TIMES evoke

MAKING MAGIC REAL

South America is the home of magic realism, literature where the everyday is utterly transformed. Suddenly, characters in novels find their lives intertwined with butterflies that mutter and pumas that sing — the real and the magical know no bounds here. But while many South American countries embellished magic realism in their writing, Costa Rica made this come alive. A quizzically-shaped land, Costa Rica links southernmost North America to South America, stirring a rich melange of Western and indigenous cultures. It has only 0.03% of the world's land — yet, endowed with mountains, mangroves and volcanos, Costa Rica is among the world's twenty leading countries containing the richest biodiversity. More than 5,00,000 species — over 5% of Earth's biodiversity — is found here and Costa Rica has zealously protected these.

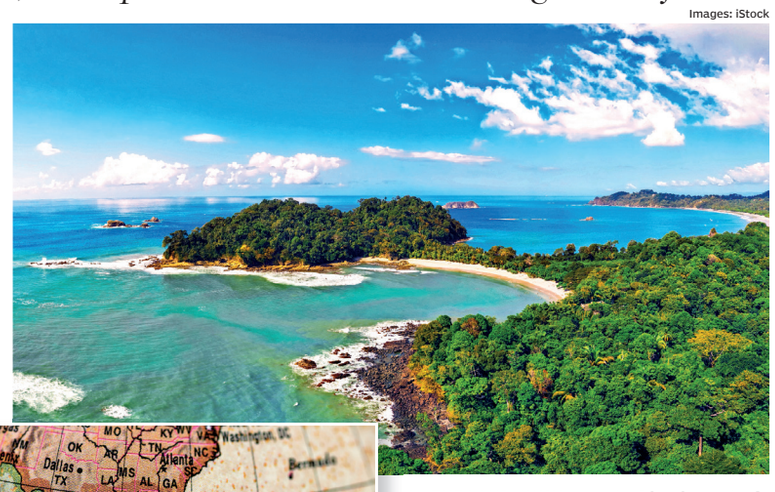
In the 1940s, struck by socio-political violence, the country saw a democratic revolution abolishing its military. This meant the availability of resources for free public education and conservation. This was no easy task though. As the World Bank explains, Costa Rica was heavily dependent on agriculture — by 1980, it had lost half its mature forests to farming. However, visionary measures were established to halt such denudation, including the Payments for Environmental Services (PES) which (also by tapping into fuel taxes) gave farmers incentives for reforestation, agroforestry and silvopastoralism, combining tree growing with livestock. Costa Rica's forest cover now encompasses 60% of its land, compared to 26% in 1983, making it the only South American nation to reverse deforestation. Alongside, 25% of the country comprises protected reserves, encouraging ecotourism, giving local communities further stakes in protecting biodiversity.

Generating 99% of its electricity from renewables now, Costa Rica is writing a modern story. It also recently became the first Latin American economy to receive World Bank payments for reducing carbon emissions linked to deforestation. As Times Evoke's global experts emphasise, this should ideally be the first tranche of returns this small, large-hearted country earns for preserving biodiversity. Other rewards, of course, include encountering hummingbirds which fly backwards, enigmatic iguanas living on trees and frogs gleaming like jewels in rainforest canopies. Join Times Evoke in exploring a country which made its magic real.

'Costa Rica's rainforest canopies tower 150 feet tall — these are the last biotic frontier'

__Nalini Nadkarni__ is Professor Emeritus of biological sciences at the University of Utah. Speaking to __Srijana Mitra Das__ at __Times Evoke__, she explains the science — and enigma — of Costa Rica's rainforest canopies:

Images: iStock



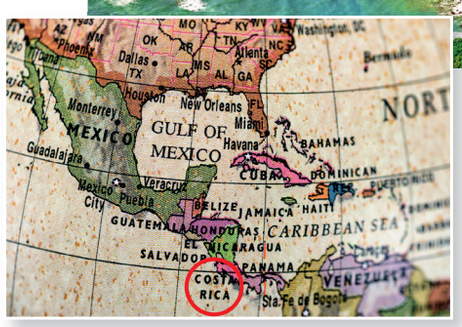
AS THE LAND SWAYS: Costa Rica is part of the elegant Central American isthmus

What is the core of your research?

■ I'm a forest ecologist. I study the plants and animals that live up in forest canopies or the top of trees in tropical rainforests. Until about 30 years ago, this was an unknown world but it was very interesting for me. My early work was more descriptive about the species that lived their entire lives in the canopy. As I grew more aware of the human effects on tropical rainforests, I started researching disturbances like deforestation and climate change impacting these canopy communities.

What are some important features of such rainforest canopies?

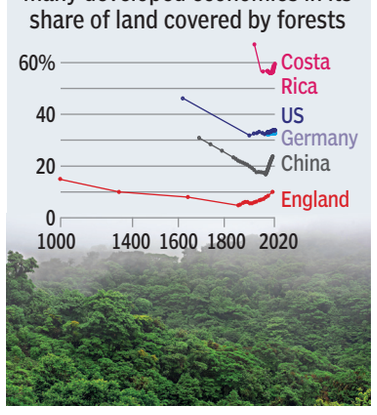
■ The environment of a canopy is very different from the forest floor — the latter is very dark and lacks sunlight. But the canopy is full of sunshine. It's much windier too, with greater extremes of temperature and humidity — due to this, a tremendous diversity of plants and animals evolved to live in this micro-environment. Thousands of such species which you'd never see on a rainforest floor flourish in the canopy. These beings also perform several important functions — they capture nutrients and provide resources for birds, mammals and insects in the canopy, further fostering diversity in the forest. Anything which affects them impacts the rainforest as a whole.



Courtesy: Sybil Gotsch via N. Nadkarni & Our World in Data

HOW TO CHERISH A CLOUD FOREST

Costa Rica scores well above many developed economies in its share of land covered by forests



Why are such canopies termed 'the last biotic frontier'?

■ One reason is that it has been very difficult to get up into these — there was no way to safely climb 150-foot-plus rainforest trees until scientists like me decided to treat them like mountains. I started using mountain climbing techniques to access the rainforest canopy — we've also used hot air balloons, cranes and walkways and recently, drone technology and satellite imagery to better observe and understand this world.

Can you tell us about your discovery of epiphytes in these environments?

■ Epiphytes are plants which grow on the trunks and branches of trees — lacking roots which can descend thus, they don't get nutrients from trees or the ground. Instead, they derive nutrients from rainfall, mist and cloud, incorporating these into their stems, flowers and roots — when they perish and fall to the forest floor, they pass these nutrients to other members of the ecosystem. So, these epiphytes function as giant sponges high up in the canopy which move nutrient resources down into the forest ecosystem.

TOUCHING THE SKIES

A student and I also conducted a study where we sat up in the canopies for six hours each day and observed which birds came to the host trees to use their flowers and fruit for nutrients and nesting materials versus which came to the epiphytes — we found about one-third of all the bird visits were to the epiphytes, not the host tree. Our conclusion emphasised the importance of these epiphytes for the lives of the birds and animals occupying such rainforests.

Do these rainforest canopies also have a bearing for human life?

■ Absolutely — this is where oxygen is produced through photosynthesis conducted by these trees and epiphytic plants. This is crucial for human life. Additionally, canopies produce materials for medicines and researchers are studying more varieties for their compounds and chemicals to see if these could combat several ailments. Finally, these are also incredibly beautiful — think of domesticated epiphytes like orchids, bromeliads or ferns. These give us beauty — that too is very important for the human spirit.

What is the conservation status of such forest canopies?

■ Costa Rica has actually been at the forefront of forest conservation — it's a very small country. Yet, it has tremendous diversity in its natural habitat. Not having an army, which was disbanded in 1948, the country could invest considerable resources into education and conservation. They have a system now of national parks and educational activities which has made their population aware of the importance of preserving rainforests. They've also established economic incentives to not cut down forests. Many countries, including the US, look to Costa Rica for ways to enable education, protection for land and incentives to maintain forests which provide oxygen, watersheds and biodiversity.

Photos Courtesy: N. Nadkarni

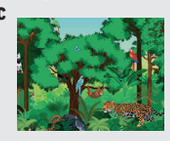
RISING TO THE OCCASION: Nadkarni's rainforest climbs have inspired movies

What has been your most memorable experience so far of climbing a Costa Rican rainforest canopy?

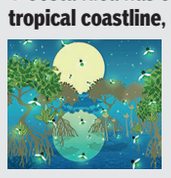
■ Every time I get into my mountain-climbing harness, start pulling my way up and see, smell, hear and feel the transition as I move from the dark forest floor up into this bright, windy canopy full of life, I'm filled with excitement. One of my most memorable experiences was when I actually spent the whole night up in the canopy. I used a cot which mountain climbers carry into the heights — at night, around two AM, I heard something moving on a branch next to me. When I looked, a poodle-sized anteater was walking along, eating leaf-cutter ants foraging at night. It looked back at me — I think we were both just amazed to see each other there. I really felt a part of the rainforest at that moment — I also belonged there, as a scientist and a being.

HOW IT CAME TO BE

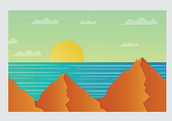
- Modern Costa Rica can be traced to **three million years ago** when the **Caribbean tectonic plate** pushed up against **the Cocos plate**, making the **Central American isthmus rise off the sea floor.** This tropical location — ten degrees north of the equator — **helped native plants and animals survive an unrelenting Ice Age**



- Costa Rica has **over 800 miles of tropical coastline**, the **mountainous Pacific** on one side and **the sandy and humid Caribbean** on the other. While the latter has mangroves and swamps, the former has lagoons and rainforests

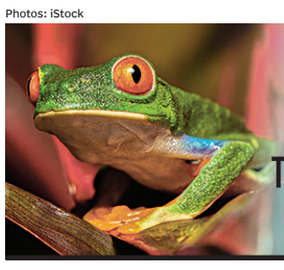


- Its biodiversity is living evidence of its geological past — alongside, Costa Rica has **stratovolcanos like the Arenal in Alajuela.** This is **5,358 feet tall and just under 7,500 years old.** Dormant now, it serves as **a watershed producing hydropower**



Research: National Geographic, Smithsonian Magazine, CNN

Photos: iStock



THEIR HOME IN THE WORLD

- The **red-eyed tree frog** of Costa Rica is distinctive with its vibrant green body — and bright red eyes. A gentle soul which grows three inches in size, **this lives in rainforest trees**, hardly descending. It's even **grown suction cups on its feet** to cling without falling. Unlike other vividly-hued frogs, **this isn't poisonous** — it uses its colours only for a **'startle reflex'** to scare predators

- Costa Rica is home to the delightful **'oso perezoso' or 'lazy bear'.** Housing two of the world's four sloth species — **the two-toed and three-toed sloth** — its woodlands offer these smiling beings twigs, flowers and cecropia trees to feed on. The latter being low-energy food, sloths are **usually slow with low body temperatures.** However, life isn't all just dull hanging-about — sloths can even sport a **stylish green-tinted fur as camouflage**

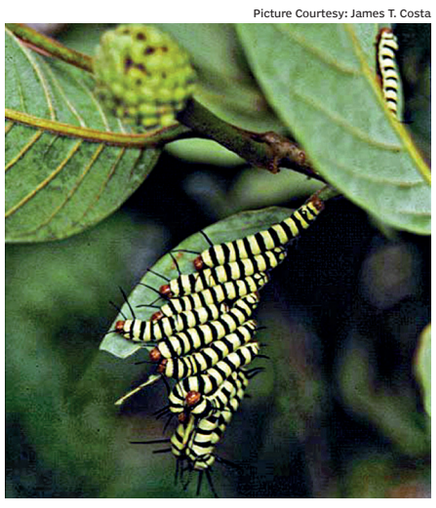
- The **green iguana** is found in Costa Rica, southern Brazil and Paraguay. It **grows over 5.6 feet long but remains arboreal,** living on trees — iguanas can fall 50 feet without suffering harm. They **can also swim using their tail** to propel them. They have sharp teeth but iguanas, herbivores who eat mustard leaves, dandelions and fruit, are **cordial beings**, developing 'head bobs' to greet one another socially and romantically

Research: National Geographic, IUCN, Encyclopaedia Britannica

'Forming circles, neotropical weevils mirror evolution'

__James Costa__ is professor of evolutionary biology at Western Carolina University. Speaking to __Times Evoke__, he discusses unusual insect life in Costa Rica:

Picture Courtesy: James T. Costa



STAYING IN TOUCH: Neotropical silkmoths in Costa Rica forage and live together socially

I am trained as an entomologist and have a special interest in group-living or social insects with surprising forms of family life or behaviour. I began studying group-living caterpillars and larval weevils and came to learn of some very interesting social behaviour among these in Costa Rica. I was invited there to learn more about this and I worked there over about ten years, mainly in Santa Rosa National Park in the northwest of the country. This is ecologically the tropical dry forest of Costa Rica. Being interested in the history of science as well, I researched insect socio-biology in my first book 'The Other Insect Societies'. This led me to delve into the history of evolutionary biology itself.

The tropics of the world are fabulously biodiverse — this is also manifest in behavioural diversity, evident in insect parental care to defensive and foraging actions. I found a large number of very unusual caterpillar species — especially one related to the silkmoth — in Costa Rica. These are quite large, reaching about ten centimetres in size, and they form very big herds. These large groups rest during the day near the base of the trees they're feeding on. At dusk, they mobilise and start to march up the tree, searching for feeding sites.

LIFE ON A LEAF

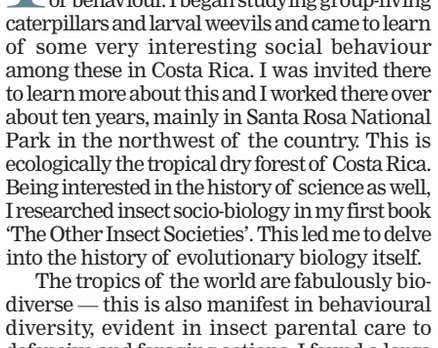
Watching this, I was curious to see whether these insect groups communicated in any manner, figuring out, for instance, how they found their way — my colleagues and I discovered a particular kind of trail-marking they would exhibit where they'd leave a chemical scent, a pheromonal trail, along the tree trunk. With this, they're able to keep tabs on each other and relocate to the same resting site the next day as they come back down over the tree.

Interestingly, this behaviour works in a social sense but not in a hierarchy. There is very little evidence of a hierarchical society involving a leader and followers among these beings. The individuals appeared to be acting mostly autonomously but they did seem to pick up on cues from other individuals in their colony — so, there was a collective behaviour which organises them but not in any hierarchical sense.

We also found a higher proportion of a very curious behaviour, a kind of defensive posture among social insect groups in the Costa Rican site. Here, they'd all band together and form a circle with their heads pointed outwards. This is reminiscent of certain mammals like bison, which also form these circles, placing vulnerable young individuals in the centre — we found these caterpillars and weevil larvae doing the same thing, forming circles or star-like formations. They also have head-to-tail processionary movements which is very uncommon among insects. Yet, in Costa Rica, like other tropical regions, you get to see this fascinating movement with insects making long formations — sometimes metres long — which can suddenly collapse into defensive circles when they feel threated by a predator. They use both chemical communication and touch or tactile signals to coordinate these actions among a large number of individuals.

This study gave us insights into the social evolution of insects. Most of the attention in this field goes to ants and bees which have spectacularly complex societies. But, evolutionarily, we now know these groups must have their origins in simpler expressions of sociality, as seen in the caterpillars and weevil larvae in Costa Rica, which live free of hierarchy but can coordinate quickly into perfect processions and defensive formations amidst the splendour of a tropical forest.

Picture: T. Fitzgerald via James Costa



ALL FOR ONE: Phelypera larval weevils studied in Costa Rica can band into defensive circles

'Birds symbolise beauty, joy and a sense of identity to people in Costa Rica'

__Daniel Karp__ is associate professor of conservation biology at the University of California, Davis. He tells __Times Evoke__ about how Costa Rica accommodates both birds and farms:

Photos: iStock

A NEW HARVEST: Costa Rica's iconic coffee farms increasingly seek sustainability

Much of my work studies the impacts of agriculture on wildlife and the other way around. This seeks to understand which opportunities can help us conserve biodiversity alongside people in working landscapes. My research includes locations in both California and Costa Rica where my colleagues and I have found a remarkable number of species in agricultural landscapes. You find a greater abundance of these in diversified farms which have mixed crops, small patches of forests or hedgerows. Importantly, birds found here are very different to the ones which live in forests. In northwest Costa Rica, we studied a beautiful bird called the long-tailed manakin, coloured blue and black. It sings an amazing song and has a mesmerising 'lekking' courtship display where the male birds coordinate and sing and dance to impress their partners. This iconic bird basically exists only in forests.

ITS BEAUTY PAST COMPARE: The flame-coloured tanager is art come to life

NATURAL RETURNS

We are now studying how climate change and habitat conversion to agricultural systems interactively affect such wildlife. One of the biggest findings we've had in Costa Rica is that species which persist in agricultural landscapes are able to cope with drier climates — species which are forest-associated need damper conditions. This is very important because climate change will impact rainfall and precipitation globally, with Costa Rica expected to get drier in the future. This means agriculture-associated species will be able to navigate such conditions better than forest-dwelling birds. That'll cause more homogenous communities, with losses in many small-range species, like the emblematic manakin I mentioned.

This is important also from a cultural perspective. In northwest Costa Rica, where I've been working recently, we studied the cultural connections people form with birds. Alejandra Echeverri Ochoa, a scholar at Stanford, interviewed people using pictures and songs of birds to ask them what they represented. Multiple people described why these birds were special and meaningful to them and how they helped foster a sense of place and local identity. Forest-associated birds were considered very culturally important for these reasons, beautiful, with charming songs and great value for future generations. It is extremely worrying that they face enhanced risks due to many anthropogenic factors now.

Agriculture-associated birds were seen somewhat less favourably. But, during my dissertation research some years ago, I worked at a coffee plantation in the southern part of Costa Rica. There, we saw birds actually helping farmers — they fed on the coffee berry borer, a primary pest which is most economically damaging. Without the birds, farmers actually faced an infestation — having them meant a big economic benefit with the birds naturally controlling pests. It is also important to note that when farmers maintain natural patches on their lands, conduct multi-cropping and grow trees, they attract more birds which are beneficial to them than ones which could simply eat their crops.

Costa Rica's farmers have played a very significant role in protecting and nurturing such biodiversity. This is probably one of the most environmentally progressive countries on Earth, with an incredibly large protected area and an amazing pace of transitioning away from fossil fuels. They draw considerable revenue from ecotourism and conservation actions. All these reasons engender a very strong environmental ethic in Costa Rica which, even in the Anthropocene, has abundant tropical forests, enjoying lots of support for these from public quarters. Many countries can learn a lot from their story.

STRIKING A POSE: The speckled tanager (L) and the slaty-tailed trogon (above) are famous

READERS WRITE

Dear Times Evoke,

Thank you for the fascinating coverage on evolutionary biology. Through James Costa's account (7th January), we got to know Alfred Wallace not just as a naturalist but an inspiring personality whose wise words on saving species must be heeded.

—Bakul Dalal, zoology graduate and under-training teacher, Delhi

I am a regular reader of TOI's Times Evoke. I found Alfred Wallace a visionary naturalist who discerned how species diversity started and faced extinction due to anthropogenic activities. His ideas emerged when there was no advanced technology for biometric analyses. His discoveries were possible only due to his profound dedication. Very inspiring, TE!

—Atul Sharma, Sr. Environmental Engineer, Gujarat Maritime Board, Gandhinagar

TE's wonderful insights into biogeography lent a fresh new air to 2023! Thanks, TE, for showing us the life of Alfred Wallace. Being a contemporary of Charles Darwin, Wallace also had an ability extending beyond just scientific interests. His legacy was uniquely presented by TE, which is a feast for all nature lovers.

—VR Gopal, Chennai

TE is just beautiful and for the Alfred Wallace article, the look was simply spell-binding! Who knew Wallace also came up with the all-important theory of evolution! What hard work he contributed, yet gave his research so benevolently to another. A most moving example of duty above all. Well done on a superb article, TE, keep it up!

—Ajay Kamath, Pune

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