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# Fauna Diversity in Tropical Rainforest: Threats from Land-Use Change

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Additional information is available at the end of the chapter

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## Abstract

Tropical rainforests are the cradle of life (perfect conditions for life) on Earth, i.e., rich in plant species composition (>250 plant species/hectare) and fauna diversity (>50% of animal species in the world). Rainforests occur near the Earth's equator and cover 6% of the Earth's surface across the tropical regions and are characterized by wet climate, i.e., heavy rainfall (125–660 cm), relative humidity (77–88%) and temperature (20–34°C). They are dominated by a wide range of broad-leaved trees that form dense canopy and the most complex ecosystem. Currently, the tropical rainforest ecosystem is changing faster than ever in human history due to anthropogenic activities, such as habitat loss and degradation due to deforestation for timber and conversion into agriculture fields (oil palm plantation), mining, fire, climate change, etc. The habitat loss and degradation had adversely influenced the distribution and richness of the fauna species. The current information on the fauna diversity of tropical rainforest is not sufficient and in the future, more research is required to document the various community parameters of the fauna species in order to conserve and protect them. For better future, conservation, and management, we must identify the major drivers of changes and how these factors alter the tropical rainforest.

**Keywords:** fauna, diversity, rainforest, landscape, vegetation

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## 1. Introduction

Tropical rainforest usually occurs 10° north and south of the equator, where climate conditions are unique such as humid, warm, and wet. The monthly mean temperature is 18°C and the annual rainfall is not less than 168 cm. Tropical rainforest occurs in four main regions; Central

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and South America, Central and West Africa, Indo-Malaya and Australia [1]. They are storehouses of a range of food resources for a wide variety of fauna species as well as for human beings, raw material for buildings, and medicines [2, 3] and affect the climate [4, 5].

### 1.1. Ecological importance of tropical rainforest

Tropical rainforests are the most diverse in the vegetation structure and composition (**Figure 1**) that supported a diversity of fauna species such as birds, reptiles, mammals, amphibians, and invertebrates, which directly or indirectly depend on them for their survival and existence. They are rich in habitat diversity and provide a variety of resources for the avian species, such as food, habitat, and shelter [6]. Tropical rainforest is vital ecosystem, i.e., it provide crucial ecosystem services such as raw materials, reservoirs of biodiversity, soil protection, sources of timber, medicinal plants, carbon sequestration, and watershed protection [7–9].

### 1.2. Threats to tropical rainforest

Tropical rainforest covers less than 10% of the land area of the Earth, representing the largest biological diversity reservoir, i.e., >50% of known plant species grow in tropical rainforest. Despite being rich in fauna diversity, every year, huge areas of tropical rainforests are being lost and degraded due to human interference [10–15]. It has been stated that 25–50% of the world's tropical rainforest has been lost and degraded due to the land-use change such as



**Figure 1.** Aesthetic view of tropical rainforest.

deforestation for palm oil plantations, agriculture expansion, cattle ranches, mining, and development of housing societies [16–19], while the rest of the rainforest areas is under a major shift in the dynamic structure and productivity.

It has been reported that Southeast Asia had the highest rate of land-use change (such as deforestation of tropical rainforest for conversion into oil palm plantation, commercial logging for timber and development of human settlement) as compared to other regions [12, 20–22]. Deforestation and fragmentation due to agriculture expansion, human settlement, logging, and fire had altered the plant species composition, richness, and diversity [23–26]. Deforestation and fragmentation, over-exploitation, invasive species, and climate change are the major factors due to which the biodiversity of tropical forest had declined at an alarming rate. For example, some of the fauna species became extinct, while others became threatened and vulnerable due to habitat loss, fragmentation, and degradation.

Changes in the vegetation structure and composition due to deforestation and fragmentation may alter the habitat suitability and food productivity. Habitat suitability, i.e., vegetation structure, species composition, species richness, canopy layers, and food productivity are key drivers, which predominantly influence fauna community parameters such as species composition, relative abundance, species richness, species diversity, and the density of tropical rainforest. Furthermore, it has been stated that the deforestation in humid tropic may be in the range of 4.9–5.7 million ha/year. Likewise, each year, 2.3 million ha of humid forests had been degraded due to logging and fire activities. Similarly, around 2.2 million ha/year tropical moist deciduous and 0.7 million ha/year tropical dry forest has been deforested due to anthropogenic activities [27].

Deforestation may cause habitat loss and fragmentation that adversely affect the population and the community parameters such as species composition, relative abundance, species richness, species diversity, and density of different wildlife species [28–30]. However, the effect of habitat loss and fragmentation on the wildlife species may vary depending on remaining vegetation and the surrounded landscape [31, 32].

Land-use change such as deforestation, i.e., depletion of tree crown cover due to conversion of forested areas in agricultural fields, human settlements, excessive logging, and road constructions are major factors of habitat loss and degradation [10, 33, 34]. The habitat loss and degradation are responsible for biodiversity loss [35], low production of food, and habitat fragmentation [27, 36, 37] that ultimately affects different fauna species. Due to deforestation, large areas become isolated, i.e., temporal refuge, which serves as corridors for different wildlife species, especially bird species [38–40].

### **1.3. Floral composition**

Tropical rainforests are the most rich tree species forest on the Earth and encompasses of broad-leaved trees with large buttress, and covered with climbers, epiphytes, and hemi-epiphytes. They have multi-layered canopy, i.e., upper, middle, and dense understory vegetation composition and are rich in diversity of flora and fauna, especially birds, mammals, reptiles, amphibians, and invertebrates [41–44]. Tropical rainforest is blessed with an enormous variety

of flora species. The vegetation species composition of rainforests encompasses of four distinct layers of trees, namely; emergent, upper canopy, understory, and forest floor.

### 1.3.1. Emergent vegetation layer

Emergent or sunlit layer is dominated by broad-leaved, hardwood and evergreen. The trees may attain the height from 30.48 to 76.2 m and a trunk size up to 4.48 m around. The winds and sunlight are major environmental factors, which play a significant role (such as pollination and seed dispersal) in the tropical rainforest management ecosystem. The emergent layer is rich in the fauna species, such as birds (hummingbirds, macaw, harpy eagle, etc.), mammals (i.e., monkeys, bats, etc.), snakes, and insects such as butterflies, moths, etc. The birds and insects play a crucial role in the pollination of tropical rainforest plant species. The microclimate of this layer often fluctuates from time to time depending upon temperature and wind speed.

### 1.3.2. Canopy layer

The canopy is the main layer of tropical rainforest ecosystems, which is thick and dense like an umbrella. This layer is composed of a variety of vegetation structures and tree species composition such as philodendron, *strychnos toxifera*, rattan palms, etc. The trees may grow up to 18.29–27.42 m above the forest floor. Epiphytes such as orchids, mosses, ferns, and lichens are a common feature of this layer, which grow on tree trunks and branches. The canopy layer is rich in food diversity and an ideal habitat for a wide range of fauna species such as birds, mammals, reptiles, amphibians, and diversity of insect species. The members of fauna species are often observed flying, jumping, gliding, and hopping for canopy gaps.

### 1.3.3. Understory layer

The understory layer encompasses usually small trees, shrubs, ferns, and native bananas, which may attain 3.66 m height. Mosses, fungi, and algae often grow on the trees. This layer is rich in insects, such as bees, stick insects, ants, beetles, and butterflies, which serve as sources of food for a wide array of birds and reptiles. The fauna species encompass bats, monkeys, snakes, lizards, jaguars, frogs, and invertebrates.

### 1.3.4. Forest floor

This is the bottom layer of tropical rainforest. This layer is dark due to dense ground vegetation and only 2% of sunlight reaches the floor. Due to less availability of sunlight, only few plant species can grow. This layer is rich in organic matter such as fallen leaves, seeds, fruits, and branches. Furthermore, this layer is rich in fungi and mosses. The fauna species of the forest floor include elephants, tigers, pumas, leopards, jaguars, ocelots, mongoose, tapirs, cassowaries, okapis, armadillos, pigs, and gorillas.

## 1.4. Environmental services provided by fauna in tropical rainforest

Faunas are the important component of the tropical rainforest ecosystem and provide a wide array of environmental services such as; they keep tropical rainforest systems in balance

through pollinating a variety of plant species, dispersing seeds, controlling pest population and reducing the damage caused by different pest species, scavenging carcasses, and recycling nutrients back into the soil.

## 2. Fauna composition

Fauna species are not only confined to specific habitats but also utilize various habitats in search of food, shelter, and reproduction. Tropical rainforest is rich in fauna species such as birds, reptiles, mammals, amphibians, and invertebrates.

### 2.1. Bird species composition of tropical rainforest

Birds are highly motile animals, i.e., they may fly to different areas in search of food, shelter, and for breeding purposes. They are ecologically diverse and had occupied a wide array of habitats. Bird species depend on the vegetation structure and composition (such as trees, shrubs, and herbs) and food resources for their survival and reproduction [45, 46]. They are the functional group of tropical rainforest ecosystems as seed dispersers, pollinators, top predators, pest control, and scavengers [47–50].

Birds are conspicuous and an important component of tropical rainforest ecosystems, often exhibit distinction associated with vegetation structure and composition (**Figures 2–4; Table 1**). They are sensitive to habitat alteration and landscape modification [51–54]. This might be because the vegetation structure and composition may influence habitat selection and foraging efficiency of all birds. For example, large trees and ground dense herbaceous vegetation layers often harbor a higher avian abundance and diversity. This might be because old growth stands provide suitable nesting and breeding sites, plenty of food resources, and also provide



**Figure 2.** Asian paradise flycatcher—*Terpsiphone paradisi*.



**Figure 3.** Wallace's hawk eagle—*Nisaetus nanus*.



**Figure 4.** Oriental/Asian pied hornbill—*Anthracoceros albirostris*.

protection from predators and harsh weather [55, 56]. Likewise, ground vegetation also offers ideal habitat and safe breeding sites and shelter for different fauna species residing in dense ground cover vegetation, such as birds, mammals, reptiles, and amphibians. It has been illustrated that height and density of the tree [57], dense understory vegetation [58, 59], and logs and snags [60] are key elements, which affect avian distribution, richness, and diversity in tropical rainforest.

Habitat alteration due to land change use may alter the avian community parameters such as relative abundance, species richness, species diversity, and density [65]. This might be that bird community structure strongly associated with canopy openness and understory vegetation

Family	Scientific name	Common name	Habitat	Authors	
Acanthizidae	<i>Gerygone chrysogaster</i>	Yellow-bellied Gerygone	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Gerygone magnirostris</i>	Large-billed Gerygone	Tropical Rainforest (Australia)	[62]	
	<i>Gerygone sulphurea</i>	Golden-bellied Gerygone	Tropical Rainforest (Malaysia)	[63]	
Accipitridae	<i>Haliastur indus</i>	Brahminy Kite	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Harpyopsis novaeguineae</i>	Papuan Harpy Eagle	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Henicopernis longicauda</i>	Long-tailed Buzzard	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Accipiter virgatus</i>	Besra	Tropical Rainforest (India)	[64]	
	<i>Spilornis cheela</i>	Crested Serpent Eagle	Tropical Rainforest (India)	[64]	
Aegithinidae	<i>Aegithina viridissima</i>	Green Iora	Hill dipterocarp tropical rainforest (Malaysia)	[6]	
Alcedinidae	<i>Alcedo euryzona</i>	Blue-banded Kingfisher	Hill dipterocarp tropical rainforest (Malaysia)	[6]	
	<i>Alcedo meninting</i>	Blue-eared Kingfisher	Hill dipterocarp tropical rainforest (Malaysia)	[6]	
	<i>Ceyx rufidorsa</i>	Rufous-backed Kingfisher	Hill dipterocarp tropical rainforest (Malaysia)	[6]	
	<i>Alcedo atthis</i>	Common Kingfisher	Hill dipterocarp tropical rainforest (Malaysia), Lowland tropical rainforest (Papua New Guinea)	[6, 61]	
	<i>Alcedo azurea</i>	Azure Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Alcedo pussio</i>	Little Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Ceyx lepidus</i>	Variable Dwarf Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Melidora macrorrhina</i>	Hook-billed Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Tanysiptera galatea</i>	Common Paradise Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Ceyx erithaca</i>	Oriental Dwarf Kingfisher	Hill dipterocarp tropical rainforest (Malaysia)	[6]	
	Apodidae	<i>Collocalia spodiopygius</i>	White-rumped Swiftlet	Tropical Rainforest (Australia)	[62]
	Ardeidae	<i>Egretta garzetta</i>	Little Egret	Lowland tropical rainforest (Papua New Guinea)	[61]
<i>Gorsachius melanolophus</i>		Malayan Night Heron	Tropical Rainforest (India)	[64]	
Artamidae	<i>Cracticus cassicus</i>	Hooded Butcherbird	Lowland tropical rainforest (Papua New Guinea)	[61]	
	<i>Peltops blainvillii</i>	Lowland Peltops	Lowland tropical rainforest (Papua New Guinea)	[61]	

Family	Scientific name	Common name	Habitat	Authors
Bucerotidae	<i>Rhyticeros plicatus</i>	Papuan Hornbill	Lowland tropical rainforest (Papua New Guinea)	[61]
Bucerotidae	<i>Ocyceros griseus</i>	Malabar Grey Hornbill	Tropical Rainforest (India)	[64]
Cacatuidae	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	Lowland tropical rainforest (Papua New Guinea), Tropical Rainforest (Australia)	[61, 62]
Campephagidae	<i>Hemipus hirundinaceus</i>	Black-winged Flycatcher Shrike	Hill dipterocarp tropical rainforest (Malaysia)	[65]
	<i>Boyer's cuckoo-shrike</i>	Boyer's Cuckoo-shrike	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Campochaera sloetii</i>	Golden Cuckoo-shrike	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Coracina melas</i>	New Guinea Cuckoo-shrike	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Coracina papuensis</i>	White-bellied Cuckoo-Shrike	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Lalage leucomela</i>	Varied Triller	Lowland tropical rainforest (Papua New Guinea), Tropical Rainforest (Australia)	[61, 62]
	<i>Hemipus picatus</i>	Bar-winged Flycatcher-shrike	Tropical Rainforest (India)	[64]
	<i>Pericrocotus flammeus</i>	Scarlet Minivet	Tropical Rainforest (India)	[64]
	<i>Caprimulgus macrurus</i>	Large-tailed Nightjar	Lowland tropical rainforest (Papua New Guinea)	[61]
Casuariidae	<i>Casuarius unappendiculatus</i>	Northern Cassowary	Lowland tropical rainforest (Papua New Guinea)	[61]
Chloropseidae	<i>Chloropsis cochinchinensis</i>	Blue-winged Leafbird	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Chloropsis cyanopogon</i>	Lesser Green Leafbird	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Chloropsis aurifrons</i>	Gold-fronted Leafbird	Tropical Rainforest (India)	[64]
Cisticolidae	<i>Prinia rufescens</i>	Rufescent Prinia	Hill dipterocarp tropical rainforest (Malaysia)	[65]
	<i>Orthotomus atrogularis</i>	Dark-necked Tailorbird	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Orthotomus sericeus</i>	Rufous-tailed Tailorbird	Tropical Rainforest (Malaysia)	[63]
	<i>Orthotomus sutorius</i>	Common Tailorbird	Tropical Rainforest (Malaysia)	[63]
Colluricinclidae	<i>Colluricincla megarhyncha</i>	Little Shrike-thrush	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Colluricincla boweri</i>	Bower's Shrike-thrush	Tropical Rainforest (Australia)	[62]

Family	Scientific name	Common name	Habitat	Authors
Columbidae	<i>Ducula pinon</i>	Pinon Imperial Pigeon	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ducula rufigaster</i>	Purple Tailed Imperial Pigeon	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ducula zoeae</i>	Zoe Imperial Pigeon	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Macropygia amboinensis</i>	Brown Cuckoo-dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilinopus coronulatus</i>	Coroneted Fruit Dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilinopus iozonus</i>	Orange-bellied Fruit Dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilinopus perlatus</i>	Pink-spotted Fruit Dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilinopus pulchellus</i>	Beautiful Fruit Dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilinopus superbus</i>	Superb Fruit-dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Reinwardtoena reinwardtii</i>	Great Cuckoo-dove	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilinopus magnificus</i>	Wompoo Fruit Dove	Tropical Rainforest (Australia), Lowland tropical rainforest (Papua New Guinea)	[61, 62]
	<i>Chalcophaps indica</i>	Emerald Dove	Tropical Rainforest (Australia), Isolated Tropical Rainforest (Malaysia)	[6, 62]
	<i>Ducula badia</i>	Mountain Imperial Pigeon	Tropical Rainforest (India)	[64]
	<i>Geopelia striata</i>	Zebra Dove	Tropical Rainforest (Malaysia)	[63]
<i>Streptopelia chinensis</i>	Spotted Dove	Tropical Rainforest (Malaysia)	[63]	
Coraciidae	<i>Eurystomus orientalis</i>	Common Dollarbird	Lowland tropical rainforest (Papua New Guinea)	[61]
Corvidae	<i>Platylophus galericulatus</i>	Crested Jay	Hill dipterocarp tropical rainforest (Malaysia)	[64]
	<i>Corvus tristis</i>	Bare-eyed Crow	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Dendrocitta leucogastra</i>	White-bellied Treepie	Tropical Rainforest (India)	[64]
Cuculidae	<i>Cacomantis merulinus</i>	Plaintive Cuckoo	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Cacomantis variolosus</i>	Brush Cuckoo	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Centropus bernsteini</i>	Lesser Black Coucal	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Centropus menbeki</i>	Greater Black Coucal	Lowland tropical rainforest (Papua New Guinea)	[61]

Family	Scientific name	Common name	Habitat	Authors
	<i>Centropus phasianinus</i>	Pheasant Coucal	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Chrysococcyx lucidus</i>	Shining Bronze Cuckoo	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Eudynamys scolopaceus</i>	Common Koel	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Probosciger aterrimus</i>	Palm Cockatoo	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Chrysococcyx minutillus</i>	Little Bronze-Cuckoo	Tropical Rainforest (Australia)	[62]
	<i>Cacomantis sonneratii</i>	Banded Bay Cuckoo	Tropical Rainforest (Malaysia)	[63]
	<i>Cuculus micropterus</i>	Indian Cuckoo	Tropical Rainforest (Malaysia)	[63]
	<i>Surniculus lugubris</i>	Drongo Cuckoo	Tropical Rainforest (Malaysia)	[63]
Dendrocolaptidae	<i>Campylorhamphus pusillus</i>	Brown-billed Scythebill	Tropical forest (Costa Rica)	[65]
	<i>Xiphorhynchus guttatus</i>	Buff-throated Woodcreeper	Tropical forest (Costa Rica)	[65]
Dicaeidae	<i>Prionochilus percussus</i>	Crimson-breasted Flowerpecker	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Dicaeum trignostigma</i>	Orange-bellied Flowerpecker	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Dicaeum geelvinkianum</i>	Red-capped Flowerpecker	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Dicaeum hirundinaceum</i>	Mistletoebird	Tropical Rainforest (Australia)	[62]
	<i>Dicaeum concolor</i>	Nilgiri Flowerpecker	Tropical Rainforest (India)	[64]
	<i>Prionochilus maculatus</i>	Yellow-breasted Flowerpecker	Tropical Rainforest (Malaysia)	[63]
Dicruridae	<i>Cheatorhynchus papuensis</i>	Pygmy Drongo	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Dicrurus bracteatus</i>	Spangled Drongo	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Dicrurus aeneus</i>	Bronzed Drongo	Tropical Rainforest (India), Isolated Tropical Rainforest (Malaysia)	[61, 64]
	<i>Dicrurus paradiseus</i>	Greater Racket-tailed Drongo	Tropical Rainforest (India), Isolated Tropical Rainforest (Malaysia)	[63, 64]
	<i>Dicrurus annectans</i>	Crow-billed Drongo	Tropical Rainforest (Malaysia)	[63]
	<i>Dicrurus remifer</i>	Lesser Racket-tailed Drongo	Tropical Rainforest (Malaysia)	[63]

Family	Scientific name	Common name	Habitat	Authors
Estrildidae	<i>Lonchura leucogastra</i>	White-bellied Munia	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Lonchura kelaarti</i>	Black-throated Munia	Tropical Rainforest (India)	[64]
Eurylaimidae	<i>Calyptomena viridis</i>	Green Broadbill	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Cymbirhynchus macrorhynchos</i>	Black-and-red Broadbill	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Eurylaimus javanicus</i>	Banded Broadbill	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Corydon sumatranus</i>	Dusky Broadbill	Tropical Rainforest (Malaysia)	[63]
Falconidae	<i>Microhierax fringillarius</i>	Black-thighed Falconet	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Herpetotheres cachinmans</i>	Laughing Falcon	Tropical forest (Costa Rica)	[65]
Formicariidae	<i>Thamnophilus bridgesi</i>	Black-hooded Antshrike	Tropical forest (Costa Rica)	[65]
Furnariidae	<i>Automolus ochrolaemus</i>	Buff-throated Foliage-gleaner	Tropical forest (Costa Rica)	[65]
Halcyonidae	<i>Lacedo pulchella</i>	Banded Kingfisher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Todiramphus sanctus</i>	Sacred Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Dacelo gaudichaud</i>	Rufous-bellied Kookuburra	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Syma torotoro</i>	Yellow-billed Kingfisher	Lowland tropical rainforest (Papua New Guinea)	[61]
Hirundinidae	<i>Hirundo tahitica</i>	Pacific Swallow	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Hirundo rustica</i>	Barn Swallow	Hill dipterocarp tropical rainforest (Malaysia)	[6]
Icteridae	<i>Cacicus uropygialis</i>	Scarlet-rumped Caciue	Tropical forest (Costa Rica)	[65]
	<i>Psarocolius wagleri</i>	Chestnut-headed Oropendola	Tropical forest (Costa Rica)	[65]
Irenidae	<i>Irena puella</i>	Asian Fairy-bluebird	Tropical Rainforest (India), Hill dipterocarp tropical rainforest (Malaysia)	[6, 64]
Laniidae	<i>Lanius cristatus</i>	Brown Shrike	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Lanius tigrinus</i>	Tiger Shrike	Hill dipterocarp tropical rainforest (Malaysia)	[6]
Leiotherichidae	<i>Garrulax jerdoni</i>	Kerala Laughingthrush	Tropical Rainforest (India)	[64]
	<i>Garrulax delesserti</i>	Wynaad Laughingthrush	Tropical Rainforest (India)	[64]
Maluridae	<i>Malurus amabilis</i>	Lovely Fairy-wren	Tropical Rainforest (Australia)	[62]

Family	Scientific name	Common name	Habitat	Authors
Megalaimidae	<i>Megalaima rubricapilla</i>	Crimson-fronted Barbet	Tropical Rainforest (India)	[64]
	<i>Talegalla jobiensis</i>	Brown-collared Brush Turkey	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Megapodius reinwardt</i>	Orange-footed Scrubfowl	Tropical Rainforest (Australia)	[62]
Melanocharitidae	<i>Melanocharis nigra</i>	Black Berrypecker	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Oedistoma iliolophus</i>	Plumed Longbill	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Toxorhamphus novaeguineae</i>	Yellow-bellied Longbill	Lowland tropical rainforest (Papua New Guinea)	[61]
Meliphagidae	<i>Meliphaga analoga</i>	Mimic Honeyeater	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Meliphaga montana</i>	White-marked Forest Honeyeater	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Philemon meyeri</i>	Meyer's Friarbird	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Xanthotis flaviventer</i>	Tawny-breasted Honeyeater	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Philemon buceroides</i>	Helmeted Friarbird	Lowland tropical rainforest (Papua New Guinea), Tropical Rainforest (Australia)	[61, 62]
	<i>Meliphaga notata</i>	Yellow-spotted Honeyeater	Tropical Rainforest (Australia)	[62]
	<i>Myzomela obscura</i>	Dusky Honeyeater	Tropical Rainforest (Australia)	[62]
	<i>Xanthotis macleayana</i>	Macleay's Honeyeater	Tropical Rainforest (Australia)	[62]
	<i>Meliphaga gracilis</i>	Graceful Honeyeater	Tropical Rainforest (Australia), Isolated Tropical Rainforest (Malaysia)	[62, 63]
	Meropidae	<i>Merops viridis</i>	Blue-throated Bee-eater	Hill dipterocarp tropical rainforest (Malaysia)
<i>Merops ornatus</i>		Rainbow Bee-eater	Tropical Rainforest (Australia), Lowland tropical rainforest (Papua New Guinea)	[61, 62]
Monarchidae	<i>Hypothymis azurea</i>	Black-naped Monarch	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Terpsiphone paradisi</i>	Asian Paradise Flycatcher	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 62]
	<i>Arses telescopthalmus</i>	Frilled Monarch	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Machaerirhynchus flaviventer</i>	Yellow-breasted Boatbill	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Monarcha chrysomela</i>	Golden Monarch	Lowland tropical rainforest (Papua New Guinea)	[61]

Family	Scientific name	Common name	Habitat	Authors
Muscicapidae	<i>Monarcha guttula</i>	Spot-winged Monarch	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Monarcha manadensis</i>	Hooded Monarch	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Monarcha rubiensis</i>	Rufous Monarch	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Myiagra alecto</i>	Shining Flycatcher	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Arses kaupi</i>	Pied Monarch	Tropical Rainforest (Australia)	[62]
	<i>Monarcha leucotis</i>	White-eared Monarch	Tropical Rainforest (Australia)	[62]
	<i>Monarcha trivirgatus</i>	Spectacled Monarch	Tropical Rainforest (Australia)	[62]
	<i>Ficedula nigrorufa</i>	Black-and-Orange Flycatcher	Tropical Rainforest (India)	[64]
	<i>Muscicapa sibirica</i>	Dark-sided Flycatcher	Tropical Rainforest (Malaysia)	[63]
	<i>Philentoma pyrhopterum</i>	Chestnut-winged Flycatcher	Tropical Rainforest (Malaysia)	[63]
	<i>Enicurus ruficapillus</i>	Chestnut-naped Forktail	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Eumyias thalassinus</i>	Verditer Flycatcher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Ficedula mugimaki</i>	Mugimaki Flycatcher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Ficedula zanthopygia</i>	Yellow-rumped Flycatcher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Muscicapa dauurica</i>	Asian Brown Flycatcher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Muscicapella hodgsoni</i>	Pygmy Blue Flycatcher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Philentoma pyrhoptera</i>	Rufous-winged Philentoma	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Rhinomyias umbratilis</i>	Grey-chested Jungle Flycatcher	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Copsychus malabaricus</i>	White-rumped Shama	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Microeca flavovirescens</i>	Olive-yellow Flycatcher	Lowland tropical rainforest (Papua New Guinea)	[61]
<i>Brachypteryx major</i>	White-bellied Robbin	Tropical Rainforest (India)	[64]	
<i>Cyornis pallipes</i>	White-bellied Blue Flycatcher	Tropical Rainforest (India)	[64]	
<i>Eumyias albicaudatus</i>	Nilgiri Flycatcher	Tropical Rainforest (India)	[64]	
<i>Myophonus horsfieldii</i>	Malabar Whistling Thrush	Tropical Rainforest (India)	[64]	

Family	Scientific name	Common name	Habitat	Authors
Nectarinidae	<i>Culicicapa ceylonensis</i>	Grey-headed Canary Flycatcher	Tropical Rainforest (India), Isolated Tropical Rainforest (Malaysia)	[63, 64]
	<i>Ficedula elisae</i>	Green-backed Flycatcher	Tropical Rainforest (Malaysia)	[63]
	<i>Muscicapa dauurica</i>	Asian Brown Flycatcher	Tropical Rainforest (Malaysia)	[63]
	<i>Nectarinia minima</i>	Crimson-backed Sunbird	Tropical Rainforest (India)	[64]
	<i>Arachnothera magna</i>	Streaked Spiderhunter	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Arachnothera modesta</i>	Grey-breasted Spiderhunter	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Hypogramma hypogrammicum</i>	Purple-naped Sunbird	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Anthreptes simplex</i>	Plain Sunbird	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Arachnothera flavigaster</i>	Spectacled Spiderhunter	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Arachnothera longirostra</i>	Little Spiderhunter	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Cinnyris jugularis</i>	Olive-backed Sunbird	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Nectarinia jugularis</i>	Yellow-bellied Sunbird	Tropical Rainforest (Australia)	[62]
	<i>Nectarinia lotenia</i>	Loten's Sunbird	Tropical Rainforest (India)	[64]
	<i>Hypogramma hypogrammicum</i>	Purple-naped Sunbird	Tropical Rainforest (Malaysia)	[63]
Oriolidae	<i>Oriolus xanthonotus</i>	Dark-throated Oriole	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Oriolus szalayi</i>	Brown Oriole	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Pitohui kirhocephalus</i>	Variable Pitohui	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Oriolus flavocinctus</i>	Yellow Oriole	Tropical Rainforest (Australia)	[62]
Pachycephalidae	<i>Oriolus chinensis</i>	Black-naped Oriole	Tropical Rainforest (Malaysia)	[63]
	<i>Pachycephala hyperythra</i>	Rusty-breasted Whistler	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Pachycephala simplex</i>	Grey Whistler	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Pitohui ferrugineus</i>	Rusty Pitohui	Lowland tropical rainforest (Papua New Guinea)	[61]

Family	Scientific name	Common name	Habitat	Authors
Paradisaeidae	<i>Cicinnurus regius</i>	King Bird of Paradise	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Paradisaea minor</i>	Lesser BOP	Lowland tropical rainforest (Papua New Guinea)	[61]
Pardalotidae	<i>Crateroscelis murina</i>	Rusty Mouse Warbler	Lowland tropical rainforest (Papua New Guinea)	[61]
Paridae	<i>Parus xanthogenys</i>	Himalayan Black-lored Tit	Tropical Rainforest (India)	[64]
Parulidae	<i>Dendroica virens</i>	Black-throated Green Warbler	Tropical forest (Costa Rica)	[65]
	<i>Oporornis formosus</i>	Kentucky Warbler	Tropical forest (Costa Rica)	[65]
	<i>Setophaga ruticilla</i>	American Redstart	Tropical forest (Costa Rica)	[65]
	<i>Vermivora chrysoptera</i>	Golden-winged Warbler	Tropical forest (Costa Rica)	[65]
	<i>Wilsonia pusilla</i>	Wilson's Warbler	Tropical forest (Costa Rica)	[65]
Pellorneidae	<i>Alcippe poiocephala</i>	Brown-cheeked Fulvetta	Tropical Rainforest (India)	[64]
	<i>Alcippe brunnea</i>	Brown Fulvetta	Tropical Rainforest (Malaysia)	[63]
Petroicidae	<i>Poecilodryas hypoleuca</i>	Black-sided Robin	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Microeca flavigaster</i>	Lemon-bellied Flycatcher	Tropical Rainforest (Australia)	[62]
	<i>Tregellasia capito</i>	Pale-yellow Robin	Tropical Rainforest (Australia)	[62]
Phasianidae	<i>Galloperdix spadicea</i>	Red Spurfowl	Tropical Rainforest (India)	[64]
	<i>Gallus sonneratii</i>	Grey Junglefowl	Tropical Rainforest (India)	[64]
	<i>Gallus gallus</i>	Red Junglefowl	Tropical Rainforest (Malaysia)	[63]
Phylloscopidae	<i>Phylloscopus borealis</i>	Arctic Warbler	Tropical Rainforest (Malaysia)	[63]
Picidae	<i>Sasia abnormis</i>	Rufous Piculet	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Blythipicus rubiginosus</i>	Maroon Woodpecker	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Meiglyptes tukki</i>	Buff-necked Woodpecker	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Picus mentalis</i>	Checker-throated Woodpecker	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Picus miniaceus</i>	Banded Woodpecker		[6, 63]

Family	Scientific name	Common name	Habitat	Authors
			Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	
	<i>Piculus rubiginosus</i>	Golden-olive Woodpecker	Tropical forest (Costa Rica)	[65]
	<i>Celeus brachyurus</i>	Rufous Woodpecker	Tropical Rainforest (India)	[64]
	<i>Dryocopus javensis</i>	White-bellied Woodpecker	Tropical Rainforest (India)	[64]
	<i>Picumnus innominatus</i>	Speckled Piculet	Tropical Rainforest (India)	[64]
	<i>Chrysocolaptes lucidus</i>	Greater Flameback	Tropical Rainforest (India), Isolated Tropical Rainforest (Malaysia)	[63, 64]
	<i>Dinopium javanense</i>	Common Flameback	Tropical Rainforest (India), Isolated Tropical Rainforest (Malaysia)	[63, 64]
	<i>Dinopium rafflesii</i>	Olive-backed Woodpecker	Tropical Rainforest (Malaysia)	[63]
	<i>Meiglyptes jugularis</i>	Black and buff Woodpecker	Tropical Rainforest (Malaysia)	[63]
	<i>Picus flavinucha</i>	Greater Yellownape	Tropical Rainforest (Malaysia)	[63]
	<i>Picus puniceus</i>	Crimson-winged Woodpecker	Tropical Rainforest (Malaysia)	[63]
Pipridae	<i>Corapipo leucorrhoea</i>	White-bibbed Manakin	Tropical forest (Costa Rica)	[65]
	<i>Manacus aurantiacus</i>	Orange-collard Manakin	Tropical forest (Costa Rica)	[65]
Pittidae	<i>Pitta guajana</i>	Banded Pitta	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Pitta erythrogaster</i>	Red-bellied Pitta	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Pitta sordida</i>	Hooded Pitta	Tropical Rainforest (Malaysia)	[63]
Podargidae	<i>Batrachostomus stellatus</i>	Gould's Frogmouth	Hill dipterocarp tropical rainforest (Malaysia)	[6]
Psittaculidae	<i>Lorius lory</i>	Black Capped Lori	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Loriculus vernalis</i>	Vernal Hanging Parrot	Tropical Rainforest (India)	[64]
	<i>Electus voratus</i>	Electus Parrot	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Geoffroyus geoffroyi</i>	Red-cheeked Parrot	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Geoffroyus simplex</i>	Blue-collared Parrot	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Micropsitta pusio</i>	Buff-faced Pygmy Parrot	Lowland tropical rainforest (Papua New Guinea)	[61]

Family	Scientific name	Common name	Habitat	Authors
	<i>Pseudeos fuscata</i>	Dusky Lory	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Psittaculirostris edwardsii</i>	Edward's Fig Parrot	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Cyclopsitta diophthalma</i>	Double-eyed Fig-parrot	Tropical Rainforest (Australia)	[62]
	<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	Tropical Rainforest (Australia), Lowland tropical rainforest (Papua New Guinea)	[61, 62]
	<i>Psittacula columboides</i>	Blue-winged Parakeet	Tropical Rainforest (India)	[64]
	<i>Psittacula cyanocephala</i>	Plum-headed Parakeet	Tropical Rainforest (India)	[64]
Psophodidae	<i>Psophodes olivaceus</i>	Eastern Whipbird	Tropical Rainforest (Australia)	[62]
Ptilonorhynchidae	<i>Ailuroedus buccoides</i>	White-eared Catbird	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ailuroedus melanotis</i>	Spotted Catbird	Tropical Rainforest (Australia)	[62]
Pycnonotidae	<i>Alophoixus ochraceus</i>	Ochraceous Bulbul	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Alophoixus phaeocephalus</i>	Yellow-bellied Bulbul	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Ixos malaccensis</i>	Streaked Bulbul	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Pycnonotus cyaniventris</i>	Grey-bellied Bulbul	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Pycnonotus finalysoni</i>	Stripe-throated Bulbul	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Pycnonotus melanoleucos</i>	Black-and-white Bulbul	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Iole olivacea</i>	Buff-vented Bulbul	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia),	[6, 63]
	<i>Pycnonotus simplex</i>	Cream-vented Bulbul	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Pycnonotus bruunus</i>	Red-eyed Bulbul	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Pycnonotus erythrothalmos</i>	Spectacled Bulbul	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Pycnonotus eutilotus</i>	Puff-backed Bulbul	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Pycnonotus plumosus</i>	Olive-winged Bulbul		[6, 63]

Family	Scientific name	Common name	Habitat	Authors
			Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	
	<i>Tricholestes criniger</i>	Hairy-backed Bulbul	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Hypsipetes leucocephalus</i>	Black Bulbul	Tropical Rainforest (India)	[64]
	<i>Iole indica</i>	Yellow-browed Bulbul	Tropical Rainforest (India)	[64]
	<i>Pycnonotus jocosus</i>	Red-whiskered Bulbul	Tropical Rainforest (India)	[64]
	<i>Pycnonotus melanicterus</i>	Black-capped Bulbul	Tropical Rainforest (India)	[64]
	<i>Pycnonotus priocephalus</i>	Grey-headed Bulbul	Tropical Rainforest (India)	[64]
	<i>Alophoixus finschii</i>	Finsch's Bulbul	Tropical Rainforest (Malaysia)	[63]
	<i>Pycnonotus atriceps</i>	Black-headed Bulbul	Tropical Rainforest (Malaysia)	[63]
	<i>Pycnonotus goiavier</i>	Yellow-vented Bulbul	Tropical Rainforest (Malaysia)	[63]
Ramphastidae	<i>Calormphus fuliginosus</i>	Brown Barbet	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Pteroglossus frantzii</i>	Fiery-billed Aracari	Tropical forest (Costa Rica)	[65]
Rhipiduridae	<i>Rhipidura rufiventris</i>	Northern Fantail	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Rhipidura threnothorax</i>	Sooty Thicket Fantail	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Rhipidura fuliginosa</i>	Grey Fantail	Tropical Rainforest (Australia)	[62]
	<i>Rhipidura rufifrons</i>	Rufous Fantail	Tropical Rainforest (Australia)	[62]
	<i>Rhipidura javanica</i>	Pied Fantail	Tropical Rainforest (Malaysia)	[63]
	<i>Rhipidura perlata</i>	Spotted Fantail	Hill dipterocarp tropical rainforest (Malaysia)	[65]
	<i>Rhipidura leucothorax</i>	White-bellied Thicket-Fantail	Lowland tropical rainforest (Papua New Guinea)	[61]
Sittidae	<i>Sitta frontalis</i>	Velvet-fronted Nuthatch	Tropical Rainforest (India)	[64]
Strigidae	<i>Otus rufescens</i>	Reddish Scope Owl	Hill dipterocarp tropical rainforest (Malaysia)	[6]
Sturnidae	<i>Aplonis cantoroides</i>	Singing Starling	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Mino dumontii</i>	Yellow Faced Myna	Lowland tropical rainforest (Papua New Guinea)	[61]

Family	Scientific name	Common name	Habitat	Authors
	<i>Aplonis metallica</i>	Metallic Starling	Tropical Rainforest (Australia), Lowland tropical rainforest (Papua New Guinea)	[61, 62]
	<i>Gracula religiosa</i>	Hill Myna	Tropical Rainforest (India)	[64]
Tephrodornithidae	<i>Tephrodornis gularis</i>	Large Woodshrike	Tropical Rainforest (India)	[64]
Thamnophilidae	<i>Cercomacra tyrannina</i>	Dusky Antbird	Tropical forest, Costa Rica	[65]
Thraupidae	<i>Piranga flava</i>	Hepatic Tanager	Tropical forest (Costa Rica)	[65]
	<i>Tangara guttata</i>	Speckled Tanager	Tropical forest (Costa Rica)	[65]
	<i>Tangara gyrola</i>	Bay-headed Tanager	Tropical forest (Costa Rica)	[65]
Timaliidae	<i>Malacocincla sepiaria</i>	Horsfield's Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Malacopteron affine</i>	Sooty-capped Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Pellorneum capistratum</i>	Black-capped Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Stachyris erythroptera</i>	Chestnut-winged Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Stachyris maculata</i>	Chestnut-rumped Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Stachyris poliocephala</i>	Grey-headed Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[65]
	<i>Trichastoma bicolor</i>	Ferruginous Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[65]
	<i>Trichastoma rostratum</i>	White-chested Babbler	Hill dipterocarp tropical rainforest (Malaysia)	[65]
	<i>Macronous gularis</i>	Striped Tit-babbler	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Macronus ptilosus</i>	Fluffy-backed Tit-Babbler	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Malacocincla malaccensis</i>	Short-tailed Babbler	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Malacopteron cinereum</i>	Scaly-crowned Babbler	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Malacopteron magnirostre</i>	Moustached Babbler	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Malacopteron magnum</i>	Rufous-crowned Babbler		[6, 63]

Family	Scientific name	Common name	Habitat	Authors
			Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	
	<i>Stachyris nigricollis</i>	Black-throated Babbler	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Garritornis isidorei</i>	Isidore's Rufous Babbler	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Ptilorrhoa caerulescens</i>	Blue Jewel-babbler	Lowland tropical rainforest (Papua New Guinea)	[61]
	<i>Megalaima viridis</i>	White-cheeked Barbet	Tropical Rainforest (India)	[64]
	<i>Pellorneum ruficeps</i>	Puff-throated Babbler	Tropical Rainforest (India)	[64]
	<i>Pomatorhinus horsfieldii</i>	Indian Scimitar Babbler	Tropical Rainforest (India)	[64]
	<i>Rhopocichla atriceps</i>	Dark-fronted Babbler	Tropical Rainforest (India)	[64]
	<i>Turdoides subrufus</i>	Rufous Babbler	Tropical Rainforest (India)	[64]
	<i>Pellorneum capistratum</i>	Black-caped Babbler	Tropical Rainforest (Malaysia)	[63]
	<i>Napothera epilepidota</i>	Eyebrowed Wren-babbler	Tropical Rainforest (Malaysia)	[63]
	<i>Stachyris erythroptera</i>	Chestnut-winged Babbler	Tropical Rainforest (Malaysia)	[63]
	<i>Yuhina zantholeuca</i>	White-bellied Yuhina	Tropical Rainforest (Malaysia)	[63]
Tityridae	<i>Pachyramphus aglaiae</i>	Rose-throated Becard	Tropical forest (Costa Rica)	[65]
Trochilidae	<i>Campylopterus hemileucurus</i>	Violet Sabrewing	Tropical forest (Costa Rica)	[65]
	<i>Phaethornis guy</i>	Green Hermit	Tropical forest (Costa Rica)	[65]
	<i>Phaethornis longuemareus</i>	Little Hermit	Tropical forest (Costa Rica)	[65]
Troglodytidae	<i>Thryothorus rufalbus</i>	Rufous-and-white Wren	Tropical forest (Costa Rica)	[65]
Trogonidae	<i>Harpactes diardii</i>	Diard's Trogon	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Harpactes orrhophaeus</i>	Cinnamon-rumped Trogon	Hill dipterocarp tropical rainforest (Malaysia)	[6]
	<i>Trogon bairdii</i>	Baird's Trogon	Tropical forest (Costa Rica)	[65]
	<i>Harpactes fasciatus</i>	Malabar Trogon	Tropical Rainforest (India)	[64]
Turdidae	<i>Copsychus saularis</i>	Oriental Magpie Robin		[6, 63]

Family	Scientific name	Common name	Habitat	Authors
			Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	
	<i>Luscinia cyane</i>	Siberian Blue Robin	Hill dipterocarp tropical rainforest (Malaysia), Isolated Tropical Rainforest (Malaysia)	[6, 63]
	<i>Turdus merula</i>	Common Blackbird	Tropical Rainforest (India)	[64]
	<i>Zoothera citrina</i>	Orange-headed Thrush	Tropical Rainforest (India)	[64]
Vireonidae	<i>Hylophilus decurtatus</i>	Lesser Greenlet	Tropical forest (Costa Rica)	[65]
	<i>Vireo flavifrons</i>	Yellow-throated Vireo	Tropical forest (Costa Rica)	[65]
	<i>Vireolanius pulchellus</i>	Green Shrike-vireo	Tropical forest (Costa Rica)	[65]
Zosteropidae	<i>Zosterops lateralis</i>	Silvereye	Tropical Rainforest (Australia)	[62]
	<i>Zosterops palpebrosus</i>	Oriental White-eye	Tropical Rainforest (India), Isolated Tropical Rainforest (Malaysia)	[63, 64]

**Table 1.** List of bird species that occur in tropical rainforest.

cover. Forest logging [66–68], habitat degradation and fragmentation [69], slash-and-burn agriculture [61], and fires are major factors, which had adversely affected the population of the avian species in different forest ecosystems [51]. These factors altered the vegetation structure and composition, which affects the avian richness and diversity by affecting the food resources, increased nest predation and brood parasitism. The diversity and richness of food resources are closely associated with the vegetation structure and composition, such as foliage, flowers, fruits, and barks. Furthermore, large-scale logging for valuable timber harvesting,



**Figure 5.** Bornean pygmy elephant—*Elephas maximus borneensis*.



**Figure 6.** Sambar deer—*Rusa unicolor*.

Family	Scientific name	Common name	Habitat	Authors
Emballonuridae	<i>Saccopteryx bilineata</i>	Greater Sac-winged Bat	Tropical Rainforest (Mexico)	[73]
	<i>Diclidurus virgo</i>	White Bat	Tropical Rainforest (Mexico)	[73]
Mormoopidae	<i>Pteronotus davyi</i>	Davy's Naked-backed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Mormoops megalophylla</i>	Ghost-faced Bat	Tropical Rainforest (Mexico)	[73]
	<i>Pteronotus parnellii</i>	Parnell's Mustached Bat	Tropical Rainforest (Mexico)	[73]
Muridae	<i>Rattus annandalei</i>	Annandale's Rat	Primary Rainforest (Malaysia)	[74]
	<i>Niviventer fulvescens</i>	Chestnut White-bellied Rat	Primary Rainforest (Malaysia)	[74]
	<i>Niviventer cremoriventer</i>	Dark-tailed Tree Rat	Primary Rainforest (Malaysia)	[74]
	<i>Leopoldamys edwardsi</i>	Edwards's Long-tailed Giant Rat	Tropical Rainforest (Indonesia)	[75]
	<i>Lenothrix canus</i>	Gray Tree Rat	Primary Rainforest (Malaysia)	[74]
	<i>Leopoldamys sabanus</i>	Long-tailed Giant Rat	Primary Rainforest (Malaysia), Tropical Rainforest (Indonesia)	[74, 75]
	<i>Niviventer rapit</i>	Long-tailed Mountain Rat	Tropical Rainforest (Indonesia)	[75]
	<i>Rattus tiomanicus</i>	Malayan Field Rat	Primary Rainforest (Malaysia)	[74]
	<i>Sundamys muelleri</i>	Muller's Giant Sunda Rat	Primary Rainforest (Malaysia), Tropical Rainforest (Indonesia)	[74, 75]
	<i>Maxomys rajah</i>	Rajah Spiny Rat	Primary Rainforest (Malaysia), Tropical Rainforest (Indonesia)	[74, 75]
	<i>Maxomys surifer</i>	Red Spiny Rat	Primary Rainforest (Malaysia)	[74]
	<i>Maxomys whiteheadi</i>	Whitehead's Spiny Rat	Primary Rainforest (Malaysia), Tropical Rainforest (Indonesia)	[74, 75]
	Natalidae	<i>Natalus stramineus</i>	Mexican Funnel-eared Bat	Tropical Rainforest (Mexico)
Phyllostomidae	<i>Desmodus rotundus</i>	Common Vampire Bat	Tropical Rainforest (Mexico)	[73]
	<i>Choeroniscus godmani</i>	Godman's Long-tailed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Mimon bennettii</i>	Golden Bat	Tropical Rainforest (Mexico)	[73]

Family	Scientific name	Common name	Habitat	Authors
	<i>Artibeus lituratus</i>	Great Fruit-eating Bats	Tropical Rainforest (Mexico)	[73]
	<i>Chiroderma villosum</i>	Hairy Big-eyed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Platyrrhinus helleri</i>	Heller's Broad-nosed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Sturnira ludovici</i>	Highland Yellow-shouldered Bat	Tropical Rainforest (Mexico)	[73]
	<i>Artibeus jamaicensis</i>	Jamaican Fruit-eating Bat	Tropical Rainforest (Mexico)	[73]
	<i>Vampyressa pusilla</i>	Little Yellow-eared Bat	Tropical Rainforest (Mexico)	[73]
	<i>Leptonycteris sanborni</i>	Long-nosed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Lampronnycteris brachyotis</i>	Orange-throated Big-eared Bat	Tropical Rainforest (Mexico)	[73]
	<i>Phyllostomus discolor</i>	Pale Spear-nosed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Glossophaga soricina</i>	Pallas's Long-tongued Bat	Tropical Rainforest (Mexico)	[73]
	<i>Artibeus phaeotis</i>	Pygmy Fruit-eating Bat	Tropical Rainforest (Mexico)	[73]
	<i>Carollia brevicauda</i>	Silky Short-tailed Bat	Tropical Rainforest (Mexico)	[73]
	<i>Vampyrodes major</i>	Stripe-faced Bat	Tropical Rainforest (Mexico)	[73]
	<i>Uroderma bilobatum</i>	Tent-making Bat	Tropical Rainforest (Mexico)	[73]
	<i>Artibeus watsoni</i>	Thomas's Fruit-eating Bat	Tropical Rainforest (Mexico)	[73]
	<i>Artibeus toltecus</i>	Toltec Fruit-eating Bat	Tropical Rainforest (Mexico)	[73]
	<i>Hylonycteris underwoodi</i>	Underwood's Long-tongued Bat	Tropical Rainforest (Mexico)	[73]
	<i>Enchisthenes hartii</i>	Velvety Fruit-eating Bat	Tropical Rainforest (Mexico)	[73]
	<i>Centurio senex</i>	Wrinkle-faced Bat	Tropical Rainforest (Mexico)	[73]
	<i>Sturnira lilium</i>	Yellow-shouldered Bat	Tropical Rainforest (Mexico)	[73]
Sciuridae	<i>Sundasciurus lowii</i>	Low's Squirrel	Primary Rainforest (Malaysia)	[74]
	<i>Callosciurus notatus</i>	Plantain Squirrel	Primary Rainforest (Malaysia)	[74]
	<i>Callosciurus prevostii</i>	Prevost's Squirrel	Primary Rainforest (Malaysia)	[74]

Family	Scientific name	Common name	Habitat	Authors
	<i>Sundasciurus tenuis</i>	Slender Squirrel	Tropical Rainforest (Indonesia)	[75]
	<i>Lariscus insignis</i>	Three-striped Ground Squirrel	Tropical Rainforest (Indonesia)	[75]
Thyropteridae	<i>Thyroptera tricolor</i>	Spix's Disk-winged Bat	Tropical Rainforest (Mexico)	[73]
Tupaiaidae	<i>Tupaia glis</i>	Common Treeshrew	Primary Rainforest (Malaysia), Tropical Rainforest (Indonesia)	[74, 75]
	<i>Tupaia tana</i>	Large Treeshrew	Tropical Rainforest (Indonesia)	[75]
Vespertilionidae	<i>Antrozous sp.</i>	Pallid Bat	Tropical Rainforest (Mexico)	[73]

**Table 2.** List of mammal species that occur in tropical rainforest.

Family	Scientific name	Common name	Habitat	Authors
Agamidae	<i>Gonyocephalus semperi</i>	White-Spotted Angle head	Tropical Rainforest (Philippine)	[94]
Colubridae	<i>Boiga dendrophilia</i>	Mangrove Blunt-Headed Snake	Tropical Rainforest (Philippine)	[94]
	<i>Psammodynastes pulverulentus</i>	Dark- Spotted Mock Viper	Tropical Rainforest (Philippine)	[94]
	<i>Oxyrhabdium leporinum</i>	Banded Philippine Burrowing Snake	Tropical Rainforest (Philippine)	[94]
	<i>Oligodon maculatus</i>	Barred ShortHeaded Snake	Tropical Rainforest (Philippine)	[94]
	<i>Calamaria gervaisii</i>	Gervais' Worm Snake	Tropical Rainforest (Philippine)	[94]
	<i>Lycodon dumerili</i>	Dumeril's Wolf Snake	Tropical Rainforest (Philippine)	[94]
	<i>Tropidolaemus</i> sp.	Wagler's Pit Viper	Tropical Rainforest (Philippine)	[94]
	<i>Phyton reticulatus</i>	Reticulated Phyton	Tropical Rainforest (Philippine)	[94]
Gekkonidae	<i>Gekko mindorensis</i>	Mindoro Narrow-Disked Gecko	Tropical Rainforest (Philippine)	[94]
Scincidae	<i>Sphenomorphus variegatus</i>	Black-Spotted Sphenomorphus	Tropical Rainforest (Philippine)	[94]
	<i>Sphenomorphus beyeri</i>	Beyer's Sphenomorphus	Tropical Rainforest (Philippine)	[94]
	<i>Lipinia pulchella</i>	Yellow-Striped Slender Tree Skink	Tropical Rainforest (Philippine)	[94]
	<i>Eutropis multicolorinata borealis</i>	Northern Two-Striped Mabuya	Tropical Rainforest (Philippine)	[94]
	<i>Eutropis englei</i>	Six-Striped Mabouya	Tropical Rainforest (Philippine)	[94]

**Table 3.** List of reptile species that occur in tropical rainforest.

damage to forest, and replacement of native vegetation by exotic species [70] are the main problems, which affect the fauna species. Loss of forested areas is responsible for the loss of biodiversity.

## 2.2. Mammal species composition of tropical rainforest

Tropical rainforest had harbored rich mammal diversity and density due to richness of plant communities and higher productivity (**Figures 5 and 6; Table 2**). Mammals are a versatile group of animals and a major component of the tropical rainforest ecosystem, i.e., they serve a wide range of ecosystem functions; such as pollination, seed dispersal, pest control, herb control, food source for other animals and nutrient cycling. In addition to ecological

functions, the mammals also provide a wide array of benefits to human beings, such as food, recreation, and source of income, i.e., various byproducts such as bush meat, skin, oil, musk, fur, etc. [71, 72].

Unfortunately, these rich mammal communities are facing severe threats from human activities such as over exploitation (intensive hunting), land-use change (habitat loss and degradation), and climate change [76–78]. These populations of different mammal species had declined abruptly due to change in land use, i.e., habitat fragmentation and degradation due to logging, and deforestation and habitat loss due to agriculture expansion and excessive hunting [79–83]. It has been reported that around one-fifth of mammal species in the wild are at risk of extinction due to human activities such as deforestation for agriculture expansion, logging for timber, and excessive hunting [84]. It has been stated that changes in vegetation cover may affect the richness of food resources and habitat preferences of the mammalian species [85, 86]. This could be due to fact that home range preferences of the mammal species and their population are strongly associated with the vegetation structure and composition [87].

The primates residing in a rainforest are habitat specific, some occupy large continuous forested areas such as Diademed Sifakas—*Propithecus diadema*—while others prefer fragmented forested areas such as Black Howler Monkey—*Alouatta pigra*—for their survival and reproduction [25, 88–90]. Monkeys are diet specific, they consume a variety of food resources such as fruits, seeds, flowers, leaves, arthropods, etc. [91, 92], and their diet is strongly influenced by the plant species composition and richness of the particular dwelling habitat [93].

### 2.3. Reptile species composition of tropical rainforest

Reptiles are carnivorous in nature and play a significant role in controlling various pests present in the forest, such as beetles, arthropods, caterpillars, termites, bugs, rats, mice, etc.,



**Figure 7.** Red-eye tree frog—*Agalychnis callidryas* (Male).

Family	Scientific Name	Common Name	Habitat	Authors
Bufonidae	<i>Ingerophrynus divergens</i>	Malayan Dwarf Toad	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Ansonia muelleri</i>	Mueller's Toad	Tropical Rainforest (Philippine)	[94]
Dicroglossidae	<i>Limnonectes finchi</i>	Finch's Wart Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Limnonectes ingeri</i>	Inger's Wart frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Limnonectes leporinus</i>	Giant River Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Limnonectes malesianus</i>	Malaysian Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Occidozyga baluensis</i>	Balu Oriental Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Occidozyga laevis</i>	Puddle Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	Microhylidae	<i>Chaperina fusca</i>	Brown Thorny Frog	Lowland Tropical Rainforest (Malaysia)
<i>Kalophrynus pleurostigma</i>		Black-spotted Sticky Frog	Lowland Tropical Rainforest (Malaysia)	[106]
<i>Kaloula baleata</i>		Smooth-fingered Narrow-mouthed Frog	Lowland Tropical Rainforest (Malaysia)	[106]
<i>Metaphrynella sundana</i>		Borneo Tree-hole Frog	Lowland Tropical Rainforest (Malaysia)	[106]
<i>Microhyla borneensis</i>		Matang Narrow-mouthed Frog	Lowland Tropical Rainforest (Malaysia)	[106]
<i>Kalophrynus pleurostigma</i>		Black-spotted Narrow-mouthed Frog	Tropical Rainforest (Philippine)	[94]
Ranidae	<i>Hylarana erythraea</i>	Common Green Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Hylarana glandulosa</i>	Rough-sided Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Hylarana nicobariensis</i>	Cricket Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Hylarana raniceps</i>	White-lipped Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Staurois natator</i>	Rock Frog	Tropical Rainforest (Philippine)	[94]
	<i>Rana grandocula</i>	Big-eyed Frog	Tropical Rainforest (Philippine)	[94]
	<i>Limnonectes magnus</i>	Mindanao Fanged Frog	Tropical Rainforest (Philippine)	[94]
	<i>Platymantis corrugata</i>	Rough-backed Forest Frog	Tropical Rainforest (Philippine)	[94]

Family	Scientific Name	Common Name	Habitat	Authors
	<i>Megophrys stejnegeri</i>	Mindanao Horned Frog	Tropical Rainforest (Philippine)	[94]
Rhacophoridae	<i>Nyctixalus pictus</i>	Cinnamon Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Polypedates colletti</i>	Black-spotted Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Polypedates leucomystax</i>	Common Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Polypedates macrotis</i>	Dark-eared Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Polypedates ottilophus</i>	Borneo Eared Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Rhacophorus appendiculatus</i>	Fripped Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Rhacophorus dulitensis</i>	Jade Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Rhacophorus harrissoni</i>	Brown Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Rhacophorus pardalis</i>	Harlequin Tree Frog	Lowland Tropical Rainforest (Malaysia)	[106]
	<i>Polypedates leucomystax</i>	Four-lined Tree Frog	Tropical Rainforest (Philippine)	[94]
	<i>Philautus acutirostris</i>	Pointed-Snouted Tree Frog	Tropical Rainforest (Philippine)	[94]

**Table 4.** List of amphibian species that occur in tropical rainforest.

which may cause severe loss, such as defoliation, seed, and wood damage. Even though they are crucially important for tropical forest ecosystems (**Table 3**), they are facing critical threats from human induced factors such as land-use change (i.e., deforestation, fragmentation and degradation) that have altered the natural habitat of the reptile species that directly or indirectly depend upon tropical rainforests for their survival and reproduction.

Reptiles are highly sensitive species compared to other fauna species, i.e., they become more vulnerable due to land use change, i.e., habitat alteration [95]. This might be because they have a small home range, which is adversely affected by habitat loss and degradation [96, 97]. For example, deforestation may cause severe habitat loss, fragmentation, and degradation which adversely affect the population, community parameters of reptiles inhabiting in a tropical rainforest ecosystem [98–100].

Anthropogenic activities had altered the reptilian intact habitat through land-use change, their habitats becomes degraded and lost thus ultimately becoming unsuitable for them. This is because forested reptile prefers dense and moist habitat, which provides them shelter and rich food resources for their survival, protection, and reproduction. Deforestation may disturb their breeding sites, reduce home range, and increase visibility for predators. Likewise, fragmentation reduced their home range, while degradation reduced their food resources and breeding behavior. Furthermore, land-use changes such as deforestation, fragmentation, and degradation may alter microclimatic conditions of particular dwelling habitats such as temperature, relative humidity, rainfall, and sunlight that ultimately modify the vegetation structure and composition.

#### **2.4. Amphibian species composition of tropical rainforest**

Amphibians are cold-blooded vertebrates and are carnivorous in nature. They play a key role to control the various pests, thus balancing the nature [101]. Amphibians are a significant component of the tropical rainforest ecosystem (**Figure 7; Table 4**) and play an important role in pest control. Habitat loss due highest deforestation is responsible for one-third population decline of the amphibians [10, 102–104]. One-fifth amphibians of Southeast Asia are reported as threatened species [105]. This is because they have small home ranges, i.e., specific aquatic habitat, higher vulnerability to habitat change, and visibility to predators. In addition, over-harvesting from natural habitat for food supply (human consumption), medicine (traditional use), and pet trade also had exerted great pressure on the population of amphibians [104].

#### **2.5. Invertebrate species composition of tropical rainforest**

In tropical rainforests, logging creates gaps and alters the habitat structure and microclimatic conditions, e.g., temperature, relative humidity, and light [107, 108], which influence on the invertebrate diversity and distribution. After logging, new habitat with a different microclimate may develop which tend to be unsuitable for a wide array of invertebrates [109, 110]. This indicates that land-use changes influence invertebrate diversity, richness, and distribution. It has been stated that disturbing the habitat affects invertebrate colonization and distribution [111, 112]. Basset [113] reported that the canopy of tropical rain forest is rich in Coleoptera,

Hymenoptera, Lepidoptera, and Araneae taxa. However, their home range and foraging habitats may vary from species to species depending upon the types of vegetation, forest types, and bio-geographical regions.

### 3. Conclusion and future perspective

Even though, faunas are a crucial component of tropical rainforest ecosystems, detailed information on different aspects of fauna community parameters such as species composition, distribution, diversity, richness and population trend, impact of anthropogenic activities, associated with microclimate and habitat variables is still lacking. The current review highlighted that tropical rainforest is an ideal productive habitat for a wide array of fauna species, i.e., birds, mammals, reptiles, amphibians, and invertebrates. These fauna are a major component of the food web of the rainforest ecosystem and functions. Furthermore, it was revealed that the diversity of rainforest fauna is facing many threats that directly or indirectly affected the population; community parameters of various fauna species inhabited the tropical rainforest. There is an urgent need to study various fauna species of tropical rainforest in order to reduce the impact of human activities and for future conservation and management. We hope that the findings of this chapter will provide the ways and means to conserve the fauna in and around the tropical rainforest.

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### References

- [1] Hill JL, Hill RA. Why are tropical rain forests so species rich? Classifying, reviewing and evaluating theories. *Progress in Physical Geography*, 2001; 25(3): 326–354.

- [2] Lawrence A, Phillips OL, Ismodes AR, Lopez M, Rose S, Wood D, Farfan AJ. Local values for harvested forest plants in Madre de Dios, Peru: towards a more contextualized interpretation of quantitative ethnobotanical data. *Biodiversity Conservation*, 2005; 14: 45–79.
- [3] Millennium Ecosystem Assessment. *Ecosystems and Human Well-being: Biodiversity Synthesis*. World Resources Institute, Washington, DC. 2005.
- [4] Betts RA. Global vegetation and climate: self beneficial effects, climate forcing and climate feedbacks. *Journal De Physique IV*, 2004; 121: 37–60.
- [5] Delire C, Foley JA, Thompson S. Long-term variability in a coupled atmosphere-biosphere model. *Journal of Climate*, 2004; 17: 3947–3959.
- [6] Rajpar MN, Zakaria M. Assessing the effects of logging activities on avian richness and diversity in different aged post-harvested hill dipterocarp tropical rainforest of Malaysia. *American Journal of Applied Sciences*, 2014; 11(9): 1519–1529.
- [7] Foody GM, Cutler MEJ. Tree biodiversity in protected and logged Bornean tropical rain forests and its measurement by satellite remote sensing. *Journal of Biogeography*, 2003; 30: 1053–1066.
- [8] Dent DH, Wright SJ. The future of tropical species in secondary forests: a quantitative review. *Biological Conservation*, 2009; 142: 2833–2843.
- [9] Berry NJ, Phillip SL, Lewis SL, Hill JK, Edwards DP, Tawatao NB, Ahmed N, Magintan D, Ken CV, Maryati M, Ong RC, Hamer KC. The high value of logged tropical forests: lessons from northern Borneo. *Biodiversity Conservation*, 2010; 19: 985–997.
- [10] Achard F, Eva HD, Stibig H-J, Mayaux P, Gallego J, Richards T, Malingreau P. Determination of deforestation rates of the world's humid tropical forests. *Science*, 2002; 297: 999–1002.
- [11] Curran LM, Trigg SN, McDonald AK, Astiani D, Hardiono YM, Siregar P, Caniago I, Kasischke E. Lowland forest loss in protected areas of Indonesian Borneo. *Science*, 2004; 303: 1000–1003.
- [12] Fitzherbert EB, Struebig MJ, Morel A, Danielsen F, Bruhl CA, Donald PF, Phalan B. How will oil palm expansion affect biodiversity? *Trends in Ecology & Evolution*, 2008; 23: 538–545.
- [13] Clark CJ, Poulsen JR, Malonga R, Elkan PW. Logging concessions can extend the conservation estate for central African tropical forests. *Conservation Biology*, 2009; 23: 1281–1293.
- [14] Morris RJ. Anthropogenic impacts on tropical forest biodiversity: a network structure and ecosystem functioning perspective. *Philosophical Transactions of the Royal Society of London B*, 2010; 365: 3709–3718.
- [15] Fisher B, Edwards DP, Larsen TH, Ansell FA, Hsu WW, Roberts CS, Wilcove DS. Cost-effective conservation: calculating biodiversity and logging tradeoffs in Southeast Asia. *Conservation Letters*, 2011; 84: 443–450.

- [16] Houghton RA. Why are estimates of the terrestrial carbon balance so different? *Global Change Biology*, 2003; 9: 500–509.
- [17] Lewis SL, Malhi Y, Phillips OL. Finger printing the impacts of global change on tropical forests. *Philosophical Transactions of the Royal Society of London B*, 2004; 359: 437–462.
- [18] Castelletta M, Thiollay JM, Sodhi NS. The effects of extreme forest fragmentation on the bird community of Singapore Island. *Biological Conservation*, 2005; 121: 135–155.
- [19] Lewis LS. Tropical forests and the changing earth system. *Philosophical Transactions of the Royal Society of London B*, 2006; 361: 195–210.
- [20] Wright SJ, Muller-Landau HC. The future of tropical forest species. *Biotropica*, 2006; 38: 287–301.
- [21] Sodhi NS, Koh LP, Clements R, Wanger TC, Hill JK, Hamer KC, Clough Y, Tschardtke T, Posa MRC, Lee TM. Conserving Southeast Asian forest biodiversity in human-modified landscapes. *Biological Conservation*, 2010; 143: 2375–2384.
- [22] Miettinen J, Shi C, Liew SC. Deforestation rates in insular Southeast Asia between 2000 and 2010. *Global Change Biology*, 2011; 17: 2261–2270.
- [23] Barlow J, Peres CA. Effects of single and recurrent wildfires on fruit production and large vertebrate abundance in a central Amazonian forest. *Biodiversity and Conservation*, 2006; 15: 985–1012.
- [24] Cristobal-Azkarate J, Arroyo-Rodriguez V. Diet and activity pattern of howler monkeys (*Alouatta palliata*) in Los Tuxtlas, Mexico: effects of habitat fragmentation and implications for conservation. *American Journal of Primatology*, 2007; 69: 1013–1029.
- [25] Irwin MT. Feeding ecology of *Propithecus diadema* in forest fragments and continuous forest. *International Journal of Primatology*, 2008; 29: 95–115.
- [26] Gonzalez-Zamora A, Arroyo-Rodriguez V, Chaves OM, Sanchez-Lopez S, Stoner KE, Riba-Hernandez P. Diet of spider monkeys (*Ateles geoffroyi*) in Mesoamerica: current knowledge and future directions. *American Journal of Primatology*, 2009; 71: 8–20.
- [27] Mayaux P, Holmgren P, Achard F, Eva H, Stibig H-J, Branthomme A. Tropical forests cover change in the 1990s and options for future monitoring. *Philosophical Transactions of the Royal Society of London B*, 2005; 360: 373–384.
- [28] Chagnon FJF, Bras RL, Wang J. Climatic shift in patterns of shallow clouds over the Amazon. *Geophysical Research Letters*, 2004; 31.
- [29] Soh MC, Sodhi NS, Lim SL. High sensitivity of montane bird communities to habitat disturbance in Peninsular Malaysia. *Biological Conservation*, 2006; 129: 149–166.
- [30] Trainor CR. Changes in bird species composition on a remote and well-forested island, Wallacea, South-East Asia. *Biological Conservation*, 2007; 140: 373–385.
- [31] Sodhi NS, Lee TM, Warkentin IG. Effects of disturbance or loss of tropical rainforest on birds. *The Auk*, 2008; 125: 511–519.

- [32] Laurance WF, Camargo JLC, Luizão RCC, Laurance SG, Pimm SL, Bruna EM, Stouffer PC, Williamson GB, Benítez-Malvido J, Vasconcelos HL, Van Houtan KS, Zartman CE, Boyle SA, Didham RK, Andrade A, Lovejoy TE. The fate of Amazonian forest fragments: a 32-year investigation. *Biological Conservation*, 2011; 144: 56–67.
- [33] Geist HJ, Lambin EF. Proximate causes and underlying driving forces of tropical deforestation. *BioScience*, 2002; 52: 143–150.
- [34] Maas B, Putra DD, Waltert M, Clough Y, Tschardt T, Schulze CH. Six years of habitat modification in a tropical rainforest margin of Indonesia do not affect bird diversity but endemic forest species. *Biological Conservation*, 2009; 142: 2665–2671.
- [35] Sala OE, Chapin FS, Armesto JJ, Berlow E, Bloomfield J, Dirzo R, Huber-Sanwald E, Huenneke LF, Jackson RB, Kinzig A, Leemans R, Lodge DM, Mooney HA, Oesterheld M, Poff NL, Sykes MT, Walker BH, Walker M, Wall DH. Global biodiversity scenarios for the year 2100. *Science*, 2000; 287: 1770–1774.
- [36] Bagchi R, Philipson CD, Slade EM, Hector A, Phillip S, Villanueva JF, Lewis OT, Lyal CHC, Nilus R, Madran A, Scholes JD, Press MC. Impacts of logging on density-dependent predation of dipterocarp seeds in a South East Asian rainforest. *Philosophical Transactions of the Royal Society of London B*, 2011; 366: 3246–3255.
- [37] Chaves ÓM, Stoner KE, Arroyo-Rodríguez V. Differences in diet between spider monkey groups living in forest fragments and continuous forest in Mexico. *Biotropica*, 2012; 44: 105–113.
- [38] Fischer J, Lindenmayer DB, Manning AD. Biodiversity, ecosystem function, and resilience: ten guiding principles for commodity production landscapes. *Frontiers in Ecology and the Environment*, 2006; 4: 80–86.
- [39] Arriaga-Weiss SL, Calmé S, Kampichler C. Bird communities in rainforest fragments: guild responses to habitat variables in Tabasco, Mexico. *Biodiversity & Conservation*. 2008; 17: 173–190.
- [40] Hübinger T, Schindler S, Seaman BS, Wrbka T, Weissenhofer A. Impact of oil palm plantations on the structure of the agroforestry mosaic of La Gamba, southern Costa Rica: potential implications for biodiversity. *Agroforestry Systems*. 2012; 85: 367–381.
- [41] Myers N, Mittermeier RA, Mittermeier CG, Da Fonseca G, Kent J. Biodiversity hotspots for conservation priorities. *Nature*, 2000; 403: 853–858.
- [42] Carmona, M, Armesto JJ, Aravena JC, Perez C. Coarse woody debris biomass in successional and primary temperate forests in Chiloe Island, Chile. *Forest Ecology and Management*, 2002; 164: 265–275.
- [43] Aravena JC, Carmona M, Perez CC, Armesto JJ. Changes in tree species richness, stand structure and soil properties in a successional chronosequence of forest fragments in northern Chiloe Island, Chile. *Revista Chilena de Historia Natural*, 2002; 75: 339–360.
- [44] Laurance WF, Oliveira AA, Laurance SG, Condit R, Nascimento HEM, Sanchez-Thorin AC, Lovejoy TE, Andrade A, D'Angelo S, Ribeiro JE, Dick CW. Pervasive alteration of tree communities in undisturbed Amazonian forests. *Nature*, 2004; 428: 171–175.

- [45] Poulsen BO. Avian richness and abundance in temperate Danish forests: tree variables important to birds and their conservation. *Biodiversity and Conservation*, 2002; 11: 1551–1566.
- [46] Nadkarni NM, Schaefer D, Matelson TJ, Solano R. Biomass and nutrient pools of canopy and terrestrial components in a primary and a secondary montane cloud forest, Costa Rica. *Forest Ecology and Management*, 2004; 198: 223–236.
- [47] Sekercioglu CH. Increasing awareness of avian ecological function. *Trends in Ecology & Evolution*, 2006; 21: 464–471.
- [48] Lozada T, De Koning GHJ, Marche R, Klein AM, Tschardt T. Tree recovery and seed dispersal by birds: comparing forest, agroforestry and abandoned agroforestry in coastal Ecuador. *Perspectives in Plant Ecology Evolution and Systematics*, 2007; 8: 131–140.
- [49] Kellermann JL, Johnson MD, Stercho AM, Hackett SC. Ecological and economic services provided by birds on Jamaican Blue Mountain coffee farms. *Conservation Biology*, 2008; 22: 1177–1185.
- [50] Whelan CJ, Wenny DG, Marquis RJ. Ecosystem services provided by birds. *Annals of the New York Academy of Sciences*, 2008; 1134: 25–60.
- [51] Sekercioglu CH, Ehrlich PR, Daily GC, Aygen D, Goehring D, Sandi RF. Disappearance of insectivorous birds from tropical forest fragments. *Proceedings of the National Academy of Sciences of the United States of America*, 2002; 99: 263–267.
- [52] Raman TRS. Effects of habitat structure and adjacent habitats on birds in tropical rainforest fragments and shaded plantations in the Western Ghats, India. *Biodiversity and Conservation*, 2006; 15: 1577–1607.
- [53] Gomes LGL, Oostra V, Nijman V, Cleef AM, Kappelle M. Tolerance of frugivorous birds to habitat disturbance in a tropical cloud forest. *Biological Conservation*, 2008; 141: 860–871.
- [54] Tschardt T, Sekercioglu CH, Dietsch TV, Sodhi NS, Hoehn P, Tylianakis JM. Landscape constraints on functional diversity of birds and insects in tropical agro-ecosystems. *Ecology*, 2009; 89: 944–951.
- [55] Reid S, Diaz IA, Armesto JJ, Willson MF. Importance of native bamboo for understory birds in Chilean temperate forests. *The Auk*, 2008; 121: 515–525.
- [56] Diaz IA, Armesto JJ, Reid S, Sieving KE, Willson MF. Linking forest structure and composition: avian diversity in successional forests of Chiloe Island, Chile. *Biological Conservation*, 2005; 123: 91–101.
- [57] Munoz AA, Chacon P, Perez F, Barnet ES, Armesto JJ. Diversity and host tree preferences of vascular epiphytes and vines in a temperate rainforest in southern Chile. *Austral Ecology*, 2004; 51: 381–391.
- [58] Sieving KE, Willson MF, De Santo TL. Defining corridors for endemic birds in fragmented south-temperate rainforest. *Conservation Biology*, 2000; 14: 1120–1132.

- [59] Cornelius C, Cofre H, Marquet PA. Effects of habitat fragmentation on bird species in a relict temperate forest in semiarid Chile. *Conservation Biology*, 2000; 14: 534–543.
- [60] DeSanto TL, Willson MF, Sieving KE, Armesto JJ. Nesting biology of Tapaculos (Rhinocryptidae) in fragmented south-temperate rainforests of Chile. *The Condor*, 2002; 104: 482–495.
- [61] Tvardíková K. Bird abundances in primary and secondary growths in Papua New Guinea: a preliminary assessment. *Tropical Conservation Science*, 2010; 3(4): 373–388.
- [62] Johnson DDP, Mighell JS. Dry-season bird diversity in tropical rainforest and surrounding habitats in North-east Australia. *Emu*, 1999; 99: 108–120.
- [63] Zakaria M, Rajpar MN, Moridi HW, Rosli Z. Comparison of understory bird species in relation to edge-interior gradient in an isolated tropical rainforest of Malaysia. *Environment, Sustainability and Development*, 2014; 16(2): 375–392.
- [64] Shankar Raman TR, Joshi NV, Sukumar R. Tropical rainforest bird community structure in relation to altitude, tree species composition and null models in the Western Ghats, India. *Journal of the Bombay Natural History Society*, 2005; 102(2): 145–157.
- [65] Hughes JB, Daily GC, Ehrlich PR. Conservation of tropical forest birds in countryside habitats. *Ecology Letters*, 2002; 5: 121–129.
- [66] Lim HC, Sodhi NS. Responses of avian guilds to urbanization in a tropical city. *Landscape Urban Planning*, 2004; 66: 199–215.
- [67] Fraterrigo JM, Wiens JA. Bird communities of the Colorado Rocky Mountains along a gradient of exurban development. *Landscape Urban Planning*, 2005; 71: 263–275.
- [68] Campbell SP, Witham JW, Hunter Jr ML. Long-term effects of group selection timber harvesting on abundance of forest birds. *Conservation Biology*, 2007; 21: 1218–1229.
- [69] White JG, Antos MJ, Fitzsimons JA, Palmer GC. Non-uniform bird assemblages in urban environments: the influence of streetscape vegetation. *Landscape Urban Planning*, 2004; 71:123–135.
- [70] Atlegrim O, Sjoberg K. Selective felling as a potential tool for maintaining biodiversity in managed forests. *Biodiversity and Conservation*, 2004; 13: 1123–1133.
- [71] Archabald K, Naughton-Treves L. Tourism revenue-sharing around national parks in Western Uganda: early efforts to identify and reward local communities. *Environmental Conservation*, 2001; 28: 135–149.
- [72] Fa J, Currie D, Meeuwig J. Bushmeat and food security in the Congo Basin: linkages between wildlife and people's future. *Environmental Conservation*, 2003; 30: 71–78.
- [73] Estrada A, Coates-Estrada R, Meritt Jr. D. Bat species richness and abundance in tropical rainforest fragments and in agricultural habitats at Los Tuxtlas, Mexico. *Ecography*, 1993; 16: 309–318.

- [74] Ruppert NB, Mansori A, Anuar SMS. Diversity and biomass of terrestrial small mammals at a Malaysian primary rainforest (Segari Melintang forest reserve, Peninsular Malaysia). *Journal of Tropical Life Sciences*, 2015; 5(1): 3–34.
- [75] Boubli JP, Grelle CEV, van Schaik CP. Small mammal species diversity and composition in two ecologically distinct rain forest sites in Northern Sumatra, Indonesia. *Ecotropica*, 2004; 10: 149–154.
- [76] Brodie JF, Gibbs H. Bushmeat hunting as climate threat. *Science*, 2009; 326: 364–365.
- [77] Jansen P, Muller-Landau HC, Wright S. Bushmeat hunting and climate: an indirect link. *Science*, 2010; 327, 30.
- [78] Visconti P, Pressey RL, Giorgini D, Maiorano L, Bakkenes M, Boitani L, Alkemade A, Falcucci A, Chiozza F, Rondinini C. Future hotspots of terrestrial mammal loss. *Philosophical Transactions of the Royal Society of London B*, 2011; 366: 2693–2702.
- [79] Cardillo M, Mace GM, Jones KE, Bielby J, Bininda-Emonds ORP, Sechrest W, Orme CDL, Purvis A. Multiple causes of high extinction risk in large mammal species. *Science*, 2005; 309: 1239–1241.
- [80] Laurance WF, Croes BM, Tchignoumba L, Lahm SA, Alonso A, Lee ME, Campbell P, Ondzeano C. Impacts of roads and hunting on Central African rain forest mammals. *Conservation Biology*, 2006; 20: 1251–1261.
- [81] Western D, Russell S, Cuthill I. The status of wildlife in protected areas compared to non-protected areas of Kenya. *PLoS One*, 2009; 4: e6140.
- [82] Craigie ID, Baillie JEM, Balmford A, Carbone C, Collen B, Green RE, Hutton JM. Large mammal population declines in Africa's protected areas. *Biological Conservation*, 2010; 143: 2221–2228.
- [83] Nijman, V. An overview of international wildlife trade from Southeast Asia. *Biodiversity Conservation*, 2010; 19: 1101–1114.
- [84] Hoffmann M, Belant JL, Chanson JS, Cox NA, Lamoreux J, Rodrigues ASL, Schipper J, Stuart SN. The changing fates of the world's mammals. *Philosophical Transactions of the Royal Society of London B*, 2011; 366: 2598–2610.
- [85] Ferraz G, Russell GJ, Stouffer PC, Bierregaard RO, Pimm SL, Lovejoy TE. Rates of species loss from Amazonian forest fragments. *Proceedings of the National Academy of Sciences of the United States of America*, 2003; 100: 14069–14073.
- [86] Kinnaird M, Sanderson E, O'Brien TG, Wibisono H, Woolmer G. Deforestation trends in a tropical landscape and implications for endangered large mammals. *Conservation Biology*, 2010; 17: 245–257.
- [87] Henle K, Davies KF, Kleyer M, Margules C, Settele J. Predictors of species sensitivity to fragmentation. *Biodiversity Conservation*, 2004; 13: 207–251.

- [88] Felton AM, Felton A, Wood J, Lindenmayer DB. Diet and feeding ecology of *Ateles chamek* in a Bolivian semihumid forest: the importance of *Ficus* as a staple food resource. *International Journal of Primatology*, 2008; 29: 379–403.
- [89] Silva SSB, Ferrari SF. Behavior patterns of southern bearded sakis (*Chiropotes satanas*) in the fragmented landscape of eastern Brazilian Amazonia. *American Journal of Primatology*, 2009; 71: 1–7.
- [90] Boyle SA, Smith AT. Behavioral modifications in northern bearded saki monkeys (*Chiropotes satanas chiropotes*) in forest fragments of central Amazonia. *Primates*, 2010; 51: 43–51.
- [91] Palacios E, Rodriguez A. Ranging pattern and use of space in a group of red howler monkeys (*Alouatta seniculus*) in a southeastern Colombian rainforest. *American Journal of Primatology*, 2001; 55: 233–251.
- [92] Veiga LM, Ferrari SF. Predation of arthropods by southern bearded sakis (*Chiropotes satanas*) in eastern Brazilian Amazonia. *American Journal of Primatology*, 2006; 68: 209–215.
- [93] Boyle SA, Zartman CE, Spironello WR, Smith AT. Implications of habitat fragmentation on the diet of bearded saki monkeys in central Amazonian forest. *Journal of Mammalogy*, 2012; 93(4): 959–976.
- [94] Rolex RE, Leano EP, Ates-Camin FB. Herpetofaunal endemism and diversity in tropical forests of MT. Hamiguitan in the Philippines. *Herpetological Conservation and Biology*, 2010; 6(1): 107–113.
- [95] Brown GW. The influence of habitat disturbance on reptiles in a box-ironbark eucalypt forest of south-eastern Australia. *Biodiversity and Conservation*, 2001; 10: 161–176.
- [96] Irschick DJ, Carlisle E, Elstrott J, Ramos M, Buckley C, Vanhooydonck B, Meyers J, Herrel A. A comparison of habitat use, morphology, clinging performance and escape behaviour among two divergent Green Anole Lizard (*Anolis carolinensis*) populations. *Botanical Journal of the Linnean Society*, 2005; 85: 223–234.
- [97] Kanowski JJ, Reis TM, Catterall, CP, Piper SD. Factors affecting the use of reforested sites by reptiles in cleared rainforest landscapes in tropical and subtropical Australia. *Restoration Ecology*, 2006; 14: 67–76.
- [98] Fahrig L. Effects of habitat fragmentation on biodiversity. *Annual Review of Ecology and Systematics*, 2003; 34(1): 487–515.
- [99] Rocha CFD, Bergallo HG, Van Sluys M, Alves M, Jamel C. The remnants of restinga habitats in the Brazilian Atlantic Forest of Rio de Janeiro State, Brazil: habitat loss and risk of disappearance. *Brazilian Journal of Biology*, 2007; 67 (2): 263–273.
- [100] Rocha CFD, Vrcibradic D, Kiefer MC, Menezes VA, Fontes AF, Hatano FH, Galdino CAB, Bergallo HG, Van Sluys M. Species composition, richness and nestedness of lizard

- assemblages from Restinga habitats along the Brazilian coast. *Brazilian Journal of Biology*, 2014; 74(2): 349–354.
- [101] Rajpar MN, Zakaria M. Mangrove Fauna of Asia. *In: Mangrove Ecosystems of Asia, Status, Challenges and Management Strategies* Hanum, F., Mohamad, A.L., Hakeem, K. R., Ozturk, M. (Eds.). Springer Science + Business Media New York, USA. 2014; 500 p. ISBN: 978-1-4614-8581-0.
- [102] Stuart SN, Chanson JS, Cox NA, Young BE, Rodrigues ASL, Fischman DL, Waller RW. Status and trends of amphibian declines and extinctions worldwide. *Science*, 2004; 306: 1783–1786.
- [103] Rowley J, Brown R, Bain R, Kusrini M, Inger R, Stuart B, Wogan G, Thy N, Chanard T, Trung CT, Diesmos A, Iskandar DT, Lau M, Ming LT. Opinion piece; impending conservation crisis for Southeast Asian amphibians. *Biology Letters*, 2010; 6: 336–338.
- [104] Bickford D, Iskandar DT, Barlian A. A lungless frog discovered in Borneo. *Current Biology*, 2008; 18: 374–375.
- [105] International Union for Conservation Nature. IUCN Red List of Threatened Species, Version 2009.1. Web accessed on 1st May, 2009 at URL: [www.iucnredlist.org](http://www.iucnredlist.org).
- [106] Gillespie GR, Ahmad E, Elahan B, Evans A, Ancrenaz M, Goossens B, Scroggie MP. Conservation of amphibians in Borneo: relative value of secondary tropical forest and non-forest habitats. *Biological Conservation*, 2012; 152: 136–144.
- [107] Schnitzer SA, Carson WP. Treefall gaps and maintenance of species diversity in a tropical forest. *Ecology*, 2001; 82: 913–919.
- [108] Laurance WF, Peres CA. *Emerging threats to Tropical Forests*. University of Chicago Press, Chicago, USA. 2005; 520 p. ISBN: 9780226470221.
- [109] Ewers RM, Didham RK. Confounding factors in the detection of species responses to habitat fragmentation. *Biological Reviews*, 2006; 81: 117–142.
- [110] Santos AB, Benitez-Malvido J. Insect herbivory and leaf disease in natural and human disturbed habitats: lesson from early-successional *Heliconia* herbs. *Biotropica*, 2012; 44: 53–62.
- [111] Laurance WF, Goosem M, Laurance SG. Impacts of roads and linear clearings on tropical forests. *Trends in Ecology & Evolution*, 2009; 24: 659–669.
- [112] Sendoya SF, Silva PSD, Farji-Brener AG. Does inundation risk affect leaf-cutting ant distribution? A study along a topographic gradient of a Costa Rican tropical wet forest. *Journal of Tropical Ecology*, 2013; 30(1): 82–90.
- [113] Basset Y. Invertebrates in the canopy of tropical rain forests How much do we really know? *Plant Ecology*, 2001; 153: 87–107.

