Can the morphology of fossil leaves tell us how early flowering plants grew?

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Scale bar = 1 cm. From the Potomac Group. The specimen is from the Smithsonian Institution (USNM 222855A). Credit: Courtesy of Dana Royer, Wesleyan University, Middletown, CT.

Fossils and their surrounding matrix can provide insights into what our world looked like millions of years ago. Fossils of angiosperms, or flowering plants (which are the most common plants today), first appear in the fossil record about 140 million years ago. Based on the material in which these fossils are deposited, it is thought that early angiosperms must have been weedy, fast-growing shrubs and herbs found in highly disturbed riparian stream channels and crevasses.

Dana Royer from Wesleyan University, Connecticut, and colleagues wanted to see if aspects of a fossil plant's life history, such as its growth strategy, could be determined from its morphology rather than from the matrix in which it was deposited. Could this technique corroborate the idea that these ancient plants were fast-growing species? And, importantly, how common was this life history strategy for plants 100 Ma? The results of their research are published in the March issue of the American Journal of Botany.

The authors first needed to assess whether aspects of leaf morphology in living plants today could accurately predict their life-history strategies. In previous research, Royer and colleagues had found that two simple measurements—petiole width and leaf area—could tell a lot about the ecophysiology of a plant. They found that the ratio of petiole width (squared) to leaf area is correlated to a leaf's dry mass per area.

"Leaf mass per area is a measure of the density or thickness of leaves, and it is strongly linked to how quickly a plant turns over its nutrient resources," Royer said. "Thin, cheaply built leaves (low leaf mass per area) are typically associated with plants with fast growth rates, and plants like these are usually most competitive in highly disturbed environments such as riparian corridors because their rapid growth allows them to be more opportunistic."

The authors measured the petioles and leaf areas of 93 species of living conifers and 58 species of herbaceous angiosperms and compared the resulting leaf mass per areas to those of previously published woody angiosperms. They found that these three groups could be distinguished based on their leaf mass per areas: for a given petiole width, herbaceous herbs tended to have 43%-75% lower leaf mass per area than woody angiosperms, and conifers had 19%-58% higher leaf mass per area than woody angiosperms.

The beauty of this methodology is that leaf petiole width and leaf area are measurable in many fossil specimens. Royer stated that they then used this methodology to "estimate the leaf mass per area for some of the oldest known angiosperm leaf fossils." They measured 179 fossil specimens representing 30 species from three Albian (110-105 Ma) sites across the United States.

"The majority of the fossils measured in our study have low leaf mass per area," noted Royer, supporting the idea that early angiosperms were fast-growing species similar to the flora found in riparian habitats today. If a similar relationship as today is assumed, then all of the fossil angiosperm species had leaf lifespans of less than 12 months. "This means the unrivalled capacity for fast growth observed today in many angiosperms was in place by no later than the Albian (110 Ma ago)."

"While this doesn't tell us anything directly about the earliest angiosperms—the oldest angiosperm pollen is around 140 Ma old—the Albian marks the time when angiosperms begin to be very diverse and important ecologically," Royer concludes. "It is likely that explosive growth is one reason for the success of angiosperms."

More information: http://www.amjbot.org/cgi/content/full/97/3/438

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