New research changes understanding of C4 plant evolution

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Dr. David Nelson prepares a sample for stable isotope analysis.

(PhysOrg.com) -- A new analysis of fossilized grass-pollen grains deposited on ancient European lake and sea bottoms 16-35 million years ago reveals that C4 grasses evolved earlier than previously thought. This new evidence casts doubt on the widely-held belief that the rise of this incredibly productive group of plants was driven by a large drop in atmospheric carbon dioxide concentrations during the Oligocene epoch.

The research team, led by University of Maryland Center for Environmental Science Appalachian Laboratory researcher Dr. David Nelson and University of Illinois Professor Feng Sheng Hu, examined the carbon isotope signatures of hundreds of grass-pollen grains and

found that C4 grasses were already present on the landscape during the early part of the Oligocene, some 14 million years earlier than previously thought from geological evidence. Their findings are now published online in the journal *Geology* and will shortly appear in the print edition.

"The idea that C4 grasses originated prior to global decreases in carbon dioxide levels requires us to reevaluate the way we think about the evolution of C4 photosynthesis," said Dr. Nelson. "This new information should encourage the examination of alternate evolutionary selection pressures, such as warm temperatures or dry climates."

C4 plants compose only 3 percent of flowering plant species, yet account for about 25 percent global terrestrial productivity. About 60% of C4 species are grasses, and they dominate the world's grassland and savanna biomes, particularly those in warmer, lower latitude areas. Their ecological success results from the way these species concentrate and then fix carbon dioxide in order to power photosynthesis. While the most well known C4 plants are maize and sugar cane, both of which are critical to human consumption, there is a growing interest in their use as biofuels in order to capture carbon from the atmosphere to mitigate increasing global carbon dioxide levels.

The team used an innovative technique pioneered by Dr. Nelson earlier in his career - the Single Pollen Isotope Ratio Analysis or SPIRAL – to analyze the samples. The scientists first extracted grains of grass pollen from sedimentary rocks using a micromanipulator; then analyzed the tiny samples using a microcombustion device interfaced with an isotope ratio mass spectrometer in Ann Pearson's laboratory at Harvard University, which houses one of only a handful of these devices in the world. Through this analysis, they were able to detect the signature of C4 species from their more common C3 counterparts, because C4 and C3 plants take up different ratios of carbon isotopes during photosynthesis.

"SPIRAL enables us to detect C4 grasses at much lower abundances in geological records than previous approaches, which is helping to revolutionize our ability to study their ecology and evolution," said Dr. Hu. University of Illinois graduate student Michael Urban, lead author of the paper, continues to analyze samples from other parts of the world to look at variation in C4-grass abundance in relation to past changes in atmospheric CO_2 and climate.

More information: The article, "Isotopic evidence of C4 grasses in southwestern Europe during the Early Oligocene-Middle Miocene" is online at geology.gsapubs.org/content/ea … 05/G31117.1.abstract

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