

New Addition, Different Habitats, Distribution Range and Diversity of Genus *Strobilanthes* (Acanthaceae) in Sri Lanka

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Abstract

Strobilanthes Blume (Acanthaceae) is one of the largest genera in the flora of Sri Lanka and is most interesting for its diversified habits, gregarious occurrence, and elegant flowering. Approximately 450 *Strobilanthes* species are widely distributed in the tropical and subtropical parts of Asia. Wood recognized 30 *Strobilanthes* species in Sri Lanka in 1994. Later, three species were added, *Strobilanthes willissi* in 2000, *S. cordofolia* in 2014 and *S. medahinensis* in 2021. *Strobilanthes reptans* is reported for the first time from Sri Lanka. With this new addition, Sri Lanka consists of 34 *Strobilanthes* species. Extensive plant explorations were conducted across the entire distribution range of the genus *Strobilanthes* in Sri Lanka, covering 21 administrative districts from September 2005 to April 2021. The genus *Strobilanthes* grow from 100 m to 2,500 m, in an extensive range of different habitats. We could record *S. gardneriana*, critically endangered possibly extinct species from Hantana at 1,330 m elevation in 2020 after 1927 and critically endangered species, *S. rhytisperma* from Gendagala in 2019 after 1971. Species distributions are more expansive with increasing altitude. The extended distributional record for many species of *Strobilanthes* could be found. However, several species were not found in their type locality. We could see them at other locations. Therefore necessary conservation measures should be taken to conserve such diversity and overcome threats.

Keywords: Gregarious, altitudes, undergrowth, locality, exploration

1. Introduction

Strobilanthes Blume (1826: 781) the second largest genus in family Acanthaceae, comprising about 450 species that show great morphological diversity (Mabberley, 2017; Patil, 2021; POWO, 2019). *Strobilanthes* mainly distributed in the tropical and subtropical parts of the Asia from Afghanistan through India-Sri Lanka and southeast Asia to Australia (Wood and Scotland, 2009; Josekutty *et al.*, 2018; Wood *et al.*, 2021). It is also the most interesting genera in the family, for its gregarious nature, infrequent flowering and diverse habitats, coupled with the narrow distribution of species (Mascarenhas and Janarthanam, 2013). Some species are well known for their infrequent flowering. Several species are perennial and monocarpic, with a period varying from 3 to 16 years depending on the species (Janzen, 1976). Bremekamp (1944) called such a life history 'plietesial' flowering. The mass flowering is common for almost all populations of same species. Shrubs of the genus *Strobilanthes* dominate the montane forest understory in Sri Lanka, several species often occurring together. The species of genus *Strobilanthes* grow from 100 m up to 2,500 m, and many species have a rather restricted distribution in undisturbed moist montane, sub montane and lowland forests of the central and southwestern part of the island.

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The species of *Strobilanthes* range in habit from short perennial herbs to densely branched, erect shrubs. Inflorescence very varied the flowers sessile or pedicellate in open panicles, bracteate heads or spikes. Corolla shape is variable within *Strobilanthes*, for example, in Sri Lankan species of *Strobilanthes* bear corolla tube abruptly campanulate from a narrow cylindrical base while some species have corolla tube gradually expanded from the base (Wood, 1998). Leaf shape is also variable from narrowly oblong-lanceolate to broadly oblong-elliptic. The species delimitation remains problematic because many species are poorly known and rarely collected. It is possible that new species still remain to be discovered. Wood recognized 30 *Strobilanthes* species in Sri Lanka in 1994. Later, three species were added *Strobilanthes willisii* Carine et al. (2000), *S. cordifolia* (Vahl 1794) Wood (2014) and *S. medahimmensis* Nilanthi in Nilanthi et al. (2021): Earlier, *S. cordifolia* was classified under genus *Stenociphonium* Nees (Acanthaceae). Fourteen species originally described in the genus *Hemigraphis* are now has been transferred to the genus *Strobilanthes* (Deng, 2019). The *Strobilanthes* flora of Sri Lanka has not updated document for more than two decades and this work represents the most recent study on different habitats, distribution range and diversity of *Strobilanthes* species in Sri Lanka.

2. Methodology

2.1 The study area

The location used for sample collection is given in Figure 1. The majority of sites were from the wet climates.

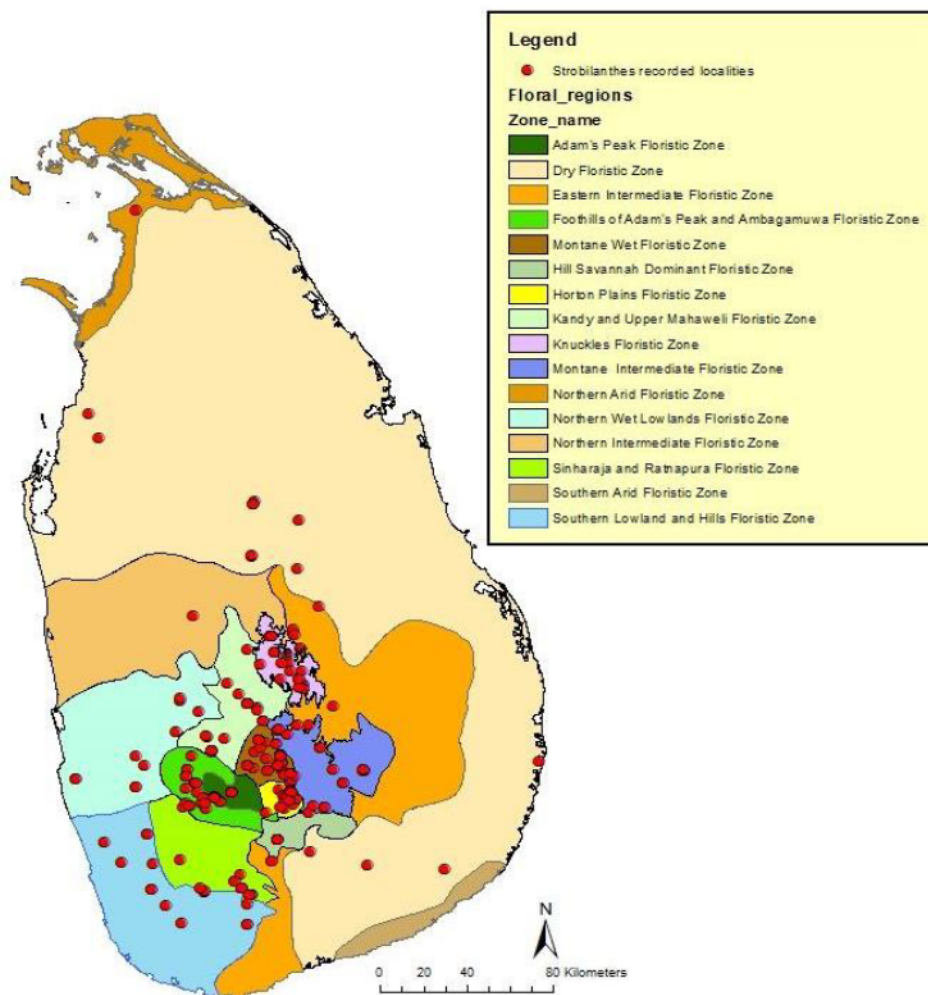


Figure 1. Distribution range of *Strobilanthes* species in Sri Lanka

2.2 Data Collection

Extensive plant explorations were conducted across the entire distribution range of the genus *Strobilanthes* in Sri Lanka covering 21 administrative districts from September 2005 to April 2021 in different seasons (Figure 1). Efforts were made to study plants in their flowering condition so as to identify them properly. Standard methods for collection and preservation were used following Alexiades (1996). Voucher specimens were deposited at the National Herbarium at Royal Botanic Gardens, Peradeniya, Sri Lanka, (PDA). Flowers were preserved in FAA solution (5% formaldehyde (v/v), 5% (v/v) acetic acid and 45% (v/v) ethanol) to study the morphological details in future. Herbarium specimens at PDA and digital herbaria such as Kew (K), University of Graz, Institute of Plant Sciences (UGPS) and online databases of digitized herbarium specimens (JSTOR) of Royal Botanic Garden, Kew and literature available on *Strobilanthes* and publications (Venu, 2006; Wood, 1994, 1995, 1998; Wood and Scotland, 2009) were consulted for the identification our collected specimens. The morphological characters obtained by direct observation of the plant specimens, Habitat, localities, altitudinal range and flowering periods were stored in MS EXCEL. The GPS coordinates of the collection sites were recorded using GARMIN GPS map 78s and mapped on Floristic Map of Sri Lanka using ARC GIS version 10.8.1 ESRI, 2020. List of species employed in the study were shown in Table 1. All taxonomic names, author details and journal abbreviations follow the International Plant Names Index available at www.ipni.org.

Table 1: List of species used in the study

| No | Name | First Published in |
|----|--|--|
| 1 | <i>Strobilanthes adenophora</i> Nees | A.P.de Candolle, Prodr. 11: 182 (1847) |
| 2 | <i>Strobilanthes anceps</i> Nees | Compan. Bot. Mag. 2: 312 (1837) |
| 3 | <i>Strobilanthes arnottiana</i> Nees | Compan. Bot. Mag. 2: 312 (1837) |
| 4 | <i>Strobilanthes calycina</i> Nees | Compan. Bot. Mag. 2: 312 (1837) |
| 5 | <i>Strobilanthes caudata</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 228 (1860) |
| 6 | <i>Strobilanthes cordifolia</i> (Vahl) J.R.I.Wood | Novon 23: 390 (2014) |
| 7 | <i>Strobilanthes deflexa</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 227 (1860) |
| 8 | <i>Strobilanthes diandra</i> (Nees) Alston | H.Trimen, Handb. Fl. Ceylon 6(Suppl.): 227 (1931) |
| 9 | <i>Strobilanthes diandra</i> var. <i>densa</i> (C.B.Clarke) J.R.I.Wood | Kew Bull. 50: 8 (1995) |
| 10 | <i>Strobilanthes exserta</i> C.B.Clarke | J.D.Hooker, Fl. Brit. India 4: 445 (1884) |
| 11 | <i>Strobilanthes gardneriana</i> (Nees) T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 226 (1860) |
| 12 | <i>Strobilanthes gossypina</i> T. Anderson | J. Linn. Soc., Bot. 9: 466 (1867) |
| 13 | <i>Strobilanthes habracanthoides</i> J.R.I. Wood | Kew Bull. 50: 22 (1995) |
| 14 | <i>Strobilanthes hamiltoniana</i> (Steud.) Bosser & Heine | Bull. Mus. Natl. Hist. Nat., B, Adansonia 10: 148 (1988) |
| 15 | <i>Strobilanthes helicoides</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 229 (1860) |
| 16 | <i>Strobilanthes hookeri</i> Nees | Compan. Bot. Mag. 2: 312 (1837) |
| 17 | <i>Strobilanthes hypericoides</i> J.R.I. Wood | Kew Bull. 50: 15 (1995) |
| 18 | <i>Strobilanthes laxa</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 228 (1860) |
| 19 | <i>Strobilanthes lupulina</i> Nees | N.Wallich, Pl. Asiat. Rar. 3: 85 (1832) |
| 20 | <i>Strobilanthes medahinnensis</i> R.M.R. Nilanthi | Nilanthi <i>et al.</i> (2021) |
| 21 | <i>Strobilanthes nigrescens</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 226 (1860) |
| 22 | <i>Strobilanthes nockii</i> Trimen | Handb. Fl. Ceylon 3: 31 (1895) |
| 23 | <i>Strobilanthes pentandra</i> J.R.I. Wood | Kew Bull. 50(1): 4.1995 |
| 24 | <i>Strobilanthes pulcherrima</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 229 (1860) |
| 25 | <i>Strobilanthes punctata</i> Nees | A.P.de Candolle, Prodr. 11: 183 (1847) |

| | | |
|----|--|---|
| 26 | <i>Strobilanthes reptans</i> (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood | Fl. China 19: 390 (2011) |
| 27 | <i>Strobilanthes rhamnifolia</i> (Nees) T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 226 (1860) |
| 28 | <i>Strobilanthes rhytisperma</i> C.B. Clarke | J.D.Hooker, Fl. Brit. India 4: 432 (1884) |
| 29 | <i>Strobilanthes schomburgkii</i> (Craib) J.R.I.Wood | Bull. 64: 46 (2009) |
| 30 | <i>Strobilanthes sexennis</i> Nees | Compan. Bot. Mag. 2: 312 (1837) |
| 31 | <i>Strobilanthes sexennis</i> var. <i>cerinthoides</i> (Nees) C.B.Clarke | Kew Bull. 50: 18 (1995) |
| 32 | <i>Strobilanthes sexennis</i> var. <i>glaberrima</i> J.R.I.Wood | Kew Bull. 50: 18 (1995) |
| 33 | <i>Strobilanthes sexennis</i> var. <i>hirsutissima</i> (Nees) C.B.Clarke | J.D.Hooker, Fl. Brit. India 4: 474 (1884) |
| 34 | <i>Strobilanthes stenodon</i> C.B. Clarke | J.D.Hooker, Fl. Brit. India 4: 432 (1884) |
| 35 | <i>Strobilanthes thwaitesii</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl. 1: 227 (1860) |
| 36 | <i>Strobilanthes vestita</i> Nees | A.P.de Candolle, Prodr. 11: 180 (1847) |
| 37 | <i>Strobilanthes viscosa</i> (Arn. ex Nees) T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 226 (1860) |
| 38 | <i>Strobilanthes viscosa</i> var. <i>digitalis</i> (Nees) C.B.Clarke | J.D.Hooker, Fl. Brit. India 4: 432 (1885) |
| 39 | <i>Strobilanthes walkeri</i> var. <i>walkeri</i> Arn. ex Nees | Compan. Bot. Mag. 2: 312 (1837) |
| 40 | <i>Strobilanthes willisii</i> Canine | Kew Bull. 55: 971 (2000) |
| 41 | <i>Strobilanthes zeylanica</i> T. Anderson | G.H.K.Thwaites, Enum. Pl. Zeyl.: 227 (1860) |
| 42 | <i>Strobilanthes_RMRN_123</i> | Unpublished |

3. Results

3.1 New records to the Genus *Strobilanthes* in Sri Lanka

According to this study *Strobilanthes reptans* (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood is reported at first time from Sri Lanka here described and illustrated.

3.1.1 Taxonomic treatment

Strobilanthes reptans (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood, Fl. China. 19: 390. 2011. *Ruellia reptans* G. Forst., Fl. Ins. Austr. 44. 1786. *R. primulifolia* Nees, Prodr. 11: 144. 1847. *Hemigraphis primulifolia* (Nees) Fern.-Vill., Nov. App. 153. 1880. *H. reptans* (G.Forst.) T.Anderson ex Hemsl., Rep. Voy. Challenger, Bot. 1(3): 173. 1885. *H. okamotoi* Masam., Trans. Nat. Hist. Soc. Formosa 25: 248. 1935. *H. pacifica* Hosok., Trans. Nat. Hist. Soc. Formosa 25: 127. 1935. *Strobilanthes primulifolia* (Nees) Y.F.Deng & J.R.I.Wood, J. Trop. Subtrop. Bot. 18: 483. 2010 (Figure 2 & Figure 3).

Herb to 12 cm tall, perennial, isophyllous. Stems short, erect with short internodes, densely covered with purple-red hairy, leaves basal, opposite. Petiole 0.5-2.1 cm long, pubescent. Leaves oblong-ovate, 1-5×0.6-3 cm, both surfaces pubescent, adaxially dark green, softly pubescent, abaxially purple-red, midrib and lateral vein densely pubescent, margin crenate to subentire, apex obtuse, base truncate to cordate, lateral veins 4-6 pairs. Inflorescences terminal spikes elongating to 6-8 cm at maturity, peduncle pubescent, bracts oblanceolate to elliptic, 0.5-2.1×0.4-0.8 cm, pubescent, margin entire and ciliate. Calyx 6.1-7.5 mm long, 5-lobed, pubescent, lobes linear-lanceolate, margins ciliate. Corolla 1-1.2 cm long, 5.5-7 mm wide, white or pale violet with darker veins, glabrous, tube basally cylindrical, slightly ventricose, stamens 4, included, didynamous, pubescent, shorter filament pair ca. 2 mm, longer filament pair ca. 4 mm, anther thecae ca. 1 mm, oblong. Ovary oblong, ca. 2 mm long, style villous ca. 5.6 mm long, stigma blunt. Capsule oblong, 6-10 mm long, apex pubescent. Seeds glabrous, 0.8-1 mm long, 0.8-1.5 mm wide, apex acute.

Phenology: The flowering occurs from October to June to September. Fruiting occurs from July to December.

Habitat: Wet soil in shade in in garden and road sides at an altitude of 30-300 m.

Distribution: Sri Lanka (lowland wet zone - present report), India, Taiwan, Japan, Malaysia, Indonesia, Papua New Guinea, Philippines, Australia.

Specimen examined: SRI LANKA, Sabaragamuwa Province, Ratnapura District, Opanayake, E 166892, N 179540, 1430 m, 24 June 2020, Nilanthi 200 (RMRN_200 PDA!).

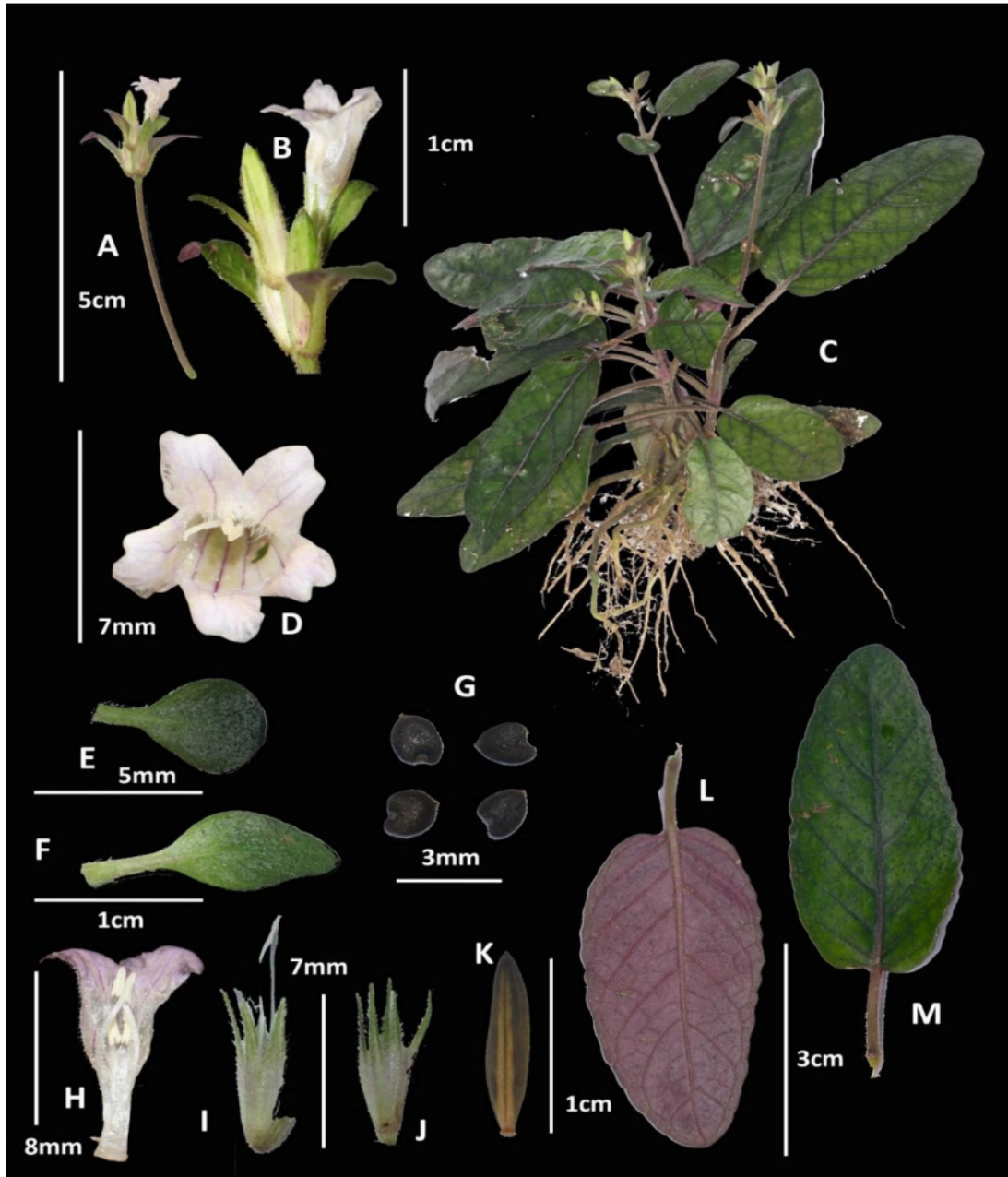


Figure 2. *Strobilanthes reptans* (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood

Inflorescence; B. Close-up of inflorescence; C. Habit; D. Flower-top view; E. Upper-most Bract; F. Lower-most Bract; G. Seeds; H. Half flower; I. Calyx with gynoecium; J. Calyx; K. Capsule; L. Ventral surface of leaf; M. Dorsal surface of leaf

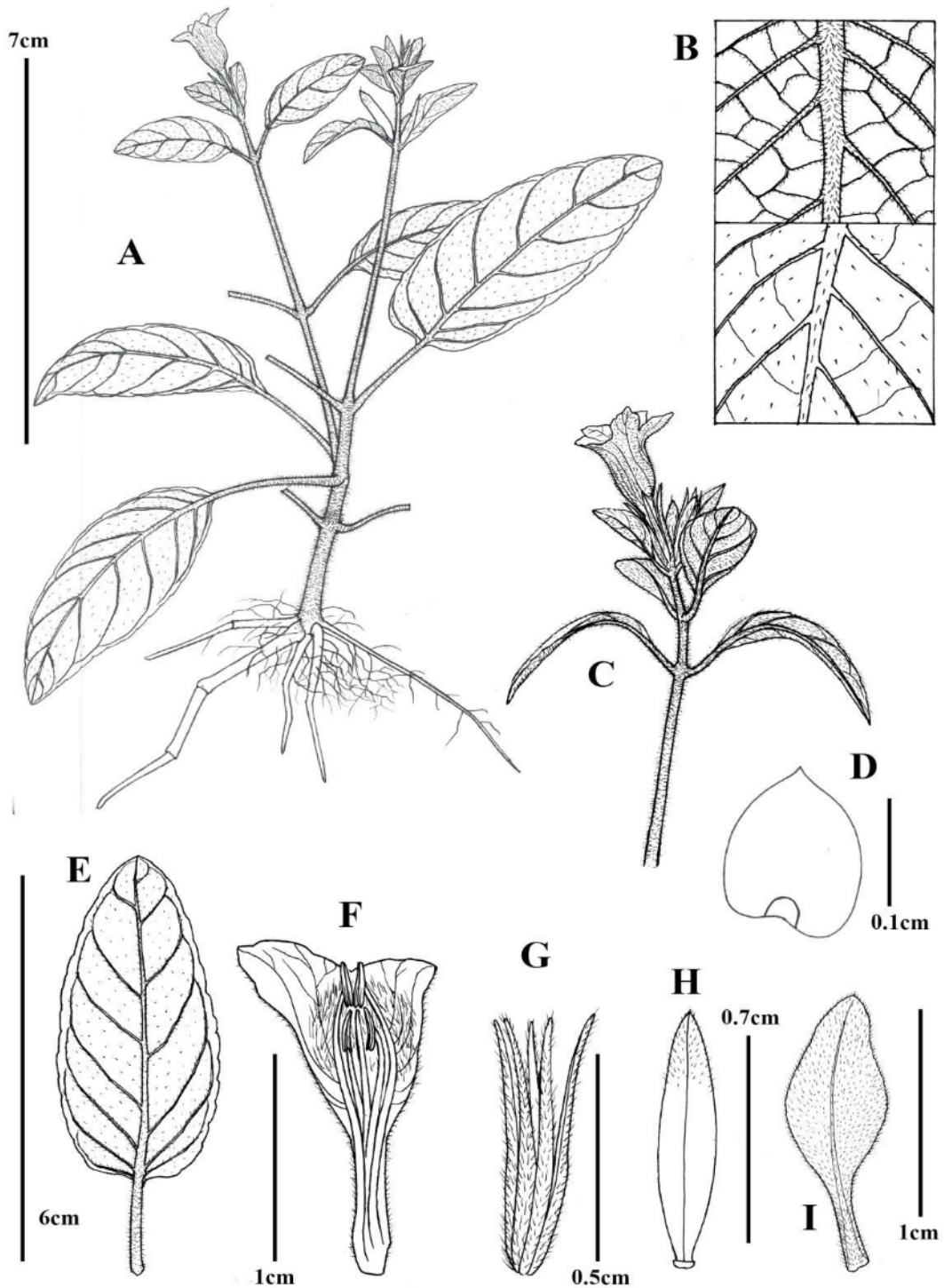


Figure 3. Line Diagram of *Strobilanthes reptans* (G.Forst.) Moylan ex Y.F.Deng & J.R.I.Wood

A. Habit; B. Close up of dorsal and ventral surface of the leaf; C. Inflorescence; D. Seed; E. Leaf; F. Half flower; G. Calyx; H. Capsule; I. Bract.

3.2 Exploration of *Strobilanthes* species

Strobilanthes laxa Anderson (1860) was described by T. Anderson in 1860 and there are records in 1882, 1883, 1973 and last record was done by Robin Foster from Piduruthalagala in 1975. After that we could record it from Bogawanthalawa, Riverstern and Knuckles in 2019.

Strobilanthes gardneriana was first collected by Gardner, #1217 K, BM in 1857 from Hantane and described by T. Anderson in 1860 and has again collected from Haggala, Nuwara Eliya in 1927. As suitable habitats of this plant have been cleared for tea plantations, this species might be disappeared. However we could collect it from Hantane at 1,330 m elevation in 2020.

Strobilanthes rhytisperma is only known from specimen, Ranwalakelle, Kaluthara in 1971 and specimen from central province where the locality unknown. After that plants of this species have not been found. We could record *S. rhytisperma* from Gendagala, Kalutara in 2019.

We recorded *S. sexennis* var. *cerinthoides* first time from Ehela Kanuwa, Adams peak in 2017 after 1975, *S. viscosa* var. *digitalis* first time from Gongala in 2019, *S. thwaitesii* first time from Pahiyangala in 2019, *S. zeylanica* first time from Gendagala, Kalutara in 2019, *S. stenodon* first time from Nildandawa, Keerthibandrapura in 2018 and *S. exserta* first time from Kudaoya, Thanamalwila, Udawalawa, Lahugala (Figure 4). However several species were not found in their type locality, we could find them at other locations.

During the plant explorations on 22nd April, 2016 by the first and third authors found an interesting *Strobilanthes* population consisting of about 250 individuals, growing in the shade and along the water stream at Rambukoluwa in Knuckles Mountain Range. It may be a new species.

3.3 Distribution of *Strobilanthes* species on floristic map of Sri Lanka

The highest numbers of *Strobilanthes* species (17 no. of species) are distributed on Foothills of Adam's Peak and Ambagamuwa Floristic Zone. The second highest numbers of *Strobilanthes* species (11 no. of species) are distributed on Knuckles Floristic Zone. The lowest numbers of *Strobilanthes* species (only one species) are distributed on Southern Arid Floristic Zone and Northern Arid Floristic Zone (Figure 5).

3.4 Habitat Diversity

The species of genus *Strobilanthes* grow from 100 m up to 2,500 m, in a very wide range of different habitats such as, dense aggregations along steep rocky slopes, along margins of grasslands, dense aggregations along slopes at lower altitudes, in plains, thick rainforest undergrowth, shaded places in ravines, open rocky cliffs, on the exposed rocks, along stream banks, evergreen forest margins, primary forests, scrambling shrub growing through other plants, moist rocks along streams (Figure 6 and 8).

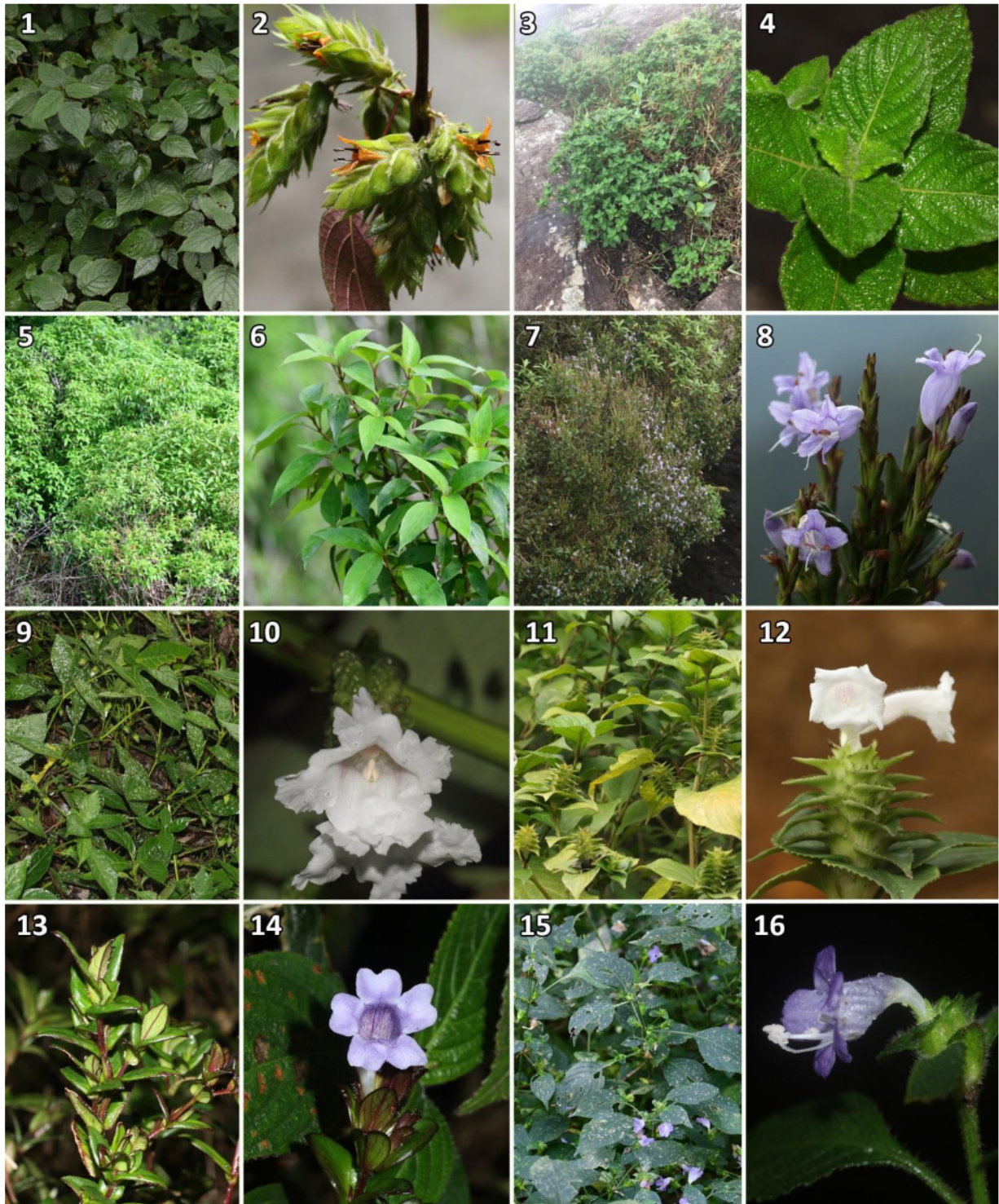


Figure.4. - *Strobilanthes laxa* 1. Habit; 2. Inflorescence; - *Strobilanthes gardneriana*; 3. Habit; 4. Leaves; - *Strobilanthes rhytisperma*, 5. Habit; 6. Branch; - *Strobilanthes viscosa* var. *digitalis*; 7. Habit; 8. Inflorescence; - *Strobilanthes thwaitesii*; 9. Habit; 10. Inflorescence; - *Strobilanthes zeylanica*; 11. Habit; 12. Inflorescence; - *Strobilanthes sexennis* var. *cerinthoides*; 13. Branch; 14. Inflorescence; - *Strobilanthes exserta*; 15. Habit; 16. Inflorescence

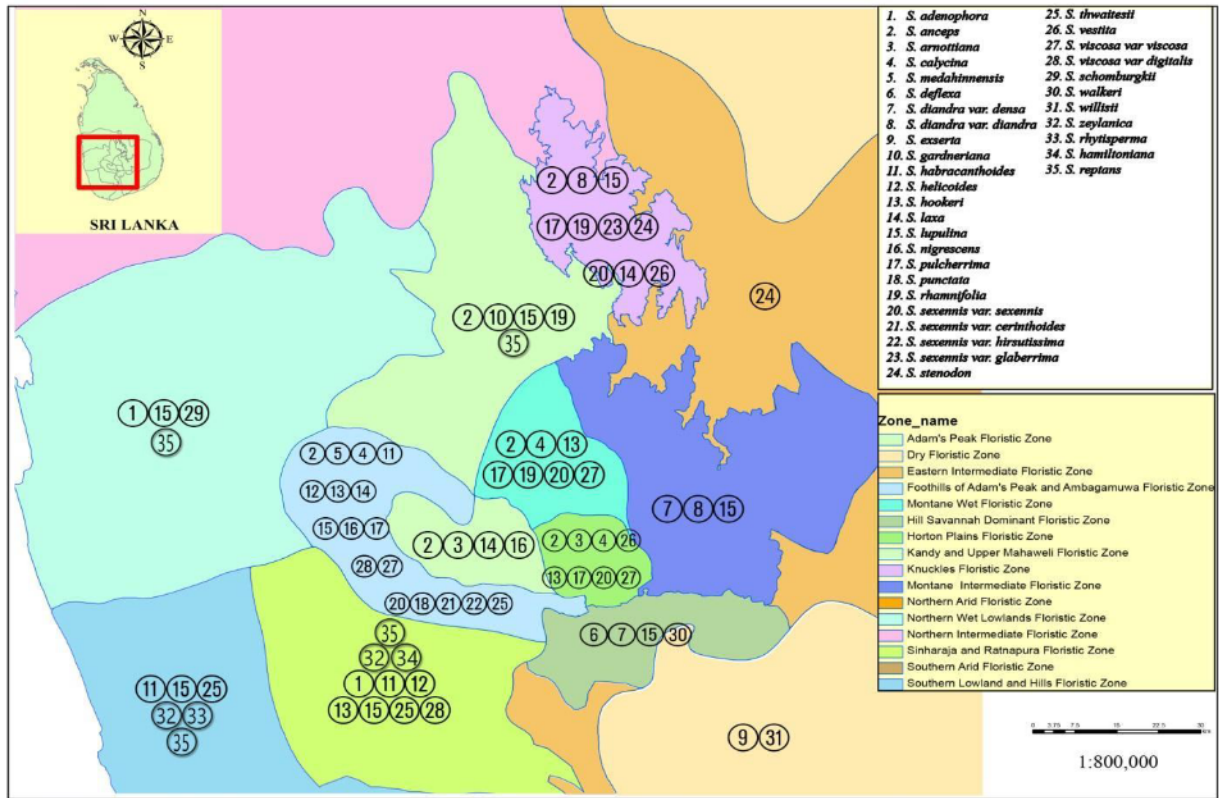


Figure 5. Distribution of *Strobilanthes* species on floristic map of Sri Lanka

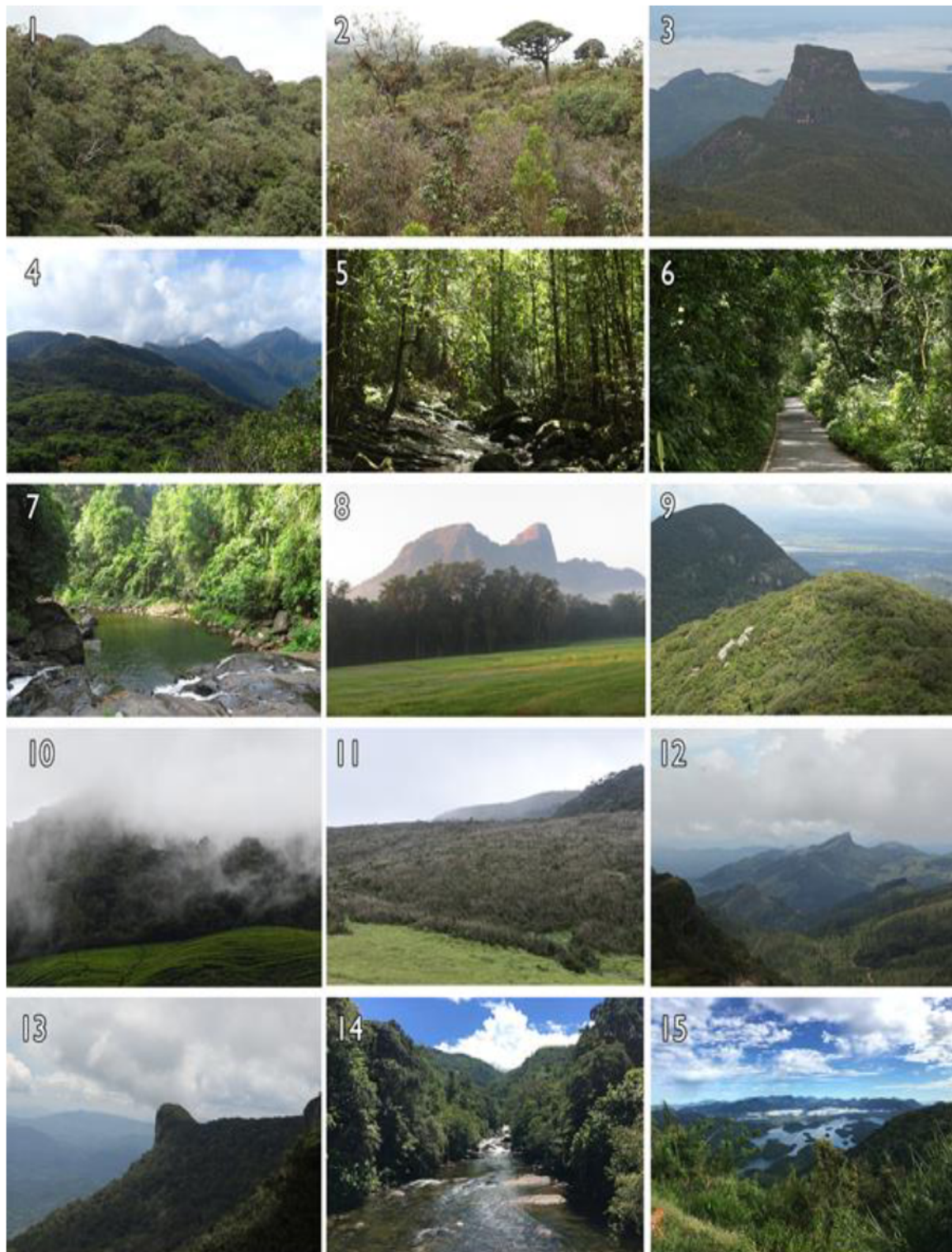


Figure 6. Different locations of *Strobilanthes* recorded sites in Sri Lanka

1. Horton plains; 2. Piduruthalagala; 3. Adam's peak; 4. Knuckles; 5. Kithulgala; 6. Meethirigala; 7. Gilimale; 8. Nilgala; 9. Ritigala; 10. Nmunukula; 11. Mandaram Nuwara; 12. Hanthana range; 13. Gongala; 14. Deraniyagala; 15. Keerthibandarapura

| # | Species | Altitudinal Range | | | | | |
|----|--|-------------------|----------|-----------|-----------|-----------|------|
| | | 0 | 500 | 1000 | 1500 | 2000 | 2500 |
| 1 | <i>Strobilanthes adenophora</i> Nees | 0-500 | | | | | |
| 2 | <i>Strobilanthes aiceps</i> Nees | | | 1000-2500 | | | |
| 3 | <i>Strobilanthes arnotiana</i> Nees | | | | | 2000-2500 | |
| 4 | <i>Strobilanthes calycina</i> Nees | | | 1000-2500 | | | |
| 5 | <i>Strobilanthes caudata</i> T. Anderson | | | 1000-2000 | | | |
| 6 | <i>Strobilanthes cordifolia</i> (Vahl) J.R.I. Wood | 0-1000 | | | | | |
| 7 | <i>Strobilanthes deflexa</i> T. Anderson | | 500-1500 | | | | |
| 8 | <i>Strobilanthes diandra</i> var. <i>diandra</i> (Nees) Alston | | 500-2000 | | | | |
| 9 | <i>Strobilanthes diandra</i> var. <i>densa</i> (C.B. Clarke) J.R.I. Wood | | | 1000-2000 | | | |
| 10 | <i>Strobilanthes exserta</i> C.B. Clarke | 0-500 | | | | | |
| 11 | <i>Strobilanthes garbneriana</i> (Nees) | | | 1000-2500 | | | |
| 12 | <i>Strobilanthes gossypina</i> T. Anderson | | | | 1500-2500 | | |
| 13 | <i>Strobilanthes habracanthoides</i> J.R.I. Wood | | 500-2000 | | | | |
| 14 | <i>Strobilanthes hamiltoniana</i> (Steud.) Bosser & Heine | | 500-2000 | | | | |
| 15 | <i>Strobilanthes helicoides</i> T. Anderson | | | 1000-2500 | | | |
| 16 | <i>Strobilanthes hookeri</i> Nees | | | 1000-2500 | | | |
| 17 | <i>Strobilanthes hypericoides</i> J.R.I. Wood | | | | 1500-2500 | | |
| 18 | <i>Strobilanthes laxa</i> T. Anderson | | | 1000-2500 | | | |
| 19 | <i>Strobilanthes lupulina</i> Nees | 0-2000 | | | | | |
| 20 | <i>Strobilanthes medahivensis</i> Nilanthi | | | 1000-2000 | | | |
| 21 | <i>Strobilanthes nerescens</i> T. Anderson | 0-1000 | | | | | |
| 22 | <i>Strobilanthes nockii</i> Timen | | | | 1500-2500 | | |
| 23 | <i>Strobilanthes pentandra</i> J.R.I. Wood | | | 1000-2000 | | | |
| 24 | <i>Strobilanthes pulcherrima</i> T. Anderson | | | | 1500-2500 | | |
| 25 | <i>Strobilanthes punctata</i> Nees | | | | 1500-2000 | | |
| 26 | <i>Strobilanthes reptans</i> (G. Forst.) Moylan ex Y.F. Deng & J.R.I. Wood | 0-1000 | | | | | |
| 27 | <i>Strobilanthes rhamnifolia</i> Nees | | 500-2000 | | | | |
| 28 | <i>Strobilanthes rhytidisperma</i> C.B. Clarke | | 500-1000 | | | | |
| 29 | <i>Strobilanthes schomburgkii</i> (Craib) J.R.I. Wood | 0-1000 | | | | | |
| 30 | <i>Strobilanthes sexensis</i> Nees | | | 1000-2500 | | | |
| 31 | <i>Strobilanthes sexensis</i> var. <i>cerinthoides</i> (Nees) C.B. Clarke | | | | | 2000-2500 | |
| 32 | <i>Strobilanthes sexensis</i> var. <i>glaberrima</i> J.R.I. Wood | | | 1000-2000 | | | |
| 33 | <i>Strobilanthes sexensis</i> var. <i>hirsutissima</i> (Nees) T. Anderson | | | | | 2000-2500 | |
| 34 | <i>Strobilanthes stenodon</i> C.B. Clarke | | 500-2000 | | | | |
| 35 | <i>Strobilanthes thwaitesii</i> T. Anderson | 0-1000 | | | | | |
| 36 | <i>Strobilanthes vestita</i> Nees | | | 1000-2000 | | | |
| 37 | <i>Strobilanthes viscosa</i> (Am. ex Nees) T. Anderson | | | 1000-2500 | | | |
| 38 | <i>Strobilanthes viscosa</i> var. <i>digitalis</i> (Nees) C.B. Clarke | | | 1000-2000 | | | |
| 39 | <i>Strobilanthes walheri</i> Am. ex Nees | | 500-2500 | | | | |
| 40 | <i>Strobilanthes willisii</i> Canire | | 500-1500 | | | | |
| 41 | <i>Strobilanthes seylanica</i> T. Anderson | 0-2000 | | | | | |
| 42 | <i>Strobilanthes</i> _RMRN_123 | 0-1000 | | | | | |

Figure 7. Altitudinal Range of *Strobilanthes* species

In Sri Lanka, many *Strobilanthes* species have a rather restricted distribution in undisturbed moist montane, submontane, and lowland forests of the central and southwestern parts of the island (Figure 7, Table 2). *Strobilanthes exserta* Clarke (1884), *S. willisii* Carine et al. (2000), and *S. cordifolia* (Vahl 1794) Wood (2014) are confined to the dry zone while *S. lupulina* Nees (1832) is distributed widely at low and high altitudes of the wet zone. About 19 no. of species are mainly distributed in montane and submontane evergreen forests whereas about 5 no. of species are confined to lowland wet evergreen forests.

Table 2: *Strobilanthes* species distributed in climate zones

| Altitude | Climate zone | Recorded Species | Number of Endemic Species |
|-----------|-----------------|---|---------------------------|
| 0-100 | Arid Zone | <i>S. exserta</i> , <i>S. cordifolia</i> | 0 |
| 0-500 | Dry Zone | <i>S. exserta</i> , <i>S. cordifolia</i> , <i>S. willisii</i> , <i>S. walkeri</i> | 2 |
| 0-1000 | Lowland Wetzone | <i>S. adenophora</i> , <i>S. anceps</i> , <i>S. deflexa</i> , <i>S. diandra</i> , <i>S. habracanthoides</i> , <i>S. hamiltoniana</i> , <i>S. helicoides</i> , <i>S. hookeri</i> , <i>S. lupulina</i> , <i>S. nigrescens</i> , <i>S. rhamnifolia</i> , <i>S. rhytisperma</i> , <i>S. schomburgkii</i> , <i>S. stenodon</i> , <i>S. thwaitesii</i> , <i>S. walkeri</i> , <i>S. zeylanica</i> | 12 |
| 1000-1500 | Sub montane | <i>S. anceps</i> , <i>S. calycina</i> , <i>S. caudata</i> , <i>S. diandra</i> , <i>S. gardneriana</i> , <i>S. habracanthoides</i> , <i>S. hamiltoniana</i> , <i>S. helicoides</i> , <i>S. hookeri</i> , <i>S. laxa</i> , <i>S. lupulina</i> , <i>S. pentandra</i> , <i>S. punctata</i> , <i>S. rhamnifolia</i> , <i>S. sexennis</i> , <i>S. vestita</i> , <i>S. viscosa</i> , <i>S. walkeri</i> , <i>S. zeylanica</i> , <i>S. medahinnensis</i> | 14 |
| 1500-2500 | Montane | <i>S. anceps</i> , <i>S. arnottiana</i> , <i>S. calycina</i> , <i>S. gardneriana</i> , <i>S. gossypina</i> , <i>S. helicoides</i> , <i>S. hookeri</i> , <i>S. hypericoides</i> , <i>S. laxa</i> , <i>S. lupulina</i> , <i>S. nockii</i> , <i>S. pulcherrima</i> , <i>S. punctata</i> , <i>S. sexennis</i> , <i>S. vestita</i> , <i>S. viscosa</i> , <i>S. walkeri</i> | 11 |



Figure. 8. Different habitats of *Strobilanthes* in Sri Lanka

1. *Strobilanthes adenophora*; 2. *S. anceps*; 3. *S. diandra*; 4. *S. exserta*; 5. *S. helicoides*; 6. *S. pulcherrima*; 7. *S. punctata*; 8. *S. rhamnifolia*; 9. *S. rhytisperma*; 10. *S. willisii*; 11. *S. zeylanica*; 12. *Strobilanthes_RMRN_123*; 13. *S. gardneriana*; 14. *S. laxus*; 15. *S. sexennis* var. *sexennis*; 16. *S. viscosa* var. *digitalis*

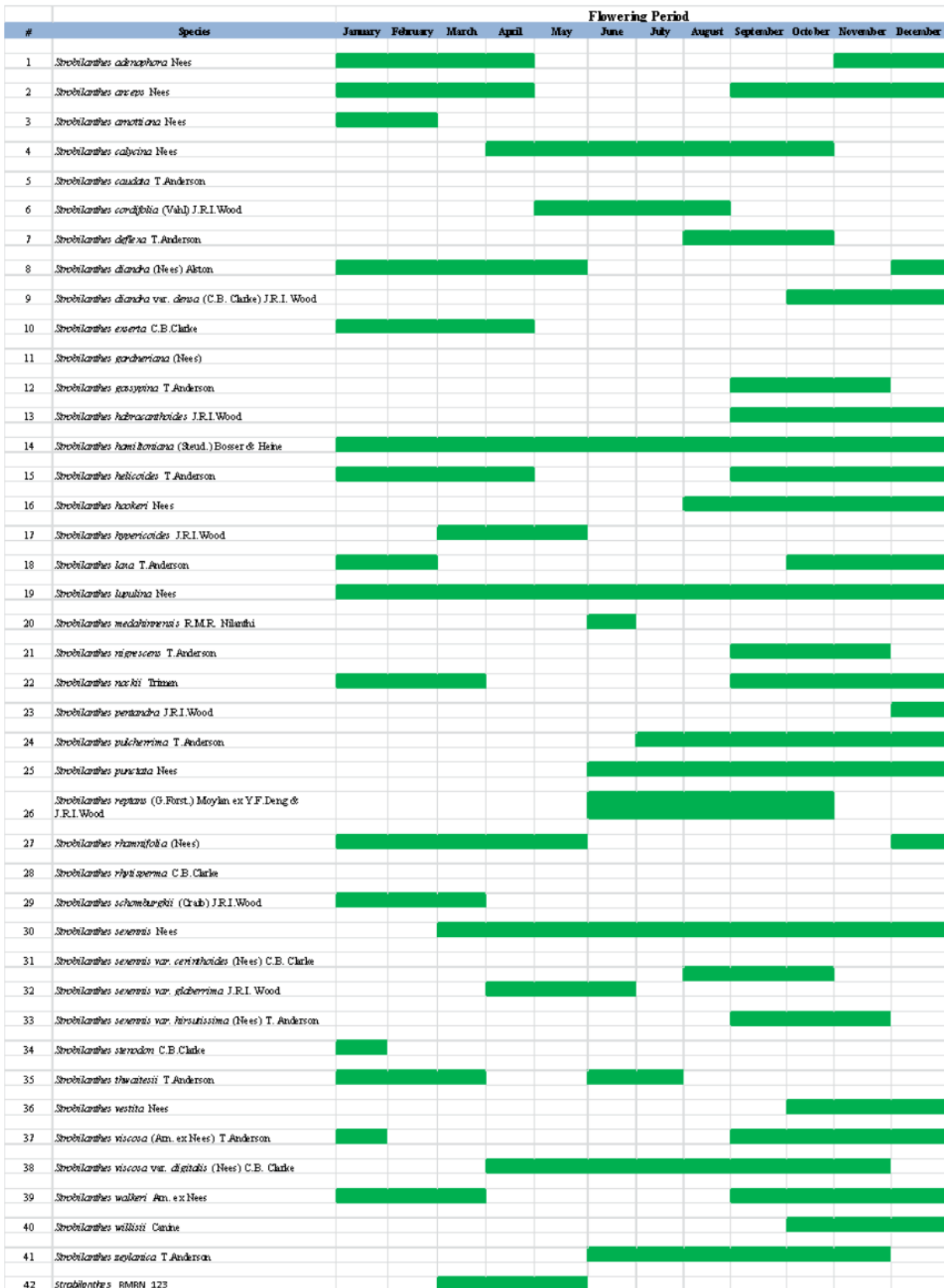


Figure 9. Flowering Period of *Strobilanthes* species

Strobilanthes has a flowering period varying from 3 to 13 years depending on the species. Similarly, *Strobilanthes* species blooming period of the year is varying according to the species (Figure 9). Most of species bloom on September to December. Some species such as *S. lupulina* and *S. hamiltoniana* bloom throughout the year. Many species are remarkable for their gregarious flowering

over large areas. Leaf shape is variable from narrowly oblong-lanceolate to broadly oblong-elliptic (Figure 10). Corolla shape is variable within *Strobilanthes*; in Sri Lankan species of *Strobilanthes* have corolla tube abruptly campanulate from a narrow cylindrical base while some species have corolla tube gradually expanded from the base (Figure 11).

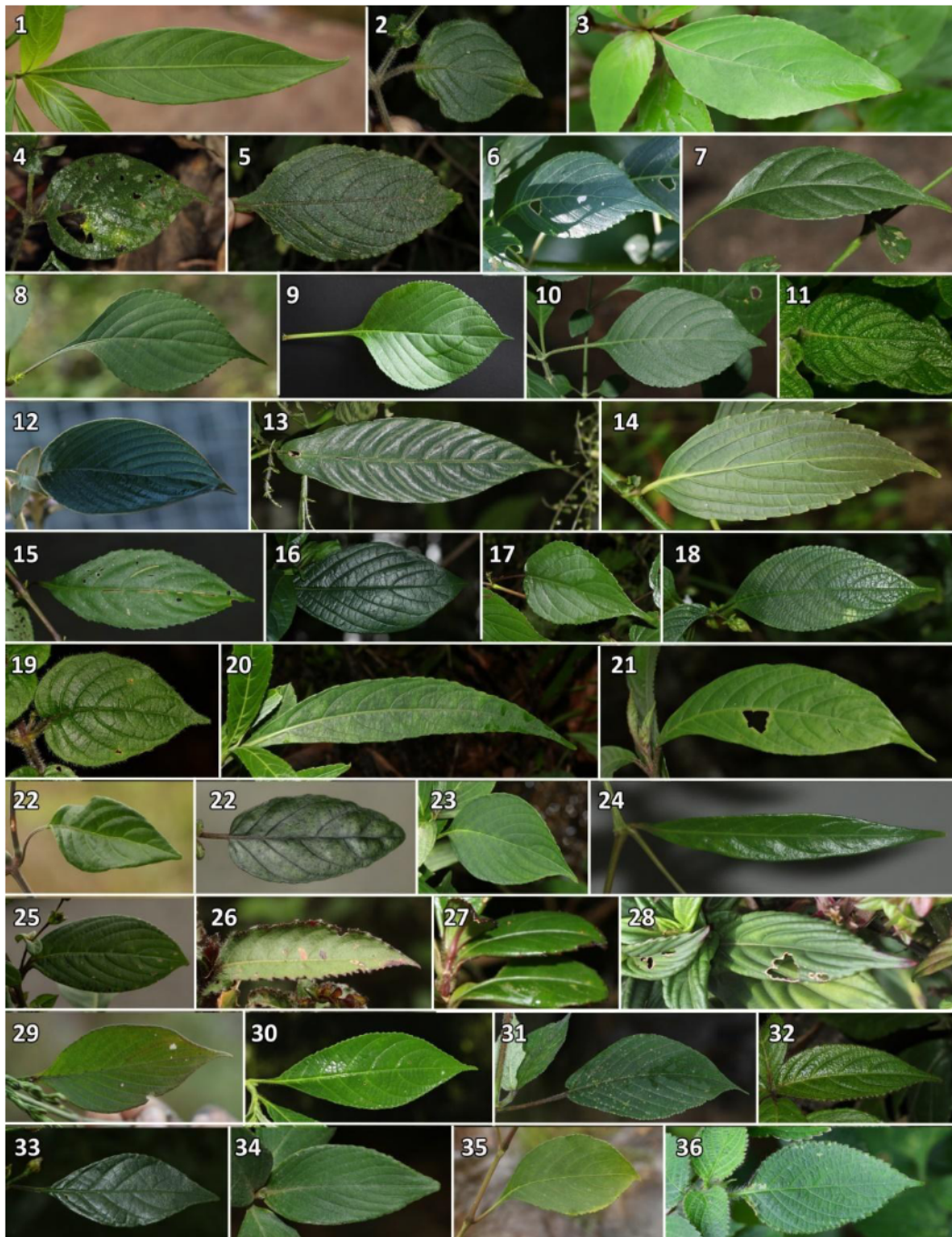


Figure 10. Morphological variation of leaf of Sri Lankan *Strobilanthes*

1. *Strobilanthes adenophora*; 2. *S. anceps*; 3. *S. rhytisperma*; 4. *S. arnottiana*; 5. *S. calycina*; 6. *S. cordifolia*; 7. *S. deflexa*; 8. *S. diandra* var. *diandra*; 9. *S. diandra* var. *densa*; 10. *S. exserta*; 11. *S. gardneriana*; 12. *S. gossypina*; 13. *S. habracanthoides*; 14. *S. hamiltoniana*; 15. *S. helicoides*; 16. *S. hookeri*; 17. *S. laxa*; 18. *S. lupulina*; 19. *S. medahimmensis*; 20. *S. nigrescens*; 21. *S. pulcherrima*; 22. *S. punctata*; 23. *S. reptans*; 24. *S. schomburgkii*; 25. *S. sexennis* var. *sexennis*; 26. *S. sexennis* var. *hirsutissima*; 27. *S. sexennis* var. *cerinthoides*; 28. *S. sexennis* var. *glaberrima*; 29. *S. stenodon*; 30. *S.*

thwaitesii; 31. *S. vestita*; 32. *S. viscosa* var. *viscosa*; 33. *S. walkeri*; 34. *S. willisii*; 35. *S. zeylanica*; 36. *S. RMRN_123*

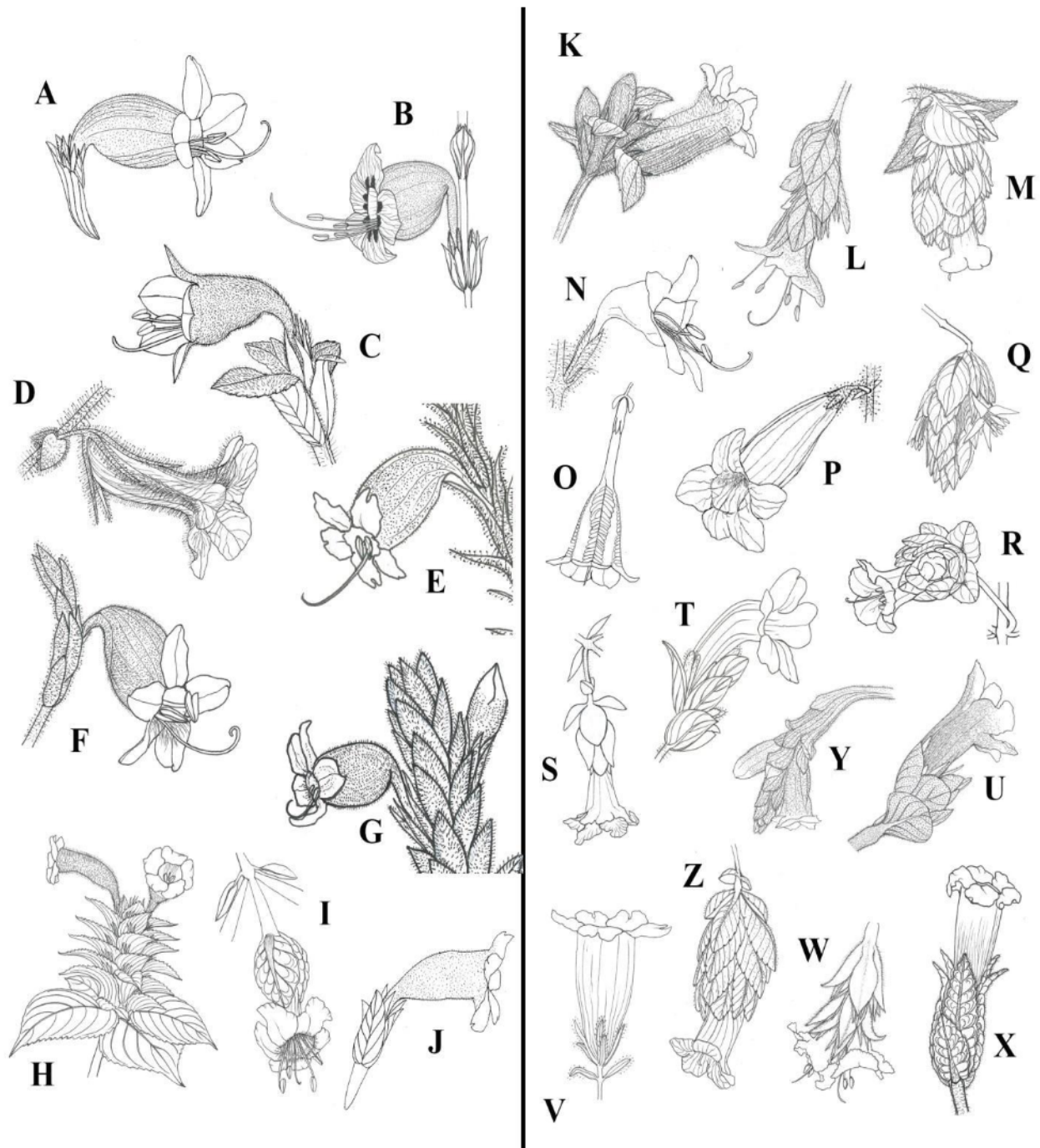


Figure.11. Corolla Shapes

Left - Abruptly campanulate from a narrow cylindrical base; A. *S. adenophora*; B. *S. cordifolia*; C. *S. exserta*; D. *S. pulcherrima*; E. *S. nigrescens*; F. *S. viscosa*; G. *S. rhamnifolia*; H. *S. zeylanica*, I. *S. walkeri*; J. *S. deflexa*. Right - Gradually expanded from the base; K. *S. anceps*; L. *S. arnottiana*; M. *S. calycina*; N. *S. diandra*; O. *S. hamiltoniana*; P. *S. habracanthoides*; Q. *S. laxa*; R. *S. hookeri*; S. *S. lupulina*; T. *S. sexennis*; U. *S. punctata*; V. *S. helicoides*; W. *S. vestita*; X. *S. thwaitesii*. Y. *S. medahimmensis*, Z. RMRN_123 (Nilanthi, 2019).

4. Discussion

The highest numbers of *Strobilanthes* species were recorded from Foothills of Adam's Peak and Ambagamuwa Floristic Zone which geographically runs from Maskeliya to the upper Kelani valleys in the northwest and south through lowland Ambagamuwa, Ginigathena, Deraniyagala, through Kuruwita-Erathne and then eastwards through Rassagala (Balangoda) to mid zone of Belihul Oya (Ashton and Gunatilleke, 1987). The region experiences high rainfall throughout the year. It is the wettest and least seasonal part of the lowlands in the whole county (Ashton and Gunatilleke, 1987). The deep valleys which flank the western part of the mountain range are refuged for highly localized endemic species. The high floristic diversity has resulted from the varied geographical and climatic conditions.

The second highest numbers of *Strobilanthes* species (11 no. of species) were distributed on Knuckles Floristic Zone which is a complex of several forest types, such as tropical lower montane forest, tropical upper montane forest, lowland tropical semi evergreen forest and lower montane tropical semi evergreen forest.

The lowest numbers of *Strobilanthes* species (only one species) are distributed on Southern Arid Floristic Zone and Northern Arid Floristic Zone because these zones are the most arid landscapes found in the north and north-western part of the island and the south-eastern corner of the island. These arid regions receive below 1,000mm (or 800mm) of rainfall annually (Somasekaram, 1988). On average, the region experiences a dry period of more than 6 months annually. The vegetation of the arid zone consists mainly of thorn woodland, with thorn bearing shrubs and scattered trees across the landscape.

S. caudata may have become extinct as a result of their habitats being lost to agriculture while *S. hypericoides* and *S. pentandra* are recorded only from the type collections. New species *S. medahinensis* has been described very recently.

The principle threats in the study area are urbanization, cultivation, tourism activities, fire, overgrazing, pollution, road and dam constructions. In near future, plant diversity may decline and threatened species may disappear in the area if necessary conservation measures are not taken.

5. Conclusion

There is a rich *Strobilanthes* diversity, different habitats and vast distribution range in Sri Lanka and It is possible that more new species remain to be discovered.

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