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Why do humans have near-equal numbers of male and female babies, unlike many other animals? A new genetic study looks for clues

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We know that boys and girls are produced in much the same frequency. But how – and why – is this 1:1 ratio achieved?

A new paper searches huge human data sets for gene variants that throw the 1:1 sex ratio off balance, and test the biological and theoretical rules of sex ratio.

What produces the 1:1 sex ratio?

Early scientists credited divine providence with ensuring that “every male should have its female”.

Of course, we now know that sex chromosomes are the real determiners of sex. Females have two X chromosomes; males have a single X and a male-specific Y.

The Y carries a male-determining gene called SRY, which kickstarts the differentiation of a ridge of cells into a testis. The embryonic testis makes male hormones which direct the embryo to develop as a boy. Without SRY, an alternative pathway is activated that makes an ovary, and the embryo develops as a girl.

The 1:1 ratio results from the way the X and Y chromosomes are doled out in sperm and eggs. Our cells all have two sets of chromosomes that constitute our genome, one set from each parent. A special type of cell division makes sperm and eggs with just a single set of chromosomes, so that a fertilised egg once again has two sets (one set from the sperm and the other from the egg).

So sperm all get a single copy of each chromosome – and just one sex chromosome, either an X or a Y. XX females make eggs with a single chromosome set, all of which carry an X.

When a sperm fertilises an egg, the sex chromosome the sperm carries determines the sex of the baby. Embryos that receive one X from the mother and another X from the father are destined to be XX girls, and embryos that receive a Y-bearing sperm will develop as XY boys.

So the 1:1 XY ratio in sperm should produce a 1:1 ratio of XX girls and XY boys.

Sex ratio variation

But there are lots of exceptions to a 1:1 ratio in the animal kingdom. There are genetic mutations that subvert the orderly segregation of the X and Y, or that preferentially kill male or female embryos.

Why should the sex ratio be stuck at 1:1 anyway? After all, a few males can fertilise the eggs of many females.

Indeed, for many animals, unequal sex ratios are the norm. For instance, the mouse-sized marsupial *Antechinus stuartii* produces only 32% males, even when assessed at birth (so it's not that male babies die more often).

Many birds have sex ratios far from 1:1, and some show very specific adaptations that make ecological sense. For instance, the second kookaburra chick to hatch, facing a lower chance of survival, is usually a female, the sex most likely to survive.

And there are systems of non-standard sex chromosomes. Polar mammals and strange rodents, for instance, are famous for systems in which a mutant X chromosome quashes SRY to form fertile XY females, or a mutated version of SRY doesn't work. In these species, females predominate, which makes sense for mammals that have to get all their breeding done in a short summer.

Insects take the cake. An extreme case is a kind of mite that produces a ratio of 15 females to 1 male. In many fruit fly species, 95% of sperm carry the X chromosome, so the progeny are largely female.

Why a 1:1 sex ratio in humans? Fisher's principle

So if sex ratio is so malleable, why have humans (and most mammals) gone for a 1:1 ratio? The great British statistician Ronald Fisher proposed that the ratio is self-correcting and will tend to 1:1 unless there are evolutionary forces that select for distortions.

The argument is simple. Given every baby must have a mother and a father, if there is a deficiency in one sex, the parents of the rarer sex will have more grandchildren than parents of the more common sex.

For instance, if males are the rarer sex, parents who by chance produce more sons than daughters will leave more grandchildren than those that produce more daughters than sons. As a result, son-producing genes will get a boost until parity is reached.

So do we see measurable and heritable departures from 1:1 in the family sex ratio of human sons to daughters? What about Fisher's principle – is there any evidence that strong evolutionary effects are constraining the human population sex ratio to be 1:1?

In the new research published this week, researchers Siliang Song and Jianzhi Zhang from the University of Michigan conducted an exhaustive examination of huge human data sets from the United Kingdom and found the answer is an emphatic no. They did identify two genetic variants that affected sex ratio, but these seemed not to be passed on through families.

So why do humans obey the 1:1 rule? Is it just statistical artefact, because any one family has relatively so few children that even large departures from a 1:1 ratio get evened out across many families?

Some families have the gene variants to produce more sons than daughters, but other families produce more daughters than sons. Song and Zhang's analysis suggests this high variability is part of the problem for demonstrating any systematic bias.

Another possibility is that humans face special evolutionary constraints. Perhaps the human tendency for monogamy places additional evolutionary pressure on humans to adhere to Fisher's principle in a way that does not apply to other animal species.

Whatever the answer, this paper by Song and Zhang raises many intriguing questions, and will be a stimulus to further research on the longstanding and fascinating question of parity in the human sex ratio.