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Species diversity and threat status of amphibians in the Kanneliya Forest, lowland Sri Lanka

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Sri Lanka is endowed with rich biodiversity and, like the Western Ghats of India, considered one of the global biodiversity hotspots (Myers 2000). Both regions have a high number of endemic species, including lower vertebrate groups such as amphibians, reptiles and fish, and invertebrates such as freshwater crabs and shrimps (Bossuyt et al. 2004). Amphibians are an important faunal group in this region, and research in this area over the past few years has revealed many new species (Dutta & Manamendra-Arachchi 1996, Manamendra-Arachchi & Pethiyagoda 2005, Meegaskumbura & Manamendra-Arachchi 2005). Sri Lanka itself has one of the highest degrees of amphibian diversity among the South Asian islands (Meegaskumbura et al. 2002, Pethiyagoda & Manamendra-Arachchi 2006). Extensive field surveys by many groups of herpetologists have resulted in the discovery of new amphibian taxa of different lineages, at present comprising 108 species of which 92 are endemic to Sri Lanka (de Silva 2009, Frost 2011, Manamendra-Arachchi & Pethiyagoda 2006, Meegaskumbura & Manamendra-Arachchi 2005, Meegaskumbura et al. 2007, Meegaskumbura et al. 2009). Two-hundred years ago, the Sri Lankan wet forests were home to more than 90% of Sri Lanka's known amphibians (Senanayake et al. 2008), but vast areas of these once extensive forests have been destroyed over the past 150 years. However, they still harbour many undiscovered species. During our survey of the Kanneliya Forest in 2009, we observed several species of the family Rhacophoridae, which may belong to new, undescribed species, as they differ from the known *Pseudophilautus* occurring in Sri Lanka. Thus, our results further highlight the importance of the Kanneliya Forest as one of the major centres of amphibian diversity in Sri Lanka and its need for prioritisation in conservation efforts.

The Kanneliya Forest Reserve is situated in the Kanneliya-Dediyagala-Nakiyadeniya (KDN) complex in the lowland wet zone of southern Sri Lanka, about 35 km northeast of the historic city of Galle. The total area of forest in the KDN complex is 12,196 hectares (Jayasuriya & Abayawardana 2008). The Kanneliya Forest is the largest of the three conjoined forests, about 6,114 hectares in extent, with an average annual rainfall of about 4445 mm mainly during the southwest monsoon season (Jayasuriya & Abayawardana 2008). The mean monthly temperature is around 27°C. The entire area of the Kanneliya Forest Reserve has the status of a Man and Biosphere Reserve with one of the most floristically rich areas in South Asia (Bandaratilaka 2003). Its great biodiversity and fauna, a mixture of high-level endemism and various affinities with other biogeographical regions, have attracted the attention of taxonomists and evolutionary biologists. In terms of the amount of biodiversity per unit, it rivals the Sinharaja World Heritage Forest (Bandaratilaka 2003).

Our study in the Kanneliya Forest was carried out during field visits from 2008 to 2009. Different parts of the forest were surveyed by visual encounter. The microhabitat of each species in different areas of the forest was recorded and the specimens were photographed on site with a Nikon D50 digital camera. Identification of live specimens captured in the field was based on various morphological characters. Live specimens were released at the site of capture soon after conclusive identification. Sampling was carried out during both day and night; a magnifying glass and an MI 24 STERX microscope were used to examine details of external morphology. Species identification was done using available published keys (Dutta & Manamendra-Arachchi 1996, Manamendra-Arachchi & Pethiyagoda 2005, Meegaskumbura & Manamendra-Arachchi 2005, Manamendra-Arachchi & Pethiyagoda 2006, Meegaskumbura et al. 2009).

The lowland of Sri Lanka harbours 37 recognized species of amphibians belonging to 16 genera (Manamendra-

Arachchi & Pethiyagoda 2006, Meegaskumbura et al. 2009) of which a total of 33 species in 14 genera in seven families were recorded for the Kanneliya Forest area during the study period. They represent about 30% of the island's total amphibian fauna and include 26 species endemic to the island. Two species recorded are critically endangered, three of them are near threatened, nine are considered endangered, four species are vulnerable, 14 species are least concern, and one is data deficient according to IUCN criteria (IUCN 2010).

We encountered 18 species of the subfamily Rhacophorinae, genera *Pseudophilautus* (Fig. 1A, B), *Polypedates* and *Taruga* (Fig. 1C); the diversity of amphibians encountered is shown in Table 1. The highest number of individuals was recorded of the species *Pseudophilautus folicola*, with many juveniles observed. *Pseudophilautus auratus* shows a particular microhabitat preference for *Freycinetia* sp., inside leaf clusters on the plant, with 100% of the specimens recorded from this microhabitat during the survey period. This is the first record for the region and it is remarkable in that it also constitutes the first record apart from its type locality, the Rakwana Massif. A few individuals of *Pseudophilautus cavirostris* were found on tree trunks during day and night searches. *Taruga longinasus* (Fig. 1C) and *Duttaphrynus noellerti* were found on three occasions on the main road through the forest, both during day and night time searches. The most common species in the fern-dominated habitat were *Pseudophilautus tanu* and *P. hoipolloi*. Tree holes are the most preferred habitat of *Ramanella nagao*, with 100% of the individuals recorded from this microhabitat. The preferred microhabitat of *Pseudophilautus sordidus*, *Adenomus kelaartii* and *Hylarana temporalis* was shaded rocky terrain near streams in dense forest.

Most of the amphibian species that were recorded during this survey belong to the genus *Pseudophilautus* and some are restricted to rainforest. The critically endangered and extremely rare *Pseudophilautus nemus* was found in Kanneliya. This finding is significant, as the species was formerly known only from its type locality. The species was described based on one specimen collected from the Haycock Forest. The records of a few unidentified amphibian species are noteworthy in this research, and taxonomic and molecular studies are in progress to evaluate their status. The most common amphibian species that were recorded during this survey are *Fejervarya limnocharis* and *Pseudophilautus popularis*. *Kaloula taprobanica* and *Hoplobatra-*

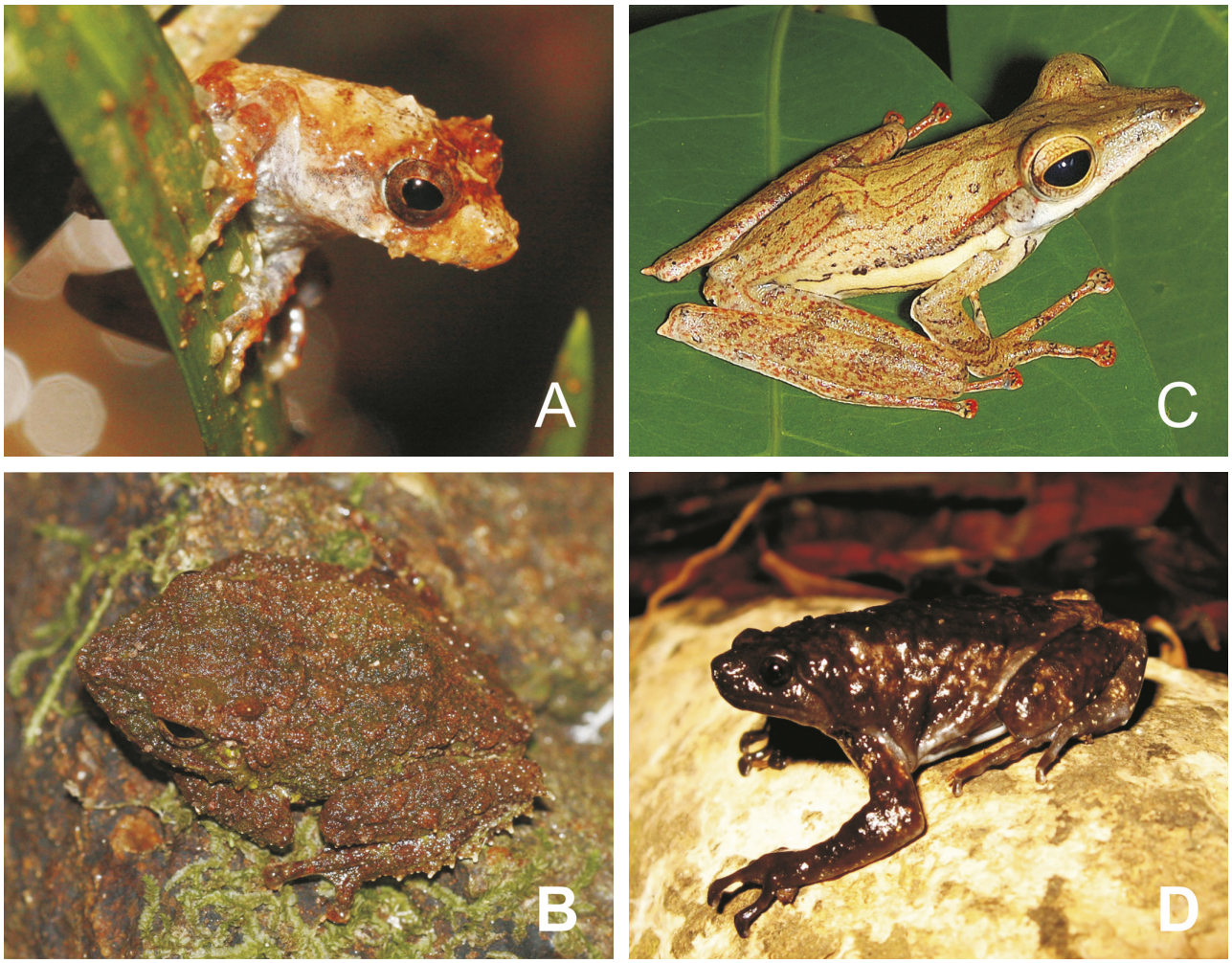

Figure 1. (A) *Pseudophilautus singu,* (B) *Pseudophilautus cavirostris,* (C) *Taruga longinasus*, (D) *Ramanella nagaoi* (Photos: M.K., O.J. and K.W.).

Table 1. Summary of geographical distribution, recognized generic diversity, and species diversity for all amphibian families represented in the Kanneliya Forest.

Family	Altitude / Geographical distribution	Species	No. of recognized genera
Ichthyophiidae	*60 < *1355m Rakwana, central highlands, Namunukula, Knuckles	*Ichthyophis glutinosus*	1
	*60 < *1525 m central highlands	*I. pseudangularis*	
Bufonidae	*60 < 1300 m central highlands, Knuckles , Rakwana	*Adenomus kelaartii*	2
	*5 < *1800 m central highlands, Knuckles	*Duttaphrynus melanostictus*	
	*61 < *400 m Rakwana	*D. noellerti*	
Dicroglossidae	*5 < 1580 m Rakwana, central highlands, Knuckles	*Fejervarya limnocharis*	2
	*61 < *1580 m Rakwana, central highlands, Knuckles	*F. kirtisinghei*	
	*60 < *1070 m Rakwana, central highlands	*Nannophrys ceylonensis*	
Microhylidae	120 < 1300 m Rakwana	*Ramanella nagaoi*	2
	17 < *460 m Deniyaya	*Kaloula taprobanica*	
Ranidae	*20 < *1710 m central highlands	*Euphlyctis cyanophlyctis*	3
	*5 < *760 m central highlands	*E. hexadactylus*	
	*20 < *465 m central highlands	*Hoplobatrachus crassus*	
	*20 < 660 m Rakwana	*Hylarana aurantiaca*	
	*5 < *1460 m Rakwana, Knuckles	*H. gracilis*	
	*60m < *1830 m central highlands, Knuckles	*H. temporalis*	
Nyctibatrachidae	*60m < 1580 m Rakwana, central highlands, Knuckles	*Lankanectes corrugatus*	1
Rhacophoridae	61 < 1270 m Rakwana	*Pseudophilautus abundus*	3
	61 < *1270 m Rakwana	*P. auratus*	
	*60 < 1300m central highlands, Knuckles, Rakwana	*P. cavirostris*	
	*60 < 1300 m Rakwana	*P. folicola*	
	*15 < * 684 m southern lowland	*P. hoipolloi*	
	61 < * 660 m southern lowland	*P. limbus*	
	*60 < *150 m southern lowland	*P. mittermeieri*	
	61 < *660 m southern lowland	*P. nemus*	
	5 < *1067 m central highlands	*P. popularis*	
	*30 < 1300 m Rakwana	*P. reticulatus*	
	*61 < 1580 m Rakwana, central highlands	*P. sordidus*	
	*60 < *515 m Rakwana	*P. stictomerus*	
	**60 < 980 m Rakwana	*P. singu*	
	24 < 660 m southern lowland	*P. tanu*	
	*5 < *1525 m Rakwana, central highlands	*Polypedates cruciger*	
	*61 < *1300 m Rakwana, central highlands	*Taruga longinasus*	

* Geographical data taken from Manamendra-Arachchi & Pethiyagoda (2006)

** Geographical data taken from Meegaskumbura et al. (2009)

chus crassus were recorded outside of the forest area near human settlements including agricultural lands. They were identified by their vocalizations, which are mainly heard during the rainy season.

The amphibian fauna in the Kanneliya Forest Reserve was extensively studied over the last 30 years. Karunaratne (1986) reported twenty-two species as occurring in the Kanneliya Forest. According to Kandamby & Batuwita (2001), one new species was recorded; Manamendra-Arachchi & Pethiyagoda (2006) found twenty species, and Meegaskumbura et al. (2009) observed one additional new species. However, two of the recorded species deserve some comments. We presume that the record of *Nannophrys guentheri* is based on misidentification. Manamendra-Arachchi & Pethiyagoda (2006) declared this species as extinct and it could not be recorded during the present study. Its original description, based on two specimens, mentions "Ceylon" (=Sri Lanka) as locality, without further data. Therefore, Karunaratne's (1986) claim that the type locality of this species is Labugama is more than questionable. Second, the web-toed ramanella (*Ramanella palmata*) found living in water filled tree-holes in Kanneliya by Karunaratne (1986) is in contradiction with the results of Manamendra-Arachchi & Pethiyagoda (2006). The latter authors mention that this species is confined to the central mountain area of the island. It is

Table 2. Threat status of amphibian species in the Kanneliya Forest; comparison with Sri Lanka's total species.

	Total island species	Total Kanneliya species
Total number of species	108	33
Total number of endemic species	92	26
Extinct	21	0
Critically Endangered	11	2
Endangered	36	9
Vulnerable	6	4
Near Threatened	3	3
Least Concern	55	14
Data Deficient	4	1
Number of non-endemic species	16	7

possible that Karunaratne's (1986) record of *Ramanella palmata* is based on misidentified specimens of *Ramanella nagaoi*.

Thirtythree amphibian species are currently known from the Kanneliya Forest, and we found 72% of these in the reserve. Important microhabitats include phytotelmata (tree holes), tree trunks, rock caves, leaf litter, soil and pools. During our field observations, nearly 20 adult specimens of *Ramanella nagaoi* were found in differently sized phytotelmata at different heights, and one subadult was found in the stream. Since this species is not a ground-dweller, it may choose trees as suitable microhabitats where it can prey effectively while remaining well camouflaged.

Habitat degradation is a common threat with many species being susceptible to changes in habitat quality. Out of the 33 species recorded, 26 are endemic to Sri Lanka (Manamendra-Arachchi & Pethiyagoda 2006, Meegaskumbura et al. 2009) and some can be considered as endangered due to various reasons (IUCN 2010). The low number of individuals recorded for most of the species (e.g., *Ichthyophis glutinosus, I. pseudangularis, Duttaphrynus noellerti, F. kirtisinghei, Pseudophilautus cavirostris, P. nemus, P. limbus, P. mittermeieri, P. singu* and *Taruga longinasus*) suggests that either their populations are relatively small, or their habits are rather secretive. Since many species are closely associated with their microhabitat for protection and camouflage, destruction of suitable natural microhabitats such as tree holes would invariably have a detrimental effect on the survival of these secretive species. Initial findings suggest that many amphibians are rather restricted in their distribution, which puts even more emphasis on the importance of proper habitat and species management (Manamendra-Arachchi & Pethiyagoda 2006, IUCN 2010).

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