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Herpetofaunal richness in Lippakelle Tea Estate, Sri Lanka

Extensive studies on diversity and ecology of Sri Lankan herpetofauna have so far been conducted mostly in and around protected areas (MENR, 2012). Studies on fauna of economically important crop plantations such as tea, rubber, coconut, and some other commercial crops are limited and few studies have been conducted in tea plantations in up country, Sri Lanka (Kottawa-Arachchi *et al.*, 2010, 2015; Sumanapala *et al*., 2012). This study was undertaken to estimate herpetofaunal diversity and identify important habitats for herpetofauna in a tea plantation ecosystem in Sri Lanka.

The study was conducted in Lippakelle Tea Estate located in Nuwara Eliya ($6^0$53'44''N, $80^0$43'33''E). The estate is situated within the Agro-ecological region WU2a (Panabokke & Kannangara, 1996). Average annual rainfall of the area is about 2250 mm and average elevation is 1600 m a.s.l. The estate consists of 281.75 ha of which 188 ha are occupied by tea cultivation. A field survey was conducted in six different habitats (home gardens, streams, *Eucalyptus* plantation, marshy lands, tea fields and rock outcrop) within the tea plantation for three months. The line transects (100 x 10 m) method was used to study the herpetofauna with four night sampling (19:00–21:00 h) and daytime (07:00–09:00 h) per month. Within each major habitat, different microhabitats (such as tree holes, stone terraces, decaying logs, leaf-litter, and water puddles) were systematically searched. Recently published taxonomic keys were used for identification and threatened species were grouped according to the National Red List (MENR, 2012).

During the present survey, 11 species of amphibians and 10 species of reptiles were recorded (Appendix 1). Interestingly, a critically endangered species *Pseudophilautus microtympanum* and six endangered amphibian species were recorded. *Duttaphrynus melanostictus* was the most common amphibian species observed and was the only one found in all six habitats. This was followed by *P. alto* and *Hylarana temporalis.* During this study, 10 species of reptiles including 6 endemic species were observed. Among them, two critically endangered species (*Cnemaspis* cf. *clivicola* and *Lankascincus* cf. *sripadensis*) and four endangered species were recorded. A lizard *Calotes calotes* was the most common reptile species in Lippakelle estate followed by *Eutropis carinata* and *Rhinophis blythii.*

Recently, Kottawa-Arachchi *et al.*, (2014) recorded 10 species of amphibians and 8 species of reptiles in Mattakelle tea estate situated in same Agro-ecological region WU2a. The critically endangered species *Pseudophilautus microtympanum* was only found in this present study but the other six endangered amphibian species were detected in both studies.

***Importance of different habitats for herpetofauna*:** The agro-ecosystems in the Lippakelle estate are dominated by tea (*Camellia sinensis*) plantation with low shade trees such as *Erythrina lithosperma, Calliandra calothrysus* and the high shade tree *Grevillea robusta*. Home gardens and abandoned lands are under household agriculture managed by the estate community for growing vegetables. Among the fruit species, *Persea americana, Mangifera indica, Psidium guajava* and *P. littorale* are dominant in the home gardens. *Cassia spectabilis* and *Spathodea campanulata* trees are found along roadsides as ornamental trees. These plant species in the tea plantation ecosystem create different conditions of shade and litter accumulation that, in turn, affects organic matter regeneration. The use of the leaf litter-layer as a microhabitat depends on the depth or thickness of the layer, the deeper ones providing more space for litter dwelling organisms (Weerawardhena & Russell, 2012). Accumulations of leaf litter around trees and

moist spots often harbor many individual herpetofauna, and depending on the moisture regime they are often highly concentrated (Vonesh, 2001).

The present study indicates that home garden habitats maintain the highest herpetofaunal diversity recording 12 species (5 amphibians + 7 reptiles) followed by tea fields (5+5) and then streams (6+3). The high species abundance in the home garden habitats and tea fields may be due to the high amount of leaf litter, shaded patches and microhabitats (e.g., tree bark, crevices, stone terraces, decaying logs, loose soil, and other small niches). The endangered reptiles *Aspidura trachyprocta* and *Rhinophis blythii* were both observed under leaf litter in home gardens. A few individuals of the small gecko *Cnemaspis* cf. *clivicola* were recorded along stone terraces. Most of the hilly areas and abandoned lands within the estate have been converted to *Eucalyptus* plantations for timber and firewood requirements. Generally, *Eucalyptus* forests are considered as poor supporters of faunal diversity due to their lack of thick understorey, less plant diversity and unfavorable micro-climates when compared to other forest plantation (Wijesinghe and de Silva, 2012). This study also revealed that the lowest species diversity occurred in *Eucalyptus* forests.

Tea fields were the second most important habitat recording ten species of herpetofauna. The most amphibian species were recorded associated with the aquatic ecosystems such as steams, ponds and marshy lands. The endemic, near threatened and widely distributed amphibian species *Hylarana temporalis* was regularly observed in the stream and pond habitats. A few individuals of the endangered frog *Pseudophilautus sarasinorum* were recorded at night on boulders in a stream near anthropogenic habitat. Two individuals of the critically endangered amphibian species *P. microtympanum* were recorded along stone terraces in tea fields and rocky outcrops in Elgin division. An endemic and endangered amphibian species *Taruga eques* was restricted to a small manmade pond in Elgin division and was not recorded in other water holes.

This survey is indicative of the importance of Lippakelle estate in providing shelter to a large number of amphibians and it is indicated that microhabitats such as the understorey near streams and water puddles are important for sustainable amphibian life. A number of individuals of *Calotes calotes* and *Eutropis carinata* were also observed during daytime in a rocky area. An endemic, endangered and venomous snake *Hypnale nepa* was only observed in rocky outcrop habitat. Therefore, this rocky habitat is ecologically valuable, an ideal place for a larger study of the ecology of amphibians as well as reptiles.

***Threats and Conservation of herpetofauna*:** Growing human population in Sri Lanka has resulted in the reduction of natural habitats as natural forests are converted to human settlements, agricultural lands, industrial areas and related infrastructure development. These activities marked the beginning of environmental problems and large scale biodiversity erosion in the country. Tea (*Camellia sinensis*) is often considered as the greatest threat to tropical montane ecosystems, especially to lower organisms. Since tea grows best in humid conditions it has attracted a large number of pests and the application of high amounts of pesticide is practiced for their control (Daniels, 2003). Toxic substances can end up in the drains and streams where amphibians breed, affecting them in a variety of ways such as reducing their growth rate and inducing deformities. Fortunately, the management of Lippakelle estate is conducting good agricultural practices, especially the zero usage of pesticides. Therefore, large population of tadpoles of *Duttaphrynus melanostictus* and *Hylarana temporalis* were observed in small water bodies near tea fields.

In Sri Lanka the majority of the endemic and threatened amphibians are confined to the wet zone and especially, the montane ecosystem where habitat loss and degradation are taking place at a rapid rate (Rajakaruna *et al.*, 2007; Erdelen, 2012). Furthermore, fragmentation of habitats also has a detrimental effect on herpetofauna, especially amphibians that have low mobility. Protection of aquatic breeding sites may be of little value if adjacent terrestrial habitats used by amphibians for feeding and shelter are destroyed. Recent research has rediscovered a few species of amphibians that were considered extinct. Gabadage *et al.* (2014) emphasized that further extensive surveys in the central highlands of Sri Lanka are essential to reveal species that are currently considered

extinct. One of the major drawbacks to conserving reptile fauna in Sri Lanka is the lack of knowledge of their distribution and ecology (Karunarathna & Amarasinghe, 2011). Due to mythical beliefs and lack of knowledge many people on the estate kill all the snakes they meet. It is therefore essential to conduct awareness programs for the estate community with practical advice on managing venomous and non- venomous reptile fauna. Lack of ecological studies in tea plantation ecosystems in Sri Lanka is a major drawback for identification of their potential threats to herpetofauna. There are a number of undesirable environmental impacts associated with fertilizer and pesticide usage in which these inputs impact on biodiversity at various levels including plant, invertebrate, and vertebrate groups (McLaughlin & Mineau, 1995). Further studies should assess the negative impact on herpetofauna in tea plantation ecosystems with special emphasis on ecological aspects and population dynamics.

Further, maintaining a good canopy of shade trees, increasing plant diversity with native species in abandoned lands, home gardens and road sides will all be supportive of increasing herpetofauna. Promoting awareness of the harmful effects of the excessive use of agro-chemicals among the estate community would certainly bring necessary beneficial changes to tea plantation ecosystems.

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Appendix 1: List of herpetofauna recorded from Lippakelle Estate; * Endemic, **CR** Critically Endangered, **EN** Endangered, **NT** Near Threatened, HG = home gardens, ST = streams, EF = *Eucalyptus* forests, ML = marshy lands, TF = tea fields, RO = rocky outcrops

Species	HG	ST	EF	ML	TF	RO	abundance
Amphibians							
Duttaphrynus melanostictus	x	x	x	x	x	x	34
Hylarana temporalis * NT		x		x			24
Pseudophilautus alto * EN	x	x	x		x	x	28
P. sarasinorum * EN		x					14
P. silus * EN	x	x	x	x		x	20
P. viridis * EN	x	x			x		21
P. reticulatus * EN	x						6
P. microtympanum * CR					x	x	6
Taruga eques * EN					x		23
Fejervarya limnocharis				x			9
Euphlyctis cyanophlyctis				x			12
Reptiles							
Aspidura trachyprocta * EN	x				x		13
Ptyas mucosa	x						3
Rhinophis blythii * EN	x	x			x		18
Hypnale nepa * EN						x	4
Calotes calotes	x	x	x	x	x	x	27
C. nigrilabris * EN				x			4
Hemidactylus frenatus	x						8
Cnemaspis cf. *clivicola* * CR	x						6
Eutropis carinata	x	x	x		x	x	21
Lankascincus cf. *sripadensis* * CR				x	x	x	12
Species richness in each habitat	12	9	5	8	10	8	