

CHAPTER 7. AMPHIBIANS OF THE INDOMALAYAN REALM

Raoul Bain, S.D. Biju, Rafe Brown, Indraneil Das, Arvin Diesmos, Sushil Dutta, David Gower, Robert Inger, Djoko Iskandar, Yoshio Kaneko, Michael Wai Neng Lau, Madhava Meegaskumbura, Annemarie Ohler, Theodore Papenfuss, Rohan Pethiyagoda, Bryan Stuart, Mark Wilkinson, and Feng Xie

THE GEOGRAPHIC AND HUMAN CONTEXT

The Indomalayan Realm (sometimes termed the Oriental region) encompasses all of South and Southeast Asia, including the Indonesian and Philippine archipelagos, and incorporating the major offshore islands of Sri Lanka, Hainan, and Taiwan, as well as Japan's Ryukyu archipelago. The western and northern boundaries follow that of Olson *et al.* (2001), reaching Pakistan, the Himalaya, and southern subtropical China, although the boundary between the Palearctic and Indomalayan Realm is somewhat unclear in south-east China. However, as here defined, the eastern boundary between Indomalaya and Australasia, which is usually taken as Wallace's line (an imaginary line named for Alfred Russell Wallace running between Borneo and Sulawesi, and between Bali and Lombok in Indonesia), is here taken to lie further to the east, such that the region includes all of Nusa Tenggara and a number of islands in Maluku (but excluding Seram, Amboin, Buru, Obi, Halmahera, Tanimbar and a few other smaller islands) (see Tyler 1999).

The geological, evolutionary, and climatic history of this region is complex and is reflected by the evolutionary history and diversity of its fauna. Peninsular India, which includes Sri Lanka, consists of a single tectonic plate (the Deccan or Indian Plate) that separated from Gondwanaland about 130 Ma and, after breaking away from Madagascar and the Seychelles around 90 Ma, rafted across the Tethys Sea eventually colliding with Eurasia at about 65–40 Ma (Beck *et al.* 2005). This massive collision resulted in the uplift of the Himalaya and the Tibetan plateau, which caused dramatic climatic changes over vast expanses across South Asia. Although the climate of almost the whole of Peninsular India is monsoonal, the region is varied both in terms of topography and vegetation, including, for example, rainforests (e.g., in the Western Ghats, south-western Sri Lanka, and Myanmar), arid areas (such as the Thar Desert in north-western India), low-lying swamps and mangroves (in the Sundarbans), and island systems (Andamans and Nicobars). Peninsular India is relatively flat, and is highest in the south-west, with the western flank of the plateau being formed by the Western Ghats.

Similarly, the coming together of the Indian plate with the Asian continental landmass has influenced much of the topography in mainland Southeast Asia, including the general north-south orientation of the mountains and main rivers. Much of this region (often referred to more generally as Indo-Burma) is characterized by distinct seasonal weather patterns (for example, in northern Vietnam and southern coastal China, the dominant weather pattern is the north or north-easterly monsoon during the northern winter and east or south-easterly monsoon in the summer). Originally, most of the region was dominated by broadleaf forests; the most diverse forests are the lowland mixed wet evergreen forests, which occur in climates with one to four dry months.

Another geological highlight of the region is the islands forming part of the Malay Archipelago, comprising the Greater Sundas – including Borneo and Sumatra (the third and sixth largest islands on earth, respectively), Java, and Sulawesi – the Lesser Sundas, the Philippines, and several islands of the Moluccas. This is one of the most active seismic regions in the world, and the site of some of the most dramatic seismic events known, including the eruption of Krakatau in 1883 and the earthquake that caused a massive tsunami in the Indian Ocean, just off the coast of Aceh, Sumatra, on December 26th, 2004. The highest point in the region is Gunung Kinabalu in northern Borneo at 4,101m. The islands of the Sunda shelf were connected to mainland Southeast Asia through most, if not all, of the Tertiary, and were also periodically connected during episodes of northern glaciation during the Quaternary, which is why the fauna and flora of these two regions have much in common. At the same time, oscillations in sea levels caused periodic severing of these ephemeral land bridges, isolating nearby continental islands, and presumably allowing for the evolution and accumulation of endemic species. The climate is tropical, and the vegetation, at least up until a few decades ago, comprised mainly lowland evergreen rainforest.

Human population density is very high across this region (averaging 124 people per square kilometre across Southeast Asia), including, as it does, several of the most populous countries on earth, such as India (with an estimated 1.1 billion people) and Indonesia (220 million). Population density ranges from a whopping 336 people per square kilometre in India, to 277 per square kilometre in the Philippines, 117 people per square kilometre in Indonesia, to 25 people per square kilometre in Lao P.D.R. The percentage of the population

concentrated in urban areas also varies, with nearly 20% of people in Cambodia concentrated in urban areas, 30% in India, around 48% in Indonesia, and nearly two-thirds of people in the Philippines and Malaysia. With the exception of Singapore (gross national income per capita of US\$24,000), all countries have a GNI per capita of less than US\$5,000.

Given the high human population densities in the region, the impact of society on ecosystems has been severe. Mainland Southeast Asia was probably one of the first regions where agriculture developed (Diamond 1997), and there has been a long history of shifting or permanent small-scale agriculture. More recently, though, the exploitation of Southeast Asia's valuable timber for commercial trade, and the demand for land to grow cash-crops and trees, have led to widespread and rampant forest loss, particularly of lowland evergreen forest, dominated mainly by the giant dipterocarps. Several estimates of forest loss across the region are available; one recent study estimates that Kalimantan's protected lowland forests declined by 56% between 1985 and 2001 primarily from logging (Curran *et al.* 2004), and that less than 33% of lowland forest and peat swamp remains across all of Indonesian Borneo (Whitten *et al.* 2005). Unfortunately, even where rainforest habitat remains relatively intact, the unmitigated harvest and trade of some of the larger species of animals has been so intensive that the term "empty forest syndrome" was coined (Redford 1992); this "empty forest" phenomenon is particularly apparent in China, Vietnam, Laos and Cambodia.

GLOBAL CONSERVATION STATUS

A total of 329 (33%) of the amphibian species in the Indomalayan Realm are considered to be globally threatened or Extinct (Figure 1). This is very similar to the global average. The Indomalayan Realm contains 17% of all globally threatened amphibians. When looking at the Red List Categories, Indomalaya accounts for only 7% of the world's CR species, but 17% of the EN species, and 21% of the VU species. Hence, on the basis of current knowledge, threatened Indomalayan amphibians are more likely to be in a lower category of threat, when compared with the global distribution of threatened species amongst categories. The percentage of DD species, 26% (255 species), is also similar to, though slightly higher than, the global average of 23%. This high percentage is not surprising, given that much of the region is still very poorly surveyed for amphibians.

Twenty of the world's 34 known amphibian extinctions (59%) have occurred in this region (Table 1), 19 of these in Sri Lanka and one in southern India. Eighteen of these species are frogs from the genus *Philautus*, and most of these probably had tiny ranges and died out as a result of extensive forest loss, perhaps as long ago as the late 1800s or early 1900s (Manamendra-Arachchi and Pethiyagoda 2005). In addition, one Critically Endangered species in the Indomalayan Realm is considered to be possibly extinct, *Philautus jacobsoni* from central Java, Indonesia. It is suspected that the apparent concentration of extinctions in Sri Lanka, as opposed to other parts of the region, is a result of better knowledge of this country due to recent herpetological work (e.g., Manamendra-Arachchi and Pethiyagoda 2005; and see Essay 4.1), in which the extant fauna has been extensively surveyed and compared with the historical baseline provided by museum specimens.

SPECIES RICHNESS AND ENDEMISM

Species Richness and Endemism Across Taxa

The 999 native amphibian species in the Indomalayan Realm represent 17% of the currently known global total of 5,915 species. Of these, 800 (or 80%) are endemic to the region (Table 2). All three amphibian orders, are represented in the Indomalayan Realm, but the frogs account for 92% of the species. Contrary to the situation in some other regions, endemism is much lower in the salamanders (46%) as compared with the frogs and toads (80%). This is because most of the Indomalayan salamanders occur in central China, on the poorly defined boundary (which is in fact a broad overlap zone) with the Palearctic, thus occurring in both regions. Caecilian endemism is 100%. Although Indomalaya has the second highest number of species of any realm (though well behind the Neotropics), it has only 14 families, which is fewer than any realm except Australasia. Three of these families are endemic. Only 45 species (5% of the species in the region) are members of these endemic families, although the treefrog family Rhacophoridae occurs only marginally in the Palearctic and Afrotropical Regions and is predominantly Indomalayan.

Under current climatic conditions, there is essentially no isolation between the Palearctic and Indomalayan Realms, especially in China, and the boundary between these two faunas is somewhat arbitrary. The effect of this indistinct boundary is to reduce the level of endemism of both regions. Summaries of the amphibian fauna of the Indomalayan Realm are provided by Bourret (1942), Inger (1999), Iskandar and Colijn (2000), and Zhao (1999).

There are 81 genera (18% of the global total) occurring in the region, of which 37 (46%) are also endemic. Endemism at the generic level is much lower among the salamanders (with no endemic genera) than it is among the frogs and toads (46%), contrary to the situation in the Palearctic. Generic level endemism is 100% among the caecilians. The most speciose endemic genera in the region are *Ichthyophis* (34 species), *Ansonia* (22 species), *Kalophrynus* (15 species), *Nyctibatrachus* (12 species) and *Micrixalus* (11 species). At the opposite end of the spectrum, there are 11 monotypic genera endemic to the Indomalayan Realm, all of which are frogs. The 44 non-endemic genera in Indomalaya include 37 frog genera (13 genera from the Ranidae, eight from the Megophryidae, seven from the Rhacophoridae, five from the Microhylidae, two from the Hylidae, and one each from Bombinatoridae and Bufonidae) and seven salamander genera (five from the Salamandridae, and one each from the Cryptobranchidae and the Hynobiidae). These non-endemics include the widespread genera *Bufo*, *Rana* and *Litoria*. It should be noted that future taxonomic changes are likely to have a major impact on the patterns outlined above, with a tendency for the number of genera (including monotypic genera) to increase.

As noted already, 29% (14/48) of the world's amphibian families occur in the Indomalayan Realm, and three of these are endemic: Nasikabatrachidae, Ichthyophidae, and Uraeotyphlidae. The characteristics of these families are provided in Chapter 1. Among the non-endemic families, the majority of Indomalayan species are in the Bufonidae (true toads), Megophryidae (Asian spadefoots), Microhylidae (narrow-mouthed toads), Ranidae (true frogs), Rhacophoridae (Asian treefrogs), and Salamandridae (newts and relatives). The

Figure 1. Summary of Red List categories for amphibians in the Indomalayan Realm. The percentage of species in each category is also given.

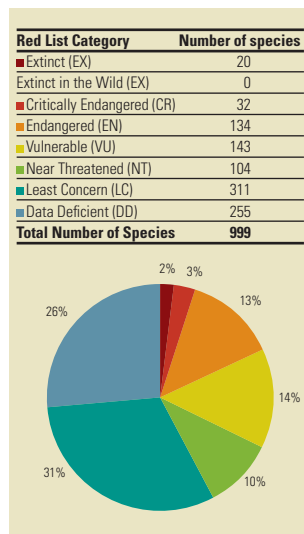


Table 1. The Extinct amphibians of the Indomalayan Realm.

Species	Country
<i>Adenomus kandianus</i>	Sri Lanka
<i>Nannophrys guentheri</i>	Sri Lanka
<i>Philautus adspersus</i>	Sri Lanka
<i>Philautus dimbuliae</i>	Sri Lanka
<i>Philautus eximius</i>	Sri Lanka
<i>Philautus extirpo</i>	Sri Lanka
<i>Philautus halyi</i>	Sri Lanka
<i>Philautus hypomelas</i>	Sri Lanka
<i>Philautus leucorhinus</i>	Sri Lanka
<i>Philautus malcolmsmithi</i>	Sri Lanka
<i>Philautus nanus</i>	Sri Lanka
<i>Philautus nasutus</i>	Sri Lanka
<i>Philautus oxyrhynchus</i>	Sri Lanka
<i>Philautus rugatus</i>	Sri Lanka
<i>Philautus stellatus</i>	Sri Lanka
<i>Philautus temporalis</i>	Sri Lanka
<i>Philautus travancoricus</i> ¹	India
<i>Philautus variabilis</i>	Sri Lanka
<i>Philautus zal</i>	Sri Lanka
<i>Philautus zimmeri</i>	Sri Lanka

Theloderma gordoni (Least Concern) is an Asian treefrog in the family Rhacophoridae. This species is known from monsoon forests in Thailand and Vietnam, and is believed to breed in cavities in trees. © Nikolai L. Orlov





Bufonidae occur widely in the Indomalayan Realm as far south and east as Sulawesi and the southern parts of the Philippines, with 84 species in eight genera. Most species in the region are endemic, but 12 species are shared with the Palearctic. All Indomalayan species breed by larval development, and occur in many different habitats.

There are 90 species across 10 genera in the Megophryidae in the Indomalayan Realm. This family is predominantly Indomalayan, with over 70% of its species occurring in the region, and 44% of them globally endemic (all other species occurring in the Palearctic Region). Thirty-four species in China cross the Indomalayan-Palearctic boundary. The family ranges from Nepal, Bangladesh, and north-eastern India, through central and southern China, and Southeast Asia as far as Java, Borneo and the Philippines.

The Microhylidae range very widely through the region, with 88 species, 77 of which are endemic. They occur in a wide variety of habitats, and all Indomalayan species breed by larval development, except for eight species of the genus *Oreophryne* in the eastern parts of Indonesia and the Philippines which are direct developers. Most of the non-endemic species are shared with the Palearctic.

The Ranidae constitute the largest family in the Indomalayan Realm, accounting for over one-third of the total amphibian fauna of the region. One-third of the ranids are in the genus *Rana*. The family is found throughout the region, occurring in most habitats, and all species breed by larval development, except in the genera *Ingerana* (5 species) and *Platymantis* (27 species).⁵

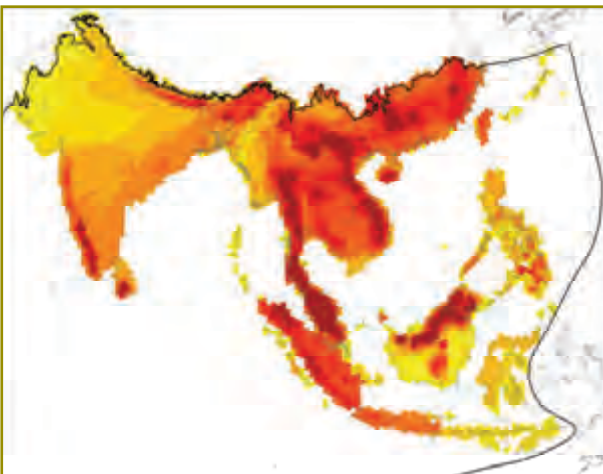


Figure 2. The species richness of amphibians in the Indomalayan Realm, with darker colours corresponding to regions of higher richness. Colour scale based on 10 quantile classes; maximum richness equals 84 species.

This close-up view of the head of *Ichthyophis tricolor* (Least Concern) shows the tentacle which is characteristic of caecilians. This subterranean species from the Western Ghats in India lives in soil in wet semi-evergreen tropical forest, but also occurs in farmland and rubber plantations. Like other members of the family Ichthyophiidae, it has aquatic larvae in streams. © Photo by John Measey, courtesy of The Natural History Museum, London



Family	Native species (endemics to region)	Percentage of species in region that are endemic (%)	Percentage of species in family that are endemic to region (%)	Native genera (endemics to region)	Percentage of genera in region that are endemic (%)	Percentage of genera in family that are endemic to region (%)
Anura						
Bombinatoridae	4 (3)	75	30	2 (1)	50	50
Bufonidae	84 (72)	86	15	8 (7)	88	21
Hylidae	12 (4)	33	0.5	2 (0)	0	0
Megophryidae	90 (56)	62	44	10 (2)	20	20
Microhylidae	88 (77)	89	18	14 (9)	64	13
Nasikabatrachidae	1 (1)	100	100	1 (1)	100	100
Ranidae	375 (290)	77	44	24 (11)	46	28
Rhacophoridae	263 (230)	87	84	8 (1)	13	11
TOTAL ANURA	917 (733)	80	14	69 (32)	46	9
Caudata						
Cryptobranchidae	1 (0)	0	0	1 (0)	0	0
Hynobiidae	6 (3)	50	7	1 (0)	0	0
Salamandridae	21 (10)	48	14	5 (0)	0	0
TOTAL CAUDATA	28 (13)	46	2	7 (0)	0	0
Gymnophiona						
Caeciliidae	10 (10)	100	9	2 (2)	100	8
Ichthyophiidae	39 (39)	100	100	2 (2)	100	100
Uraeotyphlidae	5 (5)	100	100	1 (1)	100	100
TOTAL GYMNOPIHIONA	54 (54)	100	31	5 (5)	100	15
TOTAL ALL AMPHIBIANS	999 (800)	80	14	81 (37)	46	8

Table 2. The number of Indomalayan amphibians in each taxonomic family present in the region.

The Rhacophoridae are a predominantly Indomalayan family, with 263 species (and eight genera) occurring in the region, of which 230 are endemic. The family occurs widely through the region, east to the Philippines and Sulawesi. Many of the species are arboreal, and this family includes the flying frogs. The family is split approximately evenly between direct developers (many species in the genus *Philautus*) and larval developers (some of which use foam nests).⁶

The Salamandridae are predominantly a Palearctic family, but 21 species occur in the Indomalayan Realm, 10 of which are endemic. Most of the Indomalayan species occur in southern China. All Indomalayan species breed by larval development.

Among the smaller non-endemic families, the Bombinatoridae (fire-bellied toads) have an unusual distribution. This family occurs mainly in the Palearctic, but two species also occur in southern China (one extending into northern Vietnam), and another two (in the genus *Barbourula*) are highly isolated from the rest of the family in Kalimantan (southern Borneo) and in the Palawan island group (south-western Philippines). Some of these are highly aquatic species, with the genus *Bombina* breeding by larval development (the breeding remaining unknown in *Barbourula*).

The Hylidae are absent from much of the region, but eight species in the genus *Hyla* occur in the northern parts of the region (mainly in China) and four species in the genus *Litoria* occur on islands in the extreme east of the region in Indonesia.

The giant salamanders (Cryptobranchidae) are represented in the region by a single non-endemic species (the Chinese Giant Salamander *Andrias davidianus*), which until recently occurred widely in southern China. These animals are aquatic and are associated with clear streams where they breed by larval development.

The Asian salamanders (Hynobiidae) are mainly a Palearctic family having their distribution centred on Japan and China, with six species occurring in the Indomalayan Realm. All species have larval development.

The caecilian family Caeciliidae occurs predominantly in the Neotropics and Afrotropics, but 10 species occur in India, mainly in the Western Ghats in the south of the country, though one species is present in the north-east. All Indomalayan species are assumed to have terrestrial eggs and breed by direct development, although direct evidence is very scarce (only known for one species, *Gegeneophis ramsawami*).

There are high percentages of threatened and extinct species in most families in the Indomalayan Realm (Table 3). The three small families Bombinatoridae, Nasikabatrachidae, and Cryptobranchidae are entirely composed of threatened species, and all but one species of Hynobiidae is threatened. The threat level among the salamanders is much higher than that of the frogs, with over half of the species at risk. The salamander faunas of the Palearctic, Nearctic and Neotropics also face high threat levels. In the Indomalayan Realm, over-harvesting for medicine and food, coupled with habitat loss and/or restricted range, are probably the most significant threats facing these species (see later). Conversely, threat

The Hole-in-the-Head Frog *Huia cavitytympanum* (Least Concern) is in the family Ranidae and is endemic to central and northern Borneo, where it inhabits rainforests in hilly terrain. The tadpoles cling to rocks in strong rapids in clear streams. © Nikolai L. Orlov

Table 3. The number of species within each IUCN Red List Category in each Family and Order in the Indomalayan Realm. Introduced species are not included.

Family	EX	CR	EN	VU	NT	LC	DD	Total Number of Species	Number threatened or Extinct	% Threatened or Extinct
Anura										
Bombinatoridae	0	0	1	3	0	0	0	4	4	100
Bufonidae	1	3	17	13	11	27	12	84	34	40
Hylidae	0	0	0	0	0	9	3	12	0	0
Megophryidae	0	1	6	20	10	34	19	90	27	30
Microhylidae	0	1	8	12	11	31	25	88	21	24
Nasikabatrachidae	0	0	1	0	0	0	0	1	1	100
Ranidae	1	8	43	55	43	141	84	375	107	29
Rhacophoridae	18	17	50	33	25	57	63	263	118	45
TOTAL ANURA	20	30	126	136	100	298	206	917	312	34
Caudata										
Cryptobranchidae	0	1	0	0	0	0	0	1	1	100
Hynobiidae	0	0	3	2	0	0	1	6	5	83
Salamandridae	0	1	5	3	4	6	2	21	9	43
TOTAL CAUDATA	0	2	8	5	4	6	3	28	15	54
Gymnophiona										
Caeciliidae	0	0	0	0	0	1	9	10	0	0
Ichthyophiidae	0	0	0	2	0	5	32	39	2	5
Uraeotyphlidae	0	0	0	0	0	0	5	5	0	0
TOTAL GYMNOPIHIONA	0	0	0	2	0	6	46	54	2	4
TOTAL ALL AMPHIBIANS	20	32	134	143	104	310	255	999	329	33