

# Maths model helps to unravel relationship between nutrients and biodiversity

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The level of nutrients in soil determines how many different kinds of plants and trees can thrive in an ecosystem, according to new research published by biologists and mathematicians today (10 September) in *Nature*.

For the first time ever mathematicians have modelled all the different possible relationships between nutrients and biodiversity in lab-based experimental ecosystems. They found that although nutrient availability definitely has an impact on biodiversity, the precise relationship between the two depends on which species are present in the ecosystem. This means that in some cases low levels of nutrients can lead to high levels of biodiversity.

The new study involved biologists from the University of California Santa Cruz running a lab experiment to find out how different levels of nutrients affected how many species evolved in an ecosystem. Mathematicians from Imperial College London and the University of Bath then devised a model to show how far the results could be applied to real world scenarios.

The experiments set up by the biologists in the USA consisted of mini ecosystems full of *E. coli* bacteria and a parasite that lives on the *E. coli*. These simple communities of hosts and pathogens represent complex ecosystems in the real world, like forests, in which hosts such as trees live and evolve alongside pathogens such as fungi, bacteria and viruses.

The overall aim of the study was to shed new light on the mystery of why some ecosystems such as tropical rainforests are teeming with thousands of different plant species, whereas others, like the pine forests of northern Europe, support significantly fewer types of plant life. However, investigating this phenomenon in the field can be difficult, time consuming and results hard to interpret.

Instead, the researchers used the series of mini-ecosystems in the lab, which consisted of test tubes containing *E. coli* bacteria, a sugary Lucozade-like liquid for the *E.coli* to eat, and a parasite that lives on the *E. coli*.

To mimic different environments, the scientists varied the amount of sugar in each different 'ecosystem', and then recorded how many new strains of bacteria and parasite evolved in the sugary broth over the course of 150 generations, which took 17 days.

Their results showed that as the levels of sugar in the ecosystem changed, so did the extent to which new strains evolved. This experiment showed that the highest biodiversity resulted from a low level of nutrients.

Professor Laurence Hurst from the University of Bath's Department of Biology explains: "The results in the lab showed that varying the level of sugary food in these mini-ecosystems caused the amount of biodiversity in the ecosystems to change. This suggests that the availability of nutrients is one of the factors that affect how many different plant species live in different parts of the world. This has been shown in a lab before, but what we wanted to do was use maths to show how these results, which refer to one kind of bacteria and its parasite, can be applied to other organisms and ecosystems in the real world."

The team from Bath and Imperial constructed a model to work out

whether this inverse relationship would be the same in all ecosystems – whether in the lab or in the real world. They found that although nutrients do affect biodiversity, the precise relationship between the two varies from one ecosystem to the next, depending on what species are present.

Dr Rob Beardmore from Imperial College London's Department of Mathematics explains: "Although there was a clear link between nutrients and biodiversity in the lab, our mathematical model showed that in some ecosystems you will find that higher levels of nutrients lead to more biodiversity, which is opposite to what our biologist colleagues found in the lab. It turns out that the precise nature of this nutrient-diversity relationship varies from one ecosystem to another, and it depends on the complex interactions between species evolving alongside each other."

The mathematical model can be used to predict what impact different levels of nutrients will have on biodiversity in any given lab-based ecosystem. The team say their results are very important for scientists who use small scale lab experiments to investigate phenomena in the real world.

The study also provides the first real evidence that a theory known as "geographic mosaic co-evolution hypothesis" holds up in real world ecosystems. Co-author on the paper, Dr Ivana Gudelj from Imperial College, explains: "This complicated-sounding theory basically says that nutrient availability will only have an impact on the diversity of an organism, if the organism is involved in a co-evolutionary arms race with pathogens or competitors, like our *E.coli* was with its parasite. Our biologist colleagues have shown evidence for this in the lab, and our mathematical model suggests that the theory will also hold up in real world ecosystems too."

Source: Imperial College London

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