Amphibian & Reptile Conservation 5(2):65-80.

Herpetofaunal diversity and distribution in Kalugala proposed forest reserve, Western province of Sri Lanka

[1,3]W. MADHAVA S. BOTEJUE AND [2]JAYANTHA WATTAVIDANAGE

[1]*Taprobanica Nature Conservation Society, 150/6, Stanley Thilakaratne Mawatha, Nugegoda, SRI LANKA* [2]*Department of Zoology, Faculty of Natural Sciences, The Open University of Sri Lanka, SRI LANKA*

***Abstract.*—Kalugala Proposed Forest Reserve (KPFR) is a primary lowland tropical rain forest, surrounded by secondary forest and vegetation disturbed by human activities such as cultivation, logging, and the collection of firewood. Herpetofaunal communities of selected different habitats (closed forest, forest edge, home gardens, and cultivations) were assessed and distribution patterns were compared. A total of 24 amphibian species (63% endemic and 33% Threatened) and 53 reptile species (38% endemic and 30% Threatened) were recorded. Overall, 763 individual amphibians and 1032 individual reptiles were recorded in this forest area. Reptilian distribution patterns are similar to amphibian distribution patterns, with the highest diversity in the closed forest and the lowest diversity in cultivations. We did not observe an effect of forest edge (edge effect) in amphibian and reptile diversity, except for forest edge and cultivations for reptiles. Adverse human activities such as improper agriculture practices, logging, and waste disposal have led to deforestation and habitat loss in KPFR.**

Key words. Amphibians, reptiles, conservation, ecology, habitats, rain forest, Sri Lanka, threats

Citation: Botejue WMS, Wattavidanage J. 2012. Herpetofaunal diversity and distribution in Kalugala proposed forest reserve, Western province of Sri Lanka. *Amphibian & Reptile Conservation* 5(2):65-80 (e39).

Introduction

Recent research has demonstrated the uniqueness of Sri Lankan fauna and its distinctness from the Indian mainland (Bossuyt et al. 2004, 2005; Helgen and Groves 2005). This is particularly true of the herpetofaunal assemblage (Bossuyt et al. 2004; Meegaskumbura et al. 2002). There are 110 species of amphibians in Sri Lanka, which belong to seven families and 19 genera with 95 (86%) endemic species. (Fernando et al. 2007; Frost 2008; Manamendra-Arachchi and Pethiyagoda 2006; Meegaskumbura et al. 2007; Meegaskumbura et al. 2009; Meegaskumbura et al. 2010; Meegaskumbura and Manamendra-Arachchi 2011). The reptile fauna consists of 210 species, including 120 (57%) endemic species, representing 24 families and 82 genera. (Bauer et al. 2007; Batuwita and Pethiyagoda 2007; de Silva 2006; Gower and Maduwage 2011; Maduwage et al. 2009; Manamendra-Arachchi et al. 2006; Manamendra-Arachchi et al. 2007; Smith et al. 2008; Somaweera 2006; Wickramasinghe and Munindradasa 2007; Wickramasinghe et al. 2009).

In the present period of mass extinction of biodiversity (Achard et al. 2002; Jenkins 2003) many species of animals, plants, and other organisms are disappearing at an alarming rate, primarily due to human activities such as deforestation (Bambaradeniya et al. 2003; Brook et al. 2003; Pethiyagoda 2005, 2007a), fire (Batuwita and Bahir 2005), erosion (Hewawasam et al. 2003), agrochemical use (Pethiyagoda 1994), and lack of systematic or scientific understanding (Bahir 2009; Pethiyagoda 2007b). Although the natural forest area of Sri Lanka still constitutes over 12% of the total land area (Tan 2005), human population density of the biologically rich wet zone is among the highest on earth (Cincotta et al. 2000). Furthermore, the population growth rate is increasing around protected areas (Wittemyer et al. 2008). Natural forests and the biodiversity have been rapidly diminishing over the past 100 years. The result has been the extinction of 21 species of amphibians, with 19 of these species being from the genus *Pseudophilautus* (Manamendra-Arachchi and Pethiyagoda 2005; Meegaskumbura and Manamendra-Arachchi 2005; Meegaskumbura et al. 2007). In addition, of the remaining species, 57 reptiles and 56 amphibians are considered Threatened (IUCNSL and MENRSL 2007).

Kalugala Proposed Forest Reserve (KPFR) is one of the remaining few wet zone forest patches in Sri Lanka and is threatened by human activities. We report the results of a study conducted in KPFR to assess species richness, abundance, and diversity of the herpetofauna and to evaluate the distribution patterns among different habitats.

Correspondence. *Email: [3]madhavabotejue@gmail.com*

Study area and habitats

The KPFR belongs to Agalawatta and Walallawita Divisional Secretariat of Kaluthara District, Sri Lanka, which lies between 6°25'-6°30' N and 80°12'-80°16' E (Fig. 1). The floristic structure and composition suggest KPFR retain a considerable amount of primary forest. However the boundaries of this forest are disturbed due to cultivation, logging, firewood collection, and consist of secondary and disturbed vegetation. We identified four types of habitats as study sites: closed forest (Fig. 2), forest edge (Fig. 3), home gardens (Fig. 4), and cultivations (Fig. 5a, b, c).

Originally, the KPFR was an area of approxiatemly 4,630 ha when first declared a Proposed Forest Reserve in 1992. However, due to continuous deforestation, logging, agriculture practices, and illegal encroachments, the land area has drastically reduced to about 2,907 ha (Ranasinghe 1995). Several decades ago, KPFR was part of the western-most extension of Sinharaja rainforest, however, today it has been diminished to an isolated forest patch due to extensive deforestation and other human activities (Kekulandala 2002; Ranasinghe 1995). The elevation of the area ranges from 30-300 m and the majority of its precipitation originates from the southwest monsoon (April to September) with a mean annual rainfall of 4000-5000 mm. The KPFR is a catchment area for both Benthara and Kalu rivers. Average monthly temperature in the region is ~27.3 °C (Kekulandala 2002; Ranasinghe 1995).

Closed forest is found deep in KPFR and on hilltops (Fig. 6). The major vegetation formation of this habitat type can be classified as *Doona-Dipterocarpus-Mesua* series (Ranasinghe 1995). A certain degree of stratification can be identified in the forest, and although an emergent layer cannot be clearly identified, at some places the forest rises up to about 50-60 m in height and is primarily composed of *Dipterocarpus* sp., *Shorea* sp., and *Doona* sp. The canopy layer is composed of *Anisophyllea cinnamomoides*, *Mesua* sp., *Vateria copallifera*, and *Mangifera zeylanica*, that rise to about 30-40 m. The subcanopy is about 15-30 m high with the primary trees being *Semecarpus* sp., *Garcinia* sp. *Calophyllum* sp., and *Horsfieldia iryaghedhi*. The composition of the understory is variable, but primarily this layer is comprised of *Humboldtia laurifolia*, *Strobilanthes* sp., *Cyathea* sp., saplings of *Calamus* sp., and *Glochidion* sp. The ground layer is mainly composed of species in the family Poaceae and Asteraceae, as well as ground orchids. This forest harbor a rich assemblage of climbing plants (e.g., *Pothos* sp., *Entada pusaetha*, and *Calamus* sp.) and epiphytes. Exotic species like *Alstonia macrophylla* are also found in the forest and the ground is covered with a thick and moist decomposing leaf matter layer. A considerable number of streams are located in the study area (Fig. 7). Some areas of the forest are disturbed by well-maintained trails (Fig. 8) and, in some places, the forest is directly connected to cultivations.

The forest edge is the marginal area between closed forest and home gardens or cultivations. This is highly disturbed by human activities such as logging and firewood collecting. The vegetation of this area consists of a mixture of forest vegetation and home garden vegetation, trees such as *Mesua* sp., *Dipterocarpus* sp., *Shorea* sp., *Doona* sp., *Mangifera zeylanica*, *Mangifera indica*, *Caryota urens*, *Areca catechu*, *Artocarpus nobilis*, *Artocarpus heterophyllus*, *Trema orientalis*, *Syzygium* sp., *Garcinia* sp., *Murraya paniculata*, *Elaeocarpus* sp., *Macaranga* sp., *Mallotus* sp.; shrubs such as *Ochlandra stridula*, *Osbeckia* sp., *Melastoma malabathricum*; climbers such as *Calamus* sp., and tree ferns (*Cyathea* sp.). The under growth is very dense in most parts of the forest edge, where *Dicranopteris* sp. and many other fern species dominate. Species of the family Poaceae and Asteraceae were also found in the ground layer and exotic

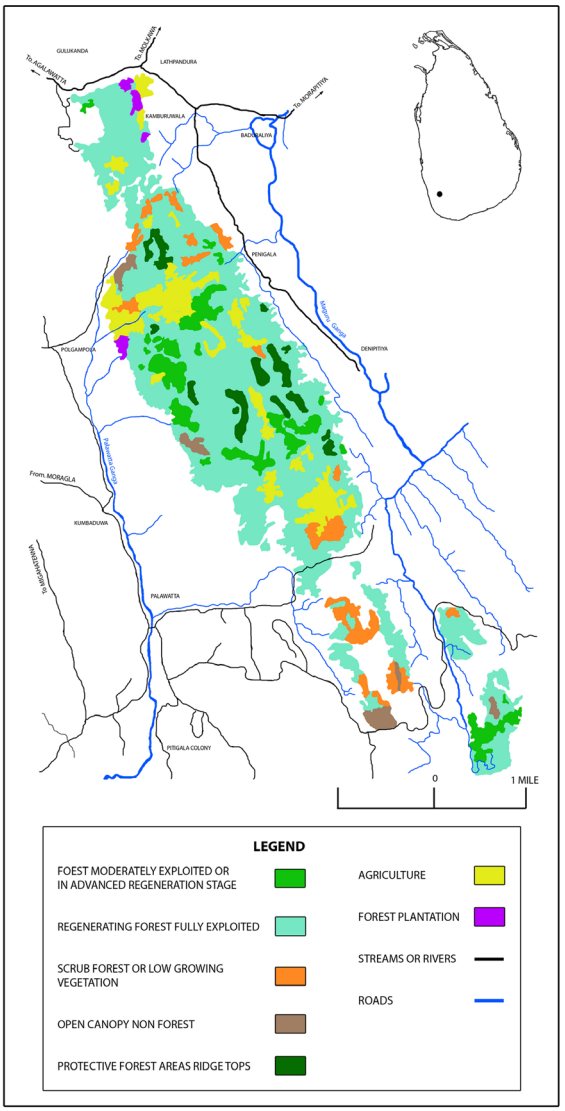

Figure 1. Geographical location and map of KPFR.

Figure 2. Closed forest.

Figure 3. Forest edge.

Figure 4. Home gardens.

Figure 5a. Cultivation (paddy).

Figure 5b. Cultivation (tea).

Figure 5c. Cultivation (rubber).

species like *Alstonia macrophylla*, *Dillenia suffruticosa*, *Eucalyptus* sp., *Acacia* sp., and *Pinus* sp. were present in this habitat type.

Home garden vegetation consists of crop, shade, and ornamental plants such as *Musa* sp., *Mangifera indica*, *Caryota urens*, *Areca catechu*, *Cocos nucifera*, *Carica papaya*, *Artocarpus heterophyllus*, *Artocarpus incisus*, *Syzygium* sp., *Garcinia* sp., *Elaeocarpus serratus*, *Macaranga peltata*, *Manihot esculenta*, *Albizia* sp., *Cassia* sp., *Nephelium lappaceum*, *Cinnamomum verum*, *Plumeria* sp., *Spondias* sp., *Piper betle*, and *P. nigrum*. Shrubs consist of *Melastoma malabathricum*, *Osbeckia octandra*, and exotic *Lantana camara*. Most home gardens are directly associated with cultivations (Fig. 9), and thus many herbaceous crop plants of the family Fabaceae, Cucurbitaceae, Poaceae, and Asteraceae, and other ornamental plants are present, as are exotic trees such as *Alstonia macrophylla* and *Acacia* sp.

Figure 6. Forest on hilltops.

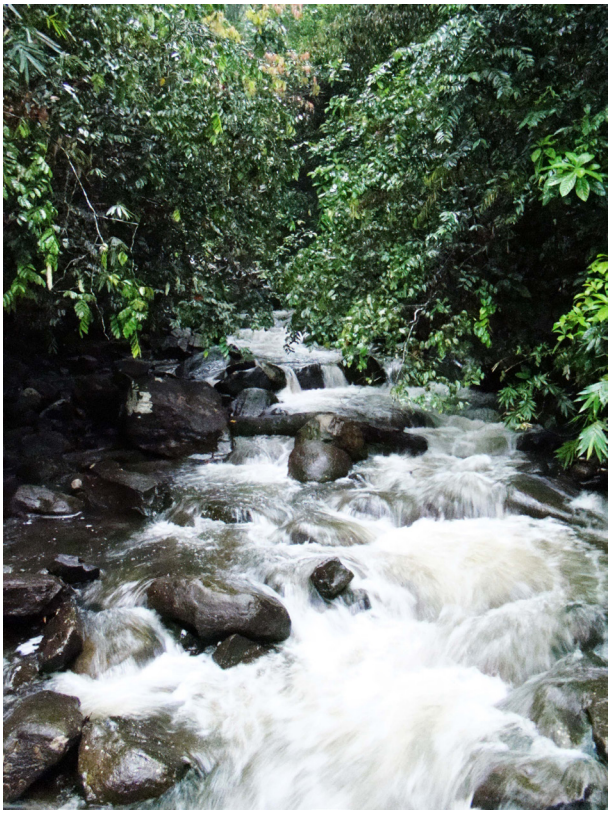

Figure 7. Streams inside the forest.

Figure 8. Well maintained trails inside the forest.

Figure 9. Home gardens associated with cultivation.

The KPFR area include three main types of cultivation: paddy, tea, and rubber. Mud pools and small rivulets in paddy-cultivated land provide many microhabitats for amphibians. Around paddy and tea cultivation other crops like banana (*Musa* sp.) and coconut (*Cocos nucifera*) can be seen. Most rubber cultivations are not well maintained and the undergrowth is high and comprised of *Dicranopteris* sp., and herbaceous plants of the family Fabaceae and Poaceae. In some locations two cultivations are in close proximity with one another, such as tea and rubber, or tea and paddy (Fig. 10a, b), and in a few locations all three cultivations can be found in close proximity.

Materials and methods

Data collection

Dates of field study were determined using a random number table. A total of 12 field visits were conducted for a total of 480 hours. Visual encounter surveys and line transects (200 m) were used for data collection, including night visits with the aid of head lamps. Belt transects (4 × 50 m) used for data collection and observations conducted 20 cm deep into the leaf litter. Quadrat sampling (5 × 5 m) was employed for habitat-specific sampling, with quadrats being placed in pairs in every location of each habitat type. All quadrats were surveyed once during the day and once at night by 4-5 people moving slowly inward from the periphery. Randomly placed pitfall traps were used to sample small terrestrial reptiles where others were hand captured. Temperature and humidity were measured using a digital thermometer and a digital humidity meter, respectively. Weather, cloud cover, and canopy cover were assessed visually. In total, 24 quadrats, 12 line transects, and four belt transects were used, equating a total sampling area of 1400 m^2 + 2000 m with equal observation time being allocated to each habitat.

Data analysis

The Shannon-Wiener Index [$H' = -\sum (p_i \ln p_i)$] was used to determine the diversity of species heterogeneity (where, H' = species diversity, and p_i = proportional frequency of the ith species). The non-parametric Mann-Whitney *U*-test at the 10% significant level was used to test differences in independent samples of amphibian and reptile distribution among habitats.

Species Identification

All amphibian and reptile species were identified and classified using Dutta and Manamendra-Arachci (1996), de Silva (2009), Howlader (2011), Manamendra-Arachchi and Pethiyagoda (2006), Meegaskumbura et al. (2009), Meegaskumbura et al. (2010), and Meegaskumbura and Manamendra-Arachchi (2011) for amphibians; Bahir and Silva (2005), Bauer et al. (2010a and 2010b), Das and de Silva (2005), Deraniyagala (1953 and 1955), de Silva (1990 and 2006), Günther (1864), Manamendra-Arachchi et al. (2007), Pethiyagoda and Manamendra-Arachchi (1998), Smith (1935), Somaweera (2006), Somaweera and Somaweera (2009), Taylor (1953), and Whitaker and Captain (2004) for reptiles. Plant species were identified using Ashton et al. (1997), Dassanayake and Fosberg (1980-1991), Dassanayake et al. (1994-1995), Dassanayake and Clayton (1996-2000), Gunatilleke and Gunatilleke (1990), and Senaratna (2001). The lists of Threatened species were based on the most recent national Red List (IUCNSL and MENRSL 2007).

Results

Species richness

A total of 24 species of amphibians (representing 15 genera in 7 families) were recorded, with 15 species (63%) being endemic, and eight (33%) being Threatened (Table 1). A total of 53 species of reptiles (representing 38 genera and 12 families) were recorded, with 20 species (38%) being endemic and 16 (30%) being Threatened (Table 2). The greatest species richness for both amphibians and reptiles was in closed forest, with all 24 species of amphibians being recorded there, and 45 species (85%) of reptiles. For amphibians, 23 species (96%; excluding *Pseudophilautus reticulatus*) were recorded in forest edge, followed by home gardens, and cultivations with comparatively low, 18 species (75%) and 10 species (42%), respectively. In terms of reptiles, 44 species (83%), 36 species (68%), and 25 species (47%) were recorded in forest edge, home gardens, and cultivations, respectively (Fig. 11).

Species diversity

Overall the herpetofaunal diversity and both amphibian and reptile diversity in KPFR was high. The Shannon-Wiener Index for overall herpetofauna (H'_H) was 3.838. The Shannon-Wiener Index for amphibian diversity (H'_A) was 2.508 and for reptile diversity (H'_R) 3.635 (Fig. 12a, b).

Table 1. Checklist of the amphibians (n = 24) recorded from KPFR. Abbreviations: E – Endemic; EN – Endangered; VU – Vulnerable; NT – Near Threatened; CF – Closed forest; FE – Forest edge; HG – Home Gardens; CU – Cultivations.

Scientific name	Recorded habitats			
	CF	FE	HG	CU
Ichthyophiidae				
Ichthyophis glutinosus [E]	x	x	x	–
Bufonidae				
Adenomus kelaartii [E]	x	x	x	–
Duttaphrynus melanostictus	x	x	x	x
Microhylidae				
Kaloula taprobanica	x	x	x	x
Microhyla rubra	x	x	x	–
Ramanella variegata	x	x	x	–
Dicroglossidae				
Euphlyctis cyanophlyctis	x	x	x	x
Euphlyctis hexadactylus	x	x	x	x
Zakerana kirtisinghei [E]	x	x	x	x
Zakerana syhadrensis	x	x	x	x
Hoplobatrachus crassus	x	x	x	x
Nannophrys ceylonensis [E, VU]	x	x	x	–
Nyctibatrachidae				
Lankanectes corrugatus [E]	x	x	x	x
Ranidae				
Hylarana aurantiaca [VU]	x	x	x	–
Hylarana temporalis [E, NT]	x	x	x	–
Rhacophoridae				
Pseudophilautus abundus [E]	x	x	–	–
Pseudophilautus cavirostris [E, EN]	x	x	–	–
Pseudophilautus folicola [E, EN]	x	x	–	–
Pseudophilautus hoipolloi [E]	x	x	x	–
Pseudophilautus popularis [E]	x	x	x	x
Pseudophilautus reticulatus [E]	x	–	–	–
Pseudophilautus stictomerus [E, NT]	x	x	–	–
Polypedates cruciger [E]	x	x	x	x
Taruga longinasus [E, EN]	x	x	–	–

Table 2. Checklist of the reptiles (n = 53) recorded from KPFR. Abbreviations: E – Endemic; EN – Endangered; VU – Vulnerable; NT – Near Threatened; CF – Closed forest; FE – Forest edge; HG – Home Gardens; CU – Cultivations.

Scientific name	Recorded habitats			
	CF	FE	HG	CU
Pythonidae				
Python molurus	x	x	x	x
Colubridae				
Ahaetulla nasuta	x	x	x	–
Ahaetulla pulverulenta NT	x	–	x	–
Amphiesma stolatum	x	x	x	x
Aspidura guentheri E, NT	x	x	–	–
Atretium schistosum	x	x	–	–
Balanophis ceylonensis E, VU	x	–	–	–
Boiga ceylonensis	x	–	x	–
Boiga forsteni	x	x	x	x
Cercaspis carinatus E, VU	x	–	x	–
Chrysopelea ornate NT	x	x	x	–
Coelognathus helena	x	x	x	x
Dendrelaphis bifrenalis	x	–	–	–
Dendrelaphis caudolineolatus VU	x	x	–	–
Lycodon aulicus	x	–	x	x
Lycodon osmanhilli E	x	x	x	x
Oligodon arnensis	x	x	x	x
Oligodon sublineatus E	–	x	x	x
Ptyas mucosa	x	x	x	x
Sibynophis subpunctatus	x	x	x	x
Xenochrophis asperrimus E	x	x	–	–
Xenochrophis piscator	x	x	–	–
Cylindrophiidae				
Cylindrophis maculatus E, NT	x	x	x	–
Elapidae				
Bungarus ceylonicus E, NT	x	x	x	–
Naja naja	–	x	x	x
Typhlopidae				
Ramphotyphlops sp.	x	x	–	–
Typhlops sp.	x	x	–	–
Uropeltidae				
Rhinophis sp.	x	x	–	–
Viperidae				
Daboia russelii	x	x	x	x
Hypnale hypnale	x	x	x	x
Trimeresurus trigonocephalus E	x	x	–	–
Agamidae				
Calotes calotes	–	x	x	x
Calotes liolepis E, VU	x	x	x	x
Calotes versicolor	–	x	x	x
Ceratophora aspera E, EN	x	–	–	–
Lyriocephalus scutatus E, NT	x	x	–	–
Otocryptis wiegmanni E, NT	x	x	x	x
Gekkonidae				
Cnemaspis silvula E	x	x	x	–
Cnemaspis sp.	x	x	–	–
Geckoella triedrus E, NT	x	–	–	–
Gehyra mutilata	–	–	x	x
Hemidactylus depressus E	x	x	x	–
Hemidactylus frenatus	x	x	x	–
Hemidactylus parvimaculatus	x	x	x	–
Lepidodactylus lugubris EN	x	x	x	–
Scincidae				
Eutropis carinata	x	x	x	x
Eutropis madaraszi E, NT	x	x	–	–
Lankascincus fallax E	x	x	x	x
Lankascincus gansi E, NT	x	x	–	x
Lankascincus greeri E	x	x	x	x
Varanidae				
Varanus bengalensis	–	x	x	x
Varanus salvator	–	x	x	x
Bataguridae				
Melanochelys trijuga	–	x	x	x

Species abundance

During field visits a total of 763 individual amphibians were recorded, with *Zakerana syhadrensis* being most abundant, followed by *Euphlyctis cyanophlyctis* and *E. hexadactylus*. The least abundant species were *Ramanella variegata*, *Pseudophilautus abundus*, *P. cavirostris*, *P. reticulatus*, and *P. stictomerus*, followed by *Microhyla rubra*, *Taruga longinasus*, and *Ichthyophis glutinosus*. A total of 1,032 individual reptiles were recorded with *Hypnale hypnale* being most abundant, followed by *Otocryptis wiegmanni* and *Lankascincus fallax*. The least abundant species were *Ahaetulla pulverulenta*, *Balanophis ceylonensis*, *Geckoella triedrus*, *Ramphotyphlops* sp., *Typhlops* sp., and *Rhinophis* sp., followed by *Aspidura guentheri*, *Atretium schistosum*, *Boiga ceylonensis*, and *Ceratophora aspera*.

Among habitats, abundance was greatest in the forest edge, with 269 (35%) individual amphibians and 373 (36%) individual reptiles being recorded. The lowest amphibian abundance was documented in closed forest: 158 (20%) individuals; where the lowest reptile abundance was in cultivations: 171 (17%) individuals. In home gardens, 172 (23%) individual amphibians and 215 (21%) individual reptiles were recorded, while 164 (22%) individual amphibians were recorded in cultivations and 273 (26%) individual reptiles were recorded in closed forest (Fig. 13).

Figure 10a. Closely connected cultivation (tea and rubber).

Figure 10b. Closely connected cultivation (tea and paddy).

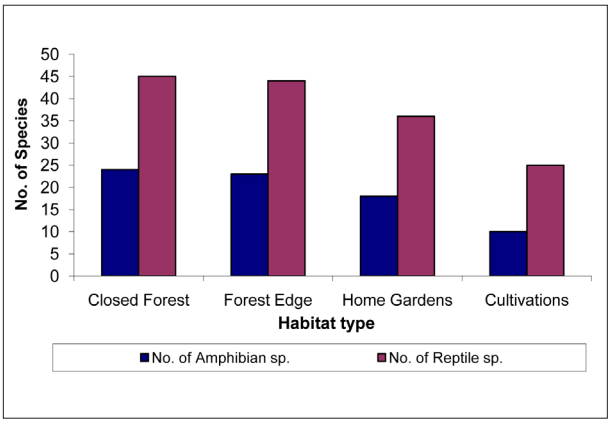

Figure 11. Number of species in different habitat types.

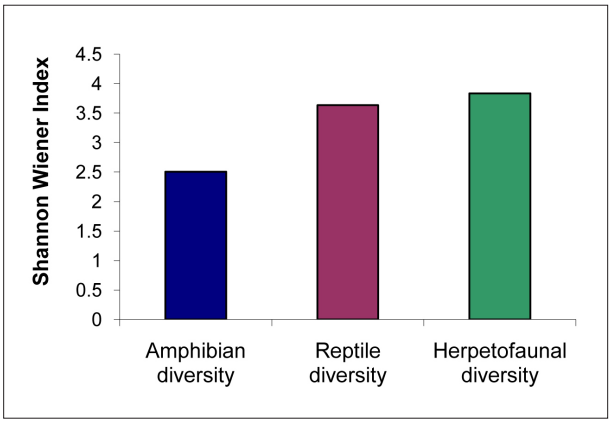

Figure 12a. Herpetofaunal diversity in KPFR.

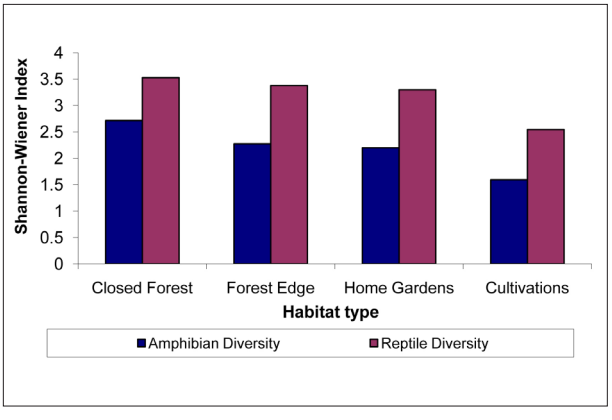

Figure 12b. Herpetofaunal diversity in different habitat types.

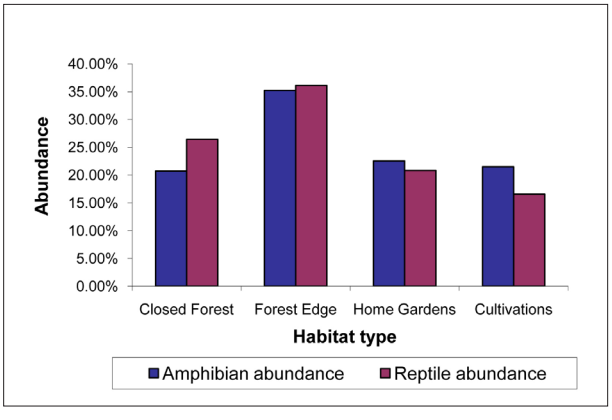

Figure 13. Species abundance in KPFR.

Species distribution

There were no significant differences in species richness of amphibians between any habitat type, however, reptiles showed a significant deference in species richness only between forest edge and cultivations (Mann-Whitney *U*-test: $Z = 2.01$, $n_1 = 44$, $n_2 = 25$, $P = 0.044$).

Discussion

Species richness of amphibians was poor in cultivated habitats such as tea, rubber, coconut, and some other commercial crops that are grown in KPFR. However, in paddy cultivations some dicroglossid frogs were found in high abundance (e.g., *Euphlyctis cyanophlyctis* and *Zakerana syhadrensis*). The higher availability of surface

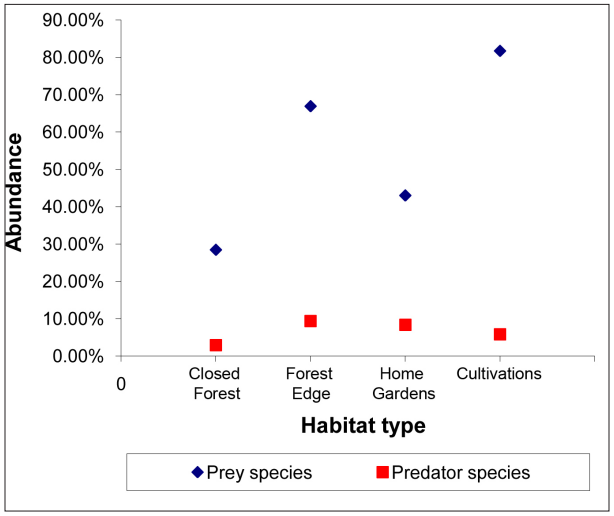

Figure 14. Distribution of some prey and predator species.

Figure 15. Deforestation inside the KPFR.

Figure 16a. Garbage dumping site of the monastery in KPFR.

Figure 16b. Garbage dumping site of the monastery in KPFR.

water may arguably facilitate these aquatic amphibians to thrive in paddy cultivations. *Euphlyctis cyanophlyctis*, however was most abundant in forest edge, along stream banks and water pools between edges of forest and cultivations. In home gardens, the most abundant species were bufonid and dicroglossid frogs including *Duttaphrynus melanostictus*, *Euphlyctis hexadactylus*, and *Zakerana syhadrensis*, which is likely related to favorable living conditions and high abundance of food.

Most of the endemic amphibian species (e.g., *Ichthyophis glutinosus*, *Nannophrys ceylonensis*, *Adenomus kelaartii*, *Hylarana temporalis*, *Pseudophilautus abundus*, *P. cavirostris*, *P. folicola*, *P. hoipolloi*, *P. popularis*, *P. reticulatus*, *P. stictomerus*, *Polypedates cruciger*, and *Taruga longinasus*) were mostly restricted to the forest habitats and were commonly not recorded in open areas such as cultivations and open home gardens. Interestingly, closed forest recorded the lowest amphibian abundance despite having the highest amphibian diversity, presumably due to high abundance of bufonid and dicroglossid frogs in other habitat types.

The distribution pattern of reptile species richness and species diversity are both similar to amphibians, the highest being in closed forest and lowest in cultivations. However, reptile abundance was highest in forest edge and lowest in cultivations, compared to amphibian abundance, highest in forest edge and lowest in closed forest. In cultivations *Hypnale hypnale* are found in high numbers potentially, which may be explained by the high abundance of prey (rodents and frogs) in those cultivated habitats. Endemic reptile species including *Aspidura guentheri*, *Balanophis ceylonensis*, *Cercaspis carinatus*, *Dendrelaphis bifrenalis*, *Xenochrophis asperrimus*, *Cylindrophis maculatus*, *Bungarus ceylonicus*, *Trimeresurus trigonocephalus*, *Calotes liolepis*, *Ceratophora aspera*, *Lyriocephalus scutatus*, *Cnemaspis silvula*, *Geckoella triedrus*, *Hemidactylus depressus*, *Eutropis madaraszi*, *Lankascincus gansi*, and *L. greeri* are mostly forest dwelling and recorded in lower abundance in other habitats, and rarely in open areas.

Edge effect encompasses biotic and abiotic changes, resulting from the interaction between two different habitat types (Murcia 1995). Extensive research on edge effect of many taxa: insects (Hochkirch et al. 2008), amphibians (Karunarathna et al. 2008), birds (Helle and

Helle 1982), and mammals (Pasitschniak-Arts and Messier 1998). However, Dixo and Martins (2008) show that edge effects do not influence leaf litter frogs and lizards in the Brazilian Atlantic forest, despite forest fragmentation. Similarly, in the present study no edge effects were detected. The only significant difference among distributions were recorded between forest edge and cultivations for reptiles (according to Mann-Whitney *U*-test). The forest edge habitats directly adjacent to cultivations have a high abundance (40%) of reptiles that prey upon amphibians. In cultivated habitats, dicroglossid and ranid frogs were found in high abundance possibly due to a number of water bodies found there (e.g., mud pools and small rivulets). Therefore, these amphibians may provide the forage base for the abundant amphibian predatory reptiles.

Edge effect also applies to succession present where vegetation is spreading outwards rather than being encroached upon. Here, different species are more suited to edges or central sections of vegetation, resulting in a varied distribution. In KPFR, many amphibian species are normally distributed in higher abundance at the forest edge rather than other habitats. These include *Ichthyophis glutinosus*, *Microhyla rubra*, *Euphlyctis cyanophlyctis*, *Zakerana kirtisinghei*, *Hoplobatrachus crassus*, *Lankanectes corrugatus*, *Hylarana temporalis*, *Pseudophilautus abundus*, *P. cavirostris*, *P. folicola*, *P. hoipolloi*, *P. popularis*, *P. stictomerus*, and *Taruga longinasus*. Reptiles such as *Ahaetulla nasuta*, *Aspidura guentheri*, *Atretium schistosum*, *Boiga forsteni*, *Chrysopelea ornate*, *Coelognathus helena*, *Dendrelaphis caudolineolatus*, *Lycodon osmanhilli*, *Oligodon arnensis*, *Sibynophis subpunctatus*, *Xenochrophis asperrimus*, *X. piscator*, *Cylindrophis maculatus*, *Bungarus ceylonicus*, *Ramphotyphlops* sp., *Typhlops* sp., *Rhinophis* sp., *Calotes calotes*, *C. liolepis*, *Otocryptis wiegmanni*, *Cnemaspis silvula*, *Cnemaspis* sp., *Hemidactylus depressu*s, *H. frenatus*, *H. parvimaculatus*, *Lepidodactylus lugubris*, *Eutropis madaraszi*, and *Lankascincus greeri* have similar preferences.

The abundance of prey items is much higher than of predators in all habitats, and predators show distribution patterns similar to prey, in many instances. For example, prey species of *Euphlyctis* and *Zakerana* show a parallel distributional pattern to predator species of *Xenochrophis*, *Varanus*, and *Ptyas mucosa* (Fig. 14). Species of *Euphlyctis* and *Zakerana* live in a mutual association (Manamendra-Arachchi and Pethiyagoda 2006) and this mutual association was clearly observed in KPFR.

Near-primary forest cover accounts for less than 5% of the total wet zone land area, and what remains are small isolated patches in a sea of human development. The existing protected forests in the wet zone, which harbor a high level of biodiversity, continue to be degraded due to illegal encroachment and suffer further fragmentation leading to adverse impacts (IUCNSL and MENRSL 2007).

Adverse human activities have led to deforestation and habitat loss (Fig. 15) in KPFR. High damage has been inflicted on the forest habitat by the illegal encroachment in forests as a result of improper agriculture practices and illegal logging; this leads to loss of habitat and biodiversity. Additionally, the use of agrochemicals is a great threat to the local biodiversity, especially for the environmentally sensitive amphibians. Habitual overuse of agrochemicals in cultivation can lead to death, malformations, and abnormalities in amphibians (de Silva 2009). Most endemic and endangered species found only in closed forest are at great risk of being exterminated from the area. One specific threat is the garbage dumps of the Kalugala Monastery (Fig. 16a, b) which are located inside the forest.

The material leakage into local streams may worsen effects on biodiversity as well as the health of people that inhabit the lower reaches of streams. Material such as polyethylene bags and other non-biodegradable materials are spread around the monastery and along footpaths inside the forest. As a result of the garbage dumps, the population of *Varanus salvator* and *Sus scrofa* may have increased, thus disrupting the ecological balance.

Although these conclusions are based on the results of this study, we recommend more research be carried out for longer durations and over a larger area. We strongly suggest the relevant authorities to take immediate action to protect this valuable tropical rain forest and to declare this area a forest reserve, before implementing any long-term conservation and management plans.

Acknowledgments.—We would like to thank Upali Amarasinghe (University of Kelaniya, Sri Lanka) for his help to improve the document and anonymous reviewers for their valuable comments. The first author wishes to thank Thasun Amarasinghe and Suranjan Karunarathna for their valuable comments on the manuscript. We are grateful to the Conservator General of the Department of Forest Conservation of Sri Lanka, for allowing the research on herpetofauna in land under their care, and to the Baduraliya Police for giving assistance to carry out the field work. We thank Tharindu Sulakshana, Nirmala Hirantha, Dinesh Gabadage, Suranjan Karunarathna, Harini Pandithasundara, and Lasanthi Kanthika for assistance during fieldwork and data collection. We thank I. K. Rajapakshe (The Open University of Sri Lanka), N. Nilakariyawasam (OUSL), W. C. W. Navaratna (OUSL), and W. M. P. C. Wijesinghe (OUSL) for all their support. We also thank the Director General of the Department of Wildlife Conservation for granting permission to capture animals for identification; Padmasiri Weerasinghe, Upathissa Weerasinghe, the villagers of Kalugala for all their support throughout the study, and Dushantha Kandambi for providing photographs. Finally, we would like to express our heartfelt gratitude to Ruchira Somaweera, Kanishka Ukuwela, Craig Hassapakis, and Eric Wild for the peer-review and editing process.

Figure 17. *Adenomus kelaartii.*

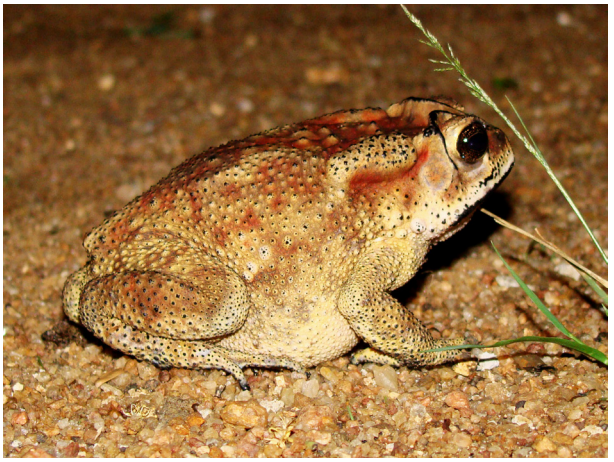

Figure 18. *Duttaphrynus melanostictus.*

Figure 19. *Kaloula taprobanica.*

Figure 20. *Microhyla rubra.*

Figure 21. *Ramanella variegata.*

Figure 22. *Euphlyctis hexadactylus.*

Figure 23. *Zakerana syhadrensis.*

Figure 24. *Hoplobatrachus crassus.*

Figure 25. *Lankanectes corrugatus.*

Figure 26. *Hylarana aurantiaca.*

Figure 27. *Pseudophilautus hoipolloi.*

Figure 28. *Pseudophilautus reticulatus.*

Figure 29. *Python molurus.*

Figure 30. *Ahaetulla nasuta.*

Figure 31. *Atretium schistosum.*

Figure 32. *Boiga ceylonensis.*

Figure 33. *Cercaspis carinatus.*

Figure 34. *Dendrelaphis caudolineolatus.*

Figure 35. *Cylindrophis maculatus.*

Figure 36. *Bungarus ceylonicus.*

Figure 37. *Daboia russelii.*

Figure 39. *Calotes liolepis.*

Figure 41. *Geckoella triedrus.*

Figure 38. *Trimeresurus trigonocephalus.*

Figure 40. *Ceratophora aspera.*

Figure 42. *Hemidactylus depressus.*

Figure 43. *Eutropis carinata.*

Figure 44. *Lankascincus greeri.*

Figure 45. *Melanochelys trijuga.*

Figure 46. *Varanus bengalensis.*

Literature cited

Achard F, Eva HD, Stibig H, Mayaux P, Gallego J, Ricahards T, Malingreau J. 2002. Determination of deforestation rates of the world's humid tropical forests. *Science* 297(5583):999-1002.

Ashton M, Gunatileke CVS, De Zoysa N, Dassanayake MD, Gunatileke N, Wijesundara S. 1997. *A Field Guide to the Common Trees and Shrubs of Sri Lanka*. Wildlife Heritage Trust of Sri Lanka, Colombo. vii + 432 p.

Bahir MM, Silva A. 2005. *Otocryptis nigristigma*, a new species of agamid lizard from Sri Lanka. *The Raffles Bulletin of Zoology*, Supplement 12:393-406.

Bahir MM. 2009. Some taxonomic inaccuracies in conservation publications. *Current Science* 96(5):632-633.

Bambaradeniya CNB, Perera MSJ, Perera WPN, Wickramasinghe LJM, Kekulandala LDCB, Samarawickrema VAP, Fernando RHSS, Samarawickrema VAMPK. 2003. Composition of faunal species in the Sinharaja world heritage site in Sri Lanka. *Sri Lanka Forester* 26:21-40.

Batuwita S, Bahir MM 2005. Description of five new species of *Cyrtodactylus* (Reptilia: Gekkonidae) from Sri Lanka. *The Raffles Bulletin of Zoology*, Supplement 12:351-380.

Batuwita S, Pethiyagoda R. 2007. Description of a new species of Sri Lankan litter skink (Squamata: Scincidae: *Lankascincus*). *Ceylon Journal of Sciences* (Biological Sciences) 36(2):80-87.

Bauer AM, de Silva A, Greenbaum E, Jackman T. 2007. A new species of day gecko from high elevation in Sri Lanka, with a preliminary phylogeny of Sri Lankan *Cnemaspis* (Reptilia, Squamata, Gekkonidae). *Mitteilungen aus dem Zoologischen Museum in Berlin*, Supplement 83:22-32.

Bauer AM, Jackmann TR, Greenbaum E, De Silva A, Giri VB, Das I. 2010a. Molecular evidence for taxonomic status of *Hemidactylus brookii* group taxa (Reptilia: Gekkonidae). *The Herpetological Journal* 20(3):129-138.

Bauer AM, Jackman TR, Greenbaum E, Giri VB, De Silva A. 2010b. South Asia supports a major endemic radiation of *Hemidactylus* geckos. *Molecular Phylogenetics and Evolution* 57(1):343-352.

Bossuyt F, Meegaskumbura M, Beenaerts N, Gower DJ, Pethiyagoda R, Roelants K, Mannaert A, Wilkinson M, Bahir MM, Manamendra-Arachchi K, Ng PKL, Schneider CJ, Oomen OV, Milinkovitch MC. 2004. Local endemism within the Western Ghats – Sri Lanka Biodiversity Hotspot. *Science* 306(5695):479-481.

Bossuyt F, Meegaskumbura M, Baenerts N, Gower DJ, Pethiyagoda R, Roelants K, Mannaert, A, Wilkinson M, Bahir MM, Manamendra-Arachchi K, Ng PKL, Schneider CJ, Oomen OV, Milinkovitch MC. 2005. Biodiversity in Sri Lanka and western Ghats. *Science* 308(5719):199.

Brook BW, Sodhi NS, Ng PKL. 2003. Catastrophic extinctions follow deforestation in Singapore. *Nature* 424:420-423.

Cincotta RP, Wisnewski J, Engelman R. 2000. Human populations in the biodiversity hotspots. *Nature* 404:990-992.

Das I, de Silva A. 2005. *A Photographic Guide to Snakes and Other Reptiles of Sri Lanka*. New Holland Publishers, UK. 144 p.

Dassanayake MD, Fosberg FR (Editors). 1980-1991. *A Revised Handbook of the Flora of Ceylon*. Oxford & IBH Publishing Co., New Dilhi. Volume I. vii + 508 p.; volume II. vii + 511 p.; volume III. vii + 499 p; volume IV. vii + 532 p.; volume V. vii + 476 p.; volume VI. vii + 424 p.; volume VII. vii + 439 p.

Dassanayake MD, Fosberg FR, Clayon WD (Editors). 1994-1995. *A Revised Handbook of the Flora of Ceylon*. Oxford & IBH Publishing Co., New Dilhi. Volume VIII. v + 458 p.; volume IX. v + 482 p.

Dassanayake MD, Clayton WD (Editors). 1996-2000. *A Revised Handbook of the Flora of Ceylon*. Oxford & IBH Publishing Co., New Dilhi. Volume X. viii + 426 p.; volume XI. 420 p.; vol. XII. 390 p.; XIII. 284 p.; volume XIV. v + 307 p.

de Silva A. 1990. *Colour Guide to the Snake Fauna of Sri Lanka*. R and A Publishing Ltd, Avon, England. 130 p.

de Silva A. 2006. Current status of the reptiles of Sri Lanka In: *Fauna of Sri Lanka: Status of Taxonomy, Research and Conservation*. Editor, Bambaradeniya CNB. The World Conservation Union (IUCN), Colombo, Sri Lanka and Government of Sri Lanka. 308 p. 134-163.

de Silva A. 2009. *Amphibians of Sri Lanka: A Photographic Guide to Common Frogs, Toads and Caecilians*. Published by the author. 82 plates + 168 p.

Deraniyagala PEP. 1953. *A Colored Atlas of Some Vertebrates from Ceylon*. *Volume 2: Tetrapod Reptila.* National Museums of Sri Lanka, Sri Lanka. 101 p.

Deraniyagala PEP. 1955. *A Colored Atlas of Some Vertebrates from Ceylon*. *Volume 3: Serpentoid Reptila.* National Museum of Sri Lanka, Sri Lanka. 121 p.

Dixo M, Martins M. 2008. Are leaf-litter frogs and lizards affected by edge effects due to forest fragmentation in Brazilian Atlantic forest? *Journal of Tropical Ecology* 24:551-554.

Dutta SK, Manamendra-Arachchi KN. 1996. *The Amphibian Fauna of Sri Lanka*. Wildlife Heritage Trust of Sri Lanka, Colombo. 230 p.

Fernando SS, Wickramasingha LJM, Rodrigo RK. 2007. A new species of endemic frog belonging to genus *Nannophrys* Günther, 1869 (Anura: Dicroglossinae) from Sri Lanka. *Zootaxa* 1403:55-68.

Frost DR. 2008. Amphibian Species of the World: An Online Reference. Version 5.2. [Online]. Electronic database. Available: http://research.amnh.org/herpetology/amphibia/index.php. [Accessed: 15 July 2008]. American Museum of Natural History, New York, USA.

Gunatilleke IAUN, Gunatilleke CVS. 1990. Distribution of floristic richness and its conservation in Sri Lanka. *Conservation Biology* 4(1):21-31.

Günther ALCG. 1864. *The Reptiles of British India*. Ray Society, Robert Hardwicke, London. xxii + 26 plates + 452 p.

Gower DJ, Maduwage K. 2011. Two new species of *Rhinophis* Hemprich (Serpentes: Uropeltidae) from Sri Lanka. *Zootaxa* 2881:51-68.

Helgen KM, Groves CP. 2005. Biodiversity in Sri Lanka and western Ghats. *Science* 308(5719):199.

Helle E, Helle P 1982. Edge effect on forest bird densities on offshore islands in the northern Gulf of Bothnia. *Annales Zoologici Fennici* 19:165-169.

Hewawasam T, von Blanckenburg F, Schaller M, Kubik P. 2003. Increase of human over natural erosion rates in tropical highlands constrained by cosmogenic nuclides. *Geology* 31:597-600.

Hochkirch A, Gärtner A-C, Brandt T. 2008. Effects of forest-dune forest edge management on the endangered heath grasshopper, *Chorthippus vagans* (Orthoptera: Acrididae). *Bulletin of Entomological Research* 98:449-456.

Howlader MSA. 2011. Cricket frog (Amphibia: Anura: Dicroglossidae): two regions of Asia are Corresponding two groups. *Bonnoprani – Bangladesh Wildlife Bulletin* 5(1-2):1-7.

Jenkins M. 2003. Prospects for biodiversity. *Science* 302(5648):1175-1177.

Karunarathna DMSS, Abeywardana UTI, Asela MDC, Kekulandala LDCB. 2008. A preliminary survey of the amphibian fauna in Nilgala forest area and its vicinity, Monaragala district, Sri Lanka. *Herpetological Conservation and Biology* 3(2):264-272.

Kekulandala LDCB. 2002. A survey of fish in Kalugala Proposed Forest Reserve. Sri Lanka. *Naturalist* 5(2):20-25.

Maduwage K, Silva A, Manamendra-Arachchi K, Pethiyagoda R. 2009. A taxonomic revision of the South Asian hump-nosed pit vipers (Squamata: Viperidae: *Hypnale*). *Zootaxa* 2232:1-28.

Manamendra-Arachchi K, Pethiyagoda R. 2005. The Sri Lankan shrub-frogs of the genus *Philautus* Gistel, 1848 (Ranidae: Rhacophorinae) with description of 27 new species. *The Raffles Bulletin of Zoology*, Supplement 12:163-303.

Manamendra-Arachchi K, Pethiyagoda R. 2006. *Sri Lankawe Ubhayajeeween* [Amphibians of Sri Lanka]. Wildlife Heritage Trust of Sri Lanka, Colombo. 88 plates + 440 p.

Manamendra-Arachchi K, de Silva A, Amarasinghe T. 2006. Description of a second species of *Cophotis* (Reptilia:Agamidae) from the highlands of Sri Lanka. *Lyriocephalus*, Supplement 1(6):1-8.

Manamendra-Arachchi K, Batuwita S, Pethiyagoda R. 2007. A taxonomic revision of the Sri Lankan day-geckos (Reptilia: Gekkonidae: *Cnemaspis*), with description of new species from Sri Lanka and southern India. *Zeylanica* 7(1):9-122.

Meegaskumbura M, Manamendra-Arachchi K. 2005. Description of eight new species of shrub-frogs (Ranidae: Rhacophorinae: *Philautus*) from Sri Lanka. *The Raffles Bulletin of Zoology*, Supplement 12:305-338.

Meegaskumbura M, Manamendra-Arachchi K. 2011. Two new species of shrub frogs (Rhacophoridae: *Pseudophilautus*) from Sri Lanka. *Zootaxa* 2747:1-18.

Meegaskumbura M, Bossuyt F, Pethiyagoda R, Manamendra-Arachchi K, Bahir MM, Milinkovitch MC, Schneider CJ. 2002. Sri Lanka: An amphibian hotspot. *Science* 298(5592):379.

Meegaskumbura M, Manamendra-Arachchi K, Pethiyagoda R. 2009. Two new species of shrub frogs (Rhacophoridae: *Philautus*) from the lowlands of Sri Lanka. *Zootaxa* 2122:51-68.

Meegaskumbura M, Manamendra-Arachchi K, Schneider CJ, Pethiyagoda R. 2007. New species amongst Sri Lanka's extinct shrub frogs (Amphibia: Rhacophoridae: *Philautus*). *Zootaxa* 1397:1-15.

Meegaskumbura M, Meegaskumbura S, Bowatte G, Manamendra-Arachchi K, Pethiyagoda R, Hanken J, Schneider CJ. 2010. *Taruga* (Anura: Rhacophoridae), a new genus of foam-nesting tree frogs endemic to Sri Lanka. *Ceylon Journal of Science* (Biological Sciences) 39(2):75-94.

Murcia C. 1995. Edge effects in fragmented forest: Implication for conservation. *Trends in Ecology and Evolution* 10(2):58-62.

Pasitschniak-Arts M and Messier F. 1998. Effects of edges and habitats on small mammals in a prairie ecosystem. *Canadian Journal of Zoology* 76(11):2020-2025.

Pethiyagoda R. 1994. Threats to the indigenous freshwater fishes of Sri Lanka and remarks on their conservation. *Hydrobiologia* 285(1-3):189-201.

Pethiyagoda R. 2005. Exploring Sri Lanka's biodiversity. *The Raffles Bulletin of Zoology*, Supplement 12:1-4.

Pethiyagoda R. 2007a. *Pearls, Spices and Green Gold, An Illustrated History of Biodiversity Exploration of Sri Lanka*. Wildlife Heritage Trust of Sri Lanka, Colombo. 241 p.

Pethiyagoda R. 2007b. The 'New species syndrome' in Sri Lankan herpetology: A cautionary note. *Zeylanica* 7(1):1-7.

Pethiyagoda R, Manamendra-Arachchi K. 1998. A revision of the endemic Sri Lankan agamid lizard genus *Ceratophora* Gray, 1835, with description of two new species. *Journal of South Asian Natural History* 1(1):77-96.

Ranasinghe PN. 1995. *Biodiversity and Management Plan: Kalugala Proposed Forest Reserve*. The Young Zoologists' Association, National Zoological Gardens, Dehiwala. 45 p. (Unpublished).

Senaratna LK. 2001. *A Check List of the Flowering Plants of Sri Lanka*. National Science Foundation of Sri Lanka, Colombo. 342 p.

Smith EN, Manamendra-Arachchi K, Somaweera R. 2008. A new species of coral snake of the genus *Calliophis* (Squamata: Elapidae) from the Central Province of Sri Lanka. *Zootaxa* 1847:19-33.

Smith MA. 1935. *The Fauna of British India Including Ceylon and Burma: Reptilia and Amphibia, Volume II Sauria*. Taylor and Francis, London. 1 plate + 440 p.

Somaweera R. 2006. *Sri Lankawe Sarpayin* [Snakes of Sri Lanka]. Wildlife Heritage Trust of Sri Lanka, Colombo. 297 p.

Somaweera R and Somaweera N. 2009. *Lizards of Sri Lanka: A Colour Guide with Field Keys*. Edition Chimaira, Serpent's Tail, German. 303 p.

Tan BC. 2005. New species records of Sri Lanka Mosses. *The Raffles Bulletin of Zoology*, Supplement 12:5-8.

Taylor EH. 1953. A review of the lizards of Ceylon. *The University of Kansas Science Bulletin* 35(12):1525-1585.

IUCN Sri Lanka (IUCNSL), The Ministry of Environment and Natural Resources (MENRSL). 2007. *The 2007 Red List of threatened Fauna and Flora of Sri Lanka*. The World Conservation Union (IUCN) Colombo, Sri Lanka. 148 p.

Whitaker R and Captain A. 2004. *Snakes of India, the Field Guide*. Draco Publication Limited, India. 479 p.

Wickramasinghe LJM, Munindradasa DAI. 2007. Review of the genus *Cnemaspis* Strauch, 1887 (Sauria: Gekkonidae) in Sri Lanka with the description of five new species. *Zootaxa* 1490:1-63.

Wickramasinghe LJM, Vidanapathirana DR, Wickramasinghe N, Ranwella PN. 2009. A new species of *Rhinophis* Hemprich, 1820 (Reptilia: Serpentes: Uropeltidae) from Rakwana massif, Sri Lanka. *Zootaxa* 2044:1-22.

Wittemyer G, Elsen P, Bean WT, Burton ACO, Brashares JS. 2008. Accelerated human population growth at protected area edges. *Science* 321(5885):123-126.

Manuscript received: 16 November 2011
Accepted:10 December 2011
Published: 2 February 2012

W. MADHAVA S. BOTEJUE has researched the fauna of Sri Lanka for the past seven years, especially ecology and behavior. He has conducted awareness programs to educate the Sri Lankan community of the importance of biodiversity and conservation. Madhava earned his B.Sc. degree in Natural Sciences from The Open University of Sri Lanka (OUSL) in 2009. Currently he serves as treasurer of the Taprobanica Nature Conservation Society, Sri Lanka and associate editor for *Taprobanica: The Journal of Asian Biodiversity*.

DR. JAYANTHA WATTAVIDANAGE has been involved in teaching and research in the fields of ecology, faunal diversity, limnology, and molecular parasitology for the past twenty years. He is strongly involved in popularizing science among the general public and is the author of a large number of newspaper and magazine articles. Currently, he is the Chairman, National Committee for Science Popularizing, National Science Foundation in Sri Lanka. He works as a Senior Lecturer in zoology at The Open University of Sri Lanka beginning in 1990. Jayantha earned his B.Sc. and M.Phil. from University of Sri Jayawardenepura and Ph.D. from University of Colombo, Sri Lanka. He conducted post doctoral research on molecular genetics of Malaria at University of Edinburgh, United Kingdom. He is also a recipient of many research awards including the Presidential Award for his research publications.