PRANAKRUSHNA PARIJA: A FORGOTTEN SCIENTIST AND ACADEMICIAN

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This article explores the life and work of Pranakrushna Parija (1891–1978), an Indian scientist with international distinction whose contributions to plant science have profoundly impacted the world. He is regarded as a distinguished botanist and a great educationalist in the fields of plant science, education and humanitarian service. He received his initial scientific training at the University of Cambridge, England, under the guidance of eminent scientist Frederick Frost Blackman. Blackman and his lab conducted extensive research in plant physiology and plant photosynthesis. In 1928, Blackman and Parija discussed the changes in permeability that may be involved in fruit ripening. Together, both elucidated the intricate relationship between fruit ripening, oxygen tension and respiration in the context of an apple. The duo published several breakthrough papers highlighting their pioneering work in plant respiration, respiratory regulation in ripening apples and mechanisms of fruit ripening. After his return to India, he was appointed professor of botany at Ravenshaw College, Cuttack, India. With his wide experience as a distinguished researcher, educationalist and academician, he has held various academic and administrative roles in India. He carried a sense of commitment and keenness to the cause of science, education and the welfare of his countrymen, whom he served until his death.

Keywords: Pranakrushna Parija, Plant Physiology, Respiration in Apples, Fruit Ripening

Introduction

Surrounded by plants and natural heritages, we often fail to realise their countless facets and complexity and the tremendous significance exhibited by them in our day-to-day life activities. Pranakrushna Parija dedicated his long career to decoding the complexities of the plant kingdom and went on to become one of the finest Indian botanists of international repute. His significant research contributions include mainly fundamental as well as different applied domains of physiology, morphology and biological studies of plants, especially with respect to respiration in leaves and apples. At the University of Cambridge, England, in the year 1914, he worked under the guidance of eminent Frederick Frost Blackman, FRS (1866–1947). Frederick Frost Blackman was a British botanist renowned for his work on plant physiology, specifically plant respiration and photosynthesis, at Cambridge University (Edward, 1948).

In plants, photosynthesis takes place in chloroplasts, which contain the essential pigments known as chlorophylls. Not much was recognised about photosynthesis before the 20th century, however key discoveries regarding photosynthesis functions began after 1900 with significant advancements in science and technology (reviewed in Stirbet et al., 2020). Leading a successful research group, Frederick Frost Blackman proposed

that photosynthesis involves two distinct phases — a light-dependent phase (called as 'light' reactions) and a temperature-dependent biochemical phase (called as 'dark' reactions, or 'Blackman reaction') (Blackman, 1905; Warburg and Uyesugi, 1924). In his paper (Blackman, 1905), Blackman recognised five noticeable controlling factors in the case of a given chloroplast engaged in photosynthesis, that includes the available volume of carbon dioxide, the available volume of water, the intensity of accessible radiant energy, the quantity of chlorophyll present and the temperature in the chloroplast. His prominent laboratory work was published in two series: "Experimental Researches on Vegetable Assimilation and Respiration" (1895–1933) and "Analytical Studies in Plant Respiration" (1928–37) (American Society of Plant Biologists, 1947). In the second series, two papers (Part I and Part II) were published, highlighting the pioneering work of Pranakrushna Parija with Blackman. Their research work highlighted that permeability dynamics may be involved in fruit ripening (Blackman and Parija, 1928; Parija, 1928; Blackman, 1928). Further, along with Kidd and West (1925), they planned pioneer research to elucidate the intricate relationship between apple ripening, oxygen tension and respiratory activities, especially in the context of apples stored in cold storage at 2.5°C (Blackman and Parija, 1928; Parija, 1928; Kidd and West, 1925). Pranakrushna Parija was revered for Tripos Part II and was a Frank Smart student at the University of Cambridge, United Kingdom. He professed botany at Ravenshaw College, Cuttack, Orissa (now Odisha) and worked in various academic-administrative capacities, such as First Vice-Chancellor, Utkal University, Odisha, for two tenures spanning from 1940–48 and 1955–66; Honorary Professor of Botany from 1949–51; Pro-Vice-Chancellor at Banaras Hindu University, Varanasi (1955–58); and Member of Legislative Assembly, Odisha. Pranakrushna Parija, for his significant contributions to teaching and research, was initially elected as the President of the Botany Section (1930) and as General President of the Indian Science Congress Association (ISCA) later in the year 1960. He was honoured with a D.Sc. (Honoris Causa) from Patna and Utkal Universities. Parija was bestowed with the OBE (Order of the British Empire) Award and Padma Bhushan (1955) by the Government of India. He was instrumental in the development of plant physiology as a discipline in India. Parija was a teacher par excellence as well as an able researcher who closely linked together the functions of teacher, scientist and educationalist.

Early Life and Education

Pranakrushna Parija was born on 1 April 1891, in the village of Iccharpur, near Cuttack (Orissa, now Odisha) and was the only son of Biswanath and Jayanti Devi. His father served as a forest guard in the princely state of Mayurbhanj, Orissa. His father was a low-paid forest guard in a faraway place in the then-princely state of Mayurbhanj. Whenever he came home, he told his only son tales of trees and forests, which created the love of plants in young 'Parani', as fondly called by the village folks. His courageous father instilled love for plants, animals and nature in him from early childhood. Pranakrushna Parija was a meritorious student during his school days and became proficient in Sanskrit and Odia at a young age. He stood first in Orissa (and seventh in the university list) in the final entrance examination conducted by Calcutta

University to secure a seat at the prestigious Ravenshaw College, Cuttack (Subramanian, 1991). He completed his education at esteemed institutes: Ravenshaw College (Cuttack), Presidency College (Calcutta) and the University of Calcutta, West Bengal. At Calcutta University, he learned science from some celebrated teachers who had achieved high international reputations, like Jagadish Chandra Bose (Physics), Prafulla Chandra Ray (Chemistry), D.N. Mullick (Mathematics), and Bankim Das Mukherjee (Mathematics). It is interesting to note that his classmates at Calcutta University included illustrious and distinguished stalwarts like Satyendra Nath Bose (Physics), Meghnad Saha (Physics), Jnan Chandra Ghosh (Chemistry), Nikhil Ranjan Sen (Applied Mathematics), and Jnanendra Nath Mukherjee (Colloid Science) (Subramanian, 1991). He had a bright academic career during his school, college and university years.

As a research scholar, he went further to the University of Cambridge, England, in the year 1914 on a Government of Bihar Scholarship. He secured first rank with a first class in Part II of the tripos examination at Cambridge and was conferred with the famous Frank Smart Prize. His education in school, college and at Cambridge University was mostly supported by scholarships, demonstrating his academic caliber and meritorious skills (Subramanian, 1991). After his return to India in 1922, he got married to a lady from a rural background, Miss Sundramani. She had completed only her elementary education, as there was only Ravenshaw Girls High School in Cuttack at that time (Das, 2012). Parija always promoted his wife as a modicum of education at home and encouraged her to participate in community activities towards the welfare of women and children in society. As a father, Parija was friendly and polite and gave the best of the opportunities to his children to enable them to have an accomplished place in life.

Research Achievements at Cambridge University (England)

Pranakrushna Parija graduated from Cambridge University, England, under the guidance of Frederick Frost Blackman (1866–1947). He was one of the most distinguished plant physiologists of his era. F.F. Blackman demonstrated the existence of thermal or dark reactions in photosynthesis and described the aspect of carbon assimilation in this process; thus, the reaction is acknowledged as 'Blackman Reaction in Photosynthesis' (Emerson and Green, 1937; Blackman, 1954). Of the 45 students who worked under the guidance of Blackman, six were from the Indian subcontinent (T. Ekambaram, R.S. Inamdar, P. Parija, Rafiq Ahmad Khan, Shri Ranjan and S.B. Singh) (Blackman, 1954). At Cambridge University, his contemporaries included Srinivasa Ramanujan (mathematics), Chintaman Dwaraknath Deshmukh (an Indian to be appointed as the Governor of the Reserve Bank of India in 1943 by the British authorities for the first time) and Birbal Sahni (a paleobotanist) (Subramanian, 1991).

F. F. Blackman and P. Parija worked extensively on plant respiration, respiratory regulation in ripening apples and mechanisms of fruit ripening. Their research encompassed studies on the respiratory behaviour of apples, and later, of potatoes (American Society of Plant Biologists, 1947). Two series of papers published by F. F. Blackman and his distinguished students

and collaborators from the Cambridge School of Plant Physiology reveal their great contribution to plant physiological work. The first series, entitled 'Experimental Researches on Vegetable Assimilation and Respiration' was published in 21 successive parts from 1895 to 1933 and the second part, entitled 'Analytical Studies in Plant Respiration' appeared in seven consecutive parts from 1928 to 1937 (American Society of Plant Biologists, 1947). Parija, in association with Blackman, published two seminal papers (1928) in the second series 'Analytical Studies in Plant Respiration' in the journal *Proceedings of the Royal Society B: Biological Sciences* (Blackman and Parija, 1928; Parija, 1928; Blackman, 1928). Blackman and Parija (1928) wrote in the Part I paper of the second series that "of all protoplasmic functions, the one which is, by tradition, most closely linked with our conception of vitality is the function for which the name of respiration has been accepted." (Blackman and Parija, 1928). They suggested the respiratory activity of a plant cell and regulation of fruit ripening, and one of the initial theories related to these regulations was named 'organisational resistance' based on their advanced work (Blackman and Parija, 1928; Parija, 1928; Blackman, 1928). He was regarded as a brilliant investigator and a perfect gentleman with a good sense of manners and consideration for others.

Return to India and His Notable Accomplishments

On his return from England in 1920, he was appointed as Professor of the Botany Department at Ravenshaw College, Cuttack, Orissa, in the cadre of the Indian Educational Service. With the entrance of Parija as a professor at the Department of Botany in 1921, Ravenshaw College attained a distinct recognition as an eminent centre for teaching and research in botanical sciences. Ravenshaw College, founded in 1868, is one of the oldest higher education institutions established in the state of Odisha and India per se. At Ravenshaw College, Parija initiated research in the field of plant physiology and biochemistry. His research was focused on the control and physiology of aquatic weeds (mostly water hyacinth), the ecology of freshwater and marine algae, experimental plant morphology, and the physiology of rice (like experimental induction on flood resistance in rice plants) (Subramanian, 1991; Das, 2012). He laid tall ethical standards and moral principles for the students and faculty members. The Department of Botany at Ravenshaw College, established in the year 1906, excelled in the field of plant science research under his able guidance. He served as the Head of the Department of Botany at Ravenshaw College (now Ravenshaw University) from 1921 to 1938. Some of the Heads of the Botany Department at Ravenshaw College include Girish Chandra Bose, followed by Raisaheb J. Rai (1921), Pranakrushna Parija (1921–1938), Debabrata Mukherjee (1938–1940), Parasuram Mishra (1940–1948), Bansidhara Samantrai (1948–1961), Gadadhar Misra (1961–1970), Sachidananda Naik (1970–1971), Braja Kumar Kar (1971–1972), Gourirani Ghosh (1972–1974), Dinabandhu Mishra (1975-1982), Kamal Kumari Patnaik (1982, 1985–1993), Chandrasekhar Sarangi (1982–1985) to name a few. He also served as the principal at Ravenshaw College, Cuttack. In 1943, the Utkal University in Bhubaneswar, Orissa (India), was founded after receiving the Governor's assent on 2 August 1943.

Pranakrushna Parija, the then Principal of Ravenshaw College at Cuttack, was selected as the founder Vice-Chancellor of the Utkal University, Bhubaneswar (tenure: 1940–48, 1955–66), and V. V. John, Assistant Professor in the Department of English at Ravenshaw College, was appointed as the Registrar of the Utkal University, Bhubaneswar. During his tenure at the university, he always carried a sense of commitment to the cause of science, education and the welfare of the fellow citizens whom he served. He faced several inevitable problems during this tenure but eased them off with his ready wit, determination and elusive humour (Subramanian, 1991). He also became the Pro-Vice-Chancellor of Banaras Hindu University, Varanasi, from 1955 to 1958.

India faced several abiotic stresses that caused extensive crop failures, major starvation deaths, and severe famines in India, such as the Great Orissa Famine of 1866 (Na'Anka Durbhikshya) and the Great Bengal Famine of 1943. All these reasons led the Government of India to think about and develop a multi-disciplinary centre of authoritative data collection for future work plans and to guide rice researchers, farmers, and other shareholders on all matters related to rice cultivation and production. The Government of India further decided to establish a Central Rice Research Institute (CRRI) in India, now called the National Rice Research Institute (NRRI) and appointed K. Ramiah as the Officer-on-Special Duty (OSD) for the development. Pranakrushna Parija, the then Director of Agriculture, Orissa, convinced K. Ramiah about the suitability of Cuttack, Orissa (now Odisha), for the positioning of the institute. Finally, on the recommendation of K. Ramiah, the Government of India decided to establish the ICAR-Central Rice Research Institute (CRRI) at Cuttack in 1946 (ICAR-National Rice Research Institute, 2019). Pranakrushna Parija was elected as the President of the Botany Section (1930) and General President (1960) of the Indian Science Congress Association (ISCA) (Indian Science Congress Association, 1960). The 49th Indian Science Congress (ISC) was held at Cuttack, Orissa, from January 3 to 9, 1962. The 49th ISC Proceedings Souvenir was edited by Pranakrushna Parija and Sarat Chandra Mukherjee (Indian Science Congress Association, 1960; Indian Science Congress et. al, 1962).

During his time, the spread of water hyacinth, an aquatic weed common in water bodies, was increasing at an alarming rate. Thus, expert committees were set up all over India and Burma to study the details of the life history and methods to control this noxious weed. With the financial assistance of the Imperial Council of Agricultural Research, Parija later studied the problem of the spreading of water hyacinths in Orissa. In yet another study, Parija reported that brief exposure to light raised the respiratory rates in the leaves of Genus *Aralia*. During his experiments, he significantly found that short exposure to the blue and violet regions of the electromagnetic spectrum raised the rate of respiration in the same way as the entire white light region of the spectrum. Meanwhile, for the first time, he and P. Mishra established in 1933 that the thorns arise from the stem of *Bridelia pubescens*. Parija and Mallick in 1936 noted that dryness alone did not induce cuticle formation in *Ficus religiosa*. Instead, dryness coupled with blue light induced the same. They also demonstrated that oily seeds resist the effects

of high temperatures better than starchy seeds. Besides, they also experimentally found that turgidity in the cells of the fruit walls is not the only cause of the bursting of the fruits of balsam. Another remarkable investigation by Parija includes the study of the dispersal, structure and growth of glandular hairs and extra-floral nectaries in *Tecoma capensis.* Pranakrushna Parija has also contributed enormously to the field of rice research. On 1 April 1937, the Government of Orissa in the Department of Agriculture recommended a rice research scheme and he was assigned to investigate the physiological aspects of this scheme, including the qualities with respect to flood, drought and salinity resistance. Breaking the dormancy in winter paddies to grow them as 'Dalua' was achieved through various seed treatments under his guidance. Additionally, he investigated the life history of the weeds of the Chilika Lake and their connection with the prevalence of malaria cases around the lake area. Parija studied the algal succession inside the lake. He worked on aquatic weeds choking the water channels, and his attempts included inducing flood, drought and salinity resistance. His investigations to utilise the aquatic flora of the Chilika Lake as raw materials for the manufacture of agar-agar are noteworthy.

Awards, Honours and Memorial Prizes in his Honour

Parija served as the President of the Indian Botanical Society, India, in 1930 (https://indianbotsoc.org) and was a foundation fellow of the National Institute of Sciences of India (now Indian Science Academy) (Subramanian, 1991). He was elected into the fellowship of the Indian National Science Academy in 1934 under the Plant Sciences section (https://fellows.ias.ac.in/profile/v/FL1934065). The Birbal Sahni Medal, instituted in 1957 by the Indian Botanical Society, was awarded to P. Parija for his contributions and devotion to the cause of Indian botany (1959). Parija, with his sincere views and analytical mind, entered the first Orissa Legislative Assembly (1951–1952) as an independent member from the Balikuda constituency (Subramanian, 1991; Das, 2012). He was conferred with 'Padma Bhushan' (1955), the third-highest civilian award of the Republic of India, in the field of literature and education (Subramanian, 1991). He was conferred with D.Sc by numerous prestigious universities in India, such as Patna University, Utkal University, Sambalpur University and Odisha University of Agriculture (https://ova.gov.in/en/Author?aid=TBCbRVIzx6k=).

The Odisha Bigyan Academy, Government of Odisha, started the 'Pranakrushna Parija Popular Science Award' to be awarded to nominated authors of popular science books in Odia (http://odishabigyanacademy.in/pranakrushna-parija-popular-science-award/). Ravenshaw University, Cuttack, regularly organises the 'Pranakrushna Parija Memorial Lecture' in his memory. The Central Library of Utkal University, Bhubaneswar, was named 'Parija Library' in memory of its first vice-chancellor and is regarded as one of the finest university libraries in India. A life-size statue of Pranakrushna Parija is also placed on the Utkal University Campus in Bhubaneswar (Fig. 1). The Utkal University has instituted 'Pranakrushna Parija Scholarship' for postgraduate students at their university. A memoir book titled '*Shikhyabit Pranakrushna Parija*' has also been authored by Gadadhar Mishra (Vidyapuri Publication).

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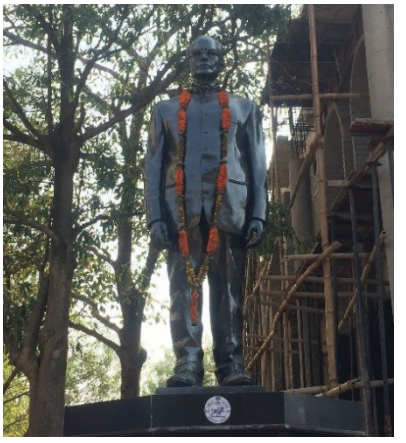

b

Fig. 1. (a) Pranakrushna Parija and (b) Statue of Pranakrushna Parija placed in Utkal University, Bhubaneswar (*Source:* Indian National Science Academy and Wikimedia Commons)

A New Specimen of Enigmocarpon Parijai, A Silicified Fruit from the Deccan, India

Parija was closely associated with Birbal Sahni, an eminent Indian paleobotanist who extensively studied the fossils of the Indian subcontinent and Mandayam Osuri Parthasarathy Iyengar, a prominent Indian botanist and phycologist (regarded as 'Father of Indian Phycology') (Subramanian, 1991). Birbal Sahni (FRS) at that time was Professor of Botany at the University of Lucknow, India. Sahni named few silicified fruits uncovered at Mohegan Kalan (east of Chhindwara, India) with the generic name '*Enigmocarpon*' (Sahni, 1943; Dwivedi, 1954). In the Sahni Collection, fossil specimens and sections from this rich fossiliferous locality were first collected by K. P. Rode of Waltair (1929–30) and later by Birbal Sahni and P. Parija (1931); Birbal Sahni (1941–1942); V. B. Shukla and others. Sahni termed a new specimen of silicified fruit uncovered at the Intertrappean Series at Mohegan Kalan, India, as '*Enigmocarpon parijai*', named after Parija (Sahni, 1943). It was reported that both the fruits and seeds of *Enigmocarpon* were adapted for aquatic dispersal and long immersion in brackish water. The occurrence of these fossil representatives in this flora supported a Tertiary age for the Deccan beds (Sahni, 1943).

Parija's life was simple and systematic. The speed with which he took decisions regarding complex problems was marvelous—intuitively quick. Seldom have his decisions been found to be faulty. He is considered a wizard and is recognised as a strict disciplinarian with a kind heart. In all the personal relationships, Parija brought in lots of warmth and sympathy. His beaming, bright, large face, disarming simplicity and rippling enthusiasm were magnetic. This is the life of Parija, in a nutshell, a thorough gentleman who contributed to and nurtured several institutions immensely. Scientists like him may be lesser known, but they made significant contributions to science, mainly plant physiology and agriculture.

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