms to alter key processes as genome size changes might explain a proportion of Darwin’s “abominable mystery”. More broadly, these data highlight the benefits of developing approaches that allow the integration of palaeobotanical observation with experimental data.