Conservation Priorities for Tree Ferns (Cyatheaceae) in Sri Lanka

R. H. G. Ranil[1*], D. K. N. G. Pushpakumara[1], T. Janssen[2], C. R. Fraser-Jenkins[3] and D. S. A. Wijesundara[4]

1. Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.
2. Department of Vascular plants, Spermatophytes and Pteridophytes, National Botanic Gardens, Meise, Belgium.
3. Student Guest House, Thamel, P.O. Box no 5555, Kathmandu, Nepal.
4. Department of National Botanic Gardens, Peradeniya, Sri Lanka.
** Correspondent author. Tel: 0094 718668109; Email: rajapaksha76@yahoo.com*

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ABSTRACT: Diversity, phytogeography and conservation status of Sri Lankan tree-ferns are discussed in this paper. The family Cyatheaceae is represented by eight taxa (seven species and one doubtful variety) in Sri Lanka with a high rate of endemism of 75%. Apart from *Cyathea walkerae* and *C. gigantea*, the other species are restricted to geographically isolated areas in the country with limited population sizes. Fortunately, all Sri Lankan species of *Cyathea* occur within the protected areas of the wet zone. However, *ex situ* conservation is limited to *C. walkerae* and *C. crinita* at Botanic Gardens in Hakgala. Despite the family being listed in Annex II of CITES, its species have not yet been assessed in Sri Lanka for the Red Listing criteria. Identification of the nature and level of threat to Sri Lankan *Cyathea* species is therefore a major priority, followed by the monitoring of populations *in situ* in protected areas in the wet zone. *Ex situ* conservation of rare species and cultivation of *Cyathea* species from spores have also been identified as priority areas. A strong programme should be developed with the National Herbarium to explore little known forest patches in the wet zone to enhance our knowledge of *Cyathea* species in Sri Lanka. Such information will provide a strong basis for preparing a conservation and management plan for tree-ferns in the country.

KEY WORDS: Conservation priorities, Cyatheaceae, endemism, Sri Lanka, tree-ferns.

INTRODUCTION

The region including Sri Lanka and the Western Ghats of India is one of 34 global biodiversity hotspots identified in the world due to exceptional species diversity combined with a high level of endemism and multiple threats faced by the natural ecosystems (Mittermeier *et al*., 2005). In Sri Lanka, a considerable level of information is available on the composition and ecology of the country's angiosperms among the flora and on the fish, amphibians, birds, reptiles and mammals among the fauna (see Bambaradeniya, 2006; Dassanayake and Clayton, 1995-2000; Dassanayake and Fosberg, 1980-1991; Dassnayake *et al*., 1994; IUCN, 2007; MFE, 1999; NSF, 2000). Several national and international publications also exist on the pteridophyte flora of the country, including checklists, description of species, families and cytology. Currently, about 348 Pteridophyte taxa from 30 families have been recorded from Sri Lanka (Shaffer-Fehre, 2006). Among Asian countries, Sri Lanka is second only to Taiwan in terms of the number of pteridophyte species per 10,000 km^2 (Ranil *et al*., 2008a). However, more than 30 pteridophyte species have not been recorded from Sri Lanka during the last and present century (Sledge, 1982) and as many as 90 species are considered as threatened (MFE, 1999). As an example of the decline, a recent study conducted by Ranil *et al*. (2006) revealed that while 29 taxa were recorded from Udawattakele forest reserve in Sri Lanka during the period 1888-1954, only nine species were recorded in 2006. Although many pteridophyte species have been reported as threatened in south Asia for many reasons (see, for example, Chandra *et al*., 2008), none of the pteridophyte species from Sri Lanka is assessed for the national Red Listing criteria (IUCN, 2007). Many previous studies and collections were conducted mainly during the colonial era, followed by the detailed cytological and monographic work of Manton and Sledge (1954) and Sledge (up to Seldge, 1982). More recently, various Sri Lankan workers have published on ferns, culminating in the publication of the *Revised Handbook of the Flora of Ceylon* (Shaffer-Fehre, 2006).

The family Cyatheaceae is one of the most interesting families among the pteridophytes due to their striking morphology and wide geographical distribution combined with pronounced local endemism (Tryon and Gastony, 1975). The family consists of about 500 species worldwide with diversity centers in tropical rain forests (Conant *et al*., 1996; Tryon and Gastony, 1975). It is represented in Sri Lanka by what is often treated nowadays as a single genus, *Cyathea*, which includes seven species and one doubtful variety (Holttum, 1965; Ranil *et al*., 2010a; Ranil *et al*., 2010b; Shaffer-Fehre, 2006; Sledge, 1982). The present paper focuses on reviewing the diversity, phytogeography and

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conservation status of the tree-ferns of Sri Lanka providing conservation priorities and required further studies.

METHODOLOGY

We have reviewed published and unpublished literature to date and studied the herbarium specimens of Cyatheaceae at the National Herbarium of the Royal Botanic Gardens, Peradeniya. Specimens from foreign herbaria listed by Philcox (2006), who cited 172 specimens, were also used. Specimens with information on the locality of collection, date, collector and herbarium have been used here for identification of the past distribution of each species. New information on the present distribution was also obtained from a series of studies and collections carried out by the authors throughout the country. Ferneries of the Royal Botanic Gardens, Peradeniya located in mid country wet zone, the Botanic Gardens, Hakgala located in the upcountry wet zone and the Henarathgoda Botanic Gardens, Gampaha located in low country wet zone of Sri Lanka were also observed to identify the presence of mature *Cyathea* collections and their status. Occurrence of *Cyathea* species in surrounding areas of Sinharaja and Kanneliya forests and Nuwara Eliya area was also observed to identify the distribution of populations outside protected areas (i.e. private lands etc). The taxonomic classification followed in this study was based on that utilised by Philcox (2006) and Sledge (1982), who followed Holttum (1965) in adopting a more conservative approach of not splitting *Cyathea* into several genera. We analyzed taxon diversity, level of endemism and the past and present distribution of taxa, for five provenances and 10 administrative districts within Sri Lanka. Conservation priorities are suggested based on information on distribution, population size and existing and potential *in situ* and *ex situ* conservation measures.

RESULTS AND DISCUSSION

Diversity and taxonomic status of *Cyathea* taxa in Sri Lanka

According to Holttum (1965), the genus *Cyathea* in Sri Lanka represented by six taxa (five species and one doubtful variety). Sledge (1982) also listed six taxa but omitted the variety as of less taxonomic importance and included a suspected natural hybrid. The recent revision of the Cyatheaceae of Sri Lanka by Philcox (2006) also suggested six taxa (five species and one doubtful variety) but omitted the suspected hybrid. However, Ranil *et al*. (2004) and in continued studies, collected a considerable number of specimens of the previously mentioned suspected natural hybrid from Kanneliya and Sinharaja forests and confirmed its taxonomic status as a species, *Cyathea sledgei* Ranil *et al*. (Ranil *et al*., 2010b). Recently, Ranil *et al.* (2010a) described a new species of *Cyathea*, *C. srilankensis* Ranil, from Sri Lanka. However, the doubtful variety was not found even in recent investigations by authors. It is therefore concluded that the family Cyatheaceae is represented by eight taxa (seven species and one dubious variety) in Sri Lanka (Table 1). Geographical isolation combined with antiquity and the wide range of climatic, elevational and edaphic variation has been suggested to be the main reasons for the exceptionally high level of endemism (75 % of the known diversity) in this family in Sri Lanka.

Morphological Clusters of the Sri Lankan Taxa

Sri Lanka contains some morphologically unique tree fern species. *Cyathea sinuata* (Fig. 1A) is the only species which has simple leaves, out of about 500 known *Cyathea* species world wide (Kramer, 1990). *Cyathea sinuata* tree trunk grows up to 2 m, usually erect, but occasionally slant and trailing on ground. Diameter of trunk is 1.4-1.6 cm, and the trunk is entirely covered by persistent dead petiole bases. *C. sinuata* can be easily distinct from other species having 45-55 cm long and 2.4-3.2 width simple leaves and 1-3 pairs of indusiate sori in beneath of the 1-3 pairs of veins.

C. hookeri (Fig. 1C) grows up to 1-3.6 m. Lamina (90-120 × 21-28 cm) crowded at the apex of the stem. It can distinguish form other Sri Lankan tree fern species which having simply pinnate lamina with, 5-14 cm long stipe, shallowly lobed pinnae, lobe to 1/4-1/3 towards costa with 3-4 pairs of simply pinnate veins. It is a relatively rare species and limited to a few isolated forest patches in Sinharaja and Kanneliya lowland rain forests, where it is associated with *C. sinuata*. It can be immediately identified and distinguished from other taxa by its unique, simply pinnate, strap-shaped fronds.

C. sledgei (Fig. 1D) is show intermediate characters of *C. sinuata* and *C. hookeri*. It grows up to 0.9-1.35 m and tree trunk entirely covered by persistent dead petiole bases. The unique character of *C. sledgei* is 60-90 cm long, deeply lobed, pinnatifid lamina. It is further differed from other species having once forked, 8-10 pairs of veins in each segment and 8-10 pairs of sori in each segment in two rows on either side of the costa.

Although little is known of the genetic diversity of any *Cyathea* species in Sri Lanka, a cluster analysis has been carried out for *C. sinuata* and its close relatives using twenty-five morphological characters, including *C. sledgei* and *C. hookeri*. In contrast to the clusters for *C. hookeri* and *C. sledgei*, *C. sinuata* showed a wide range of morphological diversity for some characters and two main subgroups were also identified, which suggests

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Table 1: Diversity of taxa of the family Cyatheaceae present in Sri Lanka and their distribution together with their conservation status.

Taxon	Distribution	Conservation status
1. *C. sinuata* Hook. & Grev.	Endemic to Sri Lanka. Restricted to Sinharaja and Kanneliya lowland rain forests, with a high local population density.	Occurs *in situ* in protected areas, no *ex situ* conservation. Protected under FFPO.
2. *C. hookeri* Thwaites	Endemic to Sri Lanka. Restricted to Sinharaja and Kanneliya rain forests, and frequently associated with *C. sinuata*, but with a low population density.	Occurs *in situ* in protected areas, no *ex situ* conservation. Protected under FFPO.
3. *C. sledgei* Ranil *et al.*	Endemic to Sri Lanka. Restricted to Sinharaja and Kanneliya rain forests, usually associated with *C. sinuata* and *C. hookeri*.	Occurs *in situ* in protected areas, no *ex situ* conservation.
4. *C. walkerae* Hook.	Endemic to Sri Lanka, widespread in the country.	Occurs *in situ* in protected areas and *ex situ* at Hakgala Botanic Gardens.
5. *C. walkerae* var. *tripinnata* Hook. & Baker	Endemic to Sri Lanka. not currently treated as being more than part of the range of variation of the species.	Not identified after 1888. A doubtful taxon probably without taxonomic significance.
6. *C. srilankensis* Ranil	Endemic to Sri Lanka. Restricted to few localities in Sinharaja forest.	Occurs *in situ* in protected areas, no *ex situ* conservation. Recently described and not yet proposed for protection, though obviously very rare.
7. *C. crinita* (Hook.) Copel.	Native to Sri Lanka and South India. In Sri Lanka, distribution restricted to fairly large populations in Nuwara Eliya district at high elevation.	Occurs *in situ* in protected areas and *ex situ* at Hakgala Botanic Gardens. Occurs in private lands of Nuwera Eliya area.
8. *C. gigantea* (Wall. *ex* Hook.) Holtt.	Native to Sri Lanka, India, Nepal, Bhutan, Myanmar, China, Thailand, Laos, Vietnam and Indonesia. In Sri Lanka, distribution mainly limited to central province and perhaps few known localities in other one or two provinces.	Occurs *in situ* in protected areas, no *ex situ* conservation.

FFPO = Fauna and Flora Protection Ordinance in Sri Lanka.

that two morphotypes of *C. sinuata* appear to exist (Ranil *et al*., 2009). These two morphotypes are often growing as separate populations. The two can be distinguished by their leaf characters, such as leaf width, and length, margins and base, number of veinlets, number of sori and their arrangement (Fig. 1B). Further study is required to investigate whether these forms are constant, or exhibit phenotypic plasticity under different conditions and how much they might overlap.

A new tree-fern species was recently described as *C. srilankensis* (Fig. 1E) by Ranil *et al*. (2010a) from the Sinharaja forest. Its trunk is erect and grows up to 2.1 m in height and 5 cm in diameter. Lamina is large (130-202 × 40-65 cm) with 18-28 cm long chestnut coloured petiole. Even though it is some what similar to *C. hookeri*, *C. srilankensis* deviated from having pinnate-pinnatisect leaves, deeply lobed pinnae sinus to the costa, free pair of basal pinnul and costa with densely hairy in adaxially.

C. walkerae (Fig. 1F) is endemic to Sri Lanka, and is distributed over a wide range of climatic and geographical areas there. It was also reported from south India by Nayar and Geevarghese (1993), but according to Fraser-Jenkins (2008a), this was a misidentification for the south Indian species, *C. nilgirensis* (Holttum) R.M. Tryon. *C. walkerae* grows in pockets, mainly along streams in secondary forests. It has relatively large tree trunk with 2.5-5 m tall and (5-)8-20 cm diameter. Tree trunk covered by persistent bases of stipes with 30-40 cm in long. Lamina bipinnate and it is deviated from having indusiate sori from other bipinnate tree ferns in Sri Lanka.

C. walkerae var. *tripinnata* Hook. & Baker is known only from the type specimen at the Kew (*C.P.* 1398) and was recorded by Thwaites (1886) without citing a locality. There have been no further records of it since and more exploration, study of the range of variation in the species, and examination of the type specimen are required. Its taxonomic status and whether it should be recognized nomenclaturally are unclear and it might perhaps be better understood as merely part of the range of variation in the species, not or hardly worthy of nomenclatural recognition. It is deviated from usual *C. walkerae* by secondary pinnae up to 15 × 3 cm, largest with several pairs of deeply-lobed, tertiary lobes.

C. gigantea (Fig. 1G) occurs commonly in many south and southeast Asian countries. It has 1-1.5 m long tree trunk with 8-10 cm diameter. About 160 × 100 cm bipinnate lamina crowded at the top of the trunk. Veins distinct on both surfaces, each lobe of secondary pinnae furnished with mid-vein with 4-6 pairs of lateral venules. Sori are 3-4.5 pairs and exindusiate. It can be distinguished easily from other species by its inverted "V" shaped soral arrangement in each pinnule lobe. Populations known until now in Sri Lanka are limited to only a few locations in Central province. But the authors identified a single individual from Kanneliya forest located in the southern part of the island. However, there is insufficient information concerning the status of its distribution, habitat and populations and collections of *C. gigantea* are too scarce due to the lack of exploration of many wet zone forests.

The magnificent tree-fern, *C. crinita* (Fig. 1H), is the largest tree fern in Sri Lanka and it grows up to 12 m in

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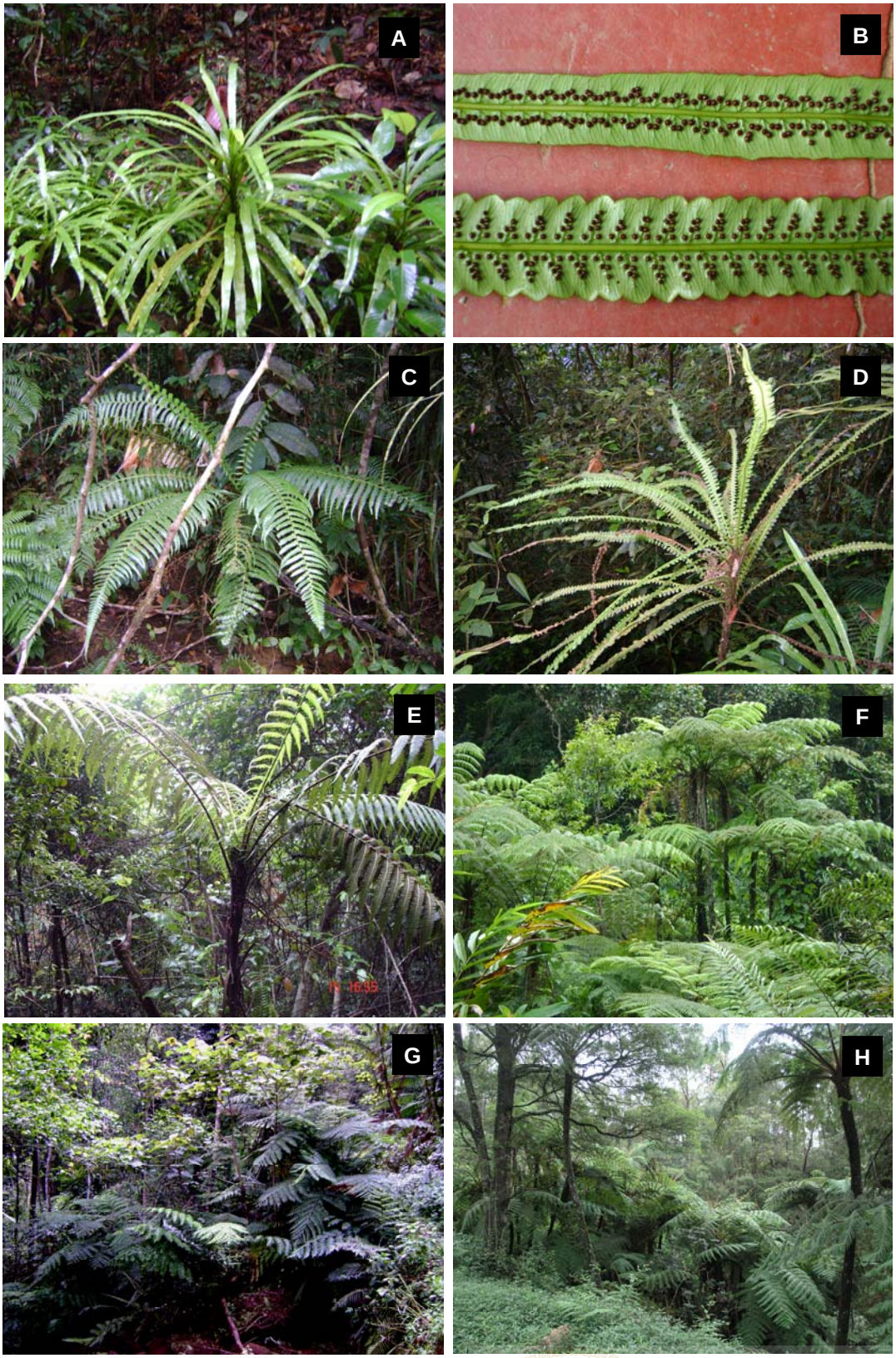


Fig. 1. Recorded *Cyathea* species in Sri Lanka and their natural habitats. A: *C. sinuata*. B: frond of two morphotype of *C. sinuata*. C: *C. hookeri*. D: *C. sledgei*. E: *C. srilankensis*. F: *C. walkerae*. G: *C. gigantea*. H: *C. crinita*.

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Table 2. Specimen collection of Cyatheaceae from Sri Lanka from 1844 to 2004.

Species	Herbaria and number of collections						
	BM	E	LIV	K	P	PDA	Total
1. *C. sinuata*	2	7	1	12	4	10	36
2. *C. hookeri*	1	1	1	6	2	8	19
3. *C. sledgei*	-	-	-	2	-	19	21
4. *C. srilankensis*	-	-	-	-	-	26	26
5. *C. walkerae*	2	1	-	34	6	21	64
6. *C. walkerae* var *tripinnata*	-	-	-	1	-	-	1
7. *C. crinita*	2	4	-	9	4	7	26
8. *C. gigantea*	1	6	-	8	3	4	22
Total	8	19	2	72	19	95	215

height and 12-25 cm diameter. It appears to be confined to Nuwara Eliya district in high altitude areas and prefers very cool climatic conditions. It is the only *Cyathea* species in Sri Lanka which has leaf scars visible on the main trunk while the trunks of other species are totally covered by persistent leaf petiole bases. It is distinct from other Sri Lankan tree ferns in having long stipe (40-85 cm), and the 3.5-4 cm long, 2-5 mm wide petiole scales with relatively large lamina (100-200× 50-100 m). It also has distinctive, very dense, pale and narrow scales at the growing apex of the trunk. *C. crinita* is relatively rare due to its restricted distribution, but is locally common where it does occur.

Phytogeographical relations

Different suggestions have been proposed with respect to the affinities of Sri Lankan tree-ferns with other regions. Of the species confined to the Sri Lankan/south Indian, or "Hindulankan" region (see Fraser-Jenkins, 2008b), Holttum (1981) suggested an affinity of some species with African elements (e.g. an affinity of *C. hookeri* and *C. srilankensis* with *C. humilis* Hieron. and *C. schliebnii* (Kuhn) Domin from Tanzania and Kenya (see also Ranil *et al*., 2010a). Such a disjunct pattern might have resulted from an ancestral species that was widespread across the ancient continent of Gondwana (Strahler and Strahler, 2005) and there is a known African element of fern species in Sri Lanka and south India. However, the African affinity of *C. hookeri* and *C. srilankensis* is probably rather doubtful, due to generally strong development of local endemism and lack of geographical overlap among tree-ferns (Tryon and Gastony, 1975). Furthermore, based on molecular study of *C. hookeri, C. sinuata* and *C. walkarae*, Janssen *et al*. (2008) have subsequently suggested that Sri Lankan tree-ferns form a monophyletic group not closely related to African tree-ferns, though this may require further study and consideration. The phylogenetic position and phytogeographical affinities of the "Hindulankan" *Cyathea* species in Sri Lanka thus remain to be determined based on both genetic and other information. As would be expected from general Sri Lankan pteridophyte phytogeography, one other species, *C. gigantea* is a southeast Asian (Malesian) element, widespread in India and southeast Asia.

Distribution and collection of tree ferns in Sri Lanka

During the period of 1844 – 2004 (excluding recent and ongoing studies), about 215 specimens of *Cyathea* species have been collected in Sri Lanka (Table 2). Nearly 90% of them were collected by foreign pteridologists during the colonial era (pre 1947) and nearly 50% are deposited herbaria outside Sri Lanka (Table 2). The type specimens of *C. hookeri*, *C. walkerae*, *C. walkerae* var *tripinnata*, and *C. crinita* are deposited at Kew, and the type of *C. sinuata* is at Edinburgh. The types of *C. sledgei* and *C. srilankensis* are deposited at the National Herbarium, Peradeniya.

The numbers of previous (before 2004) and new (after 2004) specimens of tree-ferns from different provinces of Sri Lanka are given in Table 3. In the past, the majority of specimens of *Cyathea* species were collected from Central (42%), Sabaragamuwa (27%) and Southern (22%) provinces. The majority of new specimens collected during the present study are also from these regions. These evidences indicate that lowland, sub montane and montane rain forests of Sri Lanka provide the most favorable habitats for tree-ferns. The number of new specimens we collected was limited due to collection of only a single specimen from each locality. The present specimen collection also indicates that the paucity of occurrence of *Cyathea* species in new localities.

According to previous and present observations, *C. sinuata*, *C. hookeri* and *C. sledgei* are restricted to a few isolated pockets of two lowland rain forests bordering Southern and Sabaragamuwa provinces, where the elevation ranged from 110 – 410 m altitude. Interestingly, new species were observed in the same area (Ranil *et al*., 2010a, 2010b). Of the three taxa, *C. sinuata* was observed to be the most abundant with a high population density (1,100 plants/100 m^2), whereas *C. hookeri* was of low density (14 plants/100 m^2) (Ranil *et al*., 2009). Two plant of the *C. sledgei*, was originally collected by F.

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Table 3. Before 2004 and after 2004 collections of *Cyathea* species in the different provinces and administrative districts of Sri Lanka.

Species	Central			Southern		Sabaragamuwa		Uva		Western
	A	B	C	D	E	F	G	H	I	J
1. *C. sinuata*	-	-	-	*10*	-	*16*	-	-	-	-
	-	-	-	18	-	26	-	-	-	-
2. *C. hookeri*	-	-	-	*4*	-	*11*	-	-	-	-
	-	-	-	12	-	17	-	-	-	-
3. *C. sledgei*	-	-	-	*2*	-	-	-	-	-	-
	-	-	-	6	-	13	-	-	-	-
4. *C. walkerae*	*13*	-	*12*	*14*	-	*12*	-	*7*	-	*2*
	2	3	2	4	2	2	2	*	1	2
5. *C. walkerae* var. *tripinnata*	-	-	-	-	-	-	-	-	-	-
6. *C. srilankensis*	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	26	-	-	-	-
7. *C. crinita*	*1*	-	*11*	-	-	-	-	-	-	-
	-	-	4	-	-	-	-	-	-	-
8. *C. gigantea*	*3*	*2*	*5*	-	-	-	-	*1*	-	-
	1	*	2	1	-	-	-	-	-	-
Total	***17***	***2***	***28***	***30***	**-**	***39***	**-**	***8***	**-**	***2***
	4	**3**	**8**	**41**	**2**	**84**	**2**	**-**	**1**	**2**

A = Kandy; B = Matale; C = Nuwara Eliya; D = Galle; E = Matara; F = Rathnapura; G = Kegalle; H = Badulla; I = Monaragala; J = Kalutara district. * indicates that the species was observed, but specimens were not collected. Italics numbers represent collections before 2004 and normal numbers represent collections after 2004. Thirty four specimens collected before 2004 had no locality information and are thus excluded from the table.

Ballard and W.A. Sledge from “Panangala” (close to the Kanneliya forest reserve) in 1951 and deposited at Kew (*FB* 1548 and 908). It has been identified it as a suspected hybrid between *C. sinuata* and *C. hookeri*. Fifty years after this single collection, Ranil *et al.* (2004) and in recent further studies by the authors have collected more than 30 more specimens of this species from both Kanneliya and Sinharaja forests. This formerly presumed hybrid was confirmed as a new species and named *Cyathea sledgei* Ranil *et al*. (Ranil *et al*., 2010b). Present observations reveal that this species occurs as a few number of individuals often associated with *C. sinuata* and *C. hookeri* (not more than 1 plant/100 m^2). The distribution of *C. srilankensis* is limited to few localities in the Sinharaja forest at an elevation of about 480 m. The population of this species, as presently known, is restricted to limited number of individuals on stream bank and roadside bank in the Sinharaja forest.

The endemic *C. walkerae* is the most widespread and common tree-fern species in Sri Lanka. It has a wide altitude range from 60 to 1,525 m elevation, and covers lowland, sub-montane and montane forests. Based on observations by the authors, the populations from Rathnapura district in Subaragamuwa province were the most substantial. *C. walkerae* var. *tripinnata* is known only from the type specimen at Kew. As no records are available thereafter it is difficult to assess it and reach a conclusion and more exploration is needed to attempt to refine it for further study.

Even though *C. gigantea* is of common occurrence in south and southeast Asian countries, populations in Sri Lanka are mainly limited to a few localities in Central province at up to 1,600 m elevation. According to previous records (Table 3), it is limited to medium-high elevation in Central province. However, there is a recently collected a single specimen of it from Blackwood forest of Badulla district, at an elevation of 1,525 m. The authors also collected it from Kanneliya forest in the southern part of the country at an elevation of 92 m. This shows that the presumed restriction of this species to higher elevations was merely due to lack of exploration and inadequate study and might apply to certain other plants of a similar category.

C. crinita is common to both Sri Lanka and south India and its distribution is limited to cool montane areas at elevations around 1,500-2,000 m. Nearly, all the Sri Lankan records of *C. crinita* are limited to Nuwara Eliya district of Central province, with only one other from Kandy district. *C. crinita* has been classified as of the "at risk" category in India (Chandra *et al*., 2008). The population in Sri Lanka is therefore of global importance. Although there are records of the occurrence of *C. crinita* in Sinharaja forest (at 529 m elevation) in Southern province, collected by Mueller-Dombois and Balakrishna, our current studies did not confirm the presence of *C. crinita* in Sinharaja forest. It is a misidentification of *C. walkerae* as *C. crinita.* No *C. crinita* were found in recent intensive survey on the pteridophyte flora of Sinharaja and long term monitoring of *C. sinuata* and *C. hookeri* populations there.

The distribution of all the *Cyathea* taxa in Sri Lanka

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reveals a site-specificity concentrated mainly on stream and roadside banks in primary or secondary forests. In both Sinharaja and Kanneliya forests, authors observed that despite the continuity of the stream network only some pockets have been colonized by *C. sinuata*, *C. hookeri* and *C. sledgei*. The precise reasons for their restricted distribution and site specificity remain to be investigated, though the availability of water and constantly damp environments must be presumed to be of major importance.

Conservation priorities and further research

As with many other pteridophytes, detailed information on tree-ferns in Sri Lanka is not readily available. Limited information is a major barrier to conservation and management of these species. In Sri Lanka, only *C. sinuata* and *C. hookeri* have been designated as locally threatened species under the Fauna and Flora Protection Ordinance (FFPO). Despite the family being listed in Annex II of CITES, no member of the family has been assessed for red listing. It is thus an immediate requirement to identify the levels of threat to tree-ferns and categorize them according to red listing criteria. Such information provides a strong base to prepare conservation and management guidelines and plan for the protection of tree-ferns in Sri Lanka.

Populations of almost all *Cyathea* species occur in protected areas in the wet zone of Sri Lanka. *In situ* conservation in natural forests is therefore an attainable priority for those tree-fern species. However, our preliminary study of the distribution of the species and their population sizes shows that further observation and monitoring of existing populations are required for effective conservation. This is mainly because of the restricted number of individuals observed in several species. Furthermore, recent exploration has revealed occurrences of previously undetected populations of tree ferns, and even a new species. An island-wide survey of all wet zone forests is therefore of high priority in order to explore further the availability of different species and their population sizes, especially in protected areas.

At present, *ex situ* conservation is limited only to *C. walkerae* and *C. crinita*, at the Botanic Gardens, Hakgala. No *ex situ* collection of living *Cyathea* species is available at the Royal Botanic Gardens, Peradeniya or Henarathgoda Botanic Gardens, Gampaha. Therefore, collection of germplasm and the establishment and propagation of the various taxa at national and international Botanic Gardens is urgently required as a supplementary conservation measure for Sri Lankan *Cyathea* species. The urgency of these measures is because most species are restricted to few or very few individuals and though protected, many forests are already fragmented in the wet zone area and are being subjected to increasing human disturbance.

Utilization of *Cyathea* species is not properly regulated in Sri Lanka. Illegally use of the trunks of *C. walkerae* and *C. crinita* as growth media for orchid cultivation is frequently found. *C. crinita* is also used as an ornamental landscaping plant in Nuwara Eliya District. In almost all cases the plants are collected from the wild, potted and planted or sold. It is therefore important to study and regulate this or other ethnobotanical uses of tree-ferns for their sustainable utilization with minimum disturbance to natural populations. For this purpose research into cultivation of the species is an essential requirement. No previous research has been conducted locally on spore germination and subsequent development of sporophytes on artificial media to facilitate cultivation. However, a recent paper by Ranil *et al.* (2008b) provides encouraging results on effective spore germination media, gametophyte morphology and the successful raising of sporophytes from gametophytes and their transfer to general growth media in *C. walkerae*. Public awareness programs on the conservation and sustainable utilization of tree-ferns should be initiated promoting *in situ* and *ex situ* conservation.

CONCLUSIONS

Sri Lanka contains eight taxa of tree-ferns, of which 75% are endemic to the country. Lowland rainforests and montane forests located in the wet zone harbour most of the *Cyathea* species but populations of many species are restricted to small areas in these forests. The survival of tree-ferns in Sri Lanka depends primarily on the effective *in situ* conservation and monitoring of the country's remaining fragments of rainforests and inclusion of species under *ex situ* programmes for propagation and re-establishment, utilizing the resources of Botanic Gardens. Recent new findings indicate the biological significance and diversity of Sri Lankan *Cyathea* species and the urgent necessity of further exploration of surviving wet zone forests.

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斯里蘭卡樹蕨（杪欏科, Cyatheaceae）的保育優先性

R .H. G. Ranil[1*], D. K. N. G. Pushpakumara[1], T. Janssen[2], C. R. Fraser-Jenkins[3] and D. S. A. Wijesundara[4]

1. Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka.
2. Department of Vascular plants, Spermatophytes and Pteridophytes, National Botanic Gardens, Meise, Belgium.
3. Student Guest House, Thamel, P.O. Box no 5555, Kathmandu, Nepal.
4. Department of National Botanic Gardens, Peradeniya, Sri Lanka.
* 通信作者。*Tel: 0094 718668109; Email: rajapaksha76@yahoo.com*

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摘要：本文探討斯里蘭卡樹蕨的多樣性、植物地理和保護現狀。斯里蘭卡的杪欏科由八個類群（七種類及一可疑變種）所組成，具有 75%的高特有率。除了 *Cyathea walkerae* 和 *C. gigantea* 外，其他種類在該國均為地理上孤立分布的有限族群。所幸，所有斯里蘭卡的杪欏屬植物均出現在濕地保護區的範圍內。然而，目前已進行移地保育的物種卻相當有限，僅 *C. walkerae* 和 *C. crinit*a 被保育於 Hakgala 的植物園中。儘管該科已是被列入華盛頓公約附錄 II 物種，在斯里蘭卡其各種類尚未依紅皮書的標準加以評定。因此，鑑定斯里蘭卡杪欏屬植物的特性及其受威脅程度為主要的優先事項，其次為監測分布於濕地保護區的種群；移地保育珍稀的杪欏屬種類，並以孢子進行培養也是優先的保育措施。斯里蘭卡當局應發展一個強固的計畫與國家植物標本館合作，探索在森林區塊中鮮為人知的潮濕地帶，以提升對杪欏屬植物的知識。這些資料將為該國在樹蕨保育及管理計畫的準備工作提供有力的依據。

關鍵詞：保育優先性、杪欏科、固有性、斯里蘭卡、樹蕨。

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