Centre for Ecological Sciences, Indian Institute of Science

25 years of Ecology, Evolution, Behaviour & Conservation

CENTRE FOR ECOLOGICAL SCIENCES
Indian Institute of Science

1984-2009
25 years of Ecology, Evolution, Behaviour and Conservation

CENTRE FOR ECOLOGICAL SCIENCES

ORIGINS

The Centre for Ecological Sciences at the Indian Institute of Science was set up in 1983 as the first Centre of Excellence of the newly established Department of Environment of the Indian Government. It was born out of ecological research initiated at the Centre for Theoretical Studies (CTS) by Madhav Gadgil, who joined CTS in 1973, having obtained a Ph.D in Biology at Harvard University with a thesis in Mathematical Ecology. Madhav pursued research in both theoretical biology and field ecology.

CTS was a purely research-oriented centre with no provision for students working with faculty members. It was however proposed that students could pursue a Ph.D in Ecology through registration in the Microbiology and Cell Biology laboratories. The first two students for this programme, P. Vijayakumaran Nair and S. Narendra Prasad were admitted in August 1977. A three month teaching programme in January-March 1978 in Bandipur in Wildlife Biology served to fulfill their course requirement. P. V. Nair went on to do a thesis on development of behaviour in elephants, and S. N. Prasad on ecology and management of bamboo resources of Karnataka. R. Sukumar, the third student, joined in 1980 and studied the ecology of human-elephant conflict on the Nilgiri-Hasanur plateau.

In 1978, the Director, Professor Satish Dhawan encouraged Madhav Gadgil to approach the University Grants Commission to support the establishment of a separate department of ecology at the Indian Institute of Science. In 1981, the Department of Environment called for special efforts in three regions, the Himalayas, the Ganga basin and the hill tracts of the Western Ghats. Since the ecological field work at IISc had focused on the Western Ghats, the IISc proposal to establish an ecology programme with support from the University Grants Commission was now posed to the newly established Department of Environment with the suggestion that the programme would focus on ecological issues in the Western Ghats. The proposal was formally submitted under the Directorship of Prof. S. Ramaseshan in 1982 and was sanctioned by the Department of Environment, leading to the establishment of the Centre in 1983.

A. EVOLUTION AND BEHAVIOUR

1. Sociobiology

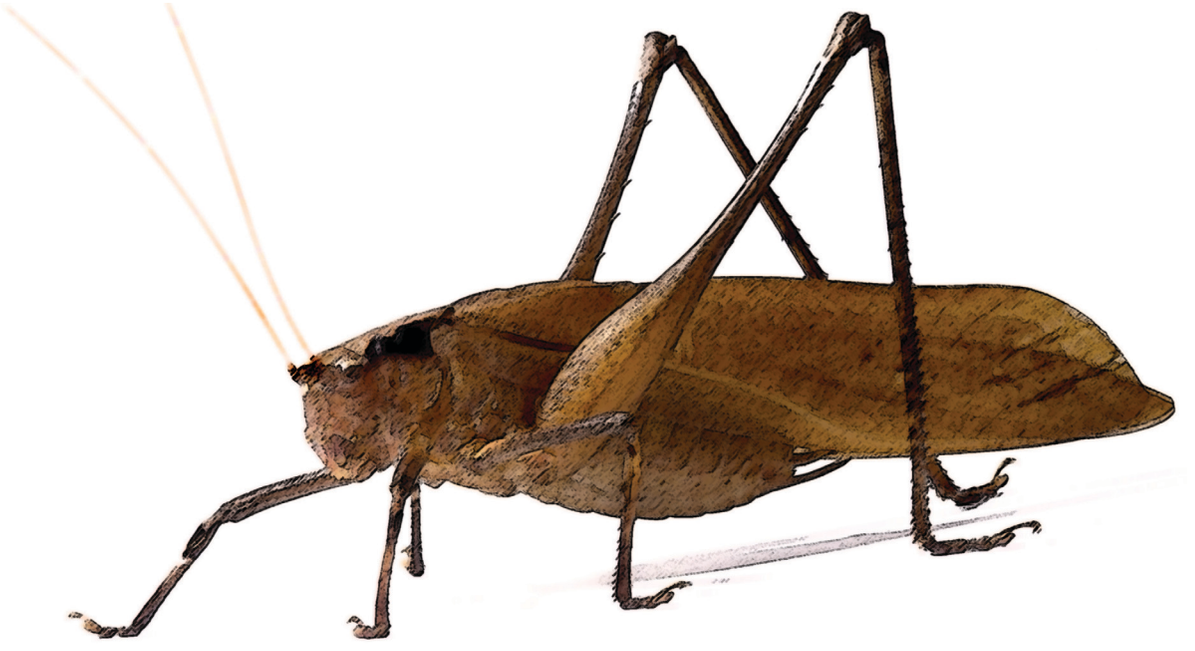
Animal species can usually be divided into those that live solitarily and those that live in groups. For example, tigers and digger wasps are solitary species, whereas elephants and honeybees live in groups. What are the factors that determine whether species live solitarily or in groups? In some species of wasps and bees, it goes further than that: several individuals live together but only one or a few of these reproduce. In this case, a large number of individuals have given up their own chance of reproduction to help a few others to reproduce. Such examples of extreme altruism were noticed by Charles Darwin, who realised that they provided a challenge to the mechanism of natural selection that he had proposed. William Hamilton offered an explanation for this in terms of kin selection: if the individuals on a nest or hive were closely related to each other, then in fact an individual may pass on more of its genes to the next generation by giving up its own reproduction in favour of helping its mother rear a large number of its siblings. Or perhaps the cost and risk associated with building one's own nest, provisioning it and looking after the offspring is great compared with that of joining others and achieving some level of reproductive success.

The wasp species *Ropalidia marginata* has offered an excellent opportunity to study these questions, since it is a species that shows variation in this behaviour: some individuals give up their own reproduction and join with others to help raise brood, whereas others (solitary females) go off to build their own nests in which they lay their eggs. Our research on this species over the past few decades has investigated the degree of relatedness among wasps in different nests, the proportions of solitary versus co-founded nests in nature and the factors, such as dominance ranks of individuals, that may serve to determine this outcome.

Soil amoebae known as cellular slime moulds offer other advantages for the study of the evolution and maintenance of apparently altruistic traits in social groups. It is easy to construct groups of predetermined genetic structure and try to relate indices of cooperation with the level of genetic similarity within a group. Our work on *Dictyostelium giganteum* shows that groups are genetically diverse in nature. Genetic and epigenetic (such as nutritional) factors impinge on social roles, as do interactions between amoebae. The maintenance of 'altruism' appears to involve competition both within and between groups.

CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH



2. Animal Behaviour: Acoustic communication

Crickets are solitary insects with short life spans, so parents never get to see the offspring that hatch out of the eggs that they lay with such care. The young grow up without parents to teach them and much of what they have to do is hard-wired into them. When a young cricket, after about ten moults, turns into an adult, it has to find a mate. But how does one recognise a member of one's own species and of the opposite sex? To do this, crickets were among the first animals on earth to produce songs that could be heard over long distances. At night, males sing songs that are unique to each species, females listen in the dark and, if they hear the right song, they move towards the caller. But there are several problems to achieving this goal: a lot of other animals use the same strategy of calling for mates after dusk, including other species of crickets, and frogs. The female has to pick up the right song in this babel of disparate voices that all mix with each other. How much do the songs really interfere with each other? To answer this, we went to an evergreen forest in Kudremukh National Park and found out who the callers were, what their songs were like, when they called and how far apart they were from each other. From this, we know that they do not avoid overlap in time and not always in space, but the calls of some species have their own frequency bands, just like radio channels. Females can tune in to these relatively private channels and reduce interference.

Once the female picks out the call of her species, she is then confronted with the problem of locating one male among many, since males often tend to call in choruses. This is a formidable problem for a small animal that does not have the luxury of millions of nerve cells dedicated to computing sound source locations, as birds and mammals do. But with the aid of a special kind of geometry of the ear and some minimal rules of information processing, crickets are able to home in on individual calling males. But how effectively do they manage to do this in the complex acoustic conditions in the field, where there are so many callers, where wind, vegetation and the very ground on which they live greatly distort the calls? To find out, we first explored the acoustic world of the cricket in its natural surroundings and then recreated this world for a virtual female cricket in a simulation. The relatively simple rules they use are good enough to get to a male most of the time.

3. Behavioural ecology: Mate choice

Female crickets are usually choosy about whom they mate with: they prefer bigger and relatively older males. Such males may have better genes or have proven their ability to survive in a difficult world, or provide them with nutritious wedding feasts that they actually secrete from their own bodies! Bigger, older and fitter males are often louder, so a simple preference for the loudest could yield benefits for a female. But we have shown that she does not automatically get to the loudest male in a chorus. This means that she must have more complicated rules to evaluate loudness than we know about.

But loudness isn't everything. In some crickets, including the long-legged katydid *Mecopoda* that rasps in the monsoon months on our campus, attracting females is also a question of timing. Males who manage to start their chirps very slightly ahead of their immediate neighbours are far more attractive to females! This precedence effect is probably a result of the way the auditory system is wired to localise sounds. So females are in some sense in an evolutionary trap: perhaps they approach these leading males because they cannot help it and males exploit this. The result of all males trying to just lead each other is that they end up synchronising their calls, just as the fireflies that also come up on our campus in the monsoon synchronise their flashes. So chorusing in unison, synchronising every chirp, such an apparently co-operative activity, may well have evolved due to fierce competition among males for females!.

Cricket females aren't the only choosy ones: mammals are too. Blackbuck are beautiful antelope that live in open grasslands in herds whose sizes can vary greatly. How do female blackbuck evaluate males and decide who to mate with? Males in some populations form leks, where two to more than a hundred males aggregate and defend tiny territories on which they perform elaborate and costly displays. These territories carry no resource attractive to females apart from males and females visit them for the sole purpose of obtaining mates. Females move through these leks and can simultaneously compare the different males. They may pick the ones with the most vigorous displays. They may also use chemistry: perhaps they evaluate a male's worth by his scent. But, interestingly, not all populations use this kind of mating strategy. In some, males may defend large territories in areas that are valuable for females: she may use the fact that he is the holder of such desirable property to choose him instead. Dissecting out these different kinds of decision rules is a challenge. What determines the different kinds of strategies that male blackbuck use? Is it linked to a female preference for different male strategies or changes in the risk of being attacked by predators or the quality and distribution of the food? What drives and maintains this flexibility in mating strategies and how does it impact the fate of a population over time? Understanding these questions could help us design better strategies to conserve this beautiful and highly endangered antelope.

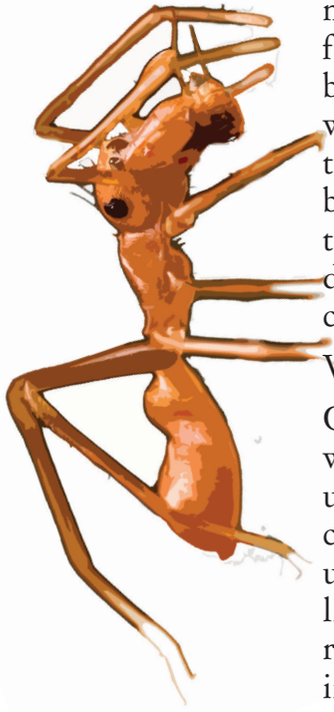
Group-level phenomena in biology are not only emergent properties of individual decision-making but influence and are influenced by them on evolutionary time scales. How decisions made by individuals impact and are impacted by such group-level phenomena remains an important open question in biology that we are trying to address.

CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH

4. Visual ecology

Navigating in the dark: A bee that flies and can see colour by starlight



The night is supposed to belong to bats and moths. Plants that flower in the night should be pollinated by such creatures, surely not by bees. Bees are seen busy at flowers in the daytime; how could they be active at night? Some bees are active at night when there is enough light from the moon, which needs to be at least half-full, to navigate between flowers and trees. But we have now found a carpenter bee that can fly at starlight. This bee flies at the lowest light levels at which bees were ever thought to be capable of flight. We are studying visual adaptations in this truly nocturnal bee in comparison with closely related day-active carpenter bees in a seasonal cloud forest in Maharashtra. We are also investigating how these different day and night bees share flowers that offer nectar and pollen at different times of the night and day. We have discovered that these nocturnal bees can also see colour at starlight.

Visual mimicry

Crab spiders mimic flowers and thus camouflage themselves on flowers, waiting for pollinating bees that they can then prey upon. Some crab spiders use their ultraviolet-reflecting body surface to attract insects. We are studying camouflage and predatory behaviour in a spider and have found that this spider uses the ultraviolet preference of insects to attract bees and capture them on lilies. These spiders make themselves conspicuous targets on non-ultraviolet reflecting backgrounds. How spiders choose such backgrounds is currently being investigated.

Understanding the structures and rules by which animals solve the tasks involved in finding food or mates allows us to find algorithms for artificial systems such as robots that can be used, for example, to navigate successfully in the dark.

5. Chemical ecology

Finding a place to lay eggs: The scent of a fig

Flowers produce scents to attract pollinators or to repel parasites. A fig tree produces hundreds of flowers that are enclosed within a round receptacle called a fig. These figs produce scents to attract pollinating fig wasps that enter the fig through a single opening. The pollinators deposit pollen on the female flowers and also lay their eggs within some pollinated flowers; the wasps die in the fig after this, and so the figs are also called tomb blossoms. The wasp larvae mature and develop into winged females and wingless males. The mated females leave the fig with pollen to enter another fig to begin the cycle all over again. Once the female wasps leave the fig, it ripens, the seeds mature, and the fig is ready to be eaten by a dispersal agent like a bird or bat. The scent of a fig varies throughout this entire process. Parasites of the pollinators and parasitoids of the parasites eavesdrop on these scents and arrive at the fig at the right stage. Predatory ants also eavesdrop on these scents and arrive to feed on the bounty of wasps hovering around the figs.

Some fig species such as the banyan and peepul have male and female flowers in the same fig, while others have male and female flowers on different trees. Trees that produce male figs containing male flowers are tomb blossoms for the pollinating wasps; but such wasps can lay their eggs and have their larvae develop and mature within them. Such figs do not produce seeds because here the wasps lay their eggs in all available flowers. The female figs, however, produce seeds but no wasps because here the wasps do not develop although eggs are laid. Thus male trees produce wasps while female trees produce seeds. A pollinating wasp that enters a female fig commits reproductive suicide because such wasps will have no progeny. There should consequently be strong selection on pollinating wasps to avoid female figs and only enter male figs. Since the attraction towards figs is through scent, wasps should evolve to tell the difference between the scents of male and female figs; however, there should also be strong selection pressure on the male and female figs to converge on the same scent so that the wasps cannot tell the difference, or else the pollination mutualism would break down. We are studying the phenomenon of chemical mimicry between the scents of male and female figs and are testing whether wasps are truly incapable of discriminating between the scents of male and female figs.

Bribes and lures: How to be an ant-plant

Plants can recruit ants as bodyguards. Some plants give up chemical defences for biotic defences in the form of aggressive patrolling ants that protect them from herbivorous insects. Such plants keep their ant bodyguards faithful by providing them food in the form of nectar from special extra-floral nectary glands on leaves, stems or other tissues, or in the form of bite-sized food packets that are packaged for ants and contain protein or lipids. These plants can also provide nesting places for the ants in specialized plant structures such as hollow stems, thorns or tubers, within which ants rear their brood. We are studying a primitive leguminous ant-plant that is on its way to becoming a full-fledged ant-plant. This plant *Humboldtia brunonis* shows variation in ant-plant traits such as those that provide ant housing, or the composition and production of extra-floral nectar. This ant-plant receives varied protection from its ant partners across a latitudinal gradient in the Western Ghats, and we are tracking its evolutionary trajectory in different populations. This plant seems to meet its right ant partner and to become a better ant-plant in its southernmost population. This ant-plant is the only known polymorphic and unspecialised ant-plant and thus affords the excellent opportunity to understand the evolution of the mutualistic relationship between ants and plants.

CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH

B. ECOLOGY AND WILDLIFE BIOLOGY

1. Large mammals

Large mammals, whether herbivores such as deer or elephants, or carnivores such as tigers and wild dogs, require large quantities of food and water for their sustenance. Both the size of home ranges and the populations of carnivores in a given area are likely determined by the number, density and distribution of prey species such as deer. If the numbers of prey change or if prey move into new areas in search of better food or of water in the summer, then predators will also have to follow them. Understanding the patterns of movement of predators and prey and estimating their numbers is of prime importance to devise effective strategies for the conservation of large mammals, given the ever-declining land area available to them. We have been monitoring the numbers and movement of large mammals in Mudumalai Wildlife Sanctuary in the Nilgiris over the past few decades.

Elephants are of particular interest: being herbivores as well as the largest land mammals, they require large tracts of forest to support them. Elephants have traditionally moved along particular migrational routes through the different seasons but these are now often disrupted due to the emergence of agriculture and the growth of towns and cities. This leads to situations of conflict with humans when elephants stray into agricultural fields and villages, where they may destroy crops. Our group has been carrying out research on human-elephant conflict, including causes and possible solutions. Interestingly, it was found that males are more likely to be crop raiders than females. Perhaps the pressure on male elephants to be in the best of condition to compete for females may have led to their more frequently raiding nutritious crop plants. In an interesting experiment in West Bengal, some large males were fitted with radio-collars so that their movements could be tracked by satellite telemetry to provide an early warning system to villages when these males appeared in the vicinity. It also provided detailed information on the movements of individual elephants.

2. Marine turtles: Marathon seafarers

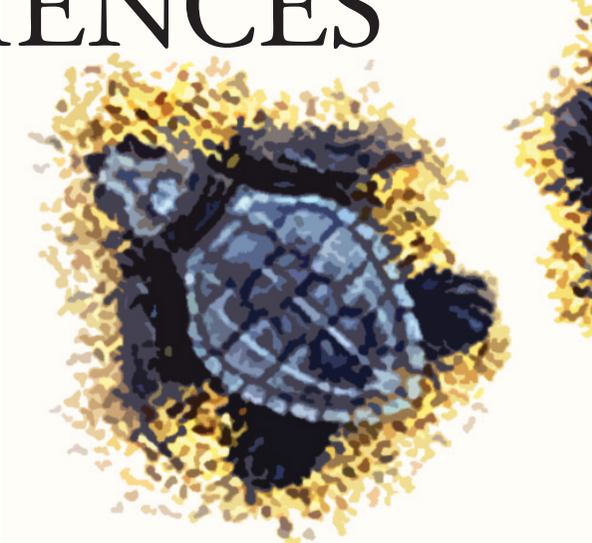
Sea turtles are remarkable creatures but their complex life cycles make them very difficult to study. For example, loggerheads undertake amongst the longest breeding migrations of over 12,000 km, while leatherbacks are amongst the deepest diving vertebrates, going up to 1,300 m below the surface in search of jellyfish. Sea turtles spend most of their life at sea, coming ashore only to lay eggs during the breeding season. When the young hatch, they make their way out into the ocean, where they take a decade or longer to mature. Incredibly, females then return to the natal beaches to lay their own eggs year after year! How they accomplish this navigational feat and where they go when they are out in the open seas is a subject of intensive study. Sea turtles orient to the earth's magnetic field and this enables them to maintain their direction out at sea. Typically, sea turtles migrate thousands of kilometres from their feeding ground to breeding grounds, exposing them to a variety of threats from humans. Sea turtle migrations are tracked by satellite telemetry and their nest site fidelity can be explored using both tagging and genetic markers.

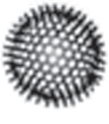
Four of the seven species of marine turtles are found in Indian coastal waters; olive ridleys nest all along the mainland coast, but mass nesting beaches are found in Orissa; leatherback, green and hawksbill turtles nest in the Andaman and Nicobar Islands, and the Lakshadweep Islands have a nesting population of green turtles. We have research programmes for olive ridley turtles in Orissa and leatherback turtles in the Andaman and Nicobar Islands, focussing on population monitoring, tagging, and genetics.

In sea turtles, sex is determined by temperature; higher temperatures produce females. Sea turtles do not as a rule produce nests that have equal sex ratios. More commonly, the nests laid during different times of the season or on different kinds of beaches are predominantly male or female, thus resulting in the production of both sexes in a population over time. This biology is significant because climate change, in particular global warming, could have significant consequences for sea turtle populations. We are examining changes in temperature and sex ratios of olive ridley turtles along the east and west coasts of India.

CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH





3. Community ecology

Diversity in time and space

Any given area typically contains a set of species of plants, animals and microbes that share the living space therein. Some of these may interact with each other in positive or negative ways, such as plants and pollinators, or predators and prey. Others may co-exist in the same space without any apparent direct interactions. How many species of plants, animals and microbes co-exist in a given area? Which ones are common and which are rare? Why are some species common and others rare? Why do some areas have more species than others? Are there correlations in levels of species diversity across animal and plant groups and across different spatial scales? These are major questions in community ecology that we have been concerned with over several years.

The distribution of diversity can be studied at various levels of organisation, from genes to ecosystems, and at various scales from local communities to macro-ecological regional scales. At the species level, what determines the structure of communities? At the genetic level, how is molecular diversity distributed within and among populations and species? What kind of patterns and mechanisms operate at large regional and continental spatial scales? And can understanding these patterns of species diversity and distribution help prioritise areas for conservation? The Western Ghats and the Andaman and Nicobar Islands are major hotspots of endemism and species richness for various taxa in India. Our work aims to understand diversification in the Western Ghats, Andaman and Nicobar Islands and other parts of India with a focus on small vertebrates, by combining molecular phylogenetics, field ecology and remote sensing approaches. We have also initiated work on coastal and marine diversity, currently focusing on nearshore and intertidal fauna, along the east and west coasts of India.

The research aims to infer evolutionary relationships and biogeographic patterns of diversification, investigate the relation of molecular divergence with various ecological conditions and formulate conservation implications of these patterns.

4. Forest ecology

What determines the composition, diversity and relative numbers of plant species in specific areas of forest? A number of factors could be involved, including amount and timing of rainfall, soil composition, slope of the terrain, temperature, fire, as well as being eaten or destroyed by herbivores or outcompeted by neighbours. These questions are being investigated in a long-term study on forest dynamics in Mudumalai Wildlife Sanctuary. The growth or death of every sapling or young plant in a given area is monitored every year, together with records of weather data, whether fire raged through in the summer or elephants passed and trampled or uprooted plants in the plot. Both rainfall and fire affect the composition and the dynamics of plant growth and survival.

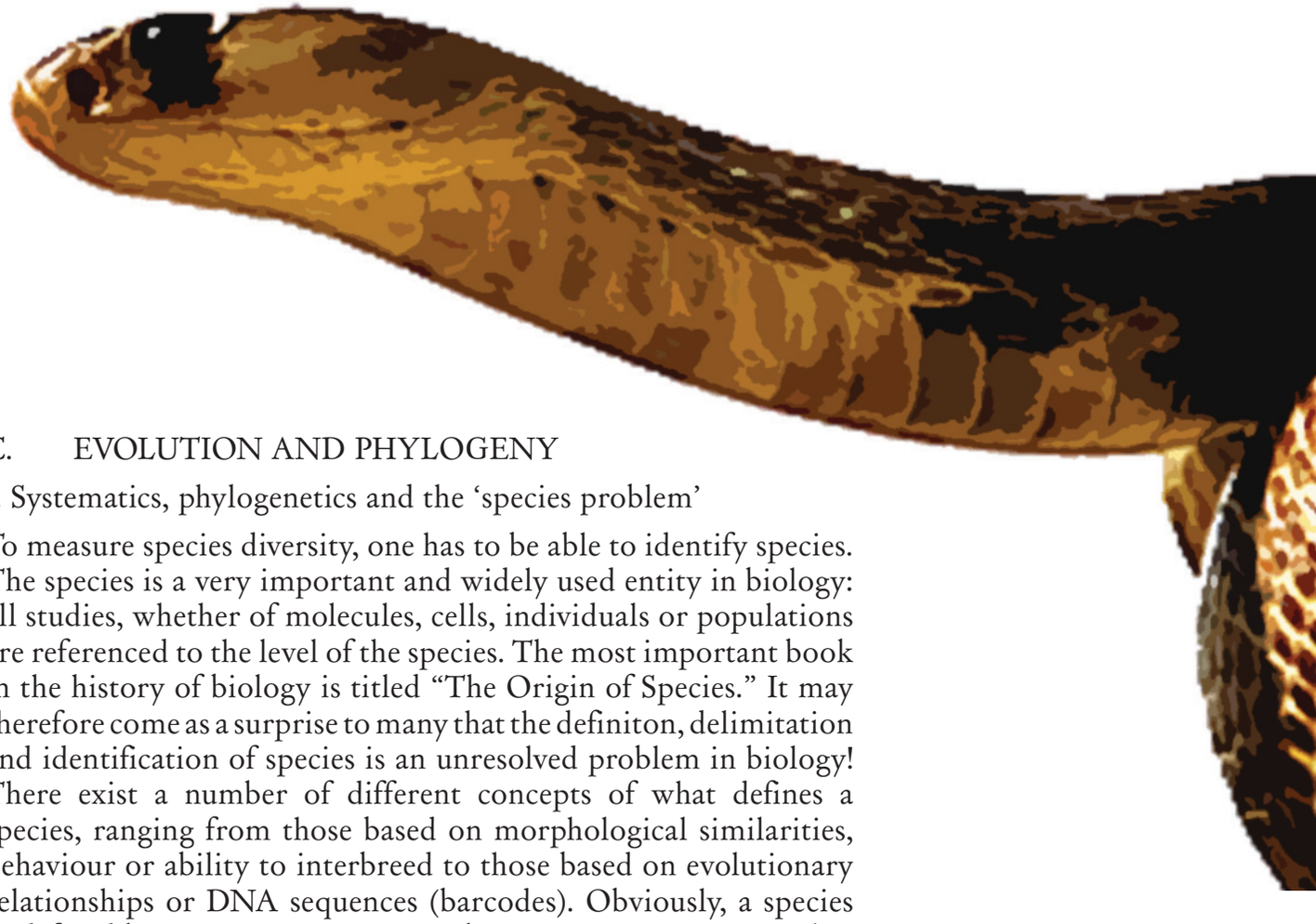
Invasive species

One of the more recent and severe problems that has resulted in drastic changes in forest plant communities is the alarming spread of a few exotic plant species, such as *Lantana camara*. This species, originally from South America, has now spread all over India, wiping out entire plant communities in some places. Most alarmingly, the understorey of many deciduous forests now consists almost entirely of this one species. This is sure to have profoundly affected the composition, distribution and densities of several animal species. These effects are virtually undocumented in any systematic fashion.

We are trying to understand the factors that allow the rapid spread of this species, including its response to fire, which may well enable its spread. But other features, such as its flowering cycle, pollination and seed dispersal strategies may also have allowed it to successfully outcompete and stifle the growth of native plant species. Perhaps it also produces chemicals that may inhibit the growth of other plants. These are questions that we hope to get answers to in the near future. We would also like to know whether there is a common set of characters that is responsible for the success of different invasive species. Understanding them may allow us to better control them.

CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH



C. EVOLUTION AND PHYLOGENY

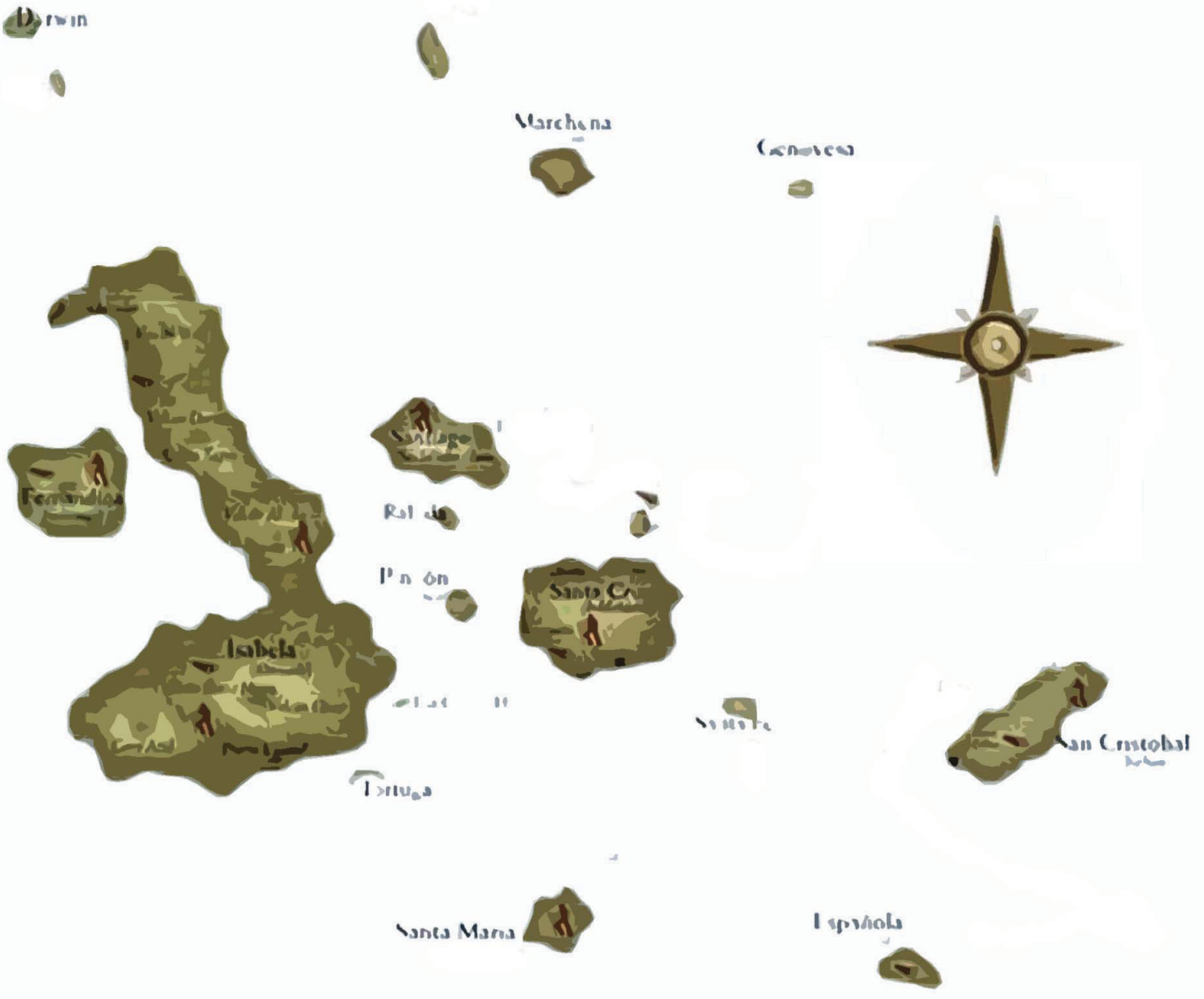
1. Systematics, phylogenetics and the 'species problem'

To measure species diversity, one has to be able to identify species. The species is a very important and widely used entity in biology: all studies, whether of molecules, cells, individuals or populations are referenced to the level of the species. The most important book in the history of biology is titled "The Origin of Species." It may therefore come as a surprise to many that the definiton, delimitation and identification of species is an unresolved problem in biology! There exist a number of different concepts of what defines a species, ranging from those based on morphological similarities, behaviour or ability to interbreed to those based on evolutionary relationships or DNA sequences (barcodes). Obviously, a species as defined by one criterion may not be a species using some other species concept. This would directly impact estimates of species diversity.

It is therefore extremely urgent and important to determine, for a number of different groups, whether species as defined by different criteria are consistent with each other: is a species as defined by the DNA sequence of one gene consistent with that defined by the criterion of ability to interbreed, for example? Or can we use the evolutionary relationships between individuals as a means of defining a "phylogenetic species" and does this correspond to that defined by morphology? We are trying to answer these questions in a number of groups of animals, including Hanuman langurs, butterflies, frogs, crickets and wasps.

2. Molecular ecology

With the advent of modern molecular tools and computer programs for genetic data analysis, traditional areas of ecology and evolution have undergone a makeover. This has led to the emergence of an exciting interdisciplinary area called molecular ecology. Molecular ecology uses the principles of population genetics and molecular phylogenetics to address questions in ecology, evolution and behaviour. Additionally, this area has many applications for taxonomy (molecular systematics) and conservation biology (conservation genetics). Typically, based on the question being addressed, one or more molecular markers are chosen. Markers might include nuclear or mitochondrial DNA sequences. Numerous statistical algorithms are in turn used to analyze these data sets. A range of exciting questions are being addressed in the areas of biogeography and phylogeography through the use of various molecular markers. Here we are trying to better understand the different historical, climatic and geological events that might have shaped the current distribution of species. The taxa currently studied include skinks, tarantulas, snakes, geckos, and centipedes.



CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH

HUMAN AND LANDSCAPE ECOLOGY

1. Human ecology: Impacts on landscapes and ecosystems

In the course of their technological and cultural development, and as a result of an explosive increase in numbers due to their phenomenal success as a species, humans have caused enormous changes to landscapes and ecosystems on earth. The advances in technology now allow one to literally see these changes as an observer from space. Remote sensing from satellites orbiting the earth provides glimpses of both the fine-grained detail and the sweeping magnitude of these changes. By comparing images taken over a decade, for example, we can track the increases and decreases in green cover or freshwater bodies over any chosen part of our planet, as we have for Bangalore City and the Western Ghats. We can then search for the possible causes such as urbanisation or industrialisation that may have led to the disappearance of forests or lakes. We can measure the exact extent of our depredations and we hope that these measurements will serve as a yardstick for wiser planning in the future, be it to bring back forests or lakes or to plan our cities better.

To conserve biodiversity, it is necessary not only to measure it but also to devise strategies for effective conservation. In a country such as ours, with the pressure of an enormous population on an increasingly fragmented landscape, this requires the co-operation of large numbers of rural human communities, who typically live in close proximity with biodiversity-rich areas. As a first step, our centre initiated outreach programs to educate school and college teachers in Karnataka on the importance of biodiversity and ways to record and measure it. In parallel, studies have been undertaken to assess local peoples' understanding and views on biodiversity, in the form of the Peoples' Biodiversity Register.

We have also studied the impact of humans on their local environment at very local levels, for example, at the level of a single village. By interviewing villagers and by studying their use of water, fuel, food and fodder, together with the social, political and cultural milieu in which they live, we are beginning to unravel the strands of the complex web of interactions between people and the natural environment. Only by understanding this web of interactions can we really decide what caused the changes that we see today and what can be done to steer change in directions that might benefit both local people and ecosystems.

2. Climate change: Understanding the past, predicting the future

Human activities and technological progress over the past century have caused increasing amounts of carbon dioxide to be released into the earth's atmosphere. This has resulted in global warming, so that the average global temperature is now higher than ever before in the earth's history. The increased carbon dioxide concentrations together with higher temperatures and changes in rainfall patterns are likely to have large effects on the vegetation of ecosystems and consequently on the fauna.

Can we hope to understand even to a small extent what is likely to happen? One way is to look back into the geological past, when large episodes of changes in rainfall and temperature occurred. The peat bogs in the Upper Nilgiris held the clue to what happened about 20000 years ago, when the climate was much drier. Examining fossil pollen and spores showed that this period was dominated by grasses. Perhaps one may again expect forests to shrink and yield to grasslands.

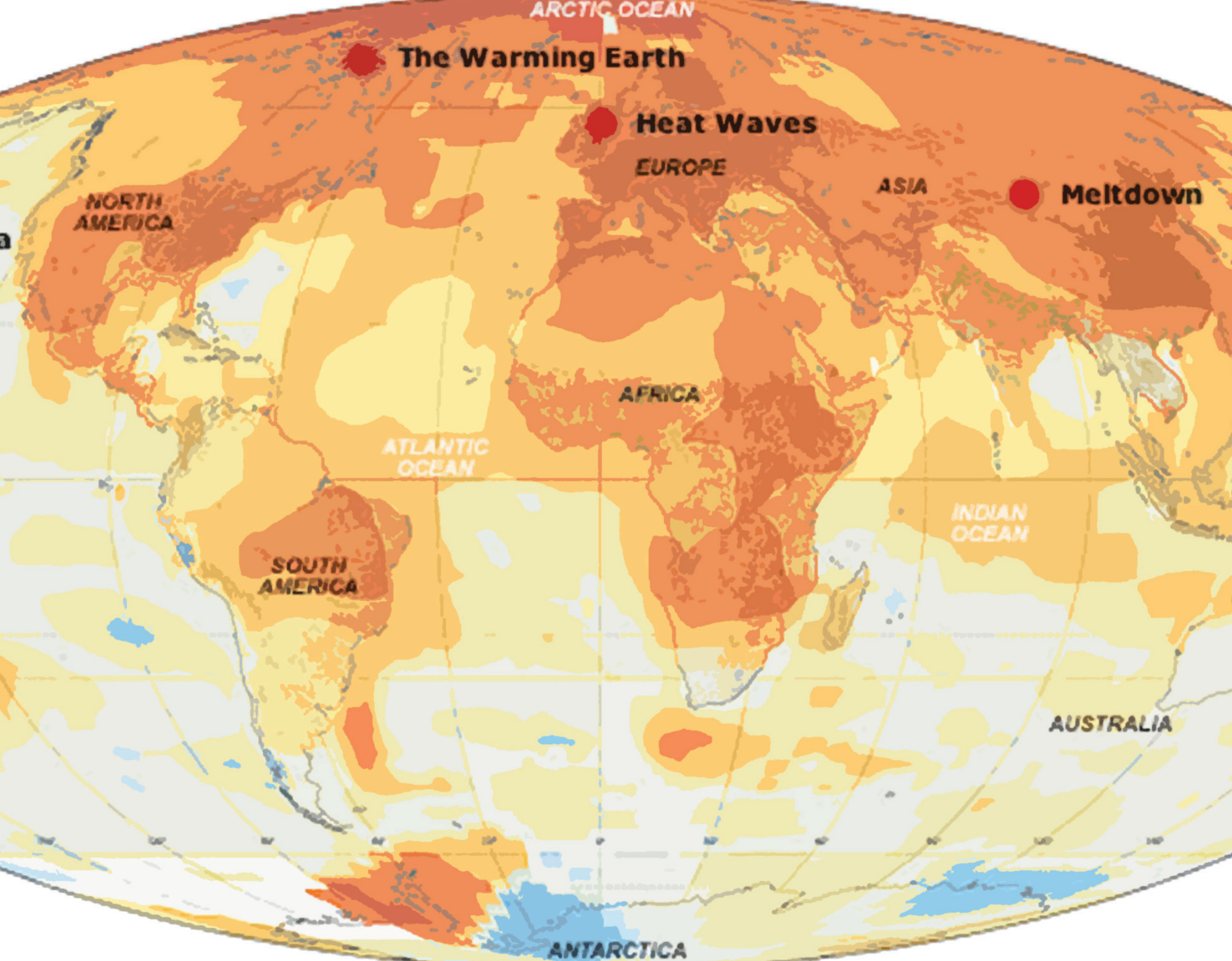
But it is of course more complicated: another approach is to use global circulation models to simulate scenarios of global temperature and carbon dioxide increase. Although these depend on a number of assumptions and the interaction of so many factors, they are all we have to go by! Our present models for the Indian subcontinent seem to indicate drier climate in the North-West of India and greater rainfall in Southern India. But these are of course very coarse predictions and the truth is, we do not know. The best course would be to try and prevent global temperatures and carbon dioxide levels from rising beyond a certain point by changing both lifestyles and technologies.

On a global scale, engineers are trying to build more fuel-efficient engines for cars and planes to reduce carbon dioxide emissions. On local scales too, fuel-efficient cooking stoves and solar-powered lighting and heating systems are being developed. By growing trees on degraded lands close to villages, we are trying to put carbon from the atmosphere back into plants. Plantations on wastelands can also serve to offset the cutting of trees from forests for fuel. Ultimately, only the harnessing of energy sources other than fossil fuels and a conscious change of lifestyles away from consumerism can stem the build-up of carbon dioxide in our fragile atmosphere.

We will continue our quest to understand life at all levels and we hope that every one of us will make the decisions that allow us as a species to continue not only to live but also to let live all the wonderful life forms that have evolved over four billion years on this planet.

CENTRE FOR ECOLOGICAL SCIENCES

RESEARCH


ARCTIC OCEAN
The Warming Earth
Heat Waves
EUROPE
ASIA
Meltdown
NORTH AMERICA
AFRICA
ATLANTIC OCEAN
INDIAN OCEAN
SOUTH AMERICA
AUSTRALIA
ANTARCTICA

CENTRE FOR ECOLOGICAL SCIENCES

PEOPLE

Madhav Gadgil was born in 1942 in the city of Pune, where he developed an interest in plants, birds, insects and trekking from an early age. He was the holder of the Maharashtra State Junior and Pune University High Jump records. These outdoor interests further fostered his love of ecological field work, which has been his life long passion.

He studied Zoology at the Universities of Pune and Bombay, before becoming the first biology student at Harvard University to receive a Ph.D. degree for a thesis based on mathematical modeling. This won him an IBM Fellowship of Harvard Computing Center and became a Citation Classic. His scientific interests focus on ecology and evolutionary biology, conservation biology, human ecology, natural resource management and ecological history, and he has published 225 scientific papers and written 5 books in English and 2 in Marathi.

Madhav Gadgil has been a Lecturer in Biology at Harvard, a Distinguished Indo-American Lecturer at UC Berkeley and a Visiting Professor at Stanford. From 1973 to 2004 he was on the faculty of the Indian Institute of Science, where he established the Center for Ecological Sciences. He was a member of the Science Advisory Council to the Prime Minister of India from 1986-90, and chaired the Science & Technology Advisory Panel of Global Environment Facility, a UN granting agency from 1998-2002. He chaired NCERT's panel on Environmental Education and is currently a member of the National Tiger Conservation Authority.

Madhav Gadgil wrote a series of 10 articles on animal behaviour in the Marathi science magazine "Srishtidnyan" when he was in 10th standard in High School. Subsequently he has written over 300 popular articles in English and Marathi in many newspapers and magazines. His books have been translated into Hindi, Kannada, Malayalam and Gujarathi.

Madhav Gadgil has been elected to all the Science Academies of India, the Third World Academy of Sciences and the U.S. National Academy of Science. He is an Honorary Member of the British and American Ecological Societies. He is a recipient of Shantiswarup Bhatnagar and Vikram Sarabhai Awards, Volvo Environment Prize and Harvard University's GSAS Centennial Medal, Karnataka's Rajyotsava Award and Padma Shri as well as Padma Bhushan.

Madhav Gadgil joined the Indian Institute of Science in 1973, having obtained a Ph.D in Biology at Harvard University with a thesis in mathematical ecology. Madhav pursued research in both theoretical biology and field ecology. He looked at the possibilities of evolution of spiteful social behaviour and showed that in social groups in small populations, individuals could be selected to perform spiteful behaviours.

Madhav Gadgil initiated field studies at the newly established Bandipur Tiger Reserve in 1974 on the dry deciduous forest ecosystem dotted with man-made ponds and extensive open areas covered with grass. The area had large populations of chital, sambar, gaur, elephants, wild pig, wild dogs, panthers and tigers. Bandipur was part of a far more extensive natural ecosystem on the Mysore and Wynaad plateaus and the Nilgiri hills. Madhav conducted an ecological reconnaissance of this whole tract and formulated a proposal for the establishment of a large nature reserve in this region. This eventually led to the establishment of the country's first Biosphere Reserve, the Nilgiri Biosphere Reserve in 1986. Elephants were a striking component of the wildlife of this tract and Madhav Gadgil organized the first ever census of wild elephants in the country in these areas.

In 1974, there was an agitation by the basket-weavers of Karnataka contending that their livelihood was threatened by overuse and exhaustion of bamboo resources by paper mills. The Karnataka State Council for Science and Technology asked Madhav Gadgil to look into the ecology and management of bamboo resources of the state. The studies demonstrated that the bamboo resources of the state had been overestimated by a factor of ten, that the harvesting practices of bamboo enhanced the damage done to new shoots by wild animals, and that there was no good basis for the so-called scientific management of bamboo resources. The studies also demonstrated that paper mills were not using bamboo resources in a sustainable fashion at all, but were engaged in a pattern of sequential overexploitation, starting with resources in Karnataka and going further afield, eventually all the way to Meghalaya!

While working on management of bamboo resources, Madhav Gadgil became involved in assessing the role of Gavli Dhangars, a pastoral caste of the forested hill tracts of the Western Ghats. Apart from quantitative field studies of the impact of their livestock on forest regeneration involving grazing exclosures, he undertook an investigation of their overall ecological role. The resulting study examined their shift over historical time from buffalo-keepers to goatherds to cultivators of increasingly marginal hill tracts in the context of forest exploitation, malaria control and the dairy development programmes. A fall-out of the study was a broader enquiry into the ecological correlates of the Indian caste system.

Madhav Gadgil's research at CES has largely focused on field studies in the district of Uttara Kannada, initiated in 1975 as a part of the study of management of bamboo resources of the state, conducted from the base provided by the Paper Mill in Dandeli. This was complemented

Madhav Gadgil

by the work initiated in 1979 through a public assessment of the environmental impact of a hydroelectric project on the Bedthi River in Uttara Kannada district, funded by the orchard owners' cooperative society and in collaboarion with students and teachers of MG College, Sirsi. This was prompted when the official committee of which Madhav Gadgil was a member cleared the project hastily, without due care. Pressure was brought on MG to halt this investigation, but Dr. Satish Dhawan, the then Director of our Institute staunchly backed him. The public discussion that followed the participatory appraisal was the first time such an open, participatory process had gone on in India. The Government took cognizance of the findings which showed the project to have a thoroughly unfavourable benefit: cost ratio. With this began a long collaboration with orchard owners focusing on ecodevelopment action research in villages of Uttara Kannada.

In Uttara Kannada MG worked with several young scientists, amongst them M.D. Subash Chandran, Ranjit Daniels and Harini Nagendra in investigating plant and bird communities of the district. With H S Negi, MG investigated the interrelation of diversity levels amongst a range of groups of organisms from lichens, mosses and flowering plants to ants. With Natabar Hemam, MG studied the revival of sacred groves in villages of Gangte tribals in Manipur hills, prompted by the need to maintain a ring of forest around the village as a fire break. These studies are notable for considering human impact as an integral part of processes moulding ecosystems.

MG has also collaborated with Ram Guha, today a leading historian of post-independence India, on interpreting India's environmental history as well as contemporary environmental issues, leading to the writing of two books, "This Fissured Land" the first book ever on the ecological history of India, and "Ecology and Equity" on contemporary environmental issues.

A major focus of MG's work at the Centre for Ecological Sciences has been on organizing decentralized, networked approaches to monitoring of biodiversity. The challenges are immense, for valuable elements of biodiversity are not restricted to a few pockets, such as national parks. Thus, wild relatives of rice occur in numerous wetlands dispersed over the Indian countryside and the insectivorous *Drosera* plants are being quietly collected and exported to Japan from small rain puddles on sheet rocks along the Western Ghats. Hence the task must truly cover all of the country, and concern itself as much with lowly leeches and mushrooms as with tigers and cranes. Such a task cannot be carried out in a routine, centralized fashion for the ecological systems are highly variable in space and time, and must be investigated and more importantly managed in ways sensitive to this variation. So it is necessary to organize an effective network covering the entire country. Such a network will have to be erected on two pillars: the large numbers of students and trained biologists working as teachers in undergraduate colleges throughout the country and the even larger number of practical ecologists - fisherfolk and shepherds, dispensers of herbal medicine and rat-catchers who depend on living resources for their livelihoods. If mobilized, such a group will not only generate valuable information of both basic and applied interest but the process will also serve as an excellent training in science.

MG has also been instrumental in setting up the Lifescape project and in pioneering the Peoples Biodiversity Registers. While the work on the preparation of these PBRs was in progress, MG served as a member of the committee to draft India's Biological Diversity Act, finally enacted in 2002.

Raghavendra Gadagkar obtained B.Sc (Hons) and M.Sc. in Zoology from Bangalore University and Ph.D. in Molecular Biology from the Indian Institute of Science, Bangalore. During the past 25 years he has established an active school of research in the area of Animal Behaviour, Ecology and Evolution. The origin and evolution of cooperation in animals, especially in social insects, such as ants, bees and wasps, is a major goal of his research. By identifying and utilizing crucial elements in India's biodiversity, he has added a special Indian flavour to his research.

Gadagkar is now Professor and JC Bose National Fellow at the Centre for Ecological Sciences, Indian Institute of Science, Chairman, Centre for Contemporary Studies, IISc, Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research, Non-Resident Permanent Fellow of the Wissenschaftskolleg (Institute for Advanced Study) in Berlin and Adjunct Professor, Indian Institute of Science Education and Research, Kolkata. He has published over 200 research papers and articles and two books. His book entitled Survival Strategies (Harvard University Press, USA, 1997 and Universities Press, Hyderabad, 1998, since translated into Chinese and Korean), explains recent advances in behavioural ecology and sociobiology to a general audience. His more technical book entitled The Social Biology of *Ropalidia* (Harvard University Press, USA, 2001) summarizes over twenty years of his research aimed at understanding the evolution of eusociality. His research work has been recognized by a number of awards including the Shanthi Swarup Bhatnagar Prize, B.M.Birla Science Prize, Homi Bhabha Fellowship, B.P. Pal National Environment Fellowship on Biodiversity, the Third World Academy of Sciences award in Biology and the H. K. Firodia award to name a few. He is an elected fellow of the Indian Academy of Sciences, the Indian National Science Academy, the National Academy of Sciences, India, the Academy of Sciences for the Developing World (TWAS) and Foreign Associate of the National Academy of Sciences, USA.

He is or has been on the editorial boards of several national and international scientific journals, including the board of reviewing editors of Science. He has delivered over 500 invited lectures in universities, institutes, schools and colleges in India and abroad. He was invited to USA as the Michener Lecturer and by the Royal Society to deliver a public lecture in London, on the occasion of India day and has delivered plenary lectures at a number of national and international conferences. He is, or has been, a member of a number of national and international professional scientific bodies and government and non government advisory committees including the Scientific Advisory Committee to the Cabinet, Government of India.

As the founder chair of the Centre for Contemporary Studies, Gadagkar has initiated a new experiment that endeavours to engage some of the best practitioners of different disciplines in the human sciences, such as philosophy, sociology, economics, law, literature, poetry, art, music, cinema, etcetra and aims to forge meaningful interaction between the natural and human sciences with special focus on understanding the diverse research methodologies of different disciplines and create opportunities to rethink the foundations of our own disciplines.

Raghavendra Gadagkar

Understanding Insect Societies

Many insect species such as ants, bees, wasps and termites organize themselves into societies that resemble, if not better, human societies in the organization and integration of their colonies, communication and division of labour and even in their caste systems. Perhaps the most striking feature of insect societies is that reproduction is limited to one or a small number of individuals while most colony members function as sterile or nearly sterile workers. The evolution by natural selection of insect societies and of their altruistic workers constitutes one of the most important unsolved problems in modern evolutionary biology. As is demanded by this evolutionary puzzle, we have pursued a combination of theoretical and empirical research, the latter involving both field and laboratory studies. As might be expected, empirical research on the question of the evolution of insect societies, is perhaps best conducted by focusing on species that appear to be intermediate between solitary and social life styles. Thus we have chosen the primitively eusocial wasp *Ropalidia marginata*, widely distributed in peninsular India, as our favourite model system.

In the past 25 years we have addressed questions at various levels to understand the social organization of *R. marginata*. These wasps are called paper wasps because they use cellulose material from natural sources to make paper nests. There is always a single egg-layer in the colony, referred to as the queen. All workers are females. Males stay in their natal nest for about a week and leave, to lead a nomadic life and attempt to mate with females from other colonies. *R. marginata* is a primitively eusocial wasp with a difference. As in other primitive societies, colonies are headed by a queen that is not morphologically distinguishable from the workers. But, unlike in other species, here the queen is not physically aggressive, and does not appear to use physical aggression to suppress reproduction by the workers.

R. marginata is not only different from other primitive species in having a docile, non-interactive

queen, but also in having de-centralised, self-organized regulation of foraging by the workers. Workers use dominance-subordinate interactions among themselves to regulate the rate of foraging in the colony and display a well developed age polyethism. These are very unusual features for primitive insect societies. Though the *R. marginata* queen is a docile individual, the process of queen establishment involves a high level of aggression, which is shown by a single worker towards all others. We call this individual the potential queen, as she steps up her aggression when the queen is lost, and eventually develops her ovaries and becomes the new queen of the colony. Interestingly, the potential queen's heightened aggression appears to have the function of helping the potential queen to boost her own ovarian development rather than to suppress other contenders to the position of the queen. The potential queen becomes evident within minutes of queen removal, and does not face any challenge from the other workers. We have shown that even though we cannot predict the identity of the potential queen in the presence of the previous queen, her identity is 'known' to the wasps themselves. Since the queen in *R. marginata* does not use aggression to maintain her reproductive monopoly, we have tested the hypothesis that she might be using a pheromone to regulate worker reproduction, as queens of highly eusocial species do. We now have evidence that this may indeed be the case and that the queen applies a non-volatile pheromone produced by her Dufour's gland on the nest surface. Since the pheromone is expected to be an honest signal of the queen's reproductive capacity the workers are expected to refrain from reproducing as long as a healthy queen is present in the colony. However, some workers do attempt to increase their reproductive fitness by splitting the colony and leaving with one or a few workers to start their own nest. Nest founding in *R. marginata* can be by a single or by a small group of foundresses, and subsequent joiners are also quite common in pre-emergence colonies. We are carrying out genotypic studies to understand the metapopulation structure of *R. marginata*. Our current understanding of the *R. marginata* society permits us to place *R. marginata* somewhere in between typical primitively eusocial species and typical highly eusocial ones.

We have also begun to study the congeneric, sympatric *R. cyathiformis*, which is a typical primitively eusocial species. In *R. cyathiformis*, the queen is the most aggressive individual in the colony, who also acts as the central pacemaker of the colony and regulates worker activities. If the queen is lost, then the next most aggressive individual succeeds her as the potential queen. A comparative study of the two species helps us to understand how *R. marginata* has evolved into a higher level of social organization compared to a typical primitively eusocial species such as *R. cyathiformis*.

More recently, we have also initiated the study of two species of queenless ants *Diacamma ceylonense* and *Diacamma sp.* from "*nilgiri*". These ants have lost their queen caste over evolutionary time, and the function of egg-laying in these ants is carried out by mated workers called gamergates. These queenless ants can be considered as primitively eusocial and I have proposed that they can be thought of as examples of the beginnings of the loss of eusociality. These two species of queenless ants are very similar in their social structure, but there is a most fascinating difference. In *D. ceylonense*, the gamergate maintains her reproductive monopoly by mutilating the gemmae (wing-buds) of all workers and renders them incapable of mating. But the gamergate of *D. "nilgiri"* maintains reproductive monopoly without mutilating her workers and thus without rendering them incapable of posing her a challenge. Our preliminary studies suggest that, like *R. marginata* and *R. cyathiformis*, *D. ceylonense* and *D. "nilgiri"* may also represent two different levels of social organization. Thus we now may appear to have four model species for a comparative study of the gain and loss of eusociality.

Raman Sukumar had his school, undergraduate and postgraduate education in Biology at Madras (Chennai). In 1979 he moved to Bangalore to do a Ph.D. in Ecology (awarded 1985) at the Indian Institute of Science where he eventually joined as faculty at the Centre for Ecological Sciences. His doctoral research on the interactions between elephants and humans, published as a monograph by Cambridge University Press, is recognized as pioneering work in the field of wildlife-human conflicts. Since then his interests have expanded to the relationship between humans and nature, conservation biology, tropical forest ecology and climate change. Apart from academic research his activities extend to field conservation and shaping government policy in conservation.

Raman Sukumar is presently Professor and Chairman of the Centre for Ecological Sciences. He is a Fellow of the Indian Academy of Sciences and the Indian National Science Academy. In 1997, Sukumar set up the Asian Nature Conservation Foundation which has since carried out several field projects in India and other Asian countries on elephants and their habitats. During 1997-2004, Sukumar was Chair of the IUCN/SSC Asian Elephant Specialist Group. Sukumar has been a Fulbright Fellow at Princeton University (1991-92) and Adjunct Faculty (2001-present) at Columbia University, New York. He is the recipient of several national and international honors and awards including the Order of the Golden Ark, The Netherlands (1997), Whitley Gold Award for International Nature Conservation, U.K. (2003), University Grants Commission National Award in Environmental Science and Ecology, India (2006), International Cosmos Prize, Japan (2006), B.P. Pal National Environment Fellowship Award for Biodiversity, India (2007) and a Commendation by the Prime Minister of India for contributions to the Intergovernmental Panel on Climate Change (IPCC) that shared the Nobel Peace Prize (2007).

My interests in natural history and conservation developed during my college days at Chennai where the Guindy Park, the Adyar river and the east coast provided ideal laboratories for weekend pursuits. Later, my study of a long-lived animal, the elephant, for my doctoral research brought home the need to appreciate the role of scale in ecology before deriving firm conclusions on a particular phenomenon. My approach to ecology has thus been to understand patterns of plant and animal populations in space and time; accordingly the research work of my laboratory spans a hierarchy of spatial and temporal scales from that of an individual plant or animal to communities, landscapes and the Indian subcontinent, and from the late Quaternary to the present and the future.

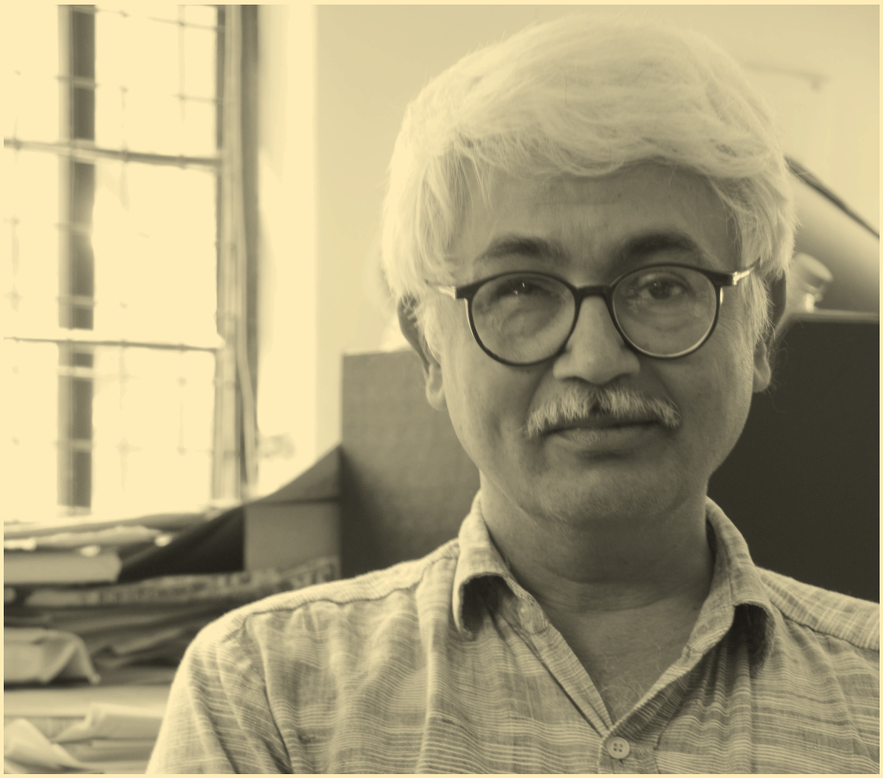
My passion for studying the elephant, a keystone species in Asia's rich tropical forests, has not diminished over the years. We have monitored elephant population distribution and habitat since the 1980s across the country and in other south-east Asian countries (Vietnam and Myanmar). Besides providing ecological insights into the population dynamics of the largest land mammal in Asia, this work has helped assess impacts of ivory poaching on Asian elephant populations. With increasing habitat loss, increase in human and elephant populations, human-elephant conflict is a major concern across the elephant's range in the continent. Our group has continued to address the ecological basis of conflict between a large mammal and humans along with trying to design techniques to mitigate this conflict. We are currently involved in monitoring the nature and extent of wildlife-human conflict involving various mammals at several sites across India. In the course of our work, we have used new technology to further our understanding of the ecology and behavior of this large mammal. For instance, we have quantified home-ranges, movement patterns and use of corridors by Asian elephants using radio- and GPS-based telemetry in West Bengal. Recently, our group has proposed a new phylogeography and evolutionary history of the Asian elephant across its range through analyses of population genetic structure using DNA extracted from dung. The molecular genetic work has also uncovered new facets of the social organization of the elephant.

After helping design the Nilgiri Biosphere Reserve during 1985-86, India's first such reserve, I began a long-term project that interfaces with conservation and management of this highly biodiverse region. Beginning in 1988 a number of permanent plots, including a large plot of 50 hectares, was set up in the Nilgiris (mainly in Mudumalai) for long-term research of the dynamics of tropical forest communities in relation to climate, fire, impact of elephants and human disturbances. These plots monitor the fate of about 50,000 individual trees from about 300 species and this is the largest and longest running programme of its kind in the country. We have characterized patterns of mortality, recruitment, phenology, growth and dispersal mechanisms for these vegetation communities. This monitoring has brought out an interesting aspect of the adaptation of tropical dry forests; in spite of environmental stress in the form of fire, drought and herbivory by large mammals, the forest community has shown amazing resilience in maintaining species richness and increasing carbon stocks. Concurrently, we have been monitoring large mammal communities using a set of permanent line transects.

Raman Sukumar

The elephant has also strangely guided me into another area of ecology, namely climate change, which has become topical in recent years. A dead elephant in a valley in the upper Nilgiri plateau helped me discover a peat bog that is an archive of the past vegetational and climatic history of this region going back to the late Quaternary (about 40,000 years before present). Stable carbon and oxygen isotope analyses of these peat bogs revealed that the past climate of southern India was largely in tune with well-known global climatic events of the past. More recently, we have been involved in modelling potential impact of future climate change on forests in India and its implications for protected areas and wildlife conservation during the 21st century.

The emphasis on large mammals (in particular the elephant), tropical forests and climate change has not precluded research on other aspects of ecology. Whenever an interesting theoretical question in ecology has come by, my graduate students have pursued research on it. The topics they have covered range from host-parasite relationships (intestinal parasites in the larger mammals) to ecological gradient theory (bird communities along altitudinal gradients) and "island" biogeography (rodent populations in montane forest patches and grasslands). Thus students in my laboratory have an opportunity to pursue a variety of interests from theoretical investigations to field-based observations and laboratory work.



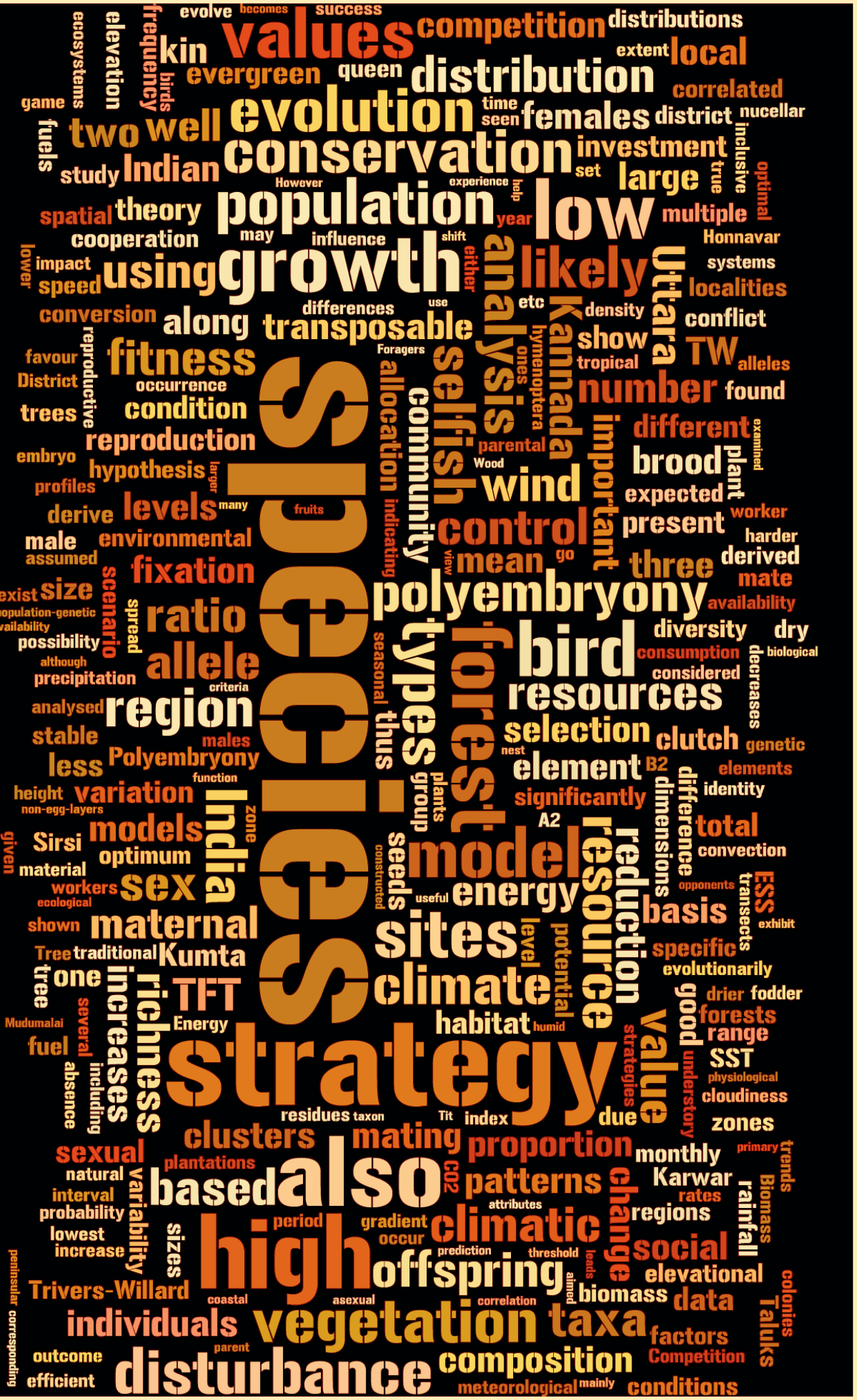
N. V. Joshi obtained his B.Sc. (physics and mathematics) from the Institute of Science, University of Bombay in 1972 and his M.Sc. degree in physics (spectroscopy and X-ray crystallography) from the Indian Institute of Technology, Powai, Bombay in 1974. In the same year, he joined the Molecular Biophysics Unit, Indian Institute of Science as a research student, and obtained his Ph.D. in 1980 under the supervision of Prof. V. S. R. Rao. His work was exclusively computational in nature, and involved the determination of the preferred conformations of molecules of biological interest (such as hexose and pentose sugars, beta lactam antibiotics such as penicillin) using the techniques of molecular mechanics. These studies were successful in correlating the molecular structure and biological activity, for example, the sensitivity of some of the penicillin derivatives to lactamases.

In 1978, during the course of his Ph.D., N.V. Joshi joined the Center for Theoretical Studies (CTS) at the Institute as a mathematical programmer. In that capacity, he interacted with the faculty members of the center (Prof. Madhav Gadgil, Prof. Sulochana Gadgil, Prof. H. Sharat Chandra) as well as with many of the visiting scientists. These inteactions provided a very valuable experinence in the setting up of mathematical models, and of analysis of data from many disciplines - meteorology, ecology, animal behaviour, molecular biology etc. After working as a Scientific Officer in CTS between 1984 to 1987, he joined the Center for Ecological Sciences (CES) as a lecturer and is presently an associate professor at the center. He also served as the chairman of the center for a couple of years around 2001.

NV Joshi was elected as a fellow of the Indian Academy of Sciences in 1992. He has served as a member of the editorial board of the Journal of Biosciences of the Indian Academy of Sciences, of the Journal of the Indian Institute of Science, and of Current Science. He has been one of the associate editors of Current Science since mid 2005.

Niranjan V. Joshi

As a scientist interested in the modeling and statistical analysis of biological systems, N. V. Joshi has worked on a wide variety of topics. This weighed cloud of words is generated from the abstracts and keywords of some of his many research publications and indicates his many interests.



I knew very early that I wanted to study how the living world worked. I studied zoology and microbiology for a bachelor's degree at Saint Xavier's College in Bombay. The exciting intellectual atmosphere in this college was invigorating as was the academic freedom. I had access to the famous Blatter Herbarium housed in this college where I could learn much about the wild flora of the Western Ghats. I was also an active member of the Bombay Natural History Society and learned much from the week end trips into various habitats, as well as from interactions with the staff.

I went on to do a master's degree in animal physiology from the University of Bombay, taking time off to attend a month-long course in wildlife science at Kanha National Park organized by the US Fish and Wildlife Service. This was followed by a PhD in evolutionary ecology at the University of Miami during which I came back to India to study the foraging ecology of the Indian giant squirrel *Ratufa indica*. I worked in Magod, North Kanara, and at Bhimashankar Wildlife Sanctuary, Maharashtra, for this research, and the latter place has been one of the principal foci of my research over the years.

I also studied people–wildlife conflicts at Bhimashankar and went on to document the socioeconomic profile of the local Mahadeo Koli tribe and their knowledge and relationship with the forest. After my PhD, I was associated with the Wildlife Institute of India, Dehradun, where I taught community ecology to several batches of students studying for their master's degree in wildlife biology.

I also served as Deputy Director, Research, at the Bombay Natural History Society for several years where I designed and taught the first diploma course in conservation biology. I joined the Centre for Ecological Sciences, at the Indian Institute of Science, where I currently have a lab that is active in the study of species interactions.

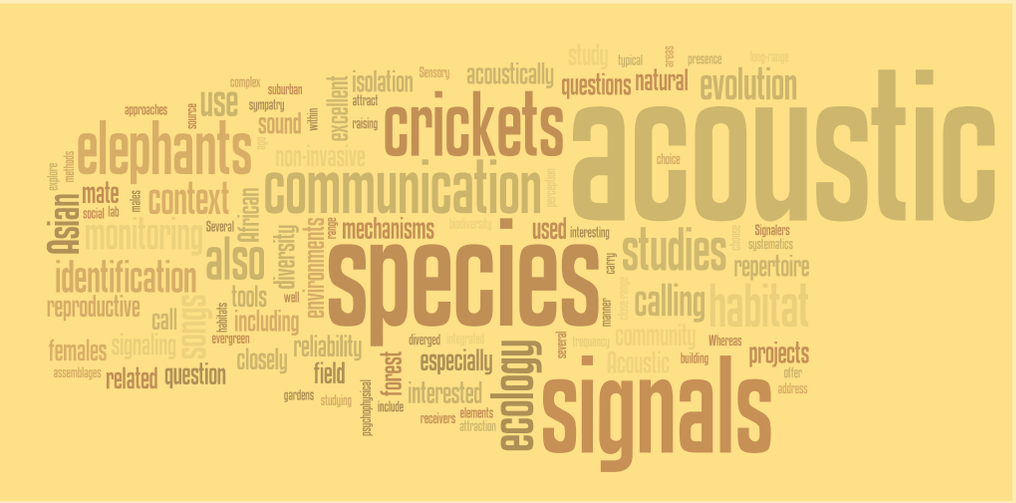
I still continue to study the giant squirrels, now through modeling their foraging movements through the forest canopy using movement algorithms that can help to predict how much should giant squirrels exploit and explore their resource base. My lab is thus open to questions and techniques that will help to understand the evolution of the myriad positive and negative or neutral interactions between species.

I am interested in many things, but my principal current interest is the evolution of the interactions between species, especially those involving plants and animals. I am currently studying the evolution of the interactions between ants and plants using an unspecialized leguminous ant-plant *Humboldtia brunonis* that occurs in the Western Ghats. Some individuals of this plant have swollen hollow internodes that harbour ants; however ants are not the only inhabitants, since these specialized internodes called domatia may also contain arboreal earthworms and a host of other invertebrates, among which are pollinating bees. The plant also attracts ants via extrafloral nectar produced from glands on the young leaves and flower buds. While plants provide housing as well as nectar for the purpose of attracting ants that will protect the plants against herbivores, not all ants are protective, nor is all nectar and all housing attractive to ants. Furthermore, even non-protective ants that live within these plants may actually contribute to the reproductive success of the plants by feeding these plants with nitrogen from their nest debris. We are examining these trophic interactions between ants and plants using stable isotope analysis. We are therefore studying the conditions that are suitable for the development of a stable mutualism between ants and plants by examining the mechanisms employed by plants and ants to assess the benefits or costs of potential partners.

We also study a fascinating nursery-pollination system that is about 60 million years old: the relationship between figs and fig wasps. In this system, the pollinating wasps are bred within the fig syconia where they also pollinate flowers and produce seeds. This mutualism is subject to attack by non-pollinating fig wasps that parasitise the fig wasp pollinators. The wasps are also subject to predation by ants. Furthermore, figs signal their pollination receptivity by emitting specific volatile organic compounds that are highly attractive to the pollinator wasps. We study the chemical communication between figs and their pollinators and also how this communication is eavesdropped upon by ants as well as the non-pollinating fig wasps. We also examine the volatile signals meant to attract dispersal agents such as birds and bats. Some ripe figs also produce repellant compounds, and we are studying the reaction of dispersal agents to these repellants. Besides wasps, ants, birds, and bats, figs also interact with nematodes that use the fig wasps as vectors to move from one fig to another. We study the chemical interactions between all these players in the fantastic ecological and evolutionary theatre that is constituted by the fig syconium.

We have discovered the world's first nocturnal bee *Xylocopa tranquebarica* that can fly at starlight and that can also see colour at starlight and moonlight levels. We are now assessing how these nocturnal bees share resources with diurnal bee species within the Bhimashankar Wildlife Sancutuary where there are not many flower species that bloom at night. Whether the low population levels and the life history traits of the nocturnal bees are a result of constraints on resource availability are questions that we are currently addressing. In this fascinating field of visual ecology we have also shown that crab spiders can perceive ultraviolet light and use this perception to exploit the ultraviolet sensitivity of their honeybee prey that are attracted to the ultraviolet reflectance of the spider abdomens. The spiders do so by choosing hunting backgrounds that have low ultraviolet reflectance and thus form highly attractive ultraviolet targets for the bees; the spiders thus lay sensory traps for the bees. We also study the chemical and visual basis of the mimicry between ants and spiders. We study a group of ant-mimicking jumping spiders that employ chemical and visual signaling. These spiders also determine species specificity and reproductive status from signals present on spider silks. We are investigating questions of cryptic species and within-species signaling using the chemistry of the silks.

Renee Borges



I cannot remember a time when I was not fascinated by animals. The flashes of fireflies and the eerie glow of glow worms crawling in the dark sparked off an interest in insects and other creatures of the night, which has been with me ever since. The highlights of high school in Dehradun were the trips we made to Kumaon and Bharatpur, where I had my first introduction to wild elephants and birdwatching. After high school, I firmly refused to become an engineer or doctor and studied zoology instead, first as an undergraduate in Mount Carmel College in Bangalore and then at Pune University. Even though classes were sometimes boring, we did interesting field trips that more than made up for the tedium of classrooms. When the time came to do a doctoral dissertation, however, there were few opportunities to study wildlife ecology and behaviour in India and all doors eventually closed on me. So I took up for a doctoral degree in behaviour genetics in flies at TIFR, Bombay, a period when I learned much, worked hard and, after scoring millions of flies under the microscope, decided that I could do this no more! I then started the convoluted journey that brought me back, over a decade almost, to where I wanted to be: listening in the dark to a multitude of forest sounds, each with its own special meaning.

My lucky break into the world of animal acoustic communication came with an advertisement in *Nature* by Jerry Pollack for a trained electrophysiologist to work on crickets: I replied to this ad saying that I had the wrong background, was not a good physiologist and had no interest in the project being advertised, but was interested in behaviour and communication. Incredibly, I was offered the position! My postdoctoral years in Canada and Germany gave me extensive experience in bioacoustics and behaviour. My second lucky break came with the faculty position I now hold. I applied for the job and resigned myself to being the outsider with the wrong pedigree for an ecologist: a 'non-wildlifer.' I was all set to quit science and take up a career in something entirely different, such as setting up a bistro (cooking being my second passion) when I received an e-mail saying that I had a job!

The last ten years have allowed me to indulge every interest, intellectually and practically, from systematics to behaviour to ecology; from natural history to experiment to theory, and from infrasound in elephants to ultrasound in bats. I have learned much, with and from my students and enjoyed every new sound, every new animal and every new problem that has challenged me. So...

'*I have to say it now / It's been a good life all in all /*

It's really fine / To have a chance to hang around' - John Denver

The Bioacoustics Lab

We are interested in the structure, diversity, perception and function of acoustic communication signals in an ecological and evolutionary context. Orthopteran insects, including crickets and grasshoppers, provide excellent systems to study these questions because they use a repertoire of acoustic signals for both long- and close-range communication in the context of mate attraction. Since they occupy a range of habitats from suburban gardens to tropical rainforests, they also offer excellent opportunities for studies in community and habitat ecology.

Our research projects span the areas of bioacoustics, animal behaviour, community and habitat ecology, and systematics. Theoretical, experimental and observational approaches are used in an integrated manner in most of the projects, which typically involve both laboratory and field studies. We are also interested in the use of acoustic signals as tools for non-invasive species identification and biodiversity monitoring.

Sensory ecology and evolution of acoustic communication

Male field crickets use long-range acoustic signals or calling songs to attract conspecific females. The calling songs are highly stereotyped and species-specific and effect reproductive isolation, especially between closely related species in sympatry. Several features of the calling songs, including the carrier frequency as well as temporal elements, are used by females to recognize and choose between males of their own species.The specific questions that we explore include mechanisms of sound source localization by crickets in real-world, acoustically complex environments; the role of acoustic signals in reproductive isolation among closely related species and in mate choice within a species, the mechanisms and evolution of acoustic synchrony in crickets and the patterns of evolution of acoustic signals.

Signalers and receivers in natural assemblages

In a typical natural habitat, such as an evergreen forest, several acoustically communicating species call together, raising the question of how each species manages to communicate its message in the presence of so many interfering calls of other species. Our studies in Kudremukh National Park address the question of acoustic interference and of the transmission of signals in forest environments. We also examine the habitat ecology of crickets, their distribution and diversity.

Acoustic signals as tools for non-invasive species identification and monitoring

We study the reliability of acoustic signals as cues for species identification and the reliability of acoustic monitoring methods, both psychophysical and instrument-based. To this end, we are building libraries of the calls of cricket, bat and bird species. We also carry out detailed taxonomic studies, especially on crickets.

Acoustic communication in Asian elephants

Whereas African elephants have been extensively studied with respect to their acoustic communication, we know very little about acoustic signaling in Asian elephants. We are studying the call repertoire and social context of acoustic signaling in wild Asian elephants, which diverged from African elephants about 5-6 million years ago.

Rohini Balakrishnan

When I try to recall how I landed up doing what I am doing today many interesting moments from the past come to mind. I remember as a child I was always fascinated by the living world around us and was attracted to wild and desolate areas away from human habitation. Thus when ever I got an opportunity I would slip out of the house to such places looking for bird nests. These excursions of course would cause much anxiety to my mother. But the single "significant" event that changed my life and prevented me from hurtling down the MBBS-BE path was a nature camp organized by WWF. The camp was in Anamalai wildlife sanctuary (now called Indira Gandhi wildlife sanctuary) and it was in this camp that I got hooked on to birdwatching. By the time I was in 10th standard I knew that I wanted to get into wildlife research and hopefully do a Ph.D. some day in this area.

After my schooling I joined the BSc Agriculture program, mainly because I loved the very large scrub patch within the campus of the University of Agricultural Sciences, Bangalore. As expected I spent more time outside than inside the class. It was during my BSc that I took up my first serious study on birds. For three years I studied cooperative breeding behaviour in green bee eaters on campus which got published in Current Science in 1993.

After my BSc I was in Dr. Gadagkar's lab at CES as a visitor for four months, where I worked on training bees to identify patterns. In 1994 I registered for Ph.D. in Ecology, Evolution, and Behaviour at State University of New York (Albany). For my PhD I worked on the molecular phylogeny of langurs of Asia. I completed my Ph.D. in 2000, after which I spent a year in the Institute of Evolution, Haifa University studying blind mole rat population genetics.

From 2002 to 2005 I was a post doctoral associate at Yale University, USA. At Yale I was involved in the setting up and day to day running of the Ancient DNA laboratory. While at Yale I also worked on the biogeography of Malagasy lemurs and plated lizards. Since my return from the US, I have been working in CES where I have established a full-fledged molecular ecology laboratory.

Praveen Karanth

Laboratory of molecular phylogenetics and biogeography

We are interested in studying genetic variation both within species (population genetics) and among species (phylogenetics) to address questions in ecology, evolution, behavior and conservation biology. The lab is primarily concerned with trying to find answers to exciting problems in biology in an evolutionary framework, i.e., through the use of molecular phylogenies. Broad areas of interest include character evolution, molecular systematics, phylogeography and biogeography. In addition we are also interested in population and conservation genetics.

Current research

Devising an operational definition for a species: Using a combination of molecular, morphological, behavioral, and ecological data to delimit species. This work will help us to identify evolutionary significant units as well as cryptic species.

Biogeography and phylogeography: Applying phylogenetic methods to understand past climatic and geological events that might have shaped the current distribution of fauna and flora of the Indian subcontinent.

Molecular systematics: Using phylogenetic methods to resolve the taxonomy of problematic groups and using this information in rating species for conservation.

Population genetics: Genetic consequence of habitat fragmentation on endangered species and human mediated gene flow.

We employ a range of systems such as mammals, lizards, insects, arachnids and centipedes to address these questions. Typically multiple nuclear and mitochondrial markers are sequenced from various species of the study system. These sequences are aligned and the alignment is subjected to phylogenetic analysis using various computer programs such as PAUP and Mr. Bayes. The phylogenies are interpreted in conjunction with morphological, ecological and historical data.

Current projects include:

Delimiting species boundaries among Hanuman langurs.

Molecular phylogeny of centipedes of the genus *Scolopendra*.

Evolutionary origins of house geckos of the Indian subcontinent.

Understanding satyrine butterfly (Satyrinae: Nymphalidae) diversity in Peninsular India through the use of molecular tools.

Origin and diversification of endemic skinks of Western Ghats.

Biogeography and evolution of tarantulas of the genus *Poecilotheria*.

Sand on my knees and the sound of breakers ringing our ears, we crawled up to a nesting olive ridley turtle, laying a hundred or more eggs softly in the sand beneath her. We were then students of zoology in Madras Christian College. Founders of the Students Sea Turtle Conservation Network, that would survive 2 decades of disorganised student leadership. For me personally, it was a turning point.

For 3 years, through my B.Sc. and M.Sc., I helped run the SSTCN, a mostly thankless job as many subsequent generations of students will attest. Every night during the season we walked the beaches of Chennai to collect the nests before they were poached, counted dead turtles, or released hatchlings from our hatchery and excavated stinky nests. Then attended class after a few hours of sleep. Rewarding as always in retrospect.

In 1992, after a year teaching students some biology and a little basketball in Rishi Valley (but catching a fairly wide variety of snakes that found their way into all manner of rooms), I joined CES for a Ph.D. which was on small mammals in the Nilgiris. During this time, I worked on the shola grassland ecosystem, looking at island populations of rodents, and aspects of community ecology, diversity and population biology.

Following the Ph.D., I returned to work on sea turtles focusing on the phylogeography of olive ridley turtles on the east coast of India at the Wildlife Institute of India, Dehradun. Our work showed that this unique population is the closest relative of the Kemps ridley, a sister species that nests only in Mexico, and was probably ancestral to populations found in the Pacific and Atlantic Oceans. Following this project, I have continued to work on the genetics of olive ridley turtles throughout India and on other species such as green turtles, leatherbacks and hawksbills in the Andaman and Nicobar and Lakshadweep Islands.

At WII, I also worked on a project on sea turtle conservation throughout India, through which I became involved in the establishment of networks for coastal and marine conservation, which is beginning to gain momentum now.

After a brief stint at the Madras Crocodile Bank Trust, I joined the Ashoka Trust for Research in Ecology and Environment, where we established the Coastal and Marine Conservation Programme, combining social, policy and ecological research to inform conservation action. This work continues today through the Dakshin Foundation.

In 2006, I returned to CES. Today, the students and I work on a variety of topics including community ecology, biogeography and evolution on a range of taxa including amphibians, reptiles, birds and small mammals. I continue to work on sea turtle biology and conservation, and have recently become interested in the social and anthropological aspects of natural resource management, in fisheries along the coast, and in terms of human wildlife conflict in terrestrial systems.

Community ecology, biogeography and macroecology

We are working on the distribution of diversity at various levels of organisation, from genes to ecosystems, and at various scales from local communities to macro-ecological regional scales. We are working on a range of small vertebrates in forest systems and coastal and marine fauna. We combine field ecology, phylogenetic information and ecological modelling to understand evolutionary and biogeographic patterns, and assist conservation prioritisation. Current research projects include studies of mixed foraging flocks of birds, distribution patterns of birds, and phylogeny and biogeography of snakes and frogs.

Marine turtle biology and conservation

Five of the seven species of marine turtles are found in Indian coastal waters and at least four have significant nesting beaches and/or feeding areas. We are continuing molecular genetic studies of these turtles to explore phylogeography and population genetics, and study other aspects such as multiple paternity. We are also initiating tagging and telemetry studies for leatherback turtles in the Andaman and Nicobar Islands. We have a long term population monitoring programme for olive ridley turtles in Orissa. Most recently, we have initiated a collaborative effort with small NGOs along the mainland coast to monitor temperatures, and potential impact of climate change on sea turtle populations through its impact on sex ratios.

Socio-ecological studies of conflict

There is conflict between humans and wildlife in many contexts, which usually manifests itself in the form of loss of lives and livelihoods either directly or indirectly (loss of access to resources). In the terrestrial realm, we are developing a synthetic framework to examine conflict in different ecological, sociological and economic contexts, in order to identify the drivers of conflict and develop solutions. We are also beginning work on the political ecology of natural resource management in coastal and marine systems, and its implication for the conservation of these resources.

Coastal conservation networks

During our work on sea turtles in Orissa, it became clear that there are common means to protect turtles and the rights of traditional fishermen. In order to achieve this, we had earlier facilitated the creation of a common platform for sea turtle conservation in Orissa called the Orissa Marine Resources Conservation Consortium (OMRCC), which has since been working together to achieve common marine conservation goals. With collaborators at various institutions, we are currently setting up a nationwide network of NGOs which are involved in sea turtle and coastal conservation, while putting in place mechanisms that will sustain both the monitoring and education and awareness programs.

Kartik Shanker

I did my undergraduate studies in Zoology at the Madras Christian College (Chennai). I then completed a Masters in Wildlife Science at the Wildlife Institute of India in Dehradun. While designing and conducting my Masters research, I discovered that what excited me most in ecology was watching animals and puzzling out the ecological backdrop and the evolutionary reasons explaining their intricate and varied behaviour.

My masters research, with YV Jhala, focussed on the rare and extraordinary lek-mating system of the blackbuck antelope. In this mating system, males congregate on open grounds where they defend tiny territories that are clustered together. These territories hold little but the displaying territorial owners and females visit these aggregations, called leks, in search of a mate. For my Masters research, I examined the territorial behaviour of males on leks and studied how costs and benefits of holding territories changed depending on the position of the territory in the lek. I also looked at whether males allocated their time differently towards costly reproductive activities, such as displays, courtship and fighting, versus essential feeding and resting activities, depending on the payoff they could expect,. The idea tested was that males who potentially stood to gain much would adopt high-risk tactics while those whose expectations were relatively low would instead show low-cost behaviour.

I received a PhD in Zoology from the University of Florida (Gainesville, USA) in 2003. For my thesis, supervised by Jane Brockmann, I continued to focus on blackbuck leks and studied the evolution of this mating system. I worked on two main questions, first why do males form leks given the enormous costs of aggression and starvation they experience as a result of their defence of territories on leks? Second, what information do females use to choose mates on leks?

I then worked for three years in the University of Cambridge (Cambridge, UK) as a post-doctoral research fellow in Tim Clutton-Brock's Large Animal Research Group. Here, I worked on comparative analyses of sexual selection and life history strategies in mammals. Some of the topics I worked on were examining why female lifespans were much longer than male lifespans in some mammals but not in others; the diversity in overt and covert mating tactics that males and females displayed; why male mating success is highly skewed in some species so that only a few males gain matings while in others mating success is distributed fairly uniformly among males; and what the consequences are of such reproductive competition on male body size and behaviour. After a short period as a Visiting Fellow at the National Centre for Biological Sciences (Bangalore), I joined CES in May 2007.

Evolutionary ecology research group

Animals display a bewildering diversity of solutions to similar problems, such as how to avoid predators, whom to mate with, how many offspring to have, and how much resources to allocate to each offspring. We are interested in understanding the evolutionary reasons for such diversity in behaviour and life history traits. A powerful approach to understanding this diversity has been to focus on individual decision-making. This approach entails measuring the costs and benefits associated with alternative decisions. The cost/benefit of a particular decision changes with the ecological context. Therefore, the behaviour that is optimal differs from one set of ecological conditions to the next and this may explain why we see such diversity in behaviour.

We are also interested in studying the implications of these evolved behaviour and life history traits for populations and communities. These evolved traits influence how individuals respond to their environment and, therefore, have important consequences towards the dynamics of populations and their responses to environmental change. We use an individual-based approach to study how populations and communities respond to changing ecological conditions. Finally, we are also interested in applying behavioural and evolutionary principles to the conservation of species.

Our research group currently has two main themes: behavioural ecological studies of vertebrates and invasive species ecology. Current projects include the ecological basis of social behaviour and mating systems in the blackbuck antelope. What are the factors influencing individuals joining and leaving groups? How flexible are grouping strategies and what cues do individuals respond to? What are the ecological and evolutionary processes that favour different optimal and stable group sizes in different populations? What information do females use to choose mates? What are the roles of striking visual displays and scent marks in attracting females and repelling competitors?

A second project looks at mating strategies and spacing patterns in the highly sexually dimorphic rock agamas. What are the different mating strategies males show? What explains why some males are very successful while others never gain mates? We are also examining, more generally, the diversity among mammals in mating tactics and competition for mates and relating this reproductive competition to the differences we see between species in male phenotype (body size, weapons, lifespan, behaviour).

In addition to basic science, we also apply principles from behavioural ecology towards conservation problems. In an ongoing project, we examine crop damage by blackbuck by taking a behavioural ecological approach to understanding their foraging and movement strategies. This research investigates ecological explanations for blackbuck foraging and movement behaviour across a mosaic of natural grassland and agricultural landscapes to understand why and when blackbuck are attracted to crops and what could potentially deter them.

The second theme in our research group focuses on invasive species ecology. How widespread are invasive species in different natural habitats in India? What is their impact, both positive and negative? How do the life history strategies of invasive species affect their abundance and spread? What are the mechanisms by which they affect native species and habitats?

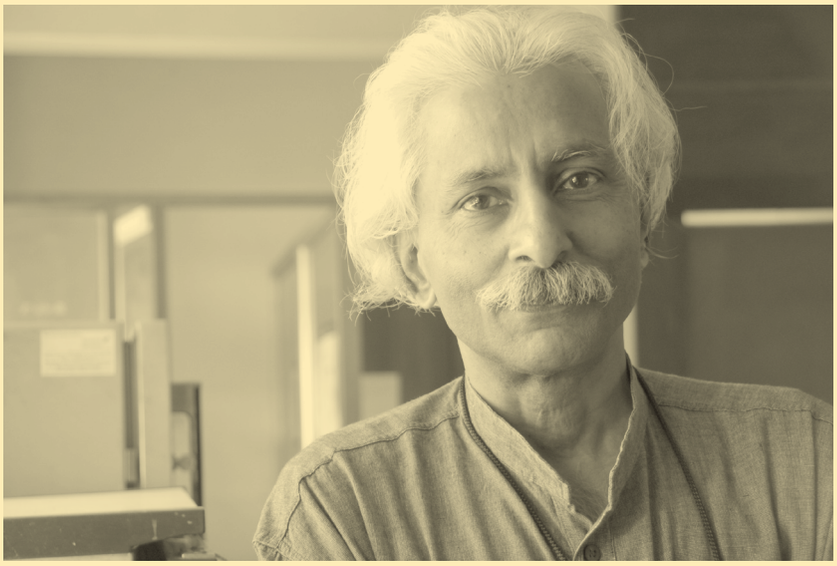
Kavita Isvaran

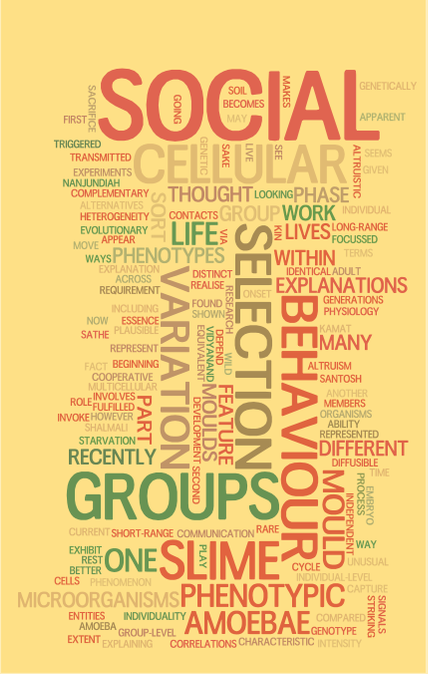
After some moving around between small towns (Latur, Sholapur), a city (Hyderabad) and a hill station (Coonoor), my matriculation took place in 1963 from Don Bosco High School in Mumbai, then Bombay. A four-year stint as a B.Sc. student at St. Xavier's College came next, with physics (principal) and mathematics (subsidiary) as the main subjects. Chemistry, Mathematics and English were taught excellently and one used to hear about the interesting work going on in the History department. Any inclination towards biology was kept at bay by the quality of instruction in Botany and Zoology. The question of making a switch to mathematics as the principal subject kept recurring, but physics retained its grip. Prof. R V Kamat was primarily responsible for this. After the B.Sc. there was a personally enriching and academically dispiriting year at IIT Powai.

Entry into the Physics Ph.D. program at the University of Chicago followed in September 1968. The 'U of C' allowed seemingly infinite freedom. But because of the demanding atmosphere, especially in the Physics department with its forbidding history – there were still people around who could recall seeing Enrico Fermi discussing quantum electrodynamics with his students while working on a lathe - , the freedom was more possible than real. The importance of critical thinking dominated above all else. Many worked out a compromise, namely to be well-organised in spurts. With all that there was not much stress, thanks mainly to fellow-students. The bulk of the work that went into my thesis seemed to have got done within a hectic six month period at the very end.

A latent interest in biology slowly reawakened during the stay in Chicago. There were many reasons, the chief one being that Morrel Cohen, my research supervisor, had become interested in applying ideas of self-organisation to biological systems, specifically to the cellular slime moulds. He was one of a small group largely made up from other departments that constituted a Committee on Mathematical Biology, later Department of Theoretical Biology. It included Jack Cowan, Richard Lewontin, Richard Levins, Stuart Rice, Stuart Kauffman, and Art Winfree. Through them I got to listen to other biologists and near-biologists (including Ilya Prigogine, Michael Gaze and René Thom). The experience was wonderful because there was a substantial amount of learning by osmosis without any necessity to pass exams or otherwise show what one had learnt. An audited course on developmental biology given by Alberto Monroy of the Naples Zoological Station was an eye-opener, not least for Monroy's blackboard artistry. At the time my studies were coming to a close, a casual look in the library had turned up a paper on wave propagation in amphibian embryos. A letter to the author, Koki Hara, produced a quick positive response and the chance to work with axolotl embryos for one year in the Hubrecht Laboratory in Utrecht. Theo Konijn had just left the Hubrecht for Leiden but dropped by frequently and kept me supplied with slime mould amoebae. Koki Hara's help and expertise made it possible for their aggregation waves to be filmed and interpreted. That led to a further three years of post-doc-ing in the laboratory of Guenther Gerisch, initially in the Max-Planck-Institut, Tuebingen, and then in the Biozentrum, Basel, to carry out experiments on signalling in cellular slime mould amoebae.

My first job was at the Centre for Theoretical Studies, Indian Institute of Science. It was an ideal place in which to begin an independent life in research, a true haven. Looking back, it is hard to imagine what a friendly and nurturing place it was and how few were the demands made on a young faculty member 33 years ago. Among the departments at the Institute, CES comes closest to the old (and now non-existent) CTS. I moved to the Molecular Biology Group, Tata Institute of Fundamental Research, Bombay, four years later and returned to the Indian Institute of Science after spending seven years there. My research continues to be on the development of pattern and evolution of social behaviour in the cellular slime moulds. The evolution of phenotypic plasticity is a second and related interest.





Research: Phenotypic variation and social behaviour in the cellular slime moulds

The cellular slime mould amoebae are unusual microorganisms that live in the soil as independent entities during the first part of their lives and as social groups during the second part. The move from individuality to social behaviour is triggered by starvation and involves communication between cells via long-range diffusible signals as well as short-range contacts. The social phase of the cellular slime mould life cycle can be compared to multicellular development, namely the process by which an embryo becomes an adult. A feature of the social life of these amoebae is that some members of a group appear to sacrifice their lives for the sake of the rest. Apparent altruism of this sort, which was thought to be rare at one time, has recently been found in many other microorganisms. Evolutionary explanations for altruistic behaviour invoke kin selection, group selection or individual selection. Until recently it was thought that these explanations represented distinct alternatives. One is beginning to realise now that they represent different but equivalent ways of explaining the same phenomenon. However, one sort of explanation may capture the essence of what is going on better than another.

Our work with the cellular slime moulds makes it plausible that individual-level selection (within groups) and group-level selection (between groups) both have a role to play in the social life of these organisms. Social behaviour seems to depend on the ability of an amoeba (of a given genotype) to exhibit different phenotypes – in fact, complementary phenotypes. Even before the onset of the social phase, phenotypic heterogeneity is a characteristic feature of cellular slime mould physiology. We continue to study phenotypic variation between genetically identical amoebae and the extent to which such variation can be transmitted across generations. Ongoing research is focussed on looking for correlations between genetic variation within social groups in the wild and the intensity of cooperative behaviour in such groups.

Vidyanand Nanjundiah

My introduction to evolutionary biology dates back to 1965 when I read Fisher's classic book to try and figure out the relationship of the Malthusian parameter to the survival and fertility rates in a population at the suggestion of a fellow graduate student at Harvard-Madhav. That led to a keen interest in mathematical modeling which was nurtured by the atmosphere at Harvard at that time with Wilson and Bossert Solbrig on the faculty and Bob Trivers, John Roughgarden, Tom Schoener and Joel Cohen amongst the graduate students.

In 1973, I joined the truly interdisciplinary faculty of the Centre for Theoretical Studies (CTS) at the Institute. Although my first passion was always the monsoon, I started some work on mathematical modelling in collaboration with the other faculty. At this stage I also studied evolutionary biology seriously and contributed to the teaching in the several workshops we organized. The work at CTS in this area got a boost with Vidyanad Nanjundiah joining CTS. Vidyanand, Madhav and I worked on Maynard Smith's game theoretic approach to interacting populations and got some interesting results on evolutionarily stable strategies. The high point of the years at CTS were bright young students who were drawn to Evolutionary Biology such as Raghavendra, Joshi, Ganeshaiah, Uma Shanker and Sukumar.

When CES was founded I was drafted to teach Theoretical Population Biology, a job I did for several years. That gave me a chance to interact with the next generation-Milind Watwe, Negi and several others. In collaboration with Prof. Joshi, I delineated the coherent rainfall zones of the Indian region using an algorithm we specifically developed for the purpose. Joshi and I, along with P V Joseph of India Meteorological Department also investigated the relationship between the large-scale cloud systems over the ocean and the surface temperature of the ocean. We discovered that the relationship is highly nonlinear and there is a threshold of the ocean temperature of about 27.50 C above which there is a high propensity of such cloud systems. With analysis of the recent satellite data it has been shown that this relationship, discovered from an analysis of the first satellite data on clouds over the Indian Ocean, holds over all the tropical oceans.

The Centre for Atmospheric and Oceanic Sciences was founded around the same time as CES and a substantive fraction of my time and energy since the mid-80s was spent in research in atmospheric and oceanic sciences and building up this centre. As an associate faculty member of CES, I worked on climate variability and agricultural strategies using complex models of crops along with the rich data on rainfall over the Indian region. This work was done in collaboration with a student of CES, Seshagiri Rao and a network of farmers in the Pavgada region. We have derived farming strategies tailored to the rainfall variability of the region. We have also developed a model of pest-disease incidence triggered by wet and dry spells on the basis of the knowledge of the farmers.

I am very happy that I have been a witness to the evolution of the young students I first met at CTS into top-rate scientists and the vibrant growth of CES as well as CAOS.

Sulochana Gadgil

This weighed cloud of words is generated from the abstracts and keywords of some of Sulochana Gadgil's many research publications and indicates her many research interests.

I started my research career working on rural energy issues and biomass production for energy. Next I focused my research on community and sustainable forestry. Since around 1995, I started my research on climate change. During those years, climate change was not a fancy area of research. Many colleagues used to say that I am wasting my time focusing on an area which will not be important for India. Now climate change has emerged as a major scientific, technological and policy challenge, and has caught the imagination of the research as well as policy community every where.

I have contributed to research on climate change and forests at national as well as international levels. Climate change is linked to the forest sector in three ways. Firstly, forest sector (tropical deforestation) contributes about 20% of global CO_2 emissions leading to climate change. Secondly, forest and land-use sector has a large mitigation potential to sequester about 2 giga tonnes of carbon annually to mitigate climate change. Thirdly, the projected climate change is likely to adversely impact forest ecosystems and biodiversity. I have made contribution to all these three areas of research.

I have contributed to Eight IPCC Assessment Reports during the last 10 years, including the latest IPCC Report, 2007. Further I went on to write seven books, out of which four books are on climate change.

N. H. Ravindranath

I was one of the Principal Authors (Convening Lead Author) for the two reports on GHG Inventory Guidelines of IPCC for land use sectors and these reports have been accepted by the UNFCCC and are in use by all the countries. These two Guidelines suggest methods for estimating inventory of five carbon pools and non-CO_2 gases (CH_4 and N_2O) from all land categories, namely forest, cropland, grassland, wetland, settlements and other land. Contrary to the belief that forest sector in India is a major contributor to CO_2 emissions, a detailed assessment (for the first time) of CO_2 emissions and removal (uptake) from the forest sector showed that CO_2 emissions (from forest conversion) were nearly offset by CO_2 uptake (due to afforestation).

A comprehensive assessment of the CO_2 sequestration or mitigation potential of forest sector in India has been made. Contrary to the belief that forest sector in India has limited carbon mitigation potential due to high human and livestock population density, our studies show a very high mitigation potential.

IPCC reports have concluded that even moderate warming and climate change will impact forest ecosystems and biodiversity adversely. Our study for the first time made a detailed assessment of impacts of climate change on forests at national level for India and showed that majority of forest locations will be impacted by climate change in less than 100 years.

I have made a comprehensive assessment of climate change science and policy issues from the perspective of developing countries, and published it in a book on "Climate Change and Developing Countries".

Our studies and findings are used in the IPCC reports as well as in formulating the National Climate Change Action Plan of Government of India.

We have an excellent team working on climate change issues at the Institute, which includes Prof. N.V. Joshi, Prof. R. Sukumar and Prof. Bala. The team also includes Rajiv Kumar Chaturvedi, Indu K Murthy, Mathangi J, Rakesh Tiwari, Shilpa S and Swarnima Singh.

Energy and Wetlands Research Group

The research goal of this group is to achieve environmental sustainability in the context of diverse environmental challenges: from rapid population growth, deforestation, energy scarcity and climate change to livelihoods of people and natural resources management.

Salient features

Regional Integrated Energy Plan: We have developed an innovative and easily implementable energy plan, based on mathematical modelling and optimisation. The central theme of decentralized energy planning is to prepare regional energy plans to meet energy needs and the development of alternate energy sources at least cost to the economy and environment. This involves finding a set of sources and conversion devices to meet the total energy requirement in an optimal manner. This optimality can be achieved by minimising the total annual cost of energy and the dependence on non-local resources or by maximising overall system efficiency. Such an energy plan decision support system was evolved for Kolar district in Karnataka.

Renewable energy and energy auditing: We have developed an ecologically sound alternative model for the Bedthi Hydroelectric Project in Karnataka, which reduces the submergence area from 95 sq. km to 5.8 sq. km without any reduction in the power generation capacity. This design was accepted by the government and is being implemented. In addition, we have identified several sites to tap hydel potential in an ecologically sound way through small hydel projects. Three microhydel projects were implemented and commissioned in 2002 on the basis of these research outputs. We have also performed detailed household and industrial energy auditing and proposed a methodology to assess the bioresource status of a region.

Diatoms for sustainable gasoline: We are examining methods of harvesting oil from diatoms, using biochemical engineering and also a new solar panel approach that utilizes genetically modifiable aspects of diatom biology, offering the prospect of "milking" diatoms for sustainable energy by altering them to actively secrete oil products.

Geographic Resources Decision Support System (GRDSS): Sustainable development of a region depends on an integrated planning approach, which requires timely and accurate spatial data. With the increased number of developmental programs, the need for appropriate decision support systems has increased. To analyse and visualise the spatial and temporal aspects of natural resources, Geographic Information Systems (GIS) based on a combination of remote sensing and local field data are useful and can be applied to make decisions at various hierarchical levels (from village panchayat to Planning Commission). We have developed GRDSS, an open source decision support system for this purpose.

Landscape ecology and biodiversity: The Western Ghats, one of the well-known biodiversity hotspots of the world, harbours 289 species of freshwater fish of which 119 are endemic. A study was conducted in the Sharavathi River of the central Western Ghats to understand fish species composition in relation to terrestrial landscapes. The study showed that streams having their catchments in areas with high levels of evergreenness and endemic tree species were also richer in fish diversity and endemism compared to those catchments with other kinds of vegetation. Two new species of fish, *Schistura nagodiensis* and *S. sharavathiensis*, and one new species of frog, *Philautus neelanethrus* were also described from the Sharavathi basin.

Western Ghats Biodiversity Information System: We have designed and developed a web-based information system documenting the biodiversity of the Western Ghats Currently the information system contains 4500 plant species with attribute information. The faunal database is being developed with information on amphibians, fish and mammals.

T. V. Ramachandra

Janardhanan Pillai

It was on 21st April 1986, I first came to CES to report for work. I had an offer for the post of Computer Programmer in the Environmental Information System (ENVIS). It is a very memorable day. As soon as I met Prof. Madhav Gadgil, who was the founder chairman, he took me around the department, introduced me to everyone and I felt very much at home. It was his warm welcome and the cordial environment that he provided that made me continue in CES and I joined the CES core team in 1990. When I joined CES, we had just two personal computers, one PC with just two floppy drives and another one with a floppy drive and hard disk. That was our entire in-house computing facility. And I was given the charge of this facility, the computer room. We allowed only an hour's allotment to use those computers and users had to book a week in advance! The booking program was one of the first programs that I wrote during my early days in CES.

It is interesting to look back and make a note of developments in the personal computing environment. By the late eighties, we got many more desktop personal computers. We had to go for open tender even to buy a single desktop PC during the early nineties. We got our own e-mail server in CES as early as 1992, when many other departments on campus did not have one, thanks to the then chairman, who was tech savvy, Prof. Raghavendra Gadagkar. Developments in personal computing and computer networks were very fast in the nineties and we kept ourselves in sync with them. All our labs were connected to the computer network and by now almost every staff/student has one networked desktop or laptop. I played a major role at every step of this development, getting the first e-mail server and getting it working, getting the computer network installed and managing it. I also started teaching computer programming as part of the population theory course sometime in the nineties. And when it was realized that more extensive coaching was required in programming, the programming course was made a full semester course as a pre-requisite for the population theory course, a course that I still enjoy teaching.

D. M. Bhat

I joined CES in 1985 and have been worked with Prof. Gadgil and Prof. Ravindranath and their students extensively. I have assisted colleagues in CES with field data collection during plant diversity studies in Western Ghats and in assessing the field performance of selected species in order to develop nursery techniques for their propagation. I have helped in laying nine 1-ha permanent forest plots for long-term monitoring to assess forest dynamics. I've been part of the eco-development project that aimed at the revegetation of Betta-lands in Uttara Kannada. I have assisted in collecting data on vegetation and biomass use in selected microcatchments. I have also assisted high school and junior college students in biodiversity documentation as part of the Peoples Biodiversity Registers (PBR). I have also been involved in mangrove studies.

ANINDITA BHADRA (CES: 2001 -2009)

abhadra@ces.iisc.ernet.in

Queens and their successors: the story of power in the primitively eusocial wasp *Ropalidia marginata*.

with Prof. Raghavendra Gadagkar

I submitted my thesis on Nov 22nd, 2007, the first birthday of our son, Ujaan. The next day I was in the lab, planning further experiments with our lovely wasps. In the last year or so, nothing much has changed in life, other than a new prefix to my name, which I hardly ever use. Outside the lab, I am always busy with Ujaan and the activities of MukhOsh, the Bangla theatre group started by my husband and me. Recently, I have started observing stray dogs within the campus, as a pilot study for my future research on the behavioural ecology of dogs.

ANURADHA BHAT (CES: 1995 -2002)

anubhat@indiana.edu

A study of the diversity and ecology of the freshwater fishes of four river systems of Uttara Kannada District, Karnataka, India

with Prof. Madhav Gadgil

My primary areas of research are biodiversity, conservation, fish behavior and evolutionary ecology. I started my research as a PhD scholar at CES, investigating factors influencing species diversity and abundance of fish assemblages in tropical stream ecosystems of the Western Ghats. As a Royal Society postdoctoral researcher, I then worked with Prof. Anne Magurran at University of St. Andrews, where I diversified my interests to fish behavior, studying shoaling preferences among guppies (*Poecilia reticulata*, a common Poeciliid fish species native to S. America and West Indies), which revealed interesting insights into familiarity and recognition among individuals in fish shoals. At Indiana University, I am currently studying behavioral divergences in wild zebrafish (*Danio rerio*, native to northeastern India) populations to understand the genetic, physiological and ecological mechanisms underlying these variations.

ARATHI SESHADRI (CES: 1991 -1998)

arathi@lamar.colostate.edu

Social organization in genetically mixed colonies of the primitively eusocial wasp, *Ropalidia marginata*

with Prof. Raghavendra Gadagkar

Professional: My current research is aimed at understanding the ecological and evolutionary bases of plant-pollinator interaction. In addition, I am also pursuing questions relating to plant sexual selection focusing on aspects of pollen and ovule competition and factors determining seed set in plants. I explore analogies of sexual strategies between animals and plants - applying concepts of kin selection, parent-offspring conflict and genomic imprinting to study patterns of seed set and reproductive success.

Other: I like being outdoors - hiking, camping and bicycling. I also have an avid interest in knitting, crochet and the like, and am constantly designing new projects.

ARUN VENKATARAMAN (CES: 1985 -2001)

Nestmate discrimination in the primitively eusocial wasp, *Ropalidia marginata* and its implications for the evolution of eusociality

with Prof. Raghavendra Gadagkar

You never know where life will take you. After the intensive laboratory and theoretical experience investigating the evolution of sociality in primitively eusocial wasps at CES, I had no inkling that a deep passion for living in the wilds and unobtrusively studying social behaviour among Asiatic dholes and a strong disdain for corporatised conservation in international NGOs, would lead me where I am today. The bridge was elephants when I accepted my first "job" at the Asian Elephant Research and Conservation Centre. The bigger the creature the more the issues and the more the issues, the more you digress from academic conservation. At AERCC, I was offered a job to run the CITES Monitoring of Illegal Killing of Elephants for South Asia from Delhi, where I thoroughly enjoyed working with and providing technical advice to the Indian Government. Next, I accepted the job of Conservation Director, WWF Malaysia. At present I oversee our two large programmes in Peninsular Malaysia and Borneo which have projects ranging from the impact of oil palm and unsustainable logging on biodiversity to marine conservation in the clear blue waters of the South China sea.

ASHOK GOPINATH (CES: 1995 -2002)

ashgmenon@yahoo.com

Intra-colony relatedness and population genetic structure in the queenless, ponerine ant, *Diacamma*.

with Prof. Raghavendra Gadagkar / Prof. M R S Rao

I am currently working in a Biotech Company called Connexios Life Sciences Pvt. Ltd. Considering my predominately academic profile, which traces a path from St.Josephs College in Bangalore to a postdoctoral stint at Cornell University in Ithaca, New York, my life has well and truly come full circle. This journey to Destination Bangalore as it stands was made with some of the most memorable stop-overs, in MSU Baroda, and IISc Bangalore. The latter of which I will unflinchingly say made me the person I am today. In an information age, learning has never before been so much fun. This theme has underpinned my choices in life and indeed my most recent endeavor with Connexios, to harness knowledge in a unique way and leverage it towards drug discovery. The people I have met in life's journey and the places I have been to, color a large part of an unfinished picture; yet somehow the brightest of these colors are from that 6 year stint (errrr...give-or-take a few) in a picturesque campus in The North of Bangalore, where a "curious boy" was assured that he could make a living being a "curious man".

CENTRE FOR ECOLOGICAL SCIENCES

ALUMNI

K CHANDRASHEKARA (CES: 1983 -1993)
kchandra@uasbangalore.edu.in

Social Biology of the tropical primitively eusocial wasp *Ropalidia marginata* (Lep.) (Hymenoptera:Vespidae)

with Prof. Raghavendra Gadagkar

Since leaving CES, I have been working as an entomologist at the University of Agricultural Sciences, Bangalore. Most of my work revolves around developing methods for managing insect pests of crops and engaging in outreach activities for farmers. As part of my work, I did manage to show that *Ropalidia* can be set upon caterpillar pests to save crops – but the last mile hurdles of logistics and acceptance by farmers have remained. Over the last several years I have continued to visit the Western Ghats to chase insects, particularly the dung beetles and ants. In the midst of all this, I had the opportunity to help the Zoo Authority of Karnataka establish a Butterfly Park at Bannerghatta. The last couple of years have been taken up in exploring the rich diversity of insects – dung beetles, ants and butterflies – as sources of antimicrobial peptides. The most enjoyable of all I do, is teaching. Courses in Research Methodology, Biology and Ecology of Immature Stages of Insects and Insect Behaviour have kept rust at bay!

DHRUBA NAUG (CES: 1992 -1997)

dhruba@lamar.colostate.edu

Organization of work in the primitively eusocial wasp *Ropalidia marginata*.

with Prof. Raghavendra Gadagkar

I combine my interests in the behavioral and cognitive ecology of social groups and the individuals that comprise these societies to understand the dynamics of group living. I like to address questions regarding how individuals make decisions about what they do, how a social organization emerges from these decisions, and what are the functional outcomes of this organization. My current research focuses on applying these interests to the context of disease dynamics and host-pathogen interactions. When not working, I enjoy the outdoors, traveling, hiking, riding my motorcycle or paragliding, as well as the indoors, reading or turning up the music.

HARINI NAGENDRA

nagendra@indiana.edu

(CES: 1994 -1997; 1999 -2000)

Using satellite imagery to assess species diversity within a landscape context: Studies in the Western Ghats, India

with Prof. Madhav Gadgil

In 2000, I left CES to join the Center for the Study of Institutions, Population, and Environmental Change (CIPEC), at Indiana University as their Asia Research Coordinator, setting up a program of land cover change research in South Asia with multiple field sites in Nepal and India. Subsequently in 2003, I began a long term independent program of research through the Society in Science: Branco Weiss Fellowship from ETH, Zurich. My research investigates the social, ecological and institutional drivers of forest regrowth, using multiple locations in South Asia and other parts of the world.

MALLIKARJUN N. SHAKARAD

smallik@mail.jnu.ac.in

(CES: 1990 -1995)

Colony founding and the evolution of eusociality in a primitively eusocial wasp, *Ropalidia marginata*.

with Prof. Raghavendra Gadagkar

For any given individual, available resources viz., time and energy are finite in a given environment. These limited resources have to be allocated to various aspects of life-history so as to derive maximum fitness. The ultimate currency of fitness is the number of offspring an individual produces. However, the individual will not be able to produce offspring if its support system i.e., the soma, is compromised. Thus allocation of resources to different aspects of life-history involves multiple trade-offs. Our aim is to understand how hard-wired the trade-offs between different life-history traits are. We look at evolution of life-histories under multiple selection pressures, specifically pressures that are conflicting in nature as evidenced by negative associations under single trait selection experiments. We use *Drosophila melanogaster* as the model organism for these studies.

MAULISHREE AGRAHARI (CES: 1996 -2003)

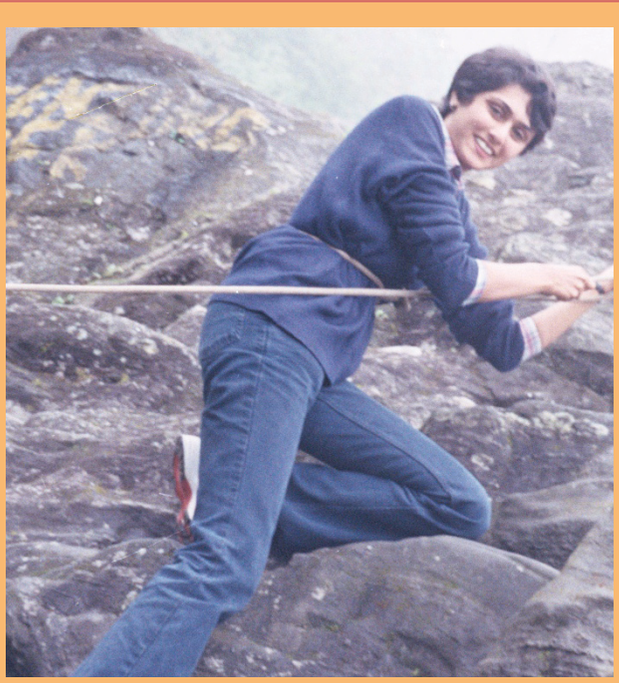
mauli@pes.edu

Division of labour and its regulation in primitively eusocial wasp, *Ropalidia marginata*

with Prof. Raghavendra Gadagkar

My research group focuses on aspects related to plasticity in learning and memory in mammals. Apart from research, I am actively involved in teaching. The aim is to frame curriculum with good emphasis on concept. This will bring about an overall change in attitude towards academics in general and science in particular. With modifications in various aspects of the teaching-learning process, we hope to enrich students' class-room experience.

I am also the academic convener of the Biotechnology Finishing School, an initiative by the IT-BT Department of Government of Karnataka. Presently I am on one-year sabbatical leave at University of Calgary, Alberta, Canada in an attempt to set an international program in India.



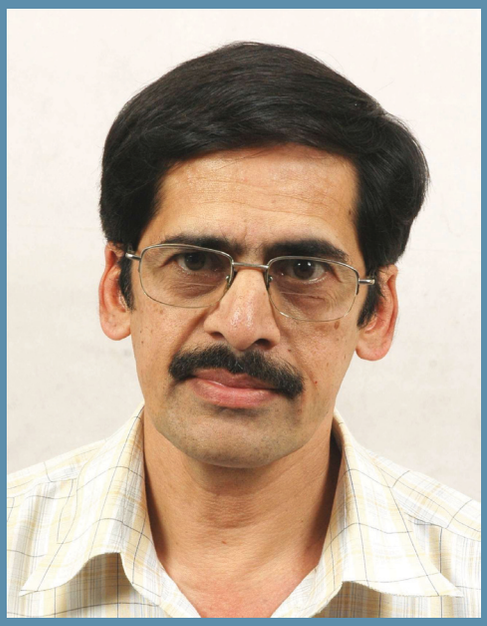
MEGHA SHENOY (CES: 2002 -2008)

shenoymegha@gmail.com

Spatial variation in interactions of the semi-myrmecophyte *Humboldtia brunonis* (Fabaceae) with ants and other invertebrates.

with Prof. Renee Borges

These days I am working on a few papers; re-writing and formatting chapters from my thesis. Hopefully, they will get published soon. Once I am done with that I will be applying for a post-doctoral position. I haven't yet finalized what I would like to work on in the future. But I do hope to work with people as friendly, encouraging and supportive as those from my lab (113), and have as much, if not more, fun than I did at CES.



MILIND GAJANAN WATVE (CES: 1989 -1992)

milind_watve@yahoo.com

The Ecology of Host Parasite Interactions in a Wild Mammalian Host Community in the Mudumalai Wild Life Sanctuary Southern India.

with Prof. Raman Sukumar

I was an undergrad teacher before joining CES and went back to teaching after my PhD. I tried to use research as a tool in teaching and much of my published work comes through this model of doing science. From 1998 to 2008 I was the HOD (Headache of the Department) and after enough headache I am thinking of shifting to something else. A little off-beat for an evolutionary ecologist, I got into founding a company called Anujeeva Biosciences Pvt Ltd and this company is devoted to "ecology based drug discovery and healthcare systems". Currently our concept of behavioral therapy for type 2 diabetes is heading towards phase III clinical trials.

MOUSHUMI SEN SARMA (CES: 1998 -2003)

moushumi@illinois.edu

Defence and Communication in the Asian dwarf honeybee *Apis florea* Fabricius

with Prof. Raghavendra Gadagkar

I am trying to understand the molecular underpinnings of the honey bee dance language. When successful foragers find an attractive food source, they return to their colony and advertise the location of this site in terms of distance, direction and quality. The dance language comprises a set of stereotyped and quantifiable symbolic movements. Different species differ from each other in the output of the behavior, described as dialects of the language. Through gene expression profiling, I am looking for molecular signatures of species differences in the behavior, as well as answers to questions such as what does a honey bee need in order to be able to collect information about a food source and convey this information to its nestmates? I am focusing on brain regions that are candidates for being involved in the dance behavior as well as genes that act as markers of neuronal activity.

K. S. MURALI (CES: 1986 -1992)

Vegetative and Reproductive phenology of a dry land forest in Mudumalai forest

with Prof. Raman Sukumar

I am currently managing projects on biodiversity conservation in seven different states in India including marine and coastal resources. Furthermore, I am also managing projects concerning adaptation and climate change in four states, and projects concerning national communication to meet requirements of UNFCCC. In addition to these I manage projects related to land degradation and biodiversity conservation in Nagaland, Rajasthan and Madhya Pradesh primarily aimed at land resource management and climate change adaptation issues.

NATASHA MHATRE (CES: 2000 -2009)

natasha@ces.iisc.ernet.in

The Prediction Of Field Cricket Phonotaxis In Complex Acoustic Environments.

with Prof. Rohini Balakrishnan

During my PhD, I'd been taking photographs and writing for a coffee table book about the wildlife in IISc. After I submitted my thesis, I spent a while getting 'Secret Lives' published. It was finally released in December 2008 as part of the IISc centenary celebrations. I still continue to write and shoot for newer projects. I also spent a while working on the biomechanics of hearing in tree-crickets. I did this work at the University of Bristol in Prof. Daniel Robert's lab, where I hope to go back and do a post-doctoral stint. We've applied for funding to look at insect tympanal ears and their function in acoustic signal processing. Until something works out, Rohini has kindly agreed to have me continue in the lab and to support my travel to Bristol on a collaborative UKIERI grant that she has with Prof. Robert.

PRABHAKAR

prabha@strandls.com

Resource Use, Culture and Ecological Change: A Case Study of the Nilgiri Hills of Southern India.

with Prof. Madhav Gadgil

Did my Post Doctoral work at the Harvard University. Came back and joined the Institute of Rural Management and taught and researched on Natural Resources Management Issues. Worked on a National Science Foundation, USA funded project on property regimes and deforestation in the Central Himalayas. Travelled the Himalayas and mapped it to hearts content!

Moved into Bangalore in 2000 and joined a startup called Strand Life Sciences, spawned out of the Indian Institute of Science. Worked on building a generic data mining platform. Used the data mining platform for building a gene expression analysis product development, currently sold as GeneSpring.

Would not rest. Took a sabbatical for the last 6 months to build a map-based biodiversity and conservation portal to be run on the public participatory wiki model. The portal is in its first version. I would like to see if the project succeeds. If platform can attract and enthuse large scale participation, allow open access data sharing and enhance the creative commons licenses for data sharing in the ecology and biodiversity domain for social benefit. The experiment is on.

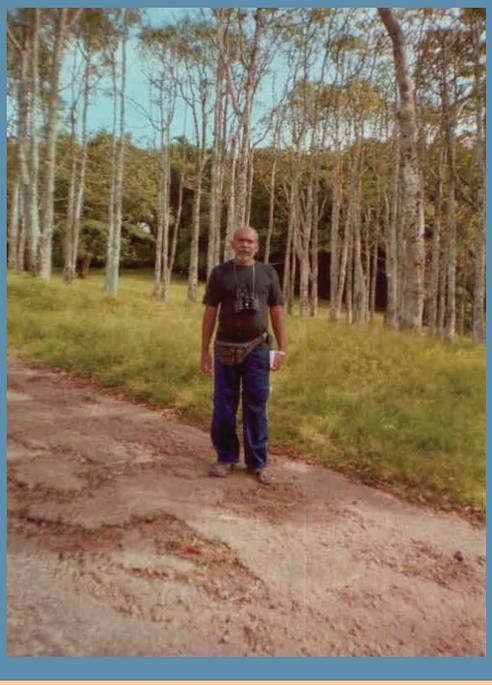
RAAMESH GOWRI RAGHAVAN

(CES: 2000 -2003)

The Social & Genetic Organisation of the Queenless Ponerine Ant *Diacamma ceylonense*

with Prof. Raghavendra Gadagkar

After CES, I tried to become a human geneticist, investigating the genetic basis of the origins of castes & tribes in Maharashtra, at the National Chemical Laboratory, using mitochondrial DNA. After that, I tried to become a *Drosophila* geneticist at TIFR, trying to figure the the relationship of the LIM family of transcription factors and their cofactors. That's when I realised that I may be a poet, linguist, and naturalist, but I am no scientist. By day I am a copywriter, by night a good sleeper, and on the weekends a French teacher, poet and reader of folk-tales. Someday I hope to have a novel in a bookstore shelf and a Booker on my hall shelf. Till then, I write punchy little lines because of which (I hope) people transfer stuff from a shop shelf to their kitchen shelf.



R J RANJIT DANIELS (CES: 1983 -1992)

ranjit.daniels@gmail.com

A conservation strategy for the birds of the Uttara Kannada district

with Prof. Madhav Gadgil

I left CES in August 1992 and after reluctantly spending a good deal of my life in NGOs in Chennai, I chose to found Care Earth in the year 2000. Care Earth that began as an Association of Scientists is now a Trust and dedicated to conservation of biodiversity with a special focus on blending development with ecology. At Care Earth we provide advisory and consultation services to the government and private agencies. I have to my credit 8 books; 7 of which were published between 1997 and 2008. I am presently working on the 9th - an undergraduate text book for environmental studies. We also maintain a small animal rescue and rehabilitation facility where at present there are more than 30 birds.

ROBERT JOHN CHANDRAN (CES: 1993 -2001)

robert.chandran@atree.org

Habitat associations, density dependence, and tree species diversity in a tropical dry deciduous forest in Mudumalai, southern India.

with Prof. Raman Sukumar

I continue to focus on the fundamental ecology of tropical forests - 'graduating' from dry tropical forests to the moist and rainforests. More specifically, I am interested in the assembly of tropical tree communities, maintenance of tree species diversity, life histories of tropical pioneer species, and plant-soil interactions. I am also currently working on some issues in applied ecology - focusing on habitat management for wildlife, monitoring wildlife populations, landscape ecology, invasive species ecology, climate change impacts on vegetation, assessing services provided by forest ecosystems, forestry options for carbon sequestration, and even urban ecology. More recently I have begun work on on the assembly of plant communities in sub-alpine and alpine ecosystems.

RUCHIRA SEN (CES: 2002 -2007)

ruchira@mail.utexas.edu

The biology of two sexes: a study of the primitively eusocial wasp *Ropalidia marginata*.

with Prof. Raghavendra Gadagkar

I work on partner choice (symbiont choice) in a classic example of mutualism: the attine ant-fungus symbiosis. Fungus growing ants cultivate monocultures of fungal clones as their major food source, and the fungus receives nutrients and protection from pathogens. I use the leaf cutter ants *Atta texana* and *Acromyrmex versicolor* to study the ecology and evolution of symbiont choice exerted by the ants on their fungi. My main objectives are to find whether ants prefer cultivars that enhance colony fitness and whether the preference is influenced by the strains associated with these ants over long coevolutionary time.

J. A. SANTOSH (CES: 1991 -1998)

santosh@intellimedia.in

Behavioural ecology of Asian elephants in southern India: the role of offspring sex and demography.

with Prof. Raman Sukumar

After having worked in the private software sector for a couple of years, I founded a multimedia technology company that designs and builds rich Internet applications, eLearning media & platforms, e-commerce & e-business solutions, usability engineering and other such services. What on Earth does all that mean? At least one thing: I don't do Ecology anymore!

CES was really wonderful. It gave me the opportunity and infrastructure to expand my curiosity, fortify my understanding and addict me to caffeine! I am so very thankful for all of that. Though I am not directly in the field today, it is my grasp of Behavioural Ecology and Evolutionary Biology that makes our services and products a cut above the rest.

Other than work, I play drums in a classic rock band that is busy on the local circuit. My life is always exciting and full of new experiences – this winter I am experiencing a new sensation of chill on the top of my head owing to a considerable loss of hair! Incidentally, CES is responsible for initiating that process too!

T. R. SHANKAR RAMAN

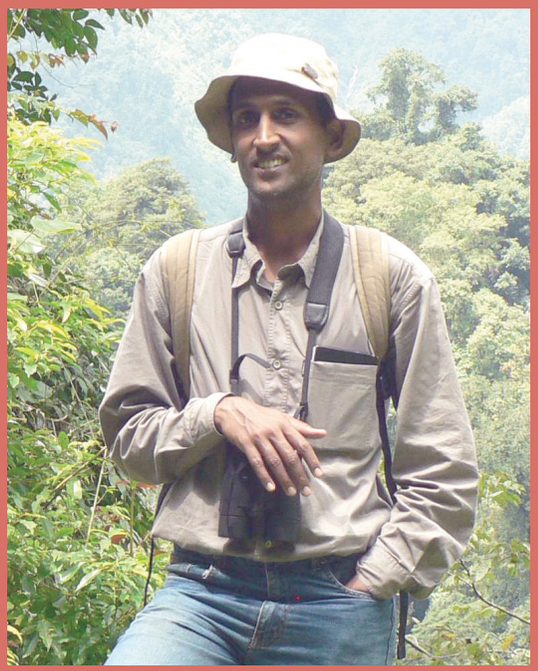
trsr@ncf-india.org

(CES: 1992; 1996-2001; 2004-2005)

Community ecology and conservation of mid-elevation tropical rainforest bird communities in the southern Western Ghats, India.

with Prof. Raman Sukumar

My primary interests in ecology and conservation focus on tropical forests, particularly their plant, bird, and mammal communities. Since 2001, I have been working as a scientist in the Nature Conservation Foundation (NCF), a conservation research NGO. My work has tried to examine conservation values of plantation habitats and their effects on animal communities in embedded forest fragments. Along with other NCF colleagues, I am currently involved in a long-term programme of restoring degraded rainforest fragments in the southern Western Ghats, research on Asian elephants and mammals, and bird and plant community studies.



SHRI NIWAS SINGH (CES: 1997)

niwasdra@sancharnet.in

Ecogeographical surveying for *in situ* conservation of wild relatives of cultivated plants in Uttara Kannada district of Karnataka state, India.

with Prof. Madhav Gadgil

After my PhD I spent a few years working on a feasibility study for a non-timber forest produce (NTFP) enterprise with an emphasis on medicinal plants in Anand, Gujarat at the Institute of Rural Management. I then went on to use remote sensing and GIS techniques to study environmental hazard zonation and optimal resource use in a Himalayan ecosystem, the Alaknanda valley with the G. B Pant Institute of Himalayan Environment & Development and with Space Application Centre, Ahmedabad. I am currently a senior lecturer at the Department of Agricultural Botany, B. R. D. P. G. College Deoria in U.P.

SILANJAN BHATTACHARYYA (CES: 1986-1993)

silanjan@gmail.com

Ecological organization of Indian rural population

with Prof. Madhav Gadgil

I visited the Morrison Institute at Stanford to continue my doctoral research where I also collaborated with Cavalli-Sforza's lab at Stanford Medical School in a study of caste groups of India. I joined Institut Francais at Pondicherry after my PhD and worked there on forest-human relationships in Wynaad and Sunderbans. I moved to Kolkata where, following some environmental and conservation consultancy assignments, in 1996 I joined the faculty of Zoology of Vivekananda College. I have been teaching UG and PG students biological sciences and motivating students with biodiversity field activities. I led the preparation of the first PBR in the state and am still deeply involved in PBR related activities with the West Bengal Biodiversity Board as a permanent invitee member. My present research interests include traditional knowledge in the sustainable management of village ecosystems and of wild animals living in non PAs. I write popular articles on ecology and evolution and am a regular columnist for the Ananda Bazar Patrika. I have published 3 books. My only asset is my family that includes my daughter Teerna, wife Susmita, my film maker brother Nilanjan and his cinematographer wife Ranu and our mom.

SONIA KAUSHIK (CES: 1995-2002)

kaushiks@unimelb.edu.au

Genetic heterogeneity and social behaviour in cellular slime moulds.

with Prof. Vidyanand Nanjundiah

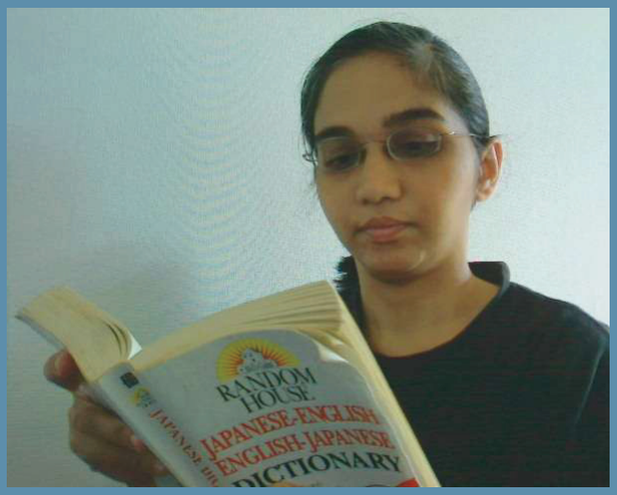
I live in Melbourne with my husband and son. After leaving IISc, I worked as a Postdoctoral fellow at the Department of Microbiology at La Trobe University. Then I had a baby boy and took a break from my work. Currently I am working as a Problem based learning (PBL) tutor and examiner for medical students at the University of Melbourne. In these tutorials we discuss real or made up medical cases and students are asked to diagnose and suggest the most appropriate treatments. My role is to facilitate these group discussions and steer the group in the right direction. For some time I also worked with children with learning difficulties and I really enjoyed it and I am thinking of making a career change in that direction.

SUDHA PREMNATH (CES: 1989-1994)

Dominanace subordinate relationship in the primitively eusocial wasp *Ropalidia marginata*.

with Prof. Raghavendra Gadagkar

After CES I have been involved in different areas of education. I was with The Centre for Environment Education for two years. Since then I have been working with The Valley School, KFI for the last twelve years. Here I have been involved in classroom teaching, in building curriculum for the sciences and environment education and in initiating and establishing a rural centre - The Kaigal Conserve. The Kaigal Education and Environment Programme (KEEP) of Kaigal Conserve is working in areas of biodiversity conservation, education, livelihood and health care. We document and maintain a data bank of the local fauna and flora and a seed bank and a forest nursery of native flora of this region. We have also started five schools (The Sanctuary Schools) in tribal villages on the fringes of the Kaundinya Wildlife Sanctuary in AP. We also conduct environment education programmes for students from different schools and colleges. With the adults in these communities we have initiated a variety of livelihood programmes. But not to forget, my most enjoyable moments are with my two grand daughters who live in Bombay.



SUJATA ABHAY DESHPANDE
d.sujata@gmail.com
(CES: 1998 -2005)

Social Biology of the primitively eusocial wasp *Ropalidia cyathiformis*

with Prof. Raghavendra Gadagkar

After leaving CES I worked as a visiting fellow at Homi Bhabha Centre for Science Education, Mumbai, India from Aug 2005 to May 2007. My work involved developing Biology curriculum for Secondary School students. I also offered a credit course on 'Introduction to Statistics' for PhD students of the centre. Apart from this professional activity I was involved with Khagol Mandal (astronomy club). I participated in the sky observation activities of the club. For one year I also worked as editor of 'Vaishwik' which is an English quarterly published by Khagol Mandal.

ANNAGIRI SUMANA
(CES: 1995 -2002)

Dominance behaviour and regulation of reproduction in the primitively eusocial wasp, *Ropalidia marginata*.

with Prof. Raghavendra Gadagkar

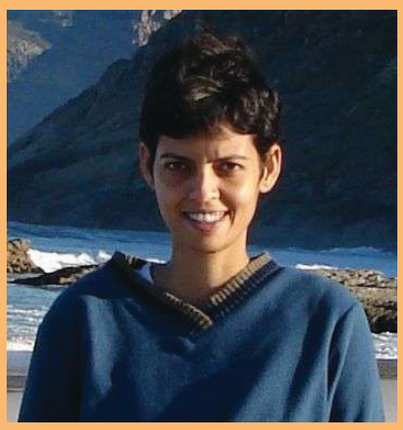
I just joined IISER so I am yet to establish my lab and get started with my research. I will be focusing on hymenopterans and their behaviour with special emphasis on the queens. After finishing my Ph.D I did my post doc at Tufts University, Boston studying behavioural and chemical means employed for communication in wasps. The last 4 years I have been enjoying raising my daughter Lavanya.

SWATI DIWAKAR
swati.diwakar@gmail.com
(CES: 2001 -2007)

Call diversity, spatio-temporal patterning and masking interference in an assemblage of acoustically communicating ensiferan species of a tropical evergreen forest in southern India

with Prof. Rohini Balakrishnan

I took a much needed break after finishing my thesis and spent time with my family. Along with my husband, I set up our home in Pune and I take pride in doing everything from scratch and doing it well! I spent time reading books which were on my 'to read' list for a long time. I am now ready to start a new phase of my career and am looking for opportunities in academics in India. I will be joining as a visiting faculty at IISER Bhopal in December. I look forward to teaching and motivating students to ecological and environmental research.



T. N. C. VIDYA (CES: 1998 -2006)
tncvidya@jncasr.ac.in

Population genetic structure and phylogeography of the Asian elephant (*Elephas maximus*) with special reference to India

with Prof. Raman Sukumar

I have long been interested in mammalian sociogenetics; so as a postdoctoral researcher at Stellenbosch University, South Africa, I worked on the sociogenetics of the facultatively social yellow mongoose and tried to examine why individuals in one population showed increased sociality and "helping" behaviour while those in another did not. This also allowed me to see the other, more famous African wildlife, a long-standing dream!

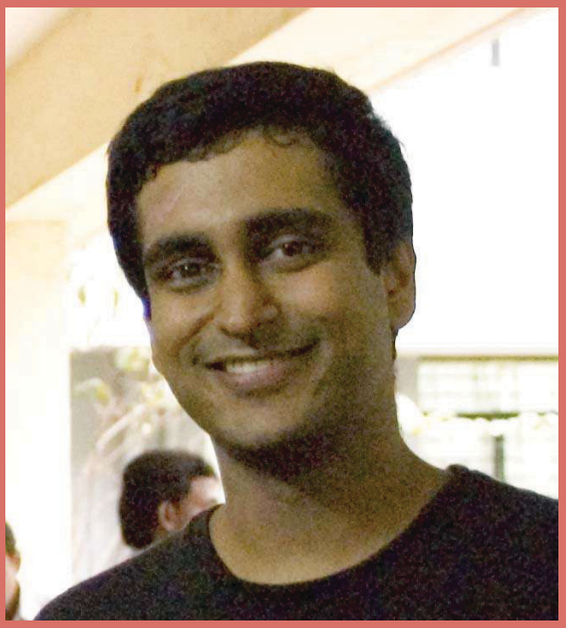
I recently joined JNCASR and plan to set up a long-term project on the social organization of the Asian elephant in southern India. While several studies on the ecology of this species exist, there has been little work on social organization and behaviour. The Asian elephant is a wonderful non-primate mammalian system to execute such research on as it is socially advanced, offers opportunity for kin selection, and inhabits ecologically diverse habitats, and such a study would further our understanding of sociality in cognitively advanced vertebrates.

VIVEK NITYANANDA
nandunata@yahoo.com
(CES: 2001 -2008)

Sensory ecology of acoustic signalling interactions in the tropical bushcricket genus *Mecopoda*: Mechanisms and evolution of synchrony.

with Prof. Rohini Balakrishnan

While applying for postdocs after my Ph. D. I've jumped into several non-academic projects including illustrating books, writing movie reviews for Tehelka, translating children's books, acting in two plays and going for a trek in Ladakh. At the end of this full year, I will now be taking up a postdoctoral position at the University of Minnesota researching acoustic processing in frogs.



CENTRE FOR ECOLOGICAL SCIENCES

ALUMNI

ALOK BANG

In societies where all individuals are reproductively totipotent and yet, at a given point only one of them reproduces, it is interesting to examine the factor(s) that may decide who will be the reproductive. I am investigating various behavioural, morphological and physiological parameters in the primitively eusocial wasp *Ropalidia marginata*, and their role in determining the queen (the reproductive) and her successors.

ANNIRUDHA MITRA

I am looking at the attributes of royalty in the primitively eusocial wasp *Ropalidia marginata*. My study looks at the development of queen status by the potential queen, during the queen establishment phase by investigating the role of the Dufour's gland in producing queen pheromone and at cuticular hydrocarbons, which are potentially involved in queen signaling and nestmate discrimination. My work involves behavioural observations, ovarian dissections and chemical analysis using GC and GCMS.

ANUSHA KRISHNAN

I am working on the consequences of synchronous and asynchronous fruiting on fig and fig wasp reproduction. The system I work on is the monoecious fig *Ficus racemosa* and its fig wasp fauna. I am investigating the causes and consequences of within-tree asynchrony in flowering and fruiting, and the impact it has on the reproduction of the fig, its pollinator wasp and the non-pollinating fig wasps.

ASHOK KUMAR MALLIK

I am interested in studying the observed patterns of species distributions and in understanding how these were caused by different past and present processes. I am using snakes as a model system and molecular techniques to address questions such as why are Western Ghats species similar to northeast Indian species, species conflict within a genus and the effect of environmental factors on species differentiation and diversification.

ATTIWILLI SUMAN

My interests are in population ecology and conservation particularly the effect of land use, habitat fragmentation and invasive species on natural populations. I am still formulating my research project.

CENTRE FOR ECOLOGICAL SCIENCES

CURRENT STUDENTS & POST-DOCTORAL ASSOCIATES

DIPTARUP NANDI

Acoustic communication in crickets forms a suitable model system to ask questions on mate choice. Despite a fairly good understanding of female preferences for different characters of male acoustic signals, little is known about how a female uses these preferences while sampling for a mate in the field. I am interested in testing proposed theoretical sampling strategies and looking at possible indicators of female choice, since these dynamics might have implications for the theory of sexual selection.

GEETHA RAMASWAMI

As a result of global anthropomorphic activity exotic plants are invading and altering the dynamics of tropical forests in an unprecedented way. I am addressing questions related to the distribution of the invasive plant *Lantana camara*, its impact on seedlings of native woody tree species and future range expansion under climate change scenarios.

HARI SRIDHAR

My research is aimed at understanding a behaviour that is fairly common in terrestrial habitats all over the world – the association of individuals of different bird species in mixed-species foraging flocks. Using a combination of quantitative syntheses and primary field data collection, I'm trying to find out what drives birds to participate in these flocks and whether there are rules which govern their assembly.

ISHAN AGARWAL

I plan to work on the phylogeography and evolution of the genus *Geckoella*, which comprises terrestrial geckos endemic to peninsular India and Sri Lanka. My project will focus on the relationships between *Geckoella* and the allied genera *Cyrtodactylus* and *Cyrtopodion*; as well as on trying to identify possible modes of speciation within this genus by combining phylogenetics and environmental niche models.

JANHAVI JOSHI

I am looking at phylogeographic structures and speciation patterns in six endemic species of the centipede genus *Digitipes*.

JOYSHREE CHANAM

I work on the trophic interactions between the ant-plant *Humboldtia brunonis* and its domatia (hollow internodes that provide nesting spaces for ants and other invertebrates) dwelling invertebrate associates. The semi-myrmecophytic character of this species makes it an excellent subject for the study of the evolutionary advantages of having domatia and thereby the evolution of myrmecophytism.

KARPAGAM CHELLIAH

I am attempting to address questions on mate choice in the Asian elephant at Kaziranga National Park, Assam. I am trying to decipher the influence of several morphological and physiological traits of male elephants on mate selection by females.

MAHUA GHARA

The ecology of non-pollinating fig wasps – I am interested in understanding the community ecology of non-pollinating fig wasps of the monoecious fig (*Ficus racemosa*) to understand their trophic interactions within fig syconia and their impact on the mutualism between figs and their pollinator wasps. I am also working on identifying the volatile organic compounds involved as cues between figs, pollinators and parasitic non-pollinating fig wasps.

MANJARI JAIN

I am interested in animal communication, signal evolution, community ecology and forest structure and dynamics. I am looking at acoustic resource partitioning in a diverse community of crickets by looking at the habitat acoustics and microhabitat selection in an ensiferan assemblage of a tropical evergreen forest.

MONISHA BHATTACHARYA

In the wild where various species of male crickets sing at the same time, a female usually recognizes her conspecific song by its unique temporal and spectral pattern. To investigate this, I am currently asking how two tree crickets *Oecanthus henryi* and *O. indicus* maintain reproductive isolation based on their calling songs. I am also investigating how female response to calling song in terms of attraction and localisation in two dimensions is affected by the fact that the carrier frequency of *O. henryi* songs changes with temperature.

NANDITA MONDAL

Fire is an important disturbance in dry forests and can alter the composition of vegetation and patch use patterns by herbivores. I am trying to understand the biotic and environmental factors affecting fire occurrences, and the environmental and successional changes that occur in vegetation after the occurrence of a fire.

NAVENDU PAGE

I am interested in the spatial patterns observed in species diversity especially in plants and amphibians. For my PhD I would like to consider questions in the field of macroecology and biogeography. Some of these questions investigate species richness patterns and species diversity along different environmental gradients and in patchy ecosystems and the historical processes which have played a role in shaping the present distribution of plants and amphibians in the Indian subcontinent.

PAROMITA SAHA

Ropalidia marginata is an extremely interesting primitively eusocial wasp whose colonies successively experience more than one queen but only one at any given time. Past observations have shown that the queen can be overthrown and one of the workers can go on to be the next queen. My specific interest is to study the proximate mechanisms of queen turnover and to ultimately resolve the various degrees of conflicts over reproductive interests between the queens and their successors.

RAGHURAM HANUMANTHAN

I am characterizing the bat community in the evergreen forests of Kudremukh National Park in the Western Ghats of Southern India. There are few studies of bat diversity in India and my work promises to provide much interesting and useful information on these nocturnal animals. I am also building a library of echolocation calls of the different species, which we hope to use in the future for acoustic monitoring of bat species.

RAJIV KUMAR CHATURVEDI

My research interest lies at the interface of climate change and forest ecosystems. My work requires me to track the carbon stocks in forest ecosystems of India through the past and the present, called inventory estimation. We also attempt to track carbon stocks through future, calling it mitigation potential estimation or impact estimation, depending on whether we are concerned with economic incentives or the physical implications of climate change itself.

RANJANA JAISWARA

My research focuses on the evolution of calling songs in crickets of the subfamily Gryllinae. I will use homologous morphological characters to build a phylogeny. The calling songs of each cricket will be optimized on this tree, allowing the study of the song pattern evolution. In crickets the shape, size and structure of the singing apparatus located on the forewing directly influences the acoustic properties of the song, in particular the calling frequency and intensity of the song and my work is expected to help explain the relationship between these.

RATNA GHOSAL

My current research involves an inter-disciplinary approach to understand and characterize the reproductive biology of Asian elephants (*Elephas maximus*). We have established a non-invasive technique to study the estrous cycle of elephants and to explore the various factors that affect the physiological dynamics of this species. I am also investigating intra-species olfactory communication using behavioural sampling. In a nutshell, I am keen to address those questions that will shed some light on the proximate mechanisms underlying various behavioural phenomena.

RITTIK DEB

Mating in crickets is mostly dominated by females, as females mount the males and decide when to terminate the mating. Females may choose a mate depending upon various acoustic and/or non acoustic cues. These cues help the females to judge a male's reproductive and competitive ability. I am working on acoustic male cues in natural conditions that may influence female choice in the tree cricket *Oecanthus henryi*.

ROHINI BANSAL

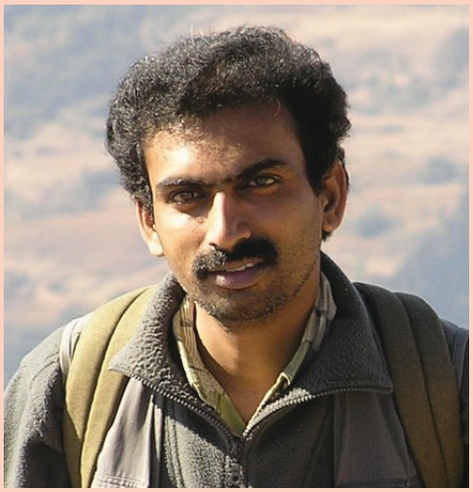
Human mediated gene flow is brought about by anthropogenic transport of a species much beyond its natural dispersal ability resulting in species introductions or the homogenization of geographically separated populations. Species introductions often result in the extinction of native species. Introduced species are expanding their range with increasing globalization, yet, not much is known about their colonization history. I am interested in the colonization history and phylogeography of three synanthropic geckos *Hemidactylus brookii*, *H. frenatus* and *H. flaviviridis* which are widely distributed in India.

RUTUJA CHITRA TARAK

I am trying to look at how woody trees in a dry deciduous forest respond to climate change. The goal is also to find out which tree species are resilient and which are sensitive to climate change. To answer these questions, I will be observing seasonal girth changes of trees found in a series of forest communities along a rainfall gradient, while simultaneously keeping track of climatic and microhabitat variables.

S. P. VIJAYKUMAR

I am on a journey to decipher the role of historical, geographical and ecological factors in the diversification of frogs in the the misty mountains of the Western Ghats. My current research interests are biogeography, landscape ecology, systematics, natural history and conservation geography.



SAIKAT CHAKROBORTY

I work on the evolution of eusociality using the primitively eusocial wasp *Ropalidia marginata* as my study system. Using microsatellite markers, I study the pattern of genetic relatedness among individuals in colonies at different stages of their development, which should give us some insights into their inclusive fitness. Using microsatellite loci, I am also investigating the population genetic structure of *R. marginata* at different spatial scales. Finally, I'm trying to assess whether genetic relatedness plays a role in deciding the queen's successor.

SAMIRA AGNIHOTRI

My Master's research on birdsong resulted in a bilingual (English and Kannada) CD that contains recordings of 94 species of birds. These recordings were made in the Biligiri Rangaswamy Temple Sanctuary, where I am now pursuing drongos for my PhD. I am also interested in conservation education, and in exploring different ways to popularise the ecological sciences as well as to encourage the preservation of traditional knowledge systems.

SANDHYA SEKHAR

I will be working on the factors that can affect dispersal ability in butterflies using a phylogeographic approach, focusing on 4 species of Satyrine butterflies that will allow a framework for comparison.

SHALU VERMA

My research project entails development of molecular diagnostics for the detection of tuberculosis (TB) in wildlife, chiefly, Asian elephants. The study should facilitate understanding the epidemiology of TB in Asian elephants and its implications for their health at the human-livestock-wildlife interface. Validation of such diagnostic tools in captive Asian elephants would be invaluable in screening and control of disease in an infected free-ranging ecosystem.

SHREEKANT DEODHAR

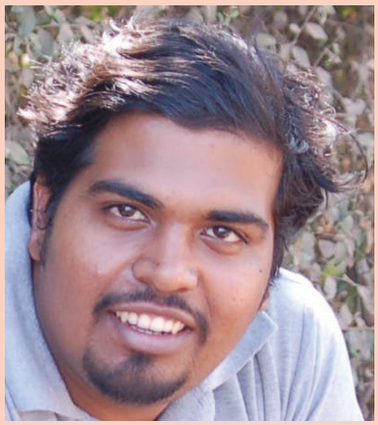
Broadly put, my fields of interest include sexual conflict, mate-choice and the effect of invasive species on native communities. I am still in the process of narrowing down upon my exact research question. My preferred study system includes freshwater fish.

SNEHA V.

I am interested in understanding the dynamics of distribution of bird species seen in the Western Ghats by studying patterns of variation in range size. Focusing on a cross-section of endemic and widespread birds, I intend to explore and analyze the key factors contributing to limiting their distribution and use this information to help prioritize areas for conservation. I am also specifically interested in the ecology and conservation of hornbills.

SOUMYA PRASAD

I am looking at fruit-frugivore interactions at Mudumalai for my doctoral thesis. I am addressing questions at community and population levels, with respect to the role played by large herbivorous mammals in seed dispersal of dry forest plants.



VARUN TORSEKAR

I am intrigued by the phenomenon of speciation and the issue of cryptic species in general. Specifically, I am interested in the evolutionary and biogeographic history of certain endemic herpetological groups of the Western Ghats, their relationships with each other, and the factors that drive speciation in these groups. Consequently, the following question is always at the back of my mind: How does one go about delimiting species? Lastly, I also keep track of topics associated with the conundrum of declining amphibian populations.

YUVRAJ RANGANATHAN

I am investigating the chemical ecology of a three partner interaction system involving the fig tree (*Ficus racemosa*), its associated fig-wasp fauna, and ants; specifically, how ants interpret the chemical communication between the figs and fig-wasps. The ants being predatory, can shift from being beneficial or detrimental to the fig and fig-wasp mutualism by preferentially preying on the non-pollinators or pollinators. We are also looking at the nature of the chemical communication, which changes dynamically across the fig developmental stage.

CENTRE FOR ECOLOGICAL SCIENCES

SUPPORTING STAFF

DATTARAJA .S. HANDANAKERE

with Prof. R. Sukumar

I joined CES in February 1986 and was posted to Kumta field research station Uttara Kannada. That was my first exposure to natural forests. I was a little nervous and my bookish taxonomic knowledge was too small even to classify a tree to its family level. Then quickly I learnt taxonomic keys and systematic botany under the guidance of Father Cecil J Saldhana, and Subhash Chandran. Cordial but brainstorming meetings in Bangalore with Madhav Gadgil exposed me to plant ecology and its importance in conservation. Then I met a young scientist, Dr R. Sukumar in 1987. His invitation to join projects at Nilgiris was my turning point. We started our long-term forest dynamics studies by setting up a 50 ha permanent plot at Mudumalai during 1987-88. I stayed with my wife Vanishree at Masinagudi for about 13 long years to set the plot up and to see that work was done smoothly, during which time my kids Nikhil Datta and Damini Datta joined us. Long-term studies exposed me to global level biological and socio-economic research within tropical forests and forest-dependent communities, and taught me to translate this information into results relevant to forest management, conservation and natural resource policies. With continued support and encouragement from Dr R.Sukumar, our work has led to the development of a network of long-term forest research sites, the CTFS plots. The unifying research tool shared by all CTFS research sites (our site is 3rd) is the Forest Dynamics plot. The plots, due to their large size, are capable of dealing with the high tree diversity of tropical forests. Policy makers and scientists of today are looking for long-term data in order to understand the changes in carbon emission and sequestration caused by global warming. Our team is proud to be a part of the people creating these valuable datasets. Finally, thanks to all my friends and colleagues at CES who provided both practical and intellectual contributions and who made my research colorful.

INDU K. MURTHY

with Prof. N.H. Ravindranath

I joined Prof Ravindranath's team just after my Masters. I have been working on issues of i) Forestry and climate change spanning areas related to clean development mechanisms, GHG emissions from land use change and the forestry sector, Impacts of climate change on the forestry sector, mitigation potential assessment and adaptation strategies; ii) forest management – particularly joint forest management and community forestry with a focus on ecological, institutional and economic issues; iii) natural resource monitoring which involves the monitoring of all the resources in a village ecosystem using a agro-ecological zone approach.

I am currently involved in developing a forestry project for carbon trading under the clean development mechanism in Himachal Pradesh and in developing an adaptation framework for the forest sector, considering the adaptive capacity and vulnerability of forest ecosystems as well as dependent communities. In the coming years I am going to be part of a initiative sensitizing and training HSBC bank volunteers on climate change and sustainable technologies.

H. S. SURESH

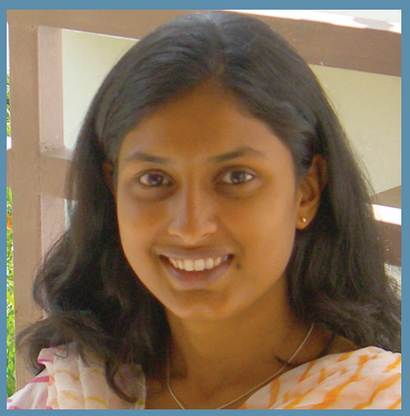
with R. Sukumar

My dream of becoming a forest biologist during my undergrad years took shape with me joining CES under Prof. Saldanha. Father, as he was fondly called, nurtured me in the fine skills of taxonomy and the ecological basis of forest classification. Prof. Madhav Gadgil taught me quantitative ecology. I was really lucky to be with these two stalwarts of ecology in India. Father introduced me to Sukumar who had joined the faculty and had a strong interest in the ecology of the Nilgiris. We (Murali, Pallav, Sukumar, Father and I) undertook my first ever trip to Mudumalai. It was on this trip that Murali, Pallav and I decided to work as a team to understand the ecology of Mudumalai. It was in May 1988 that we proudly launched the large permanent plot at Mudumalai which became our second home. It was fun to be in Mudumalai. We were a big team of people with varied interests and personalities. We used to have fun with Murali's flute, John's ideas on evolution, Manju's life (plot to cot and cot to plot), Datta's foot ball, Jaykumar's philosophy and never ending arguments between Varma and Arumugam. The field station at Masinagudi was full of life and enthusiasm. Of course, we learnt a lot of concepts and principles of forests in Mudumalai. Each day and year in the plot is now a chapter in the history of the plot. I sitting on a python while enumerating the plot is one of the must-hear stories that in-coming people should know. I met Indu here at CES. We started working on the "climate change" project which in true sense changed the climate of our lives. We have now our little darling Ketaki with us. Life in CES has been not only fun but also allowed us to expand our horizons. I have ventured into several aspects of forest ecology in CES. I have also traveled extensively both in India and abroad which not only helped expose us to current trends in ecology but also to different customs and cultures. Being from CES, I always have had a wonderful reception wherever I went, as many of my friends at different places say that we were born with "silver spoons". I have always enjoyed my association with CES and wish to be part of CES for years to come.

SMITA NAIR

with Prof. R Sukumar

Elephants have a large vocal repertoire and extensive communication network which could be attributed to their complex social system. Our research aims to understand the significance of vocal communication and social behaviour in Asian elephants. The interpretation of the repertoire may enable us to better detect and characterise herd structure, composition and elephant movement patterns, with possible implications for their management. A comparison with the African species should also yield interesting insights into the evolution of communication systems in these closely related species.



AUGUSTIN D.

with Prof. Raghavendra Gadagkar

In the year 1986, I had the privilege of beginning to work with Prof. Raghavendra Gadagkar who is an eminent ecologist and faculty in CES. During my 23 years of working with him, apart from my administrative duties, I have learnt a lot. He has always guided me and taught me to handle things efficiently whether it was office or any other work, something that has been appreciated by everybody, not only in our lab but also in the entire department. I was sent to a workshop to improve my computer skills, which has been very beneficial in my day- to-day work. It's a great privilege working for such a wonderful professor. My only wish is to continue working with him even after my retirement. All the faculty in CES, students, and staff have been very co-operative and very helpful. Finally, I wish this Centre becomes a Department in the near future.

GEETHA GADAGKAR

with Prof. Madhav Gadgil

It seems like only yesterday that I first met Prof. Madhav Gadgil at the Centre for Theoretical Studies in August 1979, thirty years ago. I have been working for him ever since. I worked in various research projects as a JRF and SRF till CES was born five years later. I enjoy the unique privilege of being the first 'permanent' employee of CES.

Working for Prof. Gadgil has been a fantastic experience; it made me a jack of all trades and perhaps master in some! Along with filling in TA bills, settling cash advances, managing correspondence, typing manuscripts and organizing workshops, I imbibed some knowledge in the fields of conservation biology, human ecology, ecological history and met a lot of interesting people – young and old, aspiring, as well as well-established ecologists, anthropologists, farmers, teachers, students and members of NGOs. Our group always had a highly motivated, noisy and crazy set of budding ecologists that helped balance work and pleasure so well that there was never a dull moment. Along the way, I picked up a couple of excellent friends and a post graduate degree in ecology and environment!

I particularly cherish my experience of attending courses in conservation biology, evolutionary biology and human ecology along with the Ph.D students and preparing manuscripts of books and innumerable articles that Prof. Gadgil wrote with amazing ease and speed.

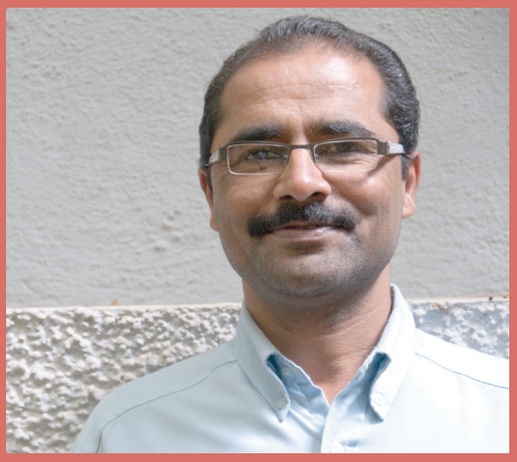
The freedom that Prof. Gadgil gave me in work, administration and in dealing with people made my life for the last 30 years very enjoyable and fulfilling. I take this opportunity to thank him for being more a friend than a boss and my older colleagues for their friendship and my younger colleagues for keeping me young.

R. LAKSHMI

with Prof. Madhav Gadgil, Prof. Raghavendra Gadagkar, Prof. N.V. Joshi, Prof. R. Sukumar

I have been assisting the faculty I have worked with in the office. In fact, I have interacted with all the faculty of CES. I have been given a lot of freedom in my work which has enabled me to learn a lot and gain experience. Any lapse on my part was not dealt severely but every mistake made me wiser. I was never denied leave during my entire service even when I was in need of it on personal grounds. I am really thankful to the entire faculty for being so kind and understanding. Given the opportunity, I would like to be at CES for my entire service at IISc. Most of all, I have always felt that CES is my home.

RAGHAVENDRA RAO



I joined the Centre for Ecological Sciences in the year 1987. I have had the privilege of working with all the chairmen of CES. In my 22 years of service I have learnt many things about administration and obtained valuable training. Discipline, punctuality, wisdom, treating others well are some of the important things that I have learnt. Our faculty members and the Chairmen always guide me and help me finish given tasks successfully. As a result, I am now able to do all my assigned work to their satisfaction. The chairmen have given me a separate system with internet access and e-mail and constantly encourage me to learn new things. It is a great privilege working under such wonderful faculty members and chairmen. My only wish is to continue working in CES even after my retirement.

SWARNALATHA CHANDRAN

with Prof. Raghavendra Gadagkar

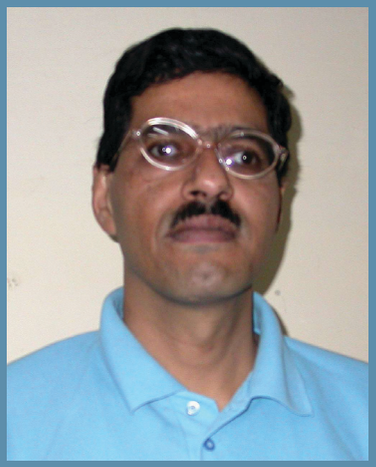
It gives me great pleasure to write a few words about my experiences at the Centre for Ecological Sciences when the centre is celebrating its Silver Jubilee and our Institute is celebrating its Centenary!

My appointment at the Centre for Ecological Sciences was in 1985, as a Project Assistant, after my Masters degree in Zoology from Bangalore University. In 1988, I was offered a permanent position. That was the beginning of my long bond with CES, which continues to this day. My first assignment was to assist Prof. Gadagkar with his experiment on nestmate recognition in the social wasp *Ropalidia marginata* along with Padmini Nair & Arun Venkataraman. The results of this joint work was soon published in Behavioural Ecology & Sociobiology in 1988. During the initial years of my joining the lab, I participated in several research projects and have been a co-author in about 9 of his scientific publications. In more recent years, on account of having developed hypersensitivity to wasp stings, I had to restrict myself to working with killed wasp specimens. I have been extremely lucky to have received guidance and assistance from Prof. Gadagkar all through my stay at CES.

It has been a great pleasure and honour for me to be associated with this great institution for more than two decades and benefit from its culture, values and traditions.

MILIND KOLATKAR

with Prof. Raghavendra Gadagkar



In 1993 I came to CES as a visitor. Prof. Gadagkar eventually offered me a job of project assistant. Presently, I work on bee keeping in the Western Ghats, Karnataka. With help from Prabhakar Bhat, I gather data to make a database of beekeeper societies. Information on different aspects of the bee keeping industry in the North Karnataka district was collected. Our analysis indicates that training camps have immediate, direct impact on number of active beekeepers, which translates into increased number of bee boxes used which in turn significantly increase honey production.

I have also gained experience maintaining computers in a virus-free condition in Prof. Gadagkars's lab. I help Prof. Gadagkar configure them and keep them updated. I teach myself and my lab mates best practices in various software. Now we are moving to an era of FOSS, opting to use Unix based laptops and OpenOffice.

YASHWANT G. KANADE

I started my professional career in 1983 in CES and had the opportunity to work with several magnificent people. Initially, I was posted to the CES IISc research field station at Sirsi, the assignment involved water flow measurement in the Bedti and Aghanashini rivers. Later, I assisted research in plant diversity, biomass productivity and phenology in the Western Ghats and the study of human ecology and economic use of plant materials. From 1990, I have been assigned the responsibility of managing the CES Library. I have also actively participated in the departmental ENVIS Programme.

My current research interests include: promotion of reading habits in India especially amongst the rural poor; citation data analysis for life sciences; information seeking behavior of ecologists; use of e-books; developing cyber libraries; evolution of information resources and multimedia services for ecologists; evaluation of hybrid library based on user satisfaction.

I have been an author on 15 research papers published in national and international journals and those presented at national and international conferences and seminars. I recieved the ASIS&T International best paper award in 2006 at Austin, Texas, USA. I have also been training library and information science students and professional personnel.

CES OFFICE STAFF

Prema

Ponanna

Nirmala

Basvaraj

Venkatappa

Murgesh

Madhu

Ganesh

Palani

Prabhakar Bhat

Gurunath Hegde

C M Shastri

Rosario Furtado

G N Hegde

Deepak Shetti

Shridhar Patgar

SIRSI & KUMTA FIELD STAFF


Suresh, Harisha, Siddha


Maran


Bomman


Krishna


Bomman, Kunmari


Bharanaiah, Mani

MUDUMALAI FIELD STAFF

CENTRE FOR ECOLOGICAL SCIENCES

PUBLICATIONS

Madhav Gadgil

Selected Publications

Gadgil, M. and Prasad, S.N. (1984) Ecological determinants of life history evolution of two Indian bamboo species. Biotropica, 16, 161 - 171.

Joshi, N.V. and **Gadgil, M.** (1991) On the role of refugia in promoting prudent use of biological resources. Theoretical Population Biology, 40 (2), 211- 229.

Daniels, R.J.R., Joshi, N.V. and **Gadgil, M.** (1992) On the relationship between bird and woody plant species diversity in the Uttara Kannada district of south India. Proc. Natl. Acad. Sci. USA. 89 (12), 5311-5315.

Gadgil, M., Berkes, F. and Folke, C. (1993) Indigenous knowledge for biodiversity conservation. Ambio, XXII (2 3), 151 156.

Gadgil, M. and Rao, P.R.S. (1994) A system of positive incentives to conserve biodiversity. Economic and Political Weekly, Aug. 6, pp. 2103 - 2107.

Gadgil, M. and Devasia, P. (1995) Intellectual property rights and biological resources : specifying geographical origins and prior knowledge of uses. Current Science, 69(8), 637-639

Gadgil, M. (1996) Deploying student power to monitor India's lifescape. Current Science, 71(9), 688 697, 10 November

Nagendra, H. and **Gadgil, M.** (1999) Biodiversity assessment at multiple scales: Linking remotely sensed data with field information. Proceedings of National Academy of Sciences, USA, 96, 9154-9158.

Gadgil, M., Rao, P.R.S., Utkarsh, G., Chhatre, A. and members of the People's Biodiversity Initiative, (2000) New meanings for old knowledge : the people's biodiversity registers programme. Ecological Applications. 10 (5) : 1307-1317. 2000

Negi, H.S. and **Gadgil, M.** (2002) Cross-taxon surrogacy of biodiversity in the Indian Garhwal Himalaya. Biological Conservation, 105, 143-155.

Books

Gadgil, M. and Guha, R. (1992) This Fissured Land : An Ecological History of India
Oxford University Press, New Delhi. and University of California Press, Berkeley. { Translated into Malayalam}

Gadgil, M. and Guha, R. (1995) Ecology and Equity : Use and Abuse of Nature in Contemporary India. Routledge, London, also published in Penguin India. { Translated into Malayalam, Hindi and Kannada }

Gadgil, M. (1997) Diversity: The cornerstone of life on earth. B. Sahgal ed. NCSTC BNHS Hornbill Series, Bombay Natural History Society, Bombay. { Translated into Kannada and Marathi}

Gadgil,M. and Rao, P.R.S. (1998) Nurturing Biodiversity: An Indian Agenda. Centre for Environment Education, Ahmedabad. {Translated into Gujarati}

Gadgil, M. (2001) Ecological Journeys. The Science and Politics of Conservation in India. Permanent Black, New Delhi.

Gadgil, M. and Guha, R. (2001) The Use and Abuse of Nature (incorporating This Fissured Land, An Ecological History of India and Ecology and Equity) Oxford University Press, New Delhi.

Gadgil, M., V. Edlabadakr, Nalini Rekha, and Devaji Tofa. (2006) Nisrg Niyojan – Lok Sahabhaagaane. Agharkar Research Institute, Pune. {In Marathi}

Gadgil, M. (2008) Let the Rightful Forests Flourish. National Center for Advocacy Studies, Pune

Gadgil, M. (2008) Baharoo de hakaachee vanaraajee. Lokayat Prakashan. {In Marathi}

Awards & Honours

Dakshina Fellow Bombay University, 1963-65.
IBM Fellow Harvard Computing Centre, 1968-69.
National Environmental Fellow, 1979-81.
"Padma Shri" awarded by the President of India, 1981.
Karnataka State Rajyotsava Award, 1983.
Rathindranath Tagore Award from Vishwa Bharathi, 1985.
Shanti Swarup Bhatnagar Award for Biological Sciences, 1986.
Swami Pranavananda Saraswathi Award of Hari Om Ashram Trust for 1989.
Vikram Sarabhai Award of the Indian Council of Social Science Research, 1990.
PEW Scholars Award in Conservation and the Environment, 1993.
Rustum Choksi award for Excellence in Science by the Indian Institute of Science, 1997.
Pandit Iswarchandra Vidyasagar Gold Plaque and Lecturership by the Asiatic Society, Calcutta for 1998.
Centennial Medal for 2002 from Harvard University, USA.
Volvo Environment Prize, 2003.
"Padma Bhushan" awarded by the President of India, 2006.
H K Firodia Award, 2007.
Vasundhara Award, 2008.
Fellow, Indian Academy of Sciences, 1979.
Fellow, Indian National Science Academy, 1983.
Fellow, National Academy of Agricultural Sciences, 1991.
Foreign Associate, U.S. National Academy of Sciences, 1991.
Fellow, Third World Academy of Sciences, 1992.
Honorary Member, British Ecological Society, 1994.
Honorary Member, Ecological Society of America, 2001.

Selected Publications

Sukumar, R. and Gadgil, M. (1988). Male-female differences in foraging on crops by Asian elephants. Animal Behaviour 36: 1233-1235.

Sukumar, R. (1991). The management of large mammals in relation to male strategies and conflict with people. Biological Conservation 55: 93-102.

Sukumar, R. and Ramesh, R. (1992). Stable carbon isotope ratios in Asian elephant collagen: Implications for dietary studies. Oecologia 91: 536-539.

Sukumar, R., Dattaraja, H.S., Suresh, H.S., Radhakrishnan, J., Vasudeva, R., Nirmala, S. and Joshi, N.V. (1992). Long term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India. Current Science 62: 608-616.

Sukumar, R., Ramesh, R., Pant, R.K. and Rajagopalan, G. (1993). A d13C record of late Quaternary climate change from tropical peats in southern India. Nature 364: 703-706.

Watve, M.G. and **Sukumar, R.** (1995). Parasite abundance and diversity in mammals: correlates with host ecology. Proceedings of the National Academy of Sciences (USA) 92: 8945-8949.

Raman, T.R.S. and **Sukumar, R.** (2002). Responses of tropical rainforest birds to abandoned plantations, edges, and logged forest in the Western Ghats, India. Animal Conservation, 5: 201-216.

Sukumar, R., Suresh, H.S., Dattaraja, H.S., Srinidhi, S. and Nath, C. (2005). The dynamics of a tropical dry forest in India: Climate, fire, elephants and the evolution of life-history strategies. In: D. Burslem, P. Michelle and S. Hartley (eds.). Biotic interactions in the tropics: their role in the maintenance of species diversity. Cambridge University Press, Cambridge, U.K. Pp. 510-529.

Kondandapani, N., Cochrane, M.A. and **Sukumar, R.** (2008). A comparative analysis of spatial, temporal, and ecological characteristics of forest fires in seasonally dry tropical ecosystems in the Western Ghats, India. Forest Ecology and Management, 256: 607-617.

Vidya, T.N.C., **Sukumar, R.** and Melnick, D.J. (2009). Range-wide mtDNA phylogeography yields insights into the origins of Asian elephants. Proceedings of the Royal Society B, 276: 893–902.

Books

Sukumar, R. (1989). The Asian Elephant: Ecology and Management. Cambridge Studies in Applied Ecology and Resource Management. Cambridge University Press, Cambridge, U. K.

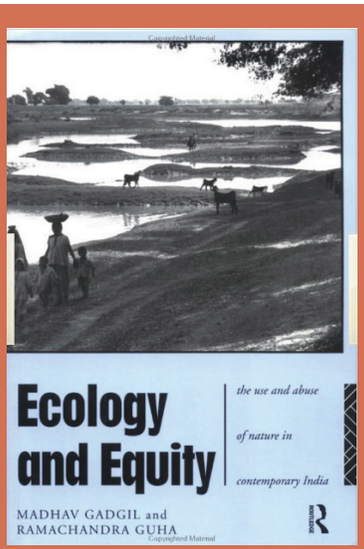
Sukumar, R. (1994). Elephant Days and Nights: Ten Years with the Indian Elephant. Oxford University Press, New Delhi.

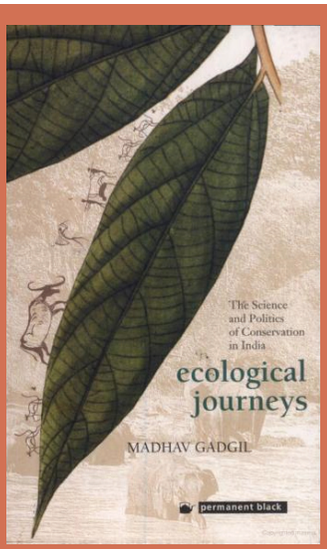
Sukumar, R. (2003). The Living Elephants: Evolutionary Ecology, Behavior and Conservation. Oxford University Press, New York.

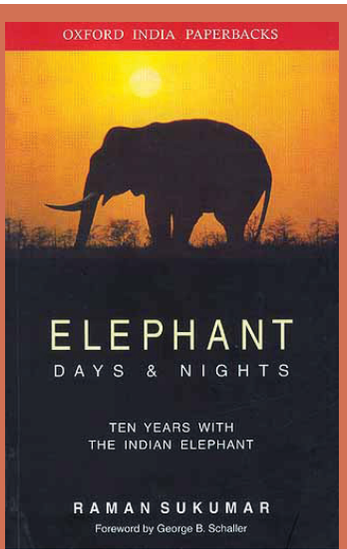
Awards & Honours

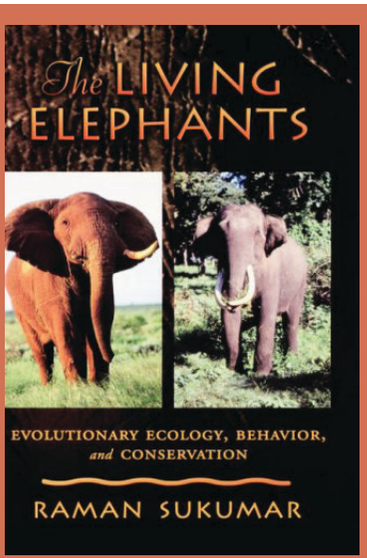
National Science Talent Award, National Council for Educational Research and Training, India, 1973.
Presidential Award of the Chicago Zoological Society, USA, 1991.
Order of the Golden Ark, The Netherlands, 1997.
Fellow of the Indian Academy of Sciences (elected in 2000), India.
Whitley Gold Award for International Nature Conservation, U.K., 2003.
TN Khoshoo Memorial Award for Conservation Science, India, 2004 (first recipient of this award).
Fellow of the Indian National Science Academy (elected in 2005), India.
University Grants Commission National Award in Environmental Science and Ecology, India, 2006.
International Cosmos Prize, Japan, 2006.
Fellow, Geological Society of India (elected in 2006).
B.P. Pal National Environment Fellowship Award for Biodiversity, India, 2007.
Commendation by the Prime Minister of India for contributions to the Intergovernmental Panel on Climate Change (IPCC) that shared the Nobel Peace Prize, 2007.

Raman Sukumar









MG & RS books

Raghavendra Gadgkar

Selected Publications

Gadagkar, R. (1990). Evolution of eusociality : the advantage of assured fitness returns. Philosophical Transactions of the Royal Society London B, 329, 17-25.

Gadagkar, R. (1991). Demographic predisposition to the evolution of eusociality - A hierarchy of models. Proceedings of the National Academy of Sciences, U.S.A., 88, 10993-10997.

Gadagkar, R., Chandrashekara, K., Chandran, S., and Bhagavan, S. (1993). Serial polygyny in the primitively eusocial wasp *Ropalidia marginata* : implications for the evolution of sociality. In: Queen Number and Sociality in Insects. (Ed. L.Keller), Oxford University press, Oxford, pp.188-214.

Gadagkar, R. (1996). The evolution of eusociality, including a review of the social status of *Ropalidia marginata*. In: Natural History and Evolution of Paper-Wasps, (Eds.) S.Turillazzi & M.J.West-Eberhard, Oxford University Press, Oxford, pp. 248-271.

Agrahari, M. and **Gadagkar, R.** (2003). Juvenile hormone accelerates ovarian development and does not affect age polyethism in the primitively eusocial wasp, Ropalidia marginata. Journal of Insect Physiology, 49, 217-222.

Sen, R. and **Gadagkar, R.** (2006). Males of the social wasp *Ropalidia marginata* can feed larvae, given an opportunity. Animal Behaviour, 71, 345-350.

Lamba, S., Kazi, Y .C., Deshpande, S., Natesh, M., Bhadra, A. and **Gadagkar, R.** (2007). A possible novel function of dominance behaviour in queen-less colonies of the primitively eusocial wasp *Ropalidia marginata*. Behavioural Processes, 74, 351-356.

8. Sumana, A., Deshpande S.A., Bhadra, A. and **Gadagkar, R.** (2008). Workers of the primitively eusocial wasp *Ropalidia marginata* do not perceive their queen across a wire mesh partition. Journal of Ethology, 26, 207-212.

Bhadra, A. and **Gadagkar, R.** (2008). We know that the wasps 'know': cryptic successors to the queen in *Ropalidia marginata*. Biol. Lett., 4, 634-637.

Gadagkar, R. (2009). Interrogating an Insect Society. Proceedings of the National Academy of Sciences, USA, 106, 10407-10414.

Books

Gadagkar, R. (1997). Survival Strategies - Cooperation and Conflict in Animal Societies. Harvard University Press, Cambridge, Massachusetts, USA and Universities Press, Hyderabad, India. (Complex) Chinese language edition, International Publishing Company Ltd., Taiwan (1999). Korean language edition, Purun Media Publishing Company (2001).

Gadagkar, R. (2001). The Social Biology of *Ropalidia marginata*: Toward Understanding the Evolution of Eusociality. Harvard University Press, Cambridge, Massachusetts, USA.

Awards & Honours

National Science Talent Scholarship. 1969
Dr. A. Krishna Murthy Award for the best paper, Society of Biological Chemists, India, 1982
Young Associate, Indian Academy of Sciences, 1984
Young Scientist Award in Biological Sciences, Karnataka Association for the Advancement of Science, 1984
Young Scientist Medal, Indian National Science Academy in Animal Sciences, 1985
Elected Fellow, Indian Academy of Sciences, 1990
Saraswathi Narayanan award for Biological Sciences, 1990-91
Professor T.N.Ananthakrishnan Award, 1990-1991
B.M.Birla Science Prize in Biology, 1991
Homi Bhabha Fellowship, November 1992 - October 1994
Elected Fellow, Indian National Science Academy, 1993
Shanti Swarup Bhatnagar Award in Biological Sciences, 1993.
B. P. Pal National Environment Fellowship on Biodiversity, Ministry of Environment & Forests, 1995-1997.
Elected Fellow, The National Academy of Sciences, India, 1995.
Elected Fellow, Indian Academy of Entomology, 1998
Third World Academy of Sciences Award in Biology, 1999
Schering-Fellow, Wissenschaftskolleg (Institute for Advanced Study) zu Berlin, Germany, 2000-2001.
Elected Fellow, Third World Academy of Sciences, 2001.
Guest of the Rektor, Wissenschaftskolleg (Institute for Advanced Study) zu Berlin, Germany, 2001-2002.
Non-Resident Permanent Fellow, Wissenschaftskolleg (Institute for Advanced Study) zu Berlin, 2002-2012.
Distinguished Visiting Scholar, University of Pretoria, South Africa, July 2003.
Swami Pranavananda Saraswathi Award in Environmental Science and Ecology for the year 2002.
2002 VASVIK Award - for contribution by way of research to Environmental Sciences & Technology.
Prof. Rustum Choksi Award for Excellence in Research for Science for the Year 2004.
Prof. U.S.Srivastava Memorial Lecture Award of the National Academy of Sciences, India, 2005.
Member, Indian Delegation to participate in the meetings of the Inter-academy Panel held in Shanghai and the International Council for Science held in Suzhou, China, October 2005.
Elected Foreign Associate, National Academy of Sciences, USA, 2006.
J C Bose National Fellowship, Department of Science & Technology, Government of India, 2006-2011.
Award of Jawaharlal Nehru Birth Centenary Visiting Fellowship – 2007 of the Indian National Science Academy, New Delhi.
Elected Foundation Fellow, Entomology Academy of India, Chennai, 2007.
H.K. Firodia Award 2008 for Excellence in Science & Technology, 2008.

Selected Publications

Ranganathan Y, **Borges R. M.** (2009) Predatory and trophiobiont-tending ants respond differently to fig and fig wasp volatiles. Animal Behaviour 77, 1539-1545.

Bhaskara R. M., Brijesh C M, Ahmed S., **Borges R. M.** (2009) Perception of ultraviolet by crab spiders and its role in selection of hunting sites. Journal of Comparative Physiology A 195, 409-417.

Somanathan H., **Borges, R. M.**, Warrant, E. J., Kelber, A. (2008) Nocturnal bees learn landmark colours in starlight. Current Biology 18, R996-997

Borges, R. M. (2008) Plasticity comparisons between plants and animals: concepts and mechanisms. Plant Signaling & Behavior 3, 367-375

Shenoy, M and **Borges, R. M.** (2008) A novel mutualism between an ant-plant and its resident pollinator. Naturwissenschaften 95. 61–65

Somanathan H, **Borges, R. M.**, Warrant E. J., and Kelber, A. (2008) Visual ecology of Indian carpenter bees I: Light intensities and flight activity. Journal of Comparative Physiology A 194, 97–107

Borges, R. M, Bessière, J-M, Hossaert-McKey M. (2008) The chemical ecology of seed dispersal in monoecious and dioecious figs. Functional Ecology 22, 484-493.

Borges, R. M., Ahmed, S. and Prabhu, V. (2007) Male ant-mimicking salticid spiders choose between retreat silks of sympatric females: implications for pre-mating reproductive isolation. Journal of Insect Behavior 20,389-402.

Gaume, L., Shenoy, M., Zacharias, M., **Borges R. M.** (2006) Co-existence of ants and an arboreal earthworm in a myrmecophyte of the Indian Western Ghats: anti-predation effect of the earthworm mucus. Journal of Tropical Ecology 22, 1-4

Gaume, L., Zacharias, M. **Borges, R. M.** (2005) Ant-plant conflicts and a novel case of castration parasitism in a myrmecophyte. Evolutionary Ecology Research 7, 435-452

Books

Borges, R. M. (1997) Evolution – the story of life. National Council for Science and Technology, New Delhi.

Awards & Honours

Fellow of the Indian Academy of Sciences, 2009.

Member of group selected to write White Paper for Indian National Science Academy on Vision for Indian Science, 2009.

Recipient of the Sunderlal Baghai Gold Medal Award for Science, Rotary Club, Bangalore, 2005

Member, Editorial Board: Acta Oecologica, Biotropica, Conservation and Society, Journal of Biosciences, Journal of Indian Institute of Science

Founder Member: Conservation and Society Journal

Reviewer for (selected): Journal of Theoretical Biology, Functional Ecology, Biological Journal of the Linnean Society, Naturwissenschaften, Journal of Tropical Ecology, Ecological Applications, Conservation Biology, Heredity, Plant Systematics and Evolution

Reviewer of proposals for (selected): National Science Foundation (NSF), USA; DST (India); Indo-US Science Forum

DST –Programme Advisory Committee member (Animal Sciences): 1993-1996

Elected to the Council of the Association of Tropical Biology (ATB) (2001-2003) – the only international association of scientists exclusively devoted to the study of tropical systems, based in USA. This association produces the widely read scientific journal Biotropica.

Recipient of the "Outstanding Teaching Assistant" award of the College of Arts and Science, University of Miami, 1987

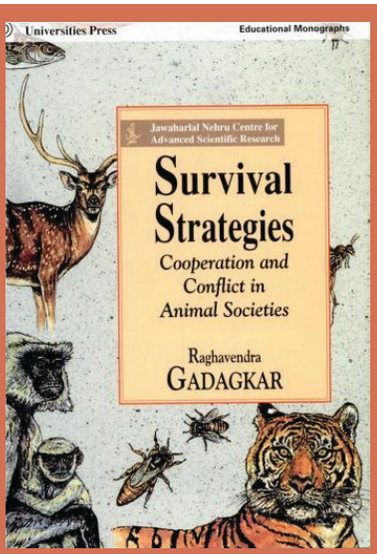
Graduate Fellowship from College of Arts and Sciences, University of Miami. 1982-1985.

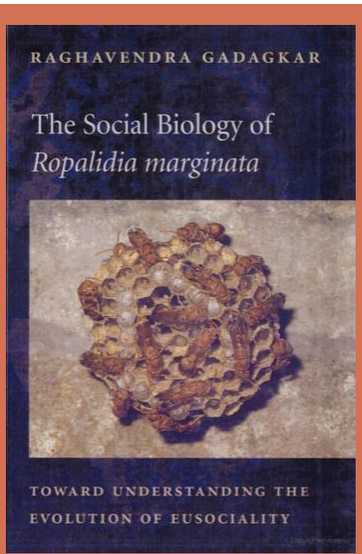
First Rank in M. Sc. (Part I) Examination. University of Bombay. 1981

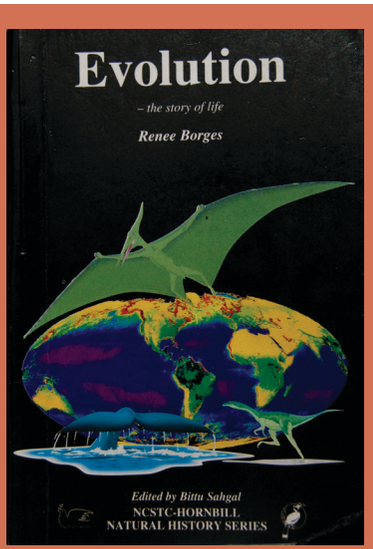
First Rank in B. Sc. Examination in Zoology. University of Bombay. 1979

Second Rank in B. Sc. Examination in Microbiology. University of Bombay. 1978

Renee Borges







RG & RB books

N H Ravindranath

Selected Publications

Ravindranath, NH and Somashekhar, BS (1995) Potential and economics of forestry options for carbon sequestration in India. Biomass and Bioenergy, 8(5), 323-336.

Ravindranath, NH, Somashekhar, BS and Gadgil M (1997) Carbon flow in Indian forests. Climatic Change, 35(3), 297-320.

Sathaye, JA and **Ravindranath, NH** (1998) Climate change mitigation in the energy and forestry sectors of developing countries. Annual Review of Energy and the Environment, 23, 387-437.

Sudha, P and **Ravindranath, NH** (1999) Land availability and biomass production potential in India. Biomass and Bioenergy, 16(3), 207-221.

Kadekodi, GK and **Ravindranath, NH** (1999) Macro-economic analysis of forestry options on carbon sequestration in India. Ecological Economics, 23(3), 201-233

Sudha, P and **Ravindranath, NH** (2000) A study of Bangalore urban forest. Landscape and Urban Planning, 47(1-2), 47-63.

Ravindranath, NH, Sudha, P and Rao S (2001) Forestry for sustainable biomass production and carbon sequesteration in India. Mitigation and Adaptation Strategies for Global Change, 6, 233-256.

Pretty, JN, Ball, AS Xiaoyun L and **Ravindranath, NH** (2002) The Role of Sustainable Agriculture and Renewable-Resource Management in Reducing Greenhouse-Gas Emissions and Increasing Sinks in China and India. Philosophical Transactions: Mathematical, Physical and Engineering Sciences, 360, 1741-1761.

Bhattacharya, SC, Salam, PA, Pham, HL and **Ravindranath, NH** (2003) Sustainable biomass production for energy in selected Asian countries. Biomass and Bioenergy, 25(5), 471-483.

Hiremath, RB, Shikh, S and **Ravindranath NH** (2007) Decentralized energy planning; modeling and application—a review. Renewable and Sustainable Energy Reviews, 11(5), 729-752.

Books

N. H. Ravindranath, M. Ostwald (2007) Carbon Inventory Methods, Springer.

N. H. Ravindranath and P. Sudha (2004) Joint Forest Management in India, spread, performance and impact. University Press (India), Hyderabad.

P. R. Shukla, Subodh K. Sharma,N. H. Ravindranath, Amit Garg and Sumana Bhattacharya (2003) Climate change and India Vulnerability Assessment and Adaptation , University Press (India), Hyderabad.

D. M. Bhat, Vidya S. Swamy and N. H. Ravindranath (2003) Nursery Manual for Forest Tree Species, University Press (India), Hyderabad.

N. H. Ravindranath and Jayant A. Sathaye (2002) Climate Change and Developing Countries (Advances in Global Change Research), Kluwer Academic Publishers.

Watson, R. T., Noble I. R., Bert Bolin, Ravindranath, N. H. David J. Verardo & David J. Dokken (2000) Land Use, Land-Use Change, and Forestry, Cambridge University Press, Cambridge.

N. H. Ravindranath, K. Usha Rao, Bhaskar Natarajan, Pradeep Monga (2000) Renewable Energy And Environment- Policy analysis for India Tata Mc- Graw Hill Publishing company.

N. H. Ravindranath, K. S. Murali and K. C. Malhotra (2000) Joint Forest Management and Community Forestry in India: An Ecological and Institutional Assessment, Oxford and IBH Publishing Co., New Delhi.

N. H. Ravindranath and D. O. Hall(1995) Biomass energy and environment: A developing country perspective from India, Oxford University Press, Oxford, 1995.

Kavita Isvaran

Selected Publications

Velho N., Datta A., **Isvaran K.** (2009) Effect of rodents on seed fate of tree species in a tropical forest in north-east India. Journal of Tropical Ecology 25, 507–514.

Karnad D., **Isvaran K.**, Kar C.S., Shanker K. (2009) Lighting the way: Reducing misorientation of olive ridley hatchlings due to artificial lighting at Rushikulya, India. Biological Conservation in press doi:10.1016/j.biocon.2009.04.004

Clutton-Brock T.H., **Isvaran K.** (2007) Sex differences in ageing in natural populations of vertebrates. Proceedings of the Royal Society of London Series B 274:3097–3104

Isvaran K. (2007) Intraspecific variation in group size in the blackbuck antelope: the roles of habitat structure and forage at different spatial scales. Oecologia 154:435–444

Isvaran K., Clutton-Brock T.H. (2007) The ecological correlates of extra-group paternity in mammals. Proceedings of the Royal Society of London Series B 274:219–224.

Clutton-Brock T.H., **Isvaran K.** (2006) Paternity loss in contrasting mammalian societies. Biology Letters 2:513–516.

Isvaran K. (2005) Variation in male mating behaviour within ungulate populations: patterns and processes. Current Science 89:1192–1199

Isvaran K. (2005) Female grouping best predicts lekking in blackbuck (Antilope cervicapra). Behavioral Ecology and Sociobiology 57:283–294

Quader S., **Isvaran K.**, Hale R., Miner B., Seavy N. (2004) Nonlinear relationships and phylogenetically independent contrasts. Journal of Evolutionary Biology 17:709–715

Isvaran K., St.Mary C.M. (2003) When should males lek? Insights from a dynamic state variable model. Behavioral Ecology 14:876–886.

Kartik Shanker

Selected Publications

Sridhar, H., G. Beauchamp and **K. Shanker** (2009) Why do birds participate in mixed-species foraging flocks? A large-scale synthesis. Animal Behaviour (in press).

Karnad, D., K. Isvaran, C.S. Kar and **K. Shanker** (2009) Lighting the way: reducing the impact of light on misorientation of olive ridley turtle hatchlings at Rushikulya, India. Biological Conservation (in press doi:10.1016/j.biocon.2009.04.004)

Seminoff, J.A. and **K. Shanker** (2008) Marine turtles and IUCN Red Listing: a review of the process, pitfalls and novel assessment approaches. Journal of Experimental Marine Biology and Ecology 356: 52-68.

Shanker, K. (2007) Deconstructing sea turtle conservation in India. In: Making Conservation Work (eds. G. Shahabuddin and M. Rangarajan), pp. 89-110. Permanent Black, New Delhi, India.

Shanker, K., A. Hiremath and K.S. Bawa (2005) Linking Biodiversity Conservation and Livelihoods in India. PLOS Biology 3: 1878-1880

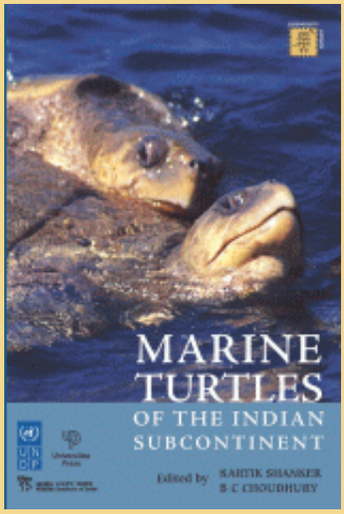
Oommen, M.A. & **K. Shanker** (2005) Regional species richness patterns emerge from multiple local scale mechanisms in Himalayan plants. Ecology 86: 3039-3047

Shanker, K. & R. Kutty (2005) Sailing the flagship fantastic: myth and reality of sea turtle conservation in India. Maritime Studies 3(2) and 4(1): 213-240.

Shanker, K., J. Rama Devi, B.C. Choudhury, L. Singh & R.K. Aggarwal (2004) Phylogeography of olive ridley turtles (Lepidochelys olivacea) on the east coast of India: implications for conservation theory. Molecular Ecology 13: 1899-1909.

Shanker, K., B. Pandav & B.C. Choudhury (2004) An assessment of the olive ridley turtles (Lepidochelys olivacea) nesting population in Orissa, India. Biological Conservation 115: 149 – 160.

Shanker, K. & R. Sukumar (1999) Synchrony in small mammal populations of montane forest patches in southern India. Journal of Animal Ecology 68: 50-59.



Books

Shanker, K. & B.C. Choudhury (2006) (Editors) Marine turtles of the Indian subcontinent. Universities Press, Hyderabad. India.

Awards & Honours

President, International Sea Turtle Society, 2009 – 2010.
Board of Directors, International Sea Turtle Society, 2005 – 2009.
Regional Vice Chair, IUCN/SSC Marine Turtle Specialist Group IUCN, 2003 - 2008.
Executive Editor, Conservation and Society, 2005.
Founding Editor, Current Conservation, 2007.
Founding Editor, Indian Ocean Turtle Newsletter, 2005.

Niranjan V Joshi

Selected Publications

Gadagkar, R. and **Joshi, N. V.** (1983) Quantitative ethology of social wasps: time-activity budgets and caste differentiation in Ropalidia marginata (Lep.) (Hymenoptera: Vespidae). Animal Behaviour 31, 26-31.

Gadgil, S., Joseph, P. V. and **Joshi, N. V.** (1984) Ocean–atmosphere coupling over monsoon regions. Nature, 312, 141-143.

Joshi, N. V. (1987) Evolution of cooperation by reciprocation within structured demes. Journal of Genetics, 66(1), 69-84.

Joshi, N. V. and Gadgil, M. (1991) On the role of refugia in promoting prudent use of biological resources. Theoretical Population Biology, 40 (2), 211-229.

Daniels, R. J. R., Hegde, M., **Joshi N. V.** and Gadgil, M. (1991) Assigning conservation value: a case study from India. Conservation Biology, 5(4), 464-475.

Daniels, R. J. R., **Joshi N. V.** and Gadgil, M. (1995) Impact of human extraction on tropical humid forests in the Western Ghats, Uttara Kannada, South India. Journal of Applied Ecology, 32(4), 866-874.

Gadgil, M., **Joshi, N. V.**, Manoharan, S., Patil, S. and Prasad, U. V. S. (1998) Peopling of India. In The Indian Human Heritage eds. D. Balasubramanian and N. Appaji Rao, University Press (India) Limited, Hyderabad, India.

T. V. Ramachandra, **Joshi, N. V.**, and Subramamian, D. K. (2000) Present and prospective role of bioenergy in regional energy system. Renewable and Sustainable Energy Reviews. 4(4), 375-430.

Iyengar, P., **Joshi, N. V.**, Balaram, P. (2006) Conformational and Sequence Signatures in β Helix Proteins. Structure, 14(3), 529-542.

Nath, C. D., Dattaraja, H. S., Suresh, H. S., **Joshi, N. V.** and Sukumar, R. (2007) Patterns of tree growth in relation to environmental variability in the tropical dry deciduous forest at Mudumalai, southern India. Journal of Biosciences, 31(5), 651-669.

Rohini Balakrishnan

Selected Publications

Metrani, S. & **Balakrishnan, R.** (2005). The utility of song and morphological characters in delineating species boundaries among sympatric tree crickets of the genus *Oecanthus* (Orthoptera: Gryllidae: Oecanthinae): a numerical taxonomic approach. Journal of Orthoptera Research 14, 5-20.

Balakrishnan, R. (2005). Species concepts, species boundaries and species identification: A view from the tropics. Systematic Biology 54, 689-693.

Balakrishnan, R. Neurobiology and behaviour: a network of connections. (2005) Current Science 89, 1147-1165.

Nityananda, V. & **Balakrishnan, R.** (2007).Synchrony during acoustic interactions in the bushcricket *Mecopoda*'Chirper' (Tettigoniidae:Orthoptera) is generated by a combination of chirp-by-chirp resetting and change in intrinsic chirp rate. Journal of Comparative Physiology A 193, 51-65.

Diwakar, S., Jain, M. & **Balakrishnan, R.** (2007). Psychoacoustic sampling as a reliable, non - invasive method to monitor orthopteran species diversity in tropical forests. Biodiversity and Conservation 16, 4081-4093.

Nityananda, V., Stradner, J., **Balakrishnan, R.** & Römer, H. (2007). Selective attention in a synchronising bushcricket: physiology, behaviour and ecology. Journal of Comparative Physiology A 193, 983-991.

Mhatre, N. & **Balakrishnan, R.** (2007). Phonotactic walking paths of field crickets in closed loop conditions and their simulation using a stochastic model. Journal of Experimental Biology 210, 3661-3676.

Nityananda, V. & **Balakrishnan, R.** (2008) Leaders and followers in katydid choruses in the field: call intensity, spacing and consistency. Animal Behaviour 76, 723-735.

Mhatre N & **Balakrishnan R.** (2008) Predicting acoustic orientation in complex real-world environments. Journal of Experimental Biology 211:2779-2785.

Nityananda, V. & **Balakrishnan, R.** (2009). Modeling the role of competition and cooperation in the evolution of katydid acoustic synchrony. Behavioral Ecology 20: 484 - 489.

Sulochana Gadgil

Selected Publications

Gadgil, S., Gadgil M. (1975) Can a single resource support many consumer species? Journal of Genetics. 62, 33-47.

Gadgil, S., Gadgil, M. (1979) Adaptive significance of the relation between root and shoot growth. Journal of the Indian Institute of Science, 61, 25-40.

Gadgil, S., Nanjundiah, N., Gadgil, M. (1980) On evolutionarily stable compositions of populations of interacting genotypes. Journal of Theoretical Biology 84, 737-759.

Gadgil, S., Joshi, N. V. (1983) Climatic clusters of the Indian region. Journal of Climatology, 3, 47-63.

Gadgil, M., Gadgil, S., Joshi, N. V. (1983) On the moulding of population viscosity by natural selection. Journal of Theoretical Biology, 104:21-42.

Gadgil, S., Joseph, P. V. and Joshi, N. V. (1984) Ocean–atmosphere coupling over monsoon regions. Nature, 312, 141-143.

Gadgil, S., Rao, P. R. S., Joshi, N. V., Sridhar, S. (1995) Forecasting rain for groundnut farmers - How good is good enough? Current Science, 68, 301-309.

Gadgil, S. (1995) Climate change and agriculture: an Indian perspective. Current Science, 69, 649-659.

Gadgil, S., Rao, P. R. S. and Rao, K. N. (2002) Use of climate information for farm-level decision making: Rainfed groundnut in Southern India, Agricultural Systems, 74, 431-457.

Gadgil, S., and Gadgil, S. (2006) The Indian Monsoon, GDP and Agriculture. Economic and Political Weekly, XLI, 4887-4895.

Books

Climate Variability and Agriculture (1996) Eds. Y P Abrol, Sulochana Gadgil and G B Pant. Narosa Publishing House, London, Delhi, Bombay.

Rice in a variable climate (1995) Eds, Y P Abrol, Sulochana Gadgil. APC Publications, Delhi.

Vidyanand Nanjundiah

Selected Publications

Gadgil, S., **Nanjundiah, V.**, and Gadgil, M. (1980) On Evolutionary Stable Compositions of Populations of Interacting Genotypes. Journal of Theoretical. Biology. 84, 737-759.

Chandra, H.S. and **Nanjundiah, V.** (1990) The Evolution of Genomic Imprinting. Development (supplement) 47-53.

Nanjundiah, V. (1992) J.B.S. Haldane: His Life and Science. Current Science 63 (9&10), 582-588.

Nanjundiah, V. (2003) Phenotypic Plasticity and Evolution by Genetic Assimilation in Origins of Organismal Form, G. Müller and S. A. Newman, eds., MIT Press, pp 244-263).

Kaushik, S. and **Nanjundiah, V.** (2003) Evolutionary questions raised by cellular slime mould development. Proceedings of the Indian National Science Academy. B69, 825-852.

Behera, N. and **Nanjundiah, V.** (2004) Phenotypic plasticity can potentiate rapid evolution, Journal of Theoretical. Biology, 226, 177-184.

Xu, C-L., Boyce, M., Gadgil, M. and **Nanjundiah, V.** (2005) Forecasting spatially structured populations: implications for resource exploitation, Journal of Theoretical. Biology., 233, 177-189.

Kaushik, S., Katoch, B. and **Nanjundiah, V.** (2006) Social behaviour in genetically heterogeneous groups of *Dictyostelium giganteum*, Behavioral Ecology and Sociobiology, 59(4), 521-530.

Cornish-Bowden, A. and **Nanjundiah, V.** (2006) The genetic basis of dominance, in "The Biology of Genetic Dominance", R. Veitia, ed., Eurekah/ Landes Bioscience, pp 1-16.

Mujumdar, N., Inouye, K. and **Nanjundiah, V.** (2009) The trishanku, gene and terminal morphogenesis in *Dictyostelium discoideum*. Evolution and Development (in press).

Awards & Honours

Former fellow, Alexander von Humboldt Foundation.
Fellow, Indian National Science Academy and Indian Academy of Sciences.
Honorary Professor, Jawaharlal Nehru Centre for Advanced Scientific Research.

Praveen Karanth

Selected Publications

Achille P. Raselimanana, Brice Noonan, **K. Praveen Karanth**, Jacques Gauthier, and Anne D. Yoder (2009) Phylogeny and evolution of Malagasy plated lizards. Molecular Phylogenetics and Evolution, 50, 336-344.

K. Praveen Karanth (2008) Primate Numts and reticulate evolutions of capped and golden leaf monkeys (Primates: Colobinae). Journal of Biosciences, 33(5) 761-770.

K. Praveen Karanth, Lalji Singh, Randall V. Collura, and Caro-Beth Stewart (2008) Molecular phylogeny and biogeography of langurs and leaf monkeys of South Asia (Primates: Colobinae). Molecular Phylogenetics and Evolution, 46, 683-694.

K. Praveen Karanth (2006) Out-of-India Gondwana origin of some Asian biota. Current Science, 90 (6) 789-792.

Anne D. Yoder, Carol Hanley, Kellie Heckman, Rodin Rasoloarison, Amy Russell, Julie Ranivo, Link E. Olson, Voahangy Soarimalala, **K. Praveen Karanth**, Achille P. Raselimanana, and Steven M. Goodman (2005) A multidimensional approach for detecting species patterns in Malagasy vertebrates. Proceedings of the National Academy of Sciences of USA, 102 (Suppl. 1) 6587-6594.

K. Praveen Karanth, Thomas Delefosse, Berthe Rakotosamimanana, Thomas J. Parson and Anne D. Yoder (2005) Ancient DNA from giant extinct lemurs confirms single origin of Malagasy primates. Proceedings of the National Academy of Sciences of USA, 102 (14) 5090-5095.

K. Praveen Karanth, Eric Palkovacs, Justin Gerlach, Scott Glaberman, Julian Pender Hume, Geisella Caccone, and Anne Yoder (2005) Native Seychelles tortoises or Aldabran imports? The importance of radiocarbon dating for ancient DNA studies. Amphibia-Reptilia, 26(1) 116 -121.

K. Praveen Karanth, Aaron Avivi, and Eviatar Nevo (2004) Microsatellite diversity in subterranean mole rats of the *Spalax ehrenbergi* superspecies populations in Israel. Biological Journal of the Linnean Society, 83, 229-241.

K. Praveen Karanth (2003) Evolution of disjunct distribution among wet zone species of the Indian subcontinent: Testing various hypothesis using a phylogenetic approach. Current Science, 85(9) 101-108.

Sathees Chandra, B.C., Geetha, L., Abraham, V.A., **Karanth, P.**, Thomas, K., Srinivasan, M.V. and Gadagkar, R. (1998). Uniform discrimination of pattern orientation by honey bees. Animal Behaviour, 56, 1391-1398.

T V Ramachandra

Selected Publications

Ramachandra T.V. (2009): Regional Integrated Energy Plan, Renewable and Sustainable Energy Reviews, 13, 285–317.

Ramachandra, T.V., D.M. Mahapatra, Karthick B. and R. Gordon (2009) Milking diatoms for sustainable energy: biochemical engineering vs. gasoline secreting diatom solar panels. Industrial & Engineering Chemistry Research. Complex Materials II special issue, 48(19).

Ramesh Maheshwari, Sankara Rao K. and **Ramachandra, T. V.** (2009) Structural characteristics of a giant tropical liana and its mode of canopy spread in an alien environment, Current Science, 96(1), 58-64.

Ramachandra T.V. and Uttam Kumar (2008). Wetlands of Greater Bangalore, India: Automatic delineation through pattern classifiers, The Greendisk Environmental Journal. Issue 26 URL:http://egj.lib.uidaho.edu/index.php/egj/article/view/3171

Subash Chandran M.D., Mesta D.K., Rao G.R., Sameer Ali, Gururaja K.V. and **Ramachandra T.V.** (2008) Discovery of two critically endangered tree species and issues related to relic forests of the Western Ghats, The Open Conservation Biology Journal, 2008, 2, 1-8.

Gururaja, K.V., Aravind, N.A., Sameer Ali, **Ramachandra, T.V.**, Velavan, T.P., Krishnakumar, V. and Aggarwal, R.K., (2007) A new frog species from the Central Western Ghats of India,and its phylogenetic position, Zoological Science, 24:525-534.

Ramachandra T.V. , Loerincik Y. and Shruthi B.V., (2006). Intra and Inter Country Energy Intensity Trends, International Journal of Energy and Development, 31(1): 43-84.

Gururaja, K.V. and **Ramachandra, T.V.**, (2006). Developmental mode in white-nosed shrub frog P*hilautus leucorhinus,* Current Science, 90(3): 450-454.

Sreekantha, Gururaja, K.V., Remadevi, K., Indra T.J. and **Ramachandra T.V.**, (2006). Two new species of the genus *Schistura* McClelland (Cypriniformes: Balitoridae) from Western Ghats, India. Zoos' Print Journal, 211(4): 2211-2216

Ahalya N, Kanamadi R.D. and **Ramachandra, T.V.** (2006) Biosorption of chromium (VI) from aqueous solutions by the husk of Bengal gram (Cicer arientinum). Electronic Journal of Biotechnology, 8(3). URL: http://www.ejbiotechnology.info/content/vol8/issue3/full/10/

Books

Ramachandra T.V., Subash Chandran M D., Gururaja K V and Ramachandra T V, 2007. Cumulative Environmental Impact Assessment, Nova Science Publishers, New York.

Ramachandra T.V., 2006. Management of Municipal Solid Waste, Commonwealth Of Learning, Canada and Indian Institute of Science, Bangalore (reprinted in 2009, TERI Press, New Delhi).

Ramachandra T.V., 2006. Soil and Groundwater Pollution from Agricultural Activities, Commonwealth Of Learning, Canada and Indian Institute of Science, Bangalore (reprinted in 2009, TERI Press, New Delhi)..

Vijay Kulkarni and Ramachandra T.V., 2006. Environmental Management, Commonwealth Of Learning, Canada and Indian Institute of Science, Bangalore (reprinted in 2009, TERI Press, New Delhi).

Ramachandra, T.V. 2003. Ecologically Sound Integrated Regional Energy Planning, Nova Science Publishers, Huntington, NY 11743-6907.

ENVIRONMENTAL INFORMATION SYSTEM (ENVIS)

The ENVIS Centre at the Centre for Ecological Sciences, Indian Institute of Science, like the Centre for Ecological Sciences itself is devoted to basic ecological research programmes in biodiversity, animal and plant ecology, conservation biology, ecological and environmental problems of the Western Ghats. The ENVIS Centre has a collection of over 10633 books, access to over 92 periodical titles, over 6164 reports, over 3220 reprints from scientific journals, 1400 maps, 220 CD-ROMs and 24 Video Cassettes. Over the last year, we have added over 110 books, 40 reprints, 113 reports, 4 periodicals and 22 CD-ROMs. ENVIS can cater to a very large number of individuals. However, our clientele is largely restricted to students, research workers and teachers in colleges and universities. These individuals regularly seek our assistance in collecting information and solving problems arising out of their day-to-day teaching and research work. Most of the queries are answered quickly and efficiently either by lending the appropriate documents or by permitting consultation within our premises.

A significant achievement of the centre is the design and development of web based Western Ghats biodiversity information system (WGBIS). Currently the information system consists of 4400 flora species with attribute information. During the current year 1000 species have been added. Apart from this, faunal database is being strengthened with the information on amphibians, fish and mammals. Details are available at http://wgbis.ces.iisc.ernet.in/biodiversity/database/database.htm

The ENVIS homepage is being used extensively from within the country as well as from abroad (number of hits over the last year 25,43,803). Development of the homepage has convinced us that a large increase in the accessibility of ENVIS Centre documents is possible with the aid of electronic media. We are always available for suggestions, comments and queries at envis@ces.iisc.ernet.in

CENTRE FOR ECOLOGICAL SCIENCES

OUTREACH

OUTREACH, CONSERVATION & CONTRIBUTIONS TO GOVERNMENT POLICY

Introduction and early activities

Over the years, the Centre for Ecological Sciences has consistently contributed to outreach activities, as well as national and international projects and policy relating to the conservation of wildlife and biodiversity, eco-development and climate change. Even before CES came into formal existence, ecologists at the Indian Institute of Science were actively involved in wildlife conservation. When the high-profile Project Tiger was launched during the early 1970s, Madhav Gadgil served on its steering committee (1978–82). In 1980, the Indian government decided to join the Man and Biosphere Programme of UNESCO, and approached Madhav Gadgil to prepare the action plan for the country's first biosphere reserve in the Nilgiris covering the states of Karnataka, Tamilnadu and Kerala. Narendra Prasad and R. Sukumar, then doctoral students in the Ecology programme, participated in the initial surveys and preparation of the first document for the proposed Nilgiri Biosphere Reserve that aimed to conserve representative areas of biodiversity across this diverse landscape, reconcile conservation with human development, and provide a site for long-term ecological research. R. Sukumar steered modifications to the original design over the next five years, leading to the establishment of the NBR in 1986. Since then CES has also taken on the role of long-term research on forest dynamics in Mudumalai, a part of the NBR.

It was in CES that Madhav Gadgil pioneered the organization of decentralized, networked approaches to monitoring of biodiversity. The challenges of such an undertaking are immense, for valuable elements of biodiversity are not restricted to Protected Areas. To achieve this, it is necessary to organize an effective network covering the entire country including the large numbers of students and trained biologists working as teachers in undergraduate colleges throughout the country and the even larger number of practical ecologists - fisherfolk and shepherds, dispensers of herbal medicine and rat-catchers – who depend on living resources for their livelihoods.

CENTRE FOR ECOLOGICAL SCIENCES
OUTREACH

Western Ghats Biodiversity Network

Prof Gadgil's efforts along these lines began with a successful project to evaluate the impact of the Western Ghats Development Programme with the help of students and teachers of 28 colleges in Karnataka in 1990-91. In 1993, a Pew Foundation Fellowship in Environment and Conservation provided support to organize a network of undergraduate colleges, university departments, and NGOs to investigate the biodiversity of the Western Ghats. This Western Ghats Biodiversity Network (WGBN), extending over the states of Maharastra, Goa, Karnataka, Tamil Nadu and Kerala, elicited enthusiastic participation by a number of undergraduate science teachers and students. A total of 300 students and 33 teachers participated in the fieldwork. An important component of the programme was to document the perceptions and knowledge of the local communities regarding the landscape over which they gather resources such as fuel wood and medicinal herbs, and the status and ongoing changes in the soil, water and biological resources. A number of the students involved took up special projects on their own, on bird and butterfly communities, and on attributes of tree bark and local knowledge.

Lifescape Series

One of the special projects spoken of was taken up by Krishnamegh Kunte. He wrote the first book, "Butterflies of Peninsular India" in the Lifescape series that Prof. Gadgil launched to mark the birth centenary of Salim Ali in 1996. A series of articles was also published in the two periodicals of the Indian Academy of Sciences, Resonance and Current Science. The Project also led to the publication of three more books, on amphibians, freshwater fishes and dragon and damselflies of peninsular India.

People's Biodiversity Registers

A natural sequel to the WGBN was the preparation of People's Biodiversity Registers (PBR) through a network coordinated by MG as a part of the Biodiversity Conservation Prioritisation Programme sponsored by World Wide Fund for Nature (India) over 1996-98. This programme was initiated through a workshop held at the Indian Institute of Science, Bangalore in March 1996 involving potential collaborators from the states of Himachal Pradesh, Rajasthan, Bihar, Assam, Orissa, Karnataka, Maharashtra and the Andaman and Nicobar Islands, selected to represent the varied ecological and social regimes of the subcontinent. This was followed by a series of further training programmes and workshops that facilitated the fieldwork spread over fifty-two sites throughout the subcontinent employing a common methodology. Sixteen of the studies pertained to protected areas, including six national parks and ten wildlife sanctuaries, three being Tiger Reserves and two Bird Sanctuaries.

The entire programme engaged 350 researchers and 200 assistants from village communities. As many as 1000 villagers had extensive involvement in the programme as local knowledgeable individuals. The methodology of field investigations included: building rapport with local people, clarifying the project rationale and obtaining their approval for the joint studies, identification of different biodiversity user groups, identification of individuals knowledgeable in different aspects of distribution and uses of biodiversity, individual as well as group interviews with members representing different user groups, mapping of the landscape of the study site, field visits to representative elements of this landscape, discussions with the entire village assembly, and discussions with outsiders affecting the resource use at the study site such as nomadic shepherds or artisans, traders and government officials. The information so generated was then synthesised into a PBR.

Biological Diversity Act

While the work on the preparation of these PBRs was in progress, MG served as a member of the committee to draft India's Biological Diversity Act, finally enacted in 2002. This act aims to promote conservation, sustainable use and equitable sharing of benefits of India's biodiversity resources, including habitats, cultivars, domesticated stocks and breeds of animals and micro-organisms. With this in view it provides for the establishment of a National Biodiversity Authority (NBA), State Biodiversity Boards (SBB) and Biodiversity Management Committees (BMC) at the level of Panchayats, Municipalities and City Corporations. These BMCs would serve to take science right down to the grass-roots, since the rules lay down that "The main function of the BMC is to prepare People's Biodiversity Register in consultation with local people. The Register shall contain comprehensive information on availability and knowledge of local biological resources, their medicinal or any other use or any other traditional knowledge associated with them."

While the Biological Diversity Act was being debated in the Parliament, the Department of Biotechnology and Ministry of Environment and Forests, Government of India, as well as the Karnataka State Government funded MG to further develop the methodology of participatory, decentralized monitoring of biodiversity. This was done in phases, involving a number of High Schools and NGOs in Karnataka, Maharashtra, Madhya Pradesh and Tamilnadu, resulting in a Relational Database Management System to support this monitoring programme. The National Biodiversity Authority discussed this methodology and the database at a National Workshop in June 2006 and recommended its country-wide adoption.

Project Elephant

Recognizing the need for a more holistic landscape-level conservation programme, the Indian government set up a task force in 1989 to prepare an action plan for Project Elephant covering four regions of the country - northwest, northeast, east-central and south – where sizeable populations of the elephant are still found. R. Sukumar was a member of this task force that identified eleven landscapes for implementing Project Elephant, whose thrust included habitat conservation and ecodevelopment, mitigation of elephant-human conflicts, controlling ivory poaching and improving the management of captive elephants in the country. He also served on the steering committee for over a decade after the launch of Project Elephant in 1992.

Asian Nature Conservation Foundation

Outreach programmes and grassroots level conservation often need an institution different from that of an academic centre, and so R. Sukumar set up the Asian Nature Conservation Foundation in 1997 to promote activities such as strengthening wildlife corridors through land acquisition, mitigating elephant-human conflicts through community participation and

providing training to researchers and field managers in field surveys and practical conservation techniques. The Whitley Gold Award for International Nature Conservation in 2003 to Sukumar helped considerably strengthen the activities of ANCF whose offices are located on campus.

Monitoring sea turtles

Five species of sea turtles – olive ridley, leatherback, green, loggerhead and hawksbill turtles - are found in waters of the Indian subcontinent. Kartik Shanker and his collaborators have been monitoring and studying marine turtles through a large part of their range in the region, in addition to various conservation and outreach programmes.

The leatherback turtle is the largest sea turtle and is restricted to the Andaman and Nicobar Islands in India. The team is working closely with the Andaman and Nicobar Forest Department and the Andaman and Nicobar Environment Team to monitor these populations, track their movements and provide training and capacity building for their conservation and management.

Orissa is one of three mass nesting sites for olive ridley turtles worldwide, but these animals are threatened by fishery related mortality and development. The team is currently involved in a project to census mass nesting and monitor olive ridley turtles in Orissa. During the past few years, they have worked with the Orissa Forest Department to produce manuals and train forest department field personnel to estimate mass nesting events.

Orissa Marine Resources Conservation Consortium (OMRCC)

The threats that are faced by the turtles along the Orissa coast, in addition to the impacts of development on the traditional fishing community have been complex and inextricably linked. Facilitated by Kartik Shanker and his colleagues at the Coastal and Marine Programme (now Dakshin Foundation) at the Ashoka Trust for Research in Ecology and the Environment (ATREE), the Orissa Marine Resources Conservation Consortium was formed to facilitate dialogue between local communities and conservationists and pursue common objectives. The OMRCC includes fishworkers' unions of Orissa, conservation organisations, development NGOs, turtle biologists, and social scientists. It is one of the few initiatives for collaborative marine conservation action in India.

CENTRE FOR ECOLOGICAL SCIENCES

OUTREACH

TAG-India (Turtle Action Group): A national network for marine turtle conservation in India

Across the country, numerous community based groups, conservation non-governmental organizations (NGOs) - local, national and international, academic institutions and government departments - have been working towards the cause of sea turtle and marine conservation. Kartik Shanker and his team facilitated a national level network to bring these groups together. and the network was formed in January 2009. The network seeks to pool resources and knowledge to address sea turtle conservation more effectively through cooperative and collaborative action and efforts at the local, state and national levels.

Indian Ocean Turtle Newsletter

Kachhapa, started as a sea turtle newsletter for the subcontinent in 1999, evolved into the Indian Ocean Newsletter (IOTN) in 2004. The IOTN aims to provide a forum for exchange of information on sea turtle biology and conservation, management and education and awareness activities in the Indian subcontinent, Indian Ocean region, and south/southeast Asia. The newsletter is distributed free of cost to 1500 government and non-government organisations and individuals in the region, and is available online at www.iotn.org. It is co-edited by Kartik Shanker and Chloe Schauble.

30th Annual Symposium on Sea Turtle Biology and Conservation

The Annual Symposium on Sea Turtle Biology and Conservation, conducted by the International Sea Turtle Society, will be held in Goa in April 2010. It is the first time that the symposium will be held in the South Asian region. Kartik Shanker currently serves as the President of the Society. The event in 2010 is being jointly hosted and organized by CES along with sea turtle conservation groups and research organizations as well as institutions that work on marine environment issues across India and South Asia. The symposium is expecting up to 700 participants, from as many as 50 countries across the world.

Environmental research outreach

School children in rural Bangalore are partners in an awareness raising program of wetland environment monitoring, which involves soil and water quality monitoring and catchment mapping using Simputers. A series of environmental engineering distance education courses on solid waste and water treatment, air, soil and ground water pollution control are being developed for professionals.

Climate Change

Climate change has added a new dimension to the challenges facing the sustainability of the planet. N.H. Ravindranath and R. Sukumar have contributed substantially to the work of the Intergovernmental Panel on Climate Change (IPCC), in particular the working groups on impacts and mitigation of climate change, since the mid-1990s. They have also served on the Expert Panel on Climate Change set up by the Indian government in 2007 to chart out a programme for adaptation in various sectors such as forests, hydrology and agriculture to future climate change in the country.

National and International conservation policy

Madhav Gadgil and R. Sukumar have served on the Indian Board for Wildlife (now the National Board for Wildlife), the apex policy-making body for conservation that is chaired by the Prime Minister. At the international level, Madhav Gadgil has served as Chair of the Global Environment Facility's Scientific, and Technical Advisory Panel (1998-2002) to address a variety of urgent global environmental issues pertaining to biodiversity, climate change, international waters and land degradation. R. Sukumar has focused on the conservation of Asian elephants across the tropical forests of South and Southeast Asia. He served as Deputy Chair (1988-1996) and Chair (1997-2004) of the Asian Elephant Specialist Group of IUCN-The World Conservation Union; during this period the group brought out an action plan for Asian elephant conservation, initiated conservation activities for the first time in several Southeast Asian countries including Myanmar and Cambodia, and helped set up a global programme for monitoring the illegal killing of elephants in Asia. Kartik Shanker served as the Regional Chair of the Marine Turtle Specialist Group (2003 – 2008).

CENTRE FOR ECOLOGICAL SCIENCES

PAST, PRESENT & FUTURE

Over the past 25 years, we have evolved a tradition of rigorous enquiry in diverse areas of ecology, evolution and behaviour. We have pioneered research in a variety of areas: sociobiology, animal behaviour, sensory ecology, wildlife biology, forest ecology, mathematical ecology, community ecology and biodiversity, human and landscape ecology, and climate change. Research is being carried out on a number of plant and animal taxa, ranging from ants to elephants, and from fungi to figs, including diatoms, nematodes, wasps, crickets, spiders, butterflies, herpetofauna, birds and mammals, and at a number of geographical scales, from local levels to large landscapes.

A number of these areas are breaking new ground in ecology, including our research on the visual and chemical ecology of plant–animal interactions, acoustic communication, sociobiology of insects, historical biogeography and forest dynamics. Other projects have significant roles in conservation, such as our research on human–elephant conflict, diversity and distributions, conservation genetics, impact of climate change on forests, strategies for mitigation and adaptation, conservation and monitoring of aquatic ecosystems, and invasive species. Exciting new areas are on the horizon, both disciplinary and geographic. CES plans to continue to pioneer new research in canopy studies, molecular ecology, marine biology, invasive species biology and climate change.

We hope to establish long term monitoring programs at key biodiversity areas to monitor responses to anthropogenic impacts and climate change, and to provide bases for capacity building, training and outreach. We also hope to establish a Natural History Museum showcasing our extensive collections of flora and fauna and to educate and entertain the public with our findings. Our teaching program has expanded and diversified over the past ten years and our student strength is at an all-time high. This will continue to be one of our lasting contributions to ecological sciences in India. Recently, students at CES have been involved in pioneering a students' conference on ecology, evolution and conservation science since 2008, now called YETI (Young Ecologists Talk and Interact). It is in such initiatives by a generation trained in the rigour of science and steeped in the spirit of collegiality and collaboration, that we see a great future for ecology and evolution in India.

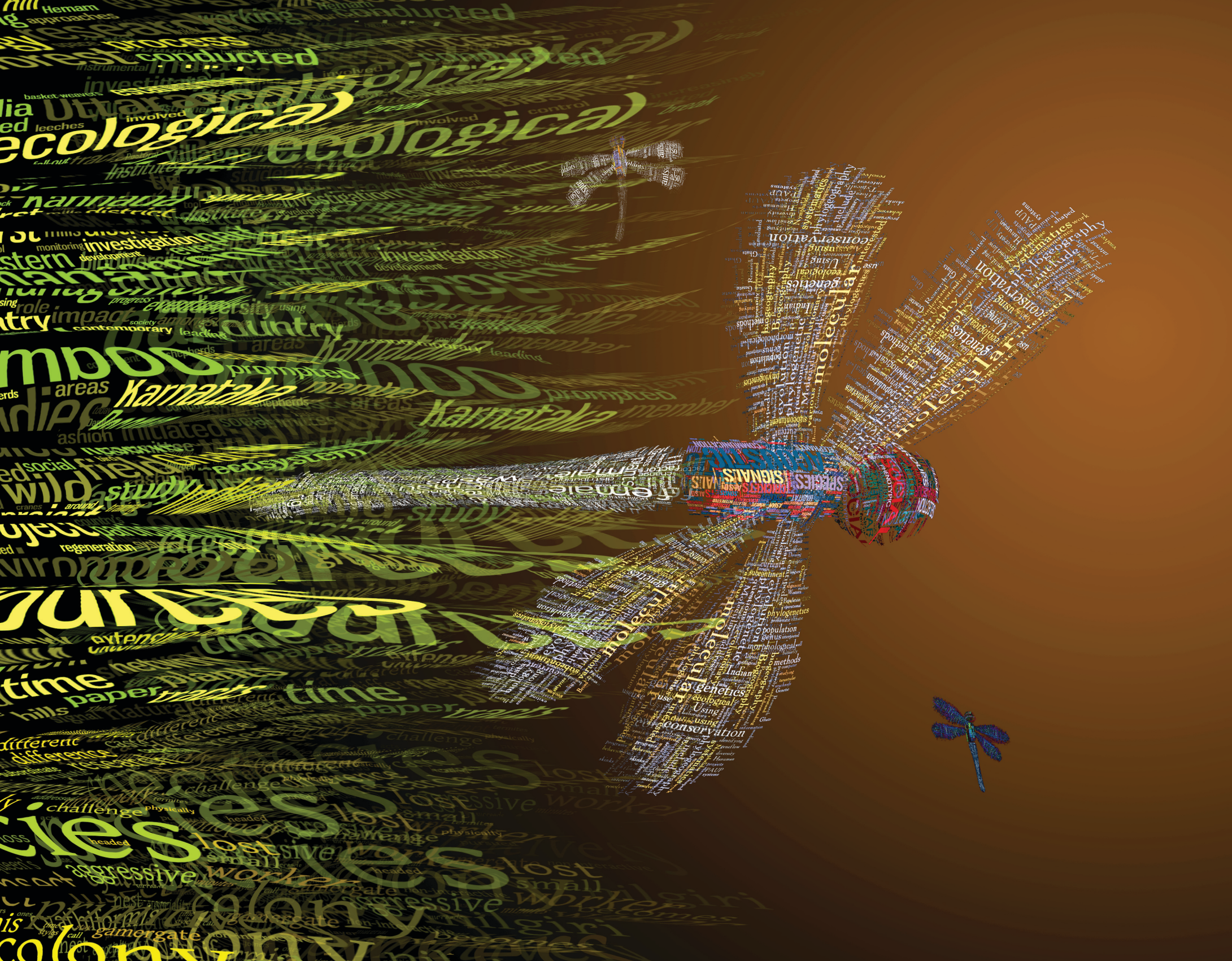
In the coming decades, CES will continue to evolve, expand and diversify its activities in teaching, research, outreach and conservation, whilst maintaining its standards of academic excellence.

Design and Cover: Natasha Mhatre

Material and Printing: Geetha Gadagkar and Hetal Hariya

Compiled and Edited by Rohini Balakrishnan and Kartik Shanker

Centre for Ecological Sciences
Indian Institute of Science


ecological
molecular
conservation
genetics
phylogenetics
Karnataka
species
colony
workers
study
time
paper
female
males
aggressive
lost
small
challenge
different
difference
Using
methods
population
genus
morphological
Indian
geographical
systematics
biogeography
SIGNALS
PHENOTYPIC