NEARLY SIXTY PERCENT OF SRI LANKA'S MAMMALS INHABITING THE RAINFORESTS FACE EXTINCTION: TIME IS SHORT TO CONSERVE THESE FORESTS AND THEIR DIVERSE DEPENDENTS

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Summary

Biodiversity conservation has been stated as a national goal for Sri Lanka. Accordingly, the urgency of implementing and extending protection for wet-zone lowland rainforest areas cannot be overstated; less than 8% of this original habitat remains intact and far less is under protection. Major protected areas are the Sinharaja and the Kanneliya-Dediyagama-Nakiyadeniya (KDN) Reserves. Like the nine to ten other smaller reserves under government administration, they are under threat from human encroachment.

The focus of this report is on the significance of lowland rainforest for the conservation of Sri Lankan mammals. These old-growth habitats are home to 85 (78%) of the 108 documented uniquely named land living mammal taxa (species and subspecies) of Sri Lanka. More than 50% of endemic mammals reside there; involving 2 genera, 8 species and 17 subspecies. Recent observations of the distribution of mammal taxa by phyto-climatic zone are consistent with historical records. These taxa are tied to their ecological niches in the rainforests even when their habitat is fragmented and degraded, thus putting their survival at risk. A minority of generalist mammals may have expanded their range slightly to an adjoining zone when habitat changes favored their ecological adaptations. The Ministry of Environment Red List assessment (2012) has determined that 50 (59%) of these 85 lowland rainforest resident mammals are threatened with extinction either as Vulnerable (n=17), Endangered (n=21) or Critically Endangered (n=12), primarily as a consequence of loss of habitat. Conservation of mammalian diversity translates into conserving their ancient habitats of the wet-zone forests.

For more than five decades biologists have emphasized the need to protect these habitats. There is sufficient taxonomic, ecological and biogeographical data available for plants and animals to guide effective conservation efforts; the priority lies not in further studies but in initiating active protection of what remains of these natural environments before there is nothing left.

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INTRODUCTION

Tropical rainforests of the world have a reputation of supporting a great diversity of life, and those of Sri Lanka stand out among them as unique refugia for plants (Gunatilleke et al., 2017) and animals (Bossuyt and Milinkovitch, 2001; Karanth, 2006) whose origins are rooted in Gondwana more than 180 mya. These forest habitats deserve protection as a natural heritage treasure of Sri Lanka; their irreplaceable contribution to global biodiversity and importance to the history of life on earth has been acknowledged internationally. Unfortunately, their future survival is threatened: Sri Lanka along with the Western Ghats, has been designated as one of thirteen global hotspot of biodiversity (Myers et al., 2000). Nature conservation in Sri Lanka might be regarded as a national priority on par with the services for health, education and economic development. In this leadership act of balancing priorities any trade-off in support of nature conservation requires an educated public (and especially leadership) that has an appreciation of the value of its natural resources. People will conserve only what they love, and will love only what they know and understand, and will understand only what they are taught.

It is in this spirit and broader perspective that this report is intended to serve a useful purpose. While many life forms contribute to biodiversity, the objective here is to focus on the role of mammals in enriching biodiversity and their plight in the highly populated and threatened habitats of the wet-zone of Sri Lanka. Excellent illustrations and accounts of all Sri Lankan mammals have been given in the tome by Yapa and Ratnavira (2013), guides (de Silva Wijeyeratne, 2008), and older works by Philips (1935, updated in 1980). Charismatic representatives have been featured in many international documentary films that showcase Sri Lanka as a tourist destination – contributing to the nations' wealth.

The specific aims here are to review and highlight: (1) the diversity of mammals typically resident in the wet-zone of Sri Lankan below 1500 m, (2) the threats facing their survival as assessed by the Ministry of Environment (MOE, 2012) and international Red Listing agents, (3) the endemic mammals involved, and (4) the few remaining pockets of natural habitat in the wet-zone that require the utmost urgency in protection and conservation attention.

METHODS

The data in this report represent a synthesis of prominently published information regarding the conservation (or red-listed status) of Sri Lankan mammals that typically reside, but not exclusively, in the wet-zone areas below 1,500 m. The synthesis makes no pretense at being exhaustive, but is intended as a useful representative sample of the status quo.

Red List assessments

The Red List status follows the Ministry of Environment assessment (MOE, 2012) that reported the National Conservation Status (NCS) as well as the Global Conservation Status (GCS) for Sri Lankan plant and animal species. The NCS followed the IUCN Global Red List Categories and Criteria (version 3.1) guidelines adapted by the Ministry of Environment to suit the information available for Sri Lankan species. In applying the Red List, criteria B (the geographic extent of occurrence and area of occupancy) was used in most cases. Criteria A (population size reduction over an extended period) and C (small population size and decline) were used in cases where population data were available (Perera et al., 2012). The IUCN categories most relevant to the present report on Sri Lankan mammals involved the three Threatened categories of Critically Endangered (CR), Endangered (EN) and Vulnerable (VU), as well as Near Threatened (NT), Least Concern (LC) and Data Deficient (DD).

Most Red List assessments (Appendix 1) were taken from the MOE report by Weerakoon (2012) where, by convention, assessments were made at the level of the species. In Red List reviews, especially within the Order Primates, the phylogenetic species concept is normally applied and assessments are made more appropriately at the level of subspecies, where each subspecies is accepted as the basic unit of conservation, also referred to as the Evolutionary Stable Unit (ESU) (Ryder, 1986; Dittus 2013). This approach ensures that the diversity within polytypic species is acknowledged for scientific and conservation management purposes (Moritz, 1994; Vogler and DeSalle, 1994); the MOE report by Weerakoon (2012) mentions this concern but adheres to the convention. Assessments for subspecies are highlighted with notations in Appendix 1, and, with exception of the primates, were not available for most Sri Lankan mammals. Therefore, the assessed category of threat, published by the NCS for any polytypic species was taken as applicable to its subspecies, with noted exceptions (Appendix 1). Insofar as the geographical distribution of subspecies is more limited than that of the parent species, the Red List status of subspecies provides a powerful tool in decisions of land use for conservation.

Endemism

Endemic genera and species were highlighted by Weerakoon (2012) in the MOE report. Taxonomic distinctions had also been published for many Sri Lankan mammal subspecies by Eisenberg and McKay (1970), Phillips (1935, and updated 1980), Yapa and Ratnavira (2013) and others. These designations of endemism at different taxonomic levels and by different authors were reviewed (Dittus, 2013) and are indicated in Appendix 1.

Distribution of mammals by habitat type and phyto-climatic zone.

Consideration of the geographical distribution of mammals rests on the evolutionary and ecological principles of niche adaptation (e.g., Peterson et al., 2011). Climate and to some

extent soil interact to determine vegetation form, which in turn influence mammalian ecology and faunal composition in any one area (Eisenberg, 1981). Detailed information on the ecological niches of different mammalian taxa is variable. But, major differences in habitat have been well documented and can be taken as proxies for major mammalian niches differences. Eisenberg and McKay (1970) were the first to relate mammalian faunal distribution in relation to seven phyto-climatic zones as described by Mueller -Dombois and Sirisena (1967). The lowland arid-zone (A) supports monsoon scrub jungles and grasslands that occur in the extreme north and northwest (A1) and extreme southeast (A2) of the island. The most extensive area (B) includes the lowland monsoon forest and grassland of what is commonly known as the 'dry-zone'. A belt of transitional inter-monsoon forest (C) separates the dry-zone from the wet-zone. Rainforests in the south-west and the central massif of the island occur below 1000 m (D1), between 1000 m to 1500 m (D2), and above 1500 m (D3). The boundaries between these habitat types are inexact (depending on measurement criteria applied) and local variations occur. For example, in zone D3, Wijesinghe et al. (1993) distinguish between an 'intermediate' and 'wet' montane zones, and following Fernando (1968) confine, the 'arid-zones' much closer to the coasts. Subsequent writers on mammalian distributions have applied the same (Weerakoon, 2012) or slightly modified zonations (e.g., Weerakoon and Gunatilake, 2006; Yapa and Ratnavira, 2013). Yapa and Ratnavira (2013) often indicated specific place names for records of observation. The demarcation of wet-zone boundaries were comparable among these different reports and some sections of the Knuckles Conservation area were considered as part of the lowland wet-zone rainforest.

RESULTS

In order to obtain an overview of the mix of factors that influence mammalian diversity, biogeographic distribution and prospects for avoiding extinction it was useful to document these different factors for each mammal taxon to the extent that information was available. Of the (n=111) land-living unique native mammalian taxa, for which there are zonal distribution data as well as Red List assessments, 85 are resident wholly or partly in the wet-zone (D1 and D2); they are indicated either as monotypic (n=70) or polytypic species (n=9), an additional smaller number (n=6) are indicated as unique subspecies separately from the nominate subspecies where such occur among polytypic species. All unique taxa inhabiting the different phytoclimatic zones are indicated (Appendix 1).

Zonal habitat distribution through time

Most information on mammalian distributions date from the late 19th to the middle of the 20th centuries. More recent records of distribution were updated as modifications of earlier ones, either adding newly cited locations, subtracting ones seen earlier or no change noted or known (Appendix 1). Updated biogeographical information was not evenly available among taxa, and involved mostly those species that had been studied in the last two decades, notably

the shrews (Meegaskumbura et al., 2007; Meegaskumura and Schneider, 2008), some of the rats and mice (McKay, 1984; Wijesinghe and Brooke, 2005; Wijesinghe, 2006; Ratnaweera and Wijesinghe, 2009; Wijesignhe, 2012), flying squirrels (Dissanayake and Oshida, 2012), bats (University of Colombo bat survey of 2004, cited by Yapa and Ratnavira 2013), macaques and langurs (Dela, 2007; Rudran, 2007; Dittus, 2012), lorises (Nekaris and Jayewardene, 2004; Perera, 2008; Gamage et al., 2017), chevrotains (Groves and Meijaard, 2005), civets (Groves et al. 2009), cats (Miththapala, 2006; Kittle et al., 2017, Kittle and Watson, in press), elephants (Jayewardene, 1994; Fernando et al. 2011). Several other taxa are fairly conspicuous or well known in their recent zonal distributions in the absence of focused studies, these include the larger deer species (spotted-deer and sambur), hares, porcupines, sloth bear, wild boar, and jackals (Yapa and Ratnavira, 2013). Additional information in the current zonal distribution of mammals would be desirable among the native rats and mice, forest squirrels, mongooses as well as pangolins.

Red Listed mammals

The level of threat for each mammal taxon (genus, species and subspecies) residing partially of wholly in the lowland (D1) and mid to upland (D2) wet-zone of Sri Lanka were given in Appendix 1 and summarized for all taxa (Figure 1) and for each family of mammals (Table 1). The levels of Red List threat varied among mammals according to their taxonomic classification and status as endemic and non-endemic (Figure 2). Resident non-endemic species (n=56), encompassed 15 endemic subspecies where species were polytypic, and 10 non-nominate unique subspecies. About half (48%) of all endemic subspecies were threatened. All endemic genera, and species were threatened, and 42% of non- endemic taxa were threatened (Figure 2).

Remnants of habitats located in the wet-zone < 1500 m.

Excluding specialized niches, such mangroves, most of the remnants of original or old-growth forest was Lowland Wet Evergreen Forest (Jayasiruya et al., 2009). Wickremanayake and Buthpitiya (2017) estimated that 13% of these forests are protected. Much of what is left of these 19 to 20 widely scattered remnants can be found in government administered forest reserves and sanctuaries. With the exception of the Sinharaja (NHWA), most are small in area and subject to degradation - taking the prevalence of Sparse and Open Forest as a sign of past disturbance (Table 2). The viability status of these forests has been assessed using basic ecological parameters to estimate the ability of this rainforest ecological system to persist and maintain its biological diversity into the future. Although the viability prospects were graded as good or very good for more than 85% of the total remaining forest areas, this was true for only a select few sites that were large in area (Jayasuriya et al. 2006; 2009).

Table 1. The distribution of endemic and non-endemic taxa and levels of threat to them among the different families of mammals resident in the wet-zone rainforests of Sri Lanka. CR = Critically Endangered, EN = Endangered, VU = Vulnerable.

Mammal taxa resident in wet-zone < 1,500 m	Number of resident genera*, **species** and [subspecies]	Red-listed level of threat for mammal genera*, **species** and [subspecies]			Number of endemic genera*, **species** and [subspecies]
		CR	EN	VU	
Polytypic Families					
Shrews	1* + **8**	1* + **3**	**4**		1* + **6**
Fruit bats	**4**		[1]		[1]
Leaf-nosed bats	**5**		**1**	**1** + [1]	[2]
Free-tailed bats	**2**	**1** + [1]			[1]
Vesper bats	**10**	[1]	**1** + [1]	**3**	[2]
Sheath-tailed bats	**3**	**1**	**1**	**1**	
False vampire bats	**2**			**1** + [1]	[1]
Horseshoe bats	**2**			[1]	[1]
Loris	[2]		[2]		**1**
Macaques & langurs	[3]	[1]	[2]		**2**
Flying squirrels	**2**		[2]		[2]
Forest squirrels	**3** + [2]			**2**	**2** + [3]
Gerbils, rats & mice	1* + **11** + [2]	**2**	1* + **1** + [1]	[1]	1* + **3** + [6]
Civets	**4**		**2**		**2** + [1]
Mongooses	**3** + [1]			**1**	[3]
Cats	**3**		**1**	**2**	[2]
Deer	**3**	**1**			[1]
Chevrotains	**1**			**1**	**1**
Monotypic Families					
Elephant	**1**		[1]		[1]
Otter	**1**			**1**	
Porcupine	**1**				
Hare	**1**				[1]
Pangolin	**1**				
Wild Boar	**1**				
Jackal	**1**				[1]
Total Genera	2*	1*			2 *
Species	**73**	**8**	**11**	**13**	**17**
Subspecies	[10]	[3]	[10]	[4]	[29]

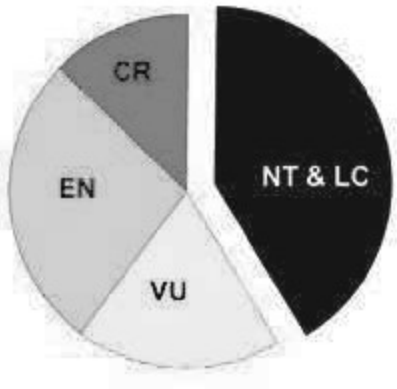

Figure 1. The Red List status of mammalian taxa resident in the wet-zone rainforests of Sri Lanka. CR = Critically Endangered, EN = Endangered, VU = Vulnerable, LC = Least Concern, NT = Not Threatened (adapted after Weerakoon, 2012).

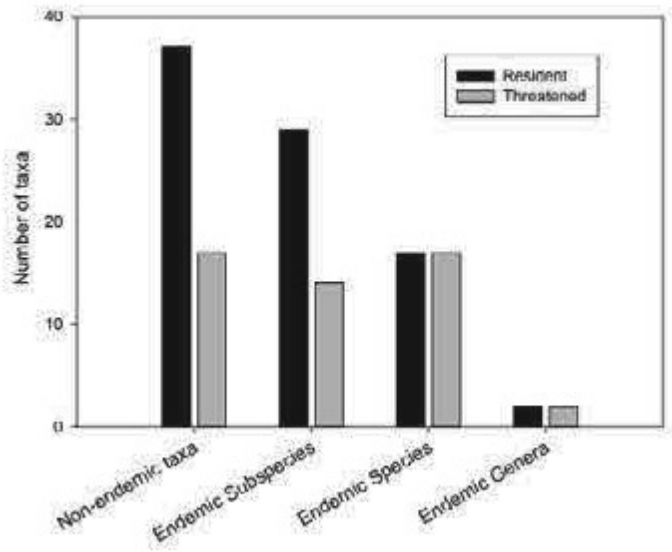

Figure 2. The numbers of mammalian taxa that are resident and threatened in the wet-zone forests according to their taxonomic and endemic status.

Table 2. Protected areas including Lowland Wet Evergreen Forest suited as ecological niches for mammals of the wet-zone.

CF= Conservation Forest, FR= Forest Reserve, LWEF = Lowland Wet Evergreen Forest, MEEF = Mid-elevational Moist Evergreen Forest, MMEF= Moist Mixed Evergeen Forest, NHWA = National Heritage Wilderness Area, PR= Proposed Reserve, SAVG = Savanna Grassland, SPOF = Sparse and Open Forest. Adapted from Jayasuria et al., 2009

Forested area	Main vegetation types	Extent, km^2	Sector Protected Area
Diyadawa	LWEF, SPOF	24.5	Forest FR
Gilimale-Eratna	LWEF, SPOF	48.4	Forest PR
Haycock	LWEF	3.6	Forest FR
Kanneliya-Dediyagala-Nakiya-deniya	LWEF, SPOF	10.4	Forest FR, PR
Kalutawawa and Labugma	LWEF, SPOF	21.0	Municipal Reservoir
Kanumuldeniya	LWEF	6.8	Forest FR
Kombala-Kottawa	LWEF, SPOF	16.2	Forest PR
Knuckles	LWEF, MEEF, MMEF, SAVG, SPOF	< 180	Forest CF
Kurulukele	LWEF, SPOF	0.1	Wildlife
Mulatiyana	LWEF	31.5	Forest FR
Oliyagankele	LWEF	4.9	Forest FR
Rammalakanda	LWEF	14.1	Forest FR
Sinharaja	LWEF, SPOF	111.9	Forest NHWA
Udawattakele	LWEF	1.0	Forest FR
Total		293+	

DISCUSSION

Mammals' fidelity to niche habitats by phyto-climatic zone

Sri Lankan landscapes and natural areas have been subject to major changes, mostly through the reduction of natural forests habitats and their fragmentation in the pursuit of conversion for economic, mostly agricultural use (Jayasuriya et al., 2006). Such change is particularly evident in the lowland (and montane) rainforests (Gunatilleke and Gunatilleke, 1983, 1991; Wickramanayake and Gunatilleke, 2002; Katriarachchi, 2012). Consideration of the magnitude of change in natural habitats invites the question of its effects on mammalian biogeographical distributions (Dittus, 2017) as well as to the survival prospects of different mammals (Weerakoon, 2012). Although ancient records of mammalian distribution are

sparse, mammalogists of the late 19th century up to about 1969 have provided a rich source of information about the taxonomic diversity of mammals and their biogeographical distribution. As such, the early records offer the best estimate of ancient patterns of mammalian diversity and its distribution over Sri Lankan landscapes. A comparison of these records with more recent ones, emerging in the past 20 to 30 years was considered a fruitful exercise to disclose the nature and extent of change in habitat on patterns of mammalian distribution, viewed at the level of the phyto-climatic zones, and threats to mammal survival.

Keeping in mind the limitations in method and empirical evidence in such a broad brush consideration, the comparison is nevertheless instructive because it highlights the following trends. Firstly, defining the core of zonal distribution for each taxon as the area of most sightings (representing perhaps the highest densities), these core zones have not changed, or can be safely assumed to not have changed, in recorded time for any taxon (Appendix 1). Secondly, distributional changes have been noted, however, with respect to zones adjacent to their originally recorded cores. About 26% of the taxa were newly recorded at sites abutting their core zones and 7% were not recently seen in adjacent areas where they had been noted earlier. The question arises are these changes biogeographically meaningful expansions or retractions of distributional ranges, or artifacts of sampling? Species of shrews, bats, rats and mice together account for nearly all new distributional records into wet-zone areas D2 and or D3, where the same species had not been recorded historically (Appendix 1). These correspond to the taxa and areas of concentrated studies in the last two decades, notably by the University of Colombo bat survey of 2004 (cited by Yapa and Ratnavira, 2013), as well as others (e.g., Jayasekera et al., 2007; Meegaskumbura and Schneider, 2008; Wijesinghe, 2012). Increased sampling scrutiny appears to have played a role in exposing the wider zonal ranges of these species (Appendix 1). By a similar argument extensive studies in the dry and arid-zones by Smithsonian Institution researchers, 1963-1970 (Eisenberg and Lockhart 1973; McKay, 1973; Ripley, 1967) appear to reflect observations, for example of some widely distributed bat species as seasonal visitors that were not observed in later short-term surveys (Appendix 1). The decline to virtual absence of significant numbers of elephants in the wet-zones (D1, D2) over time appears to reflect a response to major changes in past hunting and increased human disturbance (Jayewardene, 1994; Fernando et al., 2011).

On the other hand, habitat changes brought about by humans would underlie the expansion of the ranges and species densities of mammals typically commensal with man, such as *Suncus murinus* (Meegaskumura and Schneider, 2008) and some rodents, e.g., *Rattus rattus rats* (Kotagama and Karunaratne, 1983; Ratnaweera and Wijesinghe, 2009; Wijesinghe, 2012). Likewise, two mesopredators, the ring-tailed civet and fishing cat have been noted as new montane wet-zone areas (D2, D3) (Appendix 1). Following the logic of the cascading ecological dynamics in novel habitats (e.g., Hobbs et al., 2006; Estes et al., 2011), are the expanded distributions of these small predators a reflection of greater prey densities (of generalist rodents for example) in newly disturbed areas (Wijesinghe, 2012), or an arti-

fact of more intensive sampling, for example with camera traps (Kittle and Watson, 2018)

The conclusion that can be drawn from these, albeit broad strokes comparison, are that on ecological principles alone one would expect mammals to remain in habitats that support their adapted niches (Eisenberg, 1981), despite habitat fragmentation and reduction of available niche space. To the extent that comparisons in changes in gross habitat occupation are available over time, these predictions seems to be supported (Appendix 1).

In the case of the leopard, Kittle et al. (2014) and Kittle and Watson (2017) argue that fidelity to niche habitats results not in the abandonment of altered habitat, but in adapting their diet (to changes in prey densities) where habitats have been altered. Fishing cats, too, seem able to adapt to human presence and live in and around human habitation (Miththapala, 2006). Dela (2012) has shown the purple-faced langur changes its diet in accordance with habitat changes caused by humans. Similarly, major changes in population densities, but not shifts in zonal distribution, per se, have been documented among commensal toque macaques because of novel food sources (garbage and crops) introduced by man (Dittus 2012; Dittus et al., 2019).

A new factor, however, has been introduced by humans influencing the zonal distribution of some mammals: namely, the translocation of mammals considered as pests (Dittus, 2012; Fernando et al. 2012). Translocations of subspecies of toque macaques have occurred, for example, from zones (D1, D2 and D3) at sites such as Kandy, Peradeniya, Matale, Kegalle, Hakgala Gardens (among others) into rural and/or protected areas into zones, A, B and C that are foreign to these subspecies ecological niches (Dittus, 2012). Taxonomic and biogeographical distinctions are thereby blurred and undermine the national goal of biodiversity conservation (MOE, 2012). Not to deny the ills of human-wildlife conflict, there are more constructive and benign ways of resolving the human-wildlife conflict (Dittus, 2012; Dittus et al., 2019) other than outright extermination or translocation of localized pest populations. Translocation as a tool in wildlife management has been shown to be ineffective and has been widely decried (Craven et al., 1998).

Novel ecosystems (e.g., Pethiyagoda, 2012) created by the replacement of old growth forests with secondary growth of open landscapes are encroaching even protected reserves (Jayasekera et al. 2009) and are unsuited alternatives for sustaining the biodiversity of past millennia, primarily because they sustain adaptable generalist species rather than niche specialists as common among endemics (Wijesinghe, 2006; Ratnaweera and Wijesinghe, 2009). Notwithstanding this caveat and taking the long view, plant community succession over several hundred years potentially may eventually provide suitable niches. But in order for this to be effected old growth habitats need to be conserved as source habitats and both old and new habitats require strict protection. Given the genetic, economic and management challenges involved in such a plan preservation of existing old growth takes priority of investment.

Threats to Extinction

The above comparisons indicate that despite habitat destruction and fragmentation, mammals remain tied to the climatic zones which support their ecological niches. With the exception of some generalist mammals, and those readily converted to commensals, this close tie subjects them to the risks of extinction if their life-giving special habitats are destroyed. A case in point is manifest among endemic rodents that loose living space when their ancient old-growth niches are replaced by secondary growth (Wijesinghe, 2012). More inclusively, a finer grained inspection of geographic distribution was made for each taxon according to Red List criteria: extent of occurrence, area of occupancy and population trend (MOE, 2012). The biggest threat to all mammals in the wet-zone forest was owed to loss of habitat (IUCN Criterion B, Weerakoon, 2012).

A summary of threatened mammal taxa indicated that 59% of mammals resident in the wet-zone forests are threatened with extinction; 40% of them were either endangered or critically endangered (Figure 1). Threatened mammals included both endemic genera, all endemic species, nearly half of endemic subspecies (48%) and many (42%) of all non-endemic taxa (Figure 2).

The levels of threat varied among families of mammals, but all 17 polytypic families and two out of seven monotypic families had one or more of their lower level taxa threatened (Table 1). Mammals with low vagility (shrews, some primates, squirrels) and/or fidelity restricted to wet-zone habitat were at risk most often and seriously. In other words, mammals whose niches and livelihoods are most dependent upon the rainforests were also the most threatened with extinction through habitat loss.

Habitats for biodiversity conservation

What is the status of potential safe harbours for mammal survival? A few centuries ago lowland rainforest (12,500 km^2), montane forest (3,000 km^2) covered significant areas of Sri Lanka. Overall closed forest cover in all of Sri Lanka has dwindled from 84% in 1884 to less than 22% in 2016 (after Legg and Jewell, 1995; GOSL, 2000; FAO, 2005, 2010). Forest loss was greatest in the wet-zone, particularly in the lowlands, where most humans dwell. Of the original lowland rainforests (D1) less than 8% now remain as fragmented, degraded and isolated patches throughout the lowland wet-zone (Wickramanayake and Gunatilleke 2002; Jayasekera et al., 2009; Kathriarachchi, 2012, Gunatilleke et al., 2017). What remains in government protected areas (Table 2) continues to be subject to human encroachment and conversion from lowland rainforest as indicted by the prevalence of disturbed open forests in the majority of these protected areas (Table 2). These areas, though small in comparison to their original extents are nevertheless the last critically important refuges for biodiversity of which mammals are but one important component.

CONCLUSION

The ecological properties of lowland rainforest, threats facing them, the fauna and flora that that they support and their conservation status have been reviewed (Gunatilleke and Ashton, 1987; Senanayake et al., 1977; Gunatilleke and Gunatilleke, 1991; Ashton et al., 1997; Wikramanayake and Gunatilleke, 2002; Kathriarachchi, 2012; Wijesundara, 2012). These forests have been hailed as globally unique but the threats facing them contribute to Sri Lanka's disrepute as a hotspot in biodiversity (Myers et al., 2000). The present review lends the perspective from the mammalian inhabitants in these forests: nearly 60% of which are threatened with extinction, among them all endemic genera and species (Figure 2).

If the nation's natural heritage and aims (MoFE 1999; MoE 2012; MoMDE, 2016) to safeguard it are to be taken seriously, the urgency for meaningful protection requires an upgrade in conservation policy and its implementation (Miththapala, 2015; Wickramanayake, 2018).

While new research data are always welcome in science, there is more than sufficient taxonomic, distributional and ecological information already available for mammals to guide conservation management: the urgency for conservation action outweighs concerns over minor gaps in our knowledge (Grantham et al., 2009). For all native organisms (MOE, 2012), not merely the mammals, these actions require the protection of the last remnants of old-growth habitats supplemented by the reclamation of secondary or disturbed habitats towards their original biodiverse state (Pethiyagoda, 2012; Gunatilleke et al. 2017). The scientific and technical communities have charted the way forward (e.g., Jayasuriya et al., 2006; Wickremanayake and Buthpitiya, 2017). It is up to the nation's political stewards to fail, or not, the citizens of Sri Lanka and the world.

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Appendix 1. List of resident mammals of the wet-zone.

Asterisks denote; endemic genus (***), endemic species (**) and endemic subspecies (*). The national (NCS) and global (GCS) red-listed status follows (MOE, 2012), unless otherwise noted, and the symbols denote; Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Least Concern (LC), Not Threatened (NT) and Data Deficient (DD). Definitions of habitat zones for records of mammal taxon locations follow Eisenberg and McKay (1970); updated with distributional changes cited in Yapa and Ratnavira (2013) and Dittus (2017) unless otherwise noted. Zone update symbols denote; new records of location added to (+), or not confirming (--) earlier records of location, a blank denotes no change. Zones in parentheses denote rare records of mammal location.

Scientific name	Common name	NCS	GCS	Habitat Zone	Zone Update
Family: Soricidae (shrews)					
(**)[1]*Crocidura horsfieldii* (Tomes, 1856)	Horsfield's Shrew	CR	DD	D1,D2, (C,B)	
***Crocidura hikmiya* Meegaskumura *et al*. 2007	Sinharaja Shrew	CR		D1, D2	New taxon[8]
***Crocidura miya* Phillips, 1929	S L long-tailed Shrew	CR		D2, D3	
****Solisorex pearsoni* Thomas, 1924	Pearson's Long-clawed Shrew	CR	EN	D2,D3	
Suncus murinus (Linnaeus, 1766)	Common Musk Shrew	LC	LC	A,B,C,D1,D2	
Suncus etruscus (Savi, 1822)	Pygmy Shrew	EN	LC	A,B,C,D1,D2	
***Suncus fellows-gordoni Phillips, 1932*	Sri Lanka Pigmy Shrew	EN	EN	D3	+ D2[9]
***Suncus montanus* (Keelart, 1850)	Sri Lanka Highland Shrew	EN	VU	D3	+ D1, D2[9]
***Suncus zeylanicus* Phillips, 1928	Sri Lanka Jungle Shrew	DD	EN	(D1),D2	

Family: Cercopithecidae					
***Macaca sinica* (Linnaeus, 1771)	Toque Macaque	LC	EN[2]	all	
M. s. aurifrons (Pocock, 1931)	Wetzone Toque Macaque		EN[2]	D1,D2	
***Semnopithecus vetulus* (Erxleben, 1777)	Purple-faced Langur	EN	EN	all	
S. v. vetulus (Erxleben, 1777)	Southern Purple-faced Langur		EN[3]	D1,D2	
S. v. nestor (Bennett, 1833)	Western purple-faced Langur		CR[4]	D1	
Family: Lorisidae (species and subspecies)					
***Loris tardigradus (Linnaeus, 1758)*	Sri Lanka Red Slender Loris	VU	EN[5]	D1,D2, D3	
L. t. tardigradus (Linnaeus, 1758)	Southwestern Red Slender Loris		EN[6]	D1	
L. t. parvus (Gamage et al., 2017)	Northwestern Red Slender Loris		EN[7]	D1	New taxon[7]
Family: Emballonuridae (Sheath-tailed bats)					
Taphozous longimanus Hardwicke, 1825	Long-armed Sheath-tailed Bat	EN	LC	A,B,C,D1	
Taphozous melanopogan (Temmenick, 1841)	Black-bearded Tomb Bat	VU	LC	B,D1	+ C, D2
Saccolaimus saccolaimus Temmick, 1838	Pouch-bearing Sheath-tailed Bat	CR	LC	A,B, C, D1	-- A
Family: Hipposideridae (Leaf-nosed bats)					
**Hipposideros bicolor ater* Temleton, 1848	Bicolored Leaf-nosed Bat	LC	LC	A, B, D1	+ C, D2
Hipposideros fulvus Gray, 1838	Fulvous Leaf-nosed Bat	EN	LC	A,B,D1	+ C, D2
Hipposideros galeritus Cantor, 1846	Dekhan Leaf-nosed Bat	VU	LC	C, D1, D2	
**Hipposideros lankadiva lankadiva* Kelaart, 1850	Great Leaf-nosed Bat	VU	LC	A,B,C,D1,D2	
Hipposideros speoris (Schneider, 1800)	Schneider's Leaf-nosed Bat	LC	LC	C, D1,D2	+ A, B

Family: Megadermatidae (False vampires)					
Megaderma lyra Geoffroy, 1810	Greater False Vampire Bat	VU	LC	D1,D2	+ C
**Megaderma spasma ceylonese* (Linnaeus, 1758; Anderson, 1918)	Lesser False Vampire Bat	VU	LC	A,B,C,D1,D2	
Family: Molossidae (Free-tailed bats)					
Tadarida aegyptiaca (Geoffroy, 1818)	Continental Wrinkle-lip Bat	CR	LC	D2,D3	
**Chaerephon plicatus insularis* (Phillips, 1935)	Sri Lanka Wrinkle-lip Bat	CR	LC	D2	
Family: Pteropodidae (Fruit bats, flying foxes)					
Pteropus giganteus (Brunnich, 1782)	Flying fox	LC	LC	A,B,C, D1,D2	
Cynopterus sphinx (Vahl, 1797)	Indian Short-nosed Fruit Bat	LC	LC	all	-- D3
**Cynopterus brachyotis ceylonensis* (Muller, 1838)	Lesser Dog-nosed Fruit Bat	EN	LC	all	-- A, B
Rousettus leschenaulti (Desmarest, 1820)	Fulvus Fruit Bat	LC	LC	(A,B,C) D1,D2	
Family: Rhinolophidae (Horseshoe bats)					
**Rhinolophus beddomei* sobrinus (Anderson, 1918)	Great Horse-shoe Bat	VU	LC	A, B, D1	+ C
Rhinolophus rouxii Temminick, 1835	Rufous Horseshoe Bat	LC	LC	all	-- A

Family: Vespertilionidae (Vesper bats)					
Hesperopterus tickelii (Blyth, 1851)	Tickle's Bat	DD	LC	A,B,C,D1	-- A
Kerivoula picta (Pallas, 1767)	Painted Bat	NT	LC	B,C,D1,D2	+ A, D3
**Kerivoula hardwickii malpasi* (Phillips, 1932)	Malpa's Bat	CR		D2 (D1)	--D1
Miniopterus schreibersii (Kuhl, 1819)	Long-winged Bat	EN	(LC)	B,C,D1,D2	
Murina cyclotis Dobson, 1872	Tube-nosed Bat	NT	LC	D2, (D1)	+ C
**Pipistrellus ceylonicus ceylonicus* (Keelart,1852)	Kelaart's Pipistrel	EN	LC	C,D1,D2,D3	
Pipistrellus coromandra(Gray, 1838)	Indian Pipistrel	VU	LC	A,B,C,	+ D1
Pipistrellus tenuis (Temminck, 1840)	Pigmy Pipistrel	VU	LC	(B,C), D1	+ D2,D3
Scotophilus heathii Horsfield, 1831	Great Yellow Bat	VU	LC	C,D1	+ B, D2
Scotophilus kuhlii Leach, 1821	Lesser Yellow Bat	DD	LC	C,D1	+ B, -- D1
Family: Muridae (rats, mice, gerbils)					
Tatera indica (Hardwicke, 1807)	Gerbil	LC	LC		
**T. i. ceylonica* (Wroughton, 1906)	Sri Lanka Gerbil			A,B,C,(D1)	+ (D2, D3)
Bandicota indica (Bechstein,1800)	Malabar Bandicot	LC	LC	B,C,D1, D2	+ (A, D3)
Badicota bengalensis (Gray, 1835)	Mole Rat	LC	LC		
**B. b. gracilis* (Nehring, 1902)	Lesser Bandicoot Rat			A,B,C,D1,D2	+ D3
**Golunda ellioti ruwara* (Keelart, 1850)	Bush Rat	EN	LC	all	
**Mus booduga (cervicolor) fulvidiventris* (Blyth, 1852)	Sri Lanka Field Mouse	LC	LC	all	
Mus musculus (Linnaeus, 1758)	House Mouse	LC	LC	all	
***Mus mayori* (Thomas, 1915)	Sri Lanka Spiny Rat	EN	VU	D1,D2,D3	

M. m. mayori (Thomas, 1915)	Highland Spiny Rat			D2,D3	
M. m. pococki Ellerman, 1947	Bi-coloured Rat			D1,D2	
Rattus rattus (Linnaeus, 1758)	Common Black Rat	LC	LC	all	
**R. r. kandianu*s (Kelaart, 1850) *	Sri Lanka Highland Black Rat			D2,D3	
**R. r. kelaarti* (Wroughton, 1915)*	Sri Lanka Common Black Rat			A,B,C,D1,D2	
Rattus tanezumi Temminck, 1844		NT			
***Rattus montanus* Phillips, 1932	Nelu Rat	CR	EN	D3	+ D2
****Srilankamys ohiensis* (Phillips, 1929)	Sri Lanka Bicolored Rat	EN	VU	D2,D3	
***Vandeleuria nolthenii* Phillips, 1929	S L Long-tailed Tree Mouse	CR	EN	D2,D3	
Vandeleuria oleracea (Bennett, 1832)	Long-tailed Tree Mouse	VU	LC	A,B,C,D1	+ D2
Family: Petromyidae (Flying squirrles)					
**Petaurista philippensis lanka* (Wroughton, 1911)	Giant Flying Squirrel	EN	LC	D1,D2,D3	+ C
**Petinomys fuscocapillus layard*i (Kelaart, 1850)	Small Flying Squirrel	EN	NT	D1,D2	+ B, C
Family: Sciuridae (Squirrels)					
Ratufa macoura (Pennant, 1769)	Sri Lanka Giant Squirrel	LC	NT		
**R. m. macroura* (Pennnant, 1769)	Highland S L Giant Squirrel			D2, D3	
**R. m. melanochra* (Thomas and Wroughton, 1915)	Black and Yellow Giant Squirrel			D1	
***Funambulus layardi* (Blyth, 1849)	S L Flame-striped Jungle Squirrel	VU	VU	B,C,D1,D2,D3	Updated[10]
***Funambulus obscurus* (Pelzeln & Kohl, 1886)	Dusky-striped Jungle Squirrel	VU	VU	D1,D2,D3	

Funambulus palmarum (Linnaeus, 1766)	Palm Squirrel	LC	LC	(all)	
**F. p. olympius* Thomas and Wroughton, 1915	Highland S L Palm Squirrel			D2,D3	
Family: Felidae (cats)					
**Panthera pardus kotiya* (Meyer, 1794)	Sri Lanka Leopard	EN	NT	All	--(D1)[11]
**Prionailurus rubinosus phillipsi Pocock, 1939*	Sri Lanka Rusty-spotted Cat	EN	VU	all	
Prionailurus viverrinus (Bennet, 1833)	Fishing Cat	EN	EN	A,B,C,D1	+ D2, D3[12]
Family Herpestidae (mongooses)					
Herpestes vitticollis Bennett, 1835	Stripe-necked Mongoose	VU	LC	all	
Herpestes brachyurus Gray, 1937	Brown Mongoose	LC		A,B,D1,D2,D3	+ C
**Herpestes fuscus flavidens* (Kelaart, 1850)	Highland S L brown mongoose			D2,D3	
**Herpestes fuscus rubidior* (Pocock, 1937)	Western S L Brown Mongoose			D1	
**Herpestes smithii zeylanicus* Thomas, 1921	Sri Lanka Ruddy Mongoose	LC	LC	A,B,C, (D1,D2)	+ D3
Family: Viverridae (Civets and plam civets)					
***Paradoxurus aureus* (Cuvier, 1822)	Wet-zone Golden Palm Civet	EN		(A,B,D1,D2)[13]	--A, B[13]
***Paradoxurus montanus* Keelart, 1852	Sri Lanka Brown Palm Civet	EN		(A,B,D1,D2)[13]	--D1, D2[13]
Paradoxurus hermaphroditus (Pallas, 1777)	Common Palm Civet	LC	LC	all	
**Viverricula indica mayori Pocock, 1933*	Sri Lanka Ring-tailed Civet	LC	LC	A,B,C,D1,D2	+ D3

Family: Cervidae (deer)					
Axis porcinus (Zimmerman, 1777)	Hog Deer	CR	EN	D1	
**Rusa unicolor unicolor*Kerr, 1792	Sambur	NT	VU	all	
Muntiacus muntjak (Zimmermann, 1780)	Barking Deer	NT		all	
Family: Tragulidae (Chevrotains or mouse deer)					
***Moschiola kathygre* Groves & Meijaard, 2004	Sri Lanka Pigmy Mouse Deer	VU	LC	(A,B,C),D1,D2	-- A, B, C[14]
Family: Elephantidae (elephants)					
**Elephas maximus maximus Linnaeus, 1758*	Elephant	EN	EN	All	-- (D2, D3)[15]
Family: Mustelidae (otters)					
Lutra lutra (Linnaeus, 1758)	Otter	VU	NT	all	
Family: Hystricidae (porcupines)					
Hystrix indica (Kerr, 1792)	Procupine	LC	LC	all	
Family: Leporidae (hares)					
**Lepus nigricollis singhala* Wroughton 1915	Black-naped Hare	LC	LC	all	

Family: Manidae (pangolins)				
Manis crassicaudata Gray, 1827	Pangolin	NT	NT	A,B,C,D1,D2
Family: Suidae (pigs)				
Sus scrofa (Linnaeus, 1758)	Wild Boar	LC	LC	all
Family: Canidae (jackals)				
**Canis aureus lanka* (Wroughton, 1916)	Sri Lanka Jackal	LC	LC	A,B,C,D1,D2

[1] Possible endemic species (Yapa and Ratnavira, 2013); [2] Dittus, Watson and Molur (2008); [3] Dittus, Molur and Nekaris (2008), [4] Dela and Rowe (2006); [5] Nekaris (2008a); [6] Nekaris (2008b); [6] Molur and Nekaris (2008); [7] Gamage *et al*. (2017), [8] Meegaskumbura *et al*., (2007), [9] Meesgaskumbura and Schneider (2008); [10] Dissanayake and Oshida (2012); [11] Miththipala (2006); [12] Kittle and Watson (in press); [13] Originally *Paradoxurus zeylonicus* updated by Groves, Rajapaksha, and Manamendra-Arachchi (2009); [14] Groves and Meijaard (2005); [15] Jayewardene (1994); Fernando *et al*. (2011).