Species-rich food webs produce biomass more efficiently

October 5 2016

Food webs are made up of many dynamic feeding relationships; for example herbivore aphids feed on Ground Elder and are themselves eaten by hoverfly larvae. At the same time, ants, being larger than the larvae, prey on the aphids' predators. Credit: Bernhard Seifert

Researchers at the Senckenberg have discovered a feedback in complex food webs: Species-rich ecosystems favor large, heavy animals. Even though this increases the amount of plants consumed, the plant biomass remains approximately at the same level as in species-poor ecosystems. This is due to the fact that in species-rich ecosystems, plant communities develop whose growth is more energetically efficient. The extent of biomass production in species-rich ecosystems is more stable and thereby predictable whereas the loss of species leads to unpredictable deficiencies, which would have to be compensated by humans, according to the paper, published today in *Nature Communications*.

On a daily basis, ecosystems reflect the maxim "Eat or be eaten" on a large scale. Plants form the basis of the food chains and are consumed by herbivores, which in turn serve as prey for the carnivores. And even these carnivores may fall victim to larger animals. Many of these predators near the top of the food chain are generalists; some will occasionally also eat plant material. This leads to the establishment of dense food webs, which contain numerous complex feeding relationships. But what happens when the animal diversity decreases?

A team around Dr. Florian Schneider from the Senckenberg Research Center for Biodiversity and Climate developed a new mathematical model that computes these very connections. "Using a computer, we simulated 20,000 ecosystems and the feeding processes that occur in each of them; from ecosystems that only contain a few species of animals and plant to systems with more than one hundred species. In the beginning, it is still open which species and what number of individuals of each animal and plant species will survive until the end. A species' body mass is the decisive factor, since it not only determines the amount of food (in animals) and the metabolism, but in particular the feeding preference, as well," explains Schneider.

Despite an increase in herbivores, the plants' biomass

production remains stable

The results are surprising, for even in the presence of many different herbivorous animals, plants produced the same amount of biomass as in simulations with a low diversity of herbivore species. This was the case even though with increasing animal species diversity, both the amount of plants consumed as well as the intra-guild predation increased. This reconciles two previously opposing schools of thought. It was assumed that high animal diversity generates positive effects as the dominant consumption of animal prey lessens the pressure on plant biomass, or they are more exploitative on plants, since the numerous different animal species, due to their various preferences, consume more plant species.

Species loss favors lightweights

In the model, both scenarios occur simultaneously because changes in the number of species also lead to changes in the composition of the species communities. When the overall number of animal species is lower, this favors smaller species with a lower body mass. Species-rich ecosystems, on the other hand, tend to be profitable for larger animals at the top of the food chain. "Overall, the total weight of animals in species-rich ecosystems is therefore higher than in species-poor ecosystems," says Schneider. "Moreover, species-rich ecosystems contain a higher number of slow-growing, larger plants."

Plants regrow more efficiently in species-rich ecosystems

This is efficient, since compared to smaller species, larger plants use less energy during the growth process, e.g., through respiration. Therefore, the more species-rich an animal community is, the more energetically efficient is the plants' biomass production. The increased loss of biomass

to consumption by larger animals is thus compensated by a reduction in plant community metabolism. This enables plants to maintain their level of biomass at an approximately equal level in species-poor as well as species-rich ecosystems.

Species extinction makes biomass production harder to predict

However not all is well in the end because human-induced species loss caused impacts the predictability of biomass production. "Our simulations show that species-rich ecosystems produce biomass at a relatively stable, predictable level. In species-poor ecosystems, on the other hand, two scenarios are likely; i.e., much more or much less biomass is produced. In many ways, the well-being of humans depends on the reliability of biomass production. Species richness therefore leads to greater security," Schneider sums up.

More information: Florian D. Schneider et al. Animal diversity and ecosystem functioning in dynamic food webs, *Nature Communications* (2016). DOI: 10.1038/ncomms12718

Provided by Senckenberg Research Institute and Natural History Museum