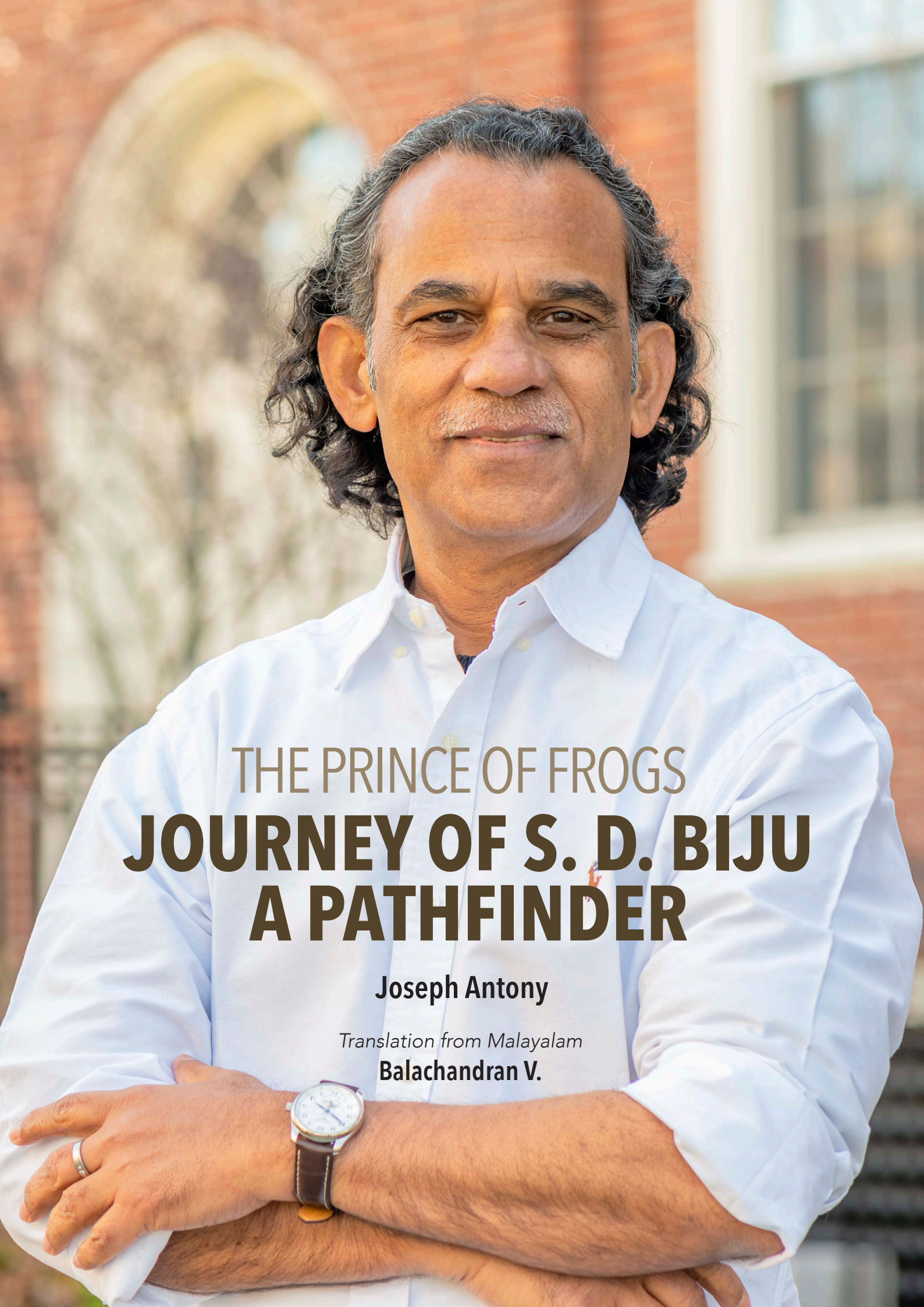

THE PRINCE OF FROGS
JOURNEY OF S. D. BIJU A PATHFINDER

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Translation from Malayalam
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Prof. S. D. Biju
Radcliffe Fellow, Harvard University
Photo: Sonali Garg, 2023.

Sathyabhama Das Biju (S. D. Biju) was born in village Kadakkal in the Kollam district of Kerala state, India. He is a leading and globally renowned amphibian biologist. To date, Biju has formally described 116 new amphibian taxa (2 families, 10 genera, 104 species) from India, Sri Lanka and Indonesia, making him one of the only few living herpetologists in the world to do so. His discoveries alone represent nearly 25% of India's amphibian diversity.

Biju is a Senior Professor at University of Delhi, India. He is currently also an Associate of the Department of Organismic and Evolutionary Biology at Harvard University and has recently been awarded the prestigious Radcliffe Fellowship for the year 2023-2024 to work full-time at Harvard in close collaboration with the department and the Museum of Comparative Zoology. Biju's research focuses on amphibian systematics, evolution, behaviour, biogeography, and contributes to conservation through discovery and documentation of species.

Biju earned his first PhD in Botany from University of Calicut, India, and contributed to knowledge on plants through several scientific publications and books. He obtained his second PhD in animal science from Vrije Universiteit Brussel, Belgium and shifted his focus to amphibians.

He has published over 100 research articles in top scientific journals like *Nature, Science* and *PNAS*. His findings have widely appeared in popular international press like Associated Press, BBC, CNN, Forbes, National Geographic, New York Times, Times, The Economist and The Guardian, to name a few. Popular media has celebrated him as the Frogman of India. Biju's contributions to amphibian research and conservation have received numerous prestigious recognitions such as the IUCN/ASG SABIN award for 2008 and more recently, the Indian State Government's highest civilian award *Kerala Sree* for 2022.

Some people cleave history into two - before and after them. Their chosen field of activity would never be the same again after they appeared on its horizon. In the world of scientific research in India too, there are personalities like Dr. Salim Ali who, through his genius and dedication, transformed Indian Ornithology of the twentieth century.

Likewise, the scene of Indian herpetology underwent a sea change after the emergence of Professor (Dr.) S. D. Biju (Sathyabhama Das Biju). Many assess the history of Indian herpetology as 'before and after Biju.' Indian herpetology underwent a total metamorphosis after Biju came up with his first paper on the frogs of the Western Ghats in 2001 (1).

Discovery of the Indian Purple frog (*Nasikabatrachus sahyadrensis*) and its new family Nasikabatrachidae brought focus on Indian amphibians and accelerated the Indian taxonomic research. "This discovery also changed my professional life." adds Biju. Photo: S. D. Biju, 2018.

Frogs are to Biju what birds were to Salim Ali! If Salim Ali was the pre-eminent field biologist of India in the 20th century, then 21st century belongs to researchers like Biju. The media that called Salim Ali, the 'Birdman of India', now tags Biju as the 'Frogman of India!' (2, 3).

Herpetology is the study of amphibians (frogs, salamanders, and caecilians) and reptiles. The number of species of amphibians reported in India was only 206, when two decades ago Biju presented his first paper on this subject. It is more than 462 now — the credit for nearly 25 percent of the new discoveries goes to Biju (4). This includes two families of amphibians, 11 genera and 104 species (5). The Frogman of India has crossed a century and remains not out!

Every new discovery of a species is an unravelling of another great mystery of nature! Through his findings, Biju has unravelled more than a hundred mysteries hitherto unknown to humans! He is one of the only few living scientists in the world who have described more than a hundred amphibians.

Biju attained this rare achievement because of his decades-long arduous search in the inaccessible parts of Western Ghats and the north-eastern states of India — the result of the troubles and travails he underwent, come rain or shine. Roughly four months a year; that is, ten years in 30 years — that's how long his research took to study amphibians and impress upon the world the need for their conservation.

"There can be at least another 100 more nameless species awaiting scientific discovery from India. Time is limited, especially my own. I am simply driven by the fact that there are still so many unknown frogs and so little time."

Biju has published his findings in over a hundred scientific papers in international journals including *Nature*, *Science* and *Proceedings of National Academy of Sciences (PNAS)*. His discoveries have made news in influential media magazines across the world, such as *National Geographic*, *The Economist*, *BBC News*, *New York Times* and *The Guardian*, to name a few. On a simple Google search, over a million hits show up on 'S. D. Biju' and his work.

"Prof. Biju's work has not only given a much-needed impetus to Indian herpetology, but in general revolutionized taxonomic research across all the overlooked forms of life in the country." says Dr. Sonali Garg, Biodiversity Post-doctoral Fellow at Harvard University, and former student of Biju.

If the paper published in 2001 heralded the entry of Biju into the world of amphibians, the 2003 paper in *Nature* raised him to stardom. Biju and the Belgian scientist, Prof. Franky Bossuyt announced the discovery of a new family of frogs for the new genus and species *Nasikabatrachus sahyadrensis* in that publication (6). Using DNA, Biju and Bossuyt deciphered the evolutionary origin of this seven-centimetre-long frog to be 130 million years ago. The frog became a living proof that the Indian subcontinent was once part of the supercontinent, the Gondwanaland. Both the scientific and popular media called it a 'discovery of the century' (7), 'the living fossil' (8) and 'once-in-a-century find' (8, 9), — a thrilling episode in the recent history of global herpetology.

There was no looking back for Biju after the 2003 discovery. The University of Delhi invited him to join as a professor in a suo motu decision. Currently Senior Professor with the Department of Environmental Studies at University of Delhi, Biju is also academically associated with one of the world's most prestigious universities, the Harvard. He is currently an Associate at Harvard's Department of Organismic and Evolutionary Biology. Later this year, Biju will also officially go on to join Harvard as a Radcliffe Fellow, a competitive and prestigious interdisciplinary position for which he has been selected among a handful of leading professionals from the world over (https://www.radcliffe.harvard.edu).

Biju, a native of Kadakkal, Kollam district, in Kerala, South India, is stepping into where two of the greatest biologists of the 20th century worked – Edward O. Wilson, known as the 'Father of Biodiversity', and Ernst Mayr, the 'Second Darwin'. As he turns 60, Biju climbs a step further. To be included among the awardees of the first '*Kerala Sree*', one of the highest civilian honors conferred by the Government of Kerala for "priceless contributions to the society", could not have come at a more appropriate moment in his life. Biju has previously been honored with awards such as the IUCN/ASG Sabin Award (2008) and Sanctuary Asia Wildlife Service Award (2011) in recognition of his

Biju with Professor Franky Bossuyt, his guide for the second PhD he took on amphibians from Vrije Universiteit Brussel in Belgium. Photo: K. Jayaram, 2003.

Chikilidae, a new family of soil-burrowing and limbless amphibians described from Northeast India by Biju and his student in 2012. A guarding mother is pictured here along with her young ones developing inside the eggs. "It is a surprising coincidence that the second new family we discovered was also a burrowing one, living a subterranean life." says Biju. Photo: S. D. Biju, 2009.

contributions to amphibian research and conservation.

"Not many researchers can be as passionate about their field as Biju. At 60, he shows the same excitement and intensity towards his research as he had when he was 35", says Dr. Ashish Thomas, Assistant Professor at Delhi University, who did his PhD under Biju's guidance.

Biju's expertise spans from the field of taxonomy to evolutionary biology. With an evolutionary history of 350 million years, amphibians were the first animals to make a transition from life in water to the land. After bringing Indian amphibians and their unique evolutionary histories into limelight, Biju will expand his research at Harvard to better understand the evolutionary journeys of amphibians across the continent of Asia, using a wide array of advanced integrative approaches now available to organismic biologists.

Prof. James Hanken, former director of the Museum of Comparative Zoology at Harvard and current Curator of Herpetology, in reply to the author's query as to how a person of his stature at Harvard views Biju's research contributions, commented over email that "Prof. Biju's professional accomplishments and research record in the area of amphibian biology are, by any measure, first-rate, and he is seen as someone who can make important contributions to research efforts here and be a valuable research collaborator."

Taxonomy – A Timeless Mantra!

According to Biju, his two teachers were the ones who transformed his life: the late Prof. V. V. Sivarajan of Calicut University and Prof. Franky Bossuyt of Vrije Universiteit in Belgium. Prof. Sivarajan was a botanist who breathed a new life into plant taxonomy studies in India.

But what role would a plant taxonomist have in the life of an eminent amphibian researcher? Therein lies the twist! Biju was initially a botanist, who obtained his first PhD in Plant Taxonomy from Calicut University. There, Biju had two research guides. Prof. Philip Mathew under whose guidance he was formally registered, and Prof. V. V. Sivarajan, who was Biju's true mentor. "While I am grateful to Prof. Mathew for his role and support as my guide, I must acknowledge that Prof. Sivarajan was the one who taught me the basics of taxonomy," remembers Biju. "Taxonomy can be tedious, but he showed me how to work on it with enthusiasm for a sustained period. He inspired me to find pleasure in taxonomy. Without Sivarajan Sir, I would have never seriously considered the possibility of a career as a taxonomist." Biju believes that taxonomy is not meant for everyone. "Taxonomy is an art. It is not rocket science, but it requires a special talent that cannot always be taught. When you hold a specimen in your hand, you must get a feel of life!"

In 1999, Biju was awarded his PhD in Botany. Bizarre it might seem; he quit Botany the next year, but not taxonomy and systematics—only, amphibians replaced plants!

Biju had gained employment as a scientist at Jawaharlal Nehru Tropical Botanical Gardens and Research Institute (JNTBGRI) at Thiruvananthapuram, while doing his PhD at Calicut University. He officially worked there

Forest expeditions typically lasting several weeks and sometimes months are necessary to search for amphibians and an integral part of field-based research. "Many believe that fieldwork is just an excursion, and even funders often ask for travel budget cuts in grant proposals without really understanding the importance of field sampling in our research" says Biju. Photo: Systematics Lab, 2008.

Biju at the herpetological collection of MCZ, Harvard University. "One of the limiting factors for amphibian researchers in India is the accessibility of type specimens that are spread across more than 14 museums, of which over 50 percent are housed outside the country, mostly in Europe and some in USA." says Biju. Photo: Sonali Garg, 2022.

from 1992 to 2004. Back then, Biju also discovered new plant species during his explorations in the Western Ghats. *Stictocardia sivaranjinii* is one among them; a tribute to his guru, Prof. Sivarajan.

And then frogs discovered Biju, somewhere, sometime in one of those trips!

Biju has written that his attention was turned to frogs while attempting to take a photograph of Malabar Gliding Frog (*Rhacophorus malabaricus*) during a botanical expedition in the Western Ghats. Excited by the result, he started taking pictures of frogs whenever he came across one.

As the collection of frog pictures grew, so did his interest to learn more about them. "I began to read more, going over research and review papers in depth. I realized that there were lacunae in the scientific understanding of Indian frogs. I discussed with amphibian experts in the country at that point, but in vain, as many frogs could not be satisfactorily identified. Gradually, study of amphibians became a part of my life."

In fact, Biju was beginning to understand the mission of his life. First confined to the Western Ghats of Kerala, his research on amphibians soon spread over the entire mountain chain of the Western Ghats. Over a survey of seven years, he collected frog samples from nearly 500 locations in the Western Ghats. He sought the help of experts from outside India too during this period. In 1998, Biju got in touch with Prof. Robert F. Inger of Field Museum, Chicago, who gave him very valuable guidance, and many years later, even went on to become the jury Chairman for his second PhD on amphibians. Biju also interacted with several other international experts such as Prof. Alain Dubois (Museum of Natural History, Paris, France), Prof. Indraneil Das (University of Malaysia, Sarawak), Prof. Mark Wilkinson (Natural History Museum, London), and Rohan Pethiyagoda who first invited him to collectively study the Indian and Sri Lankan frogs.

Biju's first research publication on amphibians in 2001 was the outcome of a seven-year long, self-funded field work, silently studying and documenting frogs. Biju came to be noticed globally as an upcoming herpetologist with this publication. At the same time, he was awarded a fellowship of the French government to study the techniques of amphibian research at Paris Museum with Prof. Alain Dubois. During the three-month-long stay at Paris, Biju could examine the collections of Indian specimens at various European museums including the British Museum of Natural History.

But the kind of generous appreciation of his work shown by experts outside the country was absent from within his native country. "The 2001 paper brought me utmost criticism and ridicule," remembers Biju. "How could a botanist talk authoritatively on frogs, was the critics' question."

In that paper Biju cautiously predicted that there can be more than a hundred species of frogs yet to be discovered in the Western Ghats and that would take the total number of frog species in Western Ghats to 200 (1). This statement irked many. Some researchers at leading institutes even published articles challenging the prediction (10). "Now, two decades later the number has crossed 200. Those critics now refer to that prediction without mentioning my name," a smile spreads across Biju's face as he talks.

While the 2001 paper was being stone-pelted by critics, Biju continued his research and turned his focus to a discovery that would stun herpetologists across the world. Biju had obtained a frog specimen split into two by a spade. It was collected by a farmer who got it while digging for a well near Thattekkad, Kerala. He preserved it in a bottle of rum and gave it to Biju!

When further search in Thattekkad for the 'Double-cut' frog bore no fruits, Biju directed his attention to Kattappana, in the Idukki district of Kerala — to the 'Double Cut' village, to be exact!

Striking Gold of Gondwana

The Purple Frog (*Nasikabatrachus sahyadrensis*) is distinctive with its purple-colored skin, pig-like nose, tiny blue eyes, very short limbs, and a ball-like body. They live up to six meters underground all the time, except for a week at the onset of summer showers when they emerge above ground for breeding. Shaped like a tortoise and with a call like that of a chicken, the Purple Frog is between 5 to 10 cm long.

"I have never described even a single new species that I have not seen in life myself. It is of utmost importance for me to personally observe those animals in their natural habitats and sample necessary data for species descriptions."

"The Malabar gliding frog (*Rhacophorus malabaricus*) was the first frog I photographed. I was so captivated by its beauty that I started to chase more frogs" said S.D. Biju. Photo: S. D. Biju, 1995.

The specimen from Thattekkad Biju got in 1997 was the first inkling about this strange creature. "Most villagers around the Western Ghats region knew me; I was the crazy one looking for frogs, running around on a Yamaha scooter, shaggy and shabby. Neither did have I much money nor my family could help much."

"It was clear that the Thattekkad specimen was different from the known frog species. Though I was penniless, I spent several days searching for it but failed to get one. We didn't know then that it had a subterranean life." But Biju didn't give up hope. When Biju along with his friend and wildlife photographer Sali Palode met the locals at Kattappana, they said the frogs appeared every year and that they have seen them at a place called 'Double Cut.'

"Had I not pursued a second PhD with Prof Franky Bossuyt and described Nasikabatrachidae, my professional life would not have been the same."

"Jayan, a local man, assisted us. I stayed at Jayan's humble house for about a month during the rainy season in June–July, watching out for the Purple Frog, but with no avail. In the following year, towards the end of the month of April, Jayan called me: 'Sir, two of them have come out! I have kept them safe in a pot!' I caught the next bus to Kattappana."

"Such a treasure it was! I cannot describe the day I saw it. Because any frog expert could see that it was no ordinary frog! Further digging at Double Cut, brought up more Purple Frogs."

Genetic studies linked with taxonomy weren't much developed in the country in those days. Those who did such studies were yet to see beyond microscopes. But Biju decided to do molecular studies on the Purple Frog. "The late Dr. J. Nagaraju, a scientist at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad, helped me obtain a DNA sequence of this frog. I went to him with the samples, stayed there for five days and learned the basics."

Biju remembers: "When I decided to drop botany, I was left with two options - one, to live a life of lies for the rest of my life, pretending to study botany and do other work, or resign from my job. Giving up a job was a great risk in those days. The sole source of income would be cut off. I did not know what to do. All I knew was that I wanted to study frogs. Only my wife knew that I was planning to resign from JNTBGRI. And she supported my decision."

It was then that Biju seriously considered taking a PhD in herpetology. He had found another guru like the late Prof. V. V. Sivarjan, who changed the future course of his

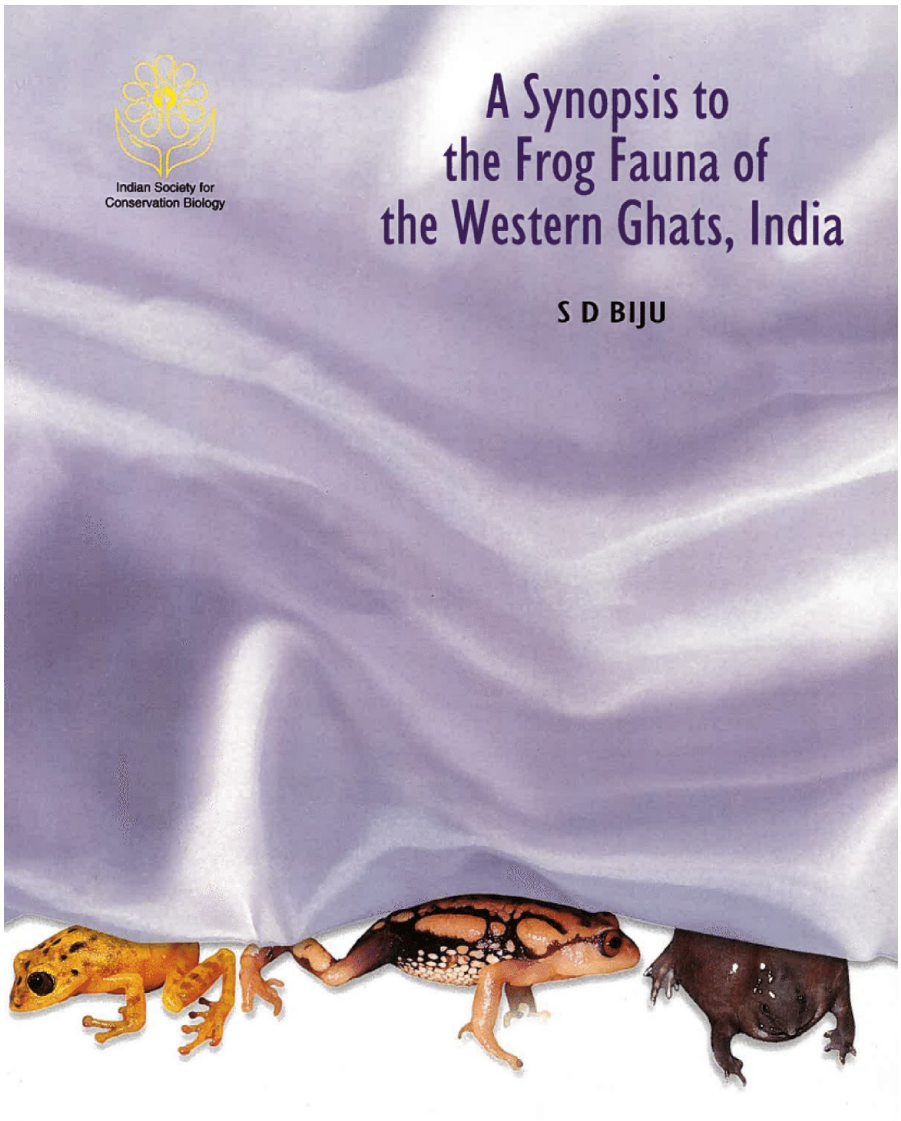
S. D. Biju at a field site along with Anil Zacharia and S. P. Vijayakumar in Parambikulam Tiger Reserve. Photo: K. Jayaram, 1999.

life — Prof. Franky Bossuyt of Vrije Universiteit in Belgium, who one fine day serendipitously contacted Biju after reading his publication from 2001.

A detailed genetic study of the Purple Frog was conducted together with Bossuyt. The study made it clear that the frog did not belong to any of the 29 families previously known. Biju and Bossuyt were enthused over the fact that they have brought to light a new family of frogs for the first time since 1929. Thus, Nasikabatrachidae became the 30th family of frogs known to the world.

There are three orders of amphibians: Anura (frogs), Caudata (salamanders), and Gymnophiona (caecilians). A large majority of species are frogs. Global databases for amphibians (4, 11) state that so far about 7600 species of frogs spread across 56 families are known globally. The number of known salamanders stands at 810 and caecilians at 221. Caecilians are limbless amphibians that look like large worms or snakes and live underground. The second amphibian family that goes to Biju's credit is the caecilian family Chikilidae that he unearthed from Northeast India in 2012 along with his PhD student (12).

The Resplendent Shrub Frog (*Raorchestes resplendens*), a unique ground-dwelling rhacophorid frog found in a small region in the Anaimalai Hills of the Western Ghats, was discovered by Biju and co-researchers in 2010. Photo: S. D. Biju, 2007.



The first scientific article on amphibians published by S. D. Biju in 2001 summarised the results of his seven-year long and extensive field research in the Western Ghats and announced the existence of at least 100 new species of frogs. Since then, researchers have described over 150 new species of amphibians from India. "This publication is still my personal favourite out of all the articles published even in leading journals of the world." says Biju.

It was clear from the genetic studies on Nasikabatrachidae that its evolutionary history goes back to the Gondwana period. It has no relatives in India. Biju and Bossuyt discovered that a frog living in the Seychelles Islands, about 3,000 kilometers away in the Indian Ocean, has a distant genetic resemblance — making it the only known closest relative of the Indian Purple Frog!

Further studies indicated that these Seychelles Island Frogs or Sooglossidae and *Nasikabatrachus sahyadrensis* had parted ways about 130 million years ago. The Nasikabatrachidae did not undergo much change since the age of Dinosaurs.

Biju and Bossuyt used phylobiogeography (study of the historical processes of geographic distributions of genealogical lineages) to trace the evolutionary path of this new family Nasikabatrachidae. "To put it in simple words — we used computer-based programs to estimate the date of origin of this frog using DNA sequences. Such a technique was in its infancy

This tiny colourful Shrub Frog (*Raorchestes beddomii*) belongs to the most speciose amphibian genera found in India. All members of this group exclusively undergo direct development and lack free swimming tadpoles. Photo: Sandeep Das.

when we worked with it. It is much more advanced now. Nonetheless, it became evident that Sooglossidae and Nasikabatrachidae shared an ancestry from the Gondwana times."

In 2003, Biju became a star overnight when the *Nasikabatrachus* discovery was finally published in the journal *Nature*. But his detractors didn't rest. "They said this was not my work!" Biju recollects. It was an achievement that many holding authority in the field could not make. "I take it as a blessing in disguise that made me only work harder. And as I look back, maybe there wouldn't exist the Biju of today if the '*saga of Nasikabatrachus*' hadn't happened in my life. The Biju minus *Nasikabatrachus* would not have been me. Unknown, uninteresting, I would have been around somewhere. But not this Biju!"

The Borderless World of Research

Biju joined Vrije Universiteit in Belgium for PhD under Prof. Franky Bossuyt after resigning from JNTBGRI in 2002. His research focused on the systematics and conservation of amphibians; the degree was awarded in 2007.

But even before that, in 2005, an unexpected phone call was received at the office of his then PhD guide. The person on the line wished to speak to Biju. Personal mobile phones were not common back then, and even if they were, Biju didn't own one. "The Delhi University authorities invited me to join as a faculty member when I was still working in Belgium." Biju recalls. "The then Vice-Chancellor of Delhi University, Prof. Deepak Nayyar and Pro-Vice Chancellor, Prof. C. R. Babu had taken the initiative. I was skeptical but Dr. M. Sanjappa, the former Director of Botanical Survey of India, who was familiar with my work from my early plant days, greatly encouraged me to join. I wouldn't be here if it wasn't for him!"

Biju had certain requirements: one, that he wouldn't start work in Delhi until the submission of his PhD thesis at Vrije Universiteit, Brussels. So, "I was appointed as Reader at Delhi University in 2005, but I came to Delhi only in 2006". After completing three years as an Associate Professor, and another ten as Professor, Biju is currently a Senior Professor at the University, and has served as the Head of his Department and the Dean of the Faculty of Science.

Second, "I needed a laboratory space in Delhi as well as funds for setting it up." Both were readily offered. An excellent molecular lab and related paraphernalia came next. That was the beginning of the Systematics Lab (https://www.frogindia.org) at

India's smallest frog (Miniature Night Frog, *Nyctibatrachus minimus*) sitting comfortably on an Indian five rupee coin, was another species discovered by Biju and co-researchers. Photo: S. D. Biju.

The LOST! Amphibians of India (LAI) is a nation-wide citizen science and conservation initiative started in 2010 under the leadership of S. D. Biju with the support of International Union for Conservation of Nature (IUCN), Critical Ecosystem Partnership Fund (CEPF) and Conservation International, USA, for rediscovering India's 'lost' species. This lost species (Chalazodes Bubble-nest Frog, *Raorchestes chalazodes*) was rediscovered in the Western Ghats after 136 years. Photo: S. D. Biju.

Delhi University for the study of amphibians. His lab studies anything and everything about amphibians, but primarily systematics, that includes nomenclature and classification and deciphering systematic relationships using morphological, molecular and various other integrative approaches, as well as evolution, biogeography, reproduction, vocalization and conservation.

But a well-equipped lab alone would not serve the purpose; samples of amphibians must be collected. For that one must take to the forests. "I am not in Delhi for about four months in a year, but in the field," stated Biju.

Prof. Deepak Pental had replaced Deepak Nayyar as the Vice Chancellor. He didn't know Biju, but it took him no time to understand the importance of Biju's work. He extended his unconditional support towards his scientific mission. "Prof. Pental was the reason I continued to work at Delhi University. He took pride in the work we produced here in our small lab and always warmly referred to me as a colleague!" In gratitude, one of the frogs discovered by Biju is named after Pental.

The two-month summer vacation period at the University coincides with the monsoon in the Western Ghats and Northeast India, where it rains mainly in June, July, and August. "To that I add my eligible leaves, altogether giving me four months for field work." He adds, "I also often try to maintain a fitness regime — not for a longer life, but to keep my health for hard field work in the jungles." For the rest of the year, he and his students work on the samples collected during the field season.

A series of high-quality papers on amphibians began flowing out of Biju's lab from 2006 itself. Soon, the Systematics Lab became one of the most active research centers of herpetology in the world. 'Delhi University' was frequently mentioned in international media. Students from foreign nations sought research possibilities at Biju's Lab. He has guided students from countries such as Ireland and Belgium at his lab.

Though he joined Delhi University, Biju did not forget his role model, Franky Bossuyt. Like the plant he named after Prof. Sivarajan, Bossuyt's name was given for two frogs – *Frankixalus jerdonii* discovered from the Northeast and *Mysticellus franki* from the Western Ghats.

Dr. M. Sanjappa, the former Director of Botanical Survey of India (BSI) and INSA Senior Scientist, has known Biju since his Calicut University days. "He does his research work with total dedication" – says Sanjappa in an email communication. "At JNTBGRI, Biju did floristic and ecological works in Silent Valley National Park, Eravikulam National Park, and other such protected areas of Kerala State. It is here that he developed his fascination for working on the taxonomy and the biology of frogs for which he literally spent whatever salary he was getting from JNTBGRI and any available family funds. His dedication was such that he would use his holidays for field study and rear and breed frogs at his residence in his makeshift laboratory."

"One cannot truly discover a new species until they closely study and compare them with other known and related species. In other words, while all discoveries are accidental, a confirmation of such findings entails much more investigations to gather further necessary scientific evidence."

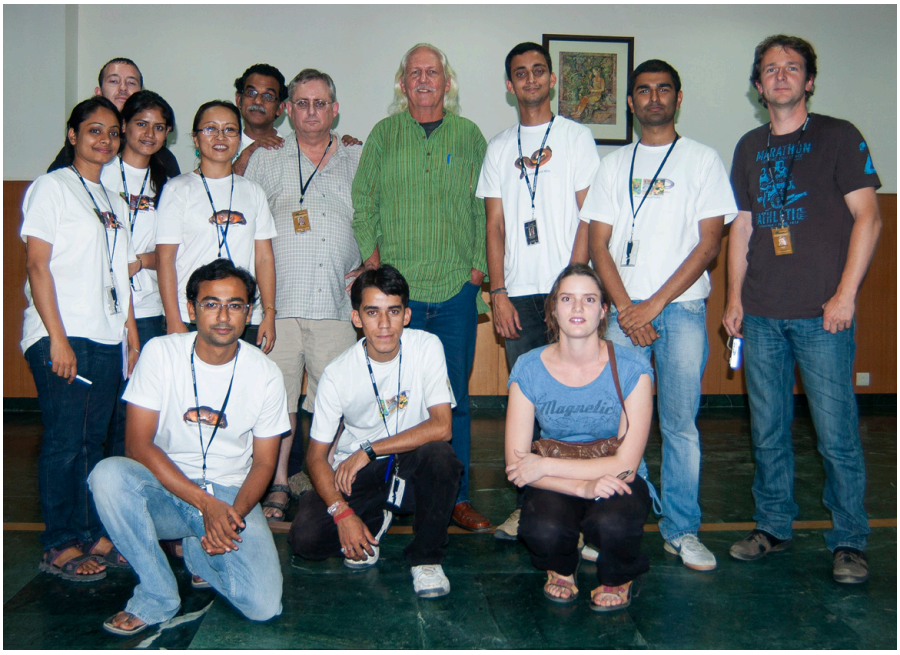
Biju and his co-researchers have discovered 14 new species of dancing frogs, a family exclusively found in the Western Ghats mountain range of India, as well as studied their unique foot flagging behaviour and fossorial tadpoles. Photo: S. D. Biju, 2016.

Biju extends the same care he has about his gurus to his students as well. "Biju Sir leads us on our field trips as if we are on an army expedition. He might seem very strict from afar, but actually he is very considerate of his students," says his former student, Dr. Ashish Thomas.

Biju has two exceptional qualities as a researcher, says Ashish — "extraordinary memory and ability to foresee the future. He can correctly recollect when and where he saw a particular frog even after years. He is always on the alert for probable changes in the existing conditions. He has the farsightedness to predict what aspect of frog studies would be relevant, what technology would be more applicable in the forthcoming years. What took him to Bossuyt's lab in Belgium is his correct anticipation that molecular studies of amphibians would take centerstage in the near future." Ashish Thomas spent six years from 2008 onwards in Kattappana, studying the Purple Frogs under Biju's supervision.

"As a teacher and mentor, Biju Sir leads by example! His passion, determination, and persuasion are contagious. His contributions to my professional life are far more than those of my parents," says Dr. Sonali Garg, also his former student. "He inspires and supports his students in every possible way. He spends most of his personal earnings on research, be it for field work or lab facilities. Our work never stops as long as there is salary remaining in his bank account. He even helps students during their personal financial difficulties. He always recalls that many people helped him during his early and difficult days, so he knows how much a single meal or a small contribution matter." Sonali has worked with Biju for over 12 years, right from being his Master's and PhD student, to their continued scientific collaboration for her postdoctoral studies.

Sonali adds, "His work is his life — and he works with all his heart; and anyone who knows him closely has seen his heart of gold," as a sense of deep respect rings in her voice. "Biju Sir is a rare specimen. From where he came, to what he has achieved, his contributions to frogs, science, and society will remain unparalleled. History will be kind to him and stand testimony, whether people choose to say it out aloud or not!"



Former masters and PhD students of Biju and members of his lab (Systematics lab, www.frogindia.org) at University of Delhi along with Prof. Darrel Frost (AMNH, USA), Romulus Whitaker (Madras Crocodile Bank Trust and Centre for Herpetology), and Prof. Franky Bossuyt (VUB, Belgium). Photo: Gopinath Sricandane, 2010.

Biju enjoying a celebratory moment after his PhD defense at VUB Belgium, along with some of the jury members. Pictured here from left to right are Dr. David Gower, Dr. Robert F. Inger (Jury Chairman) and Prof. Ludwig Triest. Photo: Franky Bossuyt, 2007.

Frog *Kamasutra*

The way Biju was once introduced by an American colleague was rather unexpected. "The only frog herpetologist ever to appear on a Stephen Colbert's Late-Night Show! Only then did I realize the importance of this TV show. Our research had made it to the drawing rooms of common US homes." laughs Biju.

Stephen Colbert's Late-Night Show is a popular program in the US TV channel, the CBS. The late-night show in June 2016 talked about the discovery of a peculiar reproductive behavior in Bombay Night Frogs (*Nyctibatrachus humayuni*) that was published in the journal *PeerJ* by Biju and his colleagues (13).

Until the publication of that paper, researchers had observed that the then 6650 frog species in the world mated in six different positions. But Biju and fellow researchers found that there was a seventh amplexus position, unique for the Bombay Night Frogs! They named it 'Dorsal straddle'! (14)

While disgorging sperm, male frogs position themselves to ensure that the sperm reach the maximum number of eggs. But in the case of Bombay Night Frogs, the male deposits sperm while in an embrace from behind and removes himself as soon as the female spawns eggs. Spermatozoa trickle down the female's back to join the eggs and fertilize them.

The seventh 'sex' or amplexus position in frogs - Dorsal straddle – was discovered in an Indian frog by Biju and co-researchers. The Bombay Night Frog breeds differently from all other frogs, as the female releases eggs without a male on her back. Pictured here is a male Bombay Night frog calling with the help of two inflated vocal sacs to attract a female for mating. Photo: S. D. Biju, 2012.

If frogs have a Kamasutra, this study added a new chapter to it!

This 2016 study shows how difficult and exciting amphibian research can be and that it is more than discovering new species. Biju first noticed the mating behavior of Bombay Night Frogs in 2002 at the Koyna Wildlife Sanctuary in Maharashtra. But it took him years to study it.

A three-hour walk through dense forests from Humberli village in Koyna Sanctuary takes you to a forest stream that gushes out from cracks in laterite rocks. That was the area selected for the detailed study of Bombay Night Frogs. A team of four spent 40 nights continuously in the heavy rainy season. "We made our observations using photographs and video recordings. We shot nearly 100 hours of video footage using multiple cameras. Most events were recorded with the help of infrared cameras, without the use of flash, to avoid disturbance to frogs during the entire mating process," says Biju.

The researchers did not focus only on the mating. They noted several other peculiarities that opened the doors to the secret life of these frogs. One was that the females also called to catch the attention of the male frogs! According to the study, only in less than 0.5 per cent of all known species of frogs were the females calls ever documented. Among the rest, it is solely the male's duty to advertise himself through calls.

Behind each of the 104 species of amphibians that Biju has formally discovered and described there are such stories and more –104 amphibians mean 104 stories, 104 reasons for nature conservation.

Not only is Biju the first frog expert to appear in a popular late night TV show, but also the first of his kind to appear on the cover of *The Economist* published from London! Emma Duncan, one of the editors of *The Economist* spent days and nights with Biju and his team in the forests of Agasthyamalai region in southern Kerala for the cover story of 2011 Christmas special!

Biju is also an accomplished photographer and scientific illustrator. Prominent scientific journals and popular magazines like *BBC, National Geographic, New Scientist, Outdoor Photographer,* and *The Economist* have published more than 300 photographs and 200 scientific illustrations drawn by Biju!

Sathyabhama, Das and Biju

Biju is world-famous today, a top scientist in his field of research. But when looking at his childhood, one wonders if someone who grew up in meagre financial circumstances could thus evolve into a world-renowned researcher. The bittersweet truth is that today's Biju is the creation of his combat with the adverse conditions and penury in his younger days.

Of the amphibian species described by Biju, 40 are named after persons who helped Biju in this journey. Two frogs described by other researchers have been given Biju's name - *Beddomixalus bijui*, discovered in 2011 from Kerala by herpetologist Dr. Anil Zachariah and team, and *Bijurana nicobarensis*, described from Nicobar Islands by a joint team of Indian and Indonesian researchers in 2020.

"Many have asked me why I haven't named a frog after my parents. I reply that my parents hold a much higher place," says Biju. "I even take their name before mine!", he laughingly adds pointing that his name is literally that. His parents are no more.

Biju was born in 1963 as one of three children of Sathyabhama and Krishnan Das of Idakkaryatthu

Frog species named after S. D. Biju: *Beddomixalus bijui* by Anil Zachariah and co-researchers in 2011 (left) and *Bijurana nicobariensis* by S. R. Chandramouli and co-researchers in 2020 (right). Photos: S. D. Biju.

Puthen Veedu in Kadakkal. He has two sisters — Mini the elder, and Biji the younger. His father was a local political leader. "He would often compete and fail in Panchayat ward and co-operative society elections," Biju laughs. This left his father little time to be involved in household affairs, and it all fell on his mother's shoulders. As a child, Biju shared the burden of caring for the family with his mother. His main occupation was to assist his mother. Going to school was secondary to keeping hunger at bay. "My mother struggled a lot to raise and educate me."

Biju's early education suffered because of the lack of sufficient resources at home. His proper education started much later in life. But he ended up doing his Pre-Degree at NSS College, studying in the IInd group (Biology). After completing his B.Sc. at University College, Thiruvananthapuram, in Botany in 1985, he did his Master's at Sree Narayana College, Kollam in 1987.

"It was at the fag end of my M.Sc. days that I met Prof. Sivarajan of Calicut University. It became my cherished dream to study under him. I already knew that I would work in taxonomy." We now know the life of Biju after arriving in Calicut University for his PhD in Botany; and like they say, the rest is history.

Biju married Dr. Anitha, who was a co-researcher in Calicut University, pursuing her PhD. While Biju's PhD was in Plant Taxonomy, Anitha's was in Plant Breeding and Genetics. The couple has two children — Anju Parvathy pursuing her doctorate in English Literature from Pennsylvania University in USA, and Kalyani Biju, third year student of BDS at Amritha Institute of Medical Sciences at Kochi.

INTERVIEW

ROOTS AND RISE OF A 'FROGMAN'

From his roots as a plant taxonomist, Professor S. D. Biju (Sathyabhama Das Biju) evolved rapidly into an amphibian biologist of international repute. The scale and significance of his achievements brought him the unofficial title of 'Frogman of India'. Biju is a Senior Professor in the Department of Environmental Studies at University of Delhi and an associate of the Department of Organismic and Evolutionary Biology at Harvard University. He was recently awarded the prestigious Radcliffe Fellowship for the year 2023-2024 to work full-time at Harvard. He will work closely with the department and the Museum of Comparative Zoology. He spoke to *Joseph Antony.*

Joseph Antony (JA): Don't you feel scared exploring forests in the night, looking for frogs and other amphibians?

S. D. Biju (SDB): In the early days, yes, I was terrified! But probably my childhood in a village helped to overcome the fear. Like most village children, I was familiar with snakes — throwing stones at them or catching frogs with hooks. With age I developed more love and respect for these animals. And who ever knew that my life would one day revolve around them. Usually, I would be in the field well into midnight, like until one o'clock. Then after returning from the forest what I saw and learnt needs to be documented. It'd be three in the morning when I go to sleep. An indigenous person from the Northeast once remarked that I am like a frog— both are nocturnal! There are many constraints during field studies; you must manage work with many limitations — sometimes one has to go without food! No stranger to starvation as a child, I could easily go without a meal or manage in any adverse circumstance during tough field trips. This has all now become part of my life.

JA: Could you tell us something about the pathfinders, the guides who assisted you during fieldwork?

SDB: It is always the local people of each particular region who have been of great help in my fieldwork. Like the late Bhagavan Kani, his son Mallan Kani and Vijayan Kani in the Kerala part of the Western Ghats. They are from the Chathankode Kani tribal settlement near Bonancaud Estate in the Agasthyamalai Valley. They taught me how to walk in the forests. I had a previous life as a botanist. Bhagavan Kani took me around then. When I returned looking for frogs, again it was him who showed me where to go. Bhagavan Kani would teach us about forests. Sometimes he'd say: "Sir, we have to move from here, now, immediately!" No questions asked. Only when we moved, we'd realize that there was a wild elephant close by! Later Mallan and Vijayan became my guides. They have been with me not only in Kerala but also in the other parts of Western Ghats of Tamil Nadu, Karnataka and Maharashtra. In fact, they are better than me at identifying frogs! No point in flexing your 'scientist muscle' with them; the indigenous people are experts. They know where the frogs are, when and how they call. They even have their own names for many frogs that relate to their specific traits; that always surprises me!

JA: What do you read, other than what is related to your studies?

SDB: I am at the threshold of 60. I work for 16 hours every day. Frog study may seem absurd to some, but this is a realm of research which is highly vibrant. You'll be obsolete if you do not update yourself then and there. So, my extra reading, outside of my research interests, is limited. Not only that, one cannot but avoid many occasions like family get-togethers, attending weddings, et cetera. On the once-in-a-blue-moon visits to my native place, my friends would make

fun of me saying that I am busier than the Prime Minister! I am like a kid when it comes to publishing my studies. I am crazy about it! Nothing can beat the sheer joy of seeing my research article published, not even what you may write about me! When my paper appears in a journal, I would read it five or six times, on the very first day of publication! In a way, the kind of work people like me do is boring. Turning 60, I do the same, repetitious work every day. But the secret of success, be it for a nuclear scientist or a taxonomist, lies in how to overcome the monotony.

JA: Why are frogs important?

SDB: Simple question, but complex to answer. This is the most common question I get asked at gatherings and it provokes me. Nobody asks why tigers are important. Nobody asks what is the use of humans? Not in retort, but I always ask — isn't this reflective of our human-centric attitude that believes that humans were created by a super being in order to lord over all other life forms? Look at the Indian scenario. There are no conservation programs, nor any mention about the so-called lower and non-charismatic species like frogs anywhere in the conservation agenda of the government. There are conservation programs for elephants and tigers. Isn't this an alarming trend? Conservation would be pointless when it is focused on a few species instead of conservation of species in its entirety. Homo sapiens is also a species, and we are a part of nature's intricate web. This mindset has to be strengthened. If we need to survive, we must survive together. Our species cannot survive by itself. It should be realized that conservation is a condition necessary for our survival too.

Frogs are also a small, yet significant, part of the wide spectrum of an ecosystem. Our survival is dependent on such billions of life forms. If frog populations in a particular habitat are healthy, we may safely assume that the health of other species in the habitat too is likely intact. The highly permeable skin in frogs is sensitive to even the slightest of change in the environment. So, a decrease in the number of frogs in a locality or an observable change in their breeding patterns is a sign of critical change in their habitat. As the number of frogs decrease, so would that of other species coinhabiting such waterbodies and wetlands. As environmental indicators , frogs are the herald of ecological balance. That's why they are also called 'Environmental Barometers.'

Mallan, Vijayan and Biju preparing a meal at Mallan's home in the Chathankodu tribal settlement of Agasthyamalai Hills. "Mallan and Vijayan have been my field companions for over 30 years. They have taught me the language of the forest and the animals I study and encounter. Their contribution to my research is invaluable." says Biju. Photo: Gopinath Sricandane, 2016.

In an ecological pyramid, there is a fine balance in prey-predator relationships. If that breaks, the entire ecological food web gets disturbed. At the same time, we need to understand that every species requires a specific kind of habitat for its survival. Take the case of tigers (many might relate with a tiger rather than a frog!). Tigers are not found in all kinds of forest types. They need a certain kind of natural prey base to survive. But if we conserve tiger habitats, that does not mean we are necessarily conserving every form of life, in every other forest type. The concept of an umbrella species would apply only to a small number of co-existing species in tiger habitats, which are not always the most diverse habitats of them all. That is why, conservation cannot be centered around a handful of mammal species. Such approaches especially neglect the lower forms of life and overlook their specific conservation requirements. Now look at frogs. In the food chain, frogs form an important part of the diet of many other animals such as birds and snakes. If their populations decline, the entire ecological pyramid will collapse. That is why they are called the 'conveyor belts of life'. Such is the ecological function of frogs.

The ancestors of modern frogs and other amphibians were the first creatures who transitioned from aquatic to terrestrial life. This shift was critical to the booming biodiversity of animal species that evolved on land. Then came the reptiles, the birds, a surge in vertebrates. Later evolved the mammals including humans. Amphibians represent this important evolutionary link between life in water and land. The relevance of frog studies does not end here. Birds can fly from one island to another, snake can swim over. But frogs are the only vertebrates that cannot tolerate or cross the salty sea water to reach other islands or continents. Thus, frogs offer us the best opportunity to study the diversification and distribution patterns of animal life across various biogeographical barriers, both in the present and the past.

Another significance of frogs is related to medical science that always seems more exciting to us humans. The chemical secretions found in the body of several frog species are resistant to viruses and bacteria. This is highly relevant for human healthcare. Many high-impact studies have been conducted on this topic. For example, morphine, though widely used for pain relief, has its side effects. But a chemical found in the skin of a particular frog in the Amazon forests has proven to be much more potent than morphine and without the latter's side effects. Such substitutes are already studied and available in the market now.

JA: Why are there too many species, especially undescribed species, in India?

SDB: There is a combination of several reasons behind the high levels of biodiversity and endemism in India. India has a unique geological history. Several million years ago the Indian landmass separated from the supercontinent Gondwana, specifically from the African regions. As India drifted northward, it was like a floating island, surrounded with water without any connections with other continents. Scientists have given it a term 'biotic ferry' that ferried many plants and animals from one part of the globe to another, across a vast ocean. This journey lasted several million years. During this long isolation India also experienced several geoclimatic changes. Life forms started to rapidly diversify to exploit a wide range of new habitats, especially in regions like the Western Ghats. Altogether many diverse life forms

evolved that could not disperse to other regions. This is why we not only have a high number of species but also a very high number of those that are not found anywhere else in the world.

But these species have existed all through the modern times. Then comes the second part of your question about a high number of undescribed species. The simplest answer is: we didn't work hard enough or look at them closely. Many more researchers are now carrying out dedicated surveys and studies in previously unexplored regions. We also have access to modern techniques, such as those required to study and compare the DNA of species. These have churned up scores of undescribed species that remained unknown to science - and much more rapidly than we could, using traditional approaches. The number of known species in all the studied groups have gone up by several folds, especially in the last two decades. Amphibian species have more than doubled. And this is not the end. We are still discovering new life forms every day from remote parts of the country. There are still many lesser-known groups that remain overlooked. We need an army of field biologists, taxonomists, and evolutionary biologists, to fully document and understand India's unique biodiversity.

"My favourite quote that resonates with me is the one made by Edward O. Wilson - "Without a trace of irony I can say I have been blessed with brilliant enemies. I owe them a great debt, because they redoubled my energies and drove me in new directions"."

A nameless species of frog! "Currently 462 species are known from India, of which I have been fortunate to discover and formally describe 104 new species along with my co-researchers. But our work is far from complete and we still do not know the exact number of species found in our country". says Biju. Photo: S. D. Biju, 2022.

While we document our species, the scientific concept of species itself is evolving. What we called a species three centuries ago, cannot be applied to improve our understanding of life we know today and its conservation. Similarly, our concept of a species today, can transform tomorrow. Species names may or may not exist. But our discovery of these unique and distinct evolutionary lineages will always remain important and valid. That is the beauty of taxonomy, and all of science.

JA: How many research scholars have you guided? How many are there now?

SDB: My first PhD student was a Belgian. She had registered under the guidance of Prof. Bossuyt and I, when I was in Belgium. Five scholars did PhD under my supervision after that. It is not the number of students I have guided that matters to me, but the quality of researchers I produce in the process. I never want my students to be unemployable. So far, all my students have done well for themselves. Two teach

The iconic Silent Valley National Park of Kerala in the southern Western Ghats, part of a leading biodiversity hotspot and centre for global amphibian diversity and endemism. "I love my country primarily because of its rich biological diversity inhabiting a wide range of ecosystems and forest types, right from tropical evergreen rainforests to ice-covered mountains and deserts." Photo: K. Jayaram, 2007.

at Delhi University, one is a research professor in Belgium, another two are scientists at the British Museum, and one is at Harvard University. Currently seven young researchers are pursuing PhD under my guidance.

JA: How did Harvard happen?

ASB: Harvard just happened to be the right opportunity, at the right time! Science is always rapidly advancing and as researchers we need to also evolve. I am always looking for ways to expand the scope of our research and the capabilities to do so. Harvard has the facilities, and most importantly, a culture of promoting basic sciences, even biodiversity research and taxonomy. To work in such an environment is refreshing and rewarding. I am fortunate to have an opportunity to work full-time at Harvard as a Radcliffe Fellow and pursue some exciting collaborations with researchers across the University. This includes departments that directly align with my research interests, such as the Department of Organismic and Evolutionary Biology and the Museum of Comparative Zoology, but also a much larger interdisciplinary community of scholars and professionals at Harvard's Radcliffe Institute.

JA: How do you see being conferred with the first 'Kerala Sree' Award?

SDB: Of course, it is a great honor, and not the kind I ever imagined I would get. I am just a crazy frog scientist going about my usual business. This has come as a surprise. Not often does one get recognized at home — it is even less common in Kerala. We usually have no qualms in inviting people to institutions and committees from any place, even if they may be far removed from the desired subject expertise. But I feel there is a tendency to neglect home-grown talent. Apart from this, being recognized for work on a tiny group of animals – frogs – and that being given importance in the wide award category of science is not common. This award therefore is not only for me but is a recognition for researchers like me that represent such overlooked forms of life, and taxonomy, a basic and necessary branch of science. Given this background, *Kerala Sree* Award will hold a special place in my heart.

JA: How would you evaluate your contributions to the society?

SDB: My straightforward answer is: I made an impact. My work has shown that the study of smaller animals like frogs

Biju conducting at a workshop for young amphibian researchers of Indonesia organised by the University of Indonesia in 2017. "When you ask what is my contribution to taxonomy other than my research, I think I have made an effort to popularise amphibian research among professional scientists, amateur naturalists and the common public, through research, education, trainings and awareness programmes" says Biju. Photo: Sonali Garg.

Biju receiving one of Kerala state's highest civilian honours - '*Kerala Sree*' - from the Governor of Kerala, Mr. Arif Mohammed Khan, in the presence of the Chief Minister of Kerala, Mr. Pinarayi Vijayan, at Thiruvananthapuram. Photo: PRDO, 2023.

do hold significance in India. The sheer number of amphibian discoveries that have come out from India during the past two decades is remarkable. This has brought fresh fascination on frogs and attracted young researchers to the field. This impact could be made not only due to intensified research but also because the outcome of these studies could be brought to public notice through media. Amphibian awareness and conservation programs like the 'Lost! Amphibians of India' were effective in awakening public interest in the subject. A crop of new frog enthusiasts came up and they could be taken to forests for frog watching in the night. The impact created 'frog watchers' of a different kind, engineers, doctors, to housewives. I think this triggered a great interest in not just frogs, but other similar overlooked forms of life, from professionals to the common people across a wide cross-section of the society in India.

JA: How do you view the contribution of the new generation of Indian researchers in field biology?

SDB: Whether in Kerala or the whole of India, a host of young researchers are now studying smaller, previously overlooked forms of life. Several are excelling in their subjects of expertise, including taxonomy, and are contributing to

A mother caecilian coiled around and guarding her eggs. "This is a remarkable example of parental care. This mother continues to be curled around these eggs till they hatch, presumably without eating for nearly 25 days" says Biju. Photo: S. D. Biju.

biodiversity research and conservation in India. They are doing better than me and my generation and this gives me hope for the future. At the same time, we need to do more to recognize these young scientists. If not, it will become increasingly difficult to sustain the brilliant researchers we are attracting to these fields.

JA: What is your response to the comment that "Dr. Biju is arrogant?"

SDB: As a little boy I used to walk to school with a broken slate board after selling milk at a shop and giving my mother a few paise. I started learning late and was like a sprinter who went off the block last. Formal education starts like a ritual for everyone early in life; it became a priority for me only after a ripe twenty. I would never catch up with the rest if I did not run much faster. I had this doggedness when I started. I have had frustrating times at the beginning. My language skill was limited to Malayalam, my mother tongue. English was alien but science was in English. It was very difficult for me to take notes while studying at University College. I could not complete a sentence on my own. The determination to succeed that flared up in me was not to beat anyone but to prove that I can achieve on my own. That shot me forward. A sense of purpose gave me sustained focus and energy. Even the political leanings I once had were dropped on the wayside. To excel in my chosen world became my mantra; I did not have time for anything else. Maybe my undivided attention to academic pursuits gave an impression of me being arrogant; my madness and struggles may have come by as rough mannerisms. I have spent neither time nor effort to change such perceptions. Those who know me understand what I truly am. I came from an ordinary rural background and worked hard to stand shoulder to shoulder with those from elite, privileged upbringings. I never had a godfather, ever! I may not be polished like others, but I am a self-made man – I am actually proud of it.

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AUTHOR'S STATEMENT: I first contacted Biju in 2003 when he published his discovery of the Indian Purple Frog. I wanted to cover a story for Mathrubhumi. Ever since, I have closely followed his research and reports on his various discoveries and contributions. This interview was conducted through a zoom meeting on 22 November 2022 and follow up communication. An abridged version of this article and interview appeared as a cover story in *Mathrubhumi Weekly* on 15 January 2023 (*Future Shock*).

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