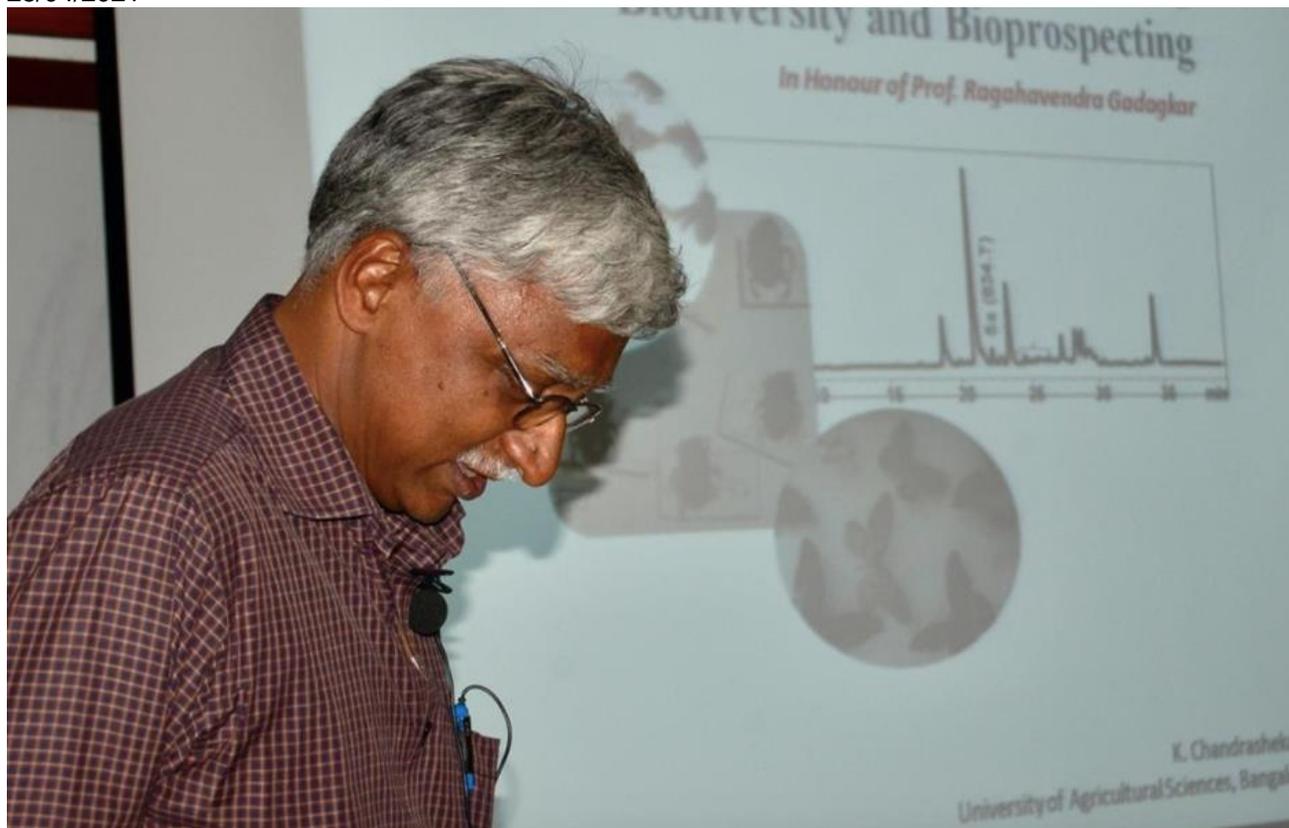


# More Fun Than Fun: Chandru's Inordinate Fondness for Insects

28/04/2021



*Krishnappa Chandrashekara delivering a lecture during the 'Being Social' symposium organised by the author's students in June 2013 at the Centre for Ecological Sciences, IISc. Photo: RG Lab Collection*



*This article is part of the '[More Fun Than Fun](#)' column by Prof Raghavendra Gadagkar. He will explore interesting research papers or books and, while placing them in context, make them accessible to a wide readership.*

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The evolutionary biologist and polymath J.B.S. Haldane is said to have remarked that “The universe is not only queerer than we imagine but queerer than we can imagine.” And one of those many queer things is that there are more species of beetles than any other kind of animal on our planet. This queer fact also apparently did not escape Haldane’s notice and repartee. Replying to theologians who inquired if there was anything that could be concluded about the Creator from the study of creation, Haldane is said to have quipped, “An inordinate fondness for beetles.”

In his [new biography](#), *A Dominant Character: The Radical Science and Restless Politics of J.B.S. Haldane*, Samanth Subramanian says no one can determine if Haldane really said so. “But, however apocryphal, the quip has never stopped sounding like him.”

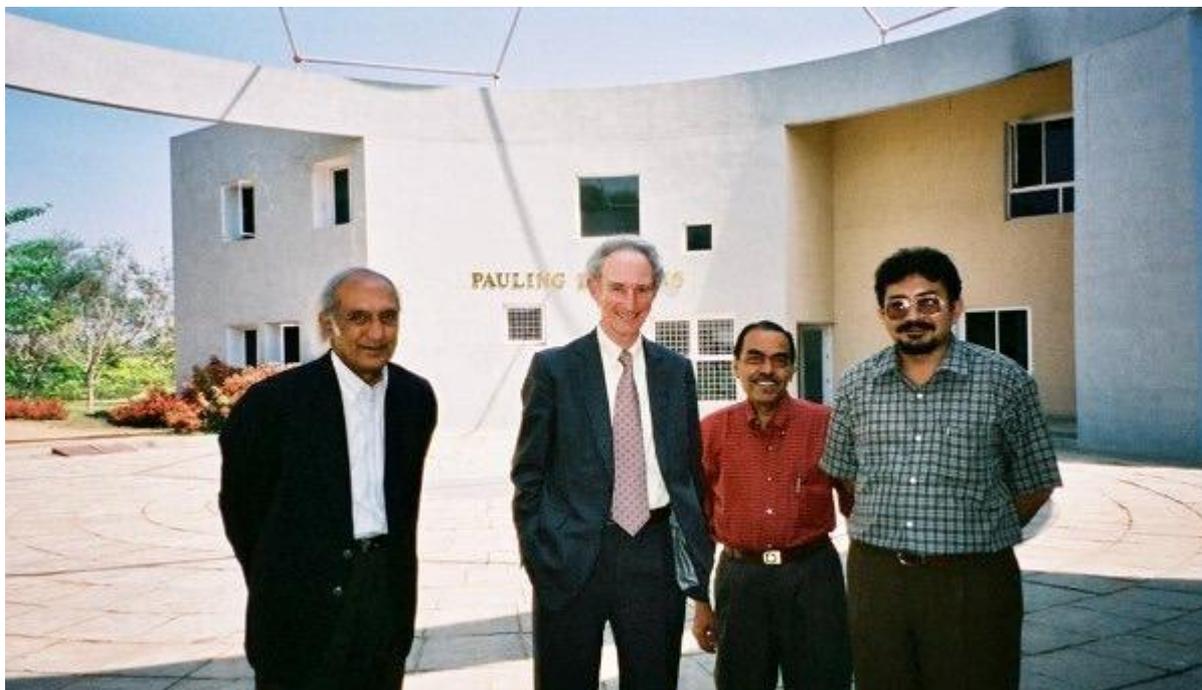
I might add that Haldane’s alleged quip has also never stopped tantalising biologists with an enduring mystery – whether for creation or evolution, why this inordinate fondness for beetles? If we consider all insects together, then, as Robert May [has said](#), “To a good approximation, all species are insects”. But again, why this inordinate fondness for insects? Before we even attempt to answer these ‘why’ questions, we need reliable estimates of the numbers of species of different kinds of animals and plants. And this, it turns out, is no trivial matter. Interestingly, there is much uncertainty both about how many species have been documented so far and how many remain to be documented.



Variability in beetles. Staatliches Museum für Naturkunde Karlsruhe, Germany.  
Photo: H. Zell, GNU Free Documentation License

## How many species?

Estimating the numbers of species of different kinds of animals and plants (not to speak of microbes) has been the life-long obsession of many a biologist, at least since the time the Swedish naturalist Carl Linnaeus developed the binomial system of nomenclature in the 1700s. One of the most prominent and charismatic figures pursuing this endeavour was [Robert May](#) (1936-2020). One might think that this messy task could not have interested a distinguished physicist-turned-theoretical ecologist and President of the Royal Society, but May thought otherwise. The numbers of species, both documented and undocumented that May provided in [an essay](#) entitled ‘The Dimensions of Life on Earth’, remain the best estimates, and indeed, the best-argued estimates to date.



(L-R) V. Krishnan, Robert May, M.K. Chandrashekar and Amitabh Joshi, on the occasion of Robert May's visit to the Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru, February 2002. Photo: Raghavendra Gadagkar

One reason for uncertainty in estimates of the numbers of already documented species is that there is a very inadequate compilation of the vast and scattered literature spread across centuries, continents and languages. The uncertainty is exacerbated by the frequent occurrence of synonymy – the same species having been given different names by different experts unbeknownst to each other. On the other hand, the reason for uncertainty in estimating the total numbers of species that exist out there, whether documented or not, is methodological. How on Earth do we determine how many species of worms that answer to a particular description are out there in the whole wide world?

Undaunted by all these difficulties, taxonomists and ecologists have continuously refined our best estimates, the latest of which are presented by Robert May. Very briefly, he estimates that scientists have documented a total of 1.5 million species, of which 720,000 are insects. He also estimates that there are at least a total of 6.8 million (but maybe up to 15 million) species of all forms of life that live on earth today. Of the estimated 6.8 million, 4 million are expected to be insects. These numbers, of course, do not include microbes that are even harder to estimate.

The most striking feature of these numbers is that 80% or more of Earth's biodiversity remains unseen, unnamed and unappreciated, without as much as even a name, well into the 21st century. The disparity between documented and the total expected numbers is not the same across different groups of plants and animals. While some 15% of plant species and 10% of vertebrate remain to be documented, a whopping 82% of insects and 97% of worms remain to be documented.

The [dearth of taxonomists](#) whose job it is to name and catalogue species has often been much lamented, at least in recent years. But Robert May candidly tackles a more sensitive issue, namely the disparity in the attention paid to different life forms. He notes that “the ratio of taxonomists to species is an order of magnitude greater for vertebrates than for plants and two orders of magnitude greater for vertebrates than for invertebrates”. May goes on to warn that “This is no way to run a

business. It reflects intellectual fashions and bears no relation to the relative importance of taxa either in the sweep of the evolutionary story or in the delivery of ecosystem services”.

Even more worrying is May’s lament that “Reorganising our priorities rapidly, to learn more about the little things that arguably run a lot of the natural world, will not be easy. Fascination with the furries and featheries goes deep: in the UK, the Royal Society for the Protection of Birds has almost 1 million members; the analogous society for plants (the Botanical Society of the British Isles) has around 10,000; and there is no corresponding society to express affection for nematodes”

In a profoundly meaningful passage Robert May says:

“The task of inventorying is sometimes mistaken for ‘stamp collecting’ by thoughtless colleagues in the physical sciences. But such information is a prerequisite to the proper formulation of evolutionary and ecological questions and essential for rational assignment of priorities in conservation biology... It is interesting to speculate whether the denizens of other inhabited planets – if there are any – share the vagaries of our intellectual history: a fascination with the fate of the universe and the structure of the atom, lagging well behind interest in the living things with which we share our world.” – Imagine these words coming from a physicist!

### **Insect diversity in the tropics**

Such questions have long bothered me. Being conscious that most biodiversity is in the tropics and realising that it was rapidly disappearing, I took to heart the Director of the Smithsonian Tropical Research Institute, Michael H Robinson’s tease that there is a negative correlation between the global distribution of biologists and biodiversity. I was itching to do something beyond studying a single species of paper wasp, however interesting. I felt the need to contribute something to the study, if not conservation, of biodiversity, much as a basic scientist might feel a moral imperative to contribute to an ongoing war effort or a national calamity.

When I was appointed a lecturer in the newly established Centre for Ecological Sciences at the Indian Institute of Science, Bengaluru, in 1984, I saw an opportunity. Insects were close to my heart, but I was not really equipped to study insect biodiversity. Then I struck gold. Krishnappa Chandrashekara, with an MSc in entomology from the University of Agricultural Sciences, Bengaluru, decided to join me as my first PhD student. Chandru, as we affectionately called him, not only had a vast knowledge of insects, but he truly had an inordinate love for insects. Thus began a friendship that lasted until Chandru tragically [succumbed to COVID-19](#) a few weeks ago. It is with a heavy heart that I recount here the fun I had in collaborating with Chandru.

We soon realised that one of the reasons for the paucity of studies on insect species diversity in the tropics must be the lack of appropriate research methodology suitable for tropical conditions. Almost all major long-term insect diversity monitoring programmes were located in well-endowed research facilities such as the Rothamsted Research Station in the UK and the Smithsonian Tropical Research Institute in Panama. More importantly, these programmes depended primarily on a powerful light trap in operation continuously for years together in the middle of the forest. Needless to say, the uninterrupted supply of electricity is nearly impossible even in our cities, let alone in the middle of the forest.

I had another misgiving about the powerful light traps that Western scientists used. I had seen and read that, by running 24×7 for years together and indiscriminately capturing all manner of insects, these light traps killed kilograms of insects, many more species and many more individuals than were needed for research. I worried that this was an enormous waste and might cause more damage to the insect fauna than their study might ever help mitigate. There was a simple solution to both these problems.



Left: A locally fabricated, low efficiency, battery-operated light trap to catch insects: insects are attracted to the light from the battery, bounce off the aluminium baffles and fall through the funnel into the plastic bottle. Right: A scented trap: insects are attracted to the fermenting liquid in the bottle and fly in to be trapped. Photos: RG Lab Collection

We built a simple, dismantlable light trap that ran on batteries that worked in the middle of the forest and caught a modest number of insects. To augment the meagre catch from this deliberately designed inefficient light trap, we simultaneously employed several other trapping methods which were more labour intensive but could be deployed anywhere. We used scented traps, consisting of no more than a plastic jar with a little bit of fermenting jaggery solution scented with vanilla and laced with a drop of insecticide. This attracted an even more modest number of flying insects that fell in and were trapped. Then we employed so-called pitfall traps, which were no more than another plastic jar with some insecticide, buried at ground level and protected from rain by a hat. We also used the method of systematically sweeping the ground vegetation with an insect net and collecting ground-level insects.

In addition to supplementing the low-efficiency light trap, we hoped that these multiple methods would together yield a greater diversity of insect species rather than more of the same. Our goal was to develop a package of standardised methods so that we might be able to make a quantitative comparison of insect species diversity in different habitats. So we marked out systematic plots of one hectare each and placed the light trap, which worked for seven hours from 1900 to 0200 hrs, in the middle of the plot. We placed five pitfall traps and five scented traps at randomly chosen locations in the plot and conducted net sweeps in six randomly chosen 10m x 10m quadrants.



Left: A pitfall trap that captures insects walking on the ground. Right: Chandru performing a systematic sweep of the vegetation to collect insects in a standardised manner. Photo: RG Lab Collection

We had three such replicate plots of one hectare, each in 12 different habitat types. Four of these habitats were located in relatively disturbed, so-called minor forests, and another four were located in relatively undisturbed, so-called reserve forests. Two of the minor and two reserve forest habitats were at the coastal level and, similarly, two minor and two reserve forest habitats were at an elevation of about 600m, all in the Western Ghats of Karnataka. In addition, we also sampled in three monoculture plantations and one leaf manure forest. Thus we sampled insects in this standardised fashion from  $12 \times 3 = 36$  plots. We hoped to compare the levels of insect species diversity between replicate plots within a habitat, between habitats with the same level of disturbance, between levels of disturbance and finally, between elevations.

Designing these traps and standardising these methods, not to mention conducting the fieldwork, were all intensely pleasurable and gave us great satisfaction. In addition to myself and Chandru, our team consisted of Ranjit Daniels, an outstanding ornithologist, D.M. Bhat, an excellent botanist, and Rozario Furtado, who doubled as a driver-cum-field assistant and in many ways was our local guardian. For sampling in the upghat (elevated) sites, we made the town of Sirsi our base camp, and for sampling coastal sites, we made the town of Kumta our base camp. Travelling from Bengaluru by overnight buses and spending a week at a time, alternately in Sirsi and Kumta, was an unforgettable and enriching experience.

While not sampling insects in the forests, we sampled life in the two towns, which could not have been more different from each other in the socio-economic status of their people, their dialect, culture and habits. But perhaps it was the food – fat-rich, pure vegetarian, Havyaka brahmin cuisine in Sirsi and protein-rich, fish and meat-based cuisine of fisherfolk in Kumta – that made the deepest impression on us. It is impossible to say which we enjoyed more. Travelling, living, eating and doing fieldwork with students and assistants for days together creates opportunities for intellectual camaraderie and a level of social bonding that can never be matched in a 9 to 5 laboratory sitting.

We preserved the insects collected in alcohol and brought them to Bangalore. Here we were joined by Padmini Nair and Vijayalakshmi Kandula in the mammoth task of processing the insect samples. We examined each collected insect, identified it at least to the family level, and assigned it to a unique recognisable taxonomic unit (RTU). In all, we had captured 16,852 insects belonging to 1789 RTUs, 219 families and 19 orders of the class *Insecta*.

We demonstrated the robustness of our quantitative sampling methodology by showing that the similarity of the insects caught in replicate plots of the same habitat was higher than those between different habitats and was even more different between coastal and elevation localities. We were vindicated in our decision to combine different trapping methods by finding that the insects caught by different methods were indeed quite different.

Thus we developed and field-tested a package of methods that could be deployed in the remotest places with the barest of facilities and infrastructure, to make reliable estimates of [tropical insect](#)

[species diversity](#). I am happy to say that our methods have received some attention and are being adopted by a few tropical ecologists. But is that enough?

### **Insect apocalypse?**

The apocalyptic scale of the loss of biodiversity, especially insect biodiversity, has reentered the public imagination since [Gretchen Vogel](#) published an article entitled ‘Where have all the insects gone?’ in *Science* magazine on May 12, 2017, and [Brooke Jarvis](#) published an article entitled ‘The Insect Apocalypse is Here’ in the *New York Times* on November 27, 2018. The Entomological Society of America has since [held a symposium](#) called ‘Insect Decline in the Anthropocene’ in November 2019. The *Proceedings of the National Academy of Sciences, USA*, published a special feature called ‘The Global Decline of Insects in the Anthropocene’ on January 12, 2021. It’s time we wake up in India and assess our insect losses and put our remedial measures in place, lest we forfeit forever the opportunity to solve Haldane’s mystery. Ignorance is not bliss in this case.



K. Chandrashekara, showing me around a public exhibition of insects that he had organised along with his colleagues and students in Bengaluru. Photo: H.M. Yeshwanth

After completing the insect species diversity project, Chandru wrote a fine PhD thesis on social organisation in the Indian paper wasp (*Ropalidia marginata*) and spent the rest of his life teaching entomology and inspiring students and colleagues alike at his alma mater. Insects will keep reminding me of Chandru, whether through their beauty or their distress. We must benefit from his tireless efforts at spreading his inordinate fondness for insects through education and outreach. We can pay him no greater tribute.

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Gadagkar, R., 2021. More Fun Than Fun : Chandru’s Inordinate Fondness for Insects. URL <https://science.thewire.in/the-sciences/krishnappa-chandrashekara-insect-population-diversity-tropics>