Squirrels that gamble win big when it comes to evolutionary fitness

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Female North American red squirrel in the Yukon, Canada with a radio-collar on. The yellow bucket is put high up in a tree to provide them with supplemental peanut butter. Credit: Ben Dantzer

Imagine overhearing the Powerball lottery winning numbers, but you

didn't know when those numbers would be called—just that at some point in the next 10 years or so, they would be. Despite the financial cost of playing those numbers daily for that period, the payoff is big enough to make it worthwhile.

Animals that live in highly variable environments play a similar lottery when it comes to their Darwinian fitness, or how well they are able to pass on their genes. In a new study led by the University of Michigan, scientists found that red squirrels that gambled at the game of reproduction outperformed their counterparts, even if it cost them in the short term.

Natural selection favors female squirrels that have large litters in years when food is abundant because they contribute lots of babies to the gene pool, said Lauren Petrullo, lead author and National Science Foundation postdoctoral research fellow in biopsychology at the University of Michigan.

"We were surprised to find that some females have large litters in years when there won't be enough food for their babies to survive the winter," she said. "Because it's biologically expensive to produce offspring, we wanted to know why these females make what appears to be an error in their reproductive strategy."

The red squirrels studied live in the Canadian Yukon and experience a "mast year," or boom in their main food source—seeds from the cones of white spruce trees—once every four to seven years. Squirrels forecast the large mast crop of food before it occurs and increase litter sizes in the months prior, ensuring better future survival for their babies and better fitness for themselves.

"There is a constant tug-of-war between the trees and the squirrels at our study site," Petrullo said, "with each player trying to deceive the other

for its own fitness gain."

Petrullo and Ben Dantzer, U-M associate professor of psychology and of ecology and evolutionary biology, used data collected by the Kluane Red Squirrel Project, a collaborative, 34-year-old field study involving U-M, the University of Colorado, the University of Alberta and the University of Saskatchewan.

"Each year, we collect data on how many babies squirrels produce and how many spruce cones the squirrels eat," Dantzer said.

The scientists quantified the reproduction of female squirrels during both food booms and busts, discovering differences in their fitness whether they gambled with their reproductive strategy or not. While some squirrels played it safe by keeping litter sizes small each year, those that took a "pie in the sky" approach by having large litters even when food was scarce enjoyed greater lifetime fitness if they got to experience a mast year, the research showed.

North American red squirrel pups after processing. Credit: Ben Dantzer

Unlike the Powerball example, though, squirrels aren't guaranteed to eventually win.

"In some ways, this strategy of gambling with litter sizes is like playing with fire," Petrullo said. "Because the average squirrel lifespan is 3.5 years and masts only happen every four to seven, a female could potentially be sabotaging her fitness by having too many babies in low-food years, hoping for a mast when she may die before she ever gets to experience a mast at all. This could be pretty costly."

Alternatively, for squirrels, the cost of not gambling at all in the game of reproduction can be insurmountable if they end up missing their shot at

the jackpot.

"It's essentially impossible for a female to recuperate the fitness costs of not ramping up reproduction in a mast year, so the stakes are extremely high," Petrullo said.

Females that increased litter sizes in low-food years did take a short-term hit to their fitness. But they were more likely to increase litter sizes if and when they experienced a mast, taking home the ultimate prize of greater lifetime reproductive success, she said.

The squirrels' best bet, according to the researchers, is to take their chances and suffer short-term fitness costs in order to avoid the unmatched cost of missing the fitness jackpot completely.

"Determining the relative costs of different types of errors is key to understanding *why* animals make what look to us like mistakes," Petrullo said.

Scientists are still unsure exactly how the squirrels are able to forecast future food production. The animals may be eating parts of the spruce trees that affect their physiology and alter the number of babies they produce, Dantzer said.

"This is exciting because it suggests that squirrels are eavesdropping on the trees, but we still have much more to do to solve this puzzle," he said.

Because many animals use cues about things like food in their environment to make reproductive decisions, and the reliability of these cues is declining due to global climate change, scientists also wonder how the costs of these types of errors will alter what is the best reproductive strategy.

"If the predictability of a food boom is reduced and squirrels can no longer forecast the future, this could impact the number of squirrels out there in the Boreal forest," Dantzer said. "This could be problematic given that squirrels are prey for many predators."

The research, "Phenotype-environment mismatch errors enhance lifetime fitness in wild red squirrels," appears in *Science*.

The study's co-authors are Stan Boutin, University of Alberta; Andrew McAdam, University of Colorado; and Jeff Lane, University of Saskatchewan.

More information: Lauren Petrullo et al, Phenotype-environment mismatch errors enhance lifetime fitness in wild red squirrels, *Science* (2023). DOI: 10.1126/science.abn0665.
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