VOLUME I | FEBRUARY, 2019

Acta botanica

EXPLORING BIODIVERSITY

THE DEPARTMENT OF BOTANY, ST. XAVIER'S COLLEGE, MUMBAI.

Team *A*cta botanica

Sudipta Kalita
Co-editor

Radhika Nair
Co-editor

Ambrose D'Souza
Assistant Editor

Reshell George
PR Head

Alina Chettiar
Finance Head

Nikhil Thomas
Head Of Photography

A Note From The Editor

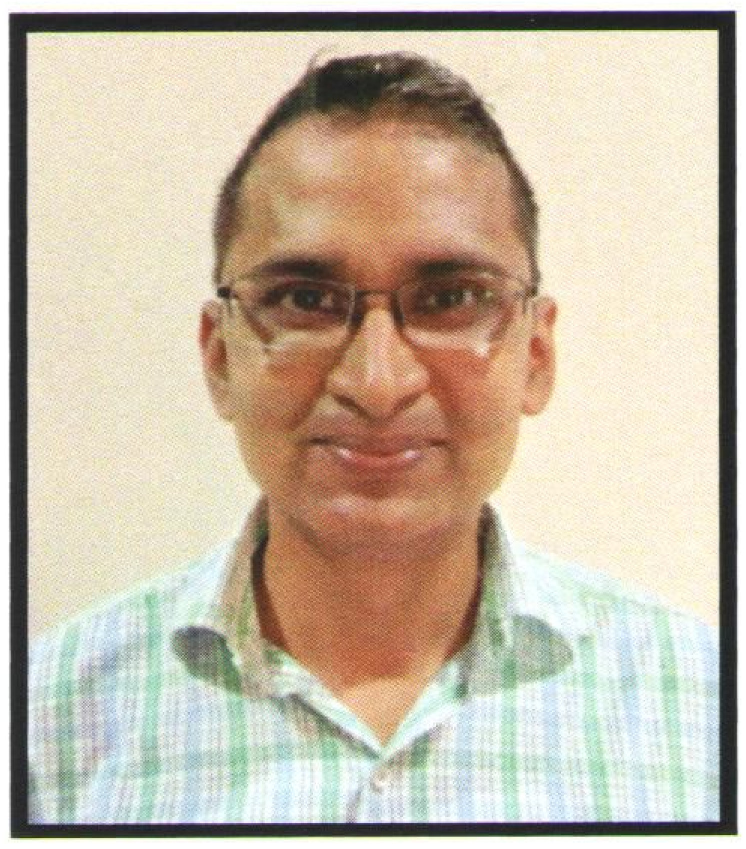
By Alok Gude, Editor In Chief

This is the first issue of the annual botany magazine- 'Acta botanica 2019' and this year we are exploring the theme of 'Biodiversity'.

We have included articles ranging from plant-animal interactions to plants that have the potential help us battle pollution. Biodiversity, as a whole is a very broad spectrum theme that we have chosen and the reason behind this theme is 'exploration'. Botany cannot be cornered and everything about plants is so vast; every little concept is no less fascinating than the other.

We have missed out on many other fascinating branches of the plant world due to the sheer vastness of our theme but we are glad that we have got some amazing content inside. We also have two pages dedicated to the campus flora of St Xavier's College (Autonomous), Mumbai.

I hope readers enjoy the articles and other content and also critically analyse our work. Since this is our very first launch of the botany magazine, we not just welcome, but are in need of suggestions to keep moving ahead with Acta Botanica in the coming years with even more amazing themes and content.



Dr. Alok Gude,
Head Of Department,
Botany,
St. Xavier's College,
Mumbai

*P*age of Contents

Cover page and photo on left: Water Willow, By Rizwan Meethawala

A Shapeshifting Mystery

A look at unexplored plant behaviour

By Himrekha Agarwal
TYBSc

There are plants that mimic insects, insects that mimic plants and even plants like *Lithops* that mimic stones, but this vine, *Boquila trifoliata* mimics other plants. It is native to the temperate rainforests of Chile and Argentina. It acts like any other vine; it crawls along the forest floor, spirals up and hangs onto host trees.

Nothing seems to be unusual about that. But unlike any other vine, it can modify its leaves to resemble those of the host trees on which it climbs. It morphs itself into an uncanny imitation of its host plant. Not only can it change the size, color and orientation of its leaves but also the petiole length and vein pattern to match the surrounding foliage.

There are some orchids which mimic other flowers, but the range is limited to one or two types. But *Boquila trifoliata* is not confined to this small range, it can mimic at least eight different host trees.

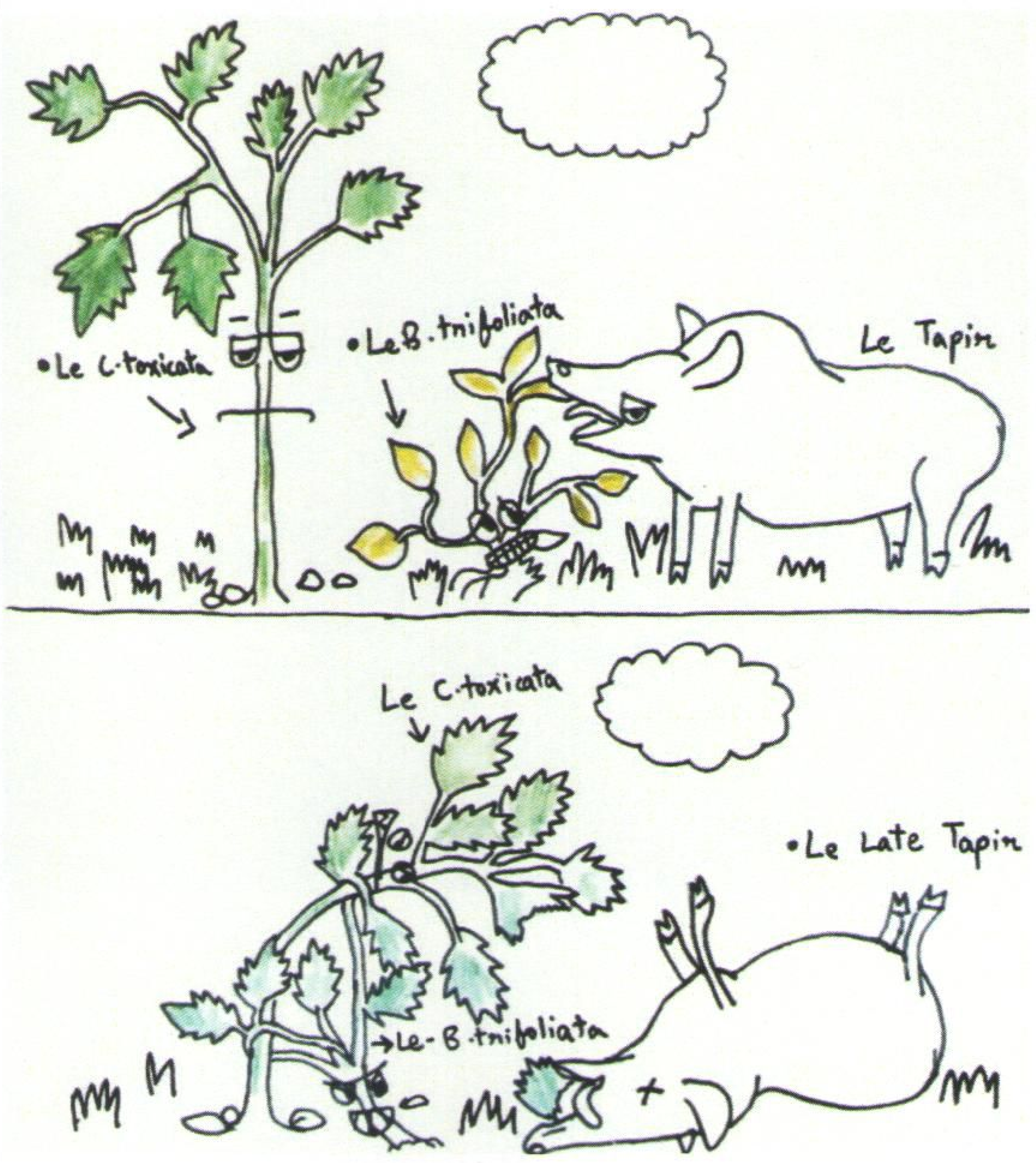
If it happens to entwine around more than one host at the same time, the single vine can mimic the leaves of several hosts. The other astonishing fact about this vine is that to mimic the host, it does not actually have to be in contact with the host tree to mimic its leaves, it just has to be in the vicinity.

Researchers currently lack a mechanistic explanation for this unique phenomenon. Many researchers have proposed that this kind of mimicry proves beneficial for the vines as it provides protection from various leaf eating animals. It may happen in two ways- first, the plant may be mimicking a host whose leaves are toxic to the animal and second, the probability of the vine being eaten by the animal decreases if its leaves are hiding among the various other leaves of the host plant.

Leaf herbivory also decreases in vines climbing on hosts compared to those that that are creeping on ground.

"It can modify its leaves to resemble those of the host trees on which it climbs".

Boquila trifoliolata. Picture credits: Corporación Vive Nativo, Chile



Artwork by Sudipta kalita

The mechanistic basis of how the vine 'senses' what tree is near and how it changes its leaf morphology is still unknown. Some researchers hypothesize that some volatile compounds emitted by the host are sensed by the vine and are used as signals to change the morphology of the leaves. Others hypothesize that this mimicry could involve a horizontal gene transfer mediated by air borne microorganisms. This can only be proved by sequencing the DNA of the vine and the host to see if transfer of gene actually occurs.

It is amazing to know that plants, which have no brains or noses, can smell 'scents' which animals cannot. This plant is sitting on a big secret which when unfolded would surely lead to a new revolution in science and would prove that plants are smarter than we had ever imagined.

Artwork by Aldrich Hezekiah

The Lepidodendrales

A look at their extraordinary success and eventual downfall.

By Amartya Mitra
TYBSc

There was a time around 300 million years ago when the vast majority of our planet was covered with lush swamp forests.

However, these swamps were significantly different from those we know of today. In addition to unnervingly large arthropods, like dragonflies the size of seagulls, they were also home to some very unique plants without which modern life as we know it, would never have come to be.

These were the Lepidodendrales or scale trees; an order of plants which dominated the prehistoric landscape around a 100 million years ago during the Silurian Period and evolved to become the very first vascular plants; fossilized remains are found all the way from North America to Australia. Like most ancient organisms, they were nothing like the trees we know of today. They would grow out of the ground like spi-

-kes and only produce branches on maturity, which would be localized to the apex.

Their leaves, once called *Lepidophylla,* were needle-shaped and grew straight out of the trunk in spiral patterns. When these were shed, they left unique diamond-shaped scars on the bark, similar to those in the palms and papaya trees of today.

"(the) lycopods had come up with a new structural polymer known as lignin, a substance which would forever change the world of plants and for that matter of humans".

Scale trees lacked seeds and instead produced many unicellular spores in reproductive cones called *lepidostrobus* which would then be released into the swampy water below for dispersal.

This was possible because the lycopods had come up with a new structural polymer known as lignin, a substance which would forever change the world of plants and for that matter of humans; it gave rise to wood. It was stronger and more rigid than cellulose and extremely difficult to degrade.

Lignin allowed the formation of a specialised tubular tissue known as xylem for the conduction of water and dissolved minerals throughout the plant. This new transport system meant that plants could grow very large and tall. Lepidodendrales in particular took advantage of this, with some growing to a staggering height of upto 50 metres! That's almost as tall as a 15-storey building!

However, scale trees were not as robust as the hardwoods we know of today. They contained relatively less amounts of lignin but were able to support their height with the help of a very thick layer of bark known as the periderm. Scale trees had a very shallow root system consisting of four massive branches which divided repeatedly, dichotomously (*Stigmaria*). The system being shallow, they trees were prone to falling over as they grew.

But this tropical swampland paradise would not last forever. The same polymer which was responsible for the lycopods' success would eventually lead to their downfall While there existed bacteria and fungi which could break down cellulose, those which could tackle lignin had yet to evolve.

This is because, while cellulose is made of chains of glucose molecules which are instant sources of energy, lignin is a phenolic polymer derived from benzene. Since phenols were not part of the biochemical pathways typically used for the obtainment of energy, it would take saprophytes another 40 million years to evolve a mechanism for digesting the lignin containing wood. So when scale trees died, their trunks just wouldn't decompose.

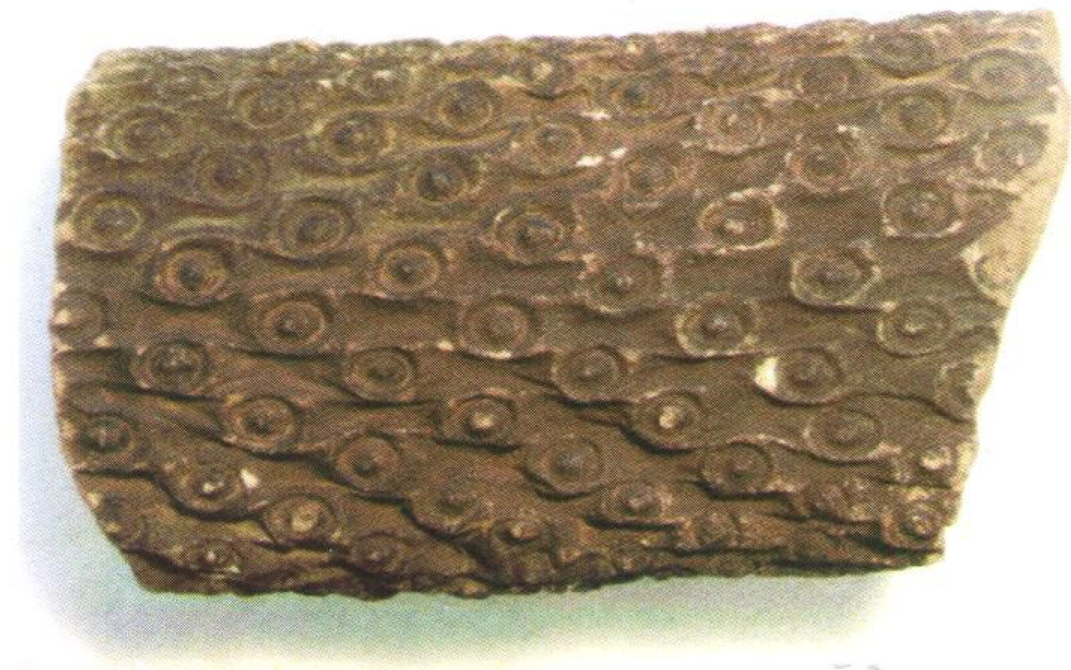
This had huge implications because all the carbon dioxide these plants had trapped within their tissues from the atmosphere, was now locked away. At the same time, they kept photosynthesizing and pumping out oxygen, causing $O2$ levels to peak at around 35%. That's around 15% higher than what's in the air we breathe today! These concentrations were a boon for terrestrial arthropods with inefficient, diffusion based respiratory systems which is why they were able to grow to unprecedented sizes.

But as atmospheric carbon dioxide levels crashed, it became increasingly difficult for plants to grow as they weren't able to photosynthesize very efficiently.

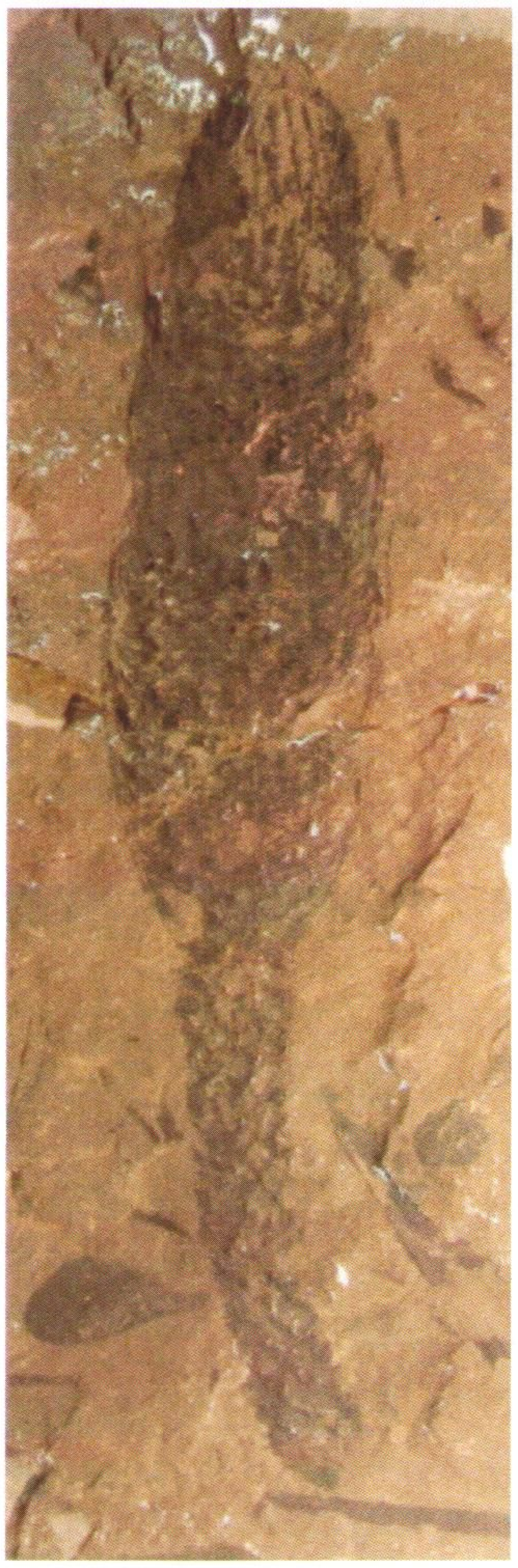
"It would take saprophytes another 40 million years to evolve a mechanism for digesting the lignin containing wood".

In addition to this, a lack of $CO2$ meant

Lepidophloios spp., Specimen housed in the Sedgwick museum, Cambridge., Verisimilus.



Stigmaria, a fossil lycopsid rhizome., Verisimilus.



Lepisodstrobus variabilis., housed at the museum of Sedgwick, Cambridge. Smith, English Wikimedia.

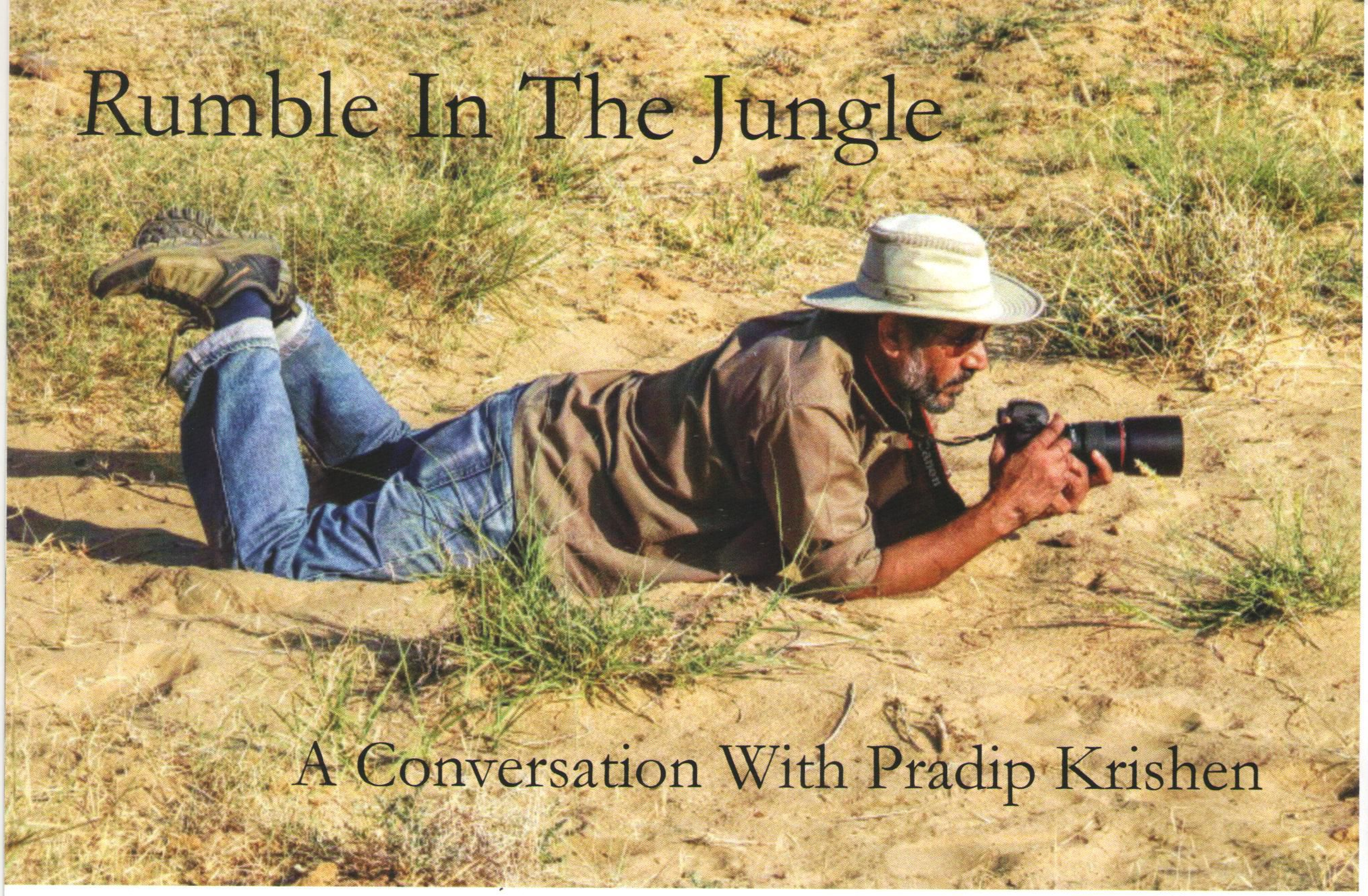
a diminished greenhouse effect and as the atmosphere lost its heat retention capacity, temperatures began to drop. This, coupled with heavy volcanic activity, plunged the earth into an ice age, triggering a mass-extinction known as the 'Carboniferous Rainforest Collapse'. And the lepidodendrales were one of its victims. While a few species managed to survive into the Permian period; by 272 million years ago they were completely extinct.

However, this was hardly the end to the legacy of the scale trees. Those trunks which piled up on the swamp floor were eventually compacted into peat and over time, transformed into coal. In fact, the amount of undecomposed biomass was so high that the rate of coal formation increased exponentially. These now long gone swamp forests are actually called coal forests!

This is the very reason we call this geological period in the earth's history, the Carboniferous. And it is the source of 90% of the coal that we use today. If not for those ancient scale trees, the Industrial Revolution would never have come to be. We humans are therefore indebted to the lepidodendrales for the comfortable livess-we lead. So the next time you turn a light on, watch some television or charge your phone, take a moment to think about the fascinating giants that made it all possible.

Rumble In The Jungle

A Conversation With Pradip Krishen



"(Indian Forestry) needs a total overhaul".

Pradip Krishen is an Indian environmentalist and forester. A self-taught botanist, he surveyed the trees of Delhi and documented it in the book, 'Trees of Delhi', which went on to become a best seller among amateur botanists and professionals alike. He is also famous for his work as an award-winning filmmaker, before he devoted himself full-time to conservation. Today, he is involved in several restoration programs, in places like Delhi, Ahmedabad and Jodhpur. His second book, 'Jungle Trees of Central India' (2013) was also a best seller. **Radhika Nair** (TYBSc) interviewed him over email.

I would like to start by asking you how you were first introduced to the field of Botany and what is it about plants that interested you?

It happened quite casually - I was building a small house for myself in Pachmarhi, at the edge of the jungle, and I would take long walks every day. I've always loved being in wild places, and Pachmarhi is just delightful. So me and my architect friend, we would walk further and further afield, enjoying the wilderness, and we were joined by a neighbour, a forester, who started teaching us the names of trees. That's how it began, tree-spotting, like bird-watching! And then slowly, haltingly, I learned to decode a Flora, consulting the glossary in order to understand what 'tomentose' meant, or 'amplexicaul'! That was literally what happened...

Your field guide, 'The Trees of Delhi' has become a favourite of Botanists and nature enthusiasts alike. What makes it different from other guides and what was the best part of the process of creating it?

I think the main reason it became popular is that it is written in a very reader-friendly way. I had so recently myself been been a 'layman', and I was writing primarily for other laymen, people like myself, who knew very little about the botanical world. I wanted to open up this arcane world of botany for ordinary people, make it more accessible, give them some delight in the things they saw around them, things they had taken for granted. To me, it's both surprising and wonderful that botanists use the book too. I had never imagined that serious students of botany would be part of the audience for my book.

The best part of creating it? Oh, undoubtedly for me, the journey that took me from being an amateur tree-spotter to burrowing as deep as it was possible for me to burrow into the world of botany! I started out with wanting to write a short booklet - maybe 30 or 40 pages - about the common trees of Delhi. Every month, this incipient book became longer and longer as I delved deeper into the subject and explored parts of Delhi I had not known. The book ran away from me, or rather with me, because in the end it bore no resemblance to the booklet I had started out to write.

Urban forestry is a field that's largely overlooked by both the public and the government. The existence of small patches of forests in cities today is threatened by various developmental projects as is seen the case of Aarey Milk Colony in Mumbai, which was recently in the news due to the dispute over the building of the car shed, which requires the felling of hundreds of trees and if carried out, will be a great loss to the green cover of the city, not to mention the wildlife that lives in that habitat. How do we protect such habitats, especially considering that they are often not considered 'forests' and thus, seen as not deserving of protection?

There's no substitute for citizens' action, for arousing public opinion, and making ourselves heard in large decibels and numbers. For all sorts of reasons, urban planners in this country, and municipal councillors and road engineers, the whole guild of people who have the powers to change things in our cities, place little or no value on trees and green spaces. So it's upto us, to citizens' groups and green activists, to do what we can, including going to the courts, to make amends for the glaring shortcomings in the way that planners plan things.

What is your opinion on the use of foreign species such as Gulmohar and Copper Pod in urban tree plantation and cultivation of green spaces?

I'm a believer in native tree species for our cities. 'Native' in a very narrow sense of the word. If we plant trees and shrubs and grasses that are truly 'native' and therefore, by definition, perfectly adapted to our climate and above all, to our moisture regime, it's a big plus for the ecology of our cities. At the same time, I don't want to sound like a 'native tree fundamentalist'! Exotic trees are dangerous because they can be thirsty and demanding of resources, and some of them also tend to be invasive like *Prosopis juliflora* and *Leucaena leucocephala* (river tamarind). Neither the gulmohur or copper pod are invasive, at least not in this part of the world, but gulmohurs have other drawbacks - they're known to be brit-

"There's no substitute for citizens' action, for arousing public opinion, and making ourselves heard in large decibels and numbers."

“I think we’re still thinking and acting like German foresters from the 19th century”.

-tle, for instance, and offer hardly any niches for birdlife. Nothing grows underneath a gulmohur, probably because they secrete alkaloids that inhibit things from growing nearby. So we have to be careful with exotics.

The thing that bothers me is that there’s literally hundreds of wild trees that we haven’t even tried out yet. There’s a whole opportunity out there for us to cultivate wild trees that might fit in beautifully into our urban landscapes, without compromising groundwater levels or needing large dollops of nutrients. .

Do you know, for instance, that India has something like 2,600 species of native trees. Do you know how many we actually cultivate in our cities and gardens? It’s no more than about 50 or 60 species, which is a mere 1.5 percent of our natural tree diversity (if my maths is correct). Isn’t that astonishing? That as a culture and civilization, we haven’t bothered to explore the trees that grow in our own backyard? There’s a lot of work for you young people to do out there, and it’s very interesting work too!

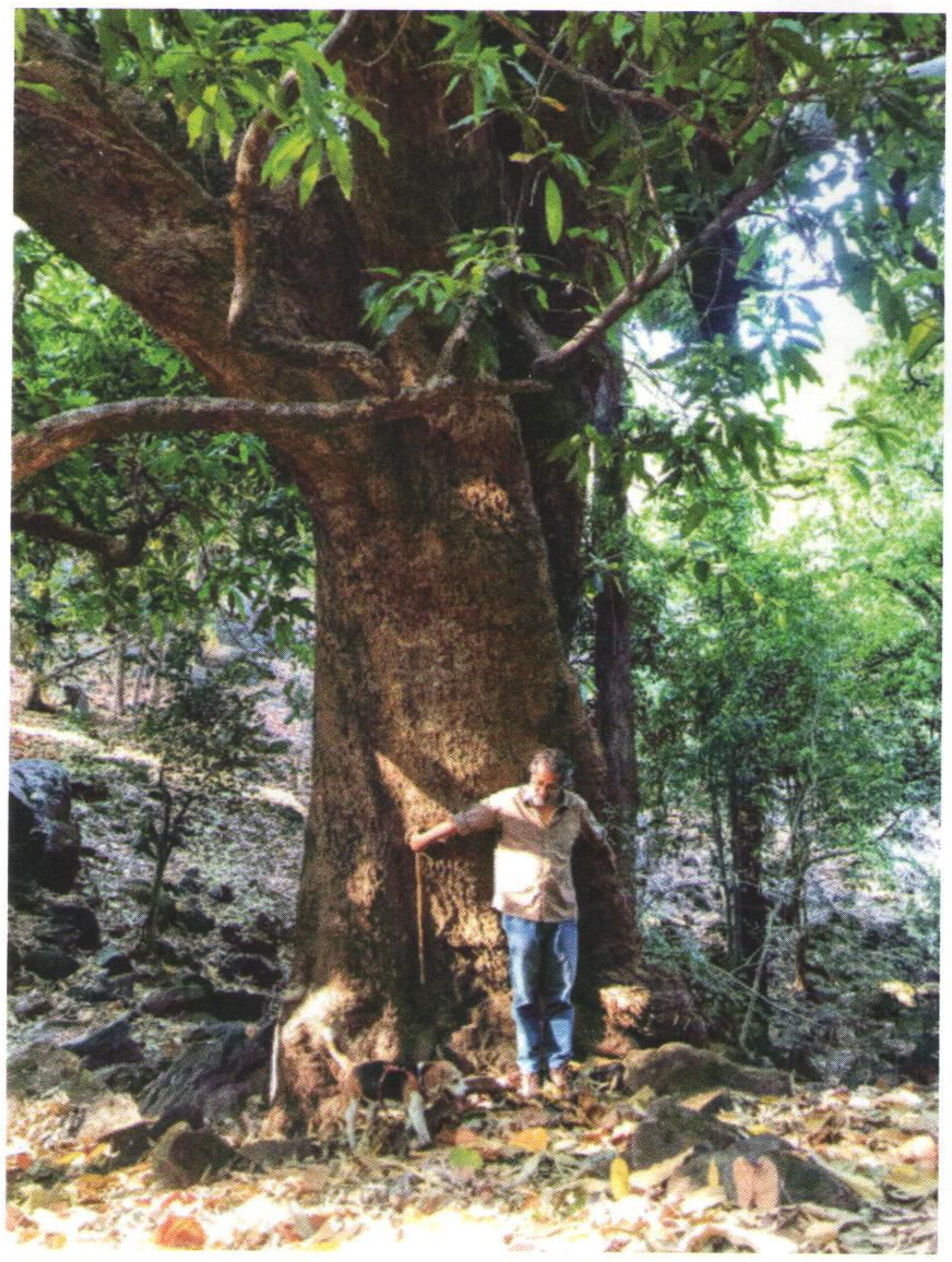
What is the most challenging thing about forest management in India? And what is the easiest?

I think we’re still thinking and acting like German foresters from the 19th century, and the most urgent thing we need to do is to throw all of that approach out of the window, and begin to think like conservationists. We actually have fairly good laws and policies in our statute books, but the people who run our forests and execute policies live in the previous century, and all they’re interested in is living like landlords and growing plantations of useful species. It’s a terribly outdated way of doing things, so I’d say we need a total overhaul.

What is your favourite species of plant and why?

That’s the most difficult of the questions you’ve asked me!

I don’t know, I have many favourites, and they change from habitat to habitat, and probably over time too. For example, in the desert of western Rajasthan, the plant I like most is phog (*Calligonum polygomoides*). And when I move to the rocky Aravallis, it’s dhok (*Anogeissus pendula*). And in south-central India, the tree I admire most is anjan (*Hardwickia binata*). D’you see what I mean?!



Photos Courtesy of Pradip Krishen.

The bizarre architechture of the *Ceropegia vincifolia* flowers serve an important purpose. Small dipterans enter inside the male flower, but it's a struggle for them to get out of the flower trapped by its infinite, minute hairs. In this process, the dipteran is covered with pollen from the pollinia which is inside, subsequently the hairs loosen and the dipteran is free only to fool its way inside a female flower, get trapped and in the process deposit the carried pollen onto the gynostegium of the a female flower.

Photograph by Mayur Mahendra Bhagwat

A Helping Hand To *Hydra*

By Jay Bathia, research fellow at University of Kiel, Germany

Algae comprise of a diverse group of uni- and multicellular members of the plant kingdom (prokaryotic blue-green algae or cyanobacteria and eukaryotic algae are traditionally included as algae. The eukaryotic algal species can be unicellular as well as multicellular. While most algal species are autotrophic, several species live in a symbiotic relationship with fungi, protists or diverse animal phyla. These symbiotic interactions are mainly mutualistic in nature where both the partners benefits mutually.

These symbiotic algae are present across various animal phyla - Porifera, Cnidaria, Acoela, Mollusca (functional kleptoplasty), Ascidia and class Amphibia. These algae are unicellular and endosymbiotic (intracellular) in nature. Most widely studied cases include Cnidarian-algal symbiosis in Coral-Dinoflagellate, Aiptasia-Dinoflagellate and *Hydra-Chlorella* and a proto-algal *Paramecium-Chlorella* symbiosis.

"Several (algal) species live in a symbiotic relationship with fungi, protists or diverse animal phyla".

They all follow some fundamental principles of symbiosis: (i) the symbiosis is established by phagocytic uptake of the algae, (ii) the algae evades the phagosome digestion like an intracellular parasite, (iii) the pH of the resulting 'symbiosome' is maintained low (~4-5) by the host and, (iv) there occurs a mutual biotrophic exchange of metabolites, i.e. exchange of the metabolites without causing any harm to either of the partner.

The alga provides photosynthetically fixed carbon to the host and in turn receives fixed nitrogen in the form of amino acids. Our lab focuses on studying these symbiotic interactions in the animal *Hydra viridissima* that harbors intracellular algae of the genus *Chlorella.*

"The algae provides photosynthetically fixed carbon to the host and in turn receives fixed nitrogen in the form of amino acids".

Hydra has a simple body-plan comprising of two epithelial stem cell layers - ectoderm and endoderm, separated by mesoglea. The endoderm is phagocytic in nature and harbors the intracellular *Chlorella* algae. Each cell contains about 40-50 algal cells.

The host derived perisymbiotic membrane surrounds each algal cell. The space between the membrane and the algae is often referred as perisymbiotic space, the pH of which is ~4. Only at this low pH, is the *Chlorella* able to release the photosynthetic sugar to the host

Hydra viridissima in symbiosis with Chlorella. Picture credits: alchetron

that drives the symbiosis. This sugar is a glucose disaccharide called maltose. The algae in turn receives the fixed nitrogen in the form of glutamine.

This maltose releasing capacity is unique to the endosymbiotic *Chlorella*. In nature, the free-living algae and plants mobilize the starch from the chloroplasts to the cytosol in the form of maltose, but it is never secreted outside the cell. However, over the course of evolution, this unique property to release maltose outside the cell rendered a group of *Chlorella* sp. with the ability to establish endosymbiosis.

With the aid of comparative transcriptomics and genomics, we could obtain some deeper insights in understanding these interactions. Published by Hamada and Schröder *et al*, the transcriptomes of symbiotic animals with native symbionts, symbiotic animals with foreign symbionts and aposymbiotic animals (without symbionts) were compared by microarray. It was shown that the maltose released by the algae is digested to glucose that brings metabolic changes within the host.

This results in the induction of symbiosis specific glutamine synthetase (GS), a phosphate transporter (Pi) and a Spot14-like domain containing protein (most likely involved in lipid metabolism). The GS produces glutamine, which is transported to the algae to support its survival.

Moreover, the algae has lost its anonymity, i.e. survival independent of the host. The algae lacks some essential genes involved in the utilization of nitrate and ammonium rendering it dependent on fixed nitrogen in the form of glutamine as taken from the host.

The claim is further strengthened by the temporary rescue of growth of algae in vitro by addition of glutamine, albeit not permanent, indicating a stronger dependence of algae on the host.

Hydra possess glycocalyx towards the outside of the ectoderm that harbors the microbiota. With growing evidence on the role of bacteria in maintaining the host homeostasis, we are currently interested in seeing if bacteria has any effect on the symbiosis and thus, achieve a basic understanding of tripartite symbiosis.

Clockwise from left: *Aeginetia indica*, a common root parasite in the forest undergrowth during the monsoon, by Maniruddin; *Commelina benghalensis*, by Trish Gonzalves; *Kaempharia scaposa,* endemic to the Western Ghats by Mayur Mahendra Bhagwat.

Left to right from previous page: A paddy field in Assam, Female Hanuman Langur with infant, both as taken by Rituraj Das; *Jaquemontia pentantha* and bee by Nikhil Thomas; *Adenoon indicum* taken at Kaas Plateau by Tanvi Patil

The Demon Flower

A Glimpse Into The Evolution Of Pitcher Plants.

By Shimontika Gupta,
TYBSc

Carnivorous plants have fascinated botanists and evolutionary biologists for centuries. They were considered biological oddities and over the years have inspired generations of scientists.

One such type of carnivorous plant is the pitcher plant. Recognized by its characteristic 'pitfall traps', there are five genera; the palaetropic *Nepenthes*, the neotropical *Sarracenia, Darlingtonia* and *Heliamphora*, and lastly the monotypic *Cephalotus*. Pitcher plants show highly specialized pitfall traps derived from leaves, to attract, catch, retain, kill and digest prey, from whom they derive nutrition. Often nectar is used as a primary attractant aided by volatiles and contrasting colour patterns in both the UV and visible spectrum.

They even have specialized waxy or slippery surfaces and complex micromorphology to trap insects along with several other adaptations. So how did these mysterious complex carnivorous plants even evolve?

As recently as the 1980s, people believed that all extant carnivorous plants were derived from a common ancestor but modern molecular data shows that they have evolved from multiple phylogenetic lineages. Pitcher plants which belong to different genera have

Chrysopogon zizanioides, commonly known as Vetiver, is a perennial bunch grass of the family Poaceae, and is native to India. The plant is closely related to sorghum but shares many morphological characteristics with other fragrant grasses such as lemon grass, citronella and palmarosa.The vetiver grass has a gregarious habit and grows in tufts. The root system of vetiver is finely structured and extremely strong; it can grow upto 3 or 4 metres deep within the first year. Vetiver has neither stolon nor rhizomes. Vetiver acts as a 'miracle grass' for soil and water conservation, and has great potential for the application of this technology because of its characteristic tolerance to heavy metals .

Truong (1999) reported that the distribution of heavy metals in vetiver plant can be divided into three groups: (i) very little of the arsenic, cadmium, chromium and mercury absorbed, which were translocated to the shoots (1-5%); (ii) a moderate proportion of copper, lead, nickel and seleniumtranslocated (16-33%); (iii) zinc was almost evenly distributed between shoot and root (40%). However, numerous investigators concluded that vetiver root systems accumulated higher heavy metal concentrations than shoot systems. It was found that when vetiver plants were matured, the shoot heavy metal concentrations decreased, possibly due to the dilution effect of increasing biomass, whilst the root heavy metal concentrations increased.

The ratio of metal concentrations in shoot to root is defined as the translocation factor (TF) which refers to the ability of the plant to translocate metals from the root to the shoot. The heavy metal translocation ability of vetiver grown in industrial wastewaters varied depending on the growth media and metal. The ability of vetiver to translocate heavy metal was quite low when hydroponically cultured in wastewaters with average TFs of 0.070.67.

However, vetiver grown on iron tailings and zinc mine soils could translocate higher quantities of heavy metal from root to shoot with TFs of 0.55-0.86 and 0.50-0.89, respectively.

Soil amendments applied to iron ore tailings and zinc mine soil affected the ability of heavy metal translocations by some of the

Tufts of *Crysopogon zizanoides* or vetiver grass. (Above).

- nivorous plants include structures like epicuticular wax crystals on the inner walls of the pitcher, to reduce the area of contact along with trichomes and other structures on the peristome and the inner surface, that are oriented to help insects climb in but do not allow them to escape; and lastly, the presence of slippery surfaces. These similarities indicate that all carnivorous plants share similar selective pressures which lead to a change in ecological processes and evolutionary dynamics.

These plants, spread across the world have also evolved several unique features of their own; adapting their own nutrient acquiring strategies based on habitat characteristics. *N. albomarginata,* a very picky eater, targeting only termites, is the first of its kind, offering up its own tissue as bait. It produces a ring of white, lichen-mimicking trichomes that termites find irresistible. From the termites that come to feed on this, those that accidentally fall in, fall prey to the pitcher.

N. ampullaria on the other hand has turned vegetarian; situated in clusters on the floor of the dense jungle, it is urn-shaped with a vestigial lid and no nectar glands and obtains its nitrogen content from leaf litter. The four famous Bornean species are in fact highly specialized toilets; wide orifices and a concave lid perfectly oriented to a position below the Tree Shrew, for faeces capture, while also offering them nectar in return. Another wonderful adaptation is seen in *Nepenthes hemsleyana* which provides a roosting site for bats in return for their nitrogen-rich feces. Finally, we have *Nepenthes bicalcarata,* which has evolved a mutualistic relationship with ants, wherein it provides them with nectar and nesting sites in return for protection and the waste generated by the colony, which serves as nutrition.

So why evolve carnivory?

The varied and independent evolution of carnivory in diverse plant families suggests that it is an adaptation to the low-nutrient, overly-bright, waterlogged areas, where these plants are usually found. These plants obviously depend on insects for their nutrition but their reliance on insect-derived nutrition differs across species. In general, it is seen that their dependence on insect-derived nitrogen increases as their carnivorous structures become more and more complex. Even within a plant, the relative contribution of insect-derived nutrition to the total plant nitrogen content varies with time.

This is seen in some plants where juvenile, non-functional pitchers derive their nitrogen from the soil and from insects captured by older pitchers whereas young, newly functional pitchers, retain all their nutrients derived from prey and do not shunt any nutrients to nonfunctional pitchers.

It is also seen that carnivorous plants have lower rates of photosynthesis, but increased vigor in terms of sexual and asexual reproduction, which could be due to the sufficient nutritional benefits that carnivory supplies, thus overcoming the cost of a lower photosynthetic rate.

Therefore, carnivory, in general, is beneficial to the plant; however, the flowers of all carnivorous plants are insect pollinated and hence there arises a conflict between pollination and prey capture. Some plants are long-lived perennials and reproduce vegetatively, but for annuals, resolution of this conflict is crucial. To combat this issue, some plants have a very clear spatial and temporal distriibution of flowers, whereas in some plants these carnivorous leaves and flowers are present in close association but there is a distinction between the species targeted by each.

For example, flowers might be pollinated by larger insects like butterflies and bees, while the pitchers primarily target smaller insects like thrips and beetles. This is mainly seen in sunny habitats where larger insects are present. In shady areas, however, the plants depend on these thrips and beetles for both nutrition and pollination. As a result, the prey-pollinator conflict is a lot higher.

Studies of UV reflection patterns for pitcher plant traps has also shown that flowers and traps have different sizes, shapes and contrasts, and have evolved to prevent pollinators from becoming prey. The more we learn about pitcher plants, the more complex they are revealed to be. There is much more to study in them, not only to help us understand their ecophysiology, but also the mechanisms of adaptive evolution.

The Indian Pitcher Plant:

Nepenthes khasiana, exists as isolated subpopulations, known to occur in the Jaintia, South Garo and East Khasi Hills region of Meghalaya to which this plant is endemic.

The aboriginal people of the North East have a long association with the plant. The Khasi people call it "*tiew-rakot*", meaning 'the demon flower'; the Jaintias call it "*kset phare*" meaning 'the lidded fly net'; while the Garo people call it "*memang koksi*", meaning the 'basket of the devil'.

N. khasiana grows mostly in acidic, moist, nutrient deficient soils and sometimes in sandy areas. Where the medium is light and airy, it grows as a climbing or scrambling vine which ranges from few centimeters to several meters in height. The outer side of the pitcher is yellowish green, sometimes mottled with faint red or orange blotches while the inner side of the pitcher is yellow, orange or pink and the lid often has a red underside. This curious and unique pitcher-shaped plant is in great demand for its ornamental value and also for its medicinal properties which has led to its over exploitation.

The population is severely fragmented and its area of occupancy is estimated to be a poor 250 square kilometers. As a result, the species has been categorized as 'Endangered' on the IUCN Red List, and has been included in the Appendix- I of CITES and Negative List of Exports of the Government of India.

The natural habitat of the species is disturbed mainly by habitat destruction due to mining, deforestation, urban development and forest fires. It has rendered them increasingly vulnerable to inbreeding-depression, high infant mortality and susceptibility to environmental stochasticity.

Conservation strategies need to pay more attention towards managing disturbance to the natural habitat of the species. A few pitcher plant sanctuaries have been set but there is a need for effective conservation efforts such as trade regulation and sustainable collection along with the cultivation and propagation of these plants. These plants are truly a treasure of our country and we have so much more to learn from and about them, and it is thus our responsibility to not only protect them but also raise awareness about their dire state.

*H*ome Sweet Plant

Exploring an extraodrinary symbiotic relationship between a plant and the bat that calls it home.

By Vidisha Bansal,
TYBSc

Whenever we consider a symbiotic relationship between a plant and an animal, we only think about pollination. Well, somewhere in a peat swamp in Borneo there's a bat roosting in a pitcher plant proving you wrong.Hardwickes woolly bat (*Kerivoula hardwickii*) roosts inside tropical pitcher plants (*Nepenthes hemsleyana*) which is a more luxurious and private place.

These carnivorous plants usually attract insects, but this particular species lacks the scents that others possess, so few are successfully lured in. Instead, it benefits from the faeces of this tiny bat, which provides more than a third of its required nitrogen content and may be crucial to the plant's survival.

N. hemsleyana pitchers have acquired traits that are highly attractive to the bats. This includes a pitcher shaped to fit the body of the bat perfectly and a more stable internal mi-croclimate than in the pitchers of any other. *Nepenthes* species. This pitcher plant enhances its conspicuousness to the bats by possessing echo-reflecting structural modifications. It has a disc shaped structure at the opening of its mouth which is called the reflector. This reflector makes it easier for the bats to locate the pitchers as the sound waves emitted by the bats are reflected back.

Moreover, several adaptations of *N. hemsleyana* plants that might have originally existed in order to capture arthropods are beneficial to the bats. The inner wall of *N. hemsleyana* pitchers is covered by a waxy layer, which does not allow arthropods to place their eggs, larvae or pupae there. Consequently, the bats that choose to roost exclusively in these pitchers are free of certain ecto-parasites that depend on the roosting bats for parts of their development, and thus, need to switch their roosting positions less often and are thus healthier than the individuals using other alternatives, such as furled leaves. *N. hemsleyana* pitchers are also available on most days unlike furled leaves (which may soon unfurl), thus making the pitchers the most inviting spots for the bats.

Why is this plant investing so much effort into making itself the perfect roosting place for a bat? The answer is simple; *N. hemsleyana* grows in the peat swamps of Borneo, whose soil nitrogen content is very less and as it also can't trap as many insects as other *Nepenthes* species, it turns to bats for its nitrogenous needs. The concentration of digestive juices inside the pitcher is very low, low enough for the bat to not get harmed by it. The plant derives more than 33% of its nitrogen by digesting bat droppings. This compensates for the lack of its ability to catch enough insects. In fact, this is not the only *Nepenthes* species to turn away from carnivory; species like *N. lowii* catch bird and Tree Shrew droppings, which account for al-most 100% of the nitrogen used up by the plant for its physiological processes.

This is the first time plants have been found to possess an adaptation to attract bats that does not exist for the purpose of pollination. This discovery is also remarkable for what it reveals about the changing nature of the re-lationship that exists between plant and ani-mal; wherein a group of plants that evolved to prey on animals eventually branched out into species that live in mutualistic harmony with animals, revealing yet another marvel of the natural world.

Hardwicke's woolly bat flying in to roost in the Pitcher plant. ©MerlinTuttle.org

A Witness To History

Jomon Sugi, the oldest tree on Japan's Yukushima Island.

Some of the longest living organisms in the world are trees. Until recently, the oldest living tree in the world was believed to be Methuselah, a 4,845 year old Bristlecone Pine (*Pinus longaeva*) living in the White Mountains of California.

Yew trees, are another species famous for their longevity, with the Llangernyw Yew of North Wales being around 4000 years old. The tree pictured above is an individual of the *Cryptomeria* species. Named Jomon Sugi, it lives on Yukushima Island in Japan, and is estimated to be 7,200 years old.

However, all of these seem young when compared to species that live in clonal colonies - genetically identical trees connected to each other by the roots and surviving as a single organism - such as quaking aspen or *Populus tremuloides*. One such colony lives in Utah, and is estimated to be 80,000 years old!

Trees are aged using Carbon-14 dating of their roots. Longevity in trees is achieved by several unique behaviours, such as, the retention of stem cell-like meristematic cells; the ability to replace organs as required; a sectored vascular system that allows one part of the tree to survive while the other is damaged; a sophisticated hormone control system that coordinates physiological functions, and complex defense systems, to name a few. There is much that we do not understand about these magnificent creatures and until we can know more, we can only wonder at the secrets they hold within.

The Cloak Of Invisibility

By Magdalene D'Silva, TYBSc

Diphylleia grayi, also known as the skeleton flower belongs to the family Berberidaceae. It is a perennial plant that grows to 0.4m (1ft 4 inches). It blooms from mid-spring to early summerand is native tothe colder regions of Japan. The species is hermaphrodite (has both male and female organs). The plant is easier to spot if you look for its large, umbrella-shaped leaves. The flowers bloom in the axils of the leaves in small clusters. They prefer shady conditions and should only receive partial sunlight.

At first glance it may appear to be an ordinary plant, but there is actually something quite extraordinary about it.

Pictured above is the flower in its transparent state, after rain.

This plant turns transparent when it rains. The petals are normally opaque white color, but when it rains, the petals turn crystal clear. The veins in the petals look like bones, hence the name "skeleton flower".

On contact with water, they become transparent; not because of any pigment, rather it is due to the loose cell structure in the petals. On rainy days water enters the petals yielding a water-water interface and increasing light transmission through the petals so that they turn transparent.

(Pictured left is the flower in its normal state)

On sunny days, the air-liquid interface of the petals causes diffuse reflectance (when the incident ray of light scatters at many angles), endowing the petals with a white color This strange and unique quality of these resplendent blooms certainly make them a remarkable find for flower hunters.

The Sacred Fig

"Eventually, these aerial roots enclose or *strangle* the host plant and kill it, with the fig tree succesfully taking its place".

By Anushia Anthony,
TYBSc

The *Ficus* genus is one of the largest, with 800 species in the world and 150 species found in India. *Ficus benghalensis* belongs to the family Moraceae. *Ficus benghalensis* (Banyan), also known as the sacred tree is native to India and is very important in Hindu philosophy. It has the ability to survive and grow for centuries and is often compared to the shelter given by God to his devotees. Indians knew the banyan tree as the 'Vatvriksha'.

When the British came to India, they noticed that members of the trading or *bania* community used to gather under a large shady fig tree, which they named the Banyan.

It is the national tree of our country because of its characteristic longevity, with individuals being known to live upto more than 300 years, one example being The Adyar banyan tree in Chennai. Another example is the Thimmamma Marrimanu banyan tree located in Andhra Pradesh, which is famous for being the largest tree in the world, with a canopy that covers nearly five acres.

Banyan trees are generally large and spreading with aerial roots, also known as prop roots. The roots have a very important role as they support the heavy trunks by acting as a pillar when they get rooted into the soil and thus, they help the tree spread laterally by then forming new branches. The group of plants called banyans, begin their life as epiphytes, growing from seeds that have fallen onto branches of other, 'host' trees, usually through bird or bat droppings.

From the seedling arise aerial roots, which look more or less stem-like. These roots grow down the host's trunk to the ground, and so the adult plant is now connected to the soil. The plant is not a parasite since it uses the host plant only for support and does not derive nutrition from it.

Eventually, these aerial roots enclose or strangle the host plant and kill it, with the fig tree succesfully taking its place. It is for this specific behaviour that banyan trees, as well as several other related plants are called 'strangler figs'.

This type of growth habit is thought to have started as an adaptation for growing in dark forests where there is immense competition amongst plants for light.

The banyan tree serves as shelter for a great variety of animals and birds. The figs produced are often mistaken for fruits, but in reality are the plant's inflorescence. Figs are remarkable for the symbiotic relationship they have with fig wasps. The deeply entwined life of the fig wasps and fig tree is highly species specific. These figs release certain volatile chemicals that attracts the female fig wasp.

The female wasp lays eggs in the sterile flowers, inside the fig. The wasp larvae feeds on the single seed present inside each female flower in the fig. The male wasps emerge first. They do not possess wings so they crawl from flower to flower in search of a female wasp.

After mating, the male wasp pierces through the fig with his mandibles, thus releasing the female wasp. The fertilised female wasp crawls over the male flowers, gathering pollen and leaves through the channel formed by the male, to fly to another tree and find the perfect fig in which to oviposit. Thus, the fig wasp's life cycle is completed alongwith the successful pollination of the fig tree.

Another variant of *Ficus benghalensis* is *Ficus benghalensis* var. *krishnae.* The unique and most interesting feature about this tree, is the leaf; it has a pocket-like fold at the base, which makes it look like a cup. As with most things in India, there is a mythological story that Lord Krishna,being fond of butter often stole it.
Once, when he was caught by his mother, Yashoda, he tried to hide the butter by rolling it up in a leaf of this tree. Since then, the leaves of these trees are believed to have retained this shape.

The cup shaped leaves develop only if the tree is grown from a cutting of the *krishnae* variant; plants which develop from seeds of this variant may grow as normal *Ficus benghalensis* leaves indicating that they are not different species as once believed.

The leaves are stalked, ovate or heart shaped with 3 prominent veins and when young., they are velvety on both sides.The upper surface of the leaves forms the outside of the pocket.This plant not only has a mythological importance but also has some medicinal importance as the plant parts are used to treat ulcers, vomiting, fever and inflammation.

Ficus benghalensis, as taken by P. Jeganathan

On A Heavy Metal Diet

A species with immense potential for phytoremediation.

By Saswati Sarma

Heavy metal contamination commonly results from human activities which has become a serious environmental problem today. Phytoremediation is the process of removing contaminants from the environment via living plants. Besides being an economical, energy efficient and environmentally friendly method, phytoremediation can be applied to large areas and is useful for a wide range of contaminant types. The two main sub-proccesses include phytoextraction and phytostabilization, through uptake of heavy metals into their aerial parts and in which plants decontaminate the soil through uptake of heavy metals into their aerial parts and then can be harvested and removed from the site. For phytoextraction purposes, this process is repeated several times in order to reduce contamination to acceptable levels.

Therefore, apart from taking up large amounts of contaminants, plants should be able to transport the contaminants to the shoots, which then enable their removal. A plant which has been identified as especially suited to this purpose is Vetiver.

Chrysopogon zizanioides, commonly known as Vetiver, is a perennial bunch grass of the family Poaceae, and is native to India. The plant is closely related to sorghum but shares many morphological characteristics with other fragrant grasses such as lemon grass, citronella and palmarosa.The vetiver grass has a gregarious habit and grows in tufts. The root system of vetiver is finely structured and extremely strong; it can grow upto 3 or 4 metres deep within the first year. Vetiver has neither stolon nor rhizomes. Vetiver acts as a 'miracle grass' for soil and water conservation, and has great potential for the application of this technology because of its characteristic tolerance to heavy metals .

Truong (1999) reported that the distribution of heavy metals in vetiver plant can be divided into three groups: (i) very little of the arsenic, cadmium, chromium and mercury absorbed, which were translocated to the shoots (1-5%); (ii) a moderate proportion of copper, lead, nickel and seleniumtranslocated (16-33%); (iii) zinc was almost evenly distributed between shoot and root (40%). However, numerous investigators concluded that vetiver root systems accumulated higher heavy metal concentrations than shoot systems. It was found that when vetiver plants were matured, the shoot heavy metal concentrations decreased, possibly due to the dilution effect of increasing biomass, whilst the root heavy metal concentrations increased.

The ratio of metal concentrations in shoot to root is defined as the translocation factor (TF) which refers to the ability of the plant to translocate metals from the root to the shoot. The heavy metal translocation ability of vetiver grown in industrial wastewaters varied depending on the growth media and metal. The ability of vetiver to translocate heavy metal was quite low when hydroponically cultured in wastewaters with average TFs of 0.070.67.

However, vetiver grown on iron tailings and zinc mine soils could translocate higher quantities of heavy metal from root to shoot with TFs of 0.55-0.86 and 0.50-0.89, respectively.

Soil amendments applied to iron ore tailings and zinc mine soil affected the ability of heavy metal translocations by some of the

Tufts of *Crysopogon zizanoides* or vetiver grass. (Above).

vetiver plants. It was seen that chelating agents (EDTA and DTPA), especially in combination with compost, could elevate Cu translocation in both types of mine soils. Application of soil amendments increased iron translocation slightly invetiver grown on iron ore tailings while manganese translocation was seen to be decreased. The compost and chelating agents did not, however, affect zinc translocation invetiver grown on both types.

Certain soil amendments could enhance translocations of certain metals; the TFs for studied heavy metals were all less than one.

The process of phytoremediation depends on the tolerance of the plant to the contaminant. Truong (1999) demonstrated that vetiver is highly tolerant to many heavy metals. For vetiver growth, the shoot threshold level of the metals arsenic, cadmium,copper, chromium and zinc are 21-72, 45-48, 13-15, 5-18 and > 880 mg kg-1, respectively. Vetiver grown in iron ore tailings was shown to accumulate high concentrations of copper in shoot (47 mg kg-1) and in root (66 mg kg-1), which was higher than the threshold level.

The treatment of industrial wastewater by vetiver, was tested by growing vetiver- in wastewater from a milk factory (labelled W1) and was seen to have the best growth due to low heavy metal content; while the worst growth was found in vetivers grown in wastewater from an ink manufacturing facility (labelled W4), which was found to have manganese, iron and specifically copper, with levels as high as 118.92 mg kg-1 above the industrial effluent standard (≤ 20 mg kg-1). They appeared unhealthy; with stunted growth, few tillers and whitish-yellow old leaves. Roots were seen to be stunted

"Vetiver roots can prevent leaching and runoff of heavy metals to nearby areas and into the ground water table by immobilizing and stabilizing heavy metal".

This was probably caused by copper toxicity as its principal effect is on root growth. In zinc mine soil with extremely high concen-tration of several heavy metals, vetiver ap-peared to suffer from severe chlorosis; with light yellowish to white colouration on young leaves. This may be a symptom of zinc tox-icity as the concentration of zinc in the soil, which was seen to be as high as 5,039 mg kg-1, is very much higher than the accepted limits of toxicity (900 mg kg-1) in soil.

Phytoremediation is an interesting alternative to current environmental cleanup meth-ods that are energy intensive and expensive. However, it requires 'hyperaccumulator' plants such as alpine pennycress (*Thlaspi caerulescens*), Indian mustard (*Brassica juncea*), Chinese brake (*Pteris vittata*) as they success-fully concentrate high pollutants. However, some characteristics of these plants, like slow growth, low biomass and a shallow root system, can limit phytoremediation efficiency. With vetiver phytoremediation, the long and dense root systems of vetiver can

absorb heavy metals from the deep soil layers and transfer them to aerial parts for harvest and thus, reduce the metal concentration in soil.

At the same time, vetiver roots can pre vent leaching and runoff of heavy metals to nearby areas and into the ground water table by immobilizing and stabilizing heavy metals.

Moreover, on land affected by degradation and contamination, this plant can be an excellent pioneer plant to conserve water and improve soil quality. When hydroponic culture is applied for waste water treatment, vetiver shoots and roots can be harvested easily to remove the pollutants. To clean up soil, the aerial part can be harvested occasionally without replanting.

An important advantage of harvested vetiver is that it is not considered hazardous waste, unlike hyperaccumulator residual.

Thus, it can be used safely for bioenergy production, compost or even as material for handicrafts. This versatile technology is applicable to sites with low to moderate contamination. For extremely polluted sites, it is more suitable to use it in conjunction with other remediation methods. However, as previously mentioned, factors affecting vetiver growth and metal uptake must be considered before introducing vetiver. Further studies should be site based and focused on optimizing agronomic management practices. Genetic engineering and mutation breeding can increase utilisation of *C.zizanoides.*

The Hibernating Herb

By Clarita Mendes, TYBSc

Selaginella sp., by Anthony Mendoza.

As summer arrives, plants show signs of withering due to loss in water content; a direct indication of their reliance on water. Yet, in some of the hottest parts of the world, the flora has learnt to survive on negligible amounts of water. Come harsh weather, the plants are forced to learn to survive without water or perish. Those that survive have adapted to be tolerant to desiccation. One such species that has brilliantly solved the problem of surviving in the absence of water is a tiny plant belonging to the spike moss family, commonly known as the 'resurrection plant'.

Selaginella lepidophylla, better known as the false rose of Jericho, is known for its resistance to dehydration and desiccation. When dry seasons arrives, the branches of the plant curl inwards to form a ball that looks akin to a tumbleweed. But as soon as it receives sufficient moisture, the plant springs back to life. Such an adaptation may have arisen due to its endemicity to the Chihuahuan desert of the US and Mexico. When the plant comes in contact with water, it unfurls and turns green again, thus earning itself the title of the 'resurrection plant'. The name is, however, scientifically inaccurate as the plant does not die per se; rather, it remains in a dormant, ametabolic state that is induced by extreme dehydration.

S. lepidophylla belongs to the phylum Ly-

“As soon as it receives sufficient moisture, the plant springs back to life”.

-copodiophyta which are known for their characteristic ‘microphylls’, or leaf like appendages that have a single vascular vein and closely resemble ferns and are one of the earliest vascular plants to have evolved, with fossils dating back to the Devonian period. Their acute sensitivity to the environment has helped them adapt to its changes.

As the plant is subject to dehydration, *S. lepidophylla* curls into a ball; the roots no longer anchor the plant, allowing it to be blown around like a tumbleweed until it gets wedged into a crack or crevice. On receiving adequate amounts of water, it unfurls and starts the process of photosynthesis. This is a continuous cycle of short duration as the habitat these plants are found inreceives water in short bursts of rain, rather than long steady showers.

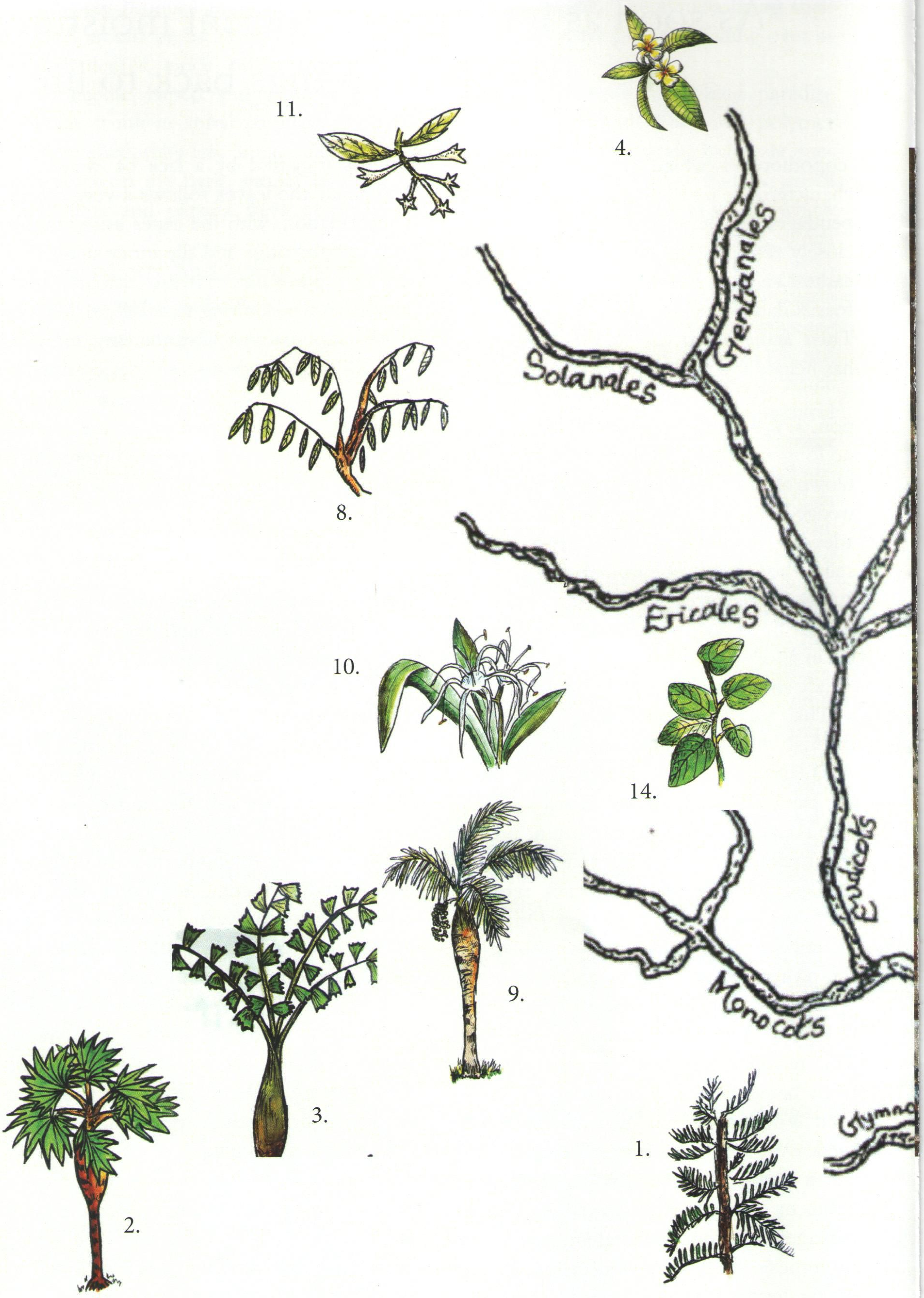
This feat of “stayin’ alive” is acquired through various adaptations. The ability of the plants to survive desiccation is due to the presence of the sugar trehalose. Trehalose is useful in binding important proteins and membranes which protects them from damage and also allows a quick return to their functions once rehydrated. Other sugars such as sorbitol and xylitol also help in the protection of proteins and membranes. Unlike other plants, *S. lepidophylla* has flexible cell walls which allow curling of the leaves. This protects the photosynthetic apparatus from being damaged by strong UV radiation. When strong UV rays are taken in by the leaves, there is an overproduction of reactive oxygen species in chloroplasts due to deficient rates of photosynthesis. This can damage the components taking part in photosynthesis and lead to desiccation. By curling the leaves, photosynthesis is inhibited. This is triggered by a lack of water. The curling of the leaves follows a very specific conformation, with the outer leaves curling into circular rings and the inner stems curling into spirals due to hydro- actuated strain gradient present along their length. This facilitates compact packing and easy unfurling.

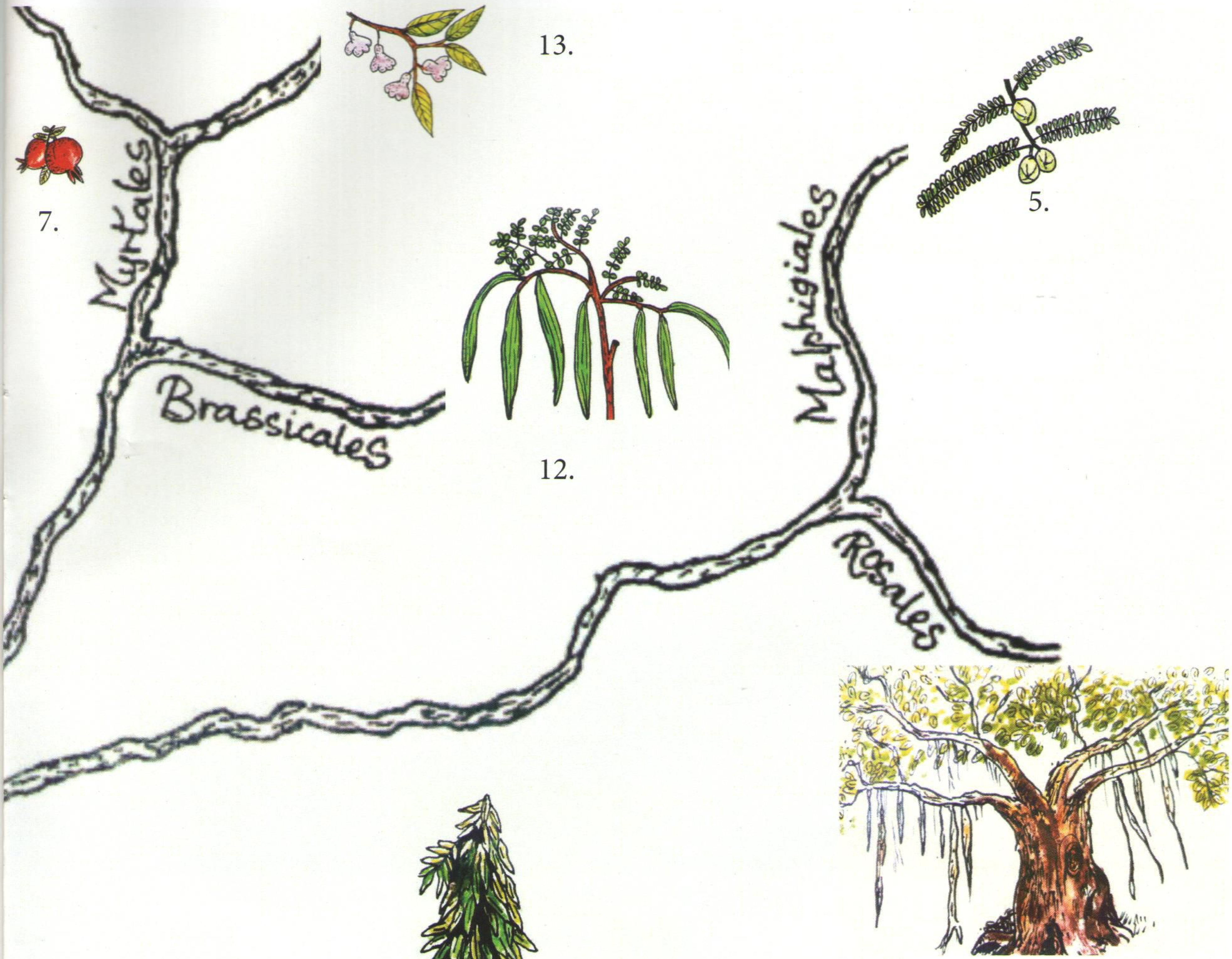
During the period of desiccation, an arsenal of enzymes are active in order to maintain the cellular structure and provide osmoprotectants and sunscreen pigments to decrease light damage till the time of resurrection.

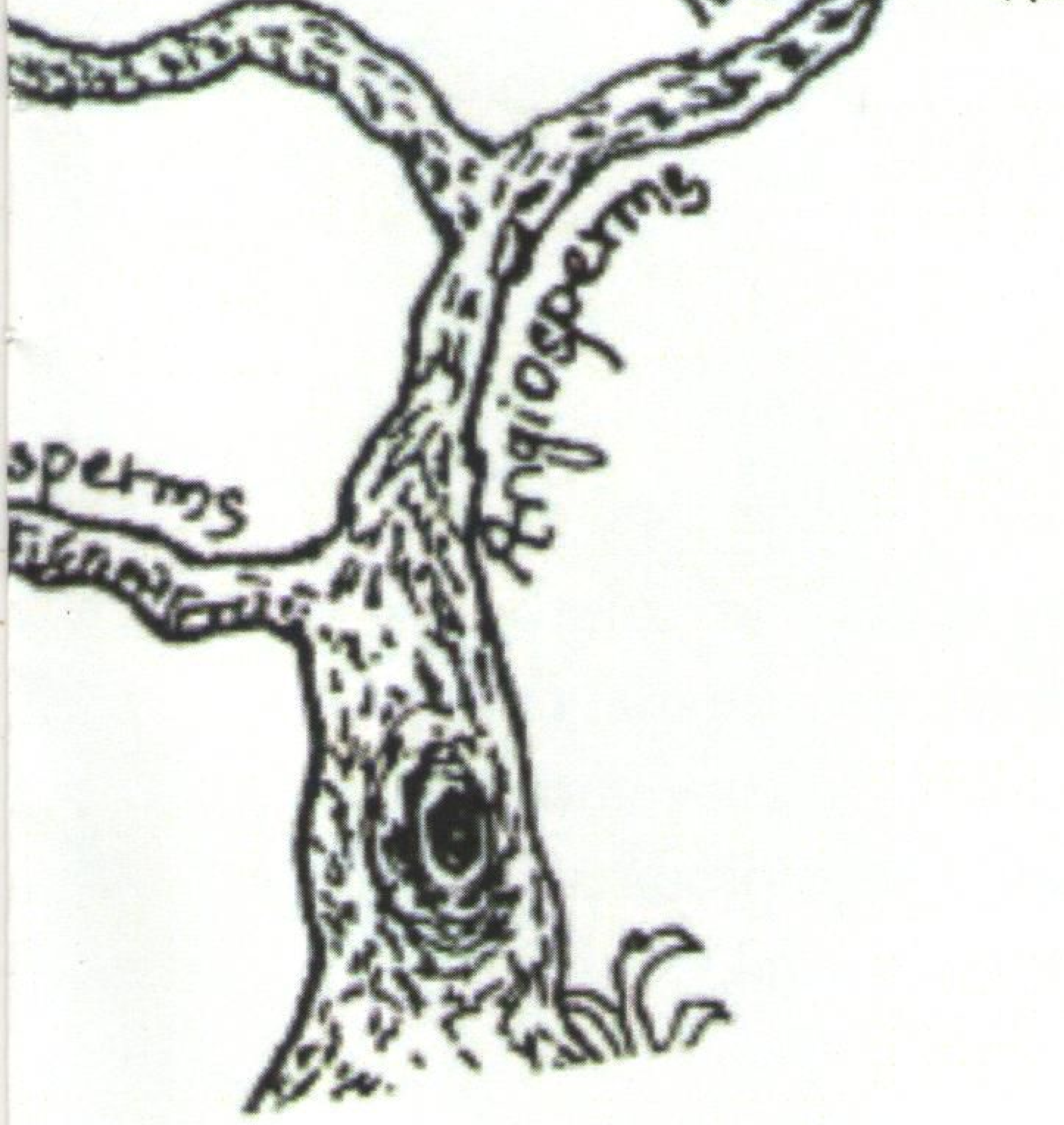
During the period of resurrection, the enzyme activity level is high enough to allow fast response on rehydration. Enzyme activity is lowest during dormancy in order to maintain a reduced rate of respiration.

S. lepidophylla, like other desiccation tolerant plants has genetic factors that allows it to be more sensitive towards desiccation. The stems and leaves contain a genetic program for desiccation tolerance that is otherwise only found in seeds. This along with their rapid response to water loss allows them to survive and reproduce in unfavourable conditions for long periods of time.

Selaginella bryopteris (sanjeevani) is a lithophytic plant occuring in the dry Aravalli Range in India, also behaves very similarly to *S. lepidophylla*. By studying the properties of plants such as these, researchers hope to understand these unique physiological processes in order to increase desiccation tolerance in crop plants and introduce the genes responsible for this behaviour into model organisms and thus increase the levels of productivity in commercial agriculture.


11.
4.
Gentianales
Solanales
8.
Ericales
10.
14.
Eudicots
Monocots
9.
3.
2.
1.





*B*iodiversity On St. Xavier's Campus

*B*iodiversity on St. Xavier's Campus

Please refer to the previous spread.

1. *Araucaria columnaris*
Family: Araucariaceae
The Cook pine, commonly called as Christmas Tree in India, is a tree native to the Cook Island, north-east of Australia in the South Pacific. Can reach 60 m in natural habit.

2. *Borassus aethiopium*
Family: African fan palm
Also known African Fan Palm or Borassus Palm it is a bottle shaped and smooth palm that can reach up to 25 m high when fully matured. The tree is an excellent fire break and is drought-resistant.

3. *Caryota urens*
Family: Arecaceae
It is commonly called as Fishtail palm because it has a leaf shape that resembles the lower fin of a fish. It is an Asian species that grows from India to Burma and on the island country of Sri Lanka.

4. *Plumeria rubra*
Family: Apocynaceae
Commonly called Plumeria or Frangipani, it is native to warm tropical areas of the Pacific Islands, Caribbean, South America and Mexico. Temple Tree, Champa and Dead man's fingers are other synonyms of Frangipani.

5. *Phyllanthus emblica*
Family: Phyllanthaceae
Distributed in the tropical parts of India, it is also found in wild in forests. Commonly known as the Indian gooseberry, it is an important medicinal plant in the traditional Indian system of Ayurvedic medicine.

6. *Ficus benghalensis*
Family: Moraceae
A native to the Indian sub-continent, it is our national tree. It grows as tall as 20-25 meters with branches spreading up to 100 meters.

7. *Punica granatum*
Family: Lythraceae
A shrub or small tree native to southwestern Asia having large red many-seeded fruit.

8. *Diospyros nigra*
Family: Ebenaceae
Common names include chocolate pudding fruit and black soapapple. The tropical fruit tree is native to eastern Mexico, the Caribbean, Central America.

9. *Roystonea regia*
Family: Arecaceae
A native of Cuba and a truly aristocratic palm which makes a memorable impression wherever it is grown. Massive and symmetrical with a smoothly sculpted trunk this palm looks almost artificial.

10. *Hymenocallis sp.*
Family: Amaryllidaceae
A reliable, perennial wildflower, it is often used as an ornamental plant.

11. *Cestrum nocturnum*
Family: Solanaceae
Also, known as the Night Jasmine. An evergreen woody shrub. The flowers give a powerful sweet perfume at night.

12. *Moringa oleifera*
Family: Moringaceae
Commonly known as drumstick, nzmed after its fruits; a common delicacy in most parts of India.

13. *Syzygium samarangense*
Family: Myrtaceae
The tree is indigenous from Malaya to the Andaman and Nicobar Islands where there are wild trees in the coastal forests. Heavy bearer of fruits and can bear up to 700 fruits at a time.

14. *Epipremnum aureum*
Family: Araceae
Epipremnum aureum commonly called golden pothos or devil's ivy, is native to the Solomon Islands. It is a climbing vine that produces abundant yellow-marbled foliage.

15.*Polyalthia longifolia*
Family: Annonaceae
Also known as False Ashok. It is a tall evergreen, native to India and harbours many butterfly species.

References

The Lepidodendrales:

http://palaeos.com/plants/lycopodiophyta/lepidodendrales.html
http://www.devoniantimes.org/who/pages/lycopsid.html
https://sites.google.com/site/paleoplant/home-1/embryophytes/polysporangiophytes/rhyniophytes/eutracheophyte/lycophytes/club-mosses/lepidodendrales
https://sites.google.com/site/paleoplant/home-1/embryophytes/polysporangiophytes/rhyniophytes/eutracheophyte/lycophytes/club-mosses
http://feedthedatamonster.com/home/2014/7/11/how-fungi-saved-the-world
https://www.fossils-facts-and-finds.com/carboniferous_period.html
https://www.nationalgeographic.com/science/phenomena/2016/01/07/the-fantastically-strange-origin-of-most-coal-on-earth/

A Helping Hand To *Hydra:*

Melo Clavijo, J., Donath, A., Serôdio, J. & Christa, G. Polymorphic adaptations in metazoans to establish and maintain photosymbioses. Biol. Rev. (2018). doi:10.1111/brv.12430

Davy, S. K., Allemand, D. & Weis, V. M. Cell Biology of Cnidarian-Dinoflagellate Symbiosis. Microbiol. Mol. Biol. Rev. 76, 229–261 (2012).

Hamada, M. et al. Metabolic co-dependence drives the evolutionarily ancient Hydra-Chlorella symbiosis. Elife (2018). doi:10.7554/eLife.35122.001

The Hibernating Herb:

https://www.iflscience.com/plants-and-animals/awesome-timelapse-resurrection-plant/

https://mappingignorance.org/2016/04/25/resurrection-plants-surviving-lifeless-environments/

Hydro-responsive curling of the resurrection plant Selaginella lepidophylla, Rafsanjani et al, Sci Rep, January 2005, doi- 10.1038/srep08064
These Resurrection plants spring back to life in seconds | Deep Look

A Shapeshifting Mystery
Boquila
https://www.nationalgeographic.com/science/phenomena/2016/02/19/the-sneaky-life-of-the-worlds-most-mysterious-plant/

Photo references:

F. benghalensis;, Wikimedia Commons

The Demon Flower:
Pictures as taken from Wikimedia Commons

Nepenthes : 1
By Thomas Gronemeyer, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=11826099

By Andreas Eils - own work by Andreas Eils, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=1671991 - halaiamphora

Sarracenia flava - https://www.edenproject.com/learn/for-everyone/plant-profiles/yellow-pitcher-plant

By Nepenthes_densiflora_Mount_Kemiri.jpg: Paul Kellerderivative work: Mgiganteus (talk) - Nepenthes_densiflora_Mount_Kemiri.jpg, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=10403158

The Lepidodendrales:
Artwork by Aldrich Hezekiah
Pictures of fossils as taken from Wikimedia Commons
https://commons.wikimedia.org/wiki/File:Lepidophloios.JPG
Lepidostrobilus
By Smith609 at English Wikipedia, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=6741038

Acknowledgements

Drawing and Photography

Daphisa Jana
Kim D'Silva
Aldrich Hezekiah
Mayur Mahendra Bhagwat
Maniruddin Dhabak
Trish Gonsalves
Teresa, Merlin Tuttle's Bat Conservation
Rizwan Meethawala

Content

Pradip Krishen
Jay Bathia
Saswati Sarma

Special Contributions

Dr. Rajendra Shinde
Dr. Manek Mistry