Family quarrels in seeds reveal the ways parents and offspring sometimes evolve in conflicting directions

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Arabidopsis thaliana. Credit: Wikipedia.

It's spring, finally—and in the tree branches a battle is brewing. A robin returns to her nest with an earthworm. Her nestlings all beg, but only one

will get this meal. And while Mom has an interest in making sure that all of her babies thrive, each little bird is more selfish. So the baby opens his beak again and again: give me more!

Now picture a similar clash playing out in flowers of the same tree. A new study from Washington University in St. Louis reveals the surprising way that family quarrels in seeds drive rapid evolution. Researchers in Arts & Sciences discovered that conflict over the amount of resources an offspring receives from its parent seems to play a special role in the development of certain seed tissues. The study will be published the week of April 22 in the *Proceedings of the National Academy of Sciences*.

Plant seeds contain tissues that represent three distinct genetic relatives: the mother, the embryo and a bizarre triploid tissue called the endosperm that is involved in nutrient transfer from mother to embryo.

Katherine Geist, a Ph.D. candidate in the laboratory led by David C. Queller, the Spencer T. Olin Professor of Biology in Arts & Sciences, and Joan Strassmann, the Charles Rebstock Professor of Biology, used genomic data from the model plant, *Arabidopsis thaliana*, to illuminate a dispute between these three parties over how much resources should be given to the embryo.

"When we think about how parent-offspring conflict might manifest, we have a tendency to think that there has to be two different parties interacting, a mother and baby," Geist said. Any one baby wants more for itself than for its siblings while the mother wants a fair split among her offspring.

Robin nestlings beg for the earthworm, for example. Human babies cry.

"In a seed, that might not be as obvious," Geist said. "But there's still all

of this stuff going on at a hormonal and cellular signalling level.

"These are different parties with different genetic interests," she said.

All in the family

This year Queller and Strassmann are working as fellows of the Wissenschaftskolleg, an institute for advanced study in Berlin. They are best known for their work on social evolution in amoebas and within wasp societies. The new study tackles related questions in plants, and is a test of a theoretical kin selection model that Queller first explored decades ago, initially as a graduate student.

Evolutionary conflict often leads to faster evolution—sometimes called an "arms race"—as organisms with competing interests seek to one-up each other generation after generation. This interaction is best recognized where the conflicts are very strong, such as the conflict between a host and pathogen.

"But relatedness is expected to decrease conflict," Queller said. "We wanted to see if conflicts among kin nevertheless drive rapid evolution consistent with an evolutionary arms race."

Plants squabble, too

Previously published genomic data for Arabidopsis identified the genes specialized for different parts of a parent plant's body, as well as those for its seed tissues and sub-tissues. Graduate student Geist meticulously combed through multiple iterations of this data for her focus species of Arabidopsis and a few of its cousins.

She compared the rates of adaptive evolution in the genes that control

growth in different parts of the plants.

Geist found higher rates of adaptive evolution for genes upregulated in seeds, as compared with rates in other plant organs—like floral buds, stems, leaf rosettes and roots. She also found more evidence of adaptive evolution in genes expressed in the endosperm and maternal tissues than in embryos, and more in the seeds' sub-tissues that are specifically involved in nutrient transfer.

"We see our predicted molecular evolution pattern of rapid adaptation in the regions of the genes that are involved in resource allocation, but not in those that are presumably only involved in storage," Geist said.

The results support the predictions that arms races come not just from implacable enemies—like hosts and pathogens—but also from lesser squabbles within families. They also suggest that plant families have the same kinds of squabbles as animals.

The social interactions explored in this study might have implications for seed size that could be explored investigated in future work, researchers said. The ultimate size and nutritional value of seeds is important to humans, who rely on grains like rice, wheat, barley and quinoa as major sources of food around the world.

More information: Katherine S. Geist el al., "Family quarrels in seeds and rapid adaptive evolution in Arabidopsis," *PNAS* (2019). www.pnas.org/cgi/doi/10.1073/pnas.1817733116

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