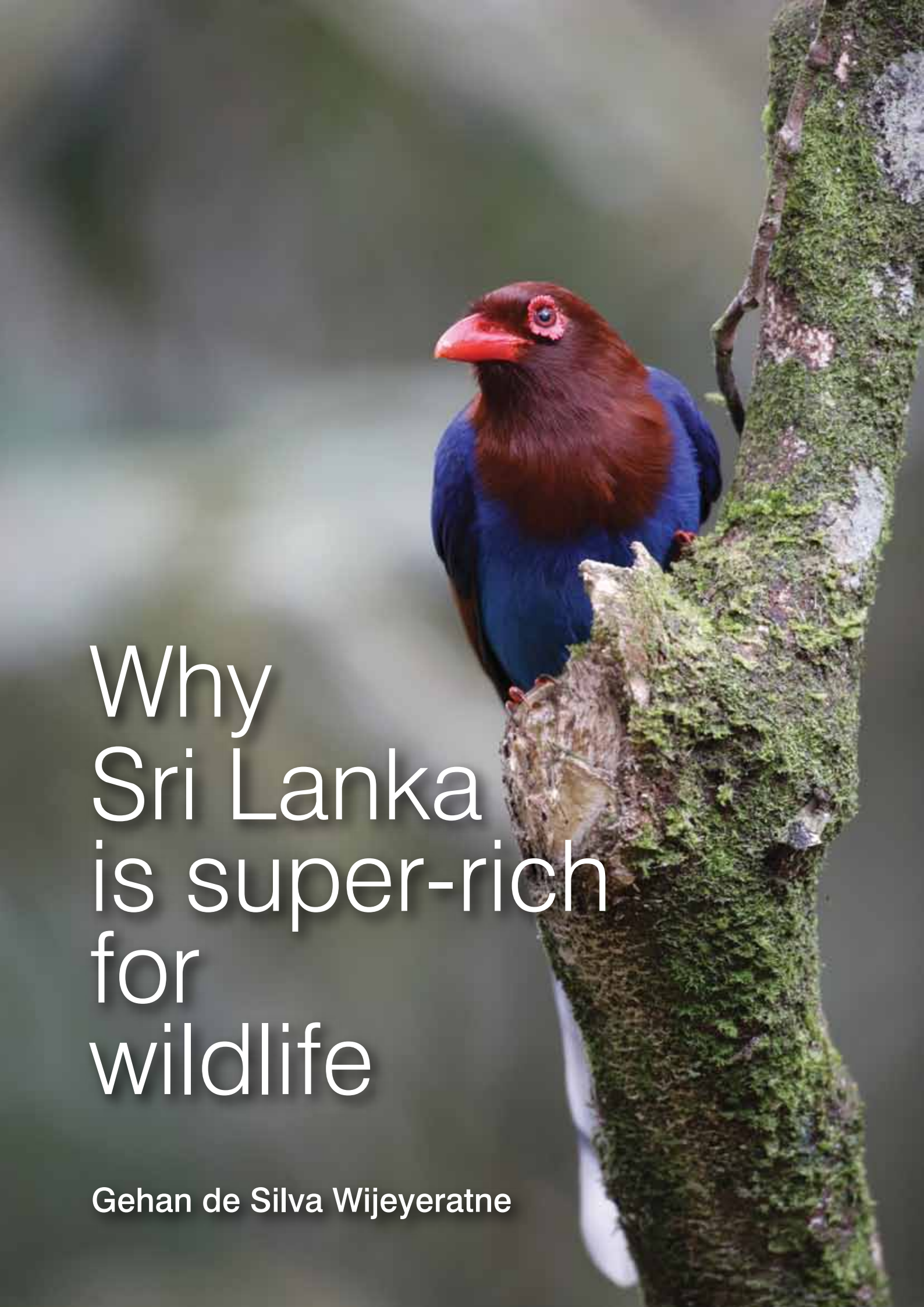


Why Sri Lanka is super-rich for wildlife

Gehan de Silva Wijeyeratne

Synopsis

This article unveils an internationally significant story. It quantifies how the species per unit area in Sri Lanka is unexpectedly anything from 5 to 13 times higher for certain species groups, than predicted by island biogeography in comparison to other large tropical islands such as Borneo, New Guinea and Madagascar.

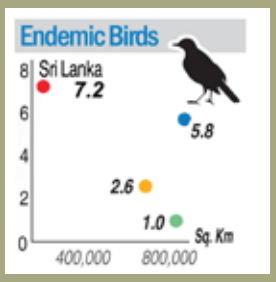
Sri Lanka is a puzzle: it has large animals which a moderately sized island should not have. In fact it has the highest annually recurring concentration of wild elephants and possibly the highest density of leopards. Unusually for a continental island, large whales are close to shore (best for Blue Whale and super-pods of Sperm Whales).

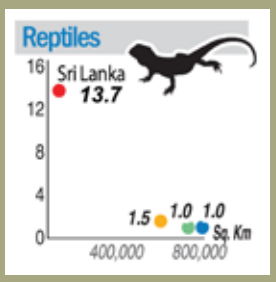
This article is the first to provide a cohesive explanation in plain English as to how planetary physics, evolutionary forces and human factors have worked, almost as if with a design to create a wildlife super-rich island; arguably the best all-round wildlife watching destination.

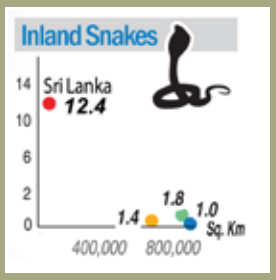
Above: *The Purple-faced Leaf Monkey is an endemic species which occurs in 4 distinct sub-species shaped by the highly varied climatic zones occurring in a compact area.*

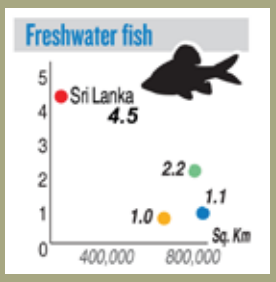
Cover: *The Ceylon Blue Magpie is one of 33 endemic birds; a relatively high number of endemic birds when compared to say Borneo with 52 endemics with a land area which is 11 times bigger.*

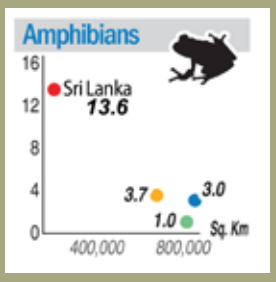
A wildlife super-rich island

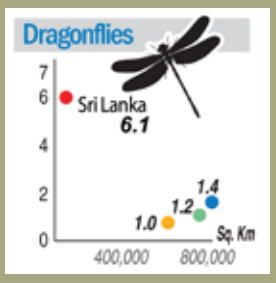












Why Sri Lanka is super-rich for wildlife...

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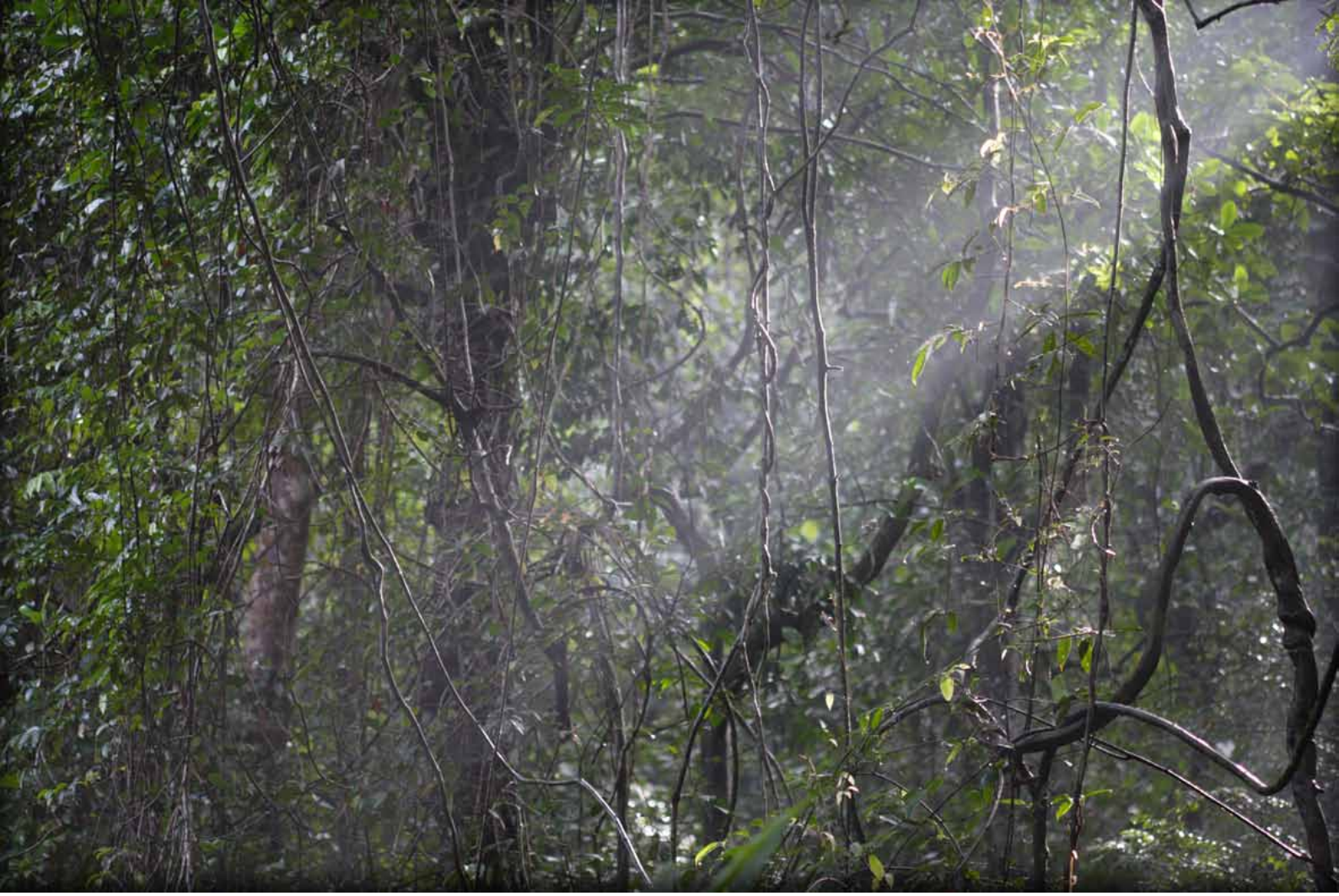


Meetirigala forest, *within an hour from the commercial capital Colombo, is one of a few tiny pockets of species-rich rainforests left in the densely populated Western Province.*

Introduction

This is the story of how evolutionary forces and ancient civilisations have made a tropical island super-rich for wildlife on a scale that is not seen anywhere on moderately sized or large islands. Sri Lanka's super-richness on a proportionate scale eclipses large islands such as Madagascar, Borneo and New Guinea. Alfred Russell Wallace, the founder of modern biogeography and Charles Darwin with whom he shared the theory of natural selection in evolution were both influenced by what they had observed on islands. Both of them would have been surprised by Sri Lanka.

Almost every key driver of evolution seems to have played a part in shaping its biodiversity. The result is an island which is rich in wildlife both in terms of endemic tropical biodiversity as well as large land animals and marine mammals and in concentrations which give rise to some of the world's most interesting wildlife spectacles. It's an island which Wallace and Darwin or modern biologists could not have imagined as so many of the biogeographical and evolutionary forces have come in to play simultaneously, to create an unrivalled richness. To top it all, it's a compact country with good tourism infrastructure making it optimal for wildlife tour operators.

This article is about the physical, evolutionary, and human factors that have made Sri Lanka something seemingly imaginary, but yet real.

In a previous article (Sunday Times: Sri Lanka, 13 January 2013) I explained why Sri Lanka has a claim to be the best all-round wildlife destination from a wildlife tour operator's perspective. In this article I explain the physical, evolutionary and human-induced forces that have made this happen. In essence, I would simplify it conceptually into a three part 'business model' for the creation of a top wildlife destination. The first is a set of **physical factors**, especially those influencing both surface and underwater topography. These together with other planetary phenomena such as plate tectonics and monsoons create structural or topographical complexity on land and under water. Together with time, the topographical or structural complexity on land with monsoonal rainfall has led to the creation of

Facing page: *Several rare and endemic species of lizards are found in the Sinharaja. Among these is the* ***Hump-nosed Lizard****, the largest lizard in the island.*

distinct climatic (and hence ecological) zones that are the engine for speciation. Sri Lanka has benefitted from other physical factors such as an ancient Gondwana start and having deep seas close to it unlike other continental islands. Having set up the right conditions for evolutionary factors, the engine of speciation needs to be fed with raw material. The output of the species production factory will be enhanced if besides the operation of long intervals of evolutionary time scales, new species production is boosted by fresh stocks of mainland species through **immigrant waves**. However, surprisingly, Sri Lanka has managed to produce a phenomenally above normal species richness (explained below with examples) primarily from evolutionary radiations within the island resulting in endemic genera and species. It seems that only later has it supplemented its cargo of species by land-bridging repeatedly with the mainland. This has become more apparent recently through phylogenetic studies using DNA.

I would describe the land-bridging as a five stage process for building up the number of species. During periods of glaciations, water is deposited as ice on land and sea levels fall forming a land bridge in the shallow seas. A land bridge is still physically evident in the discontinuous land bridge between Mannar and India, known as Adam's Bridge. New waves of immigrants are imported to the island via the land bridge and dispersed and then isolated by rising sea levels drowning the land bridge during warming after an ice age (a post glacial). The new arrivals are physically stressed into niches by complex structural and physical factors of topography and climate. In essence, the process is

Rainforest epiphytes: *Epiphytes have overcome the need to grow tall trunks and compete to reach the sunlight by adopting a strategy of leap-frogging to the canopy. Their roots bind onto other trees.*

Sri Lanka has managed to produce a phenomenally above normal species richness primarily from evolutionary radiations within the island resulting in endemic genera and species. It seems that only later has it supplemented its cargo of species by land-bridging repeatedly with the mainland.

connect – import and disperse – isolate – stress – speciate. Glaciations have been a key agent of the island's richness in allowing large land mammals to colonise and persist in Sri Lanka. However, phylogenetic studies indicate that most of the radiations of endemic species occurred before the land bridge connections of the Pleistocene epoch in the Quaternary Period. So land-bridging has helped, but still unresolved evolutionary forces have been responsible for the species super-richness which occurred before the recent Pleistocene ice age.

The third of the large scale factors is that it has benefitted from **human factors** or a cultural overlay. The last has two aspects. Firstly, the decline of ancient kingdoms has resulted in great seasonal gatherings of wild elephants and one of the best sites for leopards. This creates wildlife spectacles which make great viewing on wildlife safaris. (These spectacles have also been complemented by evolutionary factors mentioned above resulting in species radiations which are of great scientific interest even though species such as amphibians are not high on the list of commercial wildlife safaris). The second aspect of the cultural overlay is that the deep respect for life makes wildlife viewing easy as man and animals co-exist with great tolerance.

Taking Stock: What does Sri Lanka have?

Allow me to start by surprising you. If I asked you which country has the largest seasonally recurring gathering of elephants, what would your answer be? You might think it is somewhere in Africa. And if I asked you for an easy and reliable location to see Blue Whales, the largest animals to have lived on Earth and once one of the hardest animals to see, what would it be? Or consider super-pods of Sperm Whales, the largest toothed carnivore. Is there a country where there is a chance of seeing one on a commercial whale watch? Or one of the best to photograph leopards or the Sloth Bear (possibly the largest tropical bear)? The surprise is that the answer to all of these is the same country; Sri Lanka. This is both impressive and surprising given that it is in contradiction to conventional island biogeography according to which a moderately sized island (65,610km^2) is unlikely to have large terrestrial animals. Sri Lanka's potential to be the best for big game safaris outside Africa (albeit on a different and smaller scale) is only now beginning to be discovered by wildlife photographers from both within and outside the island.

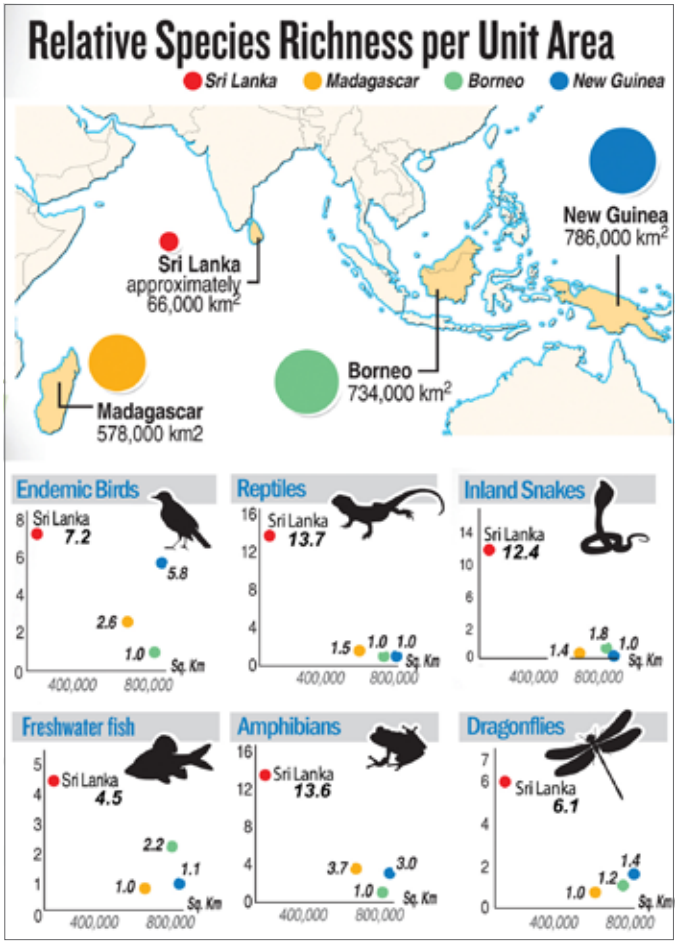
All-right, I hear you say; top marks for the big stuff. But what about biodiversity? Well, let me surprise you again and illustrate it with a recent statistic. First remember that it is well established that the larger the land area, the larger the number of species will be (the species-area relationship). Of course we also need to compare land areas from similar latitudes because species richness increases as one travels from high latitudes to the tropics. Let's take inland snakes for example. Sri Lanka has 89 species in approximately 66,000km^2. How much more would you estimate that other tropical islands which are approximately between nine to twelve times bigger will have? The numbers are surprising: New Guinea (86 species in 786,000km^2), Madagascar (91 species in 578,000km^2) and Borneo (141 species in 734,000km^2). One would have expected these islands to have ten times as many species. But none manages even twice as much and the extent which Sri Lanka is above the species-area curve is conspicuous even if you factor in that more species are to be discovered in the bigger islands. The relative species per unit area is extraordinary and is repeated with many species groups.

Elephant herd - Minneriya: *It is hard to imagine that the largest recurring annual concentration of wild elephants occurs in a moderately sized island and not in the continent of Africa. This was unknown until a banker drew attention to this.*

So why is Sri Lanka off the curve?

Clearly there is something remarkable and special going on with the forces of speciation, about which the island has still received little international publicity, although that will change when wildlife film producers pay it more attention.

For many vertebrate species, Sri Lanka ranks high in terms of species per unit area. Let's take a closer look at one vertebrate example where this may not seem to be the case. Costa Rica is synonymous with amphibians. With a land area of 51,000km^2 it is fifteen per cent smaller than Sri Lanka and has more amphibian species; 199 versus the 120 from Sri Lanka. So is Sri Lanka not special with amphibians? Although Costa Rica is smaller as a political unit, it benefits from being part of the large physical unit of South America. Therefore in a wider sense the species-area still holds as it has benefitted from being a part of the vast South American continent. A better comparison for Sri Lanka would be a similar sized or larger island which is a natural bio-geographical entity. For example, Madagascar, which is nine times bigger has only two and a half times as many amphibian species.



The graphs above *take the ratios of species per land area, set the lowest at a level of 1 and then compare the ratios of the other islands against the lowest ratio. The result is a relative ranking of species per unit area compared to the lowest in the sample of four islands.*

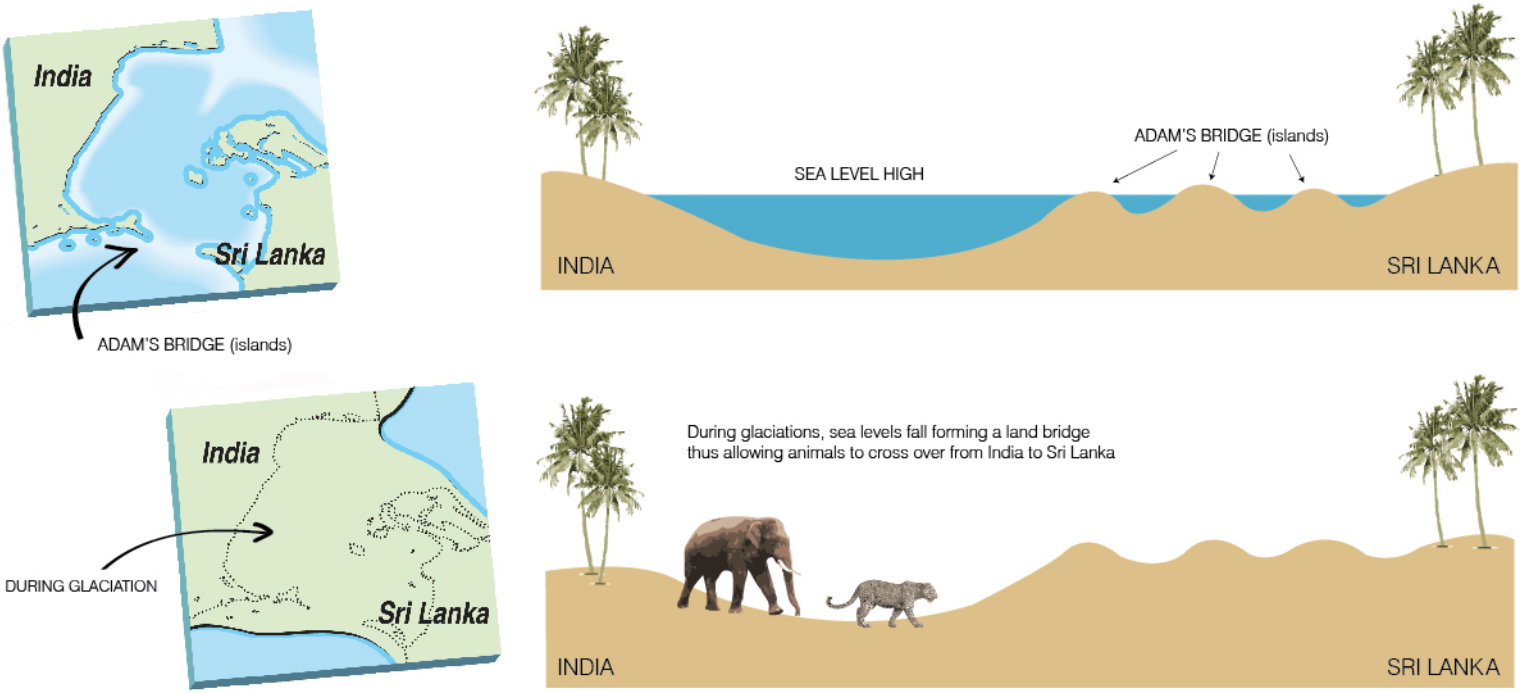
After mammals, birds are the most 'touristy' of animals. Sri Lanka has 33 species of endemic birds, largely confined to its lowland and highland wet zones. The number of endemic birds per unit area is high compared to Borneo (52 species) and Madagascar (106 species with a 51% endemism rate), but on par with New Guinea (320 species). A further fifty plus species of birds found in Sri Lanka are shared only with India (subcontinental endemics). Furthermore, it has a special avian spectacle in the **Sinharaja Bird Wave**. This is the longest continuously studied mixed species bird flock phenomenon in the world, with the largest average number of individuals in a flock from such studies and offers the most stable viewing of usually fast moving tropical bird waves. The island is the last stop on the Central Asian flyway and a million migrant shorebirds were counted one February in a land based census which suggests that Viddathalthivu in the Mannar region may even be the most important integral site for migrants on the Central Asian flyway. The shorebirds make landfall in Sri Lanka funnelling through the once powerful ancient seaport of **Mannar** through to the **Palatupana** Salterns and **Bundala** National Park in the South: the latter two offer some of the best close viewing of waders in the world.

As explained earlier, a three factor 'business model' has been at work to create this extraordinary richness and I will expand on this in the sections to follow.

The Ceylon Frogmouth: *The Ceylon Frogmouth is a subcontinental endemic found in the forests of the Western Ghats in India and in Sri Lanka, suggesting an ancient linkage.*

Creating the perfect, super-rich wildlife destination

Imagine your goal was to create the perfect location for wildlife tourism. Sri Lanka would be a good example of how to go about it. You want to keep it small so that tourists don't have to travel too far from one location to another. But not too small as small areas don't have many animals and also cannot hold on to their animals. An island would be good as isolation allows species to evolve into new species. An ancient start would help. So let's begin with Sri Lanka being split off from ancient Southern Gondwana, tethered to India and drifting north on the Indian tectonic plate, carrying an ancient cargo of species which results in affinities between species in Madagascar and Sri Lanka. Next, crash the Indian plate into the Asian land mass (creating the Himalayas) and allowing Palaearctic mammals such as the tiger to drift south into India. Anchor Sri Lanka nearby as a continental island to enable immigration of species from the Asian mainland. But leave the island isolated for sufficiently long interglacial periods (where sea levels rise cutting off the island) for the process of speciation to allow endemics to evolve.



***The central mountainous core**, with two alternating and diagonally blowing monsoons creates structural and climatic conditions which are conducive to speciation processes.*

Isolation and physical stresses have resulted in high levels of endemism (e.g. 100% freshwater crabs, 95% amphibians, 80% land molluscs, 53% freshwater-obligate fish, 52% of dragonflies, 25% flowering plants, etc.). These have been supplemented by the 'immigrants' from later land bridge connections. The down-side of repeat connections is that Sri Lanka does not have as high a proportion of endemic species or a number of endemic families as found on an island such as Madagascar.

Physical isolation is not enough and ecological isolation is also desirable, both from Asia and within the island. A good trick here is to create a central mountainous core, with two alternating and diagonally blowing monsoons (the South-west and North-east) creating a very moist 'wet zone', distinct from a 'dry zone'. The mountains also allow for a further vertical zonation, allowing more speciation to take place as some species diverge into sister species at different altitudes. **Horton Plains National Park**, the roof of Sri Lanka has many species confined to the highlands.

***Monsoon clouds** - The central mountainous core, with two alternating and diagonally blowing monsoons (the South-west and North-east) - © Mohammed Abidally*

Hanuman Langur - Sigiriya: *An alpha male Hanuman Langur bares its teeth in a threat display. This could be a relatively recent immigrant as it has not evolved into a distinct island species.*

Build on this theme by up-thrusting a few more rugged, spectacular mountain ranges such as the **Knuckles Wilderness** creating elevated wet zone 'islands 'within the wet zone. This creates point endemics such as the Tennent's Leaf-nosed Lizard in the Knuckles. For extra measure add a few mountainous edges to lowland rainforests like Sinharaja to create more point endemics like Karu's and Erdelen's Dragon-lizards in **Eastern Sinharaja** (15 of the 18 agamid or dragon-lizards are endemic). Indulge in more innovation by throwing up a mountain with a wet zone character; **Ritigala**, surrounded by a sea of dry zone with more point endemics and build a legend around it that it was a piece of medicinal herb rich mountain from the Himalayas dropped by the Monkey God Hanuman as told in the Indian epic of Ramayana. Culture and wildlife go hand in hand in this area of ancient kingdoms of **Anuradhapura** and **Polonnaruwa**, where the tallest archaeological brick buildings in the whole world; giant stupas, stand. Endemic Toque Monkeys wage ferocious tribal wars watched over by meditating saffron robed monks and are studied in one of the longest running zoological field studies in the world; the Smithsonian Primate Research project.

The Kottawa Forest Reserve *is one of many endemic species-rich forests close to the southern city of Galle. This makes Galle the rainforest gateway in Sri Lanka as well as being a good base for whale watching from Mirissa.*

The process of speciation can be accelerated further by throwing in a few evolutionary tricks like direct development in the Rhacophorid Tree Frogs. This allows them to skip the stage of laying eggs in water and having tadpoles developing in water which leaves them vulnerable to periods when ephemeral bodies of water dry out. Instead, allow them to use foam nests in which the eggs develop into little frogs which plop out fully formed allowing one of the significant species radiations discovered in the 20th century to take place. There are many other examples of species radiations; for example all 20 of the forestdamsels described so far from the island are endemic. In fact Sri Lanka has four, five, and six times as many species of dragonflies per unit area than New Guinea, Borneo and Madagascar respectively. Geological turmoil and variations in the climate creating 'ecological niches' could also have created physical stresses that favoured evolutionary variation. In fact, although I have referred to Sri Lanka's land area as 66,000 km^2, most of the endemism is packed into an area of around 15,000 km^2; less than a quarter of the total in what comprises the wet zone. This 'localisation' of small-range endemic species makes the endemicity (e.g. 740 endemic flowering plants in the wet zone) and the species richness in the wet zone even more remarkable.

Whilst all this is happening, keep stirring the evolutionary brew with fresh material. A few judiciously spaced out glaciations will lower sea levels forming a land bridge (Adam's Bridge linking India to **Mannar** across the Palk Strait) allowing mainland species to immigrate and start anew to evolve into new species. Wildlife tourists like big stuff, so keep the land bridge open to get a good population in of the elephants, leopards and Sloth Bears. Ooops! Closed it too soon as enough tigers did not make it across to establish a viable population.

A few judiciously spaced out glaciations will lower sea levels forming a land bridge allowing mainland species to immigrate and start anew to evolve into new species

Sloth Bear - Yala: *Sri Lanka is the best chance for an encounter with a wild Sloth Bear. During the fruiting of the Palu trees around June and July, they are not difficult to see.*

Having got the big stuff in, one may as well make an eco-tourism spectacle out of it. This requires some human intervention or anthropogenic factors for the technically minded. Throw in a liberal sprinkling of ancient kings who will usher a golden age of hydraulic civilisation. They will dot the island's dry zone with grand civil engineering works, with vast lakes (e.g. the Sea of Parakrama) irrigating agriculture. Allow this to go to ruin and perfect conditions are made for the Elephant Gathering at **Kaudulla** and **Minneriya** in the North-Central Province where over 300 elephants may gather on the receding lakes in search of grazing, water, mates and social networking (elephants don't use Facebook)! Allow the farmland in the South-East in **Yala** to turn to grassland where together with the man-made waterholes, conditions are perfect for high densities of Spotted Deer, in turn creating one of the highest densities of leopards. The over 2,000 man-made lakes or wewas create wildlife rich wetlands which pre-date the interventionist conservation efforts of the London Wetland Centre. In Yala at Buttuwa Wewa, this results in the largest seasonal concentration in the world of the Mugger or Freshwater Crocodile, the second largest land reptile in the world. Not far away, the soft sandy beaches are visited by five of the seven species of marine turtle including the Leatherback; a giant!

Leopard - Yala | *Sand Lizard - Mannar* | *Black-backed Jackal - Yala*

Introduce Buddhism and Hinduism, two great world religions with a respect for animal life. Most animals lose their fear of people and everything from leopards in Yala, Blue and Sperm Whales in the surrounding oceans to fighting Purple Swamphens in **Talangama Wetland** (close to the commercial capital Colombo) are embarrassingly curious and camera friendly for tourists.

With the top side sorted out, the marine side needs some attention as well. The trick here is to have deep water close to shore which suits the large whales (unlike an island like Britain which is covered with shallow seas or the islands of the Indonesian archipelago).

Improve on this by having the continental shelf pinching in at the South at Dondra Head near the fishery harbour of **Mirissa** so that Blue Whales can be seen easily close to shore on a morning whale watch from a coastline studded with luxury villas, boutique hotels and backpacker crash pads. Create a deep 400m depth isobath running north-south for Sperm Whales in **Kalpitiya** (the Sperm Whale Strip of E 79 35 to E 79 40). Slide a peninsula of golden sandy beaches out onto it so that the Sperm Whales are a mere fifteen minutes by boat. For those for whom boats are not their thing, thrust a deep submarine canyon into **Trincomalee** in the North-East so that Blue and Sperm Whales can be seen from ashore on some days from the temple atop Swami Rock or very rarely from the pool side of beach hotels. For extra good measure throw in a few more canyons on the east coast which are good for enigmatic and elusive beaked whales. All of this is being a bit greedy as the island also has shallow seas where it needs it most; close to the mainland, to allow intermittent land connections for the immigrant waves to supplement the speciation factory.

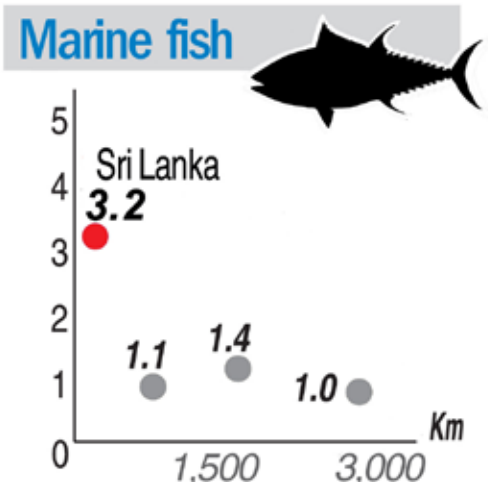
The island has the best of everything in terms of underwater topography; now add to this a generous mix of nutrients.

Top to bottom: ***Striped Dolphin (Mirissa), Sperm Whale (Trincomalee), Spinner Dolphins (Kalpitiya) and Blue Whale (Trincomalee).*** *Unusually, Sri Lanka is a continental island with parts of it being close to deep seas and also has deep canyons thrusting in. This makes it the best in the world for Blue Whales and the best chance for a super-pod of Sperm Whales on a commercial whale watch.*

Country / Site	Length (km)	Marine Fish	Relative Richness Species vs Length
Great Barrier Reef	2,600	1,500	1.0
Gulf of Cortez	1,126	700	1.1
Maldives	1,500	1,200	1.4
Sri Lanka	432	800	3.2

The table on the left is not a scientific metric, but gives a non technical reader an easy grasp of the number of species per overall length of an area with marine fish.

It shows that Sri Lanka is more relatively rich than most people imagine.



Whales need food; lots of it. The two monsoons are in charge of the kitchen, driving a hundred and three river systems (yes, that's right, 103) bringing down rich organic nutrients from the mountains, slow released from the lichen cloaked cloud forests to the lowlands creating nutrient rich soup around the island. The Blue Whales and the Cloud Forests are inter-connected. Not content with that, whip up some speed with the monsoons and create upwellings, which generate phytoplankton blooms which show up on Indian remote sensing satellites suspended in space in geo-synchronous orbits. All of this food creates fringing coral reefs which are rich in marine species.

Sri Lanka's coastline which is 432km long has approximately 800 species of marine fish recorded. Sites better publicised for their marine wildlife such as the 1,126km long Gulf of California (Sea of Cortez) has 700 species of fish. The Maldivian islands which stretch across 1,500km have around 1,200 species recorded and the Great Barrier Reef stretching over 2,600km has 1,500 species. If we consider the number of marine fish species per unit length, we can see that Sri Lanka has roughly treble the statistic for the Gulf of California and double that for the Maldives. This is a very crude measure but it helps to give a flavour to the layperson of the relative species richness. The nutrient rich water in Sri Lanka and the monsoons which lash the shores reduce visibility in the water.

The lack of good viewing has resulted in its species richness not being understood as almost everyone including dive operators in Sri Lanka think the waters are 'poor' for fish compared to other tropical destinations. I have come to realise that 'poor viewing' has been confused with 'poor species richness', which it is not.

Sinharaja: The Paradise Combtail - Belontia signata (left) and Werner's Killifish (right) are part of a treasure trove of 38 species of endemic fish. Over half of the freshwater fish in the island's streams and rivers are endemic to the island.

Leopard - Yala: *Yala National Park has one of the highest densities of leopards in the world in part of Block 1. Some leopards are becoming increasingly habituated to vehicles.*

Marsh Crocodile - Yala: *Buttuwa Wewa in Yala is believed to have the highest seasonal concentration of Marsh Crocodiles; the second largest land reptile in the world.*

Elephant and calf - Minneriya: *The Elephant Gathering in Minneriya offers unrivalled opportunities to observe the social behaviour of this highly intelligent animal.*

To be clear about context, for big game safaris many countries in Africa are unmatched. Large tropical islands such as Madagascar and New Guinea, lack large land mammal herbivores such as elephants or large carnivores such as leopards (Borneo does not have leopards and the origin of its elephants is disputed) but in absolute terms of species, have huge biodiversity. However, from the viewpoint of commercial wildlife tourism, in terms of ease of access, tourism infrastructure, affordability and with a short time frame of say two weeks, there is no country which has the array of terrestrial big game, endemism-rich species density, spectacular marine wildlife, diverse landscapes and close-knit cultural bonds (love-hate with elephants) with wildlife that is found in Sri Lanka.

In the space of two weeks I watched courting Blue Whales, scrumming Sperm Whales, had a mother and baby elephant pad silently past my vehicle and drove back to camp in the gathering dusk, passing leopards out on the hunt

The proof of the pudding of the physical, evolutionary and human factors is in the viewing. A visit of mine in April 2012 is an example of good evidence. I had an amazing trip where in the space of two weeks I watched courting Blue Whales, scrumming Sperm Whales, had a mother and baby elephant pad silently past my vehicle and drove back to camp in the gathering dusk, passing leopards out on the hunt.



***Left** Sri Lanka Keelback Water Snake, **Middle** Reticulated Shrub-frog and **Right** Green Pit Viper. Sri Lanka is disproportionately rich in reptile species.*

Less than 8% of its biodiversity-rich wet zone remains forested and more attention is needed both locally and internationally to lay emphasis on how special this island is for its wildlife.

***Kangaroo Lizard** (endemic). 15 of the 18 Agamid or Dragon Lizards in the island are endemic; an example of a species radiation.*

In this article, I have with some speculation on my part drawn together material that is known from Sri Lanka and the mechanics of large scale processes studied elsewhere. Science is dynamic and what is known and conjectured today can change. But the broad principles should hold true and I hope I have explained why Sri Lanka deserves more attention from both those viewing wildlife for pleasure as well as those studying how planetary forces and time, drive the great engine of evolution and biogeographical distributions. At this point I should add a gentle reminder that in reality evolution is a 'blind process' although I have for the purpose of telling a story, written it as if evolution had set out to make a super-rich wildlife destination.

I have to add that although it is arguably the best all-round country for multi-faceted wildlife viewing with ease, it comes with a caveat.

Sri Lanka does need improvement in terms of better interpretation and better facilities for visitors at parks and reserves and more responsible guiding. Finally and alarmingly, less than 8% of its biodiversity rich wet zone remains forested and more attention is needed both locally and internationally to lay emphasis on how special this island is for its wildlife.

***Left** Green's Jewel. All three Jewels found in Sri Lanka are endemic. **Middle** and **Right** Brinck's Forestdamsel and Blurry Forestdamsel. A remarkable species radiation is that of the Forestdamsels where all 20 described so far are endemic.*



A summary of the 3-factor super-rich model

Island Magic: How Planetary Physics, Evolution and Ancient Cultures forged a super-rich wildlife destination	
1 PHYSICAL FACTORS	**BENEFITS**
Continental Island	Permitted intermittent land connection with mainland allowing immigrant waves (see below). Also continental islands usually inherit a rich stock of species unlike oceanic islands created from volcanic activity.
Origin	Benefits from an ancient stock of species which have become island endemics but shows affinities to groups as far away as in Madagascar.
Two diagonally blowing monsoons and a central mountain range	Highly distinct and extreme climatic zones found more typically on large continental masses.
Isolation	Despite the intermittent land connections and proximity to the mainland, the creation of a climatically distinct wet zone allowed speciation to operate in the manner it does in isolated environments.
Mountain ranges	The central mountains together with the monsoons have created a topographical and climatic complexity, driving evolutionary forces to create more species. Some mountain ranges have 'point endemics' and they create pockets of isolation all over the island.
Deep seas close to shore and shallow seas with mainland. Best of both.	Sri Lanka violates the rule about continental islands having shallow seas around them by having deep seas and submarine canyons (except where it needs shallow seas the most, near the mainland to form intermittent land bridges). The deep seas create conditions for Blue Whales and Sperm Whales to be very close to shore, within sight of naked eye at times.
River systems	The 103 river systems drain a vast flow of organic nutrients into the deep seas around the island. Per unit length of distance, the coral reefs have more species than more famous marine reserves such as the Gulf of California and the Great Barrier Reef. But rich nutrient load and silt result in poorer visibility than other dive destinations.
2 EVOLUTIONARY FACTORS	**BENEFITS**
Intermittent land bridge connections to mainland	Allowed successive immigrant waves from mainland to boost the number of species in the island and to a lesser extent supply a speciation factory with new material. Later colonisers if successful may evolve into new species if they penetrated 'pockets of isolation' in the wet zones. Sri Lanka breaks the rule that moderately sized or small islands don't have large animals thanks to the intermittent land bridge.
Species radiations	For example, rainforest tree frogs in the genus Philautus have evolved direct development, skipping egg laying and tadpoles in the water allowing them to radiate into new species. Other groups such as the Shadowdamsels have all 20 plus species endemic to the island. Evolutionary forces have resulted in Sri Lanka breaking the species-area relationship for islands. Land bridges may have played a part, although present evidence is that it has been a small influence.
3 HUMAN FACTORS	**BENEFITS**
Ancient Civilisations and Religion	The Elephant Gathering and the high density of leopards in Yala are both results of intense agricultural farming. A religious respect for other living beings means Blue Whales and Sperm Whales swim up to boats. Birds and other animals are prolific and tame.
▶ OUTCOME	**BENEFITS**
Wildlife Spectacles, high proportion of endemism, large number of species, large animals and easy viewing	Sri Lanka is the best in world for some of the most charismatic or desired species (e.g. Blue Whale –largest animal, Sperm Whale super-pods – largest toothed carnivore) or has special spectacles (e.g. the largest recurring Elephant Gathering, the Sinharaja Bird Wave, high density of leopards) all in a compact island with good tourism infrastructure and good specialist guides.

Ice Ages and Speciation

The table below summarises a 5 stage process in which a continental island like Sri Lanka would have benefitted by ice ages in enhancing species diversity. This assumes that ice ages acted to lower sea levels in the tropics but did not cover the land with ice sheets as it did in temperate latitudes with islands like Britain. If an island is covered with ice sheets, it will kill species and leave it poor. Britain for example has only 35 species of trees which are native.

On the other hand a tropical island like Sri Lanka which was not covered in ice would benefit from a two way exchange of species with the mainland. The dry zone has benefitted from this connection and has species which are found in Southern India and in the northern half of Sri Lanka. The island also has large land mammals such as the elephant and large carnivores such as the leopard not typically found on moderately sized islands.

Toque Monkey - Dambulla: *The endemic Toque Monkey has been the subject of one of the longest continuously running zoological field studies in the world. It has three distinct races on the island. The distinct climatic zones in this moderately-sized island have resulted in some animals having sub-species (or geographical races) in the dry, wet and montane zones. River systems and climatic zones create further 'islands of habitat' within the island.*

Puzzlingly and inconveniently, the phylogenetic studies on plants and animals suggest that radiation of species in Sri Lanka took place in the Tertiary age before the series of ice ages in the Pleistocene Epoch (in the Quaternary Period) with the last land bridge connection being as recent as 10,000 years ago. This poses two questions. Firstly, we see that evolutionary events happened in Sri Lanka so many millions of years ago that have left it richer in species compared to much larger tropical islands. New Guinea and Borneo also have varied topographies and have the structural complexity and physical stresses that Sri Lanka has.

How ice ages could drive a 5 stage speciation process

1. Connect
2. Import
3. Isolate and Disperse
4. Stress
5. Speciate

Repeat to enhance species richness

If evolutionary events happen because of physical factors combining with random mutations in genes, why has the species per unit area not remained proportionate? Secondly, during the recent ice ages in the Quaternary Period, did the wet zone remain isolated from the Indian mainland surrounded by a sea of dry zone? For answers to the latter question more work will need to be done on the fossil record on plant pollen to understand the extent of different types of forest on the island.

The five stage process I have outlined below is a useful general model, but based on what is known at present does not provide the evolutionary answers for Sri Lanka being super-rich in species. This is still a puzzle.

Data Tables

The tables below take the ratios of species per land area and set the lowest at a level of 1. They then compare the ratios of the other islands against this score of 1. The result is a relative ranking of species per unit area compared to the lowest in the sample of four islands. New species continue to be described in all of the four islands and the numbers will continue to change.

However, unless some dramatic discoveries are made elsewhere, it's unlikely that Sri Lanka's relative super-richness will be diminished.

ENDEMIC BIRDS

Country	Endemic Birds	Land Area (sq. km.)	Species per Unit Area (multiple of lowest ratio)
Sri Lanka	33	65,610	7.2
Madagascar	106	587,041	2.6
Borneo	52	743,330	1.0
New Guinea	320	786,000	5.8

REPTILES

Country	Reptiles	Land Area	Species per Unit Area (multiple of lowest ratio)
Sri Lanka	350	65,610	13.7
Madagascar	346	587,041	1.5
Borneo	289	743,330	1.0
New Guinea	315	786,000	1.0

INLAND SNAKES

Country	Inland Snakes	Endemic	% Endemism	Land Area	Species per Unit Area (multiple of lowest ratio)
Sri Lanka	89	49	55%	65,610	12.4
Madagascar	91	91	100%	587,041	12.6
Borneo	144	35	24%	743,330	1.8
New Guinea	86	20	23%	786,000	1.0

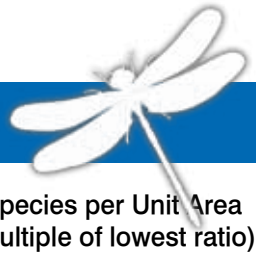
FRESHWATER FISH

Country	F'water Fish	Endemic	% Endemism	Land Area	Species per Unit Area (multiple of lowest ratio)
Sri Lanka	72	38	53%	65,610	4.5
Madagascar	143	93	65%	587,041	1.0
Borneo	394	149	38%	743,330	2.2
New Guinea	217	149	69%	786,000	1.1

AMPHIBIANS

Country	Amphibians	Land Area (sq. km.)	Species per Unit Area (multiple of lowest ratio)
Sri Lanka	120	65,610	9.9
Madagascar	295	587,041	2.7
Borneo	138	743,330	1.0
New Guinea	320	786,000	2.2

DRAGONFLIES



Country	Dragon -flies	Endemic	% Endemism	Land Area	Species per Unit Area (multiple of lowest ratio)
Sri Lanka	123	64	52%	65,610	6.1
Madagascar	181	132	73%	587,041	1.0
Borneo	275	110	40%	743,330	1.2
New Guinea	420	252	73%	786,000	1.7

MARINE FISH

Country/Site	Marine Fish	Length (km)	Species per Length (multiple of lowest ratio)
Sri Lanka	800	432	3.2
Great Barrier Reef	1,500	2,600	1.0
Maldives	1,200	1,500	1.4
Gulf of Cortez	700	1,126	1.1

Here there be giants...

It is a surprise that a moderately-sized continental island like Sri Lanka is the best place in the world to see the largest animal that has lived on the planet, the Blue Whale, as well as to be where the largest annually recurring concentration of wild elephants is found.

The Blue Whale was one of the hardest animals to see until when in May 2008 it was publicized that Sri Lanka was the Best for Blue. The Asian Elephant (smaller than the African Elephant) is the second largest land mammal. Outside the continent of Africa, the best elephant encounters are not on the mainland of another continent but on the island of Sri Lanka.

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www.amphiaweb.org.

Gehan de Silva Wijeyeratne has played a pivotal role in branding Sri Lanka for its wildlife using a blend of writing, photography, business acumen, media skills and science. He has explained that the island's combination of easy to see charismatic large land mammals, outstanding whale watching and disproportionate species richness on land and sea, compactness and tourism infrastructure, gives it a strong claim to be the best all-round wildlife destination for commercial wildlife tourism. This claim was preceded by the claim that for commercial wildlife tourism, the island was the best for big game safaris outside Africa. Gehan has played a key role in the research and development of many of the building blocks for these claims.

Gehan de Silva Wijeyeratne is responsible for establishing through field work, articles and media activism some of the biggest wildlife tourism stories of international significance. These include;

* Sri Lanka is the 'Best for Blue Whale', the largest animal that has lived on the planet and was hard to see and film until he began a media blitz in May 2008.
* Sri Lanka offers the best chance to see a super-pod of Sperm Whales on a commercial whale watch.
* Sri Lanka has the biggest annually recurring concentration of wild elephants ('The Elephant Gathering').
* Sri Lanka is one of the best places to see and photograph leopards.
* Sri Lanka offers the best chance to see a Blue Whale and a Sperm Whale on the same sailing.

Books he has written and photographed include Wild Sri Lanka (John Beaufoy Publishing), Sri Lankan Wildlife (Bradt Travel Guides) and two photographic guides to the Mammals and Birds of Sri Lanka respectively with New Holland Publishers.

He can be found on Facebook, LinkedIn and Flickr.

*The **Green Garden Lizard** is endemic to the Western Ghats and Sri Lanka*

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Above: *Rhododendron arboreum. Endemic to the central mountains of Sri Lanka above elevations of about 1,500m, its profuse, brilliant, crimson flowers make the rhododendron one of the most striking trees on Horton Plains.*

Back cover: *(Main picture) - Kalpitiya was unveiled as a whale watching hot spot only in March 2010. Super-pods visit all three sites in Sri Lanka's whale watching triangle and Sri Lanka is the best chance to see a super-pod of Sperm Whales on a commercial whale watch.*

(Montage) - Clockwise top right: Common Vine Snake; Toque Monkey; Common Garden Lizards; Crimson-backed Flameback; Ceylon Tree Nymph; Toque Monkey (montane race); Pitcher plant