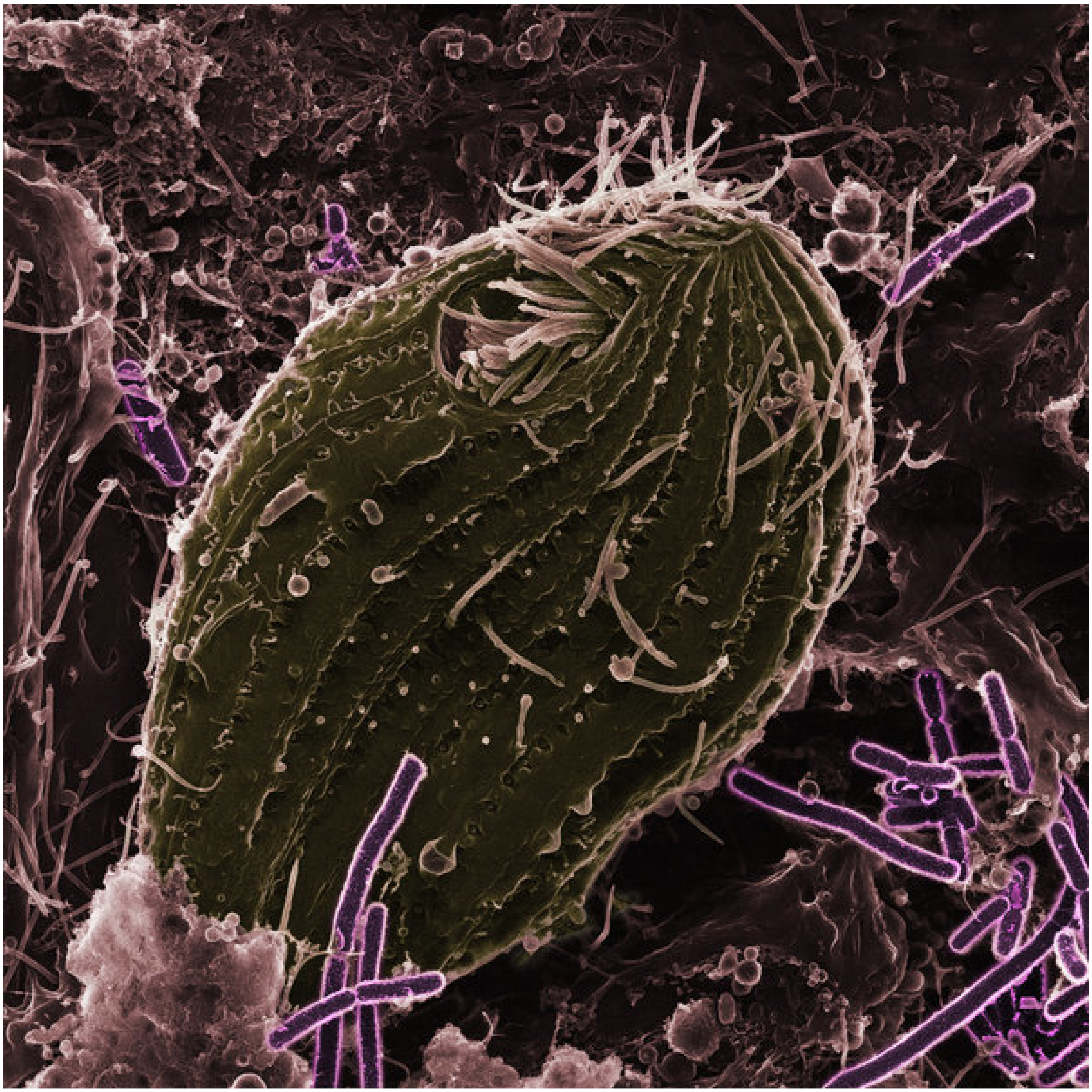
Double the stress slows down evolution

December 6 2018



The single-cell organism Tetrahymena thermophila (green) with its bacterial prey (purple). Credit: Matti Jalasvuori

Like other organisms, bacteria constantly have to fight to survive in hostile living conditions. Together with colleagues in Finland, researchers at the Max Planck Institute for Evolutionary Biology in Plön have discovered that bacteria adapt to their environment more slowly and less efficiently as soon as they are exposed to two stress factors rather than one. This is due to mutations in different genes. The slower rate of evolution led to smaller population sizes. This means that evolution can take divergent paths if an organism is exposed to several stress factors.

Bacteria rarely live alone; they are usually part of a community of species that is exposed to various stress factors. They can often react to these factors by adapting to new environmental conditions with astonishing speed. Antibiotics that enter soil and water via waste water and accumulate there in low concentrations can trigger the evolution of resistance in bacteria – even though these concentrations are so low that they inhibit bacterial growth only slightly or not at all. However, bacteria do not only have to fight antibiotics; they also have to deal with predators. This is why they often grow in large colonies that cannot be consumed by predatory organisms.

Typically, scientists investigate the effects that a single stress factor has on an organism. Researchers at the Max Planck Institute for Evolutionary Biology in Plön and the Universities of Helsinki and Jyväskylä, Finland, have now investigated the question of how microorganisms behave when they are confronted with more than one stress factor. "We simulated natural environmental conditions in the lab and exposed bacteria to both predators and antibiotics. This allows us to estimate how likely it is to find evolution of resistance to antibiotics outdoors," explains study leader Lutz Becks.

Antibiotics and predators

In the scientists' laboratory, the bacterium Pseudomonas fluorescence had to cope with both antibiotics and the predatory single-cell organism Tetrahymena thermophila. After just a short time, the team of researchers noticed that the bacterial population was changing: the bacteria were much slower and less effective in developing resistance and protecting themselves from being consumed than others of the species that were only exposed to one of these factors. Moreover, resistance against the antibiotic was much less common. "The bacteria were clearly unable to optimize both attributes at the same time," says Becks.

In the next step, the scientists analysed the genetic basis of these adaptations. Their results show that mutations for improved protection from predators appear in the same numbers and at the same places in the bacterial genome if only the predatory ciliates are present. The same applies to mutations that cause resistance to antibiotics. However, other mutations occur as soon as both stress factors influence the bacteria and the bacteria have to fight both predators and antibiotics. This causes both the bacteria's protection against predators and resistance to antibiotics to evolve more slowly and be less efficient.

Because the bacteria are less able to protect themselves from predators if they are confronted by the predatory ciliates and antibiotics simultaneously, their numbers are fewer than when they only have to defend themselves from predators. Several stress factors therefore appear to have a strong influence on whether and how often resistance to antibiotics develops and how large the population of bacteria can become.

"Microbial populations – whether in a lake or in the gut – are complex communities in which many species have to compete for resources. The various stress factors to which microbes are exposed have an enormous effect on their evolution and survival rate. It will take some time until we fully understand the interaction of all these factors and the influence of antibiotics and pesticides," explains Becks.

More information: Teppo Hiltunen et al. Dual-stressor selection alters eco-evolutionary dynamics in experimental communities, *Nature Ecology & Evolution* (2018). DOI: 10.1038/s41559-018-0701-5

Provided by Max Planck Society