When flowers turn up the heat

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Could a "hot" flower attract pollinators by serving as a reward in a plant-pollinator mutualism? Many flowering plants produce nectar and pollen as rewards in exchange for pollination services by insects and other animals. Interestingly, however, a few plants have flowers that also produce heat metabolically -- so what is the adaptive function of this flower heating?

Susanne Renner from the University of Munich, Germany and Shi-Xiao Luo from the South China Botanical Garden, along with collaborators from China and Taiwan, were interested in determining whether there was a connection between the heating of flowers and the pollination services of flies in an ancient Chinese family, Schisandraceae. Although this family is quite widespread, including Asia and the Americas, its center of diversity is in China, which is one reason Renner and colleagues chose to examine this question in two Chinese Illicium species. Their novel findings are published in the July issue of the American Journal of Botany.

"A few flowers, usually ones pollinated by beetles or flies, produce heat to help scent emission or to create especially attractive egg laying sites for their pollinators," Renner commented. "Usually such heating occurs only during flowering, simultaneous with the release of pollen and stigma receptivity. We discovered that in an Asian Illicium species, flowers reach their highest temperatures during early fruit development, and experiments revealed that this is for the exclusive benefit of the pollinator's larvae, which develop in the spent flowers."

Indeed, by combining diurnal and nocturnal observations of flower visitors with recordings of flower temperature from the onset of the female phase, through the male phase, and on through what the authors term the "nursing phase," Renner, Luo, and colleagues made a surprising discovery that the key stage of thermal warming was well after the flowers' sexual function is over.

By staying up for hours throughout the night, Luo observed that gall midges, belonging to a new species of Clinodiplosis, visit flowers in the male and female phases, carry pollen in on their bodies, and lay eggs on stigmas. At the end of the male stage, the flowers' stigmas fold inward and the styles move upright, forming a chamber around the midge eggs. It is during this "nursing phase" that the flowers produce the highest temperatures (about 2.5° C above ambient temperatures).

"Experiments revealed that heated tissues are essential for the development of the pollinators' larvae," Renner noted. When the tepal tips were trimmed, larvae in the nurseries died, presumably because of the temperature drop, but seed development was not affected. "This implies a novel role for flower heating," says Renner. "An immediate lesson from this discovery is that heat monitoring should not stop with the end of a flower's attractive phase."

When the authors examined the pattern of midge pollination and flower heating in Schisandraceae within a molecular phylogenetic context, they concluded that flower heating is an ancestral trait, which likely first evolved to attract flies through increased odor emission. Midges subsequently may have taken advantage of the warm flowers for breeding, thus setting the stage for this exclusive mutualism.

More information: Luo, Shi-Xiao, Shu-Miaw Chaw, Dianxiang Zhang, and Susanne S. Renner (2010). Flower heating following anthesis and the evolution of gall midge pollination in Schisandraceae. American

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