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Floristic Richness and the Conservation Value of Tropical Montane Cloud Forests of Dothalugala Man and Biosphere Reserve, Sri Lanka

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ABSTRACT

Plant species in Tropical Montane Cloud Forests (TMCFs) of Dothalugala Man and Biosphere (MAB) Reserve were recorded in twenty six 10 x 15 m^2 experimental plots, aiming to reveal the total species richness and the richness of endemic and threatened flowering plant species in the forest canopy and the understory and, to find out the impacts of cardamom cultivation on the plant diversity of the study area. One hundred and forty eight plant species (77 tree, 46 shrub, 24 climber and one herbaceous species) belonging to 106 plant genera and 55 plant families have been found from the area examined. A high percentage endemicity of plant species (50%) was revealed in this site due to the presence of 74 (38 tree, 29 shrub, 6 climber and one hebaceous) species endemic to Sri Lanka. Similarly, 68 out of all plant species (45.9%) and 47 out of all endemic plant species (63.5%) in these forests were either globally or nationally threatened. The endemic and 'Critically Endangered' *Stemonoporus affinis* (Dipterocarpaceae) was also found to be thrive in the area. Cardamom cultivation had caused a tremendous reduction in the floristic diversity (total number of species and the number of endemic and threatened species) and the conservation value of TMCFs in Dothalugala MAB reserve. Therefore, the cardamom cultivation and other related disturbances within and adjacent to Dothalugala MAB Reserve should be arrested for the conservation of plant diversity in this fragile ecosystem and, this will eventually contribute towards the conservation of biodiversity not only in Sri Lanka but also in the globe as a whole.

Keywords: cardamom cultivation, disturbances, endemic plants, species richness, *Stemonoporus affinis*, threatened plant species.

INTRODUCTION

Sri Lanka abounds a rich plant diversity with 7000 indigenous flora (Abeywickrama, 1986), including 3156 flowering plants of which 894 are endemic to Sri Lanka (Wijesundara *et al*., 2012). This high endemism of plant species and preceding threats have led Sri Lanka together with the Western Ghats of peninsular India to be considered as a biodiversity hotspot (Myers *et al*., 2000). Thus, the endemic plants of Sri Lanka are considered as an essential element which expresses the conservation value of the flora of the country. However, the conservation of Sri Lankan flora has received much less attention than its fauna (Pethiyagoda, 2012).

By referring to the Sri Lankan flora, Trimen (1885), an eminent scientist who pioneered botanical explorations in Sri Lanka, has stated that the individuality and interest of any flora lies mainly on its endemic species. Endemic plants of Sri Lanka appear to be distributed unequally across plant families as well as over space. Some plant families such as Balsaminaceae and Lauraceae contain many endemic species. Tropical Montane Cloud Forests (TMCFs) which are characterized by the presence of persistent or frequent wind-driven clouds (Hamilton *et al*., 1995) are always reputed for their high endemicity (Gentry, 1993; Ledo *et al.*, 2009). For instance, five sixths of the Sri Lanka's endemic plants are reported to be included among the hill flora (Trimen, 1885).

Although TMCFs extend over less than 1% of the total land area of Sri Lanka (IUCN, 2007), these constitute many plants that are endemic to the country. As reported by Ranasinghe *et al.* (2006), more than 50% of the residing species in TMCFs are endemic to the country. Tropical Montane Cloud Forests in the world are not different from those in Sri Lanka either. These cover about 1.6% of the total area of tropical mountain forests in the world (Kapos *et al*., 2000) and possess distinct biological communities and high levels of species

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endemism and biodiversity (*e.g*. Gentry, 1993; Ledo *et al.*, 2009).

In many parts of the world, the flora of TMCFs has received poor attention from scientists (*e.g.* Kumaran *et al*., 2010) though the factors affecting the formation of cloud forests and the TMCF climate had decorously been explained (*e.g*. Bruijnzeel and Veneklaas, 1998; Grubb, 1971; Grubb and Whitmore, 1965, 1966). The fate of TMCFs in relation to the changing climate has recently been receiving the attention of scientists (Foster, 2001; Loope and Giambelluca, 1998; Still *et al*., 1999). In Sri Lanka, many of the research work conducted in mountain regions of the country were related to the identification and classification of forest types, to describe the forest structure or to explain the forest climate (*e.g*. Balasubramaniam, 1988; Broun, 1900; de Rosayro, 1958; Gaussen *et al*., 1968; Greller and Balasubramaniam, 1980; Koelmeyer, 1957; Perera, 1975; Vincent, 1883; Werner, 1982). However, the high conservation value of Sri Lankan TMCFs due to the presence of endemic plant species has been acknowledged by several scientists (*e.g*. Green and Jayasuriya, 1996; Jayasuriya *et al*., 1988; Rathnayake, 1994; Wijesundara, 1991). Much of this work appears to be based on field surveys. However, some quantitative studies had also been conducted in different places, *viz*., Corbert's Gap and Rangala of the Knuckles massif (Jayasuriya *et al*., 1988), Agra Bopath and some parts of the Kelani valley forest of the Peak Wilderness area (Nisbet, 1961), Hakgala Strict Nature Reserve (Rathnayake and Jayasekara, 1998; Wijesundara, 1991) and Thangappuwa and Kalupahana of the Knuckles massif (Rathnayake, 1994).

All over the world, the number of species threatened with extinction far exceeds the conservation resources available and this situation appears to be becoming worse (Myers *et al*., 2000). Frequent disturbances and subsequent diminishing of the forest cover, especially in ecologically sensitive areas may have led many plant species to be extinct from the earth. Conversion of forests to agricultural land, fuel wood extraction (Sarmiento, 1995), illegal logging (Aubad *et al*., 2008) and human population densities and trends (Young and León, 1995) have been cited as major threats to TMCFs, leading to their fragmentation or disappearance. Thus, in Sri Lanka, 3,000 ha of montane forests are left in the island at present (Wijesundara, 2012). In the Knuckles region of Sri Lanka, cardamom cultivation has clearly been identified as a major cause towards the destruction of forested land, leading to the loss of biodiversity and increased soil erosion (Gunawardana, 2003) and, reduction in the total species richness and the richness of endemic plant species (Adikaram and Perera, 2005). In addition, many plant species endemic to Sri Lanka have been assessed as threatened by the IUCN's Red Listing process (The National Red List of Flora and Fauna of Sri Lanka, 2012). In light of this, as many as 61 endemic flowering plant species (including 23 trees) in Sri Lanka had not been recorded in the preceding 50 years (Pethiyagoda, 2012) presumably due to their extinction from the wild.

Diverse climatic conditions, which resulted due to high geographical heterogeneity as well as due to its positioning in the Sri Lankan terrain, have led the Knuckles massif to possess a wide range of rainfall and temperature regimes (Cooray, 1998; Legg, 1995). These may have potentially paved the path for the area to harbor a rich biodiversity with a high percentage of endemicity. Being located at a unique environment, TMCFs at Dothalugala may possess many more endemic plants too. A detailed quantitative survey in the forests of Dothalugala MAB Reserve area was therefore conducted. However, the current paper evaluates only the plant species taller than 1 m recorded in the experimental plots established, to reveal the floristic richness and the endemic and threatened plant species under different life form categories. This study also assesses the impacts of cardamom cultivation on the examined floristic features of TMCFs. The objective of this article is to provide a *status quo* report of the floristic richness and the conservation importance of the flora of the Reserve, but not to explain the spatial patterns of species abundances.

MATERIALS AND METHODS

Study site

The Knuckles massif of Sri Lanka is situated north of the central highlands of the country, as an isolated mountain range which is separated from the main highlands by the Dumbara valley. Dothalugala MAB Reserve extends over the southern and south eastern parts of the Knuckles Conservation Region (7º 17'– 7º 21' N and 80º 49'– 80º 57' E) (Fig. 1). The presence of 'Dothalu trees' (*Loxococcus rupicola*, Family: Arecaceae) which is endemic to Sri Lanka has led to name this area as Dothalugala by the local people (Fig. 2).

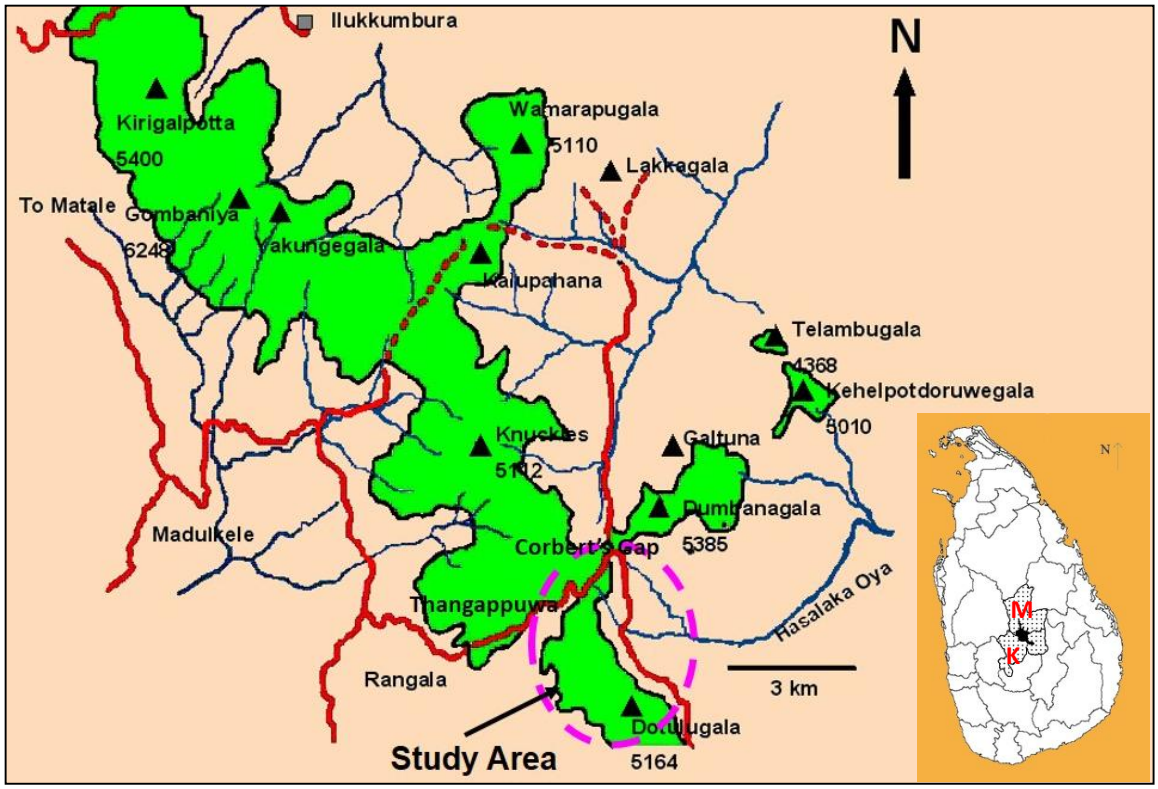

Figure 1. Location of the Knuckles mountain range in relation to the Kandy (K) and Matale (M) Districts of Sri Lanka and the location of the study area (*Source*: 1:50,000 map of the Survey Department of Sri Lanka).

Figure 2. A juvenile Dothalu (*Loxococcus rupicola*) tree in the Dothalugala forest (the palm tree at the center of the photograph).

The Dothalugala Man and Biosphere Reserve extends over 1620 ha area (Bharathie, 1989). It consists of three peaks, namely Dothalugala (1558 m), Nawanagala (1420 m) and Kobonillagala (1545 m). As stated by Cooray (1998), the average annual rainfall varies from about 2540 mm on the Eastern side to 3810-5080 mm on the main Knuckles range. Both South-western and North-eastern monsoonal rains directly influence the distribution of rainfall within the Knuckles massif as it is located almost perpendicular to the direction of the respective wind currents (de Rosayro, 1958; Legg, 1995; Werner, 1982). However, the lower eastern slopes are much drier, with less than 2000 mm of mean annual rainfall, most of which is received during the north-east monsoon (October to January) (Legg, 1995). The mean annual temperature outside the massif is more than 26 ^{o}C and this value falls down to about 21 ^{o}C at altitudes above 915 m and to about 18.5 ^{o}C at the highest altitudes (Cooray, 1998). Mountain tops in the area are frequently covered with mist or fog though these at the eastern slope may drift away with the wind during the day time.

Easily accessible drier parts have been disturbed mostly for cardamom (*Elettaria cardamomum*) cultivation. Cardamom is a perennial spice plant which has been introduced to Sri Lanka in 1805 (Gunawardana, 2003). The government has granted permission to cultivate cardamom in forested lands on lease and people have cleared the understory of montane forests to various extents; from 3 ha to more than 20 ha to cultivate cardamom (Gunawardana, 2003). A few such cultivated lands within the Dothalugala area have been abandoned 15-20 years ago and are currently under a natural process of vegetation succession.

Sampling

Twenty six 15 m x 10 m experimental plots were established at randomly chosen points in forests of Dothalugala MAB Reserve and the individuals taller than 1 m were enumerated. Among these 26 experimental plots, 14 were located on wetter parts and at the ridge tops, 8 were located at the drier eastern slopes of the Dothalugala mountain range while 4 were located at abandoned cardamom cultivation sites at the dry face of the mountain range. Voucher specimens were collected from all the individuals and identified using standard keys, Flora and by comparing with those in the National Herbarium, Peradeniya. The endemic and threatened plant species among these were identified using Floras and plant checklists. Plants were categorized as trees, shrubs, climbers, herbs *etc*. based on the basic life form features. However, the 'climber' category in this study includes both woody and semi-woody climbing plants.

RESULTS AND DISCUSSION

Many criteria based on floristic features have often been used in determining the conservation value of wilderness areas and prioritizing habitats for conservation. Some of these include the total species richness (Gentry, 1992; Trigas *et al*., 2013), endemicity of plants (Brooks *et al*., 2006; Gentry, 1992; Trigas *et al.*, 2013), threat status of candidate species (Redding and Mooers, 2006) and rarity of species (Margules and Usher, 1981; Scott *et al*., 1993; Singh and Samant, 2010 and Usher, 1986). Total species richness *per se* may not truly represent the conservation value of a given area. This is because, the species richness can be driven by common, widespread species. (Orme *et al*., 2005; Lamoreux *et al*., 2006). The use of species richness in prioritizing habitats may create serious conceptual errors due to its dependency on the size of the area sampled and the sizes of individuals in each locality. In this sense, Hurlbert's (1971) rarefaction method proved to be robust to compare the plant species richness among habitats as the method standardizes all samples to a common size. It is a common belief that habitats that are rich in species for one taxon may also be species-rich for other taxa as well (Pearson and Cassola, 1992) and therefore, the rare species may benefit from the conservation of species rich habitats (Soulé, 1986), though this may not be equally applicable to all the ecosystems in different parts of the world (Prendergast *et al*., 1993).

Rarity of species of a given site is also an important criterion to be considered but this remains difficult to quantify. Moreover, the concept of rarity has often been used in an ambiguous way in vegetation science by different authors. Some have used the term with reference to the frequency of occurrence while others have used the term to describe the abundance of participating species (Jesús, 1998).

In contrast, the degree of biotic endemism is often considered as a major criterion that is used in determining the conservation units (Gentry, 1992). Similarly, the threat status of species which has been introduced by the IUCN (World Conservation Union) provides good information on the conservation value of species (Gärdenfors *et al*., 2001). It gives guidelines to assign species

into categories of threat, based on threshold values of population parameters, such as range of occurrence and population decline (Redding and Mooers, 2006). Thus, it appears that it is easy and reasonable to describe the plant diversity and the conservation value of a given habitat by the total species richness together with the endemicity and the threat status of species in the site.

Floristic richness and the conservation value of TMCFs at Dothalugala MAB Reserve

Species richness

One hundred and forty eight flowering plant species belonging to 106 genera and 55 plant families were identified from the examined two forest strata (Appendix 1). Among these, there were 77 tree, 46 shrub, 24 climber and one herbaceous species. However, the species richness in the study site could be much higher than the recorded if all plant groups were considered. This is due to the fact that epiphytic and cryptogamic plants that prefer cooler and wetter environments thrive well in montane forests (Jacobs, 1988; White, 1983 and Whitmore, 1975).

Endemic plant species

The current study revealed a high endemicity of flowering plants at Dothalugala MAB Reserve (Appendix 1). Seventy four endemic plants species of Sri Lanka were found from the forests and this accounts for 50% of the total number of plant species that reside in the area. Of these, 38 were trees, 29 were shrubs, 6 were climbers while only one was a herbaceous species. Results of the present study were comparable with those received from other TMCFs of the Knuckles massiff. For instance, 50% of the residing plant species at Thangappuwa were endemic to Sri Lanka (Rathnayaka 1994). Further, the endemicity of plants at Dothalugala forests could be much higher if all the vegetation including herbaceous and epiphytic flora were included. A greater number of species in the plant families such as Balsaminaceae and Lamiaceae are herbaceous and as Cramer (2006) explained these two are among the families which contain a high number of endemic plant species of the country.

Out of the 74 endemic plant species, 42 (56.7%) were found to occur commonly all over the Reserve. *Agrostistachys coriacea* (Fig. 3a), *Calophyllum trapezifolium, Eurya ceylanica, Semecarpus nigro-viridis, Kendrickia walkeri* (Fig. 3b) *and Glochidium pachycarpum* (Fig. 3c) were some of the common endemic species found in the forests. In contrast, some species occurred less frequently or were highly restricted to specific localities within the reserve. Such a pattern appears to be common in other TMCFs as well. Analysis of habitat associations of tree species with respect to the terrain characteristics had shown that 36% of compositional variability in montane sites could be explained by elevation (Jarvis, 2001). In Dothalugala, species such as *Osbeckia lanata* and *Stemonoporus affinis* thrive well in ridge tops while *Litsea walkeri*, *Vernonia zeylanica* and *Fahrenheitia minor* appear to be of restricted distribution and confined to drier slopes of the Reserve. However, no point endemics have been recorded from the two forest strata in the area explored.

The endemic tree, *Stemonoporus affinis* (Fig. 3d) which belongs to the family Dipterocarpaceae, was found to occur mainly on ridge tops of Dothalugala MAB Reserve. Members of the family Dipterocarpaceae are usually reported to be common in lowland humid forests which are normally restricted up to a height of 1200 m on main mountain ranges and, 900 m or lower altitudes on isolated mountains of the Malay Peninsula and other parts of South-east Asia, India, Sri Lanka and in Africa (Greller *et al*., 1987; Symington (1943). However, Greller *et al*. (1987) stated that some species of the genus *Stemonoporus* commonly occur above 1500 m and up to 1800 m in the TMCFs of Sri Lanka.

Threatened plant species

All the plant species identified from the study area were evaluated against the National and Global Lists of threatened plants as given in the National Red List of Flora and Fauna of Sri Lanka, 2012. Among the 148 plant species found at Dothalugala MAB Reserve, 57 (38.5%) were found to be nationally threatened species (Table 1). These include 30 tree, 18 shrub, 8 climber and one herbaceous species. Similarly, 17 tree and shrub species (11.5% of the total species) that grow in the study area were found to be globally threatened (Table 2). However, 6 species have been included in both National and Global Red Lists. As given in Table 1, there are 11 other Near Threatened species as well.

Two critically endangered plant species, *viz. Memecylon sessile* (Melastomataceae) and *Stemonoporus affinis* (Fig. 3d) were found from the study area. The shrub, *M. sessile* is locally common at Dothalugala MAB Reserve and this is not an endemic species. In contrast, as mentioned elsewhere in this article, *S. affinis* is endemic to Sri Lanka and is listed as a 'Critically Endangered' species in both National and Global Threatened Lists.

According to the National Red List of Sri Lanka, 15 (7 tree, 6 shrub and 2 climber) species of TMCFs of Dothalugala fall into nationally 'Endangered' category. Of these, *Syzygium caryophyllatum* (Myrtaceae) is considered as an endangered species at global scale too. The species appeared to be restricted to the drier eastern slopes of the mountain range. Similarly, some nationally endangered species such as *Arundinaria debilis* and *Elaeocarpus hedyosmus* were found to be restricted to wetter parts of Dothalugala MAB reserve. In addition, species like *Osbeckia lanata* and *Ternstroemia gymnanthera* appeared to be confined to ridge tops with a dense cloud cover but some like *Dioscorea trimenii* and *Ilex denticulata* apparently avoided ridge tops. In contrast, several other endangered species such as *Cinnamomum litseaefolium, Gordonia ceylanica, Hortonia floribunda, Litsea glaberrima*, *Memecylon cuneatum*, *Symplocos cordifolia* (Fig. 3e) and *Syzygium fergusoni* (Fig. 3f) were found to be thriving well throughout the study area.

Moreover, 40 (nationally) vulnerable plant species were found in these relatively undisturbed forested areas (Table 1). These include 22 tree, 11 shrub, 6 climber and 1 herbaceous species. About half of these exhibits a distribution spanning the entire study area. Others show a more restricted distribution and are confined to ridge tops, wetter sites or to the dry slopes of the mountain range.

The current study further revealed that many of the endemic plant species found in the Reserve area were listed as threatened either at national or global levels (The National Red List of Flora and Fauna of Sri Lanka, 2012). Among the 74 endemic species that were found from the natural forests of Dothalugala MAB reserve area, 40 (54%) species have been listed as nationally threatened species (Table 3) while 13 (17.5%) have been listed as globally threatened species. Among these, 6 plant species are included in Red Lists at both national and global scales.

Table 1. Number of nationally 'Threatened' and 'Near Threatened' plant species of Sri Lanka that were found at Dothalugala MAB Reserve area as per the National Red List of Flora and Fauna of Sri Lanka, 2012 (Species names are given in the Appendix I).

	Number of plant species				
	Trees	Shrubs	Climbers	Herbs	Total
Critically Endangered	1	1	0	0	2
Endangered	7	6	2	0	15
Vulnerable	22	11	6	1	40
Total no. of Threatened species	30	18	8	1	57
No. of Near Threatened species	5	5	1	0	11

Table 2. Number of globally 'Threatened' plant species in Dothalugala MAB Reserve area as per the National Red List of Flora and Fauna of Sri Lanka, 2012 (Species names are given in the Appendix I).

	Number of plant species				
	Trees	Shrubs	Climbers	Herbs	Total
Critically Endangered	1	0	0	0	1
Endangered	3	0	0	0	3
Vulnerable	10	3	0	0	13
Total no. of Threatened species	14	3	0	0	17

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Figure 3. (a) *Agrostistachys coriacea* (**E, VU-N**), (b) *Kendrickia walkeri* (**E**), (c) *Glochidium pachycarpum* (**E**), (d) *Stemonoporus affinis* (**E, CR-N, CR-G**), (e) *Symplocos cordifolia* **(E, VU-N, EN-G**) and (f) *Syzygium fergusonii* (**E, VU- N, EN-G**) [**E** - Endemic; **CR** - Critically Endangered; **EN** - Endangered; **VU** - vulnerable; **N** - Nationally threatened; **G** - Globally threatened]

Table 3. Number of 'Threatened' and 'Near Threatened' *endemic* plant species of Sri Lanka that occur at Dothalugala MAB Reserve area according to the National Red List of Flora and Fauna of Sri Lanka, 2012 (Species names are given in the Appendix I).

	Number of endemic plant species				
	Trees	Shrubs	Climbers	Herbs	Total
Critically Endangered	1	0	0	0	1
Endangered	5	5	1	0	11
Vulnerable	14	10	3	1	28
Total Threatened species	20	15	4	1	40
Near Threatened species	1	4	0	0	5

Impacts of disturbances on endemic and threatened flora in the area

The floristic features of abandoned cardamom cultivation lands were compared with those of adjacent relatively less disturbed sites in the dry parts of the mountain range as given in the Table 4. Floristic richness (number of plant families, genera, total species and species of endemic and threatened taxa) in secondary forests grown after the abandonment of cardamom cultivation was lower than that in adjacent, relatively less disturbed forests in the drier slopes of the mountain (Table 4). Nearly one third of the plant families and genera and half of the natural forest species have disappeared from the land as a consequence of cardamom cultivation. A fewer number of tree and shrub species were present in secondary forests that have emerged after the abandonment of cardamom cultivation (Table 4).

Table 4. Comparison of floristic features of TMCFs and adjacent abandoned cardamom cultivation sites at the dry-face of the mountain range

Floristic feature	Number of taxa in the two vegetation types at the North-eastern slope of the mountain range	
	Relatively less disturbed natural forests (n=8)	Abandoned cardamom cultivation sites (n=4)
Plant families	47	30
Plant genera	82	50
Plant species	104	61
Life form		
Tree species	56	32
Shrub species	31	17
Climber species	17	12
Nationally Threatened species		
Critically Endangered	1	0
Endangered	9	3
Vulnerable	29	16
Near Threatened (nationally) species	9	7
Globally Threatened species		
Endangered	3	2
Vulnerable	11	5
Endemic species	55	30
Nationally Threatened endemic species		
Endangered	6	2
Vulnerable	22	13
Near Threatened (nationally) endemic species	5	3

However, it was evident that many pioneer or exotic species such as *Macaranga indica* and *Clidemia hirta* thrive well in these disturbed sites. Although the number of experimental plots established in the two forest categories were different, this would not much affect the pattern explained and any ecologist who visits the two sites can easily detect this by visual observation.

Only 30 endemic plant species were found in abandoned cardamom cultivation sites and almost all of these were widely occurring species in the study area. Some other endemic plant species, most of which may need specific micro-habitats, did not occur in the site even 15-20 years after the abandonment of cardamom cultivation. 'Critically Endangered' *Memecylon sessile* was also not found to occur in these secondary forests though the species was frequently found in relatively undisturbed natural forests.

The results of the current study are comparable with a similar study carried out at Kaelaebokka, towards Rangala of the Knuckles massif. There, approximately a 50% reduction of species was noticed in abandoned cardamom cultivated sites compared with the adjacent relatively less disturbed areas, while the endemicity of trees was as low as 22%. Some nationally endangered plant species such as *Elaeocarpus montanus* and *Gordonia zeylanica*, globally vulnerable *Antidesma pyrifolium*, nationally vulnerable *Calophyllum tomentosum* and, many endemic plant species of the country including *Lasianthus oliganthus* and *Syzygium micranthum* were absent in cardamom cultivation lands (Adikaram and Perera, 2005).

The decline of the floristic richness and the conservation value of the secondary forests investigated may be an artifact of past disturbances due to cardamom cultivation. During cardamom cultivation, the understory and ground layers are cleared (Gunawardana, 2003) and as a result, many tree, climber and herbaceous flora in the ground and understory layers are removed. Tree canopy is also damaged during cardamom cultivation so as to allow more light to penetrate to the ground layer (Gunawardana, 2003; Ranawana *et al.,* 2004). Gunawardana (2003) pointed out that these cardamom cultivation lands were also frequently found on the slopes of 30-70% steep terrain and on stream banks which were highly environmentally sensitive areas situated over an elevation of 1000 m. THESE Cardamom cultivation lands are frequently been cleaned and as a result, the soil erosion takes place (Gunawardana, 2003). Prolonged cardamom cultivation therefore, proved to remove many native plant species from the sites and the remaining plants could be a choice of the cardamom growers. At present, there is an increasing trend to grow plant species alien to the region (*e.g. Alstonia scholaris*, *Artocarpus heterophyllus*) by cardamom growers to cover canopy gaps that have occurred due to the death of native canopy trees. This salient change of species composition in cardamom cultivation lands would potentially hasten the complete devastation of this fragile ecosystem. It is true that cardamom cultivation is a profitable industry. However, in the Knuckles region, the majority of those engaged in cardamom cultivation is represented by the elites from different parts of the country whereas only a few local rural villagers may be involved in cardamom cultivation at small-scale. In addition, a vast majority of the local villagers serve as labourers in the cardamom industry and thus, this venture would not much support the rural development in the region.

Concluding remarks

The current study revealed the high plant species richness and high conservation value of TMCFs of Dothalugala while reiterating the irreparable consequences and effects of cardamom cultivation on this globally valued ecosystem. This situation is more or less the same for other parts of the Knuckles massif too. Therefore, measures should be taken to reassess the possible options for this incomparable land. Could we afford to achieve sustainable development at the cost of the biodiversity of our country? Would cardamom cultivation in this environmentally sensitive area be a sensible option for this region? Would not the development of ecotourism industry in the Knuckles region with the participation of local people be a better alternative for the sustainable development of the country? Therefore, we firmly propose strict protection of this fragile and invaluable resource through change of existing policies and strengthening of relevant institutes.

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Appendix 1. Plant families and species in TMCFs at Dothalugala MAB Reserve and their conservation status. (T-Tree; S-Shrub; C-Climber; E-endemic; N-national threat status and G-global threat status, CR-Critically endangered; EN-Endangered; VU-Vulnerable and NT-Near Threatened).

Family	Scientific Name	Life form	E	N	G
ANACARDIACEAE					
	Nothopegia beddomei Gamble	T	--	--	--
	Semecarpus nigro-viridis Thw.	T	E	--	VU
ANNONACEAE					
	Mitrephora heyneana (Hook.f. & Thoms.) Thw.	T	--	NT	--
APOCYNACEAE					
	Gymnema pergularioides (Thw.) Hook.f.	C	E	VU	--
	Rauvolfia densiflora (Wall.) Benth.ex Hook.f.	S	--		
	Tylophora pauciflora Wight & Arn.ex Wight	S	--	EN	--
AQUIFOLIACEAE					
	Ilex denticulata Wall.	T	--	EN	--
	Ilex walkeri Wight & Gardner ex Thw.	S	--	--	--
ARACEAE					
	Pothos remotiflorus Hook.	C	E	VU	--
ARALIACEAE					
	Schefflera exaltata (Thw.) Frodin	T	E	EN	--
ASPARAGACEAE					
	Asparagus falcatus L.	C	--	--	--
ASTERACEAE					
	Senecio corymbosus Wall. ex DC. var. walkeri (Arn.) Grierson	S	--	--	--
	Vernonia gardneri Thw.	S	E	VU	--
	Vernonia wightiana Arn.	S	E	VU	--
	Vernonia zeylanica (L.) Less	S	E	--	--
BUXACEAE					
	Sarcococca zeylanica Baill.	S	E	VU	--
CALOPHYLLACEAE					
	Calophyllum trapezifolium Thw.	T	E	VU	--
CANNABACEAE					
	Celtis timorensis Span.	T	--	--	--
CELASTRACEAE					
	Cassine congylos Kosterm.	T	E	VU	--
	Euonymus walkeri Wight	S	E	--	VU
	Microtropis wallichiana Wight ex Thw.	T	--		
	Salacia reticulata Wight	C	--	EN	--
CENTROPLACACEAE					
	Bhesa ceylanica (Arn. ex Thw.) Ding Hou	T	E	--	VU
CLUSIACEAE					
	Garcinia echinocarpa Thw.	T	--	VU	--
CONVOLVULACEAE					
	Argyreia hirsuta Arn.	C	--	--	--
DIOSCOREACEAE					
	Dioscorea trimenii Prain & Burkill	C	E	EN	--
DIPTEROCARPACEAE					
	Stemonoporus affinis Thw.	T	E	CR	CR
ELAEAGNACEAE					
	Elaegnus latifolia L.	S	--	--	--
ELAEOCARPACEAE					
	Elaeocarpus glandulifer (Hook.) Masters	T	E	VU	VU
	Elaeocarpus hedyosmus Zmarzty	S	E	EN	--

Family	Scientific Name	Life form	E	N	G
ERYTHROXYLACEAE					
	Erythroxylum monogynum Roxb.	S	--	NT	--
EUPHORBIACEAE					
	Agrostistachys coriacea Alston	S	E	--	VU
	Croton laccifer L.	S	--	--	--
	Fahrenheitia minor (Thw.) Airy Shaw	S	--	--	--
	Fahrenheitia zeylanica (Thwaites)Airy Shaw	S	--	--	--
	Macaranga peltata (Roxb.) Muell.Arg.	T	--	--	--
	Mallotus fuscescens (Thw.) Muell.Arg.	T	E	--	--
	Mallotus philippensis (Lam.) Muell.Arg.	T	--	--	--
	Trigonostemon nemoralis Thw.	S	--	VU	--
FABACEAE					
	Dalbergia pseudo-sissoo Miq.	C	--	--	--
GENTINACEAE					
	Fagraea ceilanica Thunb.	T	--	NT	--
ICACINACEAE					
	Apodytes dimidiata E. Meyer ex Arn.	T	--	VU	--
	Nothapodytes nimmoniana (Graham) Mabb.	T	--	NT	--
LAMIACEAE					
	Callicarpa tomentosa (L.) Murr	S	--	--	--
LAURACEAE					
	Actinodaphne ambigua (Meissner) Hook.f.	T	E	--	--
	Actinodaphne elegans Thw.	T	E	--	--
	Actinodaphne moonii Thw.	T	E	VU	--
	Actinodaphne stenophylla Thw.	T	E	VU	--
	Cinnamomum litseaefolium Thw.	T	E	EN	--
	Cinnamomum ovalifolium Wight	T	E	VU	--
	Cryptocarya wightiana Thw.	T	--	NT	VU
	Litsea gardneri (Thw.) Meissner	T	E	VU	VU
	Litsea glaberrima (Thw.) Trimen	T	E	NT	EN
	Litsea glutinosa (Lour.) C.B.Robinson	T	--	--	--
	Litsea walkeri (Meissner) Trimen	T	E	VU	--
	Neolitsea fuscata (Thw.) Alston	T	E	VU	--
	Persea macrantha (Nees) Kosterm.	T	--	VU	--
LOGANIACEAE					
	Strychnos benthamii C.B.Clarke	S	E	NT	--
MELASTOMATACEAE					
	Kendrickia walkeri (Wight ex Gardner) Triana	C	--	VU	--
	Lijndena gardneri (Thw.) Bremer	S	E	VU	--
	Memecylon cuneatum Thw.	T	E	EN	--
	Memecylon fuscescens Thw.	S	E	EN	--
	Memecylon sessile Benth.	S	--	CR	--
	Osbeckia lanata Alston.	S	E	EN	--
MELIACEAE					
	Aglaia apiocarpa (Thw.) Hiern.	T	--	--	VU
	Aglaia elaeagnoidea (A.Juss.) Benth.	T	--	--	--
MENISPERMACEAE					
	Cyclea peltata (Burm.f.) Hook.f. & Thoms.	C	--	--	--
	Stephania japonica (Thunb.) Miers	C	--	VU	--
MONIMIACEAE					
	Hortonia floribunda Wight ex Arn.	S	E	EN	--
MORACEAE					
	Ficus diversiformis Miq.	S	E	--	--
	Ficus hispida L.f.	T	--	--	--
	Ficus nervosa Heyne ex Roth	T	--	--	--

Family	Scientific Name	Life form	E	N	G
MYRISTICACEAE					
	Myristica ceylanica A. DC.	T	--	VU	VU
	Myristica dactyloides Gaertn.	T	--	--	--
MYRTACEAE					
	Eugenia cotinifolia Jacq.	S	--	--	--
	Eugenia mabaeoides Wight	T	E	--	--
	Eugenia thwaitessii Duthie	T	--	--	--
	Syzygium assimile Thw.	T	E	--	--
	Syzygium caryophyllatum (L.) Alston	T	--	--	EN
	Syzygium fergusoni Gamble	T	E	VU	EN
	Syzygium makul gaertn.	T	--	--	--
	Syzygium micranthum Thw.	T	E	--	--
	Syzygium revolutum Walp.	T	E	--	--
	Syzygium spathulatum Thw.	T	E	--	--
OLEACEAE					
	Chionanthus albidiflora Thw.	T	E	VU	--
	Chionanthus zeylanica L.	T	--	--	--
	Jasminum flexile Vahl	C	--	--	--
	Olea polygama Wight	T	--	--	--
PANDANACEAE					
	Freycinetia pycnophylla Solms	C	E	VU	--
PENTAPHYLACEAE					
	Eurya ceylanica Wight	T	E	VU	--
	Ternstroemia gymnanthera (Wight & Arn.) *Beddome*	T	--	EN	--
PHYLLANTHACEAE					
	Actephila excelsa (Dalz.) Muell.Arg.	T	--	--	--
	Antidesma pyrifolium Muell. Arg.	T	E	--	VU
	Aporusa fusiformis Thw.	T	--	VU	--
	Breynia vitis-idaea (Burm.f.) C.E.C.Fischer	S	E	--	--
	Glochidion pachycarpum Alston	T	E	--	--
	Glochidion stellatum (Retz.) Beddome	T	E	--	--
	Phyllanthus cinereus Muell. Arg.	S	E	VU	--
PIPERACEAE					
	Piper sylvestre Lam.	C	--	--	--
	Piper zeylanicum Miq.	C	E	--	--
PITTOSPORACEAE					
	Pittosporum tetraspermum Wight & Arn.	T	--	VU	--
POACEAEA					
	Arundinaria debilis Thw.	S	E	EN	--
	Davidsea attenuata (Thw.) Soderstrom & Ellis	S	E	VU	--
PRIMULACEAE					
	Ardisia gardneri Clarke	S	E	--	--
	Maesa indica (Roxb.) A.DC.	S	--	--	--
	Myrsine robusta (Mez) Wadhaw	T	E	--	--
ROSACEAE					
	Rubus gardnerianus Kuntz	C	--	NT	--
	Rubus indicus Thunb.	C	--	--	--
RUBIACEAE					
	Canthium coromandelicum (Burm.f.) Alston	S	--	--	--
	Gaertnera walkeri (Arn.) Blume	S	E	NT	VU
	Hedyotis flavescens Thw.	S	E	NT	--
	Hedyotis fumata Alston	S	E	VU	--
	Hedyotis lessertiana Arn.	S	--	--	--

Family	Scientific Name	Life form	E	N	G
RUBIACEAE (contd.)					
	Hedyotis trimenii Deb & Dutta	S	E	--	--
	Ixora jucanda Thw.	T	E	--	--
	Lasianthus foetulentus Ridsd.	S	E	VU	--
	Lasianthus strigosus Wight	S	E	--	--
	Morinda umbellata L.	C	--	--	--
	Psychotria gardneri (Thw.) Hook.f.	S	E	NT	--
	Psychotria nigra (Gaertn.) Alston	S	--	--	--
	Psychotria sordida Thw.	S	E	VU	--
	Psydrax dicoccos Gaertn.	T	--	--	--
	Saprosma foetens (Wight) Schumann	S	E	--	--
	Urophyllum ceylanicum (Wight) Thw.	S	E	--	--
RUTACEAE					
	Acronychia pedunculata (L.) Miq.	T	--	--	--
	Melicope lunu-ankenda (Gaertn.) T. Hartley	T	--	--	--
	Toddalia asiatica (L.) Lam.	C	--	--	--
SALICACEAE					
	Casearia thwaitesii Briq.	T	--	VU	--
	Casearia zeylanica (Gaertn.) Thw.	T	--	--	--
	Flacourtia indica (Burm.f.)Merr.	T	--	--	--
	Flacourtia inermis Roxb.				
	Scolopia crassipes Clos	T	E	--	--
SAPINDACEAE					
	Allophylus zeylanicus L.	T	E	--	--
SAPOTACEAE					
	Isonandra zeylanica Jeuken	S	E	VU	--
	Palaquium rubiginosum (Thw.)Engl.	T	E	VU	VU
SMILACACEAE					
	Smilax aspera L.	C	--	VU	--
	Smilax zeylanica L.	C	--	--	--
STAPHYLEACEAE					
	Gomphandra coriacea Wight	T	--	VU	--
STEMONURACEAE					
	Turpinia malabarica Gamble	T	--	--	--
SYMPLOCACEAE					
	Symplocos cochinchinensis (Lour.) S.Moore	T	--		
	Symplocos cordifolia Thw.	T	E	EN	VU
	Symplocos elegans Thw.	T	E	VU	--
THEACEAE					
	Gordonia ceylanica Wight	T	E	EN	--
VITACEAE					
	Cayratia pedata (Lam.) Juss.ex Gagnep.	C	--	--	--
	Cissus gardneri Thw.	C	E	--	--
	Cissus trilobata Lam.	C	--	--	--
	Tetrastigma nilagiricum (Miq.) Shetty	C	--	--	--
ZINGIBERACEAE					
	Zingiber cylindricum Thw.	H	E	VU	--