The story by Daniel Lingenhöhl was printed in SpektrumDirekt on 27 September 2006. It is a popular synopsis (in German) of our scientific paper on habitat loss and pitcher-plant food webs (published as Gotelli, N.J., and A.M. Ellison. 2006. Food-web models predict species abundance in response to habitat change. PLoS Biology 44(10): e324).

I first used Google Translate (http://translate.google.com) as a first pass of the story into English. The Google Translate version, which has much in common with Beat poetry, is given below in the left-hand column. It was given, along with the original German text, to P. Barry Tomlinson and Joe Holmquist at Harvard Forest, each of whom took a crack at improving the readability of the English translation. Their effort, with some additional minor editing, is in the right-hand column.

Google Translate version

Ecology

Small world

Carnivorous plant permits view of complete ecological system

Nature shrinks, and fight to ecologists desperately for the receipt of its kinds. When turning the single fates away they should not lose however the view on the whole. Because even in the simplest habitats the connections are already close enough.

Where they live, usually bitterest poverty prevails: unfruchtbare soils, hardly nutrients. They live at rather desert places, where it is always damp and all mineral materials are rapidly rinsed away, as round around the summit of the Mount Kinabalu on Borneo, the weathered high plateaus of the venezolanischen Tepuis or the moorlands of the Black forest - there however in partly large density. But over the durable lack to escape, they have a refined Sammelsurium cheat on developed, in order to lure and afterwards feed willing victims into the trap.

Redacted version

Ecology

Small world

A carnivorous plant gives insight into a complete ecosystem

As natural ecosystems decline, ecologists struggle desperately for the conservation of their species. In the study of the fate of individual examples they should, however, not lose sight of the whole. Even in the simplest habitats, connections between species can be very close.

Where carnivorous plants live, for the most part bitterest poverty prevails: unproductive soils, scare nutrients. These plants live in impoverished places, where it is always moist and all mineral materials are rapidly leached from the soil, as around the summit of the Mount Kinabalu on Borneo, the highly weathered plateaus of the Venezuelan Tepuis or the moors of the Black Forest; in these sites they grow in somewhat high densities. Nevertheless, in a permanent method of escaping, they have developed refined methods of collecting nutrients in order to lure, trap, and eventually feed on willing victims.

Their Rufnamen sound quite harmless romantical - like sun rope - and only sometimes actually rather seductive as with the Venusfliegenfalle: Plants, which deceive approaching insects, these after the[y] landing in most diverse kind catch, digest and so their incorporate chemical components, because only of They cannot survive photosynthesis. Under this aspect thereby can and hose sheetplants from the kinds *Nepenthes* or *Sarracenia*, which does not give it in Central Europe however, are particularly interesting.

They accommodate a proper in their vase-similar catch containers Fressgemeinschaft, the consequence of the vegetable meat desire is and the Wissbegierde of Nicholas Gotelli of the university of Vermont in Burlington as well as Aaron Ellison of Harvard University woke. On the basis this nearly closed ecological system they can examine in small yardstick, which quantitative influence different habitat destruction on the existence of the kinds living therein have how key species react and how the relations changes within the robber booty remainder worth net.

Its research object *Sarracenia purpurea* - one in sumps and moorlands of southern Canada and the eastern USA far spread carnivorous hose sheet plant - trains annually six to twelve on one side closed, tubular sheets, in which beside all kinds of booty also usually sufficiently much rain water collects itself, that again a complete digest-juice-resistant food chain a home place offers. When join first member misfortune-blessed ants, flies and other insects, which into the trap grope. At them the larvae of the mosquito *Metriocnemus* still delektieren themselves *knabi* and the meat fly *Fletcherimyia fletcheri* before the plant, which besides did not consume

Their common name sound harmlessly romantic - like “sundew” - but sometimes actually rather seductive, as with “Venus fly-trap”. The plants deceive passing insects, and after they are captured by the various species, are digested into their component chemicals, because the plants cannot survive on photosynthesis alone. In this respect of special interest are the plants with tubular leaves in the genera *Nepenthes* and *Sarracenia*, which do not occur in Central Europe.

These plants harbor in their vase-like traps a food web, which the plants use as a method for satisfying their developmental need for proteins. This food web has aroused the curiosity of Nicholas Gotelli (University of Vermont) and Aaron Ellison (Harvard University). They investigated and measured in this virtually closed ecosystem the relation between habitat destruction and key species, and how these responses relate to the food web dynamics.

Their research species, *Sarracenia purpurea*, is a pitcher plant that is widespread in the marshes and moorlands of southern Canada and the eastern United States. It produces annually 6-12 tubular leaves, closed on one side. In these leaves, ample rainfall collects, along with all kinds of prey and a complete food chain of organisms which are resistant to the plant’s digestive enzymes. This food web joins the unfortunate ants, flies and other insects that find their way into the traps. Among the resistant animals are larvae of the midge *Metriocnemus knabi* and larvae of the flesh fly. These larvae shred the decomposing prey, and in doing so reduce

remainders of the Kerfe pleased in here cut up.

Over these remnants then various bacteria and other single-celled organisms make themselves ago, which form again the food basis for Rädertierchen of the kind *Habrotrocha rosi* and for *Sarraceniopus gibsonii* mites. Larvae of the mosquito *Wyeomyia* smithii eat likewise at the bacteria, which becomes Protozoen as well as the Rädertierchen and even captured by the larger new generation of the meat flies - a simple image of the complicated relations network of large habitats such as corral reefs or the rain forest.

And as mankind the jungles rodet or the sharks as point robbers of the seas and thus the habitat for the respective species limits or their natural structure over-fishes wrecked, manipulated now Gotelli and Ellison the Imperium in the hoses. They increased or made the Habitat smaller, by filling up the funnels with water or lowering the mirror, and simplified the food chain by removing the Top Beutegreifer, which are in this case Fliegenund mosquito larvae.

Clearly on the existence of other kinds the loss of the *Wyeomyia* larvae affects itself, which radiate downward, where them itself at the diminishing micro organisms do in a friendly way, which take however influence just as upward, because they are fed there by the *Sarracenia* new generation. If they disappear, a modulator for their booty and food for their robbers are missing. The young mosquitoes know thus with join and right as , But give it still further strong connections in the system apply for key type in the hose. For example if the number of bacteria decreases/goes back, because

them to smaller pieces.

Various bacteria and other single-celled organisms avail themselves of the remains of the prey, and the bacteria in turn are the food supply for the rotifer *Habrotrocha rosa* and the mite *Sarraceniopus gibsonii*. Similarly, larvae of the mosquito *Wyeomyia smithii* also eat the bacteria, protozoa and even the rotifers and become the next generation of mosquitoes - a complex network of trophic relationships similar to that which can also be found in large habitats such as coral reefs and rainforests.

As mankind clears the forest, and with shark-like piracy overfishes the seas and so destroys the habitat for all species, so do Gotelli and Ellison now manipulate the empire [microcosm] in the pitchers. They ither increased the habitat volume by filling the pitchers with water or reduced the volume by siphoning water out, and also simplified the food web by removing the higher trophic levels - in this case the flesh fly and midge larvae.

Wyeomyia larvae clearly have top-down effects on species at lower trophic levels, which in turn have bottom-up effects. The latter are eaten by the new *Sarracenia* generation. Where *Wyeomyia* disappears, there is less regulation of abundance of their prey and of nutrients [in the pitcher]. The young mosquitoes can fit into the leaves, but there are still further strong conditions in the system. For example: if the number of bacteria declines, because *Metriocnemus knabi* and *Fletcherimyia fletcheri* are removed, and at the same time the volume of the pitcher is reduced, then the entire food chain is altered from

Metriocnemus separate at the same time *knabi* and *Fletcherimyia fletcheri* as häckselnde foremen and the Habitat shrinks by taking out water, then this whirls the food chain from bottom to top through and lets the insisting on broad front sink.

Altogether - simple - the food net in the hose sheet plants proves already as strongly symbiontische community, in which each kind serves a special service, from which further CO members mutually depends. Direct interferences therein affected clearly more strongly the frequentnesses of certain kinds than even strong reductions of the habitat alone: a sample that itself about also up Islands to observe has broad-made itself, on those again brought in animals or plants.

Sarracenia purpurea serves Gotelli and Ellison therefore as model for the entire planet: Until 2050 are to finally grow the earth population again by forty per cent, which might cause a further shrinking of the large ecological systems. So that tigers, elephant or Orang Utan up to then still survive, scientists and ecologists might not only be concerned with their single fate. Necessary is rather a view of the complete food net, in which they are merged - with all their requirements and entangling. Finally everyone is not like that being sufficient SAM like kannibalischen plants and lives at desert places.

Daniel Lingenhöhl

the bottom up and conditions [abundances?] decline throughout the pitcher.

Although it is relatively simple, the food web in the pitchers is a strongly symbiotic community in which each species serves a specific function upon which the other species depend. Alteration of the food web in this system clearly affects the abundance of certain species more than did a simple change in habitat volume. Similar patterns have been found on islands where introduced animals and plants can be observed to have a broad effect.

According to Gotelli and Ellison, *Sarracenia purpurea* provides a model for the entire planet [!] By 2050, the human population of Earth will have grown by 40%, which should further reduce and fragment large ecological systems. Tigers, elephans and orang-utans might survive if ecologists are concerned only with the fates of these single species. However, a view of the complete food web that they inhabit is necessary, with all its requirements and interconnections. In the end, we may all be reduced to an existence like that of carnivorous plants that live in depauperate environments.

Daniel Lingenhöhl