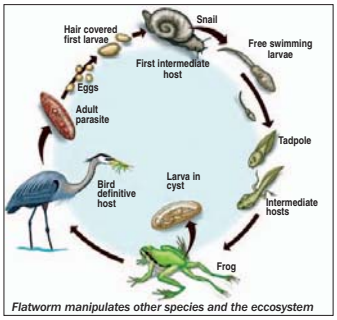
Another cheer for progress

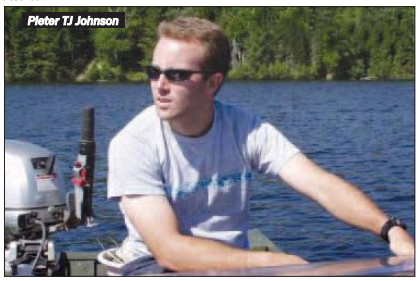
Dramatic proof of the value of biodiversity has been reported, says s ananthanarayanan



Flatworm manipulates other species and the ecosystem

THE uses of biodiversity are widely documented. That different species would draw nutrients from and replenish the soil more evenly has been accepted and has been verified in field trials. The other benefit is that while predators prevent species from growing unchecked, species also feed on each others' predators, or come in the way of their prosperity and keep predators in check. There is also general evidence that biodiversity can lead to resistance against the spread of disease.

Pieter TJ Johnson, Daniel L Preston, Jason T Hoverman and Katherine LD Richgels of the University of Colorado and Purdue University, USA, report in the journal *Nature* on a close look taken at this last feature — of biodiversity controlling the effect of a single pathogen on a specific class of target animals. With the help of ample field data and experiments where different conditions were varied, they have demonstrated that diversity of species that could harbour a virulent flatworm species that causes disease in frogs actually brought down the ability of the parasite to prosper.


Pieter TJ Johnson

Flatworm and frogs

The story starts with Professor Johnson of the University of Colorado learning that frogs were growing from tadpoles with deformities, sometimes a whole 25 per cent, even 50 per cent of frogs, in ponds in many parts of the USA. Just what was causing such largescale deformities and what were the implications became questions that demanded answers. Professor Johnson teamed up with colleague Kevin B Lunde and after an extensive survey of affected frogs and their environment and laboratory work, they identified the cause as an infection by a flat, worm-like parasite, *Ribeiroia ondatrae*. The first hosts for these flatworms are freshwater snails that abound in ponds.

"Each night each of these snails can produce thousands, sometimes tens of thousands of these microscopic parasites," says Professor Johnson. When the parasites swim out and find tadpoles, they enter at the places where the tadpole limbs are about to grow and they form a cyst. The result is a deformed frog, with no limb or a twisted limb. And these frogs are easy catch for predator birds, which get infected themselves. The birds then spread parasite eggs through their faeces and infect more snails in the pond or in far-flung ponds. "Its humbling," Professor Johnson says, "that this tiny, microscopic worm can manipulate all these other species and an ecosystem to is own benefit."

While flatworms are the reason for the deformities, the present study looks into what could be the ecological changes that make for this rise in the virulence of the flatworm parasite. The study notes that recent studies have linked biodiversity changes to shifts in disease risk of humans and animals. Many pathogens, like the flatworm in the present case, affect a number of species, and not all the species are equally effective as vectors or carriers of the pathogen.

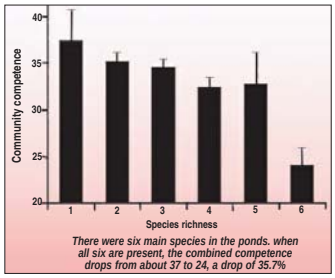
There is, in fact, a distribution of vectors and there has been established, over time, a balance of organism population. Now, if there comes about a change where the poor carriers of the pathogen start disappearing, the result will be a rise in virulence, or reduction of virulence if poor carriers begin to dominate. That the composition of the species in an ecosystem would influence the effects and drivers of changes in biodiversity has just started being recognised. And the present case, where there was a distribution of ponds and locations, with different conditions, offered an opportunity to study the effect of biodiversity on transmission of the pathogen, and then to simulate varying conditions in the lab.

Pond system survey

Johnson and colleagues noted that pond systems were well suited for this study, as they provided comparable assemblies of concerned species and allowed comparisons with assemblies that differed gradually in the number of species that supported the pathogen. Over three years, the team sampled the composition of supporting amphibians in 345 pond systems over a large region in California and over 24,000 instances of malformation of hosts were assessed. The ability of different species to support the pathogen were worked out and experiments were conducted to see if having more species together led systematically to the group of species being less supportive of the pathogen. The study also accounted for the roles played by different agents, such as freshwater snails and huge data was collected of the levels of infection of snails and then to assess the effect of diversity of hosts on the effectiveness of the snail intermediates.

It was found that in naturally occurring systems, like in the case of the ponds, the most *competent*, which is to say, the *most pathogen-supporting* species of amphibians, were also the most common species, and the fraction of this more competent component fell as the diversity of species increased, that is, when the numbers of less competent species increased. When the data of the competence of the different host species was integrated with the relative abundance of the species, it was seen that there was a 35.7 per cent decrease in the combined competence of the different species that were present, as one passed from the least diverse to the most diverse distribution.

But when it came to the effectiveness of transmission from snails to hosts, it was found that diversity, or the richness of species in a population strongly moderated transmission — the level of transmission was just a sixth in the high diversity case, as compared to the level in low diversity. These results were confirmed in laboratory simulation, where increasing species richness from one species to three species reduced transmission by 64 per cent. It is interesting that this reduction was not only because introducing more species reduces the density of the most competent species. As a test, when the density of the *Pacific tree frog* or *the Pacific Chorus frog, P.regilla*, the most competent amphibian, was kept unchanged with the addition of more species, there was still a 28 per cent reduction in overall competence. In outdoor artificial arrangements to mimic real condition, the infections in *P.regilla* decreased by 50 per cent between the least diverse state, of one species, to the diverse state of four species.



There were six main species in the ponds. when all six are present, the combined competence drops from about 37 to 24, a drop of 35.7%


Pacific tree frog or Pacific chorus frog


Malformed Pacific chorus frog

"Our results lend mechanistic insight into how host diversity can reduce disease risk… In the light of mounting evidence that higher biodiversity can buffer against pathogen exposure in human, wildlife and plant disease systems, preserving functional diversity — including both genetic diversity and community richness — has the potential to offer a novel, cost-effective approach to disease management," the authors of the paper say.

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A sensational breakthrough

steve connor reports on the first bionic hand that can feel

THE first bionic hand that allows an amputee to feel what he/she is touching will be transplanted later this year in a pioneering operation that could introduce a new generation of artificial limbs with sensory perception. The patient is an unnamed man in his 20s living in Rome who lost the lower part of his arm following an accident, according to Silvestro Micera of the Ecole Polytechnique Federale de Lausanne in Switzerland.

The wiring of the new bionic hand will be connected to the patient's nervous system with the hope that the man will be able to control the movements of the hand as well as receiving touch signals from the hand's skin sensors. Dr Micera said that the hand would be attached directly to the patient's nervous system via electrodes clipped onto two of the arm's main nerves, the median and the ulnar nerves.


Silvestro Micera.

This should allow the man to control the hand by his thoughts, as well as receiving sensory signals to his brain from the hand's sensors. It will effectively provide a fast, bidirectional flow of information between the man's nervous system and the prosthetic hand. "This is real progress, real hope for amputees. It will be the first prosthetic that will provide real-time sensory feedback for grasping," Dr Micera said.

"It is clear that the more sensory feeling an amputee has, the more likely you will get full acceptance of that limb," he told the American Association for the Advancement of Science meeting in Boston. "We could be on the cusp of providing new and more effective clinical solutions to amputees in the next year," he said.

An earlier, portable model of the hand was temporarily attached to Pierpaolo Petruzziello in 2009, who lost half his arm in a car accident. He was able to move the bionic hand's fingers, clench them into a fist and hold objects. He said that he could feel the sensation of needles pricked into the hand's palm.

However, this earlier version of the hand had only two sensory zones whereas the latest prototype will send sensory signals back from all the fingertips, as well as the palm and the wrists to give a near life-like feeling in the limb, Dr Micera said. "The idea would be that it could deliver two or more sensations. You could have a pinch and receive information from three fingers, or feel movement in the hand and wrist," he said.

"We have refined the interface (connecting the hand to the patient), so we hope to see much more detailed movement and control of the hand."

The plan is for the patient to wear the bionic hand for a month to see how he adapts to the artificial limb. If all goes well, a full working model would be ready for testing within two years, Dr Micera said.

One of the unresolved issues is whether patients will be able to tolerate having such a limb attached to them all the time, or whether they would need to remove it periodically to give them a rest. Another problem is how to conceal the wiring under the patient's skin to make it less obtrusive. The electrodes of the prototype hand to be fitted later this year would be inserted through the skin rather than underneath it but there were plans under development to place the wiring subcutaneously, Dr Micera said.

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The case of water diffusion

tapan kumar maitra explains what osmosis is all about

GIVEN that most of the discussion focuses on the transport of solutes — ions and small molecules that are dissolved in the aqueous milieu of cells, their organelles and their surroundings — the emphasis is quite appropriate because most of the traffic across membranes involves ions such as K^+, Na^+, H^+ and hydrophilic molecules such as sugars, amino acids and a variety of metabolic intermediates. But to understand solute transport fully, we also need to understand the forces that act in water, thereby determining its movement within and between cells. As we do, we will recognise that water, the universal solvent of the biological world, represents a special case in several ways.

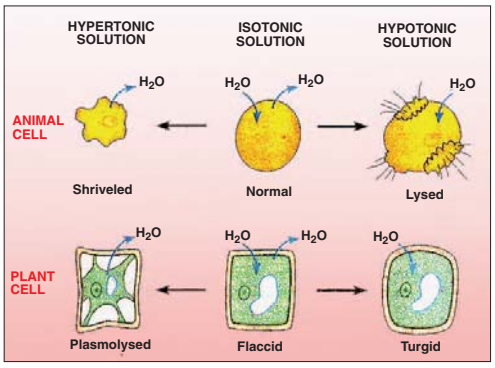
The movement of most substances across a membrane can usually be understood in terms of transmembrane concentration gradients and, for charged solutes, the membrane potential as well. Not so for water, however; its concentration is essentially the same on the two sides of a membrane, and as an uncharged molecule it is unaffected by membrane potential. Instead, water tends to move across membranes in response to differences in solute concentrations. Specifically, water tends to diffuse from the side of the membrane with the lower solute concentration to the side with the higher solute concentration. This diffusion of water, called *osmosis*, is readily observed when differentially permeable membrane separates two compartments, one of which contains a solute to which the membrane is not permeable.

Osmotic movement of water into and out of a cell is related to the osmolarity, or relative solute concentration, of the solution in which the cell finds itself. A solution with a higher solute concentration than that inside a cell is called a *hypertonic* solution, whereas one with a solute concentration lower than that side of a cell is referred to as a *hypotonic* solution. Hypertonic solutions cause water molecules to diffuse out of the cell, whereas hypotonic solutions cause water to diffuse into the cell. Osmotic movement of water, in other words, is always from a hypotonic to a hypertonic solution. A solution that triggers no net flow of water is called an *isotonic* solution.

Osmosis accounts for a well-known observation: cells tend to shrink or swell as the solute concentration of the extracellular medium changes. An animal cell that starts out in an isotonic solution (0.25 m sucrose is isotonic or nearly so for many cells) will shrink and shrivel if it is transferred to a hypertonic solution. On the other hand, the cell will swell if placed in a hypotonic solution and will actually lyse, or burst, if placed in a very hypotonic solution, such as water containing no solutes.

The osmotic movements of water occur because of differences in the osmolarity of the cytoplasm on the inside of the membrane and the solution on the outside. Under most conditions, the concentration of solutes is greater inside a cell than outside. This is due in part to the high concentration of ions and small organic molecules required for normal metabolic processes and other cellular functions. In addition, most of these metabolites are charged, as are most biological macro-molecules, and the counterions required to balance these charges also contribute significantly to the intracellular osmolarity. As a result, most cells are hypertonic compared with their surroundings, which means that water will tend to move inward across the plasma membrane. Left unchecked, this tendency would cause cells to swell and possibly lyse.

How cells cope with the problem of high osmolarity and the resulting osmotic influx of water depends mainly on the kingdom to which the organism belongs. Cells of plants, algae, fungi and many bacteria are surrounded by cell walls that are sufficiently rigid and sturdy to keep the cells from swelling and bursting in a hypotonic solution.



Instead, the cells — and the tissues, in the case of a multi-cellular organism such as a plant — become very firm as a result of the turgor pressure that builds up due to the inward movement of water. At equilibrium, the turgor pressure forces out as much water as the high solute concentration draws in. The resulting turgidity accounts for the firmness, or turgor, of fully hydrated plant tissue.

In a hypertonic solution, on the other hand, the outward movement of water causes the plasma membrane to pull away from the cell wall, a process called *plasmolysis*. The wilting of a plant or a plant part under conditions of water deprivation is due to the plasmolysis of its cells. You can demonstrate plasmolysis readily by dropping a piece of celery into a solution with a high concentration of salt or sugar.

Plasmolysis can be a practical problem when plants are grown under conditions of high salinity, as is sometimes the case in locations near an ocean. Animal cells, and other cells without walls, solve the osmolarity problem by continuously and actively pumping out inorganic ions, thereby reducing the intracellular osmolarity and, thus, minimising the difference in solute concentration between the cell and its surroundings. Animal cells continuously remove sodium ions; this is, in fact, the main purpose of the Na^+/K^+ pump. The importance of the Na^+/K^+ pump in regulating cell volume is indicated by the observation that animal cells swell and sometimes even lyse when treated with *ouabain*, an inhibitor of the Na^+/K^+ pump. Thus, cells without walls must expend significant amounts of energy to ensure that the intracellular osmolarity remains low and the cell does not swell and burst, whereas cells with walls can tolerate considerable osmotic pressure without danger of rupture.

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