Face to Face

This section features conversations with personalities related to science, highlighting the factors and circumstances that guided them in making the career choice to be a scientist.

Turning A New Leaf

H Y Mohan Ram talks to Sujata Varadarajan

Prof. H Y Mohan Ram is a man of myriad interests and talents and is above all, an outstanding botanist. His interest in plants goes back to his childhood days in Mysore; descriptions of his adventures seem reminiscent of some of R K Narayan's characters. Those days were just the beginning of an unusual and prolific journey of learning (and teaching), pausing for a little romance, and perhaps to smell the *Rosa damascena* along the way (*Figure* 1).

During his scientific career, he has worked and interacted closely with stalwarts in diverse areas of plant sciences. These include his mentor Prof. P Maheshwari (an authority on plant embryology who was Head of the Botany Department at the University of Delhi), Prof. F C Steward (a plant physiologist at Cornell University, famous for his experiments on cellular totipotency (explained later)), Dr. J P Nitsch (a well-known plant scientist at the Laboratoire de Physiologie Pluricellulaire in Gif-sur-Yvette, France, who studied plant growth and development) and Phillip R White (a pioneer in tissue culture who came to the University of Delhi as a Visiting Professor from USA).

Prof. Mohan Ram has used this breadth and rigour of training to his advantage and has worked on an astonishing range of areas in plant sciences, discovering and describing a number of intriguing biological mechanisms in plants. The research he has carried out with his students encompasses areas as diverse as endosperm (a special kind of tissue found only in the seeds of flowering plants), its growth and culture, modification of flower sex expression in plants using plant growth regulators, physiology of inflorescences of lupine, gladiolus, chrysanthemum, calendula, marigold and flowers of carnation, lantana (studying the mechanisms of flower opening, petal growth, colour and ageing in these[1]), the biology of Indian aquatic plants (of which very little

Figure 1: Prof. Mohan Ram describes the beauty of seeds and their significance in agriculture (Delhi, 2008).

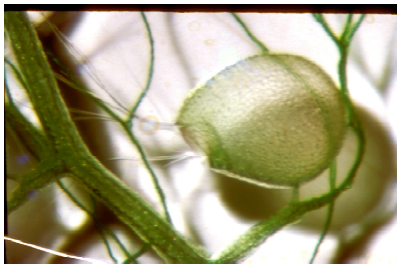

Figure 2. The bladder of the aquatic plant Utricularia inflexa var. stellaris, is a device for trapping insects. There were claims that bladderworts were obligately dependent on organic nitrogen derived from insect prey. The work of R Doreswamy and H Y Mohan Ram has shown that the plants can grow, flower and set seed on a nutrient medium containing nitrate as the sole source of nitrogen. Flowering can be induced under short days (20 cycles of 16 hour dark, 8 hour light).

is known, despite their relative abundance) such as *Ceratophyllum*, *Limnophila* and *Trapa*, in particular of *Urticularia* – an insectivorous plant, and *Podostemaceae* – an unusual family of aquatic flowering plants that lack a typical root-shoot axis and resemble liverworts and grow attached to rocks in rivers and cataracts, [2] (*Figures* 2, 3), tree biology, pollination biology, evolutionary biology and more.

Though much of his research is basic in nature, it has important applications in areas such as cultivation of certain medicinally important plants (the most noteworthy being the work done by his students Promila Gupta and Shivanna on the reproductive biology of *Commiphora wightii* – a plant that appears hard to cultivate and which yields an oleo-gum-resin called guggul, known since times of Sushruta for its ability to lower bodily weight and cholesterol levels and its anti-arthiritic properties), sustainable utilization of gum and resin yielding plants (done by him and M N B Nair and J R Bhat) and the tissue culture of some economically important species such as banana, legumes and bamboos [3].

Figure 3. (A) Hydrobryopsis sessilis; (B) Polypleurum stylosum* var *lasciniata. *These are members of the family* Podostemaceae, *a strange family of flowering plants that grow firmly attached to rocks and boulders, located under water falls and in rapidly flowing streams in Kerala and Karnataka. The plants lack a typical root-shoot axis and have a thalloid plant body that resembles a lichen or liverwort. Prof. Mohan Ram and research scholars who have worked with him, notably Vidyashankari (presently at ANU, Canberra, Australia) and Anita Sehgal (presently Reader in Miranda House), have raised six species of these plants in pure culture for the first time from sterilized seeds and have raised full-grown plants and have even induced them to flower under conditions of stress. A series of papers have been published by Prof. Mohan Ram's group on the origin of the plant body, histology, cytology, floral morphology, pollination, seed development and germination. (Photograph 3B by Suseendran, all other plant photographs by H Y Mohan Ram).*

In the course of his work, he has thrown open some completely new areas of research and having done so, has moved on in his exploration. Thus, I believe his achievements have been pioneering in nature, and that there is a lot more that needs to be delved into in the areas he has exposed. This is just a reminder of the enormous wealth of information that remains hidden within the diversity of plant species in the country, awaiting some enthusiastic and intrepid discoverer.

The hallmark of Prof. Mohan Ram's work seems to be simplicity in experimental methods combined with meticulous observation and documentation. He has convincingly shown that innovative and high quality research can be done in simple ways with basic equipment and very little money. Grants were meagre in the 1960s–80s and curiosity and hard work were requisites for successful research. Prof. Mohan Ram's style of selecting and presenting his work reveals certain aspects of his personality – unassuming, thoughtful and fascinated by nature and in particular by plants. Underlying this philosophy is a gentle yet unrelenting sense of humour that many of his colleagues have been at the receiving end of! He has other talents as well: teaching and popularizing science is a passion as are music and photography. He has a flair for writing and editing, and has been involved in the planning and writing of a range of technical and semi-technical literature, including papers, review articles, school textbooks and reminiscences. I quote from one of his autobiographical articles [4]:

"I wish I could be like a tree; deep rooted and firmly fixed, bearing a lofty bole and a broad canopy, continuously absorbing, synthesizing and renewing, bearing fragrant flowers and delicious fruits, unmindful of stresses and insults, resilient to changes and perpetually giving and not coveting. To this I must add tenacity, based on the remarkable example of a gingko tree, almost at the epicentre of the 1945 Hiroshima nuclear explosion, that sprouted from the root after its trunk had been completely demolished along with everything around it."

Although perhaps several people may have been able to pen either the former or the latter part of the above paragraph, I do not know of anyone other than Prof. Mohan Ram who might have conceived of putting both together in a distinctive and beautiful manner.

SV: Could you tell us about your early education, and how you developed an interest in studying plants?

MR: Well, going back to childhood, my mother was a keen gardener and she always took my help in planting and also in looking after the plants. I grew up in Mysore, which I would say, is one of the most picturesque cities even today. You just have to go to Chamundi Hills or to the neighbouring suburbs. I used to go to Srirangapatnam on bicycle and see lots of interesting plants growing in or close to the river Kaveri or planted by Tippu Sultan in his palace garden.

We had a wonderful biology teacher in school, Mr. R N Chakravarty, who showed us how fertilized eggs of frogs (that we collected from the ponds and brought to the laboratory) developed into tadpoles and metamorphosed into adult frogs. My interest was also stimulated by two of my teachers. One is Dr. M Ananthaswamy Rau (M A Rau as he is called). He is known as the botanist among gentlemen and gentleman among botanists (laughs). He is ninety two, he is still very active. The other teacher was Mr. B N N Rao. He was a Fellow of the Royal Horticultural Society, London. Most botanists thought that cultivated plants should not be studied, but he would say, "Look, these plants are selected by man, improved by man and domesticated by people. They are very important because we need them everyday. So you should know their names, where they came from, how they came and all that." The centres of primary diversity (or origin) are important as the wild relatives will provide a wide gene pool for the improvement of domesticated plants.

I could not go to Central College, Bangalore, for doing my MSc. We were eight children, my father could not afford to send me. He said, "My job is to educate you up to BSc. After that you're on your own. If you want to do anything further, you must find a way."

SV: Where did you do your BSc?

MR: I did my BSc from St. Philomena's College in Mysore. That college had a lot of wild plants around it. We didn't have a garden. We didn't need one because we could go out and collect materials for the classroom right from the vicinity.

I was elected Secretary of the Natural Science Society of the College. I said, "We should have some exciting activity." So I wrote a letter to Sir C V Raman. I said, "We have started a science club, would you please come and give us an inaugural lecture?"

He replied, "Yes, provided you give me petrol to come from Bangalore and go back."

I said, "Okay". Then asked him, "Why don't you give us the title of your talk so it can be announced in advance?"

He wrote, "I will decide it on the platform." He was a great scientist. We had to agree.

We had kept a beautiful seashell on the table. He picked it up and said, "I'll speak on symmetry in nature. Left handedness and right handedness in shells and even in molecules of biological importance." He spoke for one hour. We were absolutely spell bound. There were no slide projectors or even epidiascopes, what to say about LCD projectors in those days! He was a great orator. His talk had a tremendous impact on every student. Our college was outside the city limits. He asked me, "Mr. Secretary, I want to go into the town, will you permit me to use the petrol?"

I said, "That's fine Sir." The students roared in laughter. Raman was full of humour and touched not merely our heads but also our hearts!

He also told me, "Look, I must take a promise from you."

I said, "What?"

"When you become a scientist or a teacher you *must* readily agree if you are invited to speak to children or students. Will you give me that promise?"

I said, "Yes".

I have always remembered that. He was a Nobel Laureate but very nice to young people. One of the most wonderful things that you can do is to be able to address children and create a sense of awe and excitement about nature. I recall an instance when I was asked by Dr. D Balasubramanian (then Director) to visit CCMB on the National Science Day. I had a 'walk and talk' tour of their campus with children (parents also tagged along). What was scheduled for one hour stretched to four hours!

I did fairly well in college and even before the results came the Principal of the college, Mr. C J Varkey (who was a close associate of Mahatma Gandhi in formulating the basic education plan during pre-independent India in Madras) told me, "You must join as a Demonstrator in the college."

I asked, "Which subject should I teach?"

He said, "Meet the Head of any Science Department. Whoever wants to take you, go there."

So, I went to the brilliant chemistry teacher Mr. K Narayana Rao. I liked chemistry. He said, "You have botany and zoology as your other subjects. You should have had physics and mathematics. Those subjects are necessary to become a good chemist. Try the zoology department." zoology attracted me because we had an excellent teacher in Mr. T R Balakrishna. He was tall, handsome, somewhat self conscious, but a fine opening bowler and warm hearted.

The head of the zoology department was a squat person. He could not give a lecture without the help of books. He would lay open some ten books on the table in the lecture hall and keep his hands over them (as it was too windy and the pages would be turned over quickly) and read one line from each book. He could shake his leg while standing and speaking. So, I used to imitate him. On one occasion the students forced me to go on the stage and mimic him. My performance received a thundering applause. This incident must have prejudiced him. He exclaimed, "Look, you are very mischievous. I don't think you'll make a good teacher. I wouldn't like to take you." (Laughs)

Then I went to the botany department. For some reason, the botany Professor looked like a magician with large eyes and hairy earlobes. He was a wonderful man, very much interested in art and dramatics. He put his arm around me and said, "You are welcome to join my Department, but on one condition. You will take some of my theory classes also." I said, "Fine". I started as a Demonstrator in Botany with a salary of 75 rupees a month.

I was just 19-plus. I taught for one year and I had to really learn a good deal of basic Botany. I had a hard time because half the second year students were my classmates before as they had failed in matriculation or intermediate classes. But that one year's teaching experience thrilled me and changed my whole life. So I got into botany that way.

I had a deep interest to take up medicine, but was denied admission. Looking back, I don't regret being a botanist, especially a teacher.

SV: What did you do after that?

MR: Well, some of my teachers who were very fond of me, warned me, "Look, you seem to enjoy being a Demonstrator so much that we are afraid you will end up becoming a permanent Demonstrator. You must give it up now. Go and do your MSc."

I said, "Where do I go?"

Luckily I had a friend (N K Nagaraja Rao, who died recently), whose brother Dr. N K Anant Rao was teaching agronomy in Balwant Rajput College, Agra, which was not too well known then. But it had a wonderful person, Dr. R K Singh, as the Principal, who was appointed to that position at an early age of 28 or 29. Dr. Singh had done his PhD education at Harvard University under John Dewey, famous for his philosophical concepts in education. Having seen how American students struggle to take up all kinds of jobs to help finance their education, Dr. Singh was convinced that in India if there were talented young persons who had some difficulty in meeting their expenses, we should offer them part-time jobs.

My friend's brother talked to him about me. Dr. Singh said, "Let him come. I can only give him 50 rupees a month. He has to manage the rest of his expenses."

That was a great help. Another 50 rupees were sent by my eldest brother, Sharada Prasad, who never mentioned this to anyone in his lifetime. I used to teach intermediate practical classes between 7 and 10 in the morning. Between 10 and 5 or 6, I used to study for my MSc. So that's how I did my two years' MSc. The infrastructure facilities of the college were not adequate, but teachers were excellent. The head of the department, Prof. Bahadur Singh, was a former student of P Maheshwari when the latter was at Agra in the 1930's.

After I did my MSc I came back to my old college in Mysore. I had applied for jobs here and there. One of the places I was very keen on going to was Lingaraj College in Belgaum where A K Ramanujan was teaching. He was a poet and scholar who later moved to the University of Chicago and his literary works, especially translations of ancient Tamil poems and Indian stories are known throughout the world. Ramanujan and I knew each other and he was very keen that we could team up in Belgaum and lead an enlightened life. To my great disappointment, I was not selected. Ramanujan was unhappy. Anyway, I returned to Mysore and within a few weeks received a call from Delhi University to appear for a lecturer's interview. I had some money in my pocket, so I said to myself, "Let me go to Delhi and take a chance. I don't know if I'll be selected." I was fresh from college and had no PhD degree.

The interview was held on 10th October, 1953. It was a Saturday if I can recollect. I came two days earlier and had gone round the University garden, looking at various trees. The Delhi University campus was once the Viceroy's residence and estate. It still has a lot of beautiful trees.

At the interview there were P Maheshwari, B P Pal and of course Ram Deo Misra, the ecologist from Benaras besides the Vice Chancellor. They asked me whether I had seen any trees on my way to the interview. I reeled off names of numerous trees and gave brief descriptions. The committee grilled me for about fifty minutes or so. Maheshwari told me, "Come and join on Monday."

I exclaimed, "I believe that I am selected!" I hardly imagined that anyone could take me because I was too raw. I told them, "I am serving in a college in Mysore. I have not even informed them that I am coming here. So it's my duty to go back and tell them, resign and come back."

Maheshwari said, "Don't worry. I shall write a letter to your Principal."

So I didn't go back. Maheshwari sent a letter saying, "We have selected one of your students as a lecturer here, which I hope you will appreciate."

I thought I was extremely lucky to have been selected. But when I went on Monday to meet the Professor, the first thing he asked me to do was to teach plant embryology. Maheshwari was a world authority on embryology. Probably the first book by an Indian author published by the McGraw Hill and Co. in the USA was his work, 'An Introduction to The Embryology Of Angiosperms'. Having authored a kind of bible, he was asking me to teach Embryology!

I argued, "How can I do it? I have come to learn the subject from you."

He said, "That's the best way to learn. Remember to discuss with me the outline of every lecture before you go to the class."

I had to work very hard. He was a taskmaster. I enrolled myself for the Ph D course. I had twenty four hours of teaching work per week, including undergraduate and post graduate classes, looking after the herbarium and garden, besides my own research. I had no Sundays or holidays.

At that time, there was in the department, a young Bengali research scholar, Manasi Ghosh working for her PhD with Prof. B M Johri. She was intelligent and talented as a researcher. We liked each other and we decided that we should get married as soon as one of us submitted the doctoral thesis. She did it earlier. We got married, and that's it.

SV: What did you do after your PhD?

MR: I had applied for a Fulbright and Smith Mundt scholarship in 1958. I was selected and sailed to USA by boat and was placed at Cornell Univesity to work with Professor F C Steward. He told me, "Look, you're going to be here for one year. I will make it two." He said, "I'll give you an associateship even if your Fulbright Grant doesn't continue. I want you to go back after publishing good papers. First you prepare papers on the PhD work done in India."

So I sat there and wrote several papers, published them in many leading American journals. He realized that I had been thoroughly trained in editing and proofreading by Maheshwari. He said, "I am planning a ten-volume encyclopaedia of plant physiology. Since you're here, this is the right time to start. Help me with the first three volumes and by the time you go back you would have learnt a good deal of this subject."

I was pleased, not realizing that I had to stretch my daily working hours.

I had to do my research during the day, have my dinner, come back, spend another six hours at the lab. I had to go to the library and do all the reading. During this time I came into contact with the editorial people at the Academic Press who were happy with the quality of my editing and proofreading. So it was also a positive thing for me.

SV: What kind of experiments did you do in Steward's lab?

MR: I learnt all tissue culture work from Mrs. Marion O Mapes, Steward's technical assistant and helped Steward in his research. My wife received a Fulbright Travel Grant and joined me the following year. At that time Steward was interested in the biochemistry of the banana plant. He had a big grant from the United Fruit Company. Steward wanted us to do tissue culture of the banana varieties and study differences in their response to nutrient media containing different plant growth regulators. I started that work and I was the first person to publish on tissue culture of banana with F C Steward. Looking back I realize that we took a wrong tissue. We used the pulp of the immature fruit rather than the tissues from the shoot buds. Today banana

plants are being cloned through plant tissue culture; this is the most successful achievement from India.

There are two kinds of bananas – the seeded (non-edible) and the non-seeded that we eat. Manasi and I compared the structural differences between the two and traced the tissues from which the pulp develops. Whereas in most fruits seeds promote fruit development, in the banana a pulpy and sweet fruit can be formed without seeds – a phenomenon called parthenocarpy. Our work was published with Steward in the Annals of Botany, London. This work is quoted quite often in the literature. Steward sent me to Jamaica for a month in 1960 to collect various banana varieties for tissue culture and biochemical investigations. I explored the whole island and saw some curious plants besides historical plants, especially the original breadfruit trees brought by Captain Bligh from Tahiti on the 'Bounty' in Spanish Town. The ackee fruit is named after Bligh (*Blighia sapida*). Its ripe fruits are eaten as a delicacy with fish.

Steward had become famous for his outstanding research, which I think is very important even today. He demonstrated through well-designed experiments, totipotency in plant cells. Every organism starts from a single cell, the fertilized egg. In a human there may be billions of cells, a sequoia tree may have several trillion cells – but they all started from one mother cell. One of the biggest questions in biology has been: how do the products (daughter cells) of one cell become different in space and time and how do they develop different capacities? Is it that certain genes are shut off, or certain genes are switched on? Is it an intrinsic ability or is it dependent upon the position of the cell in the organism or the environment?

What Steward did was to demonstrate by taking 2 mg pieces of carrot roots (even those that had been stored for two years at 4º C) and growing them in specially designed flasks containing nutrient media and coconut water, that even mature cells could be induced to divide. Those cells that sloughed off into the medium could form embryo-like bodies, which on being transferred to tubes with agar medium of the same composition developed into new carrot plantlets. In other words, although cells had become fully differentiated to form a part of the carrot root, which would have ended in our stomach, they had still retained the ability to regenerate the entire plant. Subsequent search showed that Reinert in Germany had independently shown the same phenomenon. These studies stimulated an enormous amount of research throughout the world.

When I came back to India in August 1960, the first thing Maheshwari said was, "You must start guiding research because you've brought new ideas." For the first 2–3 years I was quite busy in guiding and selecting students. Our inputs were very low. We started doing some work on tissue culture and reproductive biology. But my interests have always been very varied.

SV: What are some of the projects you have particularly enjoyed working on?

MR: One thing which really excited us was to study the sex expression in *Cannabis* plant. Unlike animals, particularly mammals, plants are not generally dioecious : dioecious means an individual is either entirely male or female. You don't see that situation very often in plants. The same plant will bear both kinds of sex organs in the same flower or on different flowers. But in mammals there is a chromosomal basis of sex determination. The most common condition is XX (female) and XY (male). If the X sperm meets the X egg, then you will get XX offspring, that will be female. If a Y sperm meets an X egg, you get the male, XY. In flowering plants there are only about 13 species in which there is a clear cut chromosomal basis of sex determination. There are hundreds of other dioecious plants which don't have sex chromosomes. Sex determination occurs at the gene level. *Cannabis sativa* is one such plant and we chose it for this reason. The other reason we selected it is that nobody outside India can easily work with *Cannabis* because it's a banned plant (it is the plant from which marijuana is obtained). In India it occurs so commonly (and is the source of bhang, ganja and charas) that nobody bothers if you use it or collect it from the wild or work with it. That was our advantage. You know *Cannabis* is becoming more important because it is the female plant which is more potent in terms of having cannabinoids – notably Δ^9-tetrahydrocannabinol (which has also been discovered to occur naturally in the mammalian brain and uterus and named anandamide owing to its property of generating euphoria).

As we never found unequal chromosomes or sex chromosomes in *Cannabis*, we wanted to know whether we could bring about sex reversals by hormones applied from outside. My students V S Jaiswal and much later Rina Sett were associated with me in this work. So what we did was as follows: we allowed the plants to grow and as soon as the first flowers appeared, we segregated them into males and females. Unless the flowers appear you cannot tell the male from the female. So, we took genetically female plants and treated them with gibberellins (GA's for short). These are a group of hormones discovered by the Japanese scientists in rice seedlings. One of the dramatic things that GA's do is to cause elongation in genetically dwarf plants. There are now some 50–60 gibberellins. The most important of them is GA_3 or Gibberellic acid. When we applied GA_3 to the tip of a female *Cannabis* plant by means of a cotton wick, it started producing male flowers, which were exactly similar to those borne by genetically male plants. We were flabbergasted when we saw seeds had stamens growing on them!

In the next step, when we took male plants (which never form seeds) and sprayed them with a solution of ethephon – an antigibberellin, we could induce them to produce fertile female flowers and also seeds. When ethephon (2-chloroethyl phosphonic acid) is absorbed by the plants, it releases ethylene gas in the tissues which acts as a gaseous hormone.

SV: How did you think of using gibberellins?

MR: There was a report with cucurbits by Israeli scientists. But cucurbits are not dioecious,

they are plants which bear both male and female flowers in the same individual. But when we tried to repeat this with another plant, *Phyllanthus fraternus* – called 'Bhoomyamalaki' in Sanskrit (meaning amla which is close to the earth; very effective against jaundice) we didn't succeed in altering flower sex. We don't know what is special about *Cannabis* plants. In *Phyllanthus*, we find that the first four nodes (node is a point where a leaf arises) constitute the male zone. All the other leaf axils will bear only female flowers.

Another area of work which really fascinated us, which could be done with very simple and elegant methods using very little money was our work on *Lantana camara* [5]. I was walking around the Delhi University campus and found *Lantana* bushes with flowers of different colours. I didn't know whether there are flowers of different colours or whether the same flowers change colour with time. When I asked my student, Gita Mathur, to ascertain this, she was very fascinated. She found that the freshly formed flowers are yellow, next day they become orange, third day they turn scarlet and later on they become a deep magenta (*Figure* 4). We didn't know the relation between time and the events that might trigger colour change. We found that certain insects and birds pollinate these flowers. One is a very lowly evolved insect called thrips. Entomologists know that thrips are destructive to crops but couldn't believe that thrips can distinguish colours and are also pollinators.

I told Gita, "Let's go to the market." There are some shops where they sell a thousand kinds of blouse pieces of different colours - 'matching shops' as they are called. (Laughs) We took the flowers to a well known shop in Kamlanagar, close to the Delhi University campus. We kept the flowers next to the cloth and bought some pieces which matched perfectly. We made discs of different colours and placed them in petri plates and painted them with sugar solution. We then released a number of thrips inside and covered it with a larger petri plate. Believe it or not, all the thrips went to the yellow discs. This simple test confirmed that even when there is food, thrips head for the colour. Butterflies are only seasonal visitors to lantana and are able to suck nectar without pollinating the flowers. Thrips enter flowers, feed on the sticky secretion on the stigma. The flower structure is such that thrips invariably cause pollination of these flowers. Colour is actually advertisement. The reward is nectar or pollen. This work is actually very simple but we got a lot of joy doing it.

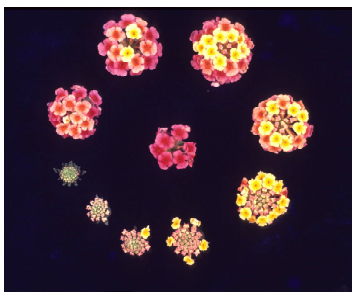

Figure 4. Young to old inflorescences of a colour variant of the pernicious weed Lantana camara. Freshly opened flowers are yellow and they change gradually to orange, scarlet and magenta.

SV: What causes yellow flowers to change their colour?

MR: We have shown that even if two pollen grains are deposited on the stigma by means of a syringe, they are able to trigger anthocyanin synthesis in the petals and cause a shift in colour. The yellow flower (rich in β carotene) is masked by delphinidin monoglucoside (which is blue in colour).

SV: Tell me why you became interested in aquatic plants. What new things have you found?

MR: I must tell you that there are roughly 2,50,000 flowering plants in the world (small number when compared to animals) out of which 2% occur in water. You know that life arose in water and moved to land. These plants have reverted to water from land and in readapting themselves to a life in water, they have undergone numerous adaptive changes that are evolutionarily significant. We are interested in studying these aspects. You will be surprised to know that the Indian subcontinent contains 50% of the total number of fresh water flowering plants of the world.

There are some plants which produce more than one kind of leaf. A classical plant is called *Limnophila heterophylla* (name changed to *Limnophila aromatica*). The leaves above the water occur in pairs at right angles to each other. The leaves inside water are whorled (several leaves arise from a single node) and are highly dissected (highly branched). The plant never flowers below water. For a flower to be formed the stem has to be above water and bear leaves that are entire (as opposed to highly dissected). We have been describing this feature but we had no explanation. So we thought it worthwhile to take a classical example and find the mechanism. If botanists did not see the aerial part, they would collect it and describe it as a different plant. (Laughs) In fact taxonomists have placed this plant in several families!

My student Sunanda Rao and another research scholar went to the lake in Mt. Abu to collect live plants. I thought, "What could this marked change be due to? Is it induced by stress?"– because the part that comes out will be subject to drought and bright light, whereas inside water the temperature and light intensity will be low. Instead of doing this (experiment) in ponds, we thought we should grow the plants in liquid nutrient medium under aseptic conditions. We thought of using a stress hormone to try and induce a change in leaf pattern. We chose abscicic acid (ABA, a growth retardant which induces dormancy of buds and causes abscission and is known to work as an anti- gibberellin) in culture flasks in a tissue culture lab. We also used mannitol and other agents which increased the osmotic pressure. As predicted, ABA caused the production of aerial leaves and also flowers, under water. We demonstrated that the change of leaf pattern can be induced by stress hormone which is linked to flowering.

We had carried out work earlier on some other aquatic systems such as *Ceratophyllum demersum* (work of Anita Sehgal). This is a plant which has both male and female flowers. It

is a submerged, free-floating plant which lacks roots. Male flowers have a large number of stamens. When the stamen is mature, it gets detached, floats to the surface where it bursts and releases abundant pollen grains. These grains germinate, put out tubes which come down in search of female flowers and fertilize them. This is a 3-dimensional pollination in water – somewhat reminiscent of a submarine torpedoing ships.

We found a lot of scum at the bottom of the flask. Anita told me, "Sir, my flask has got infected. I want to throw it." Sometimes fungal mycelia grow in the cultures.

I said, "Don't throw it. It may not be a fungus. I think there may be pollen tubes."

On closer examination we found thousands of pollen tubes and *all* of them had dropped down. In a pond how does it happen? There are not many examples of pollination in fresh water and the case of *Ceratophyllum* fascinated us. But what fascinated us was the fruit of *Ceratophyllum*. If you open it, instead of a seed you see a tiny seedling bearing 14 whorls of leaves and sometimes with one or two branches! Roots are absent. To the best of our knowledge, no botanist has reported such an advanced kind of shoot system within a seed in any other plant. Mangroves show vivipary (the condition whereby an embryo grows to break through the seed coat then emerges out of the fruit wall while still attached to the parent plant). (In mangroves) it is the root that comes out as an elongated structure that plunges into the sand and establishes a seedling.

While all these experiments were being done on *Ceratophyllum* in tissue culture, we suddenly found fruits which were very different. The fruits were so different from what we were culturing that we said, "How can the change happen under our eyes?" Obviously, we had collected from the field one or two individuals of a different species of *Ceratophyllum*. We could not see this plant in the field but we saw it in culture. Obviously we had missed the connection between the two. I could not find this plant described in any book on flora of Indian plants. I collected some fully grown plants and prepared herbarium sheets and took them to the Smithsonian Institution in Washington DC (USA). They told me that it is a North American species, *Ceratophyllum echinatum*. Then how did it come to India? It may have come through migratory birds. It was the first report of actually discovering a new plant in a tissue culture flask. So when we published it, our peers just couldn't believe it.

So, while growing these various plants we found all kinds of interesting things – one led to the other. I don't know whether or not these findings are of any significance but we just had fun observing them.

SV: What are some of your other interests?

MR: Other than botany and science, I have three or four interests. One is music, the other is photography, third is cricket, in that order. I haven't played cricket for the state or in leagues but

I'm still a cricket fan and watch most of the important games and spend a lot of time on it (laughs).

My father, H Yoganarasimham was a Sanskrit scholar, educationist, author and a musician. He himself did not take music as a profession. He thought that music is a great art but not necessarily a great profession, particularly in those days when there was not much patronage by the public. My father was mostly self taught but later on he sought Vasudevacharya as his guru. Vasudevacharya has been the greatest composer Karnataka has produced after Purandara Dasa. My father used to sing every Saturday at home and we had occasions to listen to him when he used to practice. By listening to him we learnt to sing many *kritis*. I couldn't learn music with any degree of discipline. I must say I could sing fairly well and was frequently invited to sing the invocation in meetings or cultural programmes. I wish I had a good grounding in the grammar of music. Even from childhood I had been hearing great masters. G N Balasubramanyam, T Chowdiah, D K Pattammal, M S Subbulakshmi, Balamurali Krishna, Veena Doreswamy Iyengar, Lalgudi Jayaraman, T N Krishnan, Gangubai Hangal, Bhimsen Joshi, Ustad Amir Khan, Mallikarjun Mansur, Ali Akbar Khan, Kishori Amonkar and N Rajam have left a deep and moving impression on me.

I am not a professional photographer. I started taking pictures with a box camera at the age of 13. Children were my subject; I switched to my brother's Practiflex camera later. Graduating to a manual Contaflex and Nikon, I am now the proud possessor of a D-80 Nikon digital camera gifted to me by my son Rahul. I mostly photograph trees, forests, vegetable markets, flowers etc. and I have a very large collection of slides. One of the things I am doing presently for the Indian National Science Academy is to bring out some CDs on some fascinating and useful plants. The best way to teach children is to take them on field trips. The other method is through high quality pictures and stories.

SV: What can be done to create an interest in botany amongst students?

MR: If you go to Europe or Australia, most cities have beautiful gardens. A garden is not just an assembly of plants but there is an input of science in it. It is educational and enlightening. When a young child looks at a carnivorous (insectivorous) plant, a colourful orchid flower or for that matter a drop of water under the microscope, the wonder and joy experienced is immeasurable. So we have to create opportunities for our children to be curious. They can do a Discovery Walk and see for themselves live plants and animals. Further, Natural History Museums and Science Museums must be expanded and made livelier to create curiosity, excitement and a deep motivation. These require enlightened teachers or mentors. A teacher need not be a Ph D. A school teacher can create a spirit of inquiry through conducting simple experiments and extraction of plant compounds.

If botany were to be taught with some examples which are unusual or which are unexplainable,

some children may feel interested. But there is no such attempt to do that. During admission to a college, priorities are to engineering, commerce and management courses. In basic sciences, if students don't get admission to a course in physics or chemistry, they go to zoology; if they don't get zoology they come to botany. It is pathetic that the selection of subjects is entirely on the basis of marks. I don't believe that marks are any indication of abilities or interests. Students are being driven from one institution to another. We do not try to bring out the talent in a student based on passion and aptitude.

I feel that (generating) the interest to see how nature operates should not be done only through books or in classrooms. I recently visited the Royal Botanic Gardens at Kew (fourth time). The conservatory, opened by Princess Diana, has fantastic plants from various ecosystems including insectivorous plants, succulents, aroids and aquatic plants. You can use headphones and hear the ascent of water in trees. We need Natural History Museums with fossils as well as live plants and animals and teachers who are themselves enthusiastic and energetic.

Suggested Reading

[1] **H Y Mohan Ram and I V Ramanuja Rao, Physiology of flower bud growth and opening; *Proc. Indian Acad. Sci. (Plant Sci.)* Vol.93, pp.253–274, 1984.**

[2] **H Y Mohan Ram and Anita Sehgal, Biology of Indian Podostemaceae, *Phytomorphology, Golden Jubilee Issue: Trends in Plant Sciences*, pp.365–391, 2001.**

[3] **H Y Mohan Ram and B Hari Gopal, Some observations on the flowering of bamboos in Mizoram, *Curr. Sci.* Vol.50, pp.708–710, 1981.**

[4] **H Y Mohan Ram, A Passion For Plant Life; *J. Biosci.,* Vol.27, No.7, pp.651–664, 2002.**

[5] **G Mathur and H Y Mohan Ram, Floral biology and pollination in *Lantana camara*, *Phytomorphology*, Vol.36, pp.79–100, 1986.**