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DNA barcodes change our view on how nature is structured

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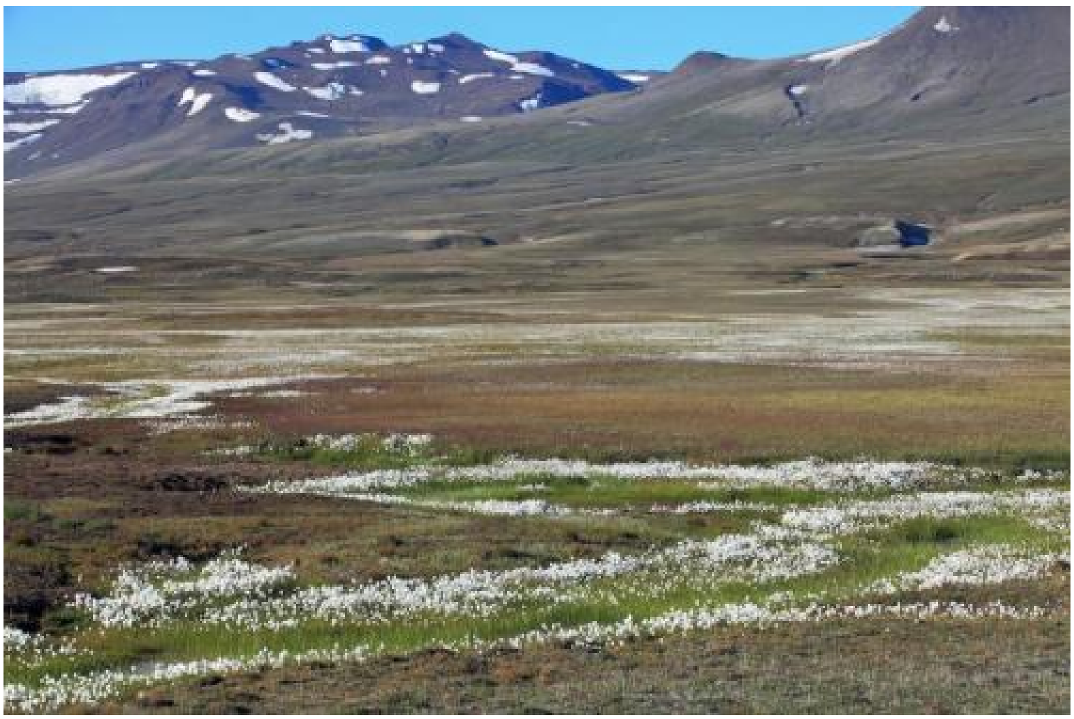

A landscape from Zackenberg valley in Northeast Greenland. Credit: Gergely Várkonyi

Understanding who feeds on whom and how often is the basis for understanding how nature is built and works. A new study now suggests that the methods used to depict food webs may have a strong impact on how we perceive their makeup. Once similar techniques are applied to food webs across the globe, we may encounter major surprises.

How you seek is what you find

To understand how feeding interactions are structured, researchers from Finland and Canada chose to focus on one of the simplest food webs on Earth: the moths and butterflies of Northeast Greenland, as attacked by their specialist enemies, parasitic wasps and flies developing on their prey (called host), killing it in the process.

"What we found in this system was mind-boggling", explains Helena Wirta, the lead author of the study. "When we supplemented the traditional technique of rearing host larvae until the emergence of either the adult or its enemy with modern molecular techniques, every measure of food web structure changed. All of a sudden, we found three times as many interactions between species as before. On average, most types of predator proved less specialized than assumed, and most types of prey were attacked by many more predators than we had thought. Thus, the full web was simply more tightly knit than we initially believed."

"To understand just how much the method affected our perception of our single target web, we may compare variation among different techniques to variation among food webs previously described for different parts of the world", explains Tomas Roslin, who initiated the work. "Web structure simply varied manifold more among our different techniques than among localities from the UK to Japan. Thus, whatever we think that we know about food web structure across the globe may be dictated as much by how we have searched as by how species really interact."

The revealing inner of a bug

What allowed the researchers to dissect the food web with a new precision was the use of DNA barcodes.

DNA barcodes for two interacting species of the High Arctic food web. Credit: Gergely Várkonyi

"The basis of this approach is to identify species based on variation in a given gene", says Sean Prosser, who spent months in the lab fine-tuning the approach. "By targeting gene regions which differ between the predator and the prey, we were able to selectively detect both immature predators from within their prey, and the remains of the larval meal (prey) from the stomachs of adult predators. By then comparing the sequences obtained to a reference library of DNA sequences of all species in the region, we were able to determine exactly who had attacked whom."

"One of the great beauties of this approach is that it allows us to retrace the life history of some really obscure players in the game", explains Gergely Várkonyi, an international expert of parasitic wasps involved in the project. "In almost any system, some of the predators will be really hard to investigate. As larvae, some of our target predators attack their prey when they are hidden in the ground or vegetation, where we humans will never discover them. By instead looking for prey remains in the guts of the more easily-detectable adult predators, we were able to establish the importance of these otherwise hidden links for the overall structure of the food web."

A five-year project

The current work is the culmination of a five-year exploration of insect food webs of Zackenberg by Tomas Roslin and Gergely Várkonyi.

"Why we wanted to work in the High Arctic was to keep things simple" says Tomas. "If you want to keep track of who interacts with whom, you should realize that things very quickly get out of hands with increasing diversity. With only a handful of species to keep track of, you can finally be confident that you really detect what goes on and what does not."

"And to be honest, we should not forget the beauty of the landscape and the excitement of working in one of the largest uninhabited regions on Earth", adds Gergely. "We have had polar bears tackling our traps and musk oxen chasing us. Such encounters tend to keep you alert."

The start of something new

"Most exciting of all are the vistas opened by our findings", says Helena. "What we have done so far is to apply these techniques to one of the simplest food webs on the globe – and yet they completely revamped our view on how this very web was structured. Now you can just imagine what will happen when we employ this approach in other settings. We still have no clue of what prior patterns may hold when we revisit them with this more sensitive looking glass."

Her coauthor Paul Hebert, who proposed the DNA barcoding concept a decade ago and now sees it applied to resolving more and more questions in nature, is prepared to take the vision one step further. "I believe that the techniques advanced here are game-changing when it comes to understanding how nature works", says he "In only a few years, the augmentation of this approach may allow us to pick up any bug, and recover DNA sequences from most other organisms which it has ever touched. Now inferring the whole interaction history of an organism, that will allow us to establish the structure of ecological interactions with a precision previously unconceived."

More information: Wirta, H.K, Hebert, P.D.N., Kaartinen, R., Prosser, S.W., Várkonyi, G., and Roslin, T. 2014. Complementary molecular information changes our perception of food web structure. *PNAS*, Early Edition, DOI: 10.1073/pnas.1316990111

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