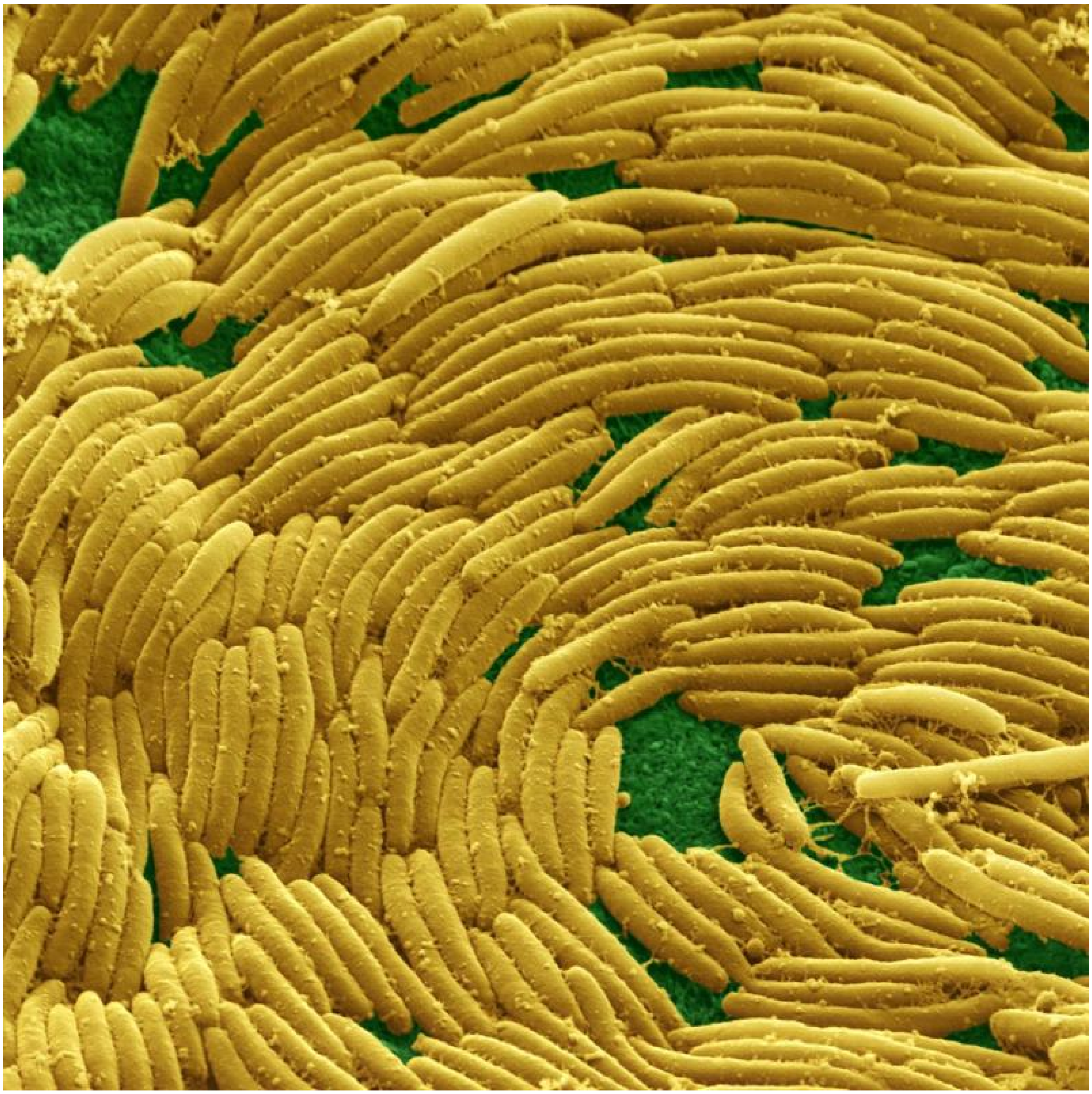
PHYS.ORG

# The winner doesn't always take all

June 11 2015, by Peter Rüegg



Numerous individuals of the soil bacterium *Myxococcus xanthus* gather in a swarm. Credit: Gregory J. Velicer / ETH Zurich

Theoretically predicted and now demonstrated experimentally for the first time using soil bacteria: weaker organisms can prevail against stronger ones—if they are superior in number. This acts as a driving mechanism in the maintenance of genetic diversity.

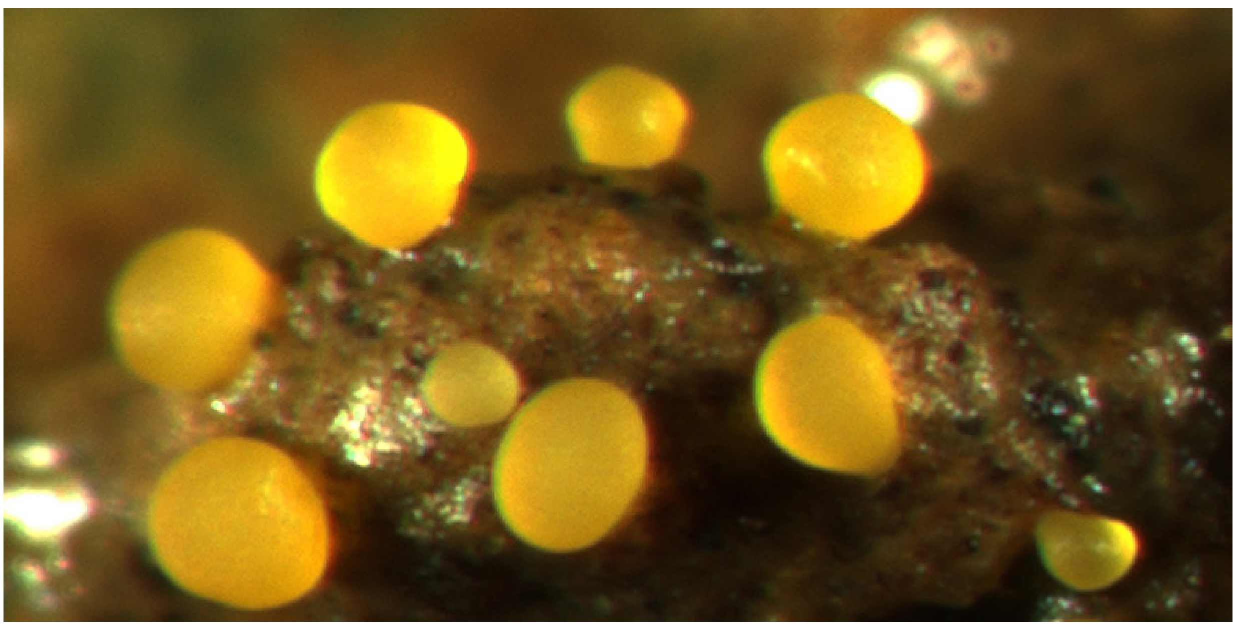
The bacterium *Myxococcus xanthus* is a microbe with special properties. It lives in soils almost all over the world and is capable of social interactions; that is, individuals join forces to go hunting together for other bacteria and fungi. In times of need, several bacteria from this species can jointly form fruiting bodies with spores that can survive without water or nutrients for a long period of time. This works particularly well with bacteria that are closely genetically related. If the individuals are too genetically different, they might mutually impede and destroy one other.

There are numerous genetic variants and strains of *M. xanthus* - some more competitive than others. The tendency is for the more competitive strains to get rid of the weaker ones, which in the long run should mean that strain diversity would go extinct. However, in reality, a different picture emerges: even at a distance of only one centimetre, numerous genetically different strains of *M. xanthus* can be present in the soil. So far, researchers have been able to only speculate as to why and how this diversity is maintained. One theory states that less competitive strains are retained in the population if they can occupy a niche of their own that the dominant bacteria cannot colonise.

## A contest between bacteria

Olaya Rendueles, a postdoctoral researcher at ETH, has now delivered the first experimental evidence of the accuracy of this theory in real bacterial life. The post-doctoral researcher works in the group of Professor Gregory J. Velicer at ETH Zurich's Institute of Integrative Biology. Velicer owns probably on of the largest collections of *M. xanthus* strains in the world - he has more than 1,000 different strains stored as cultures in refrigeration.

In order to identify the factors responsible for the wide diversity observed in soil bacteria, Rendueles compared the competitive abilities of a number of *Myxococcus xanthus* variants. Her study has recently been published in the scientific journal *Current Biology*.



M. xanthus can form yellow fruiting bodies in the event of food shortage. The more closely related the bacteria, the more successful this process is. Credit: ETH Zurich / Gregory J. Velicer

The researcher organised a sort of tournament across a number of petri dishes. First, she checked which strain prevailed in a one-to-one duel. Here, she found that the more competitive strain always prevailed and destroyed the weaker one. Diversity was therefore lost.

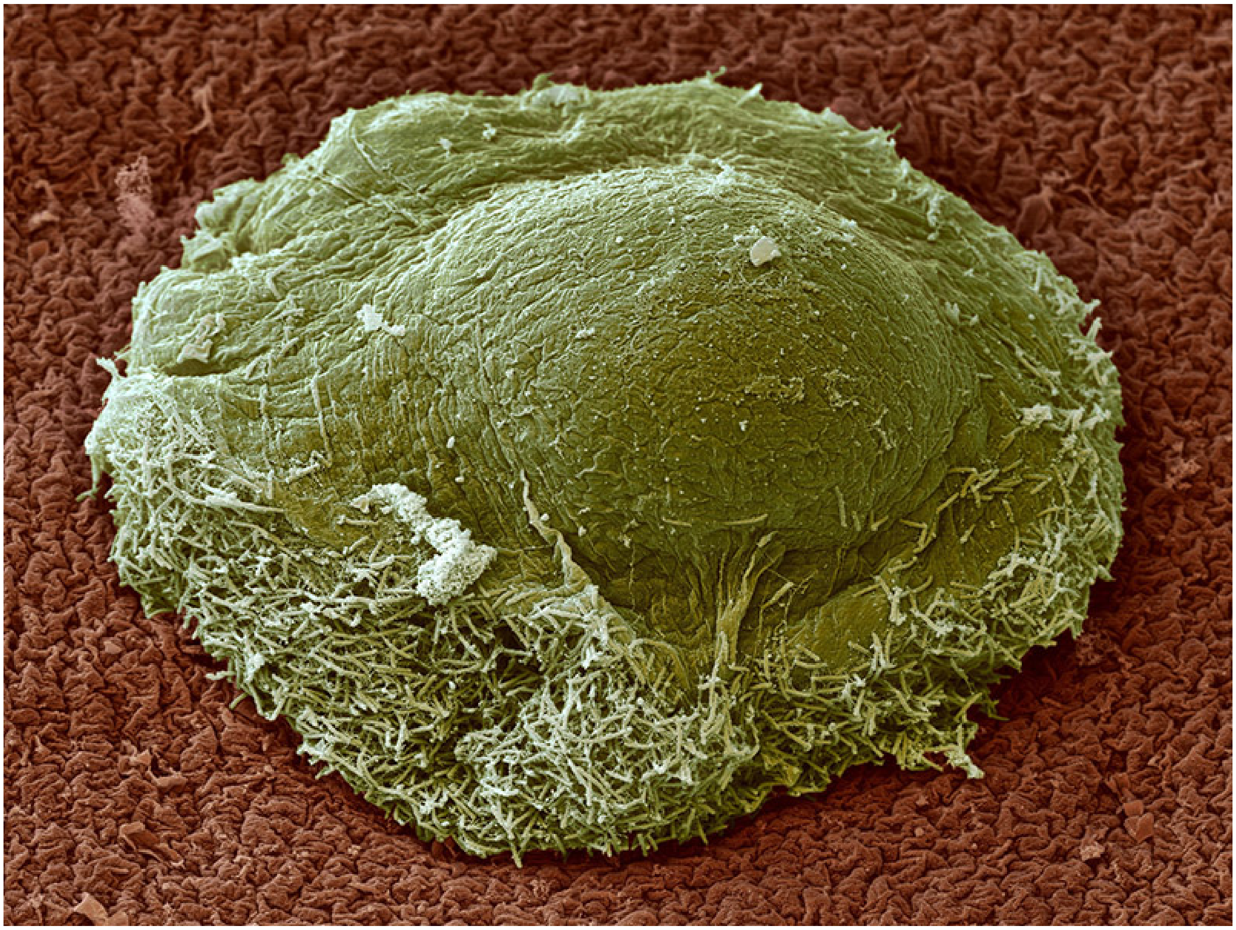
However, this was not so if the less competitive strain outnumbered the stronger strain by a ratio of 99:1. In this case, the weaker strain prevailed. Experts use the term 'positive frequency-dependent selection' to describe this selective advantage due to numerical superiority.

## Niche saves weaker strains

When Rendueles arranged the duels in a chequerboard fashion over four fields, with the weaker strain predominating on a white field and the stronger strain predominating on the black field, then the numerically superior strain always prevailed in the respective field.

If the less competitive strain prevailed in its field thanks to its numerical superiority, then it successfully held on to this field. The more competitive strain could not take over this niche. A social barrier between the genetically different strains hindered the assault. Rendueles discovered that although two different strains can fight one another when single individuals are in direct contact, they cannot fight remotely; for example, by using antibiotics to kill the opponent. Overall, diversity was therefore retained across the total population, which encompassed all four fields.

For Rendueles, this is a clear indication that positive frequency-dependent selection can maintain genotypic diversity within a population, provided the weaker variants of a species can hold on in niches that are not accessible to the dominant strain.



A fruiting body under the electron microscope. Credit: ETH Zurich / Gregory J. Velicer

## Frequency as a selective advantage

"This is the first experimental evidence of this theoretically predicted mechanism," says the postdoctoral researcher. She adds that it would have been a different story were the population evenly distributed; for example, in aqueous solution as found in the sea. In such a situation, where all the strains present are able to mix, only the most competitive or numerically superior strain of bacteria survive. This inevitably leads to a reduction in genetic diversity.

Experimental proof of the hypothesis - that positive frequency-dependent selection acts as a mechanism for maintaining diversity - is important because until now an older, well-established theory, namely negative frequency-dependent selection, was considered the main mechanism by which diversity is maintained. In this negative form of selection, rare gene variants enjoy an advantage over frequent, dominant variants because they fall victim to predators less often. For example, different colour variants of a butterfly population may escape a predator because they are better camouflaged than the majority of the population. This selective advantage persists only for as long as the camouflage gene variant remains rare.

On the other hand, until now positive frequency-dependent selection has been seen as diversity-reducing ('winner takes all'). "We can now demonstrate that positive frequency-dependent selection maintains diversity by enabling weaker gene variants to survive if they are numerically superior to dominant variants," says Rendueles.

The researchers are confident that this mechanism applies not only to *M. xanthus*, but also to numerous other organisms.

**More information:** Rendueles O, Amherd M, Velicer GJ: Positively Frequency-Dependent Interference Competition Maintains Diversity and Pervades a Natural Population of Cooperative Microbes. *Current Biology* 2015. In Press. DOI: 10.1016/j.cub.2015.04.057

Provided by ETH Zurich