Fake caterpillar study reveals global pattern in predation

May 18 2017

Plasticine caterpillars ready for deployment in Ithaca New York. Credit: Saskya van Nouhuys

A new Oxford University collaboration revealing the world's prime insect predation hotspots, achieved its landmark findings using an unusual aid: plasticine 'dummy caterpillars.'

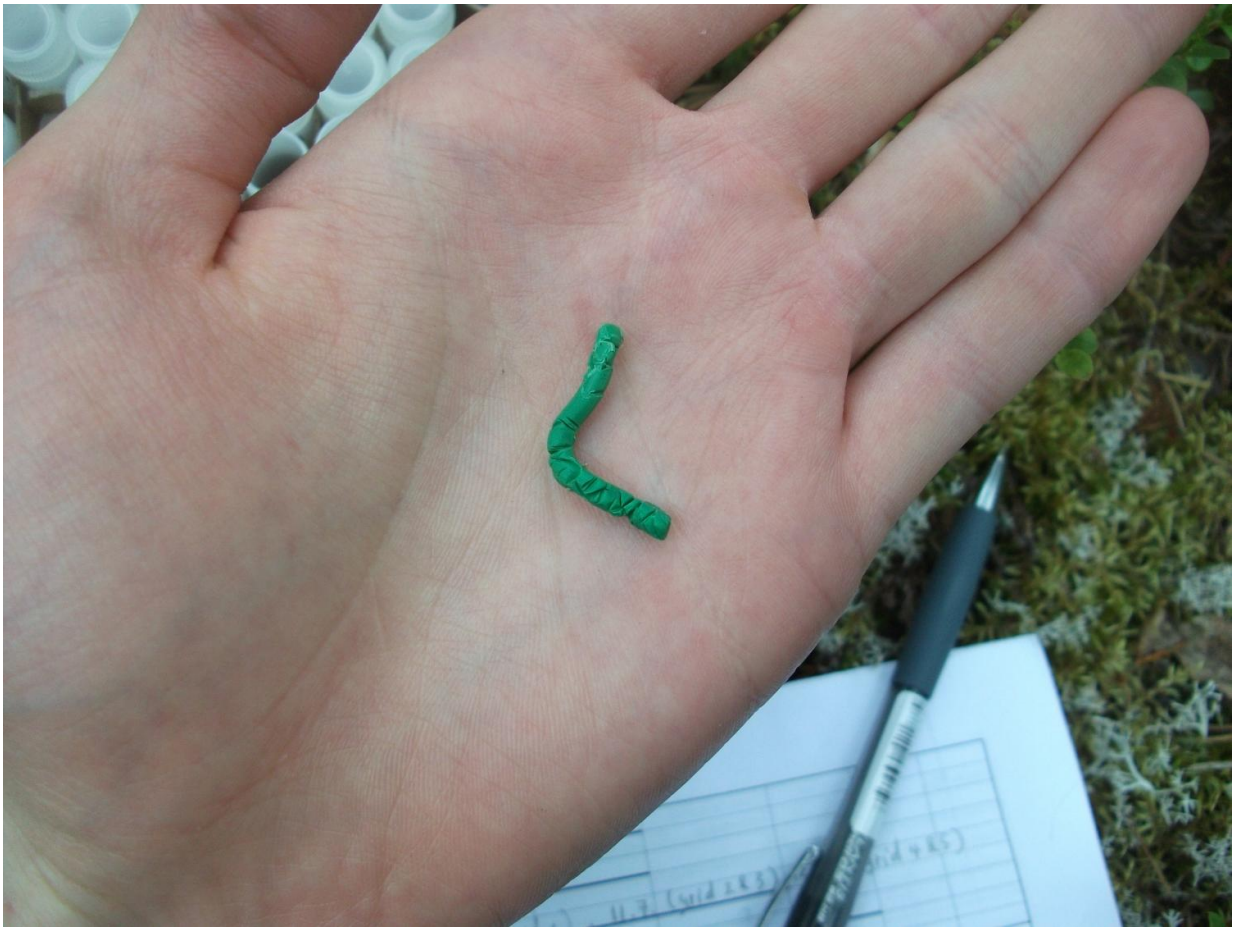
The fact that the tropics are home to more species than the Polar Regions is well known. However, whether or not there is likely to be more predatory behaviour nearer to the Equator because of this, has remained largely unknown. The new study published in *Science* has revealed a global pattern of predation on insect herbivores. The trends observed were surprising, revealing that predatory behaviour in the tropics is not driven by birds or mammals but by ants and other small arthropods.

The international team made the discovery by examining a fraction of caterpillars eaten along an 11,635 km gradient from the Arctic Circle to southern Australia. The work revealed that a caterpillar living near the Equator is eight times more likely to be eaten, than a caterpillar at the poles.

The findings were achieved with surprisingly simple materials. To measure local predation rates, researchers glued thousands of artificial caterpillars made from plasticine, to plants across 31 sites around the world. Predators of caterpillars, such as birds and ants, are then tricked into thinking the decoy insects are the real thing, and only realise that they have been deceived when they have taken a bite. The team then revisited sites several times to check for bite marks, and evidence of any predatory behaviour.

Dr Eleanor Slade, one of the study's lead authors and a researcher in Zoology at the Universities of Oxford and Lancaster, said: 'The great thing about this method is that you can track down who the predator was by inspecting the attack marks. The jaws of an insect, like an ant, will leave two small piercings, whereas a bird beak will cause wedge-shaped

marks. Mammals will leave teeth marks—well, you get the idea."



The authors used bite marks on the caterpillars to identify the predator. In this case, the plasticine caterpillar has been repeatedly pinched by the wedge-shaped beak of a bird. Credit: Tapani Hopkins

Tomas Roslin, the other lead author and Professor of Agricultural Sciences at the University of Helsinki, said: 'The pattern was not only mirrored on both sides of the Equator, but also appeared across elevational gradients. Moving up a mountain slope you find the same decrease in predation risk as when moving towards the Poles. This

suggests a common driver could be controlling species interactions at a global scale.'

Decoy insects have been used in previous ecology studies, but never before on such a broad scale. It was comparing results from these smaller initiatives that inspired the team to take their research to the next level. Eleanor Slade said: "Tomas had used plasticine caterpillars in Greenland and thought they didn't work when he found very low attack rates. I had used them in the rainforests in Borneo, and had detected very high attack rates. Just imagine if these are the two end points of a global pattern, we thought. And that is exactly what they turned out to be.'

The replica insects were placed at far-flung locations across the globe, which meant that gathering the corresponding data required a lot of team work, with a total of 40 researchers from 21 countries working on the project. Bess Hardwick, the laboratory manager for the research, at the University of Helsinki, Finland, said: "This is the beauty of what are called 'distributed experiments'. As ecologists, we typically ask questions about patterns and processes much larger than we as single researchers or teams can examine. But by designing experiments that can be split into smaller work packages, we can involve collaborators all over the world, and work together to understand the bigger picture.'

For the insights gained to be comparable, consistency and standardisation were key. The dummy caterpillars were designed at and sent to researchers from the projects central "hatchery", at the University of Helsinki, Finland. Moulded from green plasticine, the materials were shaped to closely resemble "loopers" (or "inchworms"). Even the glue used to attach them to plants was included in the kit to ensure the same look and smell of caterpillars across all sites.

A total of 2,879 were used in the study and left at the sties over the course of four to 18 days. The caterpillars were then carefully detached

from the leaves and returned to Helsinki for analysis. Led by Bess Hardwick, the team inspected the caterpillars for signs of predator-induced damage, such as bite marks. By attributing each attack mark to a specific predator group, the team was then able to identify a clear culprit behind the latitudinal gradient in attack rates.

A plasticine caterpillar glistening with moisture while probing for predator attacks in the forest of Tai Po Kau, Hong Kong. Credit: Chung Yun Tak

Dr Will Petry, Postdoctoral Research Associate at ETH Zurich, who contributed data and supported analysis from California, said: 'People often think of vertebrates as the most important predators in the tropics, but birds and mammals weren't the groups responsible for the increase in

predation risk towards the Equator. Instead tiny arthropod predators like ants drove the pattern.'

The findings may also have implications for herbivore evolution, Dr Petry said: 'Our results suggest that tropical caterpillars would do well to target their defences and camouflage specifically against arthropod predators. Closer to the poles, lower predation may allow caterpillars to let their guard down.'

Professor Roslin said: 'To understand why the world stays green and is not fully consumed by hordes of caterpillars, we should appreciate the role of arthropod predators. Our findings suggest that their role may be even further accentuated towards the Equator."

Herbivores in tropical forests remove 10 to 30 per cent of a plant's leaf area per year. Interactions between plants and their herbivores and predators will therefore affect forest eco-system structures, and in turn how they function. When there is higher predation of leaf-eating caterpillars this may cascade through the ecosystem, with knock-on effects for the growth and survival of plants. Uncovering a gradient in how species interact therefore provides a foundation for understanding global patterns in ecosystem processes (e.g. herbivory and plant productivity), ecosystem services, (e.g. carbon storage and crop yields), and how long-term changes in the environment may affect biodiversity.

Moving forward, it is hoped that the findings will stimulate further academic investigation into whether the patterns revealed translate into cascading effects for herbivory of plant leaves, and whether these patterns will ultimately affect the structure and function of forest ecosystems.

More information: T. Roslin at Swedish University of Agricultural Sciences in Uppsala, Sweden el al., "Higher predation risk for insect

prey at low latitudes and elevations," *Science* (2017). science.sciencemag.org/cgi/doi … 1126/science.aaj1631

Provided by University of Oxford

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