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Status of the Red-Listed Plant Species, *Smilax wightii* A. DC. in Nilgiri Biosphere Reserve, the Western Ghats, India

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ABSTRACT: The rare endemic plant, *Smilax wightii*, is generally distributed in shola forests at high altitudes in Nilgiri Biosphere Reserve, the Western Ghats, southern India. To determine the ecological status of the species, we surveyed 11 major shola forests in that region. *S. wightii* has a limited distribution in all sholas (frequency value of <13%). The density of the species is generally around 15/100 m^2 in the sholas except in Thiashola where it occurred at a density of 40 individuals/100 m^2. The density of *S. wightii* was generally greater in the margins of the shoals, while the interior forests contained fewer individuals per unit area. The basal cover occupied by this species ranged between 2246 and 3144 mm^2/100 m^2. The importance value index for *S. wightii* was >2 in all shoals, which indicates that the species occupies an important position in the lower stratum of shola forests of Nilgiri Biosphere Reserve.

Key words: India, Nilgiri Biosphere Reserve, Red-listed species, *Smilax wightii*, Western Ghats

INTRODUCTION

Nilgiri Biosphere Reserve, which spreads over an area of ca. 5,520 km^2 in the Western Ghats of India in Tamil Nadu, Kerala and Karnataka states (N 11° 15′-12° 15′, E 76°-77° 15′), established in the year 1986, was the first protected area for biodiversity conservation in India. The species richness of angiosperms in the reserve is high (3,238) owing to the presence of different vegetational types due to varied climatic conditions and soil types (Daniels 1992). Among the plants in the reserve, 818 species are endemic to the Nilgiris and 25 of the endemic species are listed as endangered in the Red Data Books of Indians (Mohanan and Balakrishnan 1991).

Despite the habitat protection afforded by the establishment of the Nilgiri Biosphere Reserve, some of these valuable threatened species are exploited by local people and other herb gatherers (Prasad and Balasubramanian 1996, Chandrashekara et al. 2006). For the effective conservation of these species, data on the current population and distribution of the species are essential. Unfortunately, no ecological studies of the population structure and other ecological features of endangered plant species have yet been conducted in the Nilgiri Biosphere Reserve. We conducted a quantitative analysis for one such threatened plant species, *Smilax wightii* A. DC., in the reserve over a period of one year (2004-2005) to assess its distribution, density and degree of dominance. We estimated the ecological importance of this species in its communities relative to other constituent species by calculating its importance value index (IVI) and relative value of importance (RVI).

MATERIALS AND METHODS

Species description

The plant species *S. wightii* (Smilacaceae) is a climber listed in Red Data Books of Indians as a rare species endemic to the Nilgiris (Nayar and Sastry 1987-90). However, Gamble (2004) reported this species in high elevation forests in the southern areas of the Western Ghats the Nilgiri mountains and de Candolle and de Candolle (1878) have also reported this species in high altitude forests in subtropical regions of the central and eastern Himalayas also in addition to Nilgiris. In Nilgiri Biosphere Reserve, it is generally distributed in the evergreen sholas. These forests are fragmentary and

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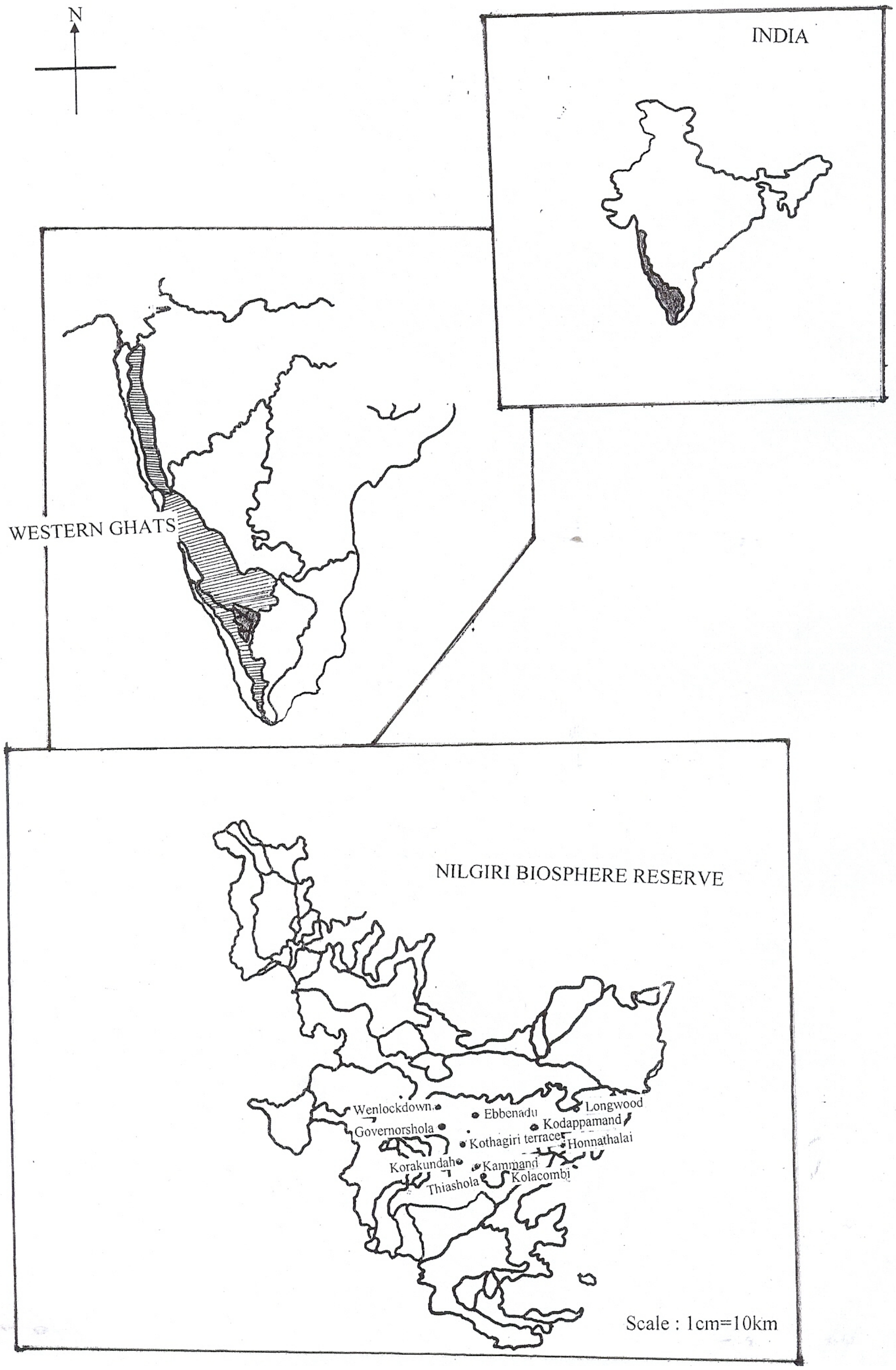

Fig. 1. Location of shola forest studied in Nilgiri Biosphere Reserve.

distributed over a total area of ca. 4225 ha in the Nilgiris above 1900 m altitude (Kumar 1993). The medicinal uses of *S. wightii* are noteworthy; it is used for the treatment of various diseases like nervous disorders, epilepsy and psychoses (Yoganarsimhan 2002, Sharma 2003, Paulsamy et al. 2008). Illegal exploitation by local people and herb gathers for medicinal uses (Rajasekaran et al. 2005) coupled with its low reproductive capacity (germination < 20%, survivability <10%) (Paulsamy 2006), is described as a factor responsible for the low population of *S. wightii* in the Nilgiri Biosphere Reserve.

Study area

Our study was carried out in 11 major shola forests of the Nilgiri Biosphere Reserve (Fig. 1), Ebbenadu, Governorshola, Honnathalai, Kammand, Kodappamand, Kolacombi, Korakundah, Kothagiri terrace, Longwood, Thiashola, and Wenlockdown, at elevations from 1700 m above msl (Kolacombai shola) to 2360 m above msl (Thiashola forest). All of the shola forests are located far apart at latitudes N 10° 45′ to 12° 15′ and E 76° 00′ to 77° 15′. The area of the individual shola forests varies from 80 ha (Kodappamand shola) to 1600 ha (Thiashola) (Singh 1994). The shoal forests in the Nilgiri Biosphere Reserve are classified as montane subtropical wet evergreen forests (Champion 1939). Since all of the sholas are a part of the Nilgiri Biosphere Reserve, effective legal protection against human pressure is now in place.

The climatic conditions of the sholas in the Nilgiris have been described elsewhere (Paulsamy et al. 2005). The temperature in shola forests ranges from 4 to 29°C. The first three months of the year are marked by drier conditions, and frosty nights are common during December and January. Thunderstorms occur during April and May. From February to May, flammable fuel loads in the adjoining grasslands are high, resulting in occasional wild fires. The spread of fires into the shola forests is prevented by stringent fire control measures taken by the forest department as a part of *in situ* conservation program in the Biosphere Reserve. The active south-west (June-August) and north-east (October–November) monsoons deposit heavy rainfall, resulting in annual precipitation from 1500 to 7800 mm. The relative humidity ranges from 90 and 97% across the sholas over the course of the year.

The texture of the soil in the shola forests of the Nilgiri Biosphere Reserve is sandy loam with bulk density between 1.09 and 1.26 g/ccs (Senthilkumar et al. 1998). The water holding capacity ranges from 40.5 to 45.8%, and the soil pH is 6.1-6.5 (Senthilkumar et al. 1998). The percentages of nitrogen, phosphorus and potassium of the soils are 0.9-1.15%, 0.04-0.07%, and 0.25-0.33%, respectively, and the organic carbon content of the soils in the study area is 4.2% (Senthilkumar et al. 1998).

The shoal forests are three- or four-storied in appearance (Paulsamy et al. 2008). The upper story contains tree species like *Cullenia excelsa*, *Machilis macrantha*, *Elaeocarpus tuberculatus* etc., while medium-sized trees like *Myristica laurifolia, Hydnocarpus alpina, Mappia foetida* etc are commonly found in the second story. The understory species richness ranges between 80 (Kolacombai shola forest) and 98 (Thiashola forest) across the sholas studied and a total of 131 species were encountered in the herbaceous stratum of these forests (Appendix I). Wild animals like Nilgiri tahr, sambar, elephants, great Indian gaur, bears, lion tailed macaques, Nilgiri langurs, and tigers also inhabit the sholas of Nilgiri Biosphere Reserve (Singh 1994).

Methods

The study was conducted for a period of one year from July 2004 to June 2005 by sampling the vegetation in alternating months. A one-ha. plot (100×100 m) was established in each shola forest starting at the forest margins and spreading toward the interior forests. Each plot was subdivided into ten sub-plots of 10×100 m size and each subplot was divided further into ten smaller plots of 10×10 m size each. All rooted individuals of the species *S. wightii*, include both free-standing and climbing plants were recorded to determine the species' level of distribution (frequency), density and basal cover (dominance) in the community following the methods of Cottam and Curtis (1956).

$$\text{Frequency} = \frac{\text{Number of sampling plots (10 x 10m) in which the species was present}}{\text{Total number of sampling plots studied}} \times 100$$

To calculate average basal area of free-standing individuals, we measured the stem circumference at 2.5 cm high from soil and for climbers, we measured the stem circumference at breast height (1.5 m). We then used the formula πr^2 to derive the average basal area. The average basal area was multiplied by the density to obtain the basal cover. The importance value index (IVI) and the relative value of importance (RVI) of *S. wightii* was calculated following the methods of Curtis and McIntosh (1950). The character IVI is used to show the real ecological importance of the species with respect to its distribution, density and basal cover in a community. To calculate this index, we summed the relative frequency, relative density and relative dominance and divided this value by 300. The RVI is the percent value of IVI. The attributes determined at every sampling were pooled and averaged to obtain mean annual values for each shola.

RESULTS AND DISCUSSION

The data on frequency, density, basal cover, IVI and RVI for the species *S. wightii* in each study shola are shown in Table 1. The low frequency value of <13%, shows that the species *S. wightii* has a limited distribution in all sholas studied. Furthermore, the field observations showed that this species is mainly distributed on host trees in the shola margins rather than on trees in the interior forests. This may be due to the fact that climbers, including lianas, are generally more abundant in high-light microclimates (Putz 1984, Willims-Linera 1990). In addition, the distribution of individuals of this species in the 11 sholas on the smaller spatial scale of 0.01 ha (10×10 m smaller sub-plots)

Table 1. Species richness of shola forests with mean annual values of frequency, density, basal cover, importance value index (IVI) and relative value index (RVI) of the red-listed plant species, *Smilax wightii* in the Nilgiris in 2004-2005.

Shola	Species richness at understorey level	Quantitative ecological characters of *Smilax wightii*				
		Frequency (%)	Density (individual/100 m^2)	Basal cover (mm^2/100 m^2)	IVI	RVI
Ebbenadu	91	8.5 ± 3.8	14 ± 0.5	2358.30 ± 858.93	2.49 (18.46)	0.83 (6.15)
Governor shola	82	9.2 ± 3.7	15 ± 0.7	2498.68 ± 919.04	4.84 (28.97)	1.62 (9.65)
Honnathalai	92	7.7 ± 2.8	17 ± 0.5	2779.43 ± 857.28	5.90 (17.16)	1.97 (5.72)
Kammand	82	12.8 ± 5.1	17 ± 0.6	2891.73 ± 1001.77	6.62 (35.09)	2.23 (11.69)
Kodappamand	85	9.8 ± 4.2	16 ± 0.7	2639.05 ± 1095.14	5.49 (18.31)	1.83 (6.10)
Kolacombai	80	12.0 ± 5.1	16 ± 0.4	2582.90 ± 1135.84	5.88 (27.05)	1.94 (5.41)
Korakundah	91	7.7 ± 2.9	13 ± 0.5	2246.00 ± 863.32	2.47 (24.66)	0.82 (8.22)
Kothagiri terrace	88	8.3 ± 2.7	16 ± 0.8	2695.53 ± 1214.32	5.89 (20.91)	1.96 (6.97)
Longwood	88	10.5 ± 6.2	16 ± 0.9	2751.35 ± 1579.00	5.68 (35.26)	1.89 (11.75)
Thiashola	98	11.0 ± 5.3	40 ± 0.9	3144.40 ± 1179.95	7.06 (57.14)	2.35 (19.86)
Wenlockdown	93	9.0 ± 3.2	18 ± 0.7	2947.88 ± 1199.43	6.88 (23.32)	2.29 (7.77)

The values followed by '±' are SD of the samples taken at the alternative months during the study period of one year.
Values in parentheses are the data for the dominant species in each shola. The dominant species of the sholas are *Oplismenus burmanii* in Ebbenadu, Kodappamand and Kothagiri terrace; *Ageratina adenophora* in Governor shola, Honnathalai, Kammand, Kolacombai, Korakundah and Wenlockdown; *Calanthe triplicata* in Longwood and Thiashola.

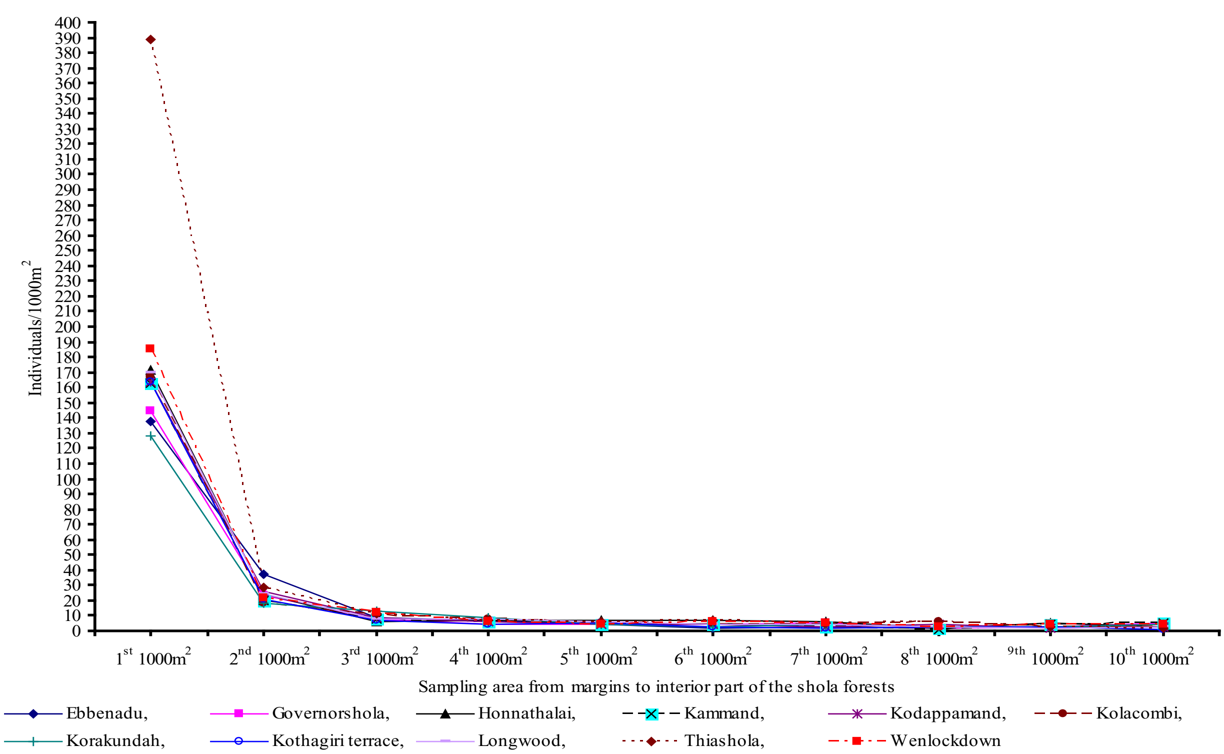

Fig. 2. Number of individuals of *S. wightii* found in every 1,000 m^2 sampling area from the forest margin to the interior.

varied by >30% over the year, which may be due to very low survivorship (<10%) of young individuals soon after germination (Paulsamy, 2005). The density of the species is generally around 15/100 m^2 in all sholas except Thiashola, where it had a higher density of 40 individuals/100 m^2. The high density in Thiashola may be attributed to the presence of a high local density of host tree species to support the growth and establishment of *S. wightii* (Paulsamy 2005), as forest structure and host tree features are the primary factors determining the distribution and density of climbers in natural forests (Chalmers and Turner 1994). Reddy and Parthasarathy (2006) also reported a higher density of climbers in evergreen forests in southern India where the richness of tree species was higher. In all shola forests, the marginal area contained greater numbers of individuals of *S. wightii* and a greater basal cover of the species than the interior forests (Fig. 2). This may be attributed to a preference for microhabitats with relatively high light intensities, a condition generally prevalent in forest edges at high altitudes.

Based on the IVI and RVI values, the plant species *Oplismenus burmanii* P. Beauv. was dominant in the understories of the Ebbenadu, Kodappamand and Kothagiri terrace shola forests, *Ageratina adenophora* R.M. King & H. Rob. was dominant in the Governor shola, Honnathalai, Kammand, Kolacombai, Korakundah and Wenlockdown shola forests, and *Calanthe triplicata* Ames. was dominant in Longwood and Thiashola (Table 1). In any natural community, the dominant plants play a major role in community metabolism and in other functions. Of the many species in the understories of the eleven sholas (80-98 species), *S. wightii* alone accounts for 10-34 per cent of the IVI and RVI values of the respective dominant species in the shola forests, which suggests that the study species, *S. wightii*, may have a considerable impact on the shola environment and community relative to other understory species. Similar observations about climbers were made by Dewalt et al. (2000) in central Panamanian forests and Perez-Salicrup et al. (2001) in eastern Bolivian forests, which may be due to climbers' ability to utilize available resources effectively.

Our observations of strong reproduction and establishment of *S. wightii* in the shola forests of Nilgiri Biosphere Reserve suggest that the *in situ* conservation measures taken by the forest department authorities, involving strict habitat protection, are effectively protecting this red-listed species. The population stock and the genetic resources of this species are well protected in the Nilgiri Biosphere Reserve of Western Ghats in India by present conservation practices. Hence, Nilgiri Biosphere Reserve may be considered as a germplasm center for the rare and endemic species *S. wightii*. Our findings on the ecology of this rare species can be used as baseline data for ongoing monitoring of the population size, distribution and ecological importance of the species in the shola communities of Nilgiri Biosphere Reserve.

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Appendix I. Plant species enumerated in the understories of the eleven study sholas in thte Nilgiri Biosphere Reserve, the Western Ghats, India.

1. *Achyranthes bidendata* Blume
2. *Acmella calva* (DC.) R.K. Jansen
3. *Ageratina adenophora* R.M. King & H. Rob.
4. *Ageratum conyzoids* L.
5. *A. houstonianum* Mill.
6. *Agrostis peninsularis* Hook. f.
7. *A. pilosula* Trin.
8. *Anaphalis beddomeii* Hook. f.
9. *A. elliptica* DC.
10. *Anemone rivularis* Buch. Ham. ex DC.
11. *Arisaema leschenaultii* Blume
12. *A. tortuosum* (Wall.) Schott
13. *Asparagus racemosus* Willd.
14. *A. fysonii* Macbr.
15. *Atylosia trinervia* (DC.) Gamble
16. *Bidens pilosa* L.
17. *Biophytum polyphyllum* Munro
18. *B. sensitivum* (L.) DC.
19. *Bothriochloa compressa* Henrard
20. *Brachypodium sylvaticum* P. Beauv.
21. *Briza maxima* L.
22. *Bromus catharticus* Vahl
23. *Calanthe triplicata* Ames
24. *Calceolaria mexicana* Kunth.
25. *Cardamine africana* L.
26. *Carex baccans* Nees
27. *C. brunnea* Thunb.
28. *C. foliosa* D. Don
29. *C. longipes* D. Don ex Tilloch & Taylor
30. *Cayratia pedata* Juss. ex Gagnep.
31. *Centella asiatica* Urban.
32. *Cerastium glomeratum* Thunb.
33. *Ceropegia pusilla* Wight & Arn.
34. *Clematis roylei* Hook. f.
35. *Clinopodium umbrosum* K. Koch.
36. *Cyanotis arachnoidea* Clarke
37. *Cynoglossum furcatum* Thunb.
38. *C. zeylanicum* Thunb.
39. *Cyrtococcum deccanence* Bor
40. *Desmodium scalpe* DC.
41. *Dichrocephala integrifolia* Kuntze.
42. *Digitaria violascens* Link
43. *Disporum leschenaultianum* D. Don
44. *Drogutia iners* Sch.
45. *Dorstenia indica* Wall. ex Wight
46. *Drymaria cordata* Roem. & Schu.
47. *Dumasia villosa* DC.
48. *Elatostemma lineolatum* Wight
49. *E. sessile* Forst & Forst
50. *Eragrostis cilianensis* Vignolo
51. *E. nigra* Nees ex Steud.
52. *Erigeron karvinskianus* DC.
53. *Eriocaulon longicuspis* Hook. f.
54. *Euphorbia rothiana* Spreng.
55. *Fragaria vesca* L.
56. *Galinsoga parviflora* Cav.
57. *Galium asperifolium* Wall.
58. *Gamochaeta coarctata* M. Kerguelen
59. *Gaultheria fragrantissima* Wall.
60. *Girardinia diversifolia* Friis
61. *Gnaphalium indicum* DC.
62. *Helichrysum hookerianum* Hook. f.
63. *H. bracteatum* Andrews
64. *Hydrocotyle javanica* Thunb.
65. *Hypochaeris glabra* L.
66. *Isachne kunthiana* Miq.
67. *Juncus effusus* L.
68. *J. leschenaultii* J. Gay
69. *Justicia simplex* D. Don
70. *Laportea terminalis* Wight
71. *Laurembergia coccinea* Kanitz.
72. *Lycianthes bigeminata* Bitter
73. *Myriactis wightii* DC.
74. *Neanotis indica* (DC.)Lewis
75. *N. leschenaultii* (DC.)Lewis
76. Ophiopogon itermedius D. Don
77. *Ophiorrhiza mungos* L.
78. *Oplismenus burmanni* P. Beauv.
79. *O. compositus* (L.) P. Beauv.
80. *Oxalis corniculata* L.
81. *O. latifolia* Kunth.
82. *O. spiralis* G. Don
83. *Passiflora calcaratus* L.
84. *P. edulis* Sims.
85. *P. leschenaultii* DC.
86. *P. mollissima* Bailey
87. *Persicaria chinensis* (L.) H. Gross.
88. *P. molle* H. Hara
89. *P. nepalensis* (L.) H. Gross.
90. *Phyllanthus virgatus* G. Forst
91. *Physalis peruviana* L.
92. *Phytolocca octandra* L.
93. *Picris hierocioides* L.
94. *Pilea angulata* Blume
95. *P. trinervia* Miq.
96. *P. wightii* Wedd.
97. *Piper brachystachyum* Wall. ex Hook. f.
98. *P. nigrum* L.
99. *Plantago erosa* Wall.
100. *Plectranthus malabaricus* R.H. Willemse
101. *Pogostemon wightii* Benth.
102. *Polycarpon tetraphyllum* (L.) L.
103. *Potentilla sundaica* Kuntze.
104. *Pouzolzia bennettiana* Wight
105. *P. bennettiana var.tomentosa* Wight
106. *Ranunculus diffusus* DC.
107. *Rubia cordifolia* L.
108. *Rubus ellipticus* Sm.
109. *R. fairholmianus* Gard.
110. *R. racemosus* Roxb.
111. *Scirpus mucronatus* L.
112. *Scutellaria violacea* Heyne ex Benth.
113. *Senecio candicans* Wall.
114. *S. corymbosus* Wall. ex DC.
115. *Setaria pumila* Roemd. & Schult.
116. *Sida caprinifolia* L.

117. *Smilax aspera* L.
118. *S. zeylanica* L.
119. *S. wightii* A. DC.
120. *Solanum nigrum* L.
121. *Sporobolus indicus* (L.) R. Br.
122. *Stephania japonica* Miers.
123. *Strobilanthes kunthiana* T. Anderson ex Benth.
124. *S. foliosa* T. Anderson
125. *Tetrastigma nilagiricum* B.V. Shetty
126. *Thalictrum javanicum* Blume
127. *Toddalia asiatica var.floribunda* Gamble
128. *Viola serpens* Wall. ex Ging.
129. *Wahlenbergia marginata* A. DC.
130. *Youngia japonica* (L.) DC.
131. *Zehneria mysorensis* Wight & Arn.