

Ecologists find predator-prey pattern consistent across diverse ecosystems

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Predator and prey communities exhibit a common but unexpected organizational structure. Credit: Amaury Laporte

Why aren't there more lions? That was what puzzled McGill PhD student Ian Hatton, when he started looking at the proportion of predators to

prey across dozens of parks in East and Southern Africa. In this case, the answer had nothing to do with isolated human hunters. The parks were teeming with potentially tasty treats for the lions. So one might imagine that the population of lions in each park would increase to match the available prey. Instead, what Hatton and the McGill-led team discovered was that, in a very systematic way, in crowded settings, prey reproduced less than they did in settings where their numbers were smaller. Moreover, they found this same pattern in a whole range of different ecosystems.

It's a surprising finding that suggests a level of organizational structure and function in ecosystems that had not previously been recognized. Although biologists have long known of very regular mathematical laws governing functions in the body like metabolism and growth, no study has ever shown that similar kinds of laws may exist at a whole other level: that of ecosystems globally. Some scientists are already suggesting that it may well be the discovery of a new law of nature.

It came about by chance.

High school holidays

"I went to high school in Zimbabwe and spent vacations in the National parks there," says Hatton, the lead author of the study that was just published in *Science*. "When I began my PhD in biology at McGill, I wanted to go back and compare whole communities of African animals across protected ecosystems to see how the numbers of carnivores are related to their herbivore prey at the scale of whole landscapes. So I gathered all the animal census data I could for parks in east and southern Africa."

When Hatton and his colleagues then started putting it all together and crunching the numbers, summing up all the carnivores (lion, hyena,

leopard, etc.) and herbivores (buffalo, zebra, impala, etc.) in these parks, they found a very unexpected and regular pattern. In every park they looked at, there seemed to be a very consistent relationship of predator to prey. But not in the simple pattern they might have expected to find.

Some surprising calculations

"Until now, the assumption has been that when there is a lot more prey, you'd expect correspondingly more predators," says Hatton. "But as we looked at the numbers, we discovered instead, that in the lushest ecosystems, no matter where they are in the world, the ratio of predators to their prey is greatly reduced. This is because with greater crowding, prey species have fewer offspring for every individual. In effect, the prey's rates of reproduction are limited, which limits the abundance of predators."

Once they observed this pattern in one setting, the researchers then began analyzing data about food pyramids, and the relationship between predators and prey in ecosystems as varied as the Indian Ocean, the Canadian Arctic and the tropical rainforests. Over the course of the next few years they analyzed data gathered about both plants and animals from more than 1000 studies done over the past 50 years covering a range of grassland, lake, forest and ocean ecosystems around the world.

In all these different settings, they found a surprising consistency in the relation of predators to prey, and confirmation that rather than the numbers of predators increasing to match the available prey, predator populations are limited by the rate at which prey reproduce.

"We kept being astonished," said Kevin McCann, of Guelph University's Department of Integrated Biology, one of the study's co-authors. "This is just an amazing pattern."

A new law of nature?

What the researchers also found intriguing was that the growth patterns they saw across whole ecosystems, where large numbers of prey seemed naturally to reproduce less, were very similar to the patterns of growth in individuals. "Physiologists have long known that the speed of growth declines with size," said co-author Jonathan Davies from McGill's Dept. of Biology. "The cells in an elephant grow more than 100 times more slowly than those of a mouse."

"The discovery of ecosystem-level scaling laws is particularly exciting," adds co-author Michel Loreau, adjunct professor in McGill's Biology Dept. and currently at the Centre national de recherche scientifique (CNRS) in France. "Their most intriguing aspect is that they recur across levels of organization, from individuals to ecosystems, and yet ecosystem-level scaling laws cannot be explained by their individual-level counterparts. It seems that some basic processes reemerge across levels of organization, but we do not yet fully understand which ones and why."

More information: The predator-prey power law: Biomass scaling across terrestrial and aquatic biomes, [www.sciencemag.org/lookup/doi/... 1126/science.aac6284](http://www.sciencemag.org/lookup/doi/10.1126/science.aac6284)

Provided by McGill University

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