How new evidence of sex reversals helps show how sex chromosomes are maintained over evolutionary time

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A new study of the European common frog, Rana temporaria, published in the advanced online edition of the journal Molecular Biology and Evolution, offers some fresh clues that challenge the conventional scientific wisdom on sex-chromosome evolution. Credit: Nicholas Perrin

When it comes to sex, frogs, just like in people, exhibit a similar XX (female) and XY (male) sex chromosome pattern of inheritance.

In humans, while the X chromosome maintains a large number of genes similar to all the other non-sex chromosomes, the poor male-associated Y has been shriveling up over eons of time. In frogs however, the Y shows no sign of degeneration, looking just like the X chromosome.

But what keeps this Y chromosome from degeneration?

A new study of the European common frog, Rana temporaria, published in the advanced online edition of the journal *Molecular Biology and Evolution*, offers some fresh clues that challenge the conventional scientific wisdom on sex-chromosome evolution.

The prevailing view is that the Y chromosome is shrinking in males because XY recombination is suppressed by either chromosomal inversions or nonhomologous regions.

In frogs however, genetic control over sex determination can vary both within and among populations, resulting in the occurrence of regular sex reversals ('leaky' genetic sex determination).

Nicolas Perrin's research group at the University of Lausanne, including work from lead author Nicolas Rodrigues, has found the first direct evidence that these sex reversals help maintain the Y over evolutionary time.

Perrin has called this the "fountain of youth" hypothesis, and the new evidence helps bring frogs some fresh "water" to his theory.

A key point of this model is that in sex-reversed XY females—-a shuffling of the genomic deck—-known as recombination between the X

and the Y chromosomes can take place.

In the study, Perrin's team used a total of 314 adult frogs from a small breeding pond, the Swiss Alpine locality of Meitreile, from which mating pairs were brought to a special outdoor facility at the Lausanne University campus, where frogs laid eggs.

One of the keys to the study was finding among the breeding adults not only a few sex-reversed XX males, but also an extremely rare, XY sex-reversed female. "Our sampling was lucky enough to get one such individual (actually the only XY individual among the 54 sampled females)," said Perrin.

Using 16 sex-linked genetic markers, they carefully measured the number of recombination events, or chromosome crossovers that occurred in their progeny.

They found that recombination in sex chromosomes depends on the phenotypic sex, but not on the genetic sex.

All that seems to matter is being male or female.

"As we show here by including sex-reversed males and females in the analysis, recombination patterns are entirely explained by phenotypic sex, with no detectable effect of genotypic sex, either alone or in interaction. Males, in particular, had strongly reduced recombination independent of sex-chromosome differentiation," said Perrin.

"More importantly (as far as evolutionary consequences are concerned), our present results provide the first direct field evidence that X and Y chromosomes recombine in XY females," said Rodrigues.

They conclude that occurrence of XY-sex reversed female followed by

recombination between X and Y chromosomes may be involved in maintaining the state of sex chromosomes in this species and others as well.

"Our results, therefore, bring strong support for the fountain-of-youth model, by showing that X and Y chromosomes recombine in naturally-occurring sex-reversed XY females," said Perrin. "This result has the potential to account for the lack of sex-chromosome differentiation in Rana temporaria, and by extension in other lineages of amphibians, fishes and non-avian reptiles where sex reversal events have alsobeen documented."

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