UC SANTA BARBARA

THE Current

October 18, 2001
Gail Brown

SEXUAL VS. ASEXUAL REPRODUCTION: SCIENTISTS FIND SEX WINS

Why are most organisms sexual? The question of why most species reproduce sexually and others reproduce asexually has stymied biologists for years (particularly since asexual reproduction has many advantages including producing more offspring.) The question is answered in part in this week's Science Magazine, published on Friday, October 19.

Studies by scientists at the University of California, Santa Barbara show that sexual reproduction wins out, in an evolutionary sense, over asexual reproduction in a major study that included 34 experiments with the common fruit fly Drosophila melanogaster.

Specifically, they discovered that the rate of progressive evolution (the accumulation of beneficial mutations) is faster in populations that reproduce sexually.

"However, there is a high cost associated with producing males," said William R. Rice, first author and professor of biology at the UC, Santa Barbara. "Just do the math and you will see. And yet, look out the window and almost every organism you see reproduces sexually."

The math is simple: with four asexual adults (females) you get eight offspring, but with two males and two females you get only four offspring. In other words, the asexual population grows twice as fast as the sexually reproducing one.

The second part of the mathematical advantage is that the asexual adult female is able to put all of her genes into the next generation, whereas with sexual reproduction, each individual is responsible for only half of the genetic information in the offspring.

"It's a dosage cost," said Rice. "My son only has half of my genes; the other half are from his mother. Only half of my genome is getting into the population. However, if I were an asexual female, my offspring would carry all of my genome. I would put twice as many genes into the next generation. With asexual reproduction you get two times as many offspring and two times as many genes into the population."

There is a broad assumption in this scenario that males do not help with the care and feeding of offspring, although in a small proportion of species they do help: people, wolves, foxes and most songbirds. In these species it is possible to produce more offspring because of the help of the male.

One hypothesis has been that the process of natural selection is more powerful when you mix genes in each generation. The UCSB scientists created populations that mixed genes and populations that didn't.

For the fruit fly experiments, Rice and Adam K. Chippindale (a post-doctoral fellow soon to be on the faculty at Queen's University in Canada), used genetic tools to manipulate the fruit fly so that half were normal flies and half were asexual, and reproduced asexually (a situation that occurs in nature in several species, such as certain lizards and insects). "We created 17 populations that mixed genes and 17 that didn't," said Rice. "In other words, we had populations that were sexual and populations that were asexual."

They followed a mutation at a gene that coded for eye color, specifically for red eyes versus white. They found that this beneficial red eye mutation began to accumulate in both the sexual and asexual populations, but not as much or as fast in the asexual populations.

The researchers found that the efficiency of natural selection is higher because the "signal to background noise ratio of natural selection is higher in the sexual

populations." This means that in evolutionary terms the sexually reproducing populations are the winners on average.

"Almost every life form is sexual, but according to theory asexual populations should win out," explained Rice. "We knew there must be a big countervailing reason that asexual reproduction loses out to sexual reproduction."

Rice and Chippindale knew that they needed a significant number of experiments in order to discover the average tendency. "Otherwise, it is like looking at whether or not wearing seat belts helps," said Rice. "You can't look at only one accident from which to draw conclusions, you need large numbers to show the average."

In the experiments, conducted over a year and a half, the researchers were able to track individual mutations over time. They found that with sexual reproduction, the gene for red eye color rose rapidly toward "fixation" or establishment in the population. The proportion of the red eye color gets higher and higher over time until it is fixed at 100 percent.

With the asexual populations the mutation began to accumulate, but eventually stopped in most cases.

"We knew that there were advantages to sexual diversity, but it was not clear why," said Rice. "Now we have evidence that the rate of progressive evolution (the accumulation of beneficial mutations) is faster in sexual populations. We simulated that and saw that the sexual population gets the good gene faster. This is the first time that this has been consistently demonstrated."

About UC Santa Barbara

The University of California, Santa Barbara is a leading research institution that also provides a comprehensive liberal arts learning experience. Our academic community of faculty, students, and staff is characterized by a culture of interdisciplinary collaboration that is responsive to the needs of our multicultural and global society. All of this takes place within a living and learning environment like no other, as we draw inspiration from the beauty and resources of our extraordinary location at the edge of the Pacific Ocean.