EDAVALETH KAKKAT JANAKI AMMAL

(1897-1984)

Elected Fellow 1957

Birth and Parentage

Dr (Miss) Edavaleth Kakkat Janaki Ammal was born in a highly cultured middle class family on November 4, 1897 at Tellicherry, in the Kerala State, to the worthy parents, Srimathi Devaki and Sri EK Krishnan. Her father was a sub-judge at Tellicherry. She had six brothers and five sisters.

Education

The town of Tellicherry which was a part of the Madras Province before the formation of the Kerala State was the scene of early schooling of Janaki Ammal at the Sacred Heart Convent. She then moved to the capital, Madras, and had her undergraduate studies at the well known women's institution, Queen Mary's College. Later she took her BA (Hons) degree in Botany of the Madras University in the year 1921, studying for the same from the prestigious centre of learning, Presidency College, Madras. Two years later, in 1923, she qualified for the MA Degree of the Madras University. After spending a couple of years in the teaching profession at the Women's Christian College, Madras, Janaki Ammal went over to the University of Michigan, USA as a Barbour Scholar and took her MSc Degree in 1925. She returned to India to continue her teaching work in the Women's Christian College. Again, she got back to the University of Michigan, USA, as the first Oriental Barbour Research Fellow and obtained her DSc Degree in 1931. Twenty five years later in 1956, the University of Michigan conferred on her the honorary degree of LLD in recognition of her contribution to Botany and Cytogenetics by her research, writings and participation in important scientific conferences. The citation further said *Blessed with the ability to make painstaking and accurate observations, she and her patient endeavours stand as a model for serious and dedicated scientific workers.*

Professional Career

After taking her BA (Hons) Degree in Botany in 1921, Janaki Ammal joined the teaching profession as lecturer in Botany at the Women's Christian College, Madras for a period of three years till 1924. Returning to India in 1926 after taking the MSc

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Degree from the Michigan University, USA, she again worked in the Women's Christian College, Madras as Professor of Botany for the period 1926-28. Her next professional assignment was as Professor of Botany in Maharaja's College of Science at Trivandrum from 1932-1934, when she returned to India from the USA with a DSc degree in Botany from the Michigan University.

Janaki Ammal's flair for original thinking and unbounded enthusiasm for research led to her leaving the teaching profession and taking up the position of Geneticist in 1934 at the internationally well known Sugarcane Breeding Station (now Sugarcane Breeding Institute) at Coimbatore. She worked here during the years 1934-39. She initiated and did pioneering cytological work on sugarcane and allied species. Leaving the country in 1939 she took up the position of Assistant Cytologist, at the John Innes Horticultural Institution, London. She worked in that position for five years (1940-45). She then moved to the Royal Horticultural Society, Wesley, London as Cytologist and worked there for five years (1946-51).

Janaki Ammal's services were, by then, required in India and deciding to settle down in India she accepted the invitation of the Government of India to work as the Officer-on-special-Duty (1952-54) for re-organizing the Botanical Survey of India and then in 1954 she became the first Director of the Central Botanical Laboratory of the Botanical Survey of India. This laboratory was first temporarily located at Chhater Manzil, Lucknow and later shifted to Allahabad. She held this post for five years (1954-59). She then moved to Jammu as Officer-on-Special-Duty at the Regional Research Laboratory for a period of three years (1959-62). For two years (1962-64) she was Chairman of the Cytogenetics Department at the Regional Research Laboratory, Jammu and Honorary Professor of Botany in the University of Jammu and Kashmir. The next five-year period (1964-69) was spent by her as Emeritus Scientist, at the Regional Research Laboratory, Jammu. For a short period of about a year (till October, 1970) she was a Visiting Professor at Bhabha Atomic Research Centre, Bombay and Honorary Professor of the University of Jammu and Kashmir.

With advancing age, Janaki Ammal decided to settle down in Madras and from November, 1970, she worked as an Emeritus Scientist with the Centre for Advanced Study in Botany of the Madras University. She stayed and worked at the field station of the Botany Department at Maduravoyal which is about 15 km. from the Madras city in rural surroundings. She continued her research work till she was hospitalised two weeks before her death on February 7, 1984. She was then 86 years.

Research Contributions

Nature's bounty in the shape of plant wealth in this vast country where all the three climatic conditions—tropical, sub-tropical and temperate—are represented giving scope for the enormous natural variation in the flora, was too much of a temptation and attraction for Janaki Ammal, in whose jugular vein botany was flowing, to stay at one place and be occupied with working on one crop. The enthusiasm to explore and study nature kept her moving from one assignment to another. But botany and cytogenetics were richer by her nomadic movements. The numerous plant species that she had handled in her research investigations and the significant and original contributions she had made bear ample testimony to it. The wide array comprises *Saccharum*, *Solanum*, *Cymbopogon*, *Datura*, *Mentha*, *Viburnum*, *Rhododendron*, *Dioscorea*, *Dianthus*, *Nerine*, *Philadelphus*, *Rauvolfia*, *Terminalia*, *Emblica*, *Eucalyptus*, *Nicandra*, *Kniphofia*, etc.

The research contributions of Janaki Ammal can be categorised broadly under (i) Cytogenetics, (ii) Polyploidy and (iii) Chromosome studies.

Cytogenetics

The first whole time research assignment of Janaki Ammal was at the Sugarcane Breeding Institute, Coimbatore as Geneticist. She laid the foundation for cytogenetical studies on *Saccharum* and allied genera, including interspecific and intergenetic hybrids. The cytogenetic analysis of *Saccharum spontaneum* revealed that in respect of chiasma formation the chromosomes fall into two types : (i) those with a single chiasma which is localised and (ii) those with one or two chiasmata which are found at random. The number of chiasmata observed was not always proportional to the length of the chromosomes. Secondary association of bivalents was also observed and there was some evidence of hybridity within the species. One of the variant forms of *Saccharum spontaneum* obtained from Burma had 96 chromosomes at the somatic metaphase which indicated that it is a triploid and possibly arose from natural hybridization between an Indian form with $n=32$ chromosomes and a tetraploid form from Sumatra or the origin of the triploid form may be from the fertilisation of an abnormal diploid gamete by a haploid one. She had worked also on the break-down of meiosis in a male-sterile *Saccharum*. Her observations for the first time include the finding of production of diploid gametes as of common occurrence in *Saccharum* and triploploids which occur following interspecific and intergeneric crosses are fertile.

Janaki Ammal successfully effected an intergeneric cross between *Saccharum spontaneum* and *Erianthus ravennae*. The hybrids showed more resemblance to *Saccharum spontaneum*. At meiosis univalents, bivalents, trivalents and quadrivalents were seen. From this it was inferred that autosynthesis has occurred among the *Saccharum spontaneum* chromosomes and that some of the *Erianthus* chromosomes were capable of pairing with *spontaneum* chromosomes. Another interesting intergeneric cross that she successfully made was between *S officinarum* (Vellai) with $2n=80$ chromosomes and the sweet corn *Zea mays* (golden beauty) with $2n=20 + B$ chromosomes. Two seedlings were obtained from the above cross of which one survived and was found to have 52 chromosomes. It is a dwarf, tillers freely, is a perennial and can be propagated vegetatively. This hybrid flowered after 40 years during the seventies and its hybrid nature was again confirmed from floral studies and this plant is available even now at the Sugarcane Breeding Institute.

Studies on Polyploidy

Detailed study of various polyploid plants was one of her favourite research work and in this Janaki Ammal has made original contributions of considerable interest.

1. Solanum

In the course of genetical studies with diploid egg plant *Solanum melongena*, she picked up an abnormal plant which proved to be a triploid and sterile. After repeated selfings it produced one fruit with 14 seeds. The plants raised from these seeds had chromosomes varying from 44 to 48. The triploid plant had 36 chromosomes and the tetraploid 48 chromosomes and the aneuploids with chromosomes 44 to 46 all showed the same chromosome morphology. She inferred from this that the 4 x plant must have arisen by the chance fertilisation of an egg with 24 chromosome by a pollen with 24 chromosomes. The viability of the gametes with a few chromosomes less than 24 was not impaired explains the existence of plants with $4x-2$ and $4x-4$ chromosomes following Darlington's convention by which x is the basic number and 2n the somatic number.

2. Cymbopogon

Of the 100 species belonging to the genus *Cymbopogon*, which are aromatic grasses, 21 species occur in India. In *C nardus* diploid, tetraploid and hexaploid races have been found. In *C flexuosus* diploids and tetraploids occur and in *C martini* and *C citratus* tetraploids and hexaploids. The polyploid races were found to be rich in oil content as compared to the diploids within species range. In *C flexuosus* the diploids have a range of 0.5 to 1.0 per cent of oil and the tetraploids had 1.5 per cent. In the ginger grass *C martini*, there is not only an increase in the oil content but also a change in the chemical composition of the oil between the diploid and tetraploid forms.

3. Terminalia

Tetraploids with $2n=48$ Chromosomes have been found among cultivated trees of *T chebula* and *T bellerica*. There was correlation between ploidy, size of fruit and tannin content.

4. Datura

The genus *Datura* is an important source of the alkaloids, hyocyamine, hyoxine and atropine. With a view to improve the alkaloid content of *D metel*, tetraploidy was induced by treatment of seeds with 0.8 per cent of aqueous colchicine solution and this gave the best results in yielding tetraploids with 2n = 48 chromosomes. These plants had larger stomata, bigger pollen grains and thicker and larger flowers than the diploid plants. However, the tetraploid plants were not uniform in alkaloid content. The tubercles on fruit, flower and stem colour also showed variation. From this it was concluded that the mother plant must have been heterozygous. The variation in alkaloid content indicates that a number of genes are possibly involved in the production of alkaloids.

5. *Dioscorea*

Tetraploidy was induced in *D deltoidea* Wall. with a view to increasing the diosgenin. The rhizomes grew slower than the diploid plants and had shoots with larger and thicker leaves.

Chromosome studies

The publication *Chromosome Atlas of cultivated plants* by Darlington and Janaki Ammal is well known to botanists and agricultural scientists all over the world. The compilation speaks of the pains taken by Janaki Ammal on this authoritative publication. The plants, the chromosomes of which has been studied by Janaki Ammal are too many to mention. While in some, mere numbers have been reported, in others she has gone into considerable depth in understanding the chromosome pattern and behaviour and come to conclusion regarding speciation and evolution. The salient findings from some of her important investigations are summarised below.

(i) *Viburnum* : Discussing the species problem in the genus *Viburnum*, Janaki Ammal found that both *V grandiflora* and *V fragrans* have 2n = 16 chromosomes. The chromosomes of the two species paired normally in the hybrid *V bodnantense* (2n = 16), and the pollen fertility was as high as 100 per cent. The hybrid between *V bitchiuense* (2n = 16) and *V carlesii* (2n = 20) *V juddii* had 2n = 18. Thus by artificial hybridization it has been possible to synthesise a plant with a basic number X = 9. A chromosome survey of *Viburnum* species to study the natural distribution of the three numbers X = 8, X = 9 and X = 10 indicated that all the deciduous species had X = 8. High polyploids occur in this section and they occur in the Sino-Himalayan region which is a region of high evolutionary activity in South East Asia. One polyploid species *V erubescens* occurs in the hills of South India. Possibly this migrated from the Himalayas during pluvial times. There was evidently once a wide and continuous distribution in the flora of Asia. Triploids are of common occurrence in nature and found abundantly in cultivation. Their presence in a population of perennial woody plant as *Viburnum* can be a constant menace to the stability of diploids owing to the possibility of continuous hybridization between them and the diploids and evolution of the species. The species *V tinus* is the only 'tertiary' polyploid

Viburnum in the old world that has survived the ice age in Europe. The Sino-Himalayan region as an area of high evolutionary activity among species of *Viburnum* is indicated by the distribution of high polyploids in the area.

(ii) *Dianthus monspessulanus*: The occurrence of three races in *D monspessulanus* has been reported. The diploids and hexaploids have small flowers and difficult to differentiate by the flower size while those of tetraploid are larger. The tetraploid plants in general, occur in higher altitudes.

(iii) *Primula melacoides* : The smaller diploid plant of *P melacoides* has $2n=18$ while the larger, tetraploid has $2n=36$. Useful information has been given regarding the diploid and tetraploid varieties and their pollen fertility for assistance in selection of parents. In the publication she concludes *And so wiih this Cytological tip let me leave the little "Fairy" Primula with a sad heart recognising how much she has changed and how much she is going to change, from the simple, elegant rosy diploid that waves its tiny flowers among the rice fields in Tuli in Yunnan to the robust, larger and more sophisticated tetraploid or hexaploid lady who to-day flaunts herself at our shows.* In 1912, *P melacoides* was a favourite plant in the green house and good for table decorations with white and pink flowers. These have arisen as mutations from the original race. In 1914, a strong vigorous form with flowers deepest pink were found and these showed $2n=36$ chromosomes, the first tetraploid in the species.

(iv) *Philadelphus* : A number of species and hybrids have been examined for chromosome numbers and the classification and distribution of the species recorded. All the species are diploid with $2n=26$. The hybrids, triploids, were found to arise by fertilisation of unreduced egg with normal reduced pollen. They are larger and more free flowering than the diploids. The author feels that for the first time polyploidy has been induced in the genus which has remained diploid since Eocene times.

(v) *Citrus* : Janaki Amnal discovered a natural hybrid between the citron (*Citrus medica*) and malta lemon in Shoranur and the hybrid has been termed a citromelon and given the name *Sukumari*. It has the thick, sweet rind of the citron and produces the fruits in bunches resembling malta lime. Both the parents and hybrid have a chromosome number of $2n=18$.

(vi) *Sorghum purpureo-sericeum* : Out of 100 plants of *Sorghum purpureo-sericeum*, 40 had extra chromosomes in the pollen mother cell divisions. The extra chromosomes behaved like the B-chromosomes of maize at meiosis. Plants with increasing number, had decreasing pollen fertility. Only the normal $2n=10$ chromosomes were found in somatic cells, the extra chromosomes being present only at meiosis.

(vii) *Morus nigra* (the black mulberry) : According to Janaki Ammal this species has the distinction of having the highest chromosome number among flowering plants ($2n=308=22x$). Persia is recorded as its original home. The origin of such a high polyploid surrounded by diploid species remained a genetical puzzle till the missing links in its chromosome history was found in *M cathyana* in Central China with 2n=56, 84 and 112 chromosomes. Today the distribution of *M nigra* and *M cathyana* is broken by the deserts of Lop-Nor and Gopi and the tree trunks burried in the sands give evidence of past continuity.

(viii) *Chromosomes and Horticulture* : In an interesting general article on the tracing of the origin of cultivated plants through chromosome study, the author concludes that modern varieties have arisen by hybridization of species which have been brought together and never had chance of crossing in their natural habitat. She cites the case of the strawberry. *In Shakespeare's play Richard III, the Bishop of Ely sent for strawberries, for his guest the Duke of Gloucester, which were small, woody Fragaria vesca. A little later, say, when Sir Isaac Newton was eating strawberries they were the species F elatior with somewhat larger fruits. Later, two species F virginiana and F chilaensis were introduced by the 18th Century. One of them was a female producing fruits only by crossing with pollen of the other. It was from the seeds of these fruits that our modern garden strawberry has descended. The wild F vesca is a diploid with 2n=14 chromosomes and F elatior has three times this number (hexaploid) and that of the American species has 8 times (Octoploid).* The author concludes *the tracing of the origin of cultivated plants by means of chromosome study is thrilling as hunting for the missing link in human history.*

(ix) *Mentha arvensis* : A tetraploid 2n=192 of *Mentha arvensis* var. *piperascens* was obtained by colchicine treatment and was found to be fertile. One seedling with over 5% oil content has been selected and named the "Jammu mint". It is propagated vegetatively.

Phytogeography and evolution : In her presidential address to the Indian Botanical Society, Janaki Ammal dealt with the effect of the Himalayan uplift on the genetic composition of the flora of Asia and the race history of a few genera of Asian plants. The rise of the Himalayas has been described as a great buckle in the earth's crust which raised the Central Asian Plateau in late Tertiary times, and a study of the post Himalayan flora of Asia has been presented. Using the method of chromosome analysis the evolution and the race history of some genera have been traced, as also the genetical changes in some plants which came into contact with the Himalayan uplift. The path of polyploidy is considered the path of evolution of new species. Examination of the so called living fossils of *Magnoliaceae, M nitida* of Yunnan and *M parviflora* of China cytologically led to their being found to be diploids (2n=38). Eight species from Upper Burmah, Nepal, Sikkim, Yunnan and Szechuan adjoining the Eastern Himalayas were found to be hexaploids (2n=114). It is inferred that polyploidy in Asian Magnolias is restricted to the deciduous Sino-Japanese types which have migrated along the Himalayas into India. In the humid tropical regions of Assam and Malaya the species have remained diploids. This phenomenon of high polyploidy has been noticed in several other genera including the *Camellia, Viburnum* and *Rhododendron.* In these genera high polyploids occur in the region where the Himalayas bend over the plateau of Assam and this region may be considered as the Centre of active speciation today. The production of unreduced gametes due to extreme cold may be considered as responsible for occurrence of triploids in cold regions. In *Viburnum* repeated hybridisation between diploids and triploids in nature has resulted in even higher basic chromosome number ($x = 10$) besides ($x = 8$ and $x = 9$). The effect of altitude on speciation in *Rhododendron* in the two groups—*Lapponicum* and *Triflorum* which are hardy mountain plants have adapted themselves to life at high altitude by polyploidy. As polyploidy increases, the size decreases in the Rhododendrons unlike in other genera. Polyploidy is one of the ways by which Rhododendrons have been able to get over the inclemency of altitude.

Honours

It is but natural that such a versatile scientist as Janaki Ammal, internationally recognised as an eminent cytogeneticist and botanist should be the recepient of Fellowship and Membership from many of the Scientific Societies in the World. These are : Fellow of the Linnean Society; Fellow of the Royal Geographic Society; Fellow of the Genetical Society of England; Fellow of the Genetical Society of America; Member of the British Association for the Advancement of Science; Member of the Sigma Zl Society of USA; Fellow of the Botanical Society of India; Fellow of the Indian Academy of Sciences; Fellow of the Indian Society of Genetics and Plant Breeding; and Fellow of the National Institute of Sciences (Indian National Science Academy).

Janaki Ammal was the Secretary of the Botanical Society of India for three years, 1935-1938 and its President in 1960. She was the President of the Indian Society of Genetics and Plant Breeding for the year 1961. She was the recepient of Birbal Sahni Medal for the year 1961. She was a delegate to the Imperial Botanical Congress held in London and to the International Botanical Congress held in Amsterdam. She was also a delegate to the International Conference of Winner Gren Foundation for Anthropological Research.

The Government of India honoured her with 'Padma Sri' in 1977 in recognition of her outstanding Scientific work.

Conclusion

Living for well over 80 years of which three score were spent in scientific research, Janaki Ammal stands out as one of the most eminent and distinguished scientists of the country. She typifies the words of Milton *They all serve who stand and wait.* Active to the last days of her life, she may well have felt what Benjamin Franklin told his wife *I wish good Lord had seen fit to make each day twice as long as it is now* to carry out her pursuit of Science.

Her list of publications is a remarkable one, not just for its length, but through the breadth of interests it reveals—sugarcane, horticultural plants, medicinal plants, trees, polyploids natural and induced, chromosome behaviour, speciation, cytogeography, interspecific and intergeneric hybridisation and finally phytogeography.

ACKNOWLEDGEMENT

I am grateful to Dr JT Rao, Retired Director, Sugarcane Breeding Institute, Coimbatore, for very useful discussion and assistance in preparing this biography of Dr EK Janaki Ammal.

S KEDHARNATH

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