How oak trees outwit their predators

When oak trees are heavily damaged by caterpillars, they open buds later the following spring. An international research team has shown that this strategy is highly effective against their predators.

Spring in the forest: Many insects, particularly caterpillars, hatch just when the trees' nutrient-rich leaves are still young and soft. This means they find a table laden with food and can start eating straight away.

If oak trees are heavily infested by caterpillars in a given year, they react to this the following spring: they delay their leaf emergence by three days. This is unfavourable for the caterpillars. After hatching, they are literally faced with empty plates, because the oak leaves are still firmly hidden in the buds.

This strategy is highly effective: the three-day delay is sufficient to drastically reduce the insects' survival rate. And it reduces the damage caused by feeding on the tree by an impressive 55 per cent.

A team of international researchers reports this in the journal *Nature Ecology & Evolution*.

Trees don't just react to the weather in spring

"The delaying tactic is more effective for the oak than a chemical defence, such as bitter tannins in the leaves", says Dr **Soumen Mallick**, a postdoc at the University of Würzburg's Biocentre and lead author of the study. This is because the tree would have to expend a great deal of energy to increase tannin production.

"This discovery fundamentally changes our previous understanding of the onset of spring in the forest," says the Würzburg researcher. It shows that trees do not merely react passively to the weather in timing their leaves emerge but also respond flexibly to biological threats.

A view of a forest in Germany from space

To demonstrate these connections, the team used state-of-the-art interdisciplinary methods from ecology and remote sensing.

Previously, researchers had to laboriously observe individual trees on the ground. For this study, however, a 2,400-square-kilometre area in Northern Bavaria was monitored continuously using Sentinel-1 satellite data. What makes these radar satellites special is that they provide precise data on the condition of tree canopies even in thick cloud cover.

The researchers analysed a total of 137,500 individual observations spanning five years, from 2017 to 2021. The satellites provided data at a resolution of 10x10 metres per pixel, which roughly corresponds to the crown of a single tree. A total of 27,500 such pixels were analysed across 60 forest areas.

The year 2019 proved particularly revealing, as the region experienced a massive outbreak of the gypsy moth. "The radar sensors recorded exactly which trees were stripped bare and how they reacted in the following year", says Professor **Jörg Müller**, University of Würzburg (Germany) Chair of Conservation Biology and Forest Ecology and co-senior author of the study.

The future of the forest: an evolutionary tug-of-war

For the first time, the study conclusively explains why, in some springs, the forest does not turn green as quickly as temperatures would suggest. Its findings are of great significance for nature conservation. Previous computer models often calculate the state of the forest inaccurately because they take into account almost exclusively "lifeless" factors such as temperature and ignore biological interactions between plants and insects.

Trees find themselves in a kind of evolutionary tug-of-war: whilst rising temperatures caused by climate change are pushing them to sprout leaves ever earlier, the pressure from insect feeding is forcing them to hold back. A key advantage of this delaying tactic is that it is temporary and

reversible. As the trees only sprout later following an actual infestation, the insects cannot adapt permanently.

“This dynamic interplay is an example of the forest’s high resilience and adaptability in a changing world”, says Professor **Andreas Prinzing,** University of Rennes (France), the other co-senior author of the study. Future experiments are intended to help understand these mechanisms even more precisely.

Participating research institutions

In addition to researchers from the University of Würzburg, scientists from the following institutions were involved in this study:

• University of Göttingen

• Thünen Institute (Federal Research Centre for Rural Areas, Forestry and Fisheries), Braunschweig

• Adam Mickiewicz University Poznań (Poland)

• Technical University of Munich

• University of Lorraine (France)

• Czech University of Life Sciences Prague (Czech Republic)

• Julius Kühn Institute (Federal Research Institute for Cultivated Plants), Dossenheim

• Bavarian Forest National Park

• Centre National de la Recherche Scientifique, University of Rennes (France)

Publication

Satellite data show trees delay budburst across landscapes to escape herbivores. Soumen Mallick et al., Nature Ecology & Evolution, 1 May 2026, DOI 10.1038/s41559-026-03071-9

Contact

Dr Soumen Mallick, Biocentre, University of Würzburg, Ecological Station Fabrikschleichach, soumen.mallick@uni-wuerzburg.de