

## Naturalization of *Dicksonia antarctica* Labill. in Pidurutalagala Mountain Forest Reserve and Adjacent *Eucalyptus* Plantation in Sri Lanka

Rajapaksha Haddokara Gedara Ranil<sup>1,\*</sup>, D. K. N. Gamini Pushpakumara<sup>1</sup>,  
K. Tilak Premakantha<sup>2</sup>, Peter D. Bostock<sup>3</sup> and Atsushi Ebihara<sup>4</sup>

<sup>1</sup>Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka

<sup>2</sup>Sri Lanka Forestry Institute, Nuwara Eliya, Sri Lanka

<sup>3</sup>Queensland Herbarium, Department of Science, Information Technology, Innovation and the Arts,  
Brisbane, Queensland, Australia

<sup>4</sup>Department of Botany, National Museum of Nature and Science,  
Amakubo 4-1-1, Tsukuba 305-0005, Japan

\*E-mail: rhgranil@gmail.com

(Received 13 June 2014; accepted 25 June 2014)

**Abstract** *Dicksonia antarctica* Labill. is a species native to Australia. In Sri Lanka, until recently, the only known record of *D. antarctica* was at the Fernery in Hakgala Botanic Gardens, Nuwara Eliya, where the species was planted in 1863. An eco-geographic survey on Sri Lankan tree ferns conducted from 2006–2013 identified a substantial population from Pidurutalagala Mountain Forest Reserve and adjacent *Eucalyptus* plantation. The detailed observation of population in natural forest and forest plantation fringe revealed natural regeneration with substantial number of immature and mature individuals. Hence, it is proposed that *D. antarctica* is naturalized in some areas of Pidurutalagala Mountain Forest Reserve and adjacent *Eucalyptus* plantation after escaping from the Fernery in the Hakgala Botanic Gardens. The substantial amount of population was observed about 30 km away from the Fernery. Further studies on population and reproductive biology are continuing.

**Key words** : introduction, natural population, population distribution, pteridophytes.

The family Dicksoniaceae is represented by three genera, namely *Calochlaena*, *Dicksonia* and *Lophosoria* (Christenhusz *et al.*, 2011). The genus *Dicksonia* comprises 20–25 species in tropical and temperate areas (Kramer, 1990). The genus shows a scattered distribution from Malaysia through Australia and New Zealand to South America. New Guinea is considered as the centre of diversity (Large and Braggins, 2004). *Dicksonia antarctica* Labill. is native to Australia and is a common and popular species in natural and man-made landscapes (Large and Braggins, 2004). Its natural range is across south-eastern Australia including Tasmania, Victoria, New South Wales and Queensland in moist, shaded

and loamy soil habitats. The family Dicksoniaceae is not naturally represented in Sri Lanka. The only known locality for *D. antarctica* is at the Fernery in the Hakgala Botanic Gardens, Nuwaraeliya where it was established in 1863. Detailed observations of the Fernery revealed a substantial number of immature and mature individuals at the Fernery. An eco-geographic survey of Sri Lankan tree ferns conducted from 2006–2013 identified a substantial population of *D. antarctica* from Pidurutalagala Mountain Forest Reserve and adjacent *Eucalyptus* plantation. The species has not been previously recorded from natural habitats. This paper discusses record of naturalized population of *D. antarctica* in Sri

Lanka, its taxonomic treatment, ecology and habitat characters, natural regeneration and future observation to monitor in naturalized populations.

### **Taxonomic description of naturalized *Dicksonia antarctica***

The taxonomic account was made after the investigation of immature and mature individuals of both the naturalized population and cultivated plants at the Hakgala Botanic Gardens. Herbarium specimens have been prepared and deposited at the National Herbarium of the Royal Botanic Gardens, Peradeniya (PDA).

*Dicksonia antarctica* Labill., Nov. Holl. Pl. 2: 100, t. 249 (1807) [Fig.1: A–F]

Trunk 1–3.5 m tall, erect, rarely prostrate, unbranched, densely covered with brown fibrous roots, producing offsets. Stipe short, brown, base persistent, base of stipes and trunk apex densely covered with glossy ginger-brown hairs. Fronds large, dense, rosette, spreading crown, 12–30 leaves crowded at the end of the stem. Stipe 20–35 cm long, stout, smooth or slightly verrucose, hairy. Lamina tripinnate, oblong-lanceolate, 2–4.5 m long, 0.5–0.9 m wide, dark green and shiny above, coriaceous. Pinnules divided, linear, sessile, with pointed apex. Veins free and simple. Sori 0.8–1.3 mm in diameter, numerous, globular, 2–6 per pinnule, marginal, solitary on each lobe. Indusia circular to oval in outline.

### **Ecology and habitat characters**

Most *Dicksonia* species occur naturally in the undergrowth of sparse forests, often in thickets or more open vegetation, and in mountain regions (Kramer, 1990). The preferred natural habitat of *D. antarctica* is high-rainfall forests from sea level to about 1,000 m; it is particularly abundant in wet, shady gullies in south-eastern Australia (Jones, 1998). Out of its natural habitat, this species thrives well in cool, moist condition and, if given plenty of water, will tolerate a fair

degree of exposure to sun (Jones, 1987; Large and Braggins, 2004). Apparently the cool mountainous micro-climate and high elevation (1,745 m) of the Hakgala Botanic Gardens are matched with the ecological requirements of *D. antarctica*. This may be the main eco-physiological reason why *D. antarctica* was introduced to the Fernery at the Hakgala Botanic Gardens during colonial era, as a way of popularizing the species (Fig. 1A). A similar micro-climatic environment also occurs in the Pidurutalagala Mountain Forest Reserve and adjacent *Eucalyptus* plantation. Both the forest area and *Eucalyptus* plantation consist of nearly 40–50% canopy cover and 20–30% steepness. There are two seasonal streams and one perennial stream flowing in the area. All individuals of *D. antarctica* are observed associated with the stream network. During the study period a total of 30 plants were recorded. Of which 90% are immature individuals suggesting that it is still in the initial stage of naturalization. Though *D. antarctica* is typically identified as a terrestrial species, out of the 27 of total immature individuals, 18 plants were observed on the base of *Cyathea walkerae* Hook. and one on another unidentified tree fern trunk (Fig. 1D). Further observations indicated that as they grew and developed, these plants formed a rhizome and connection with the soil surface.

### **Naturalization and natural regeneration of *Dicksonia antarctica***

Species that have translocated from one region to another region are defined as alien or exotic to the newly occupied region (Richardson *et al.*, 2000). Overtime some such exotic species become naturalized. Such migration is considered as a natural phenomenon which enriches ecosystems and drives evolution (Hettinger, 2001). Though naturalization of pteridophytes has not been properly studied, this phenomenon also occurs with the pteridophytes. The theoretical framework of factors mediating naturalization has been well elaborated (Catford *et al.*, 2009; Richardson *et al.*, 2000). To quote Wu *et*

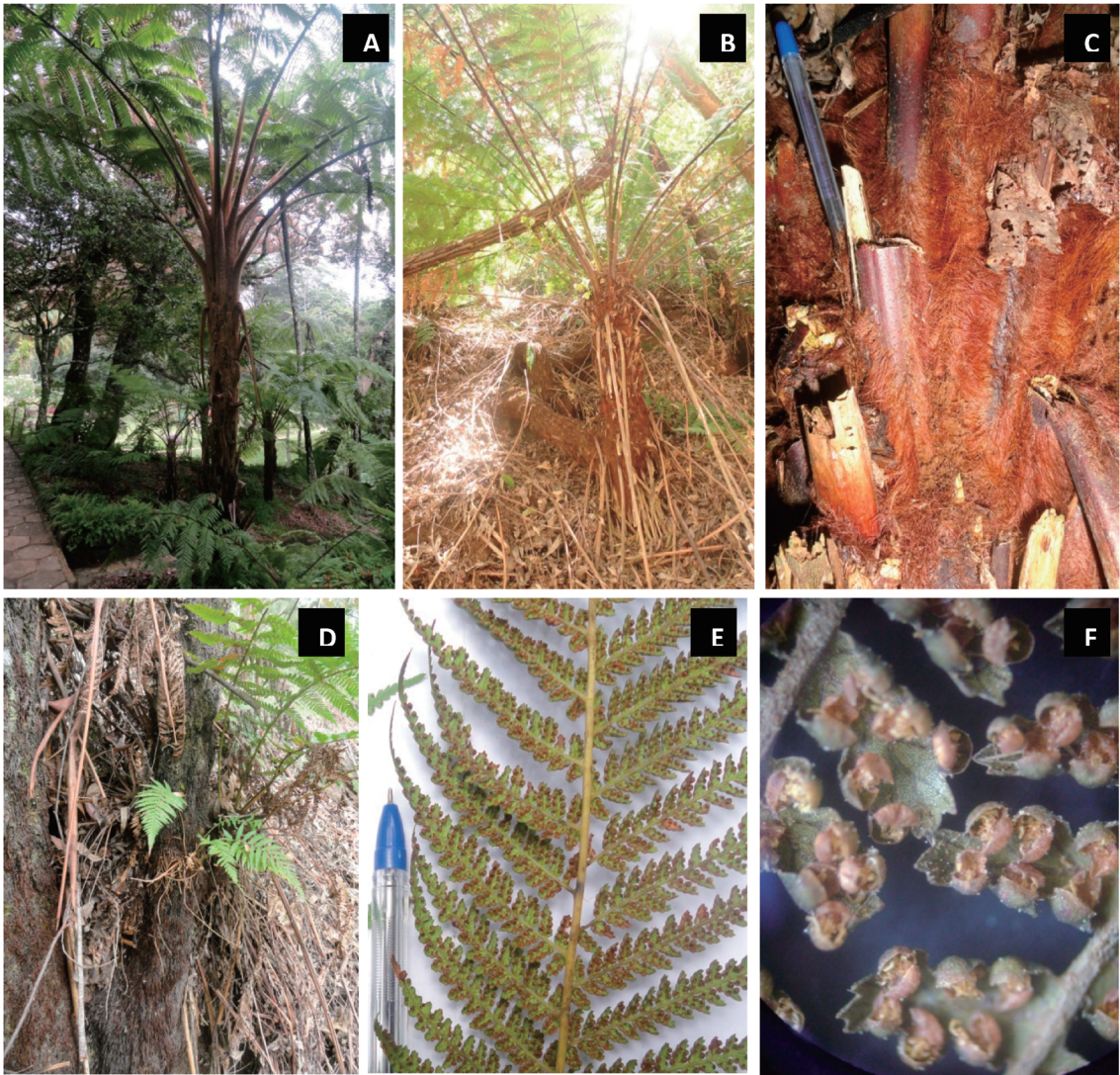


Fig. 1. *Dicksonia antarctica* Labill. A: a well grown mature individual planted in the Hakgala Botanic Gardens. B: naturalized plant with trailing stem in *Eucalyptus* plantation adjacent to Pidurutalagala Mountain Forest Reserve. C: trunk apex densely covered with glossy ginger-brown hairs. D: juvenile naturalized plant in the base of tree fern trunk of *Cyathea walkerae*. E: lower surface of lamina. F: sori in pinnule lobes ( $\times 10$ ).

al. (2010) “several hypotheses have been proposed to account for the naturalization preferences of introduced species, including similar climates (Corlett, 1992)”. Successful introduction of *D. antarctica* to the Hakgala Botanic Garden is probably due to climate similarities between its natural range and the Botanic gardens. Subsequent naturalization in adjacent Pidurutalagala Mountain Forest Reserve and adjacent *Eucalyptus*

plantation is also consistent with climate similarity. Fig. 2 shows the relative position of the Fernery of the Hakgala Botanic Gardens and records where naturalized populations have been observed. Based on the topography of the area and wind directions, it is likely that spores of *D. antarctica* have been transported to the Pidurutalagala Mountain Forest Reserve areas. Relative distribution of individuals of *Dicksonia antarctica*



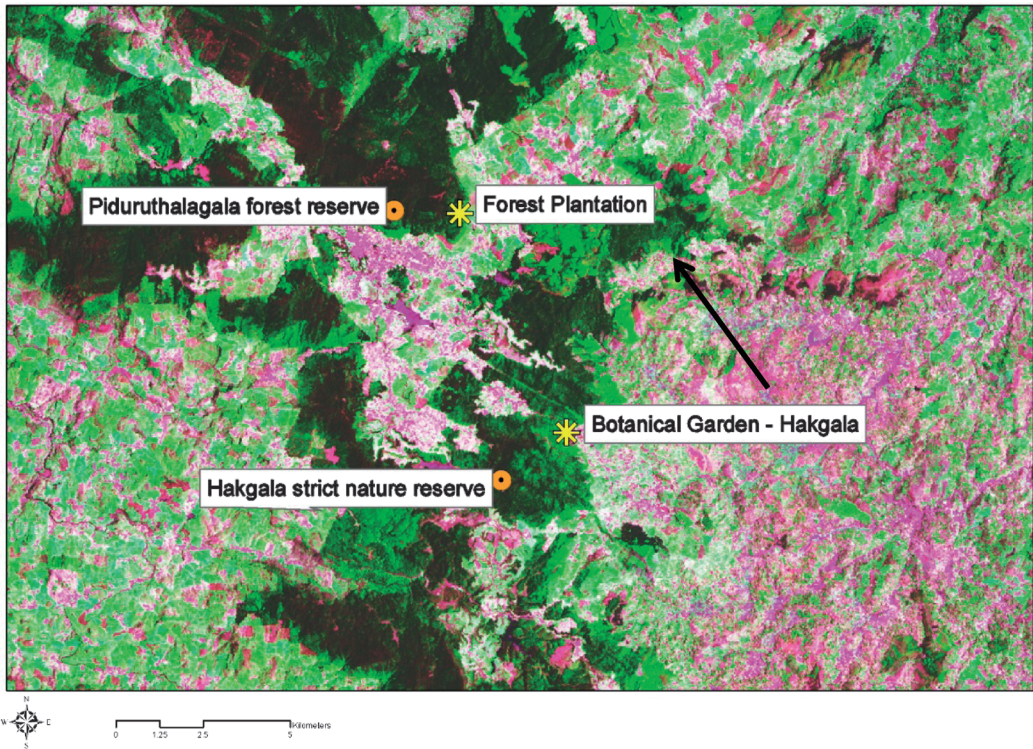


Fig. 2. Relative location of introduced and naturalized populations of *Dicksonia antarctica* in Sri Lanka (asterisk) and wind directions (arrow). [Source: The National Remote Sensing Agency, India]

under naturalized conditions in Piduruthalagala Mountain Forest Reserve is shown in Fig. 3. Intensive observation were also made in other similar areas to Piduruthalagala Mountain Forest Reserve such as Kikiliyamana Forest Reserve, Hakgala Strict Nature Reserve, Horton Plains National Park and Bomburu-ella Forest Reserve, but the species was not observed. However, why *D. antarctica* has not been naturalized in other similar areas surrounded by the Hakgala Botanic Gardens remain unclear and deserve further studies.

Botanical exploration of native Sri Lankan pteridophytes and introduction of exotic species as ornamental plants began in the British colonial era. Usually pteridophytes are intentionally introduced as ornamental garden plants. Though it is hard to find written evidence, many such ornamental pteridophytes have been introduced through the Botanic Gardens during the British

colonial era. Ranil and Pushpakumara (2012) reported the occurrence of 336 species of endemic and native ferns and lycophytes in Sri Lanka. However, the number of introduced and naturalized species is vaguely defined. After re-examination of checklists of Sri Lankan ferns by Abeywickrama (1978), Sledge (1982) Fernando (2002), Shaffer-Fehr (2006), and Fraser-Jenkins (2008), tentatively proposed about 22 pteridophytes species as naturalized exotics in the country.

There are few well-known examples for the naturalization of ferns via Botanic gardens in Sri Lanka. After their introduction as ornamental plants to the Hakgala Botanic Gardens, three other well known Australian fern species have been naturalized in submontane and montane ecosystems of Sri Lanka. *Doodia media* R.Br. [*Blechnum medium* (R.Br.) Christenh.] is native to Australia and New Guinea (Parris, 1998) and



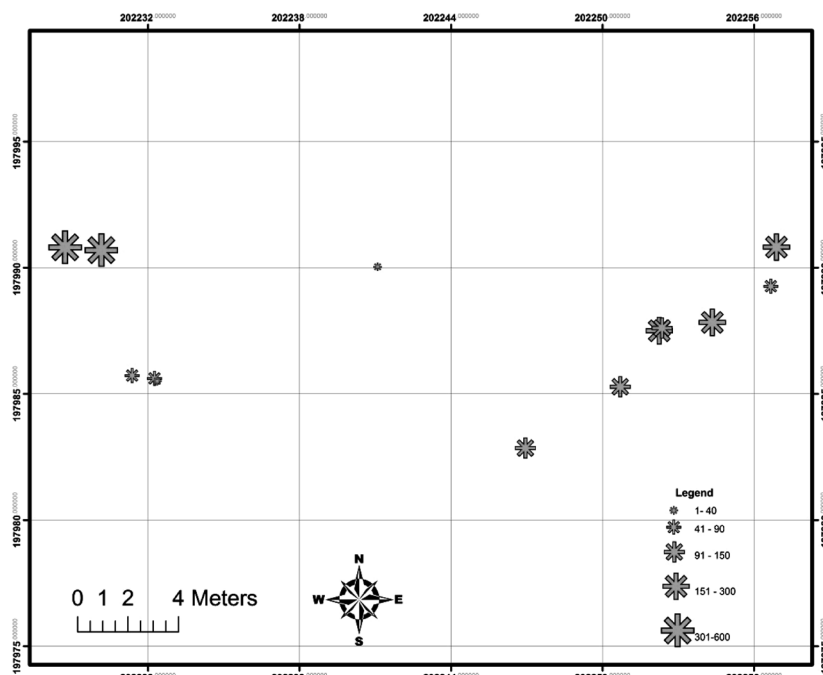


Fig. 3. Relative distribution of individuals of *Dicksonia antarctica* under naturalized conditions in Pidurutalagala Mountain Forest Reserve. Note: Canopy diameter is given in cm as a range in left corner of the map.

found in the Hakgala Botanic Gardens as an introduced garden ornamental plant. Now the species is naturalized (Jayasekara, 2006; Fraser-Jenkins, 2008) and fully established in adjacent natural forests such as the Hakgala Strict Nature Reserve, the Bomburu-ella and Kikiliyamana Forest Reserves and some of the roadside banks in Nuwara Eliya district. *Doodia caudata* (Cav.) R.Br. [*Blechnum spinulosum* Poir.] is also native to Australia and now naturalized in the Azores, Madeira, Sri Lanka and South India (Parris, 1998; Fraser-Jenkins, 2008). *Doodia squarrosa* Colenso [*Blechnum zeelandicum* Christenh.] is also native to Australia and New Zealand and now commonly occurs in adjacent forest to the Hakgala Botanic Gardens. Almost all naturalized species are commonly found in the Central highland of Sri Lanka. Even though *D. antarctica* originates in geographically distant areas, it survives well here probably due to ecological similarities.

It is important to report here that *D. antarctica* has been identified as an invasive species in São

Miguel Island, Azores (Arosa *et al.*, 2012). At present, the distribution of individuals and their regeneration did not reveal such invasiveness in Pidurutalagala Mountain Forest Reserve and adjacent *Eucalyptus* plantation. However, continuing monitoring of the population is necessary to identify whether it is, or will become, an invasive alien species in Sri Lanka.

### Conclusions

A naturalized population of *D. antarctica* was recorded for the first time from Sri Lanka. However, the present observations on *D. antarctica* suggest that it is still in the initial stage of the process of naturalization. Monitoring and further evaluation of the species especially with regard to alien invasive behaviour reported elsewhere are suggested.

### Acknowledgments

Mr. G.J.R. Gamage, Field Assistant, Nuwara

Eliya Division, Regional Forest Office, Forest Department, Nuwara Eliya is acknowledged for his support during the field observations. Department of Forests and Department of Wildlife Conservation are acknowledged for granting permissions to conduct eco-geographic survey of tree ferns in Sri Lanka. The eco-geographic survey was funded by the Nagao Natural Environment Foundation, Japan.

### References

- Abeywickrama, B. A. 1978. A Checklist of the Pteridophytes of Sri Lanka. National Science Council of Sri Lanka, Colombo., 18 pp.
- Arosa, M. L., Ceia, R. S., Quintanilla, L. G. and Ramos, J. A. 2012. The tree fern *Dicksonia antarctica* invades two habitats of European conservation priority in São Miguel Island, Azores. *Biological Invasions* 14: 1317–1323.
- Catford, J. A., Jansson, R. and Nilsson, C. 2009. Reducing redundancy in invasion ecology by integrating hypotheses into a single theoretical framework. *Diversity and Distributions* 15: 22–40.
- Christenhusz, M. J. M., Zhang, X. C. and Schneider, H. 2011. A linear sequence of extant families and genera of lycophytes and ferns. *Phytotaxa* 19: 7–54.
- Corlett, R. T. 1992. The naturalized flora of Hong Kong: a comparison with Singapore. *Journal of Biogeography* 19: 421–430.
- Fernando, B. 2002. Ferns of Sri Lanka. 30 pp. The Fern Society of Sri Lanka. Katuneriya.
- Fraser-Jenkins, C. R. 2008. Taxonomic Revision of Three Hundred Indian Subcontinental Pteridophytes with a Revised Census-list: A New Picture of Fern-Taxonomy and Nomenclature in the Indian Subcontinent. 679 pp. Bishen Singh Mahendra Pal Singh, Dehra Dun.
- Hettinger, N. 2001. Exotic species, naturalization and biological nativism. *Environmental Values* 10: 193–224.
- Jayasekara, P. 2006. Blechnaceae. In: Shaffer-Fehr, M. (ed.). A Revised Handbook to the Flora of Ceylon. Volume XV: Pteridophyta (Ferns and Fern Allies), pp. 40–47. Amrind Publishing Company Private Limited, New Delhi.
- Jones, D. L. 1987. Encyclopaedia of Ferns. An Introduction to Ferns, their Structure, Biology, Economic Importance, Cultivation and Propagation. 433 pp. Timber press, Portland.
- Jones, D. L. 1998. Dicksoniaceae. In: Orchard, A. E. and McCarthy, P. M. (eds.). *Flora of Australia*, Volume 48: Ferns, Gymnosperms and Allied Groups, pp. 187–191. Australian Biological Resources Study/CSIRO Publishing.
- Kramer, K. U. 1990. Cyatheaceae. In: Kubitzki, K. (ed.). *The Families and Genera of Vascular Plants*, Volume 1. Pteridophytes and Gymnosperms, pp. 94–99. Springer, New York.
- Large, M. F. and Braggins, J. E. 2004. *Tree Ferns*. 359 pp. Timber Press, Portland, Cambridge.
- Parris, B. S. 1998. Blechnaceae: *Doodia*. In: Orchard, A. E. and McCarthy, P. M. (eds.). *Flora of Australia*, Volume 48: Ferns, Gymnosperms and Allied Groups, pp. 385–393. Australian Biological Resources Study/CSIRO Publishing.
- Ranil, R. H. G. and Pushpakumara, D. K. N. G. 2012. Taxonomy and conservation status of pteridophyte flora of Sri Lanka. In: Weerakoon, D. K and Wijesundara, S. (eds.). *The National Red List 2012 of Sri Lanka: Conservation Status of the Fauna and Flora*, pp. 148–164. Ministry of Environment, Colombo.
- Richardson, D. M., Pysek, P., Rejmanek, M., Barbour, M. G., Panetta, F. D. and West, C. J. 2000. Naturalization and invasion of alien plants: concepts and definitions. *Diversity and Distributions* 6: 93–107.
- Shaffer-Fehr, M. 2006 (ed.). *A Revised Handbook of the Flora of Ceylon*. Volume XV: Pteridophyta (Ferns and Fern Allies). 616 pp. Amrind Publishing Company Private Limited, New Delhi.
- Sledge, W. A. 1982. An annotated checklist of the Pteridophyte of Ceylon. *Botanical Journal of the Linnean Society* 84: 1–28.
- Wu, S.-H., Yang, A., Teng, Y.-C., Chang, C.-Y., Yang, K.-C. and Hsieh, C.-F. 2010. Insights of the latest naturalized flora of Taiwan: change in the past eight years. *Taiwania* 55: 139–159.