Completing the set: 'Coupon-collection behavior' reduces sex-ratio variation among families

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A new analysis of sibling records from more than 300,000 individuals suggests that some parents continue to reproduce until they have children

of both sexes.

The practice, which the two University of Michigan biologists who conducted the study dubbed "coupon-collection behavior" in human reproduction, appears to have increased in popularity in recent decades and reduces the amount of sex-ratio variation among families.

In a study scheduled for publication Aug. 6 in the journal *Current Biology*, Jianzhi Zhang and Erping Long report that significantly more families than expected had children of the same sex except for the last-born child. The trend is more pronounced in the most recent data.

"We believe that coupon-collection behavior becomes popular only when daughters and sons are considered to have similar utility to families, which would require society-wide improvement in gender equality and appreciation of gender diversity," said Zhang, a professor in the U-M Department of Ecology and Evolutionary Biology.

The coupon collector's problem comes from probability theory, where it refers to someone who continues to buy a particular brand of cereal, each package of which contains one randomly placed coupon, until he or she collects all the different types of coupons in the set.

Zhang and Long propose that the concept also applies to reproductive behaviors that reflect a preference for having children of both sexes. At the time of this work, Long was a U-M visiting scientist from Sun Yat-sen University in Guangzhou, China.

Their conclusions are based on an analysis of sibling records from the UK Biobank database, which contains genetic, health and family information from volunteer participants in the United Kingdom, the vast majority of whom were born between 1940 and 1970.

The results relating to sex ratio, defined as the proportion of male children in a family, are best explained by 3.3% of the families using coupon-collecting behavior to pursue children of both sexes, according to the researchers. That number is considered a conservative estimate, and the true fraction of families following coupon-collection behavior is likely to be higher.

"Our hypothesis is consistent with reports that Europeans express in interviews their desires to have children of both sexes, and the observations in Denmark, Sweden and Finland that the probability for a mother to have a third child is higher when the first two children are of the same sex than when they are of different sexes," Zhang and Long wrote.

To confirm coupon-collection reproductive behavior and its rising popularity in other populations, the researchers also examined a family tree-based genealogical database that contains 241,000 Dutch families over four centuries, with known numbers and genders of children of each family. They found higher-than-expected sex ratio (SR) variations over much of the history; only after 1940 did sex-ratio variation drop below expected levels.

The Dutch data revealed "a profound difference in the among-family variation of SR after 1940 when compared with the preceding 3.4 centuries," Zhang and Long reported. "Thus, the analysis of the Dutch data confirms the finding from the UK Biobank and suggests that the coupon-collection reproductive behavior is a relatively recent phenomenon."

The odds of conceiving a boy versus a girl are believed to be 50-50, and the outcome is determined by which of the father's sperm makes it to the mother's egg first. If the egg is fertilized by a sperm bearing a Y chromosome, the result is a boy. If it's an X-bearing sperm, a girl.

But post-conception factors can affect the odds of having a boy or a girl, and scientists have known for centuries that slightly more boys are born each year than girls. In the United States, about 51% of the babies born are male.

There is growing evidence for genetic influences on the probability that a birth yields one biological sex over the other. For example, women who carry the BRCA1 and BRCA2 breast cancer susceptibility genes tend to have more female children.

Various environmental factors during pregnancy may also influence the biological sex of the child. And of course, modern contraception, fertility treatments and abortion can all affect the sex ratio in a family.

If the determination of biological sex at birth were a completely random event—like a 50-50 coin toss—then the probability that a birth yields a boy instead of a girl, known to scientists as Pboy, would be 0.5 for every birth in every family.

But increasing evidence suggests a variable Pboy among families, and the amount of variation around the 0.5 hypothetical random event is known in statistics as the standard deviation (SD) around the mean. The original goal of the study by Zhang and Long was to see whether Pboy is variable in a large set of families and, if so, to determine how variable it is.

Because the sex ratio of the children in a family provides an unbiased though imprecise estimate of the family's Pboy, the standard deviation of the sex ratio among families—the SD of SR—can be used to assess among-family variation in Pboy.

"You can imagine that the SD of SR will be higher if Pboy varies among families than when it is always 0.5," Zhang said. "Surprisingly, we found

that the SD of SR is smaller than when Pboy is always 0.5. This unexpected observation suggests that some other factors are at work."

Those other factors likely include coupon-collection behavior by a small percentage of the families, according to Zhang and Long. Zhang noted that the decline of the SD of SR does not affect the overall sex ratio in a society.

More information: The coupon collection behavior in human reproduction, *Current Biology* (2020). DOI: 10.1016/j.cub.2020.07.040 , www.cell.com/current-biology/f … 0960-9822(20)31032-0

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